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Drivers and distribution of the household-level double burden of malnutrition in Bangladesh: analysis of mother-child dyads from a national household survey

Abstract

Objective: In recent years, the double burden of malnutrition (DBM) has become an emerging public health issue in many low- and middle-income countries, including Bangladesh. This study aims to provide important evidence for the prevalence of different types of DBM at the national and subnational levels in Bangladesh.

Design: The study utilised data from the most recent Bangladesh Demographic and Health Survey (BDHS) 2017–18. This was a cross-sectional survey that used a two-stage stratified random sampling design to cover the entire population by taking a nationally representative sample. The outcome variable was the prevalence of DBM at the household level disaggregated by urban and rural households. Multivariable logistic regression was performed to identify the socio-demographic factors associated with DBM.

Participants: 8,697 mothers aged 15 to 49 years with <5 children.

Setting: Bangladesh.

Results: The overall prevalence of DBM was 21.03%, with a significantly higher prevalence in urban (24.79%) than rural areas (19.62%) in Bangladesh. High inequality was observed among underweight mother and overweight child (UWM&OWC) (Concentration Index -0.3) dyad, which indicated that poor households were more vulnerable to the DBM. A low level of inequality of DBM were observed for overweight mother & stunted child (OWM&SC) (CI 0.015), overweight mother and wasted child (OWM&WC) (CI 0.116) and overweight mother & underweight child (OWM&UWC) (CI 0.013) dyads. The age and educational status of the mother and wealth-status were significantly associated with the DBM positively while small households and mothers belonged to the Rangpur and Khulna divisions were more prone to DBM. .

Conclusions: Local government and various stakeholders should focus on issues related to the DBM and provide the necessary interventions to overcome this emerging public health problem in Bangladesh.

Keywords: Double-burden; malnutrition; mother-child dyads; urban-rural; Bangladesh

Introduction

In recent years, the double burden of malnutrition (DBM) has emerged as a global public health issue, particularly for low- and middle-income countries (LMICs) ⁽¹⁻³⁾. As per the World Health Organization (WHO), the double burden of malnutrition is characterized by the coexistence of undernutrition along with overweight, obesity, within individuals, households and populations, and across the life-course ⁽⁴⁾. Due to rapid urbanisation, economic transition and demographic dividend, many developing countries, including Bangladesh, are experiencing a nutritional transition ⁽⁵⁾. Children are particularly at risk as poor nutrition at early years can have lasting consequences throughout life. Yet, various forms of childhood malnutrition, such as stunting, wasting, being underweight, being overweight and obesity, are very common across various societal groups in many LMICs ⁽²⁾. According to the latest data, globally, approximately 149.2 million, 45.4 million and 38.9 million children under the age of five were stunted, wasted and overweight, respectively, while approximately 20 million new-borns are born with low birth weight ⁽⁶⁾. It was estimated that 45% of all deaths among children under five were directly related to childhood undernutrition, with most of these deaths occurring in Asia and Africa ⁽⁷⁾. The number of overweight children under five increased from 30 million in 2000 to 55.6 million in 2017 ⁽⁸⁾. Further, a number of mothers in the developing world are also suffering from underweight, overweight and obesity-related malnutrition ⁽⁹⁾. Per the latest estimates, approximately 1.9 billion adults are overweight or obese and 462 million people are underweight globally ⁽⁷⁾.

Although the prevalence of childhood undernutrition has declined substantially, the prevalence of undernourished children and underweight mothers is high in rural areas and among the poorest wealth quintile in Bangladesh ^(1,10). Further, due to rapid changes in global food systems, increasing urbanisation, decreased physical activity, changes in lifestyle and changes in dietary intake, many developing countries, including Bangladesh, are experiencing overweight-related issues among children and mothers ^(9,11). As a consequence, the proportion of people with overweight and obesity has increased substantially, particularly amongst the wealthiest and most educated individuals and people living in urban areas ^(1,9).

Like other developing countries, Bangladesh is experiencing a coexistence of undernutrition and overweight conditions at the population, individual, and household levels, a phenomenon referred to as the *double burden of malnutrition* (DBM), which is an emerging public health problem in Bangladesh ^(1,2). According to World Health Organization (WHO) guidelines, the DBM is characterised by the coexistence of undernutrition (including wasting, stunting and deficiencies in important micronutrients) with overweight, obesity or diet-related non-communicable diseases (NCDs) ⁽⁴⁾.

The concept of the DBM has emerged in the past three decades and recently received greater attention due to a recent series of papers in *The Lancet*, as it appears to be more permanent and widespread than previously perceived ^(12,13). It is well established that both underweight and overweight have multifaceted consequences for survival, the incidence of chronic diseases, healthy development and the economic productivity of individuals, societies and healthcare systems ⁽¹⁴⁾. Over- and undernutrition – both axes of malnutrition – are equally harmful. Undernutrition hinders physical and intellectual development, whereas over nutrition is a significant contributor to various non-communicable diseases, including diabetes and hypertension. Both forms of malnutrition cause huge direct and indirect costs to individuals, families and nations: approximately US\$3.5 trillion globally ⁽¹⁵⁾.

Bangladesh – a lower-middle-income country – has made remarkable progress in improving its population's health over the past few decades. This may be due to the pluralistic healthcare system in which private providers and various non-governmental organisations (NGOs) are engaged in healthcare delivery in Bangladesh. As a result, the prevalence of childhood stunting (low height for age) was reduced from 51%

in 2004 to 31% in 2017–18, while the prevalence of underweight (low weight for age) had reduced from 43% in 2004 to 22% in 2017–18⁽¹⁶⁾. While childhood undernutrition constitutes an enormous burden, the prevalence of childhood overweight conditions (2% in 2018) is an emerging public health problem in Bangladesh⁽¹⁶⁾. Moreover, in terms of underweight mothers, the prevalence decreased significantly from 30% in 2007 to 12% in 2017–18, while the prevalence of overweight mothers has increased alarmingly, from 12% in 2007 to 32% in 2017–18⁽¹⁶⁾. Recently, an increasing trend of being overweight or obese has been observed among urban and wealthier individuals in Bangladesh⁽¹⁷⁾. It has been noted that underweight and overweight mothers were found to coexist with stunting, wasting and underweight conditions in children within the same households in Bangladesh. The WHO policy brief on DBM indicated that most current policies tend to address either undernutrition or overweight and obesity, but not both; therefore, actions that address both conditions should be prioritised globally⁽⁴⁾. Such double-duty actions include interventions, programs and policies that have the potential to simultaneously reduce the risk or burden of both undernutrition and overweight, obesity or diet-related NCDs. This is an urgent issue, as the coexistence of various forms of malnutrition among mothers and children has continued to rise not only in Bangladesh, but globally. Notably, malnourished women are susceptible to experiencing complications related to pregnancy and childbirth⁽¹⁸⁾.

A number of studies have identified the DBM in various settings globally⁽¹⁹⁾ (1–3,20). A recent multi-country study that included Bangladesh estimated the DBM using three separate combinations of overweight or obese mothers with undernourished children (i.e. underweight, stunted and wasted children)⁽²⁾. It was also observed that the prevalence of underweight mothers remained high in rural areas while the prevalence of overweight mothers increased rapidly in both rural and urban areas, creating a DBM among mothers in Bangladesh⁽¹⁾. Another study predicted that by the year 2030, the prevalence of underweight mothers would be highest among the poorest sector of society and the prevalence of overweight and obesity would be highest among the richest sector in Bangladesh⁽²⁰⁾. A multi-country study conducted in Bangladesh referred to household-level DBM as the coexistence of overweight mothers and stunted children in the same household⁽²¹⁾. To the best of our knowledge, analysis of underweight and overweight mothers along with stunting, wasting, underweight, overweight and obesity status of the children in the same household to explore the status of DBM using nationally representative data in Bangladesh has not yet been performed. This study aims to provide important information about the prevalence of various forms of DBM at the national level and by urbanity in Bangladesh. The specific objectives of the study are to measure the prevalence, inequality and factors associated with overall double burden of malnutrition at household level in Bangladesh.

Materials and Methods

Study population and data source

The study utilised data from the most recent Bangladesh Demographic and Health Survey (BDHS) 2017–18. The survey was carried out from October 2017 to March 2018 under the authority of the National Institute of Population Research and Training, Medical Education and Family Welfare Division, Ministry of Health and Family Welfare⁽¹⁶⁾. The BDHS is a vital source of records of data used in this study, including women's body mass index (BMI) and records of stunting, wasting, underweight and overweight conditions of children under five years of age. Women aged 15 to 49 years with at least one of their children in the same household were the population of this study.

Survey design and sampling procedures

The BDHS 2017–18 was a cross-sectional survey that used a two-stage stratified random sampling design to cover the entire population by taking a nationally representative sample. This survey used a list of enumeration areas (EAs) and a standard sampling frame provided by the Bangladesh Bureau of Statistics⁽¹⁶⁾. A total of 8,772 individual mothers aged 15 to 49 years were enrolled in this study. However, 75 mothers were excluded because no children lived in their households. Thus, a total of 8,697 samples were analysed, with 2,379 and 6,319 mothers from urban and rural areas, respectively.

Outcome variables

The outcome variable was the prevalence of the DBM at the household level disaggregated by urban and rural households. The DBM was defined as the coexistence of mothers' and children's nutritional burden in the same household⁽²²⁾. Mothers' nutritional burden was defined as the existence of underweight or overweight conditions in the mother, while children's nutritional burden was defined as children with stunting, wasting, underweight or overweight. The 2017–18 BDHS used the WHO's guidelines to determine the cut-off values for mothers' BMI (i.e., underweight and overweight) and stunting, wasting, underweight and overweight status of the children⁽¹⁶⁾.

Explanatory variables

A number of explanatory variables were included in this study based on relevance and logical correlation with the DBM among women and children globally^(1–3,23). The series of explanatory variables were: age and educational and working status of the mother, mother's age at first birth, number of children, father's education and occupation, sex of children, child's birth order, household size, toilet-facilities, respondent's exposure to mass media and wealth index and administrative division of the households. The households of the study participants were categorised based on whether they were in urban or rural areas. Respondents' age was categorised into three groups: 15–19 years, 20–29 years and 30–49 years. Maternal and paternal educational status was reported by the study participant and categorised as 'no formal education', 'primary', 'secondary' and 'higher'. Mother's age at first birth was categorised into 3 groups (less than 18, 18–24 and 25 or above) and mother's working status was categorised as 'yes' and 'no'. Likewise, the respondent's number of children was categorised into three groups (one child, two children and three or more children). A composite score named the 'wealth index' was calculated using principal component analysis (PCA) based on the household's ownership of selected assets; availability of electricity supply; television; bicycle; materials used for housing construction; types of water access and sanitation facilities; use of health and other services; and health outcomes; ultimately, the wealth index was used to categorise households into the 'poorest', 'poorer', 'middle', 'richer' and 'richest' quintiles. According to DHS survey both durable household assets (e.g., radio, television, mobile phone) and household characteristics (e.g., toilet type, cooking fuel types and potable water source) that are related to wealth were used to generate the household wealth index⁽¹⁶⁾.

Measurement of inequality

Measurement of inequality was performed using the concentration curves and concentration indices. The concentration curve provides the pattern and magnitude of discriminations showing the distribution of DBM among the socioeconomic groups. The cumulative proportion of DBM in the vertical axis depicted against the cumulative proportion of the samples regarding socioeconomic status. If the DBM is more concentrated among poor people, the concentration curve will lie above the equity line and vice versa. If the concentration curve equals the 45-degree straight line exactly, this means that there is perfect equity in DBM with respect to the wealth index. The wealth index was calculated through PCA using BDHS survey data⁽¹⁶⁾. The

Concentration Index (CI) summarizes the information contained in each concentration curves and is twice the area between concentration curves and equity line ⁽²⁴⁾. CIs were calculated to measure the gap between the concentration curves and the equity line. The value of the Concentration index lies between -1 and +1 (i.e., $-1 \leq CI \leq +1$), where -1 refers to the case where DBM is fully concentrated among the poorest quintile, and +1 refers to the case where malnutrition is fully concentrated among the richest quintile. Further, a value of 0 (zero) signifies perfect equality, i.e., there is no socio-economic related inequity for double burden of malnutrition.

Statistical analysis

Descriptive analysis such as frequency distribution and cross-tabulation was applied for measuring the prevalence of DBM according to background variables. Inequality of DBM was measured by generating the Lorenz curve using Microsoft Office Excel v 16.0. Both adjusted and unadjusted logistic regression models were used to examine the significant risk factors. The dependent variable was expressed as binary, and it was represented as '1' for the coexistence of mothers' nutritional burden and children's nutritional burden in the same household, while 0 was represented for the non-coexistence of mothers' nutritional burden and children's nutritional burden in the same household. In the multivariable logistic regression models, results were presented as adjusted ORs (AORs) with 95% CIs. Results were considered to be statistically significant at the 5% alpha level ($p < 0.05$). Since the BDHS survey used a two-stage stratified cluster sampling technique, the recommended sample weights provided by the BDHS were used for the analysis ⁽¹⁶⁾. All statistical analyses were carried out using the statistical package Stata/SE 14 software (Stata Corp., College Station, TX, USA).

Results

Sociodemographic characteristics of the study participants

The sociodemographic characteristics of the study participants are described in Table 1. A total of 8,697 women with at least one child aged up to 60 months were included in this analysis, with most of the participants living in rural areas (72.65%). More than half of the respondents were young adults aged 20 to 29 years (62.41%) and had completed secondary and higher education (63.8%). Approximately 46% and 37% of rural and urban mothers, respectively, had their first pregnancy before 18 years of age, while 65% of mothers had at least two children. Approximately 59% of mothers had a BMI within the normal range, while 27% were overweight or obese and 14% were underweight. Approximately 52% of the children were male. Approximately 31% of the children were stunted, followed by underweight (22%), wasted (8%), obese (8%) and overweight (2%). Approximately one-third (31%) of the study households were large in size (6 or more family members), while only 13% of households were small in size. Most of the participants (60%) were using hygienic toilet facilities and 42% of participants had access to mass media. According to the wealth index, 26% of the rural population enrolled in the study were from the poorest quintile and 45% of the urban population in the study were from the richest quintile. The highest number of participants (26%) belonged to the Dhaka division (largest administrative unit), followed by Chittagong division (21%), while the lowest number of participants (6%) belonged to the Barisal division.

(Table 1 will be inserted here)

Prevalence of double burden of malnutrition across background characteristics

The prevalence of DBM across background characteristics is described in Table 2. The overall prevalence of DBM was 21.03%, with a higher prevalence in urban (24.79%) than rural areas (19.62%). DBM is highly prevalent (25%) among mothers aged 30 and above and among those who had no formal education (27%). DBM was observed in 24% of mothers who had their first child at the age of 25 or older, making mothers who had their first child after age 24 the group with the highest prevalence of DBM. DBM was most prevalent among the mothers who had three or more children at the time of the survey in both urban (27%) and rural areas (22%). The prevalence of DBM was found to be higher among the mothers who were employed (29%) than the mothers who were not working outside the home (23%) in urban areas. We observed that the DBM was more prevalent (23%) among the children whose fathers had no formal education than among those whose father had a higher educational level (21%). Male children had a slightly higher prevalence of the DBM than female children, while the children whose birth order was third or more were more prone to DBM in both urban (28%) and rural areas (22%). The prevalence of DBM was found to be highest among the small households (28%) compared to both the medium and large households (20%). The prevalence of DBM was highest among the richest and richer households in rural areas (22%) and the urban areas (27%) respectively. The overall DBM was highest in the Dhaka division (24%), followed by Sylhet (22%). However, the DBM was highest (30%) among individuals who lived in the urban areas of the Dhaka division and the rural areas of the Sylhet division (23%).

(Table 2 will be inserted here)

Prevalence of various forms of double burden of malnutrition among residents of rural and urban areas

The prevalence of various forms of DBM is shown in Figure 1. The DBM paired households were categorised as OWM&SC (overweight mother & stunted child); OWM&UWC (overweight mother & underweight child); OWM&WC (overweight mother & wasted child); and UWM&OWC (underweight mother & overweight child). The overall prevalence of DBM was highest for OWM&SC (4.42%) followed by OWM&UWC (3.17%). In urban areas, the prevalence of OWM&SC was higher (4.76%) than the overall prevalence of this pair and was the most common pair, followed by OWM&UWC (3.53%). In the rural areas, OWM&SC (4.29%) and OWM&UWC (3.03%) were more prevalent DBM pairs.

(Figure 1 will be inserted here)

Inequality in the prevalence of different types of double burden of malnutrition

Figure 2 shows the inequality of the prevalence of various forms of DBM using concentration curves. High inequality was observed among the UWM&OWC (Concentration Index -0.3) dyad, which indicated that poor households were more vulnerable to the DBM. A low level of inequality of DBM were observed for OWM&SC (CI 0.015), OWM&WC (CI 0.116) and OWM&UWC (CI 0.013) dyads.

(Figure 2 will be inserted here)

Factors associated with double burden of malnutrition

Table 3 shows the risk factors associated with the DBM across background characteristics. We observed that the age and educational status of the mother, size of the household, administrative division and wealth index of the household were significantly associated with the DBM. We observed a positive relationship between the age of the mother and DBM. The risk of DBM was 1.42 (CI 1.17–1.71; $p=0.001$) and 1.83 (CI 1.45–2.32; $p=0.001$) times higher among individual mothers aged 20–29 years and 30–49 years old, respectively, than the reference age group (mothers aged 15–19 years). Uneducated mothers (AOR 1.89;

CI 1.43–2.50; $p=0.001$), educated mothers who completed primary education (AOR 1.54; CI 1.24–1.93; $p=0.001$) and secondary education (AOR 1.37; CI 1.14–1.66; $p=0.001$) were more likely to exhibit the DBM compared with more highly educated mothers, and this difference was statistically significant. A higher prevalence of DBM was observed among the small households (AOR 1.54; CI 1.30–1.84; $p<0.001$) compared to the larger households. According to the administrative divisions, the DBM was less prevalent in the Rangpur division (AOR 0.80; CI 0.63–1.01; $p=0.03$) and Khulna division (AOR 0.76; CI 0.60–0.97; $p=0.01$) than the reference division (Rajshahi). In addition, DBM was more prevalent among richer (AOR 1.27; CI 1.06–1.52; $p=0.01$) and richest (AOR 1.33; CI 1.08–1.65; $p=0.001$) households compared to the poorest households. However, no significant differences were observed according to the number of children, father’s education, father’s occupation, place of residence, and birth order in the adjusted model.

(Table 3 will be inserted here)

Table 4 shows the risk factors associated with the UWM & OWC type DBM across background characteristics. We observed that the educational status and the number of children of the mother, size of the household, administrative division and wealth index of the household were significantly associated with the UWM & OWC type DBM. We observed that the educated mothers who completed primary education (AOR 9.52; CI 1.17–77.15; $p=0.03$) were most likely to exhibit the UWM & OWC type DBM compared with more highly educated mothers, and this difference was statistically significant. UWM & OWC type DBM was more prevalent (AOR 5.38; CI 1.41–20.49; $p=0.03$) among the mothers having one child than the mothers having two or more child. A higher prevalence of DBM was observed among the small (AOR 2.97; CI 1.22–7.26; $p=0.03$) and (AOR 2.63; CI 1.21–5.71; $p=0.03$) medium households than the large households. UWM & OWC type DBM was most prevalent (AOR 5.22; CI 1.65–16.53; $p<0.01$) in the Sylhet division compared to the Rajshahi division and richest quintile was least likely (AOR 0.14; CI 0.03–0.68; $P<0.05$) to manifest UWM & OWC type DBM compared to the poorest quintile.

(Table 4 will be inserted here)

Discussion

Although Bangladesh has made significant progress in reducing childhood undernutrition in the past decade, the rapid rise in overweight is a major challenge. Further, the prevalence of malnutrition among women of reproductive age is a big concern in Bangladesh ⁽²⁾. To our knowledge, this is the first study examining the prevalence of DBM that considers all forms of pairwise coexistence of malnutrition among mothers and children at the household level using nationwide representative data. Our findings provide a new perspective to researchers, policymakers and public health agencies who can take initiative to reduce this emerging public health burden in Bangladesh.

This study observed that the overall prevalence of the DBM at the household level was approximately 21%, with a significantly higher prevalence among urban households in Bangladesh. Bangladesh is experiencing rapid urban population growth; nonetheless, urban health is often neglected ⁽²⁵⁾. Further, the large-scale unplanned rural–urban migration resulted in overloaded public services, scarcity of housing, inappropriate diets, inaccessible healthcare facilities and a negative impact on health and the environment in many urban settings in Bangladesh ⁽²⁶⁾. In addition, various restaurants, supermarkets and food parks are gaining popularity in urban Bangladesh, serving as places for recreational family activities ⁽²⁷⁾. This changes the everyday food intake of urban residents, and junk food consumption was notably high among these residents due to various enabling factors, such as addictive taste, changing lifestyles, propagandist advertising and instant availability ⁽²⁸⁾. According to the latest urban health survey, only a negligible

improvement in childhood nutritional status was observed over the last seven years, with maternal health indicators being particularly unsatisfactory among slum dwellers, who comprise one-third of the urban population in Bangladesh⁽²⁹⁾. There are approximately fourteen thousand urban slums in Bangladesh, and these areas exhibit many factors that negatively affect the health and nutrition of both mothers and their children⁽³⁰⁾. Other studies in various settings found a positive association between urbanisation and BMI^(31,32).

A recent systematic review indicated an increasing trend in overweight and obesity among children, adolescents and adults over time, with a higher prevalence in urban areas of Bangladesh⁽¹⁷⁾. A recent study observed that the prevalence of overweight was significantly higher in women (79% vs 53%) than in men in urban Bangladesh⁽³³⁾. In contrast, rural mothers are more prone to underweight than urban mothers in Bangladesh, as had been observed in other resource-poor countries^(34,35). A recent multi-country study reported that women living in rural communities had a greater risk of having underweight children than urban mothers⁽³⁶⁾. Further, the prevalence of childhood undernutrition is more common in rural than urban communities in many settings^(10,34). Previous studies observed that the prevalence of childhood malnutrition was higher among Bangladeshi rural children, a phenomenon that has been frequently observed in other developing countries^(37,38).

This study assessed four different forms of DBM at the household level: UWM&OWC, OWM&SC, OWM&WC and OWM&UWC. Between 2004 and 2014, there was a 15% increase in the prevalence of overweight status and a similar decrease in the underweight status of women of reproductive age. The reduction in underweight status was of similar magnitude in both urban and rural areas, whereas there was a greater relative change in overweight status in the rural areas, which is congruent with recent review findings⁽³⁹⁾. The underweight prevalence in rural areas remained relatively high, as did the overweight prevalence among urban residents. These findings indicating a shift of nutritional burdens are an extension of previous findings, demonstrating consistency with the literature from Bangladesh^(1,40). Similar to what had previously been observed in many LMICs, this study found that the OWM&SC pair was the most prevalent DBM at the household level^(2,41). Compared with the neighbouring countries, the prevalence of OWM&SC we observed is lower than those previously reported in India (8%) and Pakistan (24%)⁽²⁾. Likewise, a higher prevalence of OWM&SC was also observed in many African and Latin American countries, such as Egypt (12.5%), Ghana (12.5%), Nicaragua (12.5%), Bolivia (15%), Peru (16%) and Guatemala (23%)⁽⁴¹⁾. Although our study did not attempt to identify the underlying reason for this difference, increases in the prevalence of overweight among women in South and Southeast Asia in recent decades appears to be an important factor⁽⁴²⁾. Regarding the OWM&UWC pair, our results were in accordance with reports from 18 LMICs of South Asia, Africa and Latin America, where the prevalence ranged from 0.3% to 5.3%⁽⁴²⁾. This study found that the prevalence of OWM&WC at the household level in Bangladesh was lower than that observed in other settings like Nepal (5%), Myanmar (6%), India (7%), Maldives (12%) and Pakistan (14%)⁽⁴¹⁾. This is likely because the prevalence of wasting (8%) is much lower than that of stunting (31%) and underweight (22%) among Bangladeshi children⁽¹⁶⁾.

