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Mother's dietary diversity and association with stunting among children <2 years old in a low socio-economic environment: A case-control study in an urban care setting in Dhaka, Bangladesh

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Abstract

Mothers are often responsible for preparing nutritious foods in their households. However, the quality of mother's diets are often neglected, which may affect both mother's and child's nutrition. Since, no single food contains all necessary nutrients; diversity in dietary sources is needed to ensure a quality diet. We aimed to study the association between mother's dietary diversity and stunting in children <2 years attending Dhaka Hospital of icddr,b, a diarrhoeal disease hospital in Dhaka, Bangladesh. A case-control study (n=296) was conducted from November 2016 to February 2017. Data were collected from mothers of stunted children <2 years [Length-for-age z-score (LAZ) <-2] as 'cases' and non-stunted (LAZ ≥-1) children <2 years as 'controls'. Mothers were asked to recall consumption of ten defined food groups 24 hours prior to the interview as per Guidelines for Minimum Dietary Diversity for Women. Among the mothers of cases, 58% consumed <5 food groups during the last 24 hours, compared to 45% in control mothers (P =0.03). Children whose mothers consumed <5 food groups were 1.7 times more likely to be stunted than children whose mothers consumed ≥5 food groups (P=0.04). Intake of food groups such as pulses, dairy, eggs, and vitamin A rich fruit was higher in control mothers. Proportion of mother's illiteracy, short stature, monthly family income <BDT 11,480, absence of bank account, and poor sanitation were also found to be higher in stunted group. Further study particularly intervention or longitudinal study to see the causality of mother's dietary diversity with child stunting is recommended.

Key words:

Child malnutrition, mother's diet, dietary diversity, stunting

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Introduction

Adequate nutrition from the early stages of development, especially during pregnancy and the first two years of life, works as a 'window of opportunity' for appropriate growth and development (Amugsi, Mittelmark, & Oduro, 2015). Nutritional deficiency during this period leads to growth faltering or stunting (World Health Organization, 2014). Nearly 165 million children under the age of five are stunted globally (Black et al., 2013). In Bangladesh, about 36% of children under the age of five are stunted, while 12% are suffering from its severe form (NIPORT et al., 2014). Early childhood stunting predicts poor cognitive and educational outcomes later in life and has significant social and economic consequences at the individual, household, and community levels (Walker et al., 2007). Considering the burden, appropriate nutrition during this critical period is essential in preventing stunting and ensuring the development of healthy and productive adults.

One of the most important factors to improve child stunting may be mother's diet, following a logic that all family members eat from the same family pot. Mothers have the principal responsibility of selecting, preparing, and serving nutritious foods to their children. Few studies have indicated that what mothers eat is strongly associated with what their children eat (Amugsi, Mittelmark, & Oduro, 2015) . However, the diets of mothers are often neglected, which can have serious consequences for both mother and child (Ruel, Deitchler, & Arimond, 2010). Due to the physiological demands of pregnancy and breastfeeding, if

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mothers nutrition is not met properly, it may cause stunting and slowed cognitive development in their offspring (FAO and FHI 360, 2016). So diversity in dietary sources is needed to ensure a balanced and healthy diet for mothers (Savy et al., 2008). In Bangladesh, 59% of women consume an inadequately diverse diet (HKI and JPGSPH, 2014). Poor dietary diversity reflects the overall nutritional status of reproductive age women in the country, as one-fifth of them are undernourished (BMI <18.5) (NIPORT et al., 2014).

Recently, the Food and Agriculture Organization of the United Nations (FAO) and the Food and Nutrition Technical Assistance III Project (FANTA) have developed a new indicator of dietary diversity to assess micronutrient adequacy in women of reproductive age, known as the Minimum Dietary Diversity – Women (MDD-W) (FAO and FHI 360, 2016). MDD-W is a dichotomous indicator of whether women of 15-49 years of age have consumed at least five out of ten defined food groups during the previous day and night. This indicator not only provides a means to measure diet quality and diversity in food sources, but it also serves as a specific threshold for micronutrient nutrition in women. A higher proportion of women consuming at least five out of the ten food groups predicts higher micronutrient adequacy in a given population. Thus, MDD-W can be used as a tool for assessment, target-setting, and advocacy of mother's nutrition (FAO and FHI 360, 2016).

Various studies have demonstrated a positive relationship between household dietary diversity and nutritional status of children (Arimond & Ruel, 2004). Mother's dietary diversity has also been shown to be associated with the dietary diversity of their offspring (Nguyen et al., 2013). However, using the MDD-W indicator to explore the relationship between mother's dietary diversity and a child's nutritional

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status is relatively a new concept. Given this information, the objective of this study was to identify the association between mother's dietary diversity and stunting among children <2 years of age seeking clinical management for diarrhoea in a diarrhoeal disease hospital in Bangladesh.

Key Messages

- Good maternal DD was associated with low prevalence of childhood stunting.
- Mothers of stunted children were less likely to consume pulses, dairy, eggs, and vitamin A rich fruit.
- Further study particularly intervention or longitudinal study to see the causality of mother's dietary diversity with child stunting is recommended.

Methods

Study design

We conducted an age and sex matched case-control study among children <2 years of age accompanied by their mothers and attending the short-stay unit of Dhaka Hospital of International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) from November 2016 to February 2017.

Study Site

Dhaka Hospital of icddr,b is situated in Dhaka, the capital of Bangladesh, a metropolitan area (1,500 sq km) with a total population of ~15 million. Established in 1962, icddr,b provides free care and treatment to around 140,000 patients annually (Ferdous et al., 2015). Most of these patients are from poor socioeconomic communities in urban and semi-urban areas of Dhaka.

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Eligibility Criteria

Children <2 years old and their mothers were enrolled in the study. Children who were not wasted or underweight (weight-for-height or weight-for-age z-score ≥-2) and having a length-for-age z-score (LAZ) < -2 were selected as case groups. We selected stunted children as cases as stunting is unlikely to be associated with an acute illness like diarrhoea, and more related to nutrient deficiency for a longer period of time. Control groups were defined as children who were not wasted or underweight (weight-for-height or weight-for-age z-score ≥-2) and had a LAZ ≥ -1.00. Children who were severely ill or suffered from congenital anomalies, chronic diseases, or any other health conditions that can affect nutritional status and normal feeding behaviour were excluded from the study. Adopted children and children whose mothers were pregnant at the time of data collection were also excluded. No socio-economic parameters were considered in the selection of participants.

Sample size (Requires mentioning of power and confidence level)

There are no nationally representative data regarding maternal dietary diversity in relation to child stunting. Thus, we assumed a 50% risk of exposure to maternal consumption of less diversified foods in the control group. We calculated the sample size for a case to control ratio of 1:1 with 80% power and 95% confidence level to detect an odds ratio of 2. This gave us 148 cases and 148 controls for a total of 296 children.

Data Collection

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During the study period, on all working days, children <2 years old who were attending the short stay unit of the hospital were recruited in the study until the desired sample size was reached. Each day, a sample list of <2 years aged children who were admitted on that particular day in the short stay unit was generated using the electronic registration system of the hospital. After obtaining written and informed consent from the mothers, anthropometric status was measured for those children. Children who satisfied the eligibility criteria were enrolled in the study. For each case, an age and sex matched control child was chosen from the same unit following the same procedure.

We recorded each child's nude weight, using a standardized digital scale with 10 g precision (Seca, model-345, Hamburg, Germany), and recumbent length to the nearest millimetre, using a calibrated, locally constructed length board. This information along with the child's age was used to derive nutritional status through the anthropometric calculator section of the WHO Anthro software (Version 3.2.2, January 2011) based on the WHO standards for weight-for-age, length-for-age, and weight-for-length. If a child was found eligible for the study, the height and weight of the mother were also measured using Seca Stable Stadiometer (precision 0.1 cm) and Tanita step-on type weighing scale (precision 1 gm) respectively.

Each day, five to six interviews were performed using a pretested, structured written questionnaire. The interviews assessed the mother's socio-economic status, dietary diversity, and child feeding practices including dietary diversity. Mother's dietary diversity was evaluated using the Guidelines for Minimum Dietary Diversity for Women (MDD-W) (FAO and FHI 360, 2016). Mothers were asked to recall consumption of ten defined food groups in the 24 hours prior to the interview. Responses were recorded

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as either 'yes, consumed' (1) or 'no, not consumed' (0). Child feeding practices were determined using WHO-specified guidelines regarding Infant and Young Child Feeding (IYCF), by which mothers were asked about their children's breastfeeding status and intake of solid and semi-solid foods during the previous day and night (World Health Organization & UNICEF, 2003). Interviews were conducted in an isolated area of the hospital at a time when the child had already received initial treatment and was in relatively stable condition.

Statistical Methods

The data was entered in STATA software for Windows (Version 13). A descriptive analysis was done first to measure general information on the characteristics of the study population. For normally distributed continuous variables, means were compared using unpaired *t*-tests. Household socioeconomic status was calculated using the WAMI score. The WAMI score (range 0 to 1) measures access to improved Water/sanitation, Assets, mother's education, and Income. This score has been previously used in the Malnutrition and Enteric Dysfunction (MAL-ED) study to measure socioeconomic status in multicounty studies including those in Bangladesh (Psaki et al., 2014). Using WHO definitions, households with access to improved water or sanitation were assigned a score of 4 for each, whereas households without access were assigned a score of 0. We used eight assets previously used for measuring the WAMI index in the MAL-ED study in Bangladesh (Psaki et al., 2014). For each of the eight assets, households were assigned a score of 1 if they had the asset and 0 if they did not have the asset. These scores were summed. Regarding mother's education, we divided the number of years of schooling between 0 to 16 years by 2. Monthly household income was converted to USD using the average exchange rate from November 2016 to February 2017. Income was divided into octiles using

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standardized scores and cutoffs. Scores in water and sanitation, assets, mother's education, and income were summed and divided by 32 to calculate a final WAMI score. The 10 MDD-W groups were summed into a score ranging from 0 to 10. This score was used to create the dichotomous MDD-W indicator by calculating the proportion of women who scored from 5 to 10 and those who scored below 5. Differences in the proportions between dietary diversity scores or socio-demographic variables and anthropometric indices were compared using a chi-squared test or Fisher's exact test. A probability of less than 0.05 was considered statistically significant. The strength of association between mother's dietary diversity and child stunting was determined by estimating odds ratios (ORs) with 95% confidence. All independent variables were analyzed initially in bivariate models and those that were found to be significantly associated with mother's dietary diversity and stunting in children and were biologically plausible were included in logistic regression models. We performed Hosmer and Lemeshow test to evaluate the model goodness of fit and it suggested that the model was good fit (Hosmer and Lemeshow value 4.23, p-value 0.75). Regarding model diagnostics, if we consider 3 sigma limit for outlier, there was no value of standardized residual > absolute value of 3 and there was no high leverage value. Besides, there was no influential observation as indicated by Cook's distance test.

Ethical considerations

This study was approved by the institutional review board [Research Review Committee and Ethical Review Committee] of icddr,b. Prior to collecting data, we obtained written informed consent from each mother. The privacy, anonymity, and confidentiality of data and identifying information of the study participants were strictly maintained. Personal identifiers recorded during the study were kept under lock and key and only study personnel had access to any sensitive information.

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Results

A total of 296 children (148 cases and 148 controls) were enrolled in the study. Each group was comprised of 91 (61%) male and 57 (39%) female children. The mean age of the study participants was 10.39 ± 5.13 months. Maternal mean age of stunted children was 24.3 ± 4.8 years and for non-stunted children, it was 25.5 ± 5.5 years (P =0.04) (Table 1). In cases, 11% of the mothers were <19 years old, whereas this proportion in the control group was only 5%. Illiteracy among mothers was nearly 3 times higher in cases compared to controls (14% vs. 5%) (P = 0.02). The average monthly household income in Bangladesh is defined as BDT 11,480 (1 US Dollar = 69 BDT), as determined by the Household Income and Expenditure survey conducted in 2010 (Bangladesh Bureau of Statistics, 2011). Our study showed that 35% of cases had a monthly family income <BDT 11480 whereas, in the control group, 22% had a monthly family income of less than the referenced value (P = 0.02) (Table 1). Regarding household assets, the proportion of case families with ownership of five selected assets was low compared to control families. Our calculation of WAMI scores showed that mean WAMI score was higher in controls (0.78 ± 0.14) than cases (0.69 ± 0.14) (P <0.001) (Table 1).

