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# Effectiveness of a community-based water, sanitation, and hygiene (WASH) intervention in reduction of diarrhoea among under-five children: Evidence from a repeated cross-sectional study (2007–2015) in rural Bangladesh

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ABSTRACT

Diarrhoea, the most common disease directly related to water, sanitation, and hygiene (WASH), still remains one of the most significant health problems among children under-five worldwide. In this reality, BRAC, the largest NGO in the world initiated a comprehensive WASH intervention in 50 upazilas (sub-districts) of Bangladesh in 2007 which was later scaled up to cover 150 upazilas in two subsequent phases. The intervention period of the programme was 2007–2011.

The present study encompassed 30 upazilas of the first phase of intervention. The aim of the study was to investigate the effectiveness of this intervention on reduction of diarrhoea among under-five children, and to identify the factors associated with childhood diarrhoea. A repeated cross-sectional study design was followed, and a population-based survey was carried out on four occasions: baseline (2007), midline (2009), endline (2011), and post-endline (2015) among 4,775 households. This analysis considers only households having at least one under-five children.

Absence of handwashing practice with soap after defecation and before eating food, unclean latrine condition, and unsafe disposal of child faeces were identified as significant risk factors associated with under-five diarrhoea from Log-binomial regression. The prevalence of under-five diarrhoea within the past 2 weeks of the survey declined from 13.7% at baseline to 3.6% at end-line ($p < 0.001$) in the WASH intervention area. However, the progress seemingly stalled after 2011, which may have occurred due to the lack of improvement in unsafe disposal of child faeces and unclean latrine condition after the intervention period.

Study findings suggest that, to reduce the prevalence of childhood diarrhoea it is important to promote safe disposal of child faeces, maintaining cleanliness of latrines, and washing hand with soap at critical times, beyond merely increasing the sanitation coverage. Findings also underline the necessity of maintaining a small-scale monitoring component involving local community, such as a WatSan committee (a local committee comprising the user communities for supervising WASH related activities) for periodic monitoring at household level for a certain period after the program intervention works to make the behavioural change more sustainable and to keep the reduction rate of under-five diarrhoeal prevalence steady.

## 1. Introduction

Diarrhoea causes an estimated 1·4 million deaths annually (Troeger et al., 2018). Worldwide, about 2.4 million deaths (4.2 percent of all deaths) could be prevented each year if everybody practiced appropriate hygiene and had good, reliable sanitation, and drinking water (Cairncross et al., 2010). Approximately 88% deaths due to diarrhoeal illness can be attributed to unsafe water, inappropriate sanitation and poor hygiene (Liu et al., 2012).

Although mortality from diarrhoea has declined considerably over the past 25 years globally, morbidity from diarrhoea has not, as risk factors related to inadequate WASH, insufficient promotion of breast-feeding, and malnutrition remain unacceptably high in many regions of the world (WHO, 2017). Diarrhoea is still an important public health

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concern in low and middle-income countries because of its consequent dehydration and nutritional losses among young children (Chowdhury et al., 2015). In fact, diarrhoea is the second leading cause of death among under-five children worldwide, leading to death of about 525000 children each year (WHO, 2017). Poor WASH facilities leads to diarrhoea among young children (Brown et al., 2013; Oloruntoba et al., 2014; Weaver et al., 2016). Poor sanitation and hygiene is accounted for about 19% of all deaths of children younger than 5 years in low-income settings (Hill et al., 2015).

Bangladesh has achieved considerable progress in ensuring access to safe drinking water and improved sanitation facilities in recent years. The percentage of population having access to improved source of drinking water increased from 68% to 87% between 1990 and 2015 (WHO and UNICEF, 2015). Much progress has also been made in the sanitation sector with 61% of the population having access to improved sanitation facilities, up from 33% in 1990 (WHO and UNICEF, 2015). However, shallow tubewells are still the primary source of drinking water in Bangladesh, which often contain faecal indicator bacteria as well as human enteric pathogens (Dey et al., 2017; Ercumen et al., 2015; Ferguson et al., 2012; Leber et al., 2011; Van Geen et al., 2011). Challenges still remain due to close proximity of tube wells and latrine pits, unsanitary conditions surrounding tubewells, lack of cleanliness of water reservoirs, and inadequate faecal sludge management, which is exacerbated by periodic monsoons and flooding (Cesa et al., 2016; Dey et al., 2017). Moreover, over 96% households in rural Bangladesh reportedly do not purify (boiling, filtering, or chemically treating) water before drinking (National Institute of Population Research and Training, Mitra and Associates, and ICF International 2016).

BRAC, with the financial support of the Government of the Netherlands initiated a large scale WASH intervention in 50 upazilas (sub-districts) of Bangladesh in 2007. BRAC selected upazilas that were low in sanitation coverage and hygiene practices. BRAC expanded the intervention to 150 sub-districts in two subsequent phases. The programme provided intervention up to 2011 in these sub-districts.

The strategy of BRAC WASH initiatives are unique where program staffs along with community people are involved in field operation, including periodic monitoring of sanitation and hygiene behaviours (Akter et al., 2014). To ensure the community participation in this process, Village WASH Committees (VWCs) were formed in the intervention areas, which acted as the focal points for involving community people at all levels to improve overall WASH situation in their villages. The major activities performed by VWCs include organizing meeting for problem identification, and their possible solutions, and organizing popular theatre, film shows, and folk songs for community awareness development. VWC members were responsible for sharing WASH related messages and motivating people from their neighborhoods to adopt safe hygiene practices. BRAC's WASH programme, through its' integrated and participatory approach, aims at increasing access to safe drinking water and improved sanitation facilities, and hygiene promotion in rural households of Bangladesh. The main objectives of the present research are therefore to identify the role of key WASH initiatives in reduction of diarrhoea among children aged less than five years in BRAC WASH intervention areas of Bangladesh and to determine risk factors associated with childhood diarrhoea.

### *1.1. BRAC WASH intervention*

BRAC's involvement in the WASH sector began in the 1970s, when diarrhoea was identified as a leading cause of mortality and morbidity among children under five years of age. Sanitation was a part of BRAC's pioneer project in Sulla sub-district in the north-eastern part of the country. In 1986, BRAC started the Essential Health Care program, with WASH as an important component. In 2007, BRAC started scaling up its WASH program in 50 sub-districts, funded by the Government of the Netherlands. It was gradually expanded to 150 more sub-districts by 2011 totaling 250 with support from the Netherlands government, the Bill and Melinda Gates Foundation, UK Aid and Australian Aid.

BRAC WASH programme was initiated based on the assumption that building capacity of the community and empowering community leaders would be more effective than simply building latrines in improving the sanitation coverage and hygiene promotion. Under this programme, selected ultra-poor households received grants from BRAC covering the cost of an improved latrine, while poor households were eligible for loans to construct a latrine. BRAC WASH programme promoted double-pit latrines of sufficient depth to eliminate the removal of faecal sludge. Gender balanced Village WASH committees (VWCs) that represent all community members were the focal points for all WASH activities. To strengthen the capacity of VWCs, one man and one woman from this committee were given a 2-day leadership training at a BRAC Learning Centre. Two current or former members of the local government or two local community leaders were selected as advisors to help each VWC. VWC meetings were held once a month, mostly at the end of the month for the first six months of its formation to summarize the activities of that particular month and to prepare a work plan for following month. However, after the first six months, the frequency of meetings were usually every two or three months. Some of the major activities of the VWCs were to make arrangements to install new improved latrines, convert unhygienic latrines to sanitary ones by changing water seals, installing tubewells, arranging educational activities including health forums, folk songs, street plays, film and video shows to increase awareness about hygienic behavior (Akter et al., 2014). VWCs, with the help of BRAC used to prepare village WASH plans; and were responsible for identifying households eligible for loans or grants to build latrines. These VWCs were provided with necessary supports by about 8,000 BRAC field staffs, including local programme assistants (PAs), field organizers, and managers to establish a process of community joint learning. Their aim was to raise awareness of WASH issues through paying regular household visits, facilitating separate community cluster meetings for women, men and for adolescent girls, adolescent boys and children etc. Programme staffs were also responsible for maintaining liaison with the local government representatives in order to ensure availability of water and sanitation-related hardware to the community. More than 5,000 sanitation entrepreneurs were trained and 1,750 were given interest-free loans to establish small businesses to sell latrines and parts. To accelerate positive behavioural change among the community people, hygiene promotion activities were regularly performed (Fig. 1).

However, beside success stories and enormous support from the communities, the programme staffs as well as the VWCs faced challenges and difficulties during the intervention period. Ensuring that the subsidies provided by BRAC reach the right people was one of the major challenges faced by programme staffs. But giving the responsibilities to the VWCs to select households eligible for grants and loans ensured minimum scope of nepotism in this selection process. As the intervention was carried out covering diverse hydro-geologic areas, some components of the intervention needed to be adjusted for that particular area. For instance, although pipe water schemes and use of tubewells were promoted throughout the intervention areas as safe source of drinking water, some of the selected areas had very high level of arsenic in groundwater while pipe water scheme proved to be too expensive, especially in coastal areas. In these cases, alternative sources such as pond sand filters (PSFs) and rainwater harvesting were promoted among the communities. However, the core components of the intervention was uniform across the intervention areas. Since-economic settings also varied from region to region, VWCs also faced some challenges while performing their activities. 6 of the 11 members of each VWC were female members, which initially raised some questions among the local communities and their inclusion were not accepted cordially. However, when the VWCs started functioning and female members began participating actively in decision making and awareness raising among the community, the problem eventually dissipated. The community people were not very comfortable in discussing sanitation and hygiene issues at the beginning and the meetings were not


**Fig. 1.** Activities performed to accelerate positive behavioural change in the community.

satisfactorily participatory. But the programme staffs and VWC members were eventually able to make the people understand the importance of safe water, proper sanitation and hygiene through their relentless efforts. But making the VWCs sustainable and keeping them functional after the intervention period was a major challenge. To overcome this challenge and to sustain the WASH activities, BRAC planned to integrate WASH activities into other BRAC programmes (microfinance, health, education) which is still in progress. A recent report by BRAC WASH programme claims that most of the VWCs were up and running in 2015 (BRAC, 2016).

BRAC WASH programme mainly focused on improving sanitation coverage, increasing access to safe drinking water and promoting safe hygiene practices in intervention area. Poor sanitation coverage, poor knowledge on hygiene, unsafe hygiene behaviour, lack of knowledge on management of latrines prior to intervention might be responsible for high under-five diarrhoea prevalence in intervention area (Fig. 2). Although reduction of diarrhoea among under-five children wasn't the main objective of the intervention, the activities performed under the programme hypothetically created a positive environment (i.e. increased sanitation coverage, better knowledge and practice of hygiene etc.) for reduction of under-five diarrhoea.

## 2. Material and methods

### 2.1. Study design and area

The present study followed a repeated cross-sectional study design covering 30 selected upazilas that were part of the first wave of the BRAC WASH intervention (Phase-I) (Fig. 3). We collected data at baseline (2007), midline (2009), endline (2011) and post-endline (2015).

### 2.2. Sample size and sampling

Three stage cluster random sampling techniques were used to select the households from BRAC WASH programme intervened upazilas. The sample size for the survey was calculated as 4800 households. For the calculation of the sample size, proportion of improved sanitation was considered as key indicator. The formula used for sample size calculation is given below:

$$n = \frac{4(r)(1-r)(deff)}{e^2(pb)(Avesize)(RR)},$$

where $n$ is the required sample size.

4 is the factor to achieve the 95 percent level of confidence
r is the estimated value of the indicator expressed in proportion (0.319)
$e$ is the admissible level of error (0.05)
$d$eff is the design effect due to cluster sampling (2.0)
$pb$ is the proportion of the total households upon which the indicator r, is based (0.70)
$Avesize$ is the average household size (4.83)
$RR$ is the predicted response rate (99%)

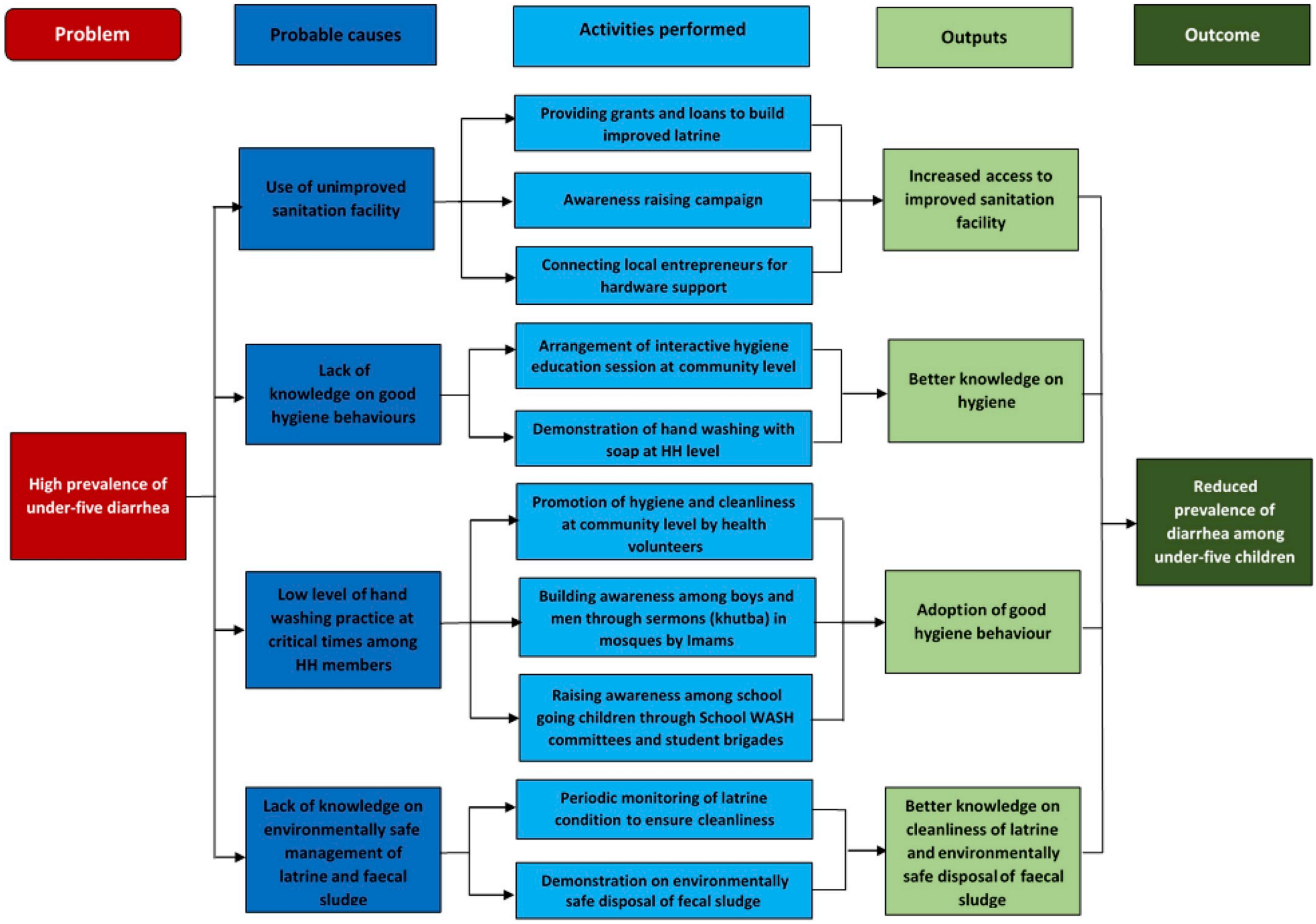


**Fig. 2.** Outcome pathway of under-five diarrhoea reduction through BRAC WASH intervention.

Estimated values of the parameters and formula used in sample size calculation were used from multiple indicator cluster survey (MICS) of 2007 (Bangladesh Bureau of Statistics (BBS) and UNICEF Bangladesh, 2007). Based on the calculation, minimum estimated sample size for each upazila were 156 households. After adjusting for loss to follow up, a sample size of 160 was proposed for each of the thirty upazilas which were selected randomly from 50 WASH intervened upazilas. From each upazila eight villages were selected randomly. Villages were considered as clusters and from each village, twenty households were selected. For selecting these twenty households, all households were listed by the village representatives. The interval size was then calculated by dividing the total number of households within a village by twenty. The first household was selected randomly from the first interval to avoid systematic bias, and the consecutive households were selected as per the estimated interval size. In total, information of 4,775 households were collected for each survey year. Households having at least one under-five children were considered for the final analysis. If a household had more than 1 under-five children, all of them were included in the analysis.

### 2.3. Data management and analysis

Trained field interviewers collected data from households through face-to-face interviews using a pre-tested structured questionnaire. In all surveys, 96 interviewers were employed, trained, and divided into 12 groups for data collection in the field. Each group had one supervisor. Self-reported sanitation and hygiene-related data, including type of latrine, ownership of the latrine, source of finance used for latrine installation, presence of water seal, and disposal of child faeces, were collected. Information regarding socioeconomic status, such as number of members in the household and age, main occupation, education, of each member, was also recorded.

Field interviewers were given adequate training on data collection before commencement of the fieldwork. A training manual with instructions about data collection procedures was developed and used as a reference in the field. The interviewers worked in teams of about eight. A female member capable of providing household level information was interviewed from each house using the pre-tested questionnaire. Female members were chosen as respondents as they typically were more familiar with the household's WASH practices and were more involved in VWCs than their male counterparts. However, if female members were not capable of providing required information or were not available, household head or other male members were interviewed to get information. To ensure completeness and consistency, the interviewers were instructed to complete and crosscheck each other's questionnaire. The field supervisor in each team re-checked 5% of previous week's completed questionnaires. Field managers also checked the quality of the interviews by randomly checking 12 completed questionnaires on a particular day and also visiting the respective households to verify the answers to some of the questions. Whenever any inconsistency was identified, a re-interview was conducted to make the necessary corrections. The authors also visited the field regularly to check whether the data collection was being carried out as instructed. The completed questionnaires were edited for completeness and consistency at the BRAC Head Office by a group of trained field interviewers. The data were entered into a computer and

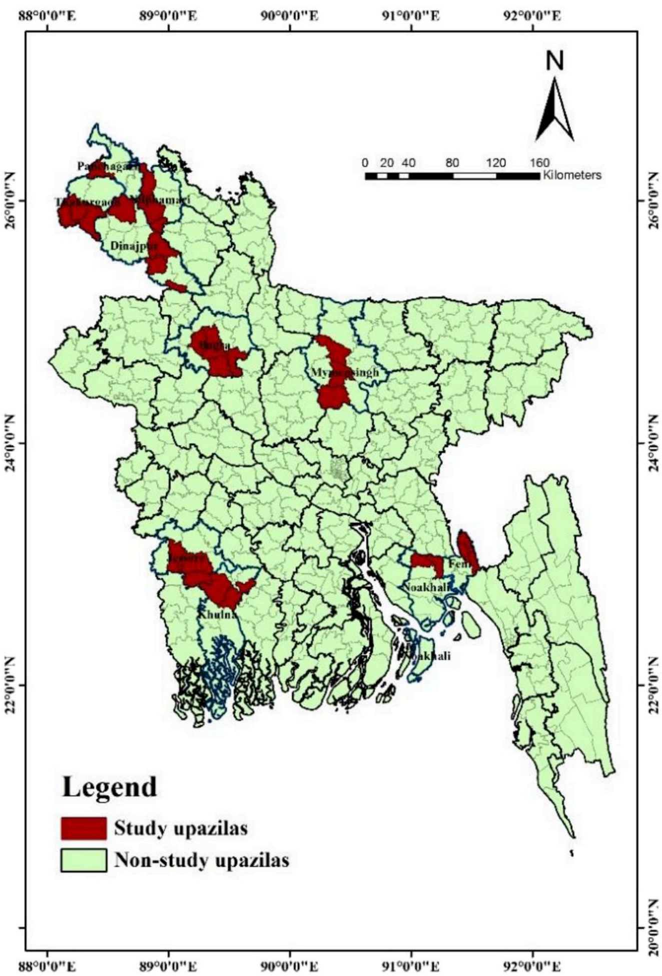


**Fig. 3.** Map showing study upazilas in Bangladesh.

cleaned using the STATA under the supervision of the authors.

### 2.4. Measurements of variables

#### 2.4.1. Outcome variable

The outcome variable was diarrhoea prevalence among children under-five years of age. In this study, diarrhoeal history of the under-five children was collected for past 2 weeks prior to each survey ("1" denoted occurrence of diarrhoea for the indicated period and "0" denoted no occurrence). Among the 4,775 households, present analysis considered only households having at least one under-five child.

#### 2.4.2. Explanatory variables

Individual information of Child's age (< 12, 12–23, 24–35, 36–47, 48–59 months), sex (male, female) were considered as explanatory variables in the analysis. Besides, household characteristics such as type of floor of the house (Sand/Earth and others, Cement), and household access to media (yes, no), regional classification based on hydrological characteristics (north-central, south-east, south-west, north-west) were studied as potential factors associated with under-five diarrhoea. WASH indicators considered for this study includes source of household drinking water (improved, unimproved), latrine condition (clean, unclean), reported disposal of child's faeces (safe, unsafe), availability of soap and sandal near latrine for handwashing (yes, no), availability of separate toilet slippers (yes, no) and reported use of soap for handwashing after defecation/before taking meal (yes, no). The UNICEF and WHO Joint Monitoring Programme's (JMP) operational definition for improved water supply was used (WHO and UNICEF, 2015). Piped water into a dwelling; piped into a yard or plot; public tap; protected well in a dwelling; protected well in a yard or plot; protected public well, and rainwater was considered as improved drinking water sources, while flush latrines, piped sewer systems, latrines with septic tank, flush to pit latrines, ventilated improved pit latrines, pit latrines with slab and com-posting latrines were counted as improved sanitation facilities. A latrine was considered clean if there was no visible stool in the slab, pan or water seal and latrine floor was clean. A child's faeces was considered to be disposed of "safely" when the child used latrine/toilet or child's faeces was put/rinsed into a toilet/latrine, whereas other methods (i.e. put, rinsed in a drain, ditch, thrown in the garbage, left or buried in the open) were considered "unsafe" (Bain and Luyendijk, 2015).

### 2.5. Statistical analysis

Descriptive analysis of basic demographic characteristics such as sex, age and wash status of the households were measured for the baseline (2007), midline (2009), endline (2011) and post-endline (2015) surveys. Chi-square test was performed to measure the association of WASH indicators as well as socio-demographic factors with under-five diarrhoeal prevalence. Furthermore, log-linear model, a class of generalized linear model was applied and risk ratios with 95% confidence interval were calculated to assess the association between diarrhoea status of under-five children and different WASH indicators. The simple log-linear model for binary outcome variable ($y = 0$ or 1) is defined as follows:

$$\ln(\pi_i) = \Pr(Y_i = 1) = \beta_0 + \beta_1 x_i, \tag{1}$$

where $x$ is the single covariate of the model, $\beta$'s are the model parameters and $\pi_i$ is the probability of being success ($y = 1$) for $i$th individual. For more than one covariate, the model is defined as follows:

$$\ln(\pi_i) = \Pr(Y_i = 1) = \beta_0 + \beta_1 x_{1i} + \dots + \beta_k x_{ki}, \tag{2}$$

where $k$ is the number of covariates, and remaining are same as before. The risk ratio can be estimated by $\exp(\beta_k)$ (Lumley et al., 2006). Crude risk ratios (CRR) and adjusted risk ratios (ARR) were calculated using these formula to uncover the statistically significant factors for under-five diarrhoea. WASH indicators with $p < 0.25$ in the bivariate analyses (CRR) were only included in the final multiple log binomial regression model. The adjusted risk ratio (ARR) and corresponding confidence interval (CI) were calculated at 5% level of significance. All statistical analysis was performed using STATA (Version 13.0).

### 2.6. Ethical issues

Informed verbal consent was taken from each respondent before the data collection. Respondent were assured that they could withdraw from the interview at any point, and that refusal to participate in the study would not affect her receiving any services from BRAC. Strict confidentiality was maintained in data handling. The name and identity of the respondent were not disclosed while reporting personal information.

## 3. Results

### 3.1. Sample characteristics

Age and sex composition of the children under-five years of age and WASH condition of the households are presented in Table 1. Percentage of male child increased from 49.9% to 51.0%, from baseline (2007) to post-endline (2015). Percentage of new born babies (age less than 12 months) was 18.7% at baseline, 22.8% at midline, 14.4% at endline and 21.0% at post-endline.

Percentage of houses with cement floors rose from 6.6% at baseline to 9.1% at midline, 12.3% at endline and 22.1% at post-endline.

 

**Table 1**
Background characteristics of the selected households.

| Characteristics | Baseline (%) | Midline (%) | Endline (%) | Post-endline (%) | Pooled (%) |
|---|---|---|---|---|---|
| | N = 2417 | N = 3277 | N = 1770 | N = 1496 | N = 8960 |
| **Socio-demographic variables** | | | | | |
| **Child's gender** | | | | | |
| Male | 49.9 | 49.7 | 50.7 | 51.0 | 50.2 |
| Female | 50.1 | 50.3 | 49.3 | 49.0 | 49.8 |
| **Child's age (months)** | | | | | |
| < 12 | 18.7 | 22.8 | 14.4 | 21.0 | 19.7 |
| 12-23 | 19.1 | 26.2 | 27.2 | 20.9 | 23.6 |
| 24-35 | 20.4 | 20.4 | 22.6 | 19.1 | 20.6 |
| 36-47 | 21.6 | 15.8 | 12.7 | 20.0 | 14.5 |
| 48-59 | 20.2 | 14.7 | 23.2 | 19.1 | 18.6 |
| **Type of floor of the house** | | | | | |
| Sand/Earth and others | 93.4 | 90.9 | 87.7 | 77.9 | 88.8 |
| Cement made | 6.6 | 9.1 | 12.3 | 22.1 | 11.2 |
| **Access to media (TV/Radio)** | | | | | |
| No | 64.4 | 62.3 | 60.3 | 47.5 | 60.0 |
| Yes | 35.6 | 37.8 | 39.7 | 52.5 | 40.0 |
| **Region** | | | | | |
| North-central | 10.6 | 10.7 | 11.9 | 13.7 | 11.4 |
| South-east | 18.0 | 18.5 | 19.3 | 19.6 | 18.7 |
| South-west | 16.1 | 16.1 | 15.5 | 17.2 | 16.2 |
| North-west | 55.3 | 54.8 | 53.2 | 49.5 | 53.7 |
| **WASH variables** | | | | | |
| **Drinking water source** | | | | | |
| Unimproved | 0.9 | 0.0 | 0.0 | 0.0 | 0.3 |
| Improved | 99.1 | 100.0 | 100.0 | 100.0 | 99.7 |
| **Latrine condition** | | | | | |
| Unclean | 70.5 | 61.3 | 51.0 | 50.7 | 60.0 |
| Clean | 29.5 | 38.8 | 49.0 | 49.3 | 40.0 |
| **Disposal of child faeces** | | | | | |
| Unsafe | 95.6 | 90.1 | 80.1 | 79.7 | 87.8 |
| Safe | 4.4 | 10.0 | 19.9 | 20.3 | 12.2 |
| **Soap near latrine (spot observation)** | | | | | |
| No | 85.6 | 83.4 | 78.3 | 64.0 | 79.8 |
| Yes | 14.4 | 16.6 | 21.8 | 36.0 | 20.2 |
| **Sandal near latrine (spot observation)** | | | | | |
| No | 96.4 | 94.0 | 86.7 | 76.3 | 90.2 |
| Yes | 3.6 | 6.0 | 13.3 | 23.7 | 9.8 |
| **Washing hand with soap after defecation (self-reported)** | | | | | |
| No | 37.3 | 27.5 | 15.8 | 9.5 | 24.8 |
| Yes | 62.7 | 72.5 | 84.2 | 90.5 | 75.2 |
| **Washing hand with soap before eating (self-reported)** | | | | | |
| No | 91.3 | 81.5 | 76.7 | 59.6 | 79.5 |
| Yes | 8.7 | 18.5 | 23.3 | 40.4 | 20.5 |

Households having access to electric media (TV/Radio) increased from 35.6% in baseline to 52.5% in post-endline. Almost all the households had access to improved drinking water sources in all survey waves. Percentage of clean latrine increased from baseline to post-endline (29.5% vs. 49.3%). The practice of safe disposal of child faeces increased from baseline to post-endline (4.4%–20.3%) among households having at least one child aged less than five years.

Enumerators observed the availability of soap and of sandals near the latrine. The percentage of households having soap and sandals near the latrine increased from 14.4% to 36.0% and from 3.6% to 23.7% respectively from baseline to post-endline. Similarly, self-reported handwashing practice using soap after defecation increased from baseline to post-endline (62.7% vs. 90.5%). Percentage of households practicing handwashing with soap before eating also increased from baseline to post-endline (8.7% vs. 40.4%)

### *3.2. Reported prevalence of diarrhoea among children under the age of five*

Diarrhoea prevalence significantly declined from 13.7% at baseline to 8.9% at midline ($p < 0.001$) and to 3.6% at endline ($p < 0.001$). However, childhood diarrhoeal prevalence rose to 5.2% at post-endline, which was significantly higher than the childhood diarrhoeal prevalence in endline ($p = 0.026$). Diarrhoea prevalence among children under the age of five was estimated based on behaviour-related risk factors, socio-demographic determinants, and environmental exposure variables (Table 2). Overall, prevalence of childhood diarrhoea was higher among children from households having unclean latrine condition, practicing unsafe disposal of child faeces and not having handwashing practice with soap at critical times (i.e. after defecation and before eating). Furthermore, diarrhoea was more prevalent among female child, child aged 12–23 months, children of households with no media access, and children residing in South-west and South-east region. Prevalence of diarrhoea at endline was significantly lower among both male ($p < 0.001$) and female ($p < 0.001$) child compared to baseline. But there was statistically insignificant increase in diarrhoeal prevalence among both male and female child from endline to post-endline. Diarrhoea reduced significantly among all age groups in endline, compared to baseline. Diarrhoea prevalence among children from households who maintained hygienic condition in latrine decreased significantly from baseline to endline (15.0% vs. 3.2%, $p < 0.001$), but again increased slightly in post-endline from endline (5.0% vs. 3.2%, $p = 0.071$). Likewise, prevalence of childhood diarrhoea reduced significantly in households practicing safe disposal of child faeces, washing hand with soap after defecation and before eating, having access to media from baseline to endline, but no such improvement was evident from endline to post-endline. Statistically significant

**Table 2**
Prevalence of diarrhoea among children by different background characteristics and risk factors.

| Variables | Prevalence of diarrhoea, % (n) | | | | | p value[a] | |
|---|---|---|---|---|---|---|---|
| | Baseline | Midline | Endline | Post-endline | Pooled | Baseline vs. Endline | Endline vs. Post-endline |
| **Socio-demographic characteristics** | | | | | | | |
| **Child's gender** | | | | | | | |
| Male | 14.9 (180) | 9.5 (155) | 3.9 (35) | 5.1 (39) | 9.1 (409) | < 0.001 | 0.232 |
| Female | 12.5 (152) | 8.4 (138) | 3.3 (29) | 5.3 (39) | 8.0 (358) | < 0.001 | 0.048 |
| **Child's age (months)** | | | | | | | |
| < 12 | 13.1 (59) | 9.2 (69) | 7.5 (19) | 5.4 (17) | 9.3 (164) | 0.023 | 0.315 |
| 12-23 | 25.8 (119) | 11.9 (102) | 4.4 (21) | 8.0 (25) | 12.6 (267) | < 0.001 | 0.033 |
| 24-35 | 13.2 (65) | 10.0 (67) | 2.5 (10) | 6.3 (18) | 8.7 (160) | < 0.001 | 0.013 |
| 36-47 | 10.2 (53) | 6.4 (33) | 2.7 (6) | 2.3 (7) | 6.3 (99) | 0.001 | 0.806 |
| 48-59 | 7.4 (36) | 4.6 (22) | 2.0 (8) | 3.9 (11) | 4.6 (77) | < 0.001 | 0.128 |
| **Type of floor of the house** | | | | | | | |
| Sand/Earth and others | 14.0 (317) | 8.8 (263) | 3.7 (58) | 5.2 (61) | 8.8 (699) | < 0.001 | 0.059 |
| Cement made | 9.4 (15) | 10.1 (30) | 2.8 (6) | 5.2 (17) | 6.8 (68) | 0.005 | 0.170 |
| **Access to media (TV/Radio)** | | | | | | | |
| No | 14.1 (219) | 9.4 (192) | 3.5 (37) | 5.5 (39) | 9.1 (487) | < 0.001 | 0.039 |
| Yes | 13.1 (113) | 8.2 (101) | 3.8 (27) | 5.0 (39) | 7.8 (280) | < 0.001 | 0.294 |
| **Region** | | | | | | | |
| North-central | 11.7 (30) | 7.1 (25) | 2.8 (6) | 5.4 (11) | 7.0 (72) | < 0.001 | 0.194 |
| South-east | 15.0 (65) | 9.4 (57) | 3.2 (11) | 7.2 (21) | 9.2 (154) | < 0.001 | 0.023 |
| South-west | 14.1 (55) | 9.5 (50) | 4.4 (12) | 8.2 (21) | 9.5 (138) | < 0.001 | 0.069 |
| North-west | 13.6 (182) | 9.0 (161) | 3.7 (35) | 3.4 (25) | 8.4 (403) | < 0.001 | 0.707 |
| **WASH variables** | | | | | | | |
| **Drinking water source** | | | | | | | |
| Unimproved | 17.4 (4) | 0 | 0 | 0 | 17.4 (4) | < 0.001 | – |
| Improved | 13.7 (328) | 8.9 (293) | 3.6 (64) | 5.2 (78) | 8.5 (763) | < 0.001 | 0.026 |
| **Latrine condition** | | | | | | | |
| Unclean | 13.2 (225) | 10.0 (201) | 4.0 (36) | 5.4 (41) | 9.4 (503) | < 0.001 | 0.170 |
| Clean | 15.0 (107) | 7.2 (92) | 3.2 (28) | 5.0 (37) | 7.4 (264) | < 0.001 | 0.071 |
| **Safe disposal of child faeces** | | | | | | | |
| No | 13.9 (322) | 9.0 (265) | 3.5 (49) | 5.5 (66) | 8.9 (702) | < 0.001 | 0.010 |
| Yes | 9.4 (10) | 8.6 (28) | 4.3 (15) | 4.0 (12) | 6.0 (65) | 0.042 | 0.846 |
| **Availability of soap near latrine** | | | | | | | |
| No | 13.1 (272) | 9.3 (253) | 3.8 (53) | 5.5 (53) | 8.8 (631) | < 0.001 | 0.050 |
| Yes | 17.3 (60) | 7.4 (40) | 2.9 (11) | 4.6 (25) | 7.5 (136) | < 0.001 | 0.168 |
| **Availability of sandal near latrine** | | | | | | | |
| No | 13.6 (316) | 9.0 (277) | 3.6 (55) | 5.2 (59) | 8.8 (707) | < 0.001 | 0.045 |
| Yes | 18.2 (16) | 8.1 (16) | 3.8 (9) | 5.4 (19) | 6.9 (60) | < 0.001 | 0.385 |
| **Washing hand with soap after defecation** | | | | | | | |
| No | 14.7 (132) | 11.2 (101) | 4.3 (12) | 10.6 (15) | 11.7 (260) | < 0.001 | 0.013 |
| Yes | 13.2 (200) | 8.1 (192) | 3.5 (52) | 4.7 (63) | 7.5 (507) | < 0.001 | 0.115 |
| **Washing hand with soap before eating** | | | | | | | |
| No | 13.9 (307) | 9.3 (249) | 3.2 (44) | 6.2 (55) | 9.2 (655) | < 0.001 | 0.001 |
| Yes | 11.9 (25) | 7.3 (44) | 4.8 (20) | 3.8 (23) | 6.1 (112) | 0.001 | 0.417 |

[a] p values are from chi square test.

($p < 0.001$) reduction in prevalence of childhood diarrhoea was evident in endline compared to baseline in all four regions. But under-five diarrhoea prevalence increased again after endline in all regions, except in North-west region where the scenario didn't change much at post-endline compared to endline (3.4% vs. 3.7%, $p = 0.707$).

### 3.3. Factors associated with childhood diarrhoeal diseases

The factors associated with diarrhoea among under-five children are summarized in Table 3. Here, 3 models were considered: using bivariate log binomial regression analysis (model I), multivariable log binomial regression analysis (model II) considering only the socio-demographic factors and multivariable log binomial regression analysis (model III) adjusted for all factors to control for any possible confounding effects. Both unadjusted and adjusted Risk Ratios (RRs) were used to address the effects of single factors. In bivariate log binomial regression, several factors such as age and gender of child, cemented floor type of house, household's access to media, clean latrine condition, handwashing practice with soapafter defecation and before taking meal, safe child faeces disposal and region were significantly associated with under-five diarrhoea. In model II, all socio-demographic factors were substantially associated with under-five diarrhoea except access to media (ARR = 0.87, 95% CI 0.75, 1.01). However, from Model III it was evident that age and gender of the child, safe child faeces disposal, handwashing practice with soap after defecation and before taking meal, latrine condition as cleaned and region were the statistically significant factors associated with childhood diarrhoea. Compared to boys, girls had 14% lower risk of suffering from diarrhoea (ARR = 0.86, 95% CI 0.75, 0.98). Meanwhile, risk of diarrhoea was higher among children of age 12–23 months compared to children younger than 12 months (ARR = 1.40, 95% CI = 1.17, 1.68). It is also evident that children aged over 24 months had comparatively lower risk of diarrhoea as of children less than 12 months of age. Children aged between 48 and 59 months had 50% lower risk of having diarrhoeal disease compared to children younger than 12 months (ARR = 0.50, 95% CI 0.39, 0.65). Although, household's characteristics like floor type and access to media (TV/Radio) had significant association with childhood diarrhoea in Model I, their association with childhood diarrhoea was not significant in Model II. Statistically significant regional effect was observed as children living in South-east (ARR = 1.60, 95% CI 1.22, 2.11), South-east (ARR = 1.49, 95% CI 1.13, 1.95) and North-west (ARR = 1.35, 95% CI 1.06, 1.72) region were more diarrhoea prone compared to children living in North-central region. Wash indicators like type of drinking water source as safe, availability of soap and

**Table 3**
Factors associated with diarrhoeal diseases among children aged < 5 years (pooled data).

| Factors | Log binomial regression | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Model I | | | Model II | | | Model III | | |
| | CRR[1] | p value | 95% CI[3] | ARR[2] | p value | 95% CI[3] | ARR[2] | p value | 95% CI[3] |
| **Socio-demographic characteristics** | | | | | | | | | |
| **Child's gender** | | | | | | | | | |
| Male | Ref | | | Ref | | | Ref | | |
| Female | 0.88 | 0.069 | 0.77 - 1.01 | 0.87 | 0.040 | 0.76 - 0.99 | 0.86 | 0.025 | 0.75 - 0.98 |
| **Child's age (months)** | | | | | | | | | |
| < 12 | Ref | | | Ref | | | Ref | | |
| 12-23 | 1.36 | 0.001 | 1.13 - 1.63 | 1.37 | 0.001 | 1.14 - 1.65 | 1.40 | < 0.001 | 1.17 - 1.68 |
| 24-35 | 0.93 | 0.512 | 0.76 - 1.15 | 0.93 | 0.472 | 0.75 - 1.14 | 0.93 | 0.521 | 0.76 - 1.15 |
| 36-47 | 0.68 | 0.002 | 0.54 - 0.87 | 0.68 | 0.001 | 0.53 - 0.86 | 0.67 | 0.001 | 0.53 - 0.85 |
| 48-59 | 0.50 | < 0.001 | 0.38 - 0.65 | 0.50 | < 0.001 | 0.38 - 0.64 | 0.50 | < 0.001 | 0.39 - 0.65 |
| **Type of floor of the house** | | | | | | | | | |
| Sand/Earth and others | Ref | | | Ref | | | Ref | | |
| Cement | 0.77 | 0.033 | 0.61 - 0.98 | 0.77 | 0.039 | 0.60 - 0.99 | 0.91 | 0.467 | 0.71 - 1.17 |
| **Access to media (TV/Radio)** | | | | | | | | | |
| No | Ref | | | Ref | | | Ref | | |
| Yes | 0.86 | 0.038 | 0.75 - 0.99 | 0.87 | 0.06 | 0.75 - 1.01 | 0.96 | 0.548 | 0.83 - 1.11 |
| **Region** | | | | | | | | | |
| North-central | Ref | | | Ref | | | Ref | | |
| South-east | 1.31 | 0.052 | 1.00–1.71 | 1.38 | 0.018 | 1.06 - 1.81 | 1.60 | 0.001 | 1.22 - 2.11 |
| South-west | 1.35 | 0.030 | 1.03 - 1.78 | 1.43 | 0.011 | 1.09 - 1.87 | 1.49 | 0.004 | 1.13 - 1.95 |
| North-west | 1.19 | 0.159 | 0.93 - 1.51 | 1.21 | 0.127 | 0.95 - 1.53 | 1.35 | 0.015 | 1.06 - 1.72 |
| **WASH indicators** | | | | | | | | | |
| **Drinking water source** | | | | | | | | | |
| Unimproved | Ref | | | | | | Ref | | |
| Improved | 0.49 | 0.118 | 0.20 - 1.20 | | | | 0.53 | 0.155 | 0.22 - 1.27 |
| **Latrine condition** | | | | | | | | | |
| Unclean | Ref | | | | | | Ref | | |
| Clean | 0.79 | 0.001 | 0.68 - 0.91 | | | | 0.85 | 0.027 | 0.73 - 0.98 |
| **Disposal of child faeces** | | | | | | | | | |
| Unsafe | Ref | | | | | | Ref | | |
| Safe | 0.67 | 0.001 | 0.52 - 0.86 | | | | 0.71 | 0.008 | 0.55 - 0.91 |
| **Availability of soap near latrine** | | | | | | | | | |
| No | Ref | | | | | | Ref | | |
| Yes | 0.85 | 0.072 | 0.71 - 1.01 | | | | 0.98 | 0.811 | 0.81 - 1.18 |
| **Availability of sandal near latrine** | | | | | | | | | |
| No | Ref | | | | | | Ref | | |
| Yes | 0.78 | 0.059 | 0.61 - 1.01 | | | | 0.99 | 0.941 | 0.75 - 1.30 |
| **Washing hand with soap after defection** | | | | | | | | | |
| No | Ref | | | | | | Ref | | |
| Yes | 0.64 | < 0.001 | 0.56 - 0.74 | | | | 0.69 | < 0.001 | 0.60 - 0.80 |
| **Washing hand with soap before eating** | | | | | | | | | |
| No | Ref | | | | | | Ref | | |
| Yes | 0.66 | < 0.001 | 0.55 - 0.81 | | | | 0.77 | 0.009 | 0.63 - 0.93 |

*CRR = Crude Risk ratio; ARR = Adjusted Risk Ratio; CI = Confidence Interval.

sandal near latrine had no significant relation with diarrhoeal disease among children under-five years of age. An inverse relationship between safe disposal of child faeces and diarrhoea prevalence was observed. Risk of suffering from diarrhoea significantly decreased if child faeces was safely disposed rather than being thrown here and there (ARR = 0.71, 95% CI 0.55, 0.91). Similarly, statistically significant reduction in the prevalence of diarrhoea was found in households with access to clean latrine (ARR = 0.85, 95% CI 0.73, 0.98). Handwashing practice of household members at critical times (i.e. after defecation and before eating) were found to have inverse association with prevalence of diarrhoea among under-five children. Children from households who practiced handwashing with soap after defecation had 31% lower risk of suffering from diarrhoea compared to children from households not having such practice (ARR = 0.69, 95% CI 0.60, 0.80). Risk of suffering from childhood diarrhoea reduced significantly if washing hand with soap before eating was practiced in that households (ARR = 0.77, 95% CI 0.63, 0.93).

## 4. Discussion

The study examines the role of BRAC WASH programme interventions in reducing diarrhoea among children less than five years of age and to identify the factors associated with childhood diarrhoea in intervention areas. The prevalence of under-five diarrhoea in BRAC WASH intervention areas fell substantially between baseline and endline ($p < 0.001$). Prevalence of childhood diarrhoea reduced by 35% in midline (prevalence 8.9%) and by 73% in endline (prevalence 3.6%) compared to baseline (prevalence 13.7%). This improvement was probably achieved through BRAC WASH programme's integrated and participatory approach in promoting sanitation and hygiene in intervention areas. At the same time, lack of data from comparison regions and the fact that childhood diarrhoea prevalence was dropping nationwide (dropped to 5.7% in 2014 from 9.8% in 2007) (National Institute of Population Research and Training, Mitra and Associates, and ICF International 2016) have made it difficult to make strong statements about the causal influence of the BRAC programme.

The present study highlighted that children aged 12–23 months were at higher risk for childhood diarrhoea than children aged < 12 months, which is similar to some earlier findings by (Konstantyner et al., 2015; Sarker et al., 2016). This finding may be justified by the facts that children younger than 12 months are more dependent on adult care, require feeding appropriate for their age, and tend to be less exposed to infectious agents and environmental risk factors (Boccolini et al., 2012). Besides, mechanisms such as maternal antibodies against enteric pathogens and current breastfeeding may act against diarrhoea in the youngest age group (Siziya et al., 2013). Study finding also reveal that boys were 14% more likely to have diarrhoea compared to girls, which is consistent with the findings of some earlier studies in similar settings (Anteneh et al., 2017; Siziya et al., 2013; Yilgwan and Okolo, 2012). Boys' greater environmental exposure might be the cause behind their greater likelihood of suffering from diarrhoea, which has been outlined by previous studies (Boccolini et al., 2012; Giugliano et al., 1986; Siziya et al., 2013). Children living in the south-west and south-east region had greater risk of diarrhoea compared to children living in other areas. The south-west and south-east regions are characterized by relatively high water table and high soil moisture content around the year; which favor the growth and movement of microorganisms (Dey et al., 2017), which may be the reason behind higher childhood diarrhoeal prevalence in these regions compared to others.

It was evident from the analysis that washing hands with soap at essential junctures (after defecation and before eating) had statistically significant association with reduced risk of diarrhoea among children, which is in line with findings of some previous studies (Adane et al., 2018; Curtis and Cairncross, 2003; Langford et al., 2011; Luby et al., 2011). The finding of the study is also consistent with the findings of few other studies conducted in different settings that identified significant association between under-five diarrhoea and unsafe disposal of child faeces (Bawankule et al., 2017; Cronin et al., 2016; Mihrete et al., 2014). The faeces of young children are often regarded as less harmful than adults by mothers/caregivers (Brown et al., 2013; Gil et al., 2004), which leads to higher rates of unsafe disposal of child faeces. Child faces, possibly having a higher loading of pathogens than the adults (WHO, 2009) thus increases the risk of childhood diarrhoea. In fact, the health impacts of unsafe child faeces disposal may extend beyond diarrhoeal disease, including increased risk of soil-transmitted helminth infections in children younger than 2 years of age and increased risk of environmental enteropathy and stunting (George et al., 2015; Roy et al., 2011). Therefore, unsafe disposal of child faeces not only may cause environmental contamination, but also can possess a serious threat to the public health.

Despite significant improvements were visible in most of the WASH indicators from endline (2011) to post-endline (2015), childhood diarrhoeal prevalence was significantly higher in post-endline compared to endline ($p = 0.026$). Risk factors significantly associated with childhood diarrhoea such as unsafe disposal of child faeces and unclean latrine condition didn't decrease as rapidly as in 2011–2015 compared to 2007–2011, which may be the probable reasons behind the lack of improvement in childhood diarrhoea reduction after 2011. Unsafe disposal of child faeces was practiced by about 80% households, while about 51% households had unhygienic condition in latrines (visible stool in the slab, pan or water seal and latrine floor) as of 2015. Activities of Village WASH Committees (VWCs), which acted as the focal points for involving community people at all levels to improve overall WASH situation, was very limited after endline. Percentage of households with at least one member attending at least one VWC meeting in last 6 months decreased from 17.1% in 2011 to 9.1% in 2015. Unsafe disposal of child faeces can be thus attributed to lack of motivation and/or knowledge of safe disposal of child faeces among mothers. Moreover, after the intervention period (2007–2011) periodic monitoring of latrine condition and hygiene practice at household level wasn't performed by the programme staffs. This absence of periodic monitoring maybe the reason behind the poor latrine condition in nearly half of the surveyed households in post-endline.

Potential reasons for the lack of association of WASH factors with childhood diarrhoea, apart from safe disposal of child faeces, handwashing with soap at critical times and latrine condition may be due to the unique contaminant exposure pathways to which young children are exposed, such as the importance of direct faecal contamination of child's hands or play areas, poor hygiene practices of mothers/caregivers or geophagy as described by (George et al., 2015; Ngure et al., 2013). Local context-specific cultural and environmental factors may also play a role in this regard (Cronin et al., 2016).

This study proves that even long term implementation and motivation measures failed to substantially improve the situation regarding unsafe disposal of child faeces and unclean latrine condition. Study findings suggest for uptaking strategies that go beyond merely increasing access to improved latrine and improved drinking water. It is necessary to uptake community based alternative strategies such as imposing fines and eliciting shame and disgust as motivation to mitigate unhealthy and unhygienic practices. The study reiterates the significance of simultaneous provision of software support (such as information, education, motivation etc.) as well as hardware support (improved latrine, improved water source) in addressing the required behaviour change to optimize the impact of WASH services in communities and institutions towards the desired health impact (Velleman et al., 2014). Although the national sanitation strategy of Bangladesh has aimed at ensuring universal sanitation coverage through safe disposal of human faeces and given emphasis on promoting sanitation and hygiene among mothers of under-five, the approach has not focused specifically on important issues such as child faeces disposal (Government of the People's Republic of Bangladesh., 2014). Therefore, this study recommends for a stronger emphasis on the safe disposal of child faeces in national sanitation policy. Since safe disposal of child faeces is related to practice and behaviours (Cronin et al., 2016), strategies such as raising awareness among mothers about the adverse effect of unsafe disposal of child faeces and educating them on environmentally safe disposal of child faeces (preferably to pit-latrine or latrine with septic tank, etc.) should be given priorities so that there is no chance of environmental pollution endangering public health. No visible change in the percentage of households with clean latrines from 2011 to 2015 also merits a stronger emphasis on keeping a small-scale monitoring component in place even after the intervention period for a certain period to ensure sustainable behavioural change among the community people.

However, this study was subjected to certain limitations. Reporting bias especially about personal and household hygiene (e.g., handwashing with soap) may have resulted in under or over-estimates of practices, which may be termed as 'courtesy bias' (Biran et al., 2008). Furthermore, the prevalence was not confirmed by microbiological pathogen tests, rather based on reported medical conditions of persons in the households. This may bias the prevalence rate.

## 5. Conclusion

The study findings reveal a significant reduction in the prevalence of diarrhoea among under-five children from baseline to endline. This improvement was likely achieved through BRAC WASH programme's integrated and participatory approach in promoting sanitation and hygiene in intervention areas. However, a significant increase of under-five diarrhoeal prevalence from endline to post-endline when intervention period was visible, which was likely because of the lack of proper monitoring of sanitation and hygiene practices at the household level after the endline. Among the WASH factors, absence of handwashing practice with soap at critical times, unclean latrine and unsafe disposal of child faeces were identified as significant risk factors of diarrhoea among under-five children from multivariable log binