Differences in risk factors associated with single and multiple concurrent forms of undernutrition (stunting, wasting or underweight) among children under 5 in Bangladesh: a nationally representative cross-sectional study

Title: Differences in risk factors associated with single and multiple concurrent forms of undernutrition (stunting, wasting, or underweight) among children under 5 years of age in Bangladesh: A nationally representative cross-sectional study

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Running title: Single and multiple concurrent forms of undernutrition among children in Bangladesh

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Abstract

Objectives: The study aims to differentiate the risk factors of single and multiple concurrent forms of undernutrition among children under 5 years of age in Bangladesh.

Design: A nationally representative cross-sectional study.

Setting: Bangladesh.

Respondents: Children age under 5 years of age.

Outcome measure: This study considered two dichotomous outcomes: single form (children without single form and with single form) and multiple concurrent forms (children without multiple forms and with multiple forms) of undernutrition.

Statistical analysis: Adjusted odds ratio (OR) and confidence interval (CI) of potential risk factors were calculated using logistic regression analysis.

Results: Around 38.2% of children under 5 in Bangladesh are suffering from undernutrition. The prevalence of multiple concurrent forms and single form of child undernutrition was 19.3% and 18.9%, respectively. The key risk factors of multiple concurrent forms of undernutrition were children born with low birth weight [AOR: 3.76, 95% CI: 2.78, 5.10]; children in the age group 24-35 months [AOR: 2.70, 95% CI: 2.20, 3.30], and in the lowest socio-economic quintile [AOR: 2.57, 95% CI: 2.05, 3.23]. In contrast, those children in the age group 24-35 months [AOR: 1.94, 95% CI: 1.61, 2.34], in the lowest socio-economic quintile [AOR: 1.79, 95% CI: 1.45, 2.21] and born with a low birth weight [AOR: 1.52, 95% CI: 1.11, 2.08] were significantly associated with a single form of undernutrition. Parental education, father's occupation, children's age and birth order were the differentiating risk factors for multiple concurrent forms and single form of undernutrition.

Conclusion: One-fifth of children under 5 years of age are suffering multiple concurrent forms of undernutrition, which is similar to the numbers suffering the single form. Parental education, father's occupation, children's age and birth order disproportionately affect the multiple concurrent forms and single form of undernutrition that should be considered evidence of the need to formulate an evidence-based strategy for reducing undernutrition among these children.

Keywords: Children, malnutrition, prevalence, determinant, co-occurrence, and Bangladesh

Strengths and limitations of this study

To the best of our knowledge, this is the first study to differentiate the factors associated with single and multiple concurrent forms of undernutrition among children aged under 5 in Bangladesh and is based on a nationally representative, probability-based cross-sectional sample survey.

The multistage sampling technique of the national survey (BDHS 2017-18) used in this study, including its sampling weight, helped in reducing potential selection bias.

The study considered a wide range of variables to assess the risk factors of the single and multiple concurrent forms of undernutrition by adopting a robust analytical method.

All three indicators, such as stunting, wasting, and underweight, were used to formulate the study outcomes without considering distinct associated factors that might affect the results.

The cross-sectional nature of the study sample does not allow for establishing causation.

Introduction

Child undernutrition refers to deficiencies or imbalances in a child's intake of energy and/or nutrients, infectious disease, or a combination of both.[1] In 2020, approximately 149 million children worldwide aged under 5 were estimated to be stunted, with 45 million estimated to be wasted, and 85 million underweight. About 45% of deaths in children are linked to these conditions.[1 2] The burden of multiple concurrent forms of undernutrition among under 5 year old children is present in 124 countries out of 141 (88%) with 41 countries (around 29%) struggling with high levels of all three concurrent forms of undernutrition (stunting, wasting, and underweight).[3] The multiple concurrent forms of undernutrition lead to a 12-fold elevated risk of child mortality compared to healthy children.[4] Also globally, around 3% of children under five years were estimated to exhibit both stunting and wasting.[5] The effect of stunting, wasting, and underweight on mortality through reduced muscle mass suggests that young infants and children are especially vulnerable to undernutrition, particularly the multiple concurrent forms.[6] A reduced muscle or fat mass (a common mechanism involving limbs being both thinner and shorter) increases the risk of death considerably when wasting and stunting are present in the same child.[6] Fat stimulates the necessary energy to maintain the immune system so a undernourished child with low muscle mass and reduced function of key organs, such as the heart, kidney, and immune system, is more likely to die during an acute food shortage.[6] Overall, undernutrition reduces the immunological capacity of a child to defend against diseases and recurrent infections, such as diarrhea, pneumonia, malaria, measles, and AIDS, that leads to inconsistent growth and development both mentally and physically.[7 8]

Child undernutrition is a global health problem and is particularly prevalent in low-and middle-income countries. In spite of a decline over the years, the rate of undernutrition in Bangladesh is still among the highest in the world with estimates putting around 40% of children aged under 5 in that category.[9 10] The risk factors leading to child undernutrition are still being debated in Bangladesh and in other developing countries. Poor maternal education, low socioeconomic status, low birth weight, poor feeding practices, frequent infections, inadequate access to health care, and water and sanitation are key risk factors.[7 11-13] However, these risk factors were identified using conventional disaggregated indicators (e.g., stunting, wasting and underweight). The findings from these studies are not sufficient to enable formulation of complete policy initiatives as many children in Bangladesh (around 30%) and

those in other developing countries are suffering from multiple concurrent forms of undernutrition that lead to a high mortality rate among children.[14]

Those factors associated with the single form and multiple concurrent forms of undernutrition have not been previously identified in Bangladesh. Chowdhury et al. (2020) tried to link several socio-demographic factors with single and multiple forms of severe undernutrition.[14] However, the study appended multiple datasets of previous national surveys that did not represent the current scenario nor the overall burden of single and multiple concurrent forms of undernutrition. Drivers or factors associated with both these forms of undernutrition have not yet been fully identified in Bangladesh or in other developing countries. According to recent research findings, age, sex, and food insecurity are linked to multiple concurrent forms of undernutrition.[4 15 16] On the other hand, factors associated with the single form have not been widely investigated in developing countries, including Bangladesh. Studies on single and multiple concurrent forms of undernutrition might present different results from those grounded in conventional disaggregated indicators. The present study aims to differentiate between the risk factors of both the multiple concurrent forms and single form of undernutrition among under 5 year old children in Bangladesh using a more recent nationally representative population-based survey. This study might therefore be useful for policymakers when addressing the needs of more nutritionally vulnerable children.