The mean LAZ was -2.71 ± 0.51 in stunted children and -0.13 ± 0.72 in non-stunted children (Table 1). In mothers, mean BMI was lower in cases compared to controls (23.23 ± 4.61 vs. 24.46 ± 4.22) (P = 0.02). The proportion of undernourished mothers (BMI<18.5) was two times higher among cases than controls (14% and 7% respectively). About 30% mothers of case children were short statured (height<145 cm),

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whereas this was true for only 8% mothers of control children (P<0.001) (Table 1). Regarding overweight and obesity, 34% mothers in the case group were overweight or obese compared to 41% mothers in the control group.

The minimum dietary diversity score for mothers was 4.23 ± 0.31 in cases and 4.89 ± 0.29 in controls (P=0.002). About 58% of mothers of cases consumed <5 food groups on the previous day of the interview, while this proportion was only 45% in control mothers (P = 0.03) (Figure 1). Almost all mothers in both groups consumed a starchy staple (rice) on the previous day (Figure 1). Intake of pulses was higher in control mothers than cases (71% vs. 59%) (P=0.03). About 16% mothers in the case group consumed dairy products compared to 26% in controls. Egg intake was also higher in controls than cases (31% vs. 25%). Consumption of vitamin A rich fruits and vegetables was lower in mothers of case children than controls (18% vs. 24%). This was true of other fruits and vegetables as well, except the consumption of dark green leafy vegetables, which was similar in both groups.

Our assessment of child feeding practices showed that only 16% of children <6 months in the cases were exclusively breastfed, while this proportion was higher in control group (24%). About 74% cases aged 12-15 months received continued breastfeeding compared to 84% of controls. In controls, overall age-appropriate breastfeeding was higher (78% vs. 71%). Predominant breastfeeding was nearly double in control children compared to cases (46% and 24% respectively) (Figure 2). In terms of dietary diversity, a higher proportion of control children met the minimum requirements (16%) than case children (7%) (Figure 2). Minimum meal frequency was also higher among controls (68% compared to 56% among case

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children). There were also differences between case and control children in meeting the minimum acceptable diet criteria (4% in cases and 11% in controls).

Bivariate analysis revealed several factors to be predictive of stunting in children (Table 2). Mother's consumption of <5 food groups, mother's illiteracy, short stature, monthly family income of less than 11480 BDT, absence of bank account, poor sanitation and low dietary diversity in children were found to be determinants of stunting. Since the association between mother's dietary diversity with a child's nutritional status may be confounded by these covariates, we further examined the risk estimate by entering variables with a p-value ≤0.5 into a multivariate regression model. Low child DD, though found positively related to child stunting, was not considered in final logistic regression due to its high correlation with mothers' DD. Stunting was evident in both the unadjusted and adjusted analysis for women who consumed<5 food groups during the 24-hour recall period. Children whose mothers consumed <5 food groups were 1.7 times more likely to be stunted than their counterparts (aOR = 1.72, 95% CI: 1.04 -2.87, P=0.04). Higher odds of children being stunted were found in women who were short statured (aOR = 4.78, 95% CI: 2.33-9.84, P<0.01). After adjustment, other variables found to be associated during bivariate analysis were not significant determinants of child stunting.

Discussion

We aimed to assess the relationship between mother's dietary diversity and stunting among children <2 years of age by doing a case-control study in Dhaka Hospital of icddr,b. Our results present a strong evidence of positive association between mother's dietary diversity and stunting after adjusting for socio-demographic factors. To our knowledge, no prior study has been done to explore the relationship between minimum dietary diversity in women and child nutrition.

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Literature suggests that mothers play a significant role in shaping their children's eating habits. A difference of one food group in mother's consumption was associated with a difference of 0.29 -0.72 groups in child's consumption (Amugsi et al., 2015) (Nguyen et al., 2013). Our bivariate analysis also showed a positive association between mother's DD and child's DD. However, since these two variables were highly correlated, we decided to exclude child's DD from the regression model as considering both mother's DD and child's DD in the model did not show any association with child stunting. Literature also suggests that child DD itself is significantly associated with stunting; either as a main effect or in an interaction. Results from 11 countries Demographic and Health Surveys (DHS) showed strong positive association between child DD and height-for-age Z-scores (HAZ) for children 6–23 months old while controlling for household wealth/ welfare and several other potentially confounding factors (Arimond and Ruel, 2004). We found a similar positive association between child DD and stunting in our bivariate analysis. As mentioned, child's DD failed to show any significant association when considered along with mothers' DD in the regression model. An important issue to be considered here is that, in our study, all children were suffering from diarrhoea and the majority of them could not eat properly on the previous day due to their morbid condition. This may have affected their regular dietary intake, resulting in low dietary diversity in both case and control groups (overall 12%). Nationally the prevalence of child's DD is comparatively much higher (28%) than what we found our study (NIPORT et al., 2014) indicating that the proportion of child's DD did not represent the real scenario.

We found a strong association between stunting in children with mother's dietary diversity. We hypothesized that the proportion of stunted children's mothers consuming less diversified food would be

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higher than the control children and our study result proved this hypothesis. Since this was a hospital based case-control study, assessing mother's dietary habits in the previous 24 hours was the only feasible option to take dietary data without imposing any stress on mothers and avoiding recall biasness. Although stunting is a chronic condition which might have happened in advance of the given exposure for this study, we assume that mother's dietary practice has been in this nature for a longer period of time which in turn had an impact on child's dietary practice as well. Besides, MDD-W is a widely used and validated proxy indicator for the probability of micronutrient adequacy of women's diets. Recently, Food Security and Nutrition Surveillance Project (FSNSP) in Bangladesh assessed women's dietary diversity using the same tool (JPGSPH and NNS, 2016) and found that urban mothers had a dietary diversity score of 4.5 which is similar to what we have found in our study (Mean DD among the participants 4.56 ± 1.89). So we can assume that a 24 hr recall of diet of a mother (with a child in hospital) will present the diet diversity behaviour in normal (non-hospital) circumstances. However, based on the results of this observational study, we can only assume that there is causality between mother's diet and child stunting. This study was done in only one hospital setting and further studies using multiple settings, particularly intervention or longitudinal study at community level could be a potential step to establish the causality.

Conclusion

We suggest further intervention or longitudinal study to evaluate the causality between mother's dietary diversity and stunting in children. Whether improving mother's dietary diversity can reduce risk of stunting or improve linear growth is also an important research issue to be considered. A greater emphasis should be placed on raising awareness for a nutritious and diverse diet for mothers. It may also be

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important for other family members to monitor mother's diet during pregnancy and lactation. We recommend an integrated approach in promoting mother's nutrition and in turn, improving nutritional status of their children.

References

Amugsi, D. A., Mittelmark, M. B., & Oduro, A. (2015). Association between Maternal and Child Dietary Diversity: An Analysis of the Ghana Demographic and Health Survey. *PLoS ONE, 10*(8).

Arimond, M., & Ruel, M. T. (2004). Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. *The Journal of Nutrition, 134*(10), 2579-2585.

Bangladesh Bureau of Statistics. (2011). *Report of the Household Income & Expenditure Survey 2010.* Bangladesh Bureau of Statistics, Statistics Division: Ministry of Planning.

Black, R. E., Victora, C. G., Walker, S. P., Bhutta, Z. A., Christian, P., de Onis, M., et al. (2013). Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, *382*(9890), 427-451.

FAO & FHI 360. 2016. Minimum Dietary Diversity for Women: A Guide for Measurement. Rome: FAO.

Ferdous, F., Ahmed, S., Farzana, F. D., Das, J., Malek, M. A., Das, S. K., et al. (2015). Aetiologies of diarrhoea in adults from urban and rural treatment facilities in Bangladesh. *Epidemiology and Infection, 143*(7), 1377-1387.

Helen Keller International (HKI) and James P. Grant School of Public Health (JPGSPH). (2014). State of food security and nutrition in Bangladesh: 2013. Dhaka, BD: HKI and JPGSPH.

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James P Grant School of Public Health (JPGSPH) and National Nutrition Services (NNS)(2016). *State of food security and nutrition in Bangladesh 2015*. Dhaka, Bangladesh: James P Grant School of Public Health and National Nutrition Services.

Nguyen, P. H., Avula, R., Ruel, M. T., Saha, K. K., Ali, D., Tran, L. M., et al. (2013). Maternal and child dietary diversity are associated in Bangladesh, Vietnam, and Ethiopia. *The Journal of Nutrition, 143*(7), 1176-1183.

Psaki, S. R., Seidman, J. C., Miller, M., Gottlieb, M., Bhutta, Z. A., Ahmed, T., et al. (2014). Measuring socioeconomic status in multicountry studies: results from the eight- country MAL-ED study. *Population Health Metrics, 12*(1), 8.

Ruel, M. T., Deitchler, M., & Arimond, M. (2010). Developing simple measures of women's diet quality in developing countries: overview. *The Journal of Nutrition, 140*(11), 2048S- 2050S.

Savy, M., Martin-Prével, Y., Danel, P., Traissac, P., Dabiré, H., & Delpeuch, F. (2008). Are dietary diversity scores related to the socio-economic and anthropometric status of women living in an urban area in Burkina Faso? *Public Health Nutrition, 11*(2), 132- 141.

USAID. (2012). *Maternal dietary diversity and the implications for children's diets in the context of food security*. Infant and Young Child Nutrition Project. USAID.

Walker, S. P., Chang, S. M., Powell, C. A., Simonoff, E., & Grantham-McGregor, S. M. (2007). Early childhood stunting is associated with poor psychological functioning in late adolescence and effects are reduced by psychosocial stimulation. *The Journal of Nutrition, 137*(11), 2464-2469.

World Health Organization & UNICEF. (2003). *Global strategy for infant and young child feeding.* Geneva: WHO Library Cataloguing-in-Publication Data.

World Health Organization. (2014). *Global Nutrition Targets 2025: Stunting Policy Brief.*

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Tables

Table 1: Anthropometric and socio-demographic characteristics of study participants

Background Characteristics	Cases N = 148 (%)	Controls N = 148 (%)	p-value
Children			
Sex			
Male	91 (61.5)	91 (61.5)	-
Female	57 (38.5)	57 (38.5)	-
Age			
<6months	25 (16.9)	25 (16.9)	-
6-12 months	63 (42.6)	63 (42.6)	-
12-24 months	60 (40.5)	60 (40.5)	-
Birth order >1	80 (53.7)	88 (59.5)	0.35
Weight in kg (mean ± SD)	6.88 ± 1.42	8.62 ± 1.89	<0.001
Length in cm (mean ± SD)	65.92 ± 6.65	72.04 ± 7.12	<0.001
HAZ score (mean ± SD)	-2.71 ± 0.51	-0.13 ± 0.72	<0.001
Mother			
Weight in kg (mean ± SD)	50.34 ± 10.78	56.67 ± 10.72	<0.001
Height in cm (mean ± SD)	147.06 ± 5.49	152.07 ± 5.47	<0.001
Maternal short stature (height <145cm)	45 (30.4)	12 (8.1)	<0.001
Body Mass Index (mean ± SD)	23.23 ± 4.61	24.46 ± 4.22	0.02
Severely/moderately/mildly thin (<18.5)	21 (14.2)	11 (7.4)	0.11
Normal (18.5-24.99)	77 (52.0)	77 (52.0)	0.13
Overweight and obese (>25)	50 (33.8)	60 (40.6)	0.46
Maternal Education			
No education	20 (13.5)	8 (5.4)	0.02
Primary	40 (27.0)	29 (19.6)	0.13
Secondary	71 (48.0)	67 (45.3)	0.64
Higher secondary or more	17 (11.5)	44 (29.7)	0.00
Maternal occupation			
Housewife	126 (85.1)	135 (91.2)	0.10
Working	22 (14.9)	13 (8.8)	0.10
Family head			
Husband	110 (74.3)	106 (71.6)	0.60

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Mother herself	11 (7.4)	14 (9.5)	0.53
Others	27 (18.2)	28 (18.9)	0.88
Husband's occupation			
Professional/Technical/Business/service	54 (49.1)	68 (64.2)	0.02
Factory worker/Labor/others	56 (50.9)	38 (35.6)	0.02
Husband's education			
No education	19 (17.3)	13 (12.3)	0.25
Primary	25 (22.7)	22 (20.6)	0.55
Secondary	55 (50.0)	35 (33.0)	<0.001
Higher secondary or more	11 (10.0)	36 (33.9)	<0.001
Monthly family income			
Income less than 11480 taka	51 (34.5)	33 (22.3)	0.02
Income 11480 taka or more	97 (65.5)	115 (77.7)	0.02
Household family members			
Less than or equal to 5	102 (69.4)	104 (70.7)	0.79
More than 5	45 (30.6)	43 (29.3)	0.79
Number of rooms in the house			
2 or less rooms	105 (71.0)	80 (54.1)	<0.001
More than 2 rooms	43 (29.0)	68 (45.9)	<0.001
Household Assets			
Mattress	138 (93.2)	146 (98.6)	0.02
Refrigerator	71 (47.9)	105 (70.9)	<0.001
TV	103 (69.6)	121(81.8)	0.01
Table	85 (57.4)	112 (75.7)	<0.001
Chair/Bench	102 (68.9)	130 (87.8)	<0.001
Use of bank account	61 (41.2)	86 (58.1)	<0.001
Separate kitchen space in household	137 (92.5)	148 (100)	<0.001
Improved sanitation	139 (93.9)	147 (99.3)	0.01
Improved source of drinking water in household	148 (100)	148 (100)	-
WAMI score	**0.69 ± 0.14**	**0.78 ± 0.14**	<0.001

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Table 2: Maternal dietary diversity and association with child stunting; results from logistic regression analysis

Variables	Unadjusted OR	95% CI	p-value	Adjusted OR	95% CI	p-value
Dietary diversity						
Maternal consumption of ≥5 food groups	1					
Maternal consumption of <5 food groups	1.68	1.06-2.66	0.03	**1.72**	**1.04 -2.87**	**0.04**
Maternal height						
Maternal height ≥145 cm	1					
Maternal height <145 cm	4.95	2.49-9.84	<0.001	**4.67**	**2.28-9.56**	**<0.001**
Maternal education						
Maternal literacy	1					
Maternal Illiteracy	2.73	1.16-6.42	0.02	2.05	.82 - 5.13	0.13
Monthly family income						
Monthly family income ≥11480 BDT	1					
Monthly family income <11480 BDT	1.83	1.10-3.07	0.02	1.19	.65 - 2.17	0.57
Bank account						
Use of bank account	1					
No use of bank account	1.98	1.25- 3.14	<0.001	1.37	.80-2.30	0.25
Sanitation						
Improved sanitation	1					
Poor sanitation	9.52	1.19-76.11	0.03	7.48	.85-65.72	0.08

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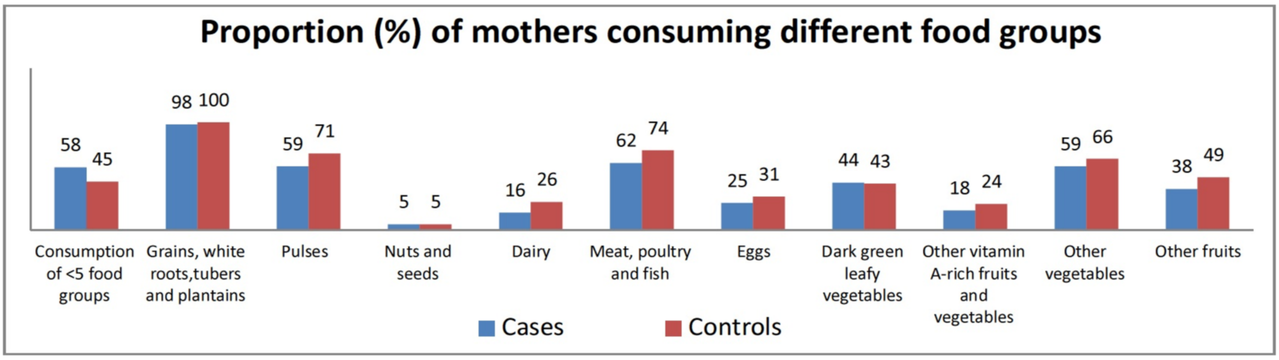

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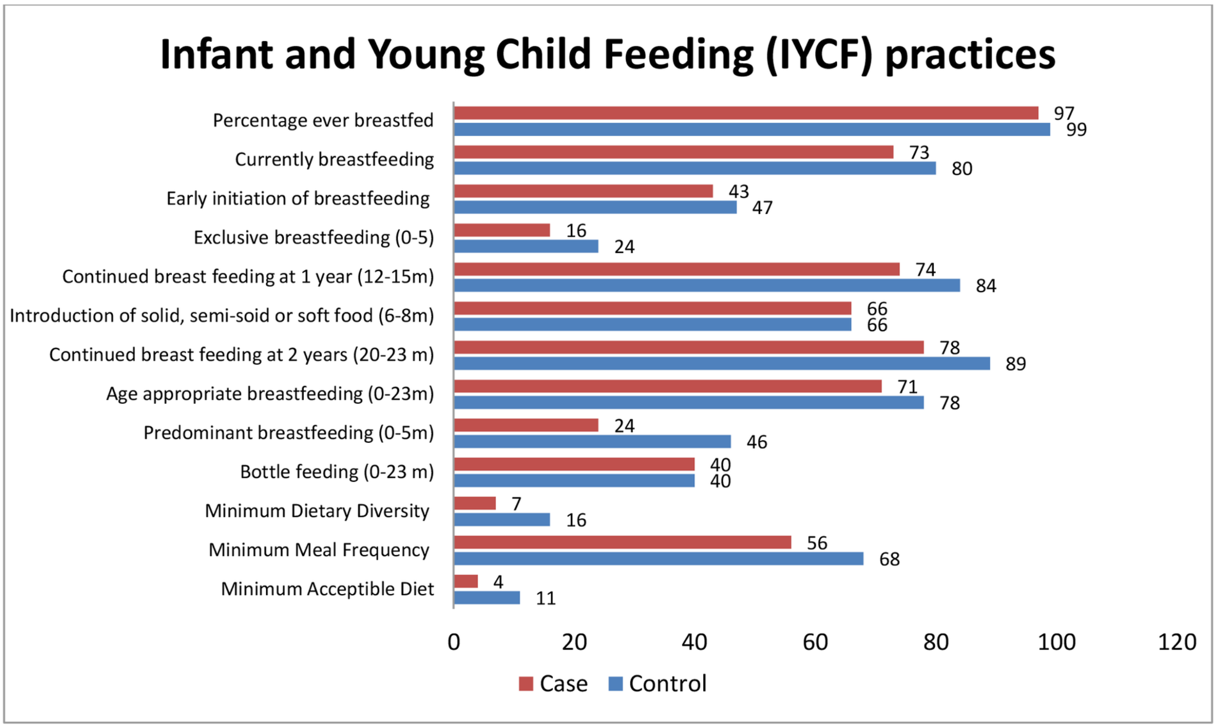

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Figures

Figure 1: Proportion (%) of mothers in stunted cases and non-stunted controls consuming different food groups in past 24 hours

Figure 2: Proportion of children (%) fed according to WHO recommended Infant and Young Child Feeding (IYCF) practices

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