Association of access to water, sanitation and handwashing facilities with undernutrition of children below 5 years of age in Bangladesh: evidence from two population-based, nationally representative surveys

Md Mehedi Hasan, Chowdhury Abdullah Al Asif, Alina Barua, Archis Banerjee, Md Abul Kalam, Abdul Kader, Tasnuva Wahed, Mohammad Wali Noman, Aminuzzaman Talukder

ABSTRACT

Objective To examine the association between household access to water, sanitation and handwashing (WaSH) facilities and child undernutrition in Bangladesh.

Design, setting and participants Cross-sectional study of children less than 5 years using data collected from the 2019 Multiple Indicator Cluster Survey (MICS) and the 2017–2018 Bangladesh Demographic and Health Survey (BDHS).

Outcome measures Stunting, wasting and underweight, defined as a Z-score < -2 SD for height-for-age, weight-for-height and weight-for-age, respectively. We applied hierarchical multiple binary logistic regression models.

Results Among 30,514 children 0–59 months, there was a high prevalence of child undernutrition (MICS: 28.0% stunted, 9.8% wasted, 22.6% underweight; BDHS: 30.8% stunted, 8.4% wasted, 21.7% underweight). Most children came from households lacking basic sanitation (MICS: 39.1%, BDHS: 55.3%) or handwashing facilities (MICS: 43.8%, BDHS: 62.6%). Children from households without access to WaSH facilities experienced the highest rates of undernutrition. Exposure-specific adjusted logistic regression models showed that a lack of access to improved water sources was associated with greater odds of wasting (MICS: adjusted OR (AOR) 1.36, 95% CI 1.00 to 1.85, p<0.05); basic sanitation facility with higher rates of stunting (MICS: 1.13, 1.04 to 1.23, p<0.01) and underweight (BDHS: 1.18, 1.02 to 1.37, p<0.05); and a lack of handwashing facilities with stunting (BDHS: 1.27, 1.10 to 1.48, p<0.01) and underweight (MICS: 1.10, 1.01 to 1.19, p<0.05). In fully adjusted models, no basic sanitation facility was associated with higher odds of stunting (MICS: AOR 1.12, 1.03 to 1.22, p<0.01) and a lack of handwashing facilities with higher odds of underweight (BDHS: AOR 1.30, 1.10 to 1.54, p<0.01; MICS: AOR 1.09, 1.01 to 1.19, p<0.05).

Conclusion These findings demonstrate a significant association between poor household WaSH facilities and high prevalence of child undernutrition. Improving WaSH may help reduce child undernutrition in Bangladesh.

INTRODUCTION

Undernutrition, defined as stunting, wasting and being underweight, continues to be a serious public health problem in children under 5 years and leads to over 1.0 million deaths, 3.9% of years of life lost and 3.8% of disability-adjusted life-years worldwide.1 2 Globally, an estimated 150 million children under 5 years of age were stunted, and 45 million were wasted in 2020.3 4 Reducing childhood stunting by 40% and limiting wasting to below 5% by 2025 were key targets set at the 65th World Health Assembly in 2012.5 In the Sustainable Development Goals (SDGs), a more ambitious target was set to eliminate all forms of malnutrition by 2030 (SDG Target 2.2).6 Bangladesh has significantly reduced childhood undernutrition in the last 25 years. From 1996 to 2018, stunting was reduced from 60% to 31%, wasting from 21% to 8% and underweight from 52% to 22%.7 Despite significant progress, the prevalence of childhood undernutrition remains unacceptably high in Bangladesh. Based on WHO criteria, stunting and wasting are still
classified as ‘very high’ and ‘medium’, respectively. Further efforts to reduce child undernutrition in Bangladesh are essential.

Childhood undernutrition is caused by primary and distal factors such as age, sex, household food insecurity, poor diet, low parental education, parental occupation, household wealth and low birth weight. Poor water, sanitation and handwashing (WaSH) facilities are key factors that can be improved. Poor WaSH facilities and behaviours lead to diarrhoea and related morbidities that exacerbate the risk of undernutrition in children. The association between WaSH and childhood undernutrition has been studied in Bangladesh. For example, Lin and colleagues showed that an improved WaSH environment was associated with increased height-for-age among children in rural Bangladesh. Poor hygiene practices increased malnutrition by twofold among children in impoverished areas of Dhaka. A systematic review reported that environmental cleanliness through improved WaSH practices was a critical factor in improving child growth outcomes at the household level in Bangladesh. One study showed a significant association between WaSH and child undernutrition in a particular district of Bangladesh. However, these pieces of evidence were based on data collected from selected locations and hence inadequate to infer the association between WaSH and child undernutrition at the national level using robust data. Responding to national policies requires national-level evidence, which is scarce in the current literature. This paucity of evidence warrants further assessment of this association at the national level to better inform broader national WaSH and nutrition policies.

We, therefore, aimed to assess the association between household access to WaSH facilities and childhood undernutrition at the national level by using two nationally representative surveys in Bangladesh.

METHODS

Data, design and participants

We performed a secondary analysis of the most recent data from two nationally representative, population-based cross-sectional surveys: the Multiple Indicator Cluster Survey (MICS) and the Bangladesh Demographic and Health Survey (BDHS) conducted in 2019 and 2017–2018, respectively. The Bangladesh Bureau of Statistics, with a support from the United Nations Children’s Fund, conducted the MICS; and the National Institute of Population Research and Training of the Ministry of Health and Family Welfare, with a support from the US Agency for International Development, conducted the BDHS in Bangladesh. Both surveys collected data on health and nutrition indicators and their sociodemographic determinants, including age, sex, wealth status and WaSH.

A detailed MICS and BDHS methodology description is available elsewhere. Briefly, the MICS and BDHS employed a two-stage stratified sampling technique to select participants for data collection. Both surveys systematically selected a specific number of Enumeration Areas (EAs), as Primary Sampling Units (PSUs), within each stratum with probability proportional to size, followed by the systematic selection of a sample of ~20 households in the MICS and ~30 households in the BDHS from each EA. A total of 64 400 and 20 160 households were sampled, of which 61 242 and 19 457 were successfully interviewed with universal response rates in both MICS (99.4% response rate) and BDHS (97% response rate), respectively. We restricted our analysis to data on participants 0–59 months.

Outcome variables

Categorical outcomes for this analysis were childhood stunting, wasting and underweight, defined as a Z-score less than −2 SD for height-for-age, weight-for-height and weight-for-age, respectively, relative to the 2006 WHO child growth standards. The formula for calculating the Z-scores is as follows:

\[ Z\text{-score} = \frac{\text{observed value} - \text{mean value of reference population}}{\text{SD value of reference population}} \]

Exposure variables

We used a standardised definition of WaSH variables for both datasets. Based on the purpose of the analysis, we selected the three main WaSH-related exposure variables and included household access to (1) an improved facility/source for safe drinking water, (2) a basic sanitation facility and (3) a handwashing facility. These variables were categorised according to the WHO-UNICEF Joint Monitoring Program 2017 guidelines as follows:

Access to an improved drinking water facility was defined as households having access to one of the following water sources: a pipe in dwelling/yard/plot, tube well or borehole, protected well, rain or bottled water.

Access to a basic sanitation facility was defined as households having flush/pour flush toilets that flush water and waste to a piped sewer system, septic tank, pit latrine or unknown destination; ventilated improved pit latrines; pit latrines with slabs; or composting toilets which were not shared with other households.

Access to a handwashing facility was defined as having access to a handwashing facility if the household has a designated place (fixed and covered) for handwashing with the availability of water and soap together on the premises.

Covariates

Given the multiple causes of child undernutrition, we identified relevant and available covariates in the MICS and BDHS datasets that fit the UNICEF conceptual framework of determinants of child undernutrition. These included the child’s age, child’s sex, child’s birth order, mother’s age at birth, mother’s education, household size, wealth index, place of residence and administrative division. For this study, we used the variables place of residence, division and wealth index constructed using
the principal component analysis technique that the MICS and BDHS provided with their datasets. Both surveys categorised households into five wealth quintiles (poorest, poorer, middle, richer and richest) based on their wealth score.

**Statistical analyses**

We applied univariate analysis to summarise the descriptive statistics of nutritional status, WaSH and the covariates. Results of the descriptive analysis were presented as percentages and frequencies (ie, number of children). Bivariate analysis using a $X^2$ test was employed to investigate whether the prevalence of childhood undernutrition differs significantly across WaSH indicators.

As our outcome variables were dichotomous, we performed a hierarchical binary logistic regression analysis to examine the association between access to WaSH facilities and child undernutrition. We examined the association of each WaSH component with child undernutrition without adjusting for covariates (model 1) and after adjusting for covariates as described above (model 2). We then fitted a full model by entering all the WaSH components together and adjusted for covariates (model 3) to understand the components to which the association pertains. We confirmed the absence of multicollinearity among the covariates (variance inflation factor <5) while fitting multivariable models in both datasets. The results of the logistic regression models were presented in terms of OR along with 95% CIs. The analyses were adjusted by the sampling weight to make the estimates representative at the population level of the same characteristics and by considering the complex survey design (eg, sampling weight, PSU (here cluster) and strata) to control the error term due to survey design. We considered a p value of <0.05 to examine the statistical significance of all the two-sided statistical tests performed. Data analyses were performed using Stata (V.16.1 SE, College Station, Texas, USA).

**Patient and public involvement**

None.

**RESULTS**

**Sample characteristics**

The analysis included 22521 and 7993 children 0–59 months of age from the MICS and BDHS, respectively. In both MICS and BDHS, a little less than half of the children were female (~48%), with the age distribution of children roughly equal (~20%) across the 0–11, 12–23, 24–35, 36–47 and 48–59 months age groups. Nearly one-third of the children were the first baby of their mothers (the first birth order was 35.8% in the MICS and 38.2% in the BDHS). Approximately two-thirds (65.2% in the MICS and 64.3% in the BDHS) of the mothers of the indexed child had at least secondary education. Three of five (59.8%) children in the MICS and two of three (67.1%) children in the BDHS lived in a household with five or more members. The distribution of children was roughly equal (~20%) across the wealth status of households. Four of every five children (79%), as per the MICS, and three of every four children (73.4%), as per the BDHS, resided in rural areas. The highest percentage of children was from the Dhaka division (23.8% and 25%), and the lowest was from the Barishal division (5.8% and 5.6%) as per the MICS and BDHS, respectively (table 1).

**Child undernutrition**

The prevalence of undernutrition in children 0–59 months of age was high in Bangladesh. According to the MICS, 28% of children were stunted, 9.8% were wasted and 22.6% were underweight. These estimates were similar when investigated from the BDHS data. According to the BDHS, nearly one-third (30.8%) of the children were stunted, 1 in 10 (8.4%) were wasted and 2 in 5 (21.7%) were underweight (table 1). The prevalence of child undernutrition varied across divisions, with Sylhet having the highest prevalence of stunting (MICS: 37.6%, BDHS: 42.2%), wasting (MICS: 11.0%, BDHS: 10.5%) and underweight (MICS: 32.1%, BDHS: 32.6%) (figure 1).

**Access to WaSH facilities**

Most of the households had access to safe water. While access to improved drinking water facilities was nearly universal (98.5% in the MICS and 98.3% in the BDHS), other WaSH facilities, such as sanitation and handwashing, were poor in Bangladesh. According to the MICS, two of every five children living in households had no access to a basic sanitation facility (39.1%) and a handwashing facility (43.8%). The lack of access to sanitation and handwashing facilities was greater in the BDHS than in the MICS. In the BDHS, more than half (55.3%) of the children lived in households with no access to a basic sanitation facility, and nearly two of every three (62.6%) children lived in households with no access to a handwashing facility where water and soap were available (table 1). Access to improved water was lowest in Sylhet (MICS: 95.7%, BDHS: 95.1%), improved sanitation was lowest in Mymensingh (MICS: 50.6%, BDHS: 32.5%) and handwashing facility was lowest in Barishal (MICS: 34.6%, BDHS: 16.7%) (figure 2).

**Association between access to WaSH facilities and child undernutrition**

The prevalence of child undernutrition varied significantly across access to WaSH facilities, with children from households with no access to WaSH facilities having the highest prevalence of undernutrition. Analysis showed significantly (p<0.05) greater prevalence of childhood stunting in households with no access to improved water (MICS: 33.6% vs 27.9%, BDHS: 42.3% vs 31.1%), basic sanitation (MICS: 32.6% vs 25%, BDHS: 35% vs 26.6%) and a handwashing facility (MICS: 32.5% vs 24.4%, BDHS: 35.8% vs 22.4%). Similarly, childhood wasting was greater in households with no access to improved water...
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(15.3% vs 9.7%) and a basic sanitation facility (MICS: 10.8% vs 9.2%, BDHS: 9.2% vs 7.4%). Correspondingly, a significantly greater prevalence of underweight was observed among children of households with no basic sanitation (MICS: 25.7% vs 20.6%, BDHS: 25.6% vs 18%) and handwashing facilities (MICS: 26.4% vs 19.6%, BDHS: 24.8% vs 16.5%) (figure 3).

The results of the regression analyses are presented in table 2. The unadjusted regression model (model 1) revealed a significant association between having no access to WaSH facilities and a higher likelihood of child undernutrition when no adjustment of covariates was made.