Methodology

Study setting

Bangladesh is a densely populated country of 165 million people, with 14 million of them under 5 years of age.[17] The country is divided into eight administrative divisions, namely, Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur, and Sylhet. Each division is divided into zilas (districts) and each zila into upazilas (sub-districts). The urban areas in an upazila are further divided into wards, and these wards are further subdivided into mohallas (suburbs). Urban areas are also classified into two groups: city corporations and areas other than city corporations. Rural areas in an upazila are divided into union parishads (villages) and then further subdivided into mouzas (small villages). Overall, the divisions separate the country into rural and urban areas with 54% of households in rural areas.[10]

Management of undernutrition in Bangladesh

The rate of undernutrition in Bangladesh is among the highest in the world. The country has developed facility-based care (therapeutic care for malnourished children with complications) and community-based care (undernourished children without complications and children who have been discharged from facility-based inpatient care) for the management of undernourished children.[18 19] In line with this, Bangladesh's government has also introduced several policies and strategies to help deal with the rate of undernutrition. For example, in 1997, the Bangladesh National Nutrition Council developed a policy called the Bangladesh National Plan of Action for Nutrition (NPAN) to improve the nutritional status and quality of life of the people of Bangladesh.[20] The NPAN was approved by the Food Planning and Monitoring Committee in August 2008 to ensure an adequate and stable supply of safe and nutritious food, to increase people's purchasing power and access to food and thereby provide proper nutrition for all individuals, especially women and children.[21] The government of Bangladesh has again taken the initiative to incorporate nutrition into public health and family planning services to improve the country's nutrition situation. The adoption of the National Nutritional Policy 2015 reflects the commitment of the State to improve the nutritional status and quality of life of the population especially for disadvantaged groups, including mothers, adolescent girls, and children.[22] A new holistic policy called "Food and Nutrition Security Policy" has also been adopted to promote the use of a "nutrition lens". This policy will help develop multi-sectoral inter-linked interventions that will improve nutritional outcomes and cover the target period 2020-2030 in synchronization with the Sustainable Development Goal (SDG).[23]

Data source

After excluding missing information regarding selected variables, a total of 7,661 children aged under 5, who were born in January 2013 or later, were included in this study with data taken from the Bangladesh Demographic Health Surveys (BDHS) 2017-18 (Figure 1). The BDHS 2017-18 data is nationally representative with a 99% response rate that includes data from adults and children (both male and female) regarding demographic and social characteristics and health and nutritional indicators to monitor a wide range of the population. The data collection was started on 24 October 2017 and ended on 15 March 2018.[10] This survey was funded by the United States Agency for International Development (USAID) and conducted by the National Institute of Population Research and Training (NIPORT) under the Ministry of Health and Family Welfare, Bangladesh. All survey-related issues were

implemented by a Bangladeshi research organization 'Mitra and Associate' with technical support from the ICF International of Calverton, Maryland, USA. The 2017-18 BDHS was reviewed and approved by the ICF Macro Institutional Review Board (USA).[10]

These surveys were based on multistage stratified sampling techniques of households. At the first stage, 675 primary sampling units (PSUs) were selected (250 PSU from urban and 425 PSU from rural) based on enumeration areas (clusters) from the census survey 2011 designed by the Bangladesh Bureau of Statistics using probability proportional to size technique. Then, a systematic sample of 30 households from each PSU were selected at the final stage using an equal probability systematic sampling technique.[10] This multistage sampling technique, including its sampling weight, helps reduce potential sampling bias.[10] In the BDHS data, sample weights were calculated in each sampling stage, each cluster and stratum were considered that had been adjusted for non-response to obtain the final standard weights.[10] In addition, all ever-married women aged 15-49 years from the pre-selected households were interviewed without replacement and change in the implementing stage to prevent selection bias.[10] Informed consent was obtained verbally from each participant to collect information about them and their children before enrolling in the study. A significant number of the study sample was illiterate, so verbal consent was considered the most suitable option to confirm participation.[10] Each BDHS used a standard questionnaire and the details, including sample design, data collection procedure, and other issues, are discussed elsewhere.[10]

Outcome variables and operational definitions

The outcomes of the study involved the identification of multiple concurrent forms and single form of undernutrition among children aged under 5 years. A child was considered to be undernourished or stunted (short stature for age), wasted (dangerously thin), and underweight (low weight for age) if the height-for-age, weight-for-height, and weight-for-age indices were two standard deviations (SDs) or more below the respective median of the WHO reference population.[24] A child was considered to have multiple concurrent forms of undernutrition when stunting and underweight and wasting and underweight, or three forms of undernutrition (stunting, wasting, and underweight) were present in the same child (Figure 2). Also, a child with a single form of undernutrition (in a composite manner) included a child living with stunting, wasting, or underweight only (Figure 2). A detailed variable scale of measurement with missing information is clearly defined in online supplemental table 1. Children were categorized 0 for 'normal' and 1 for 'undernutrition' for each of the three

indicators. After that, the values of all three indicators were added, which resulted in a score ranging from 0 to 3. The scores were again re-categorized as 0 for normal, 1 for a single form of undernutrition, and 2 to 3 for multiple concurrent forms of undernutrition. Detailed classifications and coding of outcome variables used in this study are clearly defined in online supplemental table 2.

Independent variables

Since 1990, the UNICEF conceptual framework on undernutrition has guided interventions from multi-sectoral and multidimensional perspectives.[25] This framework included the basic, underlying, and immediate causes of undernutrition. The basic causes address social, economic, environmental, and political issues that lead to the lack of or unequal distribution of financial, human, physical, social, and natural resources. The underlying causes focus on household food security, adequate care, and feeding practices, access to health services, and residing in a healthy environment. The basic and underlying causes lead to immediate causes at the individual level through inadequate food intake and disease.[25]

The candidate variables (potential causes) considered for analysis in the present study were based on relevant previous literatures.[7 26-30] These variables include maternal age in years (15-19, 20-24, 25-29, 30-34, 35-39, ≥40); parents' education (both parents uneducated, only father was uneducated when mother was educated, only mother was uneducated when father was educated, both parents educated); mother's current working status (currently not working, currently working); mother's underweight status ((normal/average (≥18.5 kg/m^2), underweight (<18.5 kg/m^2)); status of mother's antenatal and postnatal care (not received, received); mother's experience of inmate partner violence (IPV) (not experienced, experienced): a wife being beaten by partner if she went out without telling him or/and neglected the children or/and she ever argued with her partner or/and burned food or/and refused to have sex);[10] mothers' decision-making autonomy (not experienced, experienced): a woman who usually decides by herself/jointly with husband at least on her healthcare or on large household purchases or visits to family or relatives);[10] father's occupation (currently not working, manual labourer, professional and businessman); source of drinking water (improved, unimproved),[31] use of solid waste in cooking (solid, non-solid); type of toilet facility (improved, unimproved),[31] mass media exposure (no, yes: exposed to either radio, television, newspapers, or magazines at least once a week); wealth index (integrating household asset ownership and access to drinking water and sanitation)[10] and place of

residence (urban, rural). Moreover, various factors related to children, such as age, birth order, and birth weight status,[32-34] recent morbidity status (the child had at least one morbid condition out of diarrhea, fever, and cough in the two weeks preceding the survey)[10] were included. Detailed variable scales of measurement with missing information used in this study is clearly defined in online supplemental table 3, 4 & 5 .

Patient and public involvement

Patients or the public were not involved in the design, conduct, or interpretation of the study.

Statistical analysis

The background characteristics of the children and their parents were calculated using descriptive statistics. Crosstab analysis and Bivariate analysis (Chi-square test) were used to determine the prevalence/percentages and associations (*p* values) between the selected independent variables and outcomes. Further, all independent variables found to be significant in bivariate analysis were simultaneously entered into the stepwise (backword selection) multivariate regression models for adjustment to help identify risk factors for multiple concurrent forms and single form of undernutrition and when the base outcome (reference category) was normal (various forms of undernutrition vs normal/healthy children). The findings from logistic regression analysis were assessed using odds ratio (OR) and confidence interval (CI). The significance level was set at p <0.25 (2-tailed) in bivariate analyses instead of the traditional cut off point 0.05 that can fail in identifying variables known to be important.[35] On the other hand, the significance level was set at p <0.05 (2-tailed) in multivariate analyses. The data were analyzed by controlling cluster (PSU) and stratum (urban area: city corporation area and other than city corporation area and rural area) with sampling weights that represent the whole country, both urban and rural areas, to ensure the precision of the estimates. Multicollinearity was checked by examining the standard errors (SEs) of regression coefficients in the logistic regression analyses. An SE >2.0 indicates multicollinearity among the independent variables.[36] The SEs for the independent variables in the adjusted models for each outcome were <1, indicating an absence of multicollinearity. Stata version 14.2 (StataCorp LP, College Station, Texas) was used for all analyses considering the complex nature of the sampling weight of the BDHS. To adjust sampling weight in the analysis, the Stata command "svyset" was used.

Results

Table 1 shows that approximately 7% (both parents uneducated: 3.8% and only mothers were uneducated: 3.2%) of mothers had no formal education; 15% of mothers were reported underweight; more than 90% of mothers received antenatal care; one-third (33%) did not receive postnatal care and 18% experienced IPV. Around 42% of children were from poor households with 66% living in rural areas. The similar percentage distribution of children (approximately 20%) was observed among the various age categories, and 52% of them were male (Table 1).

Prevalence of multiple concurrent forms and single form of undernutrition

In Bangladesh, the overall prevalence of child undernutrition was 38%. The overall prevalence of stunting was 31%; wasting was 8% and underweight was 22% (Figure 2). The prevalence of multiple concurrent forms (from Figure 1, stunting and underweight: 13.5%; wasting and underweight: 3.1%; and stunting, wasting, underweight: 2.7%) and single form (from Figure 1, only stunting: 14.3%, only wasting: 2.1% and only underweight: 2.4%) of undernutrition among under 5 year old children were approximately estimated at 19%. Further, the prevalence of multiple concurrent forms of undernutrition was significantly higher among children of parents with no formal education (37%) when compared to educated parents (17%), children of underweight mothers (about 30%), children with fathers who were manual labourers (28%), children were ≥ 4 birth order (about 28%), and children born with low birth weight (27%) (Table 2).

The single form of undernutrition was highly prevalent among children of fathers with no formal education when mothers are educated (23%); children in the age group 12-35 months (23%); those from the poorest section of society (22%) when compared to the richest (14%); of underweight mothers and households that had no mass media exposure (21%); of fathers who were manual labourers and households with unimproved toilet facilities (21%) and children born with low birth weight (20%) (Table 3).

Risk factors

The key risk factors of multiple concurrent forms of undernutrition were children born with low birth weight (when compared to healthy weight children) [AOR: 3.76, 95% CI: 2.78,

5.10, $p<0.001$]; children in the age group 24-35 months (when compared to children in the age group 0-11 months) [AOR: 2.70, 95% CI: 2.20, 3.30, $p<0.001$]; children in the lowest socioeconomic quintile (when compared to the highest socioeconomic quintile) [AOR: 2.57, 95% CI: 2.05, 3.23, $p<0.001$]; parents with no formal education (when compared to educated parents) [AOR: 2.03, 95% CI: 1.53, 2.71, $p<0.001$]; and children with fathers who were currently unemployed (when compared to businessman fathers) [AOR: 1.98, 95% CI: 1.07, 3.16, $p=0.021$] (Table 4).

The risk factors for a single form of undernutrition include children in the age group 24-35 months (when compared to children in the age group 0-11 months) [AOR: 1.94, 95% CI: 1.61, 2.34, $p<0.001$]; children in the lowest socioeconomic quintile (when compared to the highest socioeconomic quintile) [AOR: 1.79, 95% CI: 1.45, 2.21, $p<0.001$]; children born with low birth weight (when compared to healthy weight children) [AOR: 1.52, 95% CI: 1.11, 2.08, $p=0.008$]; children of fathers who are manual labourers (when compared to businessman fathers) [AOR: 1.36, 95% CI: 1.16, 1.59, $p<0.001$]; and children of fathers with no formal education when mothers are educated (when compared to educated parents) [AOR: 1.35, 95% CI: 1.12, 1.63, $p=0.002$] (Table 4).

Discussion

The prevalence of multiple concurrent forms and single form of undernutrition among children aged under 5 in Bangladesh was nearly equal, each accounting for 19%. One out of five children suffered from both cases of undernutrition. This high figure is a concern when comparing it with developing countries from Africa and South America, such as Ethiopia, Malawi and Argentina where the prevalence of concurrent forms of undernutrition among children age under 5 stood respectively at 26%, 12% and 2%. The single form of undernutrition was respectively 23%, 39%, and 5%.[37-39] Asian countries such as Yemen and India are struggling with a high burden of both forms of undernutrition (multiple concurrent forms of undernutrition: 48% and 39% respectively; single of undernutrition: 21% and 24% respectively).[40 41] The findings indicate that Bangladesh has not still achieved sustainable improvement in reducing child undernutrition. One reason could be poor understanding of the multi-sectoral approach involving a lack of coordination among key government sectors, such as between health, agriculture, education, urban and local development to address the issue of undernutrition, and poor linkage between key institutions, for example, government

institutions, academic, research and training institutions, and national/international non-governmental organizations.[42]

This study reveals that children of mothers with no formal education in Bangladesh are living in less protective environments. Three out of five children (65.4%) of mothers with no formal education and two out of five children (37.4%) experience multiple concurrent forms of undernutrition. Also, three out of ten children (27.3%) born with low birth weight experience multiple concurrent forms of undernutrition. Further, the odds of multiple concurrent forms of undernutrition were 3.37 times higher among children born with a low birth weight than the children with a healthy birth weight. Previous studies in Bangladesh, Pakistan, Nepal, Malawi, Mexico, and Iran also reported children born with low birth weight were more likely to experience malnutrition regardless of multiple concurrent forms and single form.[43-47] Children born with low birth weight generally increase their height and weight by small increments and thus they may remain shorter and lighter and might be severely malnourished without adequate nutritional support.[48] Children with low birth weights are often born to uneducated and underweight mothers.[49 50] Maternal/parental illiteracy is associated with poor maternal healthcare access, and caregiving provided to children often leads to an adverse nutritional outcome for mothers and children.[51] This study shows that the odds of multiple concurrent forms of undernutrition were respectively 2.03 and 1.91 times higher among children of mothers with no formal education and among underweight mothers. Numerous studies assessed these factors as key determinants of child undernutrition using disaggregated indicators and need more assessment to estimate the magnitude of risks in case of multiple concurrent forms and single form of undernutrition.[7 11]

Other key risk factors of multiple concurrent forms of undernutrition include children in the older age group (3 years and above); those in the lowest socioeconomic quintile; have fathers who are currently unemployed that differs by a single form of undernutrition, to some extent, additionally with children in the younger age group (3 years and below); have mothers with no formal education (when fathers are educated) and fathers that are labourers. An assessment of the risk difference between educated and uneducated parents and the highest and lowest socioeconomic quintile for multiple concurrent forms and a single form of undernutrition indicates higher educational and wealth inequalities for the multiple concurrent forms of undernutrition. Further, the level of parental education and economic hardship is not markedly responsible for suffering from a single form of undernutrition

among children aged under 5. Earlier studies in Bangladesh and other South Asian countries highlighted parental education and wealth index as key risk factors of child undernutrition regardless of multiple concurrent forms and single form. Still, the studies need more precise estimation that could help policy makers introduce context-specific actions for reducing undernutrition.[7 11 28 30 52] Women who have low social status and less education have very limited influence on household decision-making that might influence child nutritional status. On the other hand, a large community in Bangladesh are concerned with broader issues of chronic poverty, and this would not reflect the improvement of undernutrition at a community level.[52] To reduce under 5 year old child undernutrition, it is recommended that the participation of women and girls in education is increased, especially in rural areas, the minimizing of socioeconomic inequality by raising the income-generating sectors, and strengthening the nutrition-specific health programmes.

Children in the older age group (3 years and above) have a high risk of multiple concurrent forms of undernutrition, while children in the younger age group (3 years and below) were more likely to have a single form of undernutrition. Many studies conducted in Bangladesh, Nepal, Pakistan, Ethiopia, and Congo have consistently addressed age and older children as having a higher risk of being undernourished without classifying the two conditions.[26-30] In India, younger children were found to have a higher likelihood of being undernourished.[53] Older children receive less protection in times of adverse nutritional outcomes due to poor per capita food distribution among family members in large households when they tend to be allocated less food than will meet their energy requirements with regards to their age.[54] The risk of poor parental education on multiple concurrent forms of undernutrition differs by paternal illiteracy (when mothers are educated) on a single form of undernutrition in identifying the impact of education on undernutrition. This study shows that paternal education was associated with a single form of undernutrition among children under 5 in Bangladesh. Evidence suggests that the impact of paternal education on undernutrition has not been widely addressed while maternal education has a more significant effect on child undernutrition than paternal education.[53] Parental education is associated with positive attitudes and behaviours that can reduce the incidence of child undernutrition to some extent. It needs to be recognised that the complex nature of modern health care messages and behavioural changes will not be effectively understood or practised by mothers with only the most basic literacy and numeracy skills.[55] Reducing the gender gap for enrolment in universal upper secondary education may help towards tackling the burden of all undernutrition.

This study also indicates that children of unemployed fathers are more likely to experience multiple concurrent forms of undernutrition; conversely, children of fathers who were labourers are less protected in the case of a single form of undernutrition. Additionally, three out of ten children experienced multiple concurrent forms of undernutrition, with 21% experiencing a single form. The effects of paternal unemployment on child undernutrition have not been widely explored, except for a study conducted in China that found it had a significant impact.[56] Conversely, those children of fathers that had low paid jobs (labourer, farmer, etc.) had a greater risk of suffering undernutrition.[11 14] A loss of employment or low paid jobs are typically associated with a lower income available for spending on market goods, including healthcare, non-household childcare, and nutritious consumption.[56] Increasing investment in healthcare at the domestic level could help in tackling undernutrition.

This study strongly suggests that policy implications or interventions from the perspectives of developing countries, such as Bangladesh, are needed to successfully prevent and treat both forms of undernutrition, particularly multiple concurrent forms and based on evidence and a broad-spectrum. Firstly, factors associated with undernutrition should be considered in order to formulate an evidence-based strategy for reducing undernutrition, with the emphasis on the multiple concurrent forms. Routine national and subnational level nutrition surveys, such as Multiple Indicator Cluster Surveys (MICSs), need to be modified to include multiple concurrent forms to aid in the development of programmes and policy decision-making.[57] Routine monitoring of the prevalence of multiple concurrent forms would also be required to inform effective detection and treatment.[57] Community engagement and screening for multiple concurrent forms of undernutrition could also be expanded in innovative ways by enrolling additional expertise and resources.[58] Innovative and early markers should be developed to predict, identify, and monitor children for short-term and long-term consequences.[59] Maternal factors from adolescence through pregnancy need to be scrutinised in order to identify those that can adversely affect utero and postnatal children living with three forms of undernutrition.[59] Therapeutic interventions (e.g., ready-to-use therapeutic foods) must be reviewed and adjusted to ensure that children at the highest risk of mortality, due to multiple concurrent forms of undernutrition, are included. Comprehensive nutrition programmes must be developed for pursuing SDG 2.2 in order to end undernutrition in all its forms by 2030.[59]

This study analyzed data from a national BDHS survey 2017-2018. The findings can therefore be applied to the whole country and to low- and middle-income countries whose socio-demographic characteristics and healthcare settings are similar to Bangladesh. Another strength in this study was the appropriate application of statistical tools that might help in understanding the findings. The multistage sampling technique, for instance, including its sampling weight, helped reduce potential selection bias. There were some limitations. For example, the cross-sectional nature of the data did not establish a causal relationship between risk factors and outcome variables. All three indicators (e.g., stunting, wasting, and underweight) were used to formulate the study outcomes (single and multiple concurrent forms of undernutrition) without considering distinct associated factors that might affect the results. This study did not control other important indicators, such as a child's diet pattern, parents' behaviour of parents or immunization and ethnicity, due to lack of availability and missing values across the surveys. Another limitation arises due to recall bias or information bias as a result of self-reporting of age, education, occupation and household assets for example.

Conclusion

One out of five children in Bangladesh aged under 5 years is suffering multiple concurrent forms and a single form of undernutrition. Children born with low birth weight, in the lowest socioeconomic quintile, and in the older age group (3 years and above) were identified as key risk factors for multiple concurrent forms of undernutrition. Those children in the younger age group (3 years and below), and mothers with no formal education had significant effects on the single dimension of undernutrition. Parental education, father's occupation, age of children and birth order are the main differentiating risk factors between multiple concurrent forms and single form of undernutrition. The findings highlight factors that should be considered in order to formulate an evidence-based strategy to reduce undernutrition among under 5 year old children. In addition, concerted efforts are essential for developing strong collaboration among different sectors, such as between government, non-government, educational, social, cultural, and religious institutions, in order to improve nutritional status. The findings from this study may be transferable to other low- and middle-income countries but further study is warranted in this regard.

Ethical statements

The BDHS was reviewed and approved by the ICF Macro Institutional Review Board (USA), which complies with all of the requirements of 45 CFR 46 "Protection of Human Subjects". The Bangladesh DHS was also reviewed and approved by the National Research Ethics Committee of the Bangladesh Medical Research Council (Dhaka, Bangladesh). Informed consent was obtained verbally from each participant and their intimate partners (all ever-married women aged 15–49 years old) prior to being enrolled in the study. A significant number of the study sample was illiterate, so verbal consent was considered the most suitable option to confirm participation. The BDHS surveys also included samples of very young children (under five-year-old children either born in 2014 or later) in the data collection, and so mothers of these samples were asked to provide verbal consent on behalf of their children.

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Tables

Table 1

Background characteristics of the under-5 children

Factors	Number	Percentage (%)
Total	**7,661**	**100.0**
Mothers' age (in years)		
15-19	938	12.2
20-24	2,679	35.0
25-29	2,146	28.0
30-34	1,293	16.9
35-39	481	6.3
≥ 40	124	1.6
Parents' education		
Both parents were uneducated	294	3.8
Only father was uneducated	865	11.3
Only mother was uneducated	243	3.2
Both parents were educated	6,259	81.7
Mother currently working		
No	4,560	59.5
Yes	3,101	40.5
Underweight mother[a]		
No	6,535	85.3
Yes(<18.5 kg/m^2)	1,126	14.7
Mothers received antenatal care (n=4,540)		
No	363	8.0
Yes	4,177	92.0
Mothers received postnatal care (n=4,535)		
No	1,509	33.3
Yes	3,026	66.7
Mothers experience IPV[b]		
No	6,264	81.8
Yes	1,397	18.2
Mothers' decision-making autonomy[c]		
Not practiced	1,083	14.1
Practiced	6,578	85.9
Father's occupation		
Currently not working	73	1.0
Manual labourer	5,458	71.2
Professional	472	6.2
Businessman	1,658	21.6
Source of water		
Improved	6,658	86.9
Unimproved	1,003	13.1
Type of toilet facility		
Improved	4,359	56.9
Unimproved	3,302	43.1
Solid waste use in cooking		
No	2,218	28.9
Yes	5,443	71.1
Mass media exposure[d]		
No	4,890	63.8
Yes	2,771	36.2
Wealth index [e]		
Poorest	1,708	22.2
Poorer	1,545	20.2
Middle	1,381	18.0
Richer	1,533	20.0

Richest	1,494	19.5
Place of residence		
Urban	2,605	34.0
Rural	5,056	66.0
Children's age (in months)		
0-11 months	1,673	21.8
12-23 months	1,583	20.7
24-35 months	1,475	19.3
36-47 months	1,417	18.5
48-59 months	1,513	19.7
Sex of child		
Male	3,995	52.2
Female	3,666	47.8
Birth order		
One	2,902	37.9
Two	2,507	32.7
Three	1,297	16.9
Four and above	955	12.5
Low birthweight [f](n=4,735)		
No	1,815	38.3
Yes (<2.5 kg)	326	6.9
Not weighted	2,594	54.8
Currently had disease [g]		
No	4,043	52.8
Yes	3,618	47.2

[a]underweight measured as <18.5 kg/m^2

[b]a wife being beaten if she went out without telling her partner/ neglected the children/argued with her partner/burnt food/ was forced to have sex regardless of her consent

[c]a woman usually can decide by herself or jointly on her healthcare/large household purchases/visits to family or relatives

[d]exposed television/radio/newspaper/magazine to some extent

[e]integrating household asset ownership and access to drinking water and sanitation

[f]child's weight at birth measured as ≤2.5 kg

[g]child had at least one morbid condition out of diarrhea, fever and cough in the two weeks preceding the survey

Table 2

Prevalence of multiple concurrent forms of undernutrition among under-5 children

Factors	Multiple concurrent forms of undernutrition			
	No		Yes	
	Number (%)	Proportion (95% CI)	Number (%)	Proportion/prevalence (95% CI)
Total	6133	80.7 (79.5,81.8)	1528	19.3 (18.2-20.5)
Mothers' age (in years)				
15-19	755	81.1 (78.1-83.8)	183	18.9 (16.2-21.9)
20-24	2187	81.7 (79.9-83.4)	492	18.3 (16.6-20.1)
25-29	1697	79.8 (77.9-81.6)	449	20.2 (18.4-22.1)
30-34	1029	80.6 (77.8-83.2)	264	19.4 (16.8-22.2)
35-39	378	80.1 (75.8-83.8)	103	19.9 (16.2-24.2)
≥ 40	87	71.0 (61.1-79.2)	37	29.0 (20.8-38.9)
***p* values (Chi-square test)**			0.160	
Parents' education				
Both parents were uneducated	186	62.6 (55.7-69.0)	108	37.4 (31.0-44.3)
Only father was uneducated	644	74.4 (70.9-77.7)	221	25.6 (22.3-29.1)
Only mother was uneducated	168	72.0 (65.0-78.1)	75	28.0 (21.9-35.0)
Both parents were educated	5135	82.7 (81.5-83.8)	1124	17.3 (16.2-18.5)
***p* values (Chi-square test)**			<0.001	
Mother currently working				
No	3715	82.2 (80.7-83.6)	845	17.8 (16.4-19.3)
Yes	2418	78.4 (76.6-80.1)	683	21.6 (19.9-23.4)
***p* values (Chi-square test)**			0.0004	
Underweight mother				
No	5353	82.3 (81.0-83.5)	1182	17.7 (16.5-19.0)
Yes (<18.5 kg/m^2)	780	70.5 (67.5-73.3)	346	29.5 (26.7-32.5)
***p* values (Chi-square test)**			<0.001	
Mothers received antenatal care				
No	266	73.8 (68.7,78.4)	97	26.2 (21.6-31.3)
Yes	3476	84.0 (82.6,85.2)	701	16.0 (14.8-17.4)
***p* values (Chi-square test)**			<0.001	
Mothers received postnatal care				
No	1290	85.8 (83.7-87.7)	219	14.2 (12.3-16.3)
Yes	2448	81.7 (80.1-83.3)	578	18.3 (16.7-19.9)
			p=0.001	
Mothers experienced IPV				
No	5055	81.3 (80.1-82.5)	1209	18.7 (17.5-19.9)
Yes	1078	77.8 (75.2-80.2)	319	22.2 (19.8-24.8)
***p* values (Chi-square test)**			0.005	
Mothers' decision-making autonomy				
Not practiced	852	79.5 (76.7-82.1)	231	20.5 (17.9-23.3)
Practiced	5281	80.8 (79.5-82.1)	1297	19.2 (17.9-20.5)
***p* values (Chi-square test)**			0.370	
Father's occupation				
Currently not working	52	71.9 (58.6-82.2)	21	28.1 (17.8-41.4)
Manual labourer	4277	79.1 (77.7-80.4)	1181	20.9 (19.6-22.3)
Professional	425	90.4 (87.1-92.9)	47	9.6 (7.1-12.9)
Businessman	1379	84.0 (81.8-86.0)	279	16.0 (14.0-18.2)
***p* values (Chi-square test)**			*p*<0.001	
Source of water				
Improved	5309	80.3 (79.0-81.6)	1349	19.7 (18.4-21.0)
Unimproved	824	82.9 (80.1-85.4)	179	17.1 (14.6-19.9)
***p* values (Chi-square test)**			0.092	
Type of toilet facility				
Improved	3587	82.6 (81.1-84.0)	772	17.4 (16.0-18.9)
Unimproved	2546	78.1 (76.2-79.9)	756	21.9 (20.1-23.8)

			0.0001	
Solid waste use in cooking				
No	1888	84.7 (82.7-86.5)	330	15.3 (13.5-17.3)
Yes	4245	78.9 (77.5-80.3)	1198	21.1 (19.7-22.5)
***p* values (Chi-square test)**			<0.001	
Mass media exposure				
No	2095	76.2 (74.2-78.1)	676	23.8 (21.9-25.8)
Yes	4038	83.1 (81.7-84.3)	852	16.9 (15.7-18.3)
***p* values (Chi-square test)**			<0.001	
Wealth index				
Poorest	1248	73.6 (71.0-76.0)	460	26.4 (24.0-29.0)
Poorer	1172	77.2 (74.8-79.5)	373	22.8 (20.5-25.2)
Middle	1105	81.3 (78.6-83.7)	276	18.7 (16.3-21.4)
Richer	1266	82.8 (80.2-85.1)	267	17.2 (14.9-19.8)
Richest	1342	89.8 (87.7-91.5)	152	10.2 (8.5-12.3)
***p* values (Chi-square test)**			*p*<0.001	
Place of residence				
Urban	2152	82.8 (80.5-84.8)	453	17.2 (15.2-19.5)
Rural	3981	79.9 (78.5-81.3)	1075	20.1 (18.7-21.5)
***p* values (Chi-square test)**			0.032	
Children's age (in months)				
0-11 months	1454	88.0 (86.2-89.6)	219	12.0 (10.4-13.8)
12-23 months	1293	82.7 (80.5-84.7)	290	17.3 (15.3-19.5)
24-35 months	1141	77.6 (75.0-80.1)	334	22.4 (19.9-25.0)
36-47 months	1097	77.7 (75.0-80.2)	320	22.3 (19.8-25.0)
48-59 months	1148	76.1 (73.6-78.5)	365	23.9 (21.5-26.4)
***p* values (Chi-square test)**			<0.001	
Sex of child				
Male	3188	80.4 (78.8-82.0)	807	19.6 (18.0-21.2)
Female	2945	80.9 (79.3-82.4)	721	19.1 (17.6-20.7)
***p* values (Chi-square test)**			0.645	
Birth order				
One	2385	82.3 (80.5-83.9)	517	17.7 (16.1-19.5)
Two	2043	82.1 (80.3-83.7)	464	17.9 (16.3-19.7)
Three	1023	80.4 (78.0-82.6)	274	19.6 (17.4-22.0)
Four and above	682	72.4 (68.8-75.8)	273	27.6 (24.2-31.2)
***p* values (Chi-square test)**			<0.001	
Low birth weight				
No	1618	89.5 (87.7-91.0)	197	10.5 (9.0-12.3)
Yes (<2.5 kg)	230	72.7 (67.1-77.7)	96	27.3 (22.3-32.9)
Not weighted	2043	79.7 (77.8-81.4)	551	20.3 (18.6-22.2)
***p* values (Chi-square test)**			<0.001	
Currently had disease				
No	3277	81.5 (79.9-82.9)	766	18.5 (17.1-20.1)
Yes	2856	79.8 (78.1-81.4)	762	20.2 (18.6-21.9)
***p* values (Chi-square test)**			0.103	

No undenutrition for multiple concurrent forms includes healthy children and children with single form of undernutrition
CI, confidence interval

Table 3

Prevalence of single form of undernutrition among under-5 children

Factors	Single form of undernutrition			
	No		Yes	
	Number (%)	Proportion (95% CI)	Number (%)	Proportion/prevalence (95% CI)
Total	6205	81.1 (80.1-82.1)	1456	18.9 (17.9-19.9)
Mothers' age (in years)				
15-19	745	79.9 (76.8-82.7)	193	20.1 (17.3-23.2)
20-24	2174	81.2 (79.4-82.8)	505	18.8 (17.2-20.6)
25-29	1759	82.0 (80.1-83.8)	387	18.0 (16.2-19.9)
30-34	1031	79.9 (77.4-82.1)	262	20.1 (17.9-22.6)
35-39	391	81.0 (76.7-84.7)	90	19.0 (15.3-23.3)
≥ 40	105	85.7 (77.7-91.2)	19	14.3 (8.8-22.3)
***p* values (Chi-square test)**			0.533	
Parents' education				
Both parents were uneducated	233	80.9 (75.5-85.3)	61	19.1 (14.7-24.5)
Only father was uneducated	666	77.0 (73.9-79.8)	199	23.0 (20.2-26.1)
Only mother was uneducated	191	78.2 (71.3-83.8)	52	21.8 (16.2-28.7)
Both parents were educated	5115	81.8 (80.6-82.9)	1144	18.2 (17.1-19.4)
***p* values (Chi-square test)**			0.017	
Mother currently working				
No	3704	81.5 (80.0-82.8)	856	18.5 (17.2-20.0)
Yes	2501	80.5 (78.9-82.1)	600	19.5 (17.9-21.1)
***p* values (Chi-square test)**			0.396	
Underweight mother				
No	5323	81.5 (80.3-82.6)	1212	18.5 (17.4-19.7)
Yes (<18.5 kg/m^2)	882	78.8 (76.1-81.2)	244	21.2 (18.8-23.9)
***p* values (Chi-square test)**			0.053	
Mothers received antenatal care				
No	279	77.5 (72.5-81.8)	84	22.5 (18.2-27.5)
Yes	3334	79.8 (78.5-81.2)	843	20.2 (18.8-21.5)
***p* values (Chi-square test)**			0.327	
Mothers received postnatal care				
No	1210	80.5 (78.1-82.8)	299	19.5 (17.2-21.9)
Yes	2398	79.2 (77.6-80.7)	628	20.8 (19.3-22.4)
			0.335	
Mothers experienced IPV				
No	5071	81.2 (80.0-82.3)	1193	18.8 (17.7-20.0)
Yes	1134	80.8 (78.5-82.9)	263	19.2 (17.1-21.5)
***p* values (Chi-square test)**			0.744	
Mothers' decision-making autonomy				
Not practiced	881	82.2 (79.6-84.5)	202	17.8 (15.5-20.4)
Practiced	5324	80.9 (79.8-82.0)	1254	19.1 (18.0-20.2)
***p* values (Chi-square test)**			0.377	
Father's occupation				
Currently not working	63	87.0 (76.2-93.3)	10	13.0 (6.7-23.8)
Manual labourer	4347	79.5 (78.3-80.6)	1111	20.5 (19.4-21.7)
Professional	414	89.0 (85.6-91.6)	58	11.0 (8.4-14.4)
Businessman	1381	84.3 (82.2-86.3)	277	15.7 (13.7-17.8)
***p* values (Chi-square test)**			<0.001	
Source of water				
Improved	5399	81.1 (80.0-82.2)	1259	18.9 (17.8-20.0)
Unimproved	806	80.9 (78.2-83.3)	197	19.1 (16.7-21.8)
***p* values (Chi-square test)**			0.857	
Type of toilet facility				
Improved	3583	82.3 (80.9-83.6)	776	17.7 (16.4-19.1)
Unimproved	2622	79.5 (78.0-81.0)	680	20.5 (19.0-22.0)

			0.006	
Solid waste use in cooking				
No	1846	83.2 (81.3-84.9)	372	16.8 (15.1-18.7)
Yes	4359	80.2 (79.0-81.4)	1084	19.8 (18.6-21.0)
***p* values (Chi-square test)**			0.008	
Mass media exposure				
No	2175	78.8 (77.0-80.4)	596	21.2 (19.6-23.0)
Yes	4030	82.4 (81.0-83.6)	860	17.6 (16.4,19.0)
***p* values (Chi-square test)**			0.0009	
Wealth index				
Poorest	1324	77.9 (75.7-79.9)	384	22.1 (20.1-24.3)
Poorer	1213	79.0 (76.7-81.2)	332	21.0 (18.8-23.3)
Middle	1136	82.3 (80.1-84.4)	245	17.7 (15.6-19.9)
Richer	1246	81.2 (78.9-83.3)	287	18.8 (16.7-21.1)
Richest	1286	85.8 (83.5-87.9)	208	14.2 (12.1-16.5)
***p* values (Chi-square test)**			<0.001	
Place of residence				
Urban	2173	84.0 (82.2-85.7)	432	16.0 (14.3-17.8)
Rural	4032	80.1 (78.8-81.3)	1024	19.9 (18.7-21.2)
***p* values (Chi-square test)**			0.0004	
Children's age (in months)				
0-11 months	1406	83.8 (81.9-85.6)	267	16.2 (14.4-18.1)
12-23 months	1215	77.1 (74.7-79.4)	368	22.9 (20.6-25.3)
24-35 months	1139	77.1 (74.5-79.6)	336	22.9 (20.4-25.5)
36-47 months	1137	80.7 (78.3-82.9)	280	19.3 (17.1-21.7)
48-59 months	1308	86.7 (84.6-88.5)	205	13.3 (11.5-15.4)
***p* values (Chi-square test)**			0.001	
Sex of child				
Male	3241	81.0 (79.6-82.4)	754	19.0 (17.6-20.4)
Female	2964	81.2 (79.7-82.6)	702	18.8 (17.4-20.3)
***p* values (Chi-square test)**			=0.863	
Birth order				
One	2377	81.9 (80.3-83.4)	525	18.1 (16.6-19.7)
Two	2040	81.4 (79.6-83.1)	467	18.6 (16.9-20.4)
Three	1032	79.4 (76.8-81.8)	265	20.6 (18.2-23.2)
Four and above	756	80.1 (77.3-82.6)	199	19.9 (17.4-22.7)
***p* values (Chi-square test)**			0.285	
Low birth weight				
No	1502	82.4 (80.2-84.3)	313	17.6 (15.7-19.8)
Yes (<2.5 kg)	260	79.7 (74.2-84.3)	66	20.3 (15.7-25.8)
Not weighted	2001	77.5 (75.8-79.1)	593	22.5 (20.9-24.2)
***p* values (Chi-square test)**			0.002	
Currently had disease				
No	3251	80.9 (79.5-82.3)	792	19.1 (17.7-20.5)
Yes	2954	81.3 (79.8-82.7)	664	18.7 (17.3-20.2)
***p* values (Chi-square test)**			0.699	

No undenutrition for single form includes healthy children and children with multiple concurrent forms of undernutrition
CI, confidence interval

Table 4

Risk factors of multiple concurrent forms and single form of under-5 child undernutrition (results of stepwise logistic regression with backword selection)

Factors	Multiple concurrent forms		Single form	
	AOR (95% CI)	*p* values	AOR (95% CI)	*p* values
Parents' education [a,b]				
Both parents were uneducated	2.03 (1.53-2.71)	<0.001	1.33 (0.95-1.85)	0.095
Only father was uneducated	1.37 (1.14-1.65)	0.001	1.35 (1.12-1.63)	0.002
Only mother was uneducated	1.57 (1.14-2.16)	0.006	1.37 (0.98-1.91)	0.067
Both parents were educated	1.00		1.00	
Underweight mothers [a,b]				
No	1.00		1.00	
Yes	1.91 (1.62-2.25)	<0.001	1.30 (1.09-1.55)	0.003
Father's occupation [a,b]				
Currently not working	1.98 (1.11-3.54)	0.021	1.11 (0.53-2.31)	0.784
Manual labourer	1.25 (1.06-1.46)	0.007	1.36 (1.16-1.59)	<0.001
Professional	0.76 (0.53-1.09)	0.139	0.71 (0.50-1.01)	0.053
Businessman	1.00		1.00	
Wealth index [a,b]				
Poorest	2.57 (2.05-3.23)	<0.001	1.79 (1.45-2.21)	<0.001
Poorer	2.33 (1.86-2.92)	<0.001	1.63 (1.33-2.01)	<0.001
Middle	1.83 (1.46-2.30)	<0.001	1.26 (1.02-1.55)	0.035
Richer	1.79 (1.43-2.25)	<0.001	1.42 (1.16-1.74)	0.001
Richest	1.00		1.00	
Children's age (in months) [a,b]				
0-11 months	1.00		1.00	
12-23 months	1.78 (1.45-2.19)	<0.001	1.76 (1.46-2.10)	<0.001
24-35 months	2.70 (2.20-3.30)	<0.001	1.94 (1.61-2.34)	<0.001
36-47 months	2.51 (2.05-3.07)	<0.001	1.54 (1.27-1.87)	<0.001
48-59 months	2.35 (1.93-2.87)	<0.001	0.95 (0.77-1.16)	0.607
Birth order [a,b]				
One	1.00			
Two	1.02 (0.88-1.19)	0.753		
Three	1.06 (0.88-1.27)	0.538		
Four and above	1.42 (1.17-1.73)	0.001		
Low birth weight [b]				
No	1.00		1.00	
Yes	3.76 (2.78-5.10)	<0.001	1.52 (1.11-2.08)	0.008

Note: baseoutocme or reference category of regression model was normal chidren (multiple concurrent forms vs normal and single form vs normal) and AOR indicates adjusted odds ratio.

a, stepwise logistic regression model for multiple concurrent forms of undernutrition includes maternal age, parents' education, mother's current working status, mother's underweight status, mother's experience IPV, father's occupation, use of solid waste in cooking, type of toilet facility, mass media exposure, wealth index, place of residence, age of children and birth order

b, stepwise logistic regression model for multiple concurrent forms of undernutrition includes maternal age, parents' education, mother's current working status mother's underweight status, status of mother's antenatal and postnatal care, mother's experience IPV, father's occupation, use of solid waste in cooking, type of toilet facility, mass media exposure, wealth index, place of residence, age of children, birth order, and birth weight status

a, stepwise logistic regression model for single form of undernutrition includes parents' education, mother's underweight status, father's occupation, use of solid waste in cooking, type of toilet facility, mass media exposure, wealth index, place of residence and age of children

b, stepwise logistic regression model for multiple concurrent forms of undernutrition includes parents' education, mother's underweight status, father's occupation, use of solid waste in cooking, type of toilet facility, mass media exposure, wealth index, place of residence, age of children and birth weight status

Figure 1

Sample size selection

Figure 2

Trends of the prevalence of stunting, wasting and underweight