This study highlights the socioeconomic inequality of the DBM, particularly for the pair underweight mother and overweight child, with poor households at a greater disadvantage than the rich. Of note, the current situation of maternal undernutrition in Bangladesh is similar to that observed in other LMICs⁽⁴³⁾. Various studies found that the wealth index plays a vital role in shaping women's nutritional status and that mothers from poor households in Bangladesh were more prone to being underweight⁽⁴⁰⁾. Social expectations regarding body size, beliefs and cultural practices about food, nutrition and physical activity may explain the association between overweight status and higher wealth quintiles^(2,3). For instance, a recommendation to follow a reduced-fat diet at the household level can reduce the BMI for those with overweight and obesity, but this intervention could increase the risk for underweight members in the same

household. In such a situation, the prevention programs should provide a health information that promotes the optimal weight for all individuals in the household. For example, an intervention of reduced energy consumption should be implemented for overweight individuals, particularly for urban residents and those belonging to the wealthiest strata ⁽⁴⁴⁾. In such interventions, the target population needs to be motivated to consume food with fewer calories and to increase physical activity such as walking. Awareness programs about the consequences of overweight and obesity, including prevention activities, should be available in schools, the workplace and the community. In contrast, a poor socioeconomic condition is associated with underweight women in Bangladesh because individuals in such conditions cannot afford expensive items such as milk, meat, poultry, fruits and other nutritious foods. For these individuals, the focus should be on healthy diets (e.g. consumption of fruits and vegetables) that lead to optimal BMI and other health outcomes for vulnerable households.

We observed that the age and educational status of the mother, size of the household, administrative division and wealth status of the household were significantly associated with the prevalence of DBM among mother–child pairs at the household level in Bangladesh. We found that older mothers had an increased risk of DBM compared to younger mothers. This result is consistent with several studies that suggested that the prevalence of overweight/obesity was higher in older age groups than in younger age groups ^(1,20). Explanations for this includes reduced activity of the mothers as they age, taking in more calories than they require and slowing of metabolic processes as they age. This finding is in line with other studies that showed that women aged 30 years or older were more likely to be overweight and obese than younger women in Bangladesh ⁽⁹⁾. Due to sedentary lifestyles and a reduction in metabolic rates, obesity tends to increase with age among women ^(9,11). A previous study observed that the prevalence of underweight and overweight women aged 15–49 years in Bangladesh was 22.4% and 14.1%, respectively. These conditions are crucial for determining the overall health condition of a child, as maternal health status plays a significant role in child health ⁽⁴⁵⁾. Our study also demonstrated that maternal education was a significant factor for controlling the DBM. Various other studies also observed a negative association between higher education and malnourished children, as improved knowledge of healthy behaviours can help parents nurture their children ^(37,38). This is likely because more highly educated mothers tend to have better knowledge of child health and nutrition and can thus choose healthy foods for their household ⁽⁴⁶⁾. A study conducted in Bangladesh suggested that secondary or higher education of mothers may have contributed in reducing the risk of DBM in the households studied ⁽⁴⁷⁾. Another study indicated that discordant mother–child pairs were significantly less likely to occur in households in which the mother had secondary or higher education than in those in which the mother had no formal education ⁽⁴¹⁾. Furthermore, knowledge of infant and young child feeding practices was also poor among uneducated mothers in Bangladesh, which emphasises the importance of maternal education for better child health, which could contribute to reducing the household-level DBM in Bangladesh ⁽⁴⁸⁾. Various study showed that underweight is more common among less educated mothers while the overweight is more concentrated among educated woman. This may be because higher educated individuals often prefer desk jobs where the occupational sitting time is relatively high which might be contribute to overweight status^{(49,50)(51)(52)}. Therefore target-based educational awareness program such as the importance of balanced diet and sufficient nutrition should be introduced in various levels of the society.

This study indicated that the size of the household and the administrative division have important implications for the DBM in Bangladesh. We found that small households were often prone to DBM, probably as due to the lack of extra members in their households, they were often unable to prepare home-cooked meals and tended to use more convenient options (processed foods) that could lead to increased weight ⁽⁵³⁾. Moreover, every member of a small household always try to feed excessive amount of food (both home-cooked and processed foods) to the youngest member (children) to show their love and

affection in Bangladeshi context, which puts them at an even higher risk of being malnourished ⁽⁵⁴⁾. Although this study did not attempt to explain these findings, increasing maternal and child overweight/obesity may be an important factor. Therefore, further investigation should be conducted. Regarding administrative divisions, we found that households located in the Khulna and Rangpur divisions were less likely to develop the DBM. Khulna and Rangpur is considered high performing in various health indicators, such as literacy rates, high maternal nutrition, low mortality rate, low fertility rate, low childhood malnutrition and high socioeconomic status ⁽³⁷⁾. In terms of wealth index, we observed that, richer and richest households were more likely to generate DBM. Our results are similar to many earlier studies which have shown that there is a significant positive relationship between wealth index and household level DBM ^(2,21,55). It was observed that underweight is more prevalent among poorer households while the overweight is more common among wealthy mothers in Bangladesh which is also line with other settings ⁽⁵¹⁾⁽⁵²⁾. It may be due to having access to western or fast food, higher occupational sitting time and excess energy intakes which often lead to overweight and obesity ^{(19)(56,57)}. Various studies also indicated that children from disadvantaged households in Bangladesh are often prone to be stunted, wasted, and underweight while overweight children were more concentrated among the wealthiest households ⁽⁵⁸⁾⁽³⁷⁾⁽⁵⁹⁾. Therefore, policy should prioritize the mitigation of the unequal wealth distribution for tackling the DBM issues from all strata of society. Our findings and those of other studies suggests that it is high time for policymakers and public health professionals to take the necessary steps to prevent and control the DBM among Bangladeshi women. However, it is quite challenging to implement an intervention for a country in which both undernutrition and overnutrition coexist, as an intervention to address one problem might exacerbate the other. Therefore, target-specific interventions must be formulated and implemented and health literacy should be encouraged so that people can make the best decisions for themselves given their individual circumstances. The government should sponsor initiatives to educate and encourage affluent women to embrace a healthy lifestyle and generate awareness of the health impact of being underweight or overweight using mass media; to refashion transport facilities, particularly in urban areas, by making footpaths; and to provide a safe environment for women and adolescent girls to perform physical activities. Physicians and community health workers also can advise their patients, especially pregnant women, so that women receive counselling about weight management before or during early pregnancy. The government should also take the initiative to restrict the production, purchase and advertisement of junk food as well as to make fruits and vegetables accessible and affordable to people from all socioeconomic groups. Further, the development of comprehensive surveillance systems at the household, regional and national levels should be prioritised to tackle the DBM in Bangladesh.

Strengths and limitations

This study has several limitations. First, the study was based on cross-sectional data and so we were unable to establish a causal relationship. Second, in the absence of income or expenditure data, we used household asset-based wealth index as a proxy to assess households' economic status. Third, due to unavailability of data, various potential confounders (such as physical activity, caregiving practices, cultural influences, postpartum- weight resolution, food taboos and more detailed components of nutritional status, such as body composition or biochemical or metabolic status) that might affect the DBM cannot be included in the analysis. Therefore, further exploration is warranted to ascertain the contribution of these potential determinants on the development of various forms of DBM in Bangladesh. Despite these limitations, a strength of the present study was that the data were extracted from a nationally representative demographic and health survey with a large randomised sample and low percentages of missing information; thus, our findings can be considered representative of the entire country. The findings of this study will offer strong insights to policymakers and will help them set target-specific, focused public health interventions to tackle

the DBM, which is in line with the goal of the latest National Food and Nutrition Security Policy in Bangladesh.

Conclusion

The current study indicates the overall prevalence of DBM was about 21%, with a significantly higher prevalence in urban areas of Bangladesh. Higher inequalities in the DBM were observed among the pair of underweight mothers with overweight children, which indicated that poor households were more vulnerable to the DBM. In contrast, a low level of inequality of DBM was observed for overweight mothers with stunted, wasted and underweight children. Therefore, health policymakers, concerned authorities and various stakeholders should stress the issues related to DBM and provide the necessary interventions to overcome this emerging public health problem.

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Table 1. Socio-demographic characteristics of the Study Participant (n=8,697)

Variables	Urban (n=2,379)	Rural (n=6,319)	Overall (n=8,697)
	Frequency (%)	Frequency (%)	Frequency (%)
Double burden			
No	1789 (75.21)	5079 (80.38)	6868 (78.97)
Yes	590 (24.79)	1240 (19.62)	1829 (21.03)
Mothers age			
15-19 years	275 (11.58)	833 (13.19)	1109 (12.75)
20-29 years	1463 (61.51)	3965 (62.75)	5428 (62.41)
30-49 years	640 (26.92)	1520 (24.06)	2161 (24.84)
Mothers' educational status			
No formal education	178 (07.48)	466 (07.37)	644 (07.40)
Primary	610 (25.66)	1894 (29.98)	2505 (28.80)
Secondary	1056 (44.38)	3156 (49.94)	4212 (48.42)
Higher	535 (22.48)	803 (12.70)	1337 (15.38)
Mothers age at first birth			
Less than 18	871 (36.61)	2915 (46.13)	3785 (43.52)
18-24	1306 (54.91)	3180 (50.33)	4486 (51.58)
25 or more	202 (08.48)	224 (03.55)	426 (04.90)
Number of children			
One child	927 (38.96)	2101 (33.25)	3028 (34.82)
Two children	888 (37.33)	2300 (36.40)	3188 (36.66)
3 or more child	564 (23.71)	1917 (30.34)	2481 (28.53)
Mothers BMI			
Underweight	258 (10.84)	926 (14.65)	1183 (13.61)
Normal weight	1189 (49.96)	3972 (62.87)	5161 (59.34)
Overweight	656 (27.57)	1101 (17.43)	1757 (20.20)
Obese	277 (11.63)	319 (05.06)	596 (06.85)
Mothers working status			
No	1607 (67.56)	3544 (56.09)	5151 (59.23)
Yes	772 (32.44)	2774 (43.91)	3546 (40.77)
Fathers' education			
No formal education	306 (12.84)	1155 (18.28)	1461 (16.80)
Primary	699 (29.40)	2238 (35.43)	2938 (33.78)
Secondary	763 (32.08)	2034 (32.18)	2797 (32.16)
Higher	611 (25.67)	891 (14.11)	1502 (17.27)
Fathers' occupation			
Day labor	1439 (60.48)	4650 (73.59)	6089 (70.01)
Business	643 (27.02)	1166 (18.46)	1809 (20.80)
Service	229 (09.61)	254 (04.01)	482 (05.55)
Unemployed	16 (00.68)	50 (00.79)	66 (00.76)
Others	52 (02.20)	199 (03.15)	251 (02.89)
Sex of children			
Male	1207 (50.74)	3333 (52.75)	4540 (52.20)
Female	1172 (49.26)	2985 (47.25)	4157 (47.80)
Child Stunting (n=7,818)			
Yes	524 (25.32)	1877 (32.66)	2402 (30.72)

No	1546 (74.68)	3871 (67.34)	5417 (69.28)
Child Wasting (n=7,804)			
Yes	186 (09.02)	473 (08.24)	659 (08.44)
No	1872 (90.98)	5273 (91.76)	7145 (91.56)
Child Underweight (n=8,041)			
Yes	407 (19.10)	1345 (22.77)	1753 (21.80)
No	1726 (80.90)	4562 (77.23)	6288 (78.20)
Child Overweight (n=7,781)			
Yes	45 (02.20)	72 (01.25)	117 (01.50)
No	2007 (97.80)	5657 (98.75)	7664 (98.50)
Child Obesity			
Yes	253 (10.65)	419 (06.63)	672 (07.73)
No	2126 (89.35)	5900 (93.37)	8025 (92.27)
Birth order			
First	996 (41.86)	2340 (37.04)	3336 (38.36)
Second	799 (33.58)	1989 (31.48)	2788 (32.05)
Third or more	584 (24.56)	1989 (31.48)	2573 (29.59)
Household size			
Small (<4)	421 (17.72)	722 (11.42)	1143 (13.14)
Medium (4-6)	1347 (56.62)	3508 (55.51)	4855 (55.82)
Large (6 and more)	610 (25.66)	2089 (33.06)	2700 (31.04)
Division			
Dhaka	1109 (46.63)	1128 (17.85)	2237 (25.73)
Chittagong	466 (19.60)	1343 (21.25)	1809 (20.80)
Rajshahi	182 (07.65)	828 (13.10)	1010 (11.61)
Rangpur	133 (05.61)	786 (12.44)	920 (10.57)
Khulna	184 (07.74)	612 (09.69)	796 (09.16)
Mymensingh	122 (05.12)	604 (09.56)	726 (08.34)
Sylhet	104 (04.37)	612 (09.69)	716 (08.23)
Barisal	78 (03.28)	406 (06.42)	484 (05.56)
Toilet facility			
Hygienic	1871 (78.64)	3389 (53.64)	5260 (60.48)
Unhygienic	508 (21.36)	2929 (46.36)	3437 (39.52)
Mass media exposure			
Yes	1501 (63.08)	2184 (34.56)	3684 (42.36)
No	878 (36.92)	4135 (65.44)	5013 (57.64)
Wealth index			
Poorest	206 (08.64)	1669 (26.41)	1874 (21.55)
Poorer	149 (06.24)	1617 (25.59)	1766 (20.30)
Middle	279 (11.72)	1353 (21.42)	1632 (18.77)
Richer	672 (28.24)	1073 (16.97)	1744 (20.05)
Richest	1074 (45.16)	607 (09.60)	1681 (19.33)
Total	2379 (27.35)	6319 (72.65)	8697 (100)

Table 2. Prevalence of double burden by socio-demographic characteristics

Variables	Urban (n=505)	Rural (n=1,076)	Overall (n=1,581)
	N (%)	N (%)	N (%)
Mothers age			
15-19 years	53 (19.15)	128 (15.39)	181 (16.33)
20-29 years	355 (24.28)	752 (18.97)	1108 (20.40)
30-49 years	182 (28.38)	359 (23.61)	541 (25.02)
<i>P-value</i>	0.013	0.000	0.000
Mothers' educational status			
No formal education	57 (32.23)	117 (25.09)	174 (27.07)
Primary	165 (27.08)	381 (20.09)	546 (21.80)
Secondary	255 (24.14)	604 (19.15)	859 (20.40)
Higher	112 (20.97)	138 (17.17)	250 (18.69)
<i>P-value</i>	0.012	0.021	0.001
Mothers age at first birth			
Less than 18	225 (25.85)	586 (20.09)	811 (21.42)
18-24	306 (23.41)	613 (19.27)	919 (20.48)
25 or more	59 (29.13)	41 (18.35)	100 (23.46)
<i>P-value</i>	0.039	0.972	0.383
Number of children			
One child	232 (25.01)	412 (19.63)	644 (21.28)
Two children	205 (23.08)	411 (17.88)	616 (19.33)
3 or more child	153 (27.11)	416 (21.69)	569 (22.92)
<i>P-value</i>	0.102	0.031	0.006
Mothers working status			
No	369 (22.98)	715 (20.17)	1084 (21.04)
Yes	220 (28.56)	525 (18.92)	745 (21.02)
<i>P-value</i>	0.008	0.061	0.772
Fathers' education			
No formal education	79 (25.76)	259 (22.38)	337 (23.09)
Primary	176 (25.10)	410 (18.30)	585 (19.92)
Secondary	184 (24.13)	407 (20.03)	592 (21.15)
Higher	151 (24.78)	164 (18.41)	315 (21.00)
<i>P-value</i>	0.468	0.019	0.089
Fathers' occupation			
Day labor	356 (24.77)	923 (19.84)	1279 (21.01)
Business	158 (24.52)	208 (17.82)	365 (20.20)
Service	57 (24.90)	46 (18.33)	103 (21.44)
Others	03 (19.54)	11 (23.03)	15 (22.17)
Unemployed	16 (29.76)	51 (25.66)	67 (26.51)
<i>P-value</i>	0.603	0.016	0.035
Sex of children			
Male	309 (25.63)	651 (19.54)	961 (21.16)
Female	280 (23.93)	588 (19.71)	869 (20.90)
<i>P-value</i>	0.577	0.634	0.909
Birth order			
First	235 (23.62)	437 (18.66)	672 (20.14)
Second	191 (23.92)	373 (18.77)	565 (20.25)
Third or more	163 (27.98)	429 (21.59)	593 (23.04)
<i>P-value</i>	0.035	0.026	0.003

Household size			
Small (<4)	145 (34.52)	176 (24.40)	322 (28.13)
Medium (4-6)	306 (22.70)	663 (18.91)	969 (19.96)
Large (6 and more)	138 (22.69)	400 (19.16)	539 (19.96)
<i>P-value</i>	0.000	0.001	0.000
Division			
Dhaka	335 (30.20)	208 (18.44)	543 (24.27)
Chittagong	104 (22.35)	293 (21.81)	397 (21.95)
Rajshahi	34 (18.67)	178 (21.51)	212 (21.00)
Rangpur	29 (21.53)	126 (16.06)	155 (16.86)
Khulna	30 (16.42)	104 (16.97)	134 (16.84)
Mymensingh	25 (20.35)	101 (16.67)	125 (17.29)
Sylhet	18 (17.17)	142 (23.27)	160 (22.38)
Barisal	15 (19.14)	87 (21.54)	102 (21.15)
<i>P-value</i>	0.000	0.000	0.000
Toilet facility			
Hygienic	483 (25.80)	665 (19.61)	1147 (21.81)
Unhygienic	107 (21.08)	575 (19.62)	682 (19.84)
<i>P-value</i>	0.043	0.649	0.034
Mass media exposure			
Yes	378 (25.18)	435 (19.91)	813 (22.06)
No	212 (24.12)	805 (19.46)	1017 (20.28)
<i>P-value</i>	0.387	0.552	0.074
Wealth index			
Poorest	42 (20.45)	332 (19.91)	374 (19.97)
Poorer	34 (23.08)	291 (18.01)	325 (18.44)
Middle	52 (18.77)	248 (18.36)	301 (18.43)
Richer	184 (27.38)	234 (21.82)	418 (23.96)
Richest	277 (25.80)	134 (22.01)	411 (24.43)
<i>P-value</i>	0.448	0.135	0.002
Overall	590 (24.79)	1240 (19.62)	1829 (21.03)

Table 3: Factors associated with household-level double burden of malnutrition among mother-child pairs in Bangladesh

Variables	Unadjusted Model	Adjusted Model (Overall)
	OR (95% CI)	OR (95% CI)
Mothers age		
15-19 years (ref.)		
20-29 years	1.23** (1.03, 1.46)	1.42*** (1.17, 1.71)
30-49 years	1.63*** (1.35, 1.97)	1.83*** (1.45, 2.32)
Mothers' educational status		
No formal education	1.60*** (1.28, 2.00)	1.89*** (1.43, 2.50)
Primary	1.21** (1.02, 1.42)	1.54*** (1.24, 1.93)
Secondary	1.18* (1.01, 1.38)	1.37*** (1.14, 1.66)
Higher (ref.)		
Number of children		
One child	0.92 (0.81, 1.04)	1.25 (0.93, 1.68)
Two children	0.81*** (0.71, 0.92)	0.95 (0.76, 1.19)
3 or more child (ref.)		
Fathers' education		
No formal education	1.20* (1.01, 1.42)	0.93 (0.74, 1.18)
Primary	1.01 (0.86, 1.17)	0.88 (0.72, 1.08)
Secondary	1.01 (0.86, 1.18)	0.96 (0.80, 1.16)
Higher (ref.)		
Fathers' occupation		
Day labor (ref.)		
Business	0.95 (0.83, 1.08)	0.90 (0.79, 1.04)
Service	1.07 (0.87, 1.32)	0.99 (0.75, 1.30)
Unemployed	1.19 (0.67, 2.08)	0.96 (0.53, 1.73)
Others	1.50*** (1.14, 1.98)	1.3 (0.97, 1.76)
Place of residence		
Urban	1.18*** (1.06, 1.32)	1.12 (0.98, 1.28)
Rural (ref.)		
Birth order		
First (ref.)		
Second	1.01 (0.89, 1.15)	1.16 (0.94, 1.43)
Third or more	1.22 (1.08, 1.39)	1.17 (0.87, 1.56)
Household size		
Small (<4)	1.55*** (1.31, 1.82)	1.54*** (1.30, 1.84)
Medium (4-6)	1.01 (0.90, 1.14)	1.00 (0.88, 1.13)
Large (6 and more) (ref.)		
Division		
Dhaka	1.32** (1.08, 1.62)	1.03 (0.86, 1.25)
Chittagong	1.11 (0.91, 1.37)	1.04 (0.86, 1.26)
Rajshahi (ref.)		
Rangpur	0.83 (0.66, 1.05)	0.80* (0.63, 1.01)
Khulna	0.79* (0.62, 1.00)	0.76** (0.60, 0.97)
Mymensingh	0.85 (0.68, 1.07)	0.79 (0.62, 1.02)
Sylhet	1.07 (0.87, 1.32)	1.04 (0.81, 1.32)

Barisal	1.02 (0.82, 1.29)	1.07 (0.82, 1.41)
Wealth index		
Poorest (ref.)		
Poorer	0.92 (0.78, 1.09)	0.96 (0.81, 1.13)
Middle	0.98 (0.83, 1.16)	0.95 (0.79, 1.14)
Richer	1.19* (1.02, 1.40)	1.27** (1.06, 1.52)
Richest	1.21** (1.03, 1.42)	1.33*** (1.08, 1.65)
Constant		0.11*** (0.07, 0.16)
N		8,689
LR chi2 (30)		186.02
Prob > chi2		<0.001
Pseudo R2		0.0208
Log likelihood		-4380.82
Mean VIF		3.07

*p < 0.05, **p < 0.01, ***p < 0.001

Table 4: Factors associated with underweight mother & overweight child (UWM & OWC) type double burden of malnutrition (DBM) at household-level in Bangladesh

Variables	Unadjusted Model	Adjusted Model
	OR (95% CI)	OR (95% CI)
Mothers age		
15-19 years (ref.)		
20-29 years	0.74 (0.38, 1.45)	1.40 (0.65, 3.03)
30-49 years	0.61 (0.28, 1.35)	2.02 (0.69, 5.88)
Mothers' educational status		
No formal education	9.12** (1.93, 43.07)	6.22 (0.65, 59.85)
Primary	8.96** (2.14, 37.48)	9.52* (1.17, 77.15)
Secondary	4.62* (1.10, 19.49)	6.21 (0.80, 47.96)
Higher (ref.)		
Number of children		
One child	1.70 (0.93, 3.10)	5.38* (1.41, 20.49)
Two children	0.87 (0.44, 1.72)	1.71 (0.55, 5.29)
3 or more child (ref.)		
Fathers' education		
No formal education	5.48** (1.87, 16.07)	0.76 (0.23, 2.57)
Primary	3.58* (1.25, 10.27)	0.69 (0.23, 2.14)
Secondary	2.50 (0.84, 7.44)	0.77 (0.26, 2.33)
Higher (ref.)		
Fathers' occupation		
Day labor (ref.)		
Business	0.42* (0.19, 0.91)	0.73 (0.33, 1.58)
Service	-	-
Unemployed	-	-
Others	2.54* (1.08, 5.97)	2.21 (0.81, 6.05)
Place of residence		
Urban	0.74 (0.43, 1.26)	1.44 (0.73, 2.83)
Rural (ref.)		
Birth order		
First (ref.)		
Second	0.69 (0.38, 1.23)	1.10 (0.45, 2.73)
Third or more	0.75 (0.42, 1.35)	1.41 (0.39, 5.15)
Household size		
Small (<4)	3.76*** (1.74, 8.13)	2.97* (1.22, 7.26)
Medium (4-6)	2.08* (1.07, 4.06)	2.63* (1.21, 5.71)
Large (6 and more) (ref.)		
Division		
Dhaka	1.58 (0.49, 5.15)	1.89 (0.61, 5.84)
Chittagong	0.79 (0.21, 2.94)	1.07 (0.30, 3.87)
Rajshahi (ref.)		
Rangpur	1.87 (0.56, 6.24)	2.27 (0.69, 7.47)
Khulna	1.51 (0.43, 5.38)	2.24 (0.65, 7.77)
Mymensingh	1.56 (0.45, 5.34)	1.76 (0.48, 6.54)
Sylhet	3.38* (1.15, 9.96)	5.22** (1.65, 16.53)
Barisal	2.27 (0.70, 7.40)	2.57 (0.67, 9.82)

Wealth index

Poorest (ref.)		
Poorer	0.65 (0.35, 1.21)	0.66 (0.33, 1.33)
Middle	0.41* (0.19, 0.87)	0.47 (0.20, 1.12)
Richer	0.53 (0.27, 1.04)	0.73 (0.32, 1.65)
Richest	0.08** (0.02, 0.34)	0.14* (0.03, 0.68)
Constant		0.00 (<0.001, <0.001)
N		8,074
LR chi2 (30)		68.79
Prob > chi2		<0.001
Pseudo R2		0.0961
Log likelihood		-323.41
Mean VIF		3.22

*p < 0.05, **p < 0.01, ***p < 0.001

Figure 1. Prevalence of various forms of DBM among residents of rural and urban areas

Figure 2. Inequality in the prevalence of different types of double burden of malnutrition