Exposure-specific adjusted logistic regression models (model 2) depict that compared with children of households with access to a basic sanitation facility, children of households with no access to a basic sanitation facility were 13% more likely to be stunted (MICS: adjusted OR (AOR) 1.13, 95% CI 1.04 to 1.23, p<0.01). Similarly, children of households with no access to a handwashing facility were 27% more likely to be stunted than those with access to a handwashing facility (BDHS: AOR 1.27, 95% CI 1.10 to 1.48, p<0.01). Access to improved water facilities was associated with childhood wasting, with children of households with no access to improved water facilities being 36% more likely to be wasted than children of households with access to water facilities (MICS: AOR 1.36, 95% CI 1.0 to 1.85, p<0.05). For underweight, a significantly greater likelihood of being underweight was observed among children of households with no access to a basic sanitation facility (BDHS: AOR 1.18, 95% CI 1.02 to 1.37, p<0.05) and no handwashing facility (MICS: AOR 1.10, 95% CI 1.01 to 1.19, p<0.05) than their counterparts who had access to basic sanitation and handwashing facilities.

Full models (model 3) reveal that the significant associations between having no access to a basic sanitation facility with greater odds of stunting (MICS: AOR 1.12,
95% CI 1.03, 1.22, p<0.01) and having no handwashing facility with stunting (BDHS: AOR 1.30, 95% CI 1.10, 1.54, p<0.01) and underweight (MICS: AOR 1.09, 95% CI 1.01, 1.19, p<0.05) persist.

**DISCUSSION**

We explored the association between access to WaSH and undernutrition of children at the national level using the most recent population-based data from two nationally representative surveys. This study demonstrates (1) a higher prevalence of child undernutrition in households with no access to WaSH facilities; (2) a significant and consistently positive association between access to WaSH facilities and child undernutrition, with no access to water facilities being associated with 36% increased odds of wasting, no access to sanitation facility with 13% increased odds of stunting and 19% increased odds of underweight, and no access to handwashing facility with 27% increased odds of underweight.

**Figure 1** Prevalence of undernutrition among children 0–59 months of age by division. BDHS, Bangladesh Demographic and Health Survey; MICS, Multiple Indicator Cluster Survey.

**Figure 2** Prevalence of households with unimproved water, sanitation and hygiene facilities by division. BDHS, Bangladesh Demographic and Health Survey; MICS, Multiple Indicator Cluster Survey.
odds of stunting and 10% increased odds of underweight while the effect of other potential covariates remains constant; and (3) significantly increased odds of stunting and underweight for children of households with no access to sanitation and handwashing facilities when all three exposures were entered in the model. These findings depict that access to improved water facilities is not enough, given its universal access, rather improvements in access to sanitation and handwashing facilities, is central to combating child undernutrition in Bangladesh.
Our findings on linking higher rates of child undernutrition in households with no access to WaSH facilities are consistent with a large body of evidence drawn from epidemiological studies in many settings worldwide.23-30 Previous studies report an association between poor hygiene practices and a two-fold increased likelihood of being undernourished among children living in the Dhaka slum of Bangladesh,16 while an improved WaSH environment (eg, the presence of improved handwashing, sanitation and drinking water supply facilities) leads to a superior height-for-age outcome among children in rural Bangladesh.15 A systematic review on stunting reduction in developing countries suggests that environmental cleanliness through improved WaSH practices at the household level is an important pathway to improving child growth outcomes in Bangladesh.17 Other studies conducted in South and South East Asia report a need of better WaSH facilities for increasing linear growth and decreasing undernutrition in Cambodia,23 India,24 Peru,27 Nepal,29 Pakistan30 and Sri Lanka.31 Previous investigators have shown a significant association between poor WaSH facilities and high prevalence of child undernutrition and/or impacts of WaSH interventions in reducing child undernutrition in African countries such as Ethiopia,32,33 Tanzania,34 Togo,35 Tunisia25 and Uganda,35 and in Latin American countries such as Bolivia,35 Lesotho36 and Peru.37

In contrast, our findings are inconsistent with a randomised controlled trial in Bangladesh where improving WaSH did not reduce child undernutrition.36 This trial was conducted in rural areas only and overlooked the urban slum areas where improved access to WaSH was scarce. On the other hand, our study captured both urban and rural areas and inferred the association between WaSH and child undernutrition at the national level. These geographical variations in study settings likely explain the differences reported. Moreover, it could happen that the WaSH interventions of the trial were not sufficient to reduce exposure to environmental pathogens for reducing child undernutrition in Bangladesh.38 However, this null effect of WaSH intervention does not necessarily mean that the effect of a WaSH intervention flawed the hypothesis of the effect of WaSH on the reduction of child undernutrition. These conflicting findings suggest a continuation of future research to explore customised strategies while implementing WaSH interventions aiming to reduce child undernutrition in Bangladesh.

Poor WaSH facilities can affect child undernutrition through multiple direct or indirect channels, likely by triggering the incidence of diarrhoeal episodes, intestinal worms, parasitic infections and environmental enteropathy...
caused by poor sanitation and hygiene. The mediating role of diarrhoea, parasitic infections and environmental enteropathy linking poor WaSH facilities to developmental deficits is well reported. Diarrhoea and intestinal infections have the potential to affect the nutritional status of children by lowering appetite, impairing nutrient absorption and increasing nutrient losses. Therefore, attention to increasing access to WaSH facilities is essential to mitigate morbidity attributable to diarrhoeal diseases and intestinal infections and to improve the nutritional status of children as a result.

Several action plans should be considered to make access to WaSH facilities universal. National health and nutrition strategy should prioritise the establishment of WaSH facilities on the doorstep of those who have no access to these facilities as previously identified. Installing communal safe drinking water sources at the nearest visible central places may help increase the coverage of access to a safe drinking water source for rural, remote and hard-to-reach dwellers with minimum investment. Increasing access to WaSH facilities, particularly sanitation facilities, may require sufficient financial support for the poorest rural households to set up this facility in the households. If so, the government, along with the development partners, should come forward with financial aid such as cash support and supplementation of materials for sanitation to set up this facility in households having no access to a basic sanitation facility. In addition to installing sanitation facilities, faecal sludge management in both urban and rural areas is also equally important to prevent disease burden associated with pathogens. Management of faecal sludge can be improved by including subsequent effluent treatment while implementing septic tanks and anaerobic baffled reactors to treat blackwater for reducing the pathogen load and delivering comprehensive rather than piecemeal sanitation coverage. On the other hand, increasing access to handwashing facilities may not require much more investment in installing water and/or sanitation facilities. For increasing the coverage of access to handwashing facilities, the use of soapy water could be a strategic and cost-effective way to be administered at the national level. The recipe for preparing soapy water is easy, which consists of three steps: pour 30 g of detergent into a water bottle with 1.5 L of water, drill in the top of the bottle’s original cap to dispense soapy water and tighten the cap and shake the bottle to mix the soapy water. The promotion of using soapy water is feasible and acceptable in both rural and urban settings of the country. The uttermost advantage of soapy water is that it is easily shareable and economically installable at the shared handwashing station. The preparation of 1.5 L of soapy water requires only US$0.06. Given its easiest preparation and installation process with the negligible cost involved, promoting the use of soapy water may increase habitual handwashing by addressing the barriers of cost and availability of handwashing agents near water sources. Further research should inform optimal strategies to scale up soapy water as a handwashing agent and study its impact on nutrition and health. Installing WaSH facilities may not work alone unless increasing its appropriate practices at a greater level. To optimise WaSH practices, the knowledge of WaSH benefits must need to be increased at the mass level beforehand. Integration of promoting WaSH knowledge into the WaSH interventions may aid in making the WaSH practices sustainable once access to WaSH facilities is ensured.

This study has several strengths. The use of two nationally representative high-quality data, with a high-response rate, covering both rural and urban areas, made the estimates of this study robust. The analysis of this study, controlled for many covariates associated with child undernutrition, suggests that the association between WaSH and child undernutrition is not confounded by these factors. The methodology of all the surveys included was similar. Also, the indicators, particularly related to WaSH, were created by following the same definitions. This unique methodology and construction of indicators allow this study for a cross-source comparison of estimates and associations. However, this study has some limitations as well. The use of cross-sectional data impedes us to ascertain a causal association between WaSH and child undernutrition. However, examining the association between exposures and outcomes is well evidenced in several cross-sectional studies. It might be possible that households that reported not having WaSH facilities have access to improved WaSH from their neighbours. We were unable to adjust some important covariates such as maternal nutritional status and maternal healthcare-related indicators due to the unavailability and/or missing values of these indicators in the data-sets analysed.

CONCLUSIONS
This study demonstrates that lack of access to WaSH facilities is associated with a greater likelihood of childhood undernutrition in Bangladesh. Improving WaSH as an intervention may play a crucial role in reducing child undernutrition in Bangladesh. However, the quality of some facilities, such as water quality, is important to ensure while implementing programmes. For a rapid increase in the coverage of access to WaSH facilities and to tackle the resulting undernutrition due to the lack of access to such facilities, future investments in tailored WaSH interventions should target the most vulnerable populations. To address child undernutrition, the Government of Bangladesh should prioritise WaSH interventions in areas where WaSH facilities are lacking and child undernutrition rates are high. Provisioning access to improved WaSH facilities with ensured quality may help children survive and grow healthy.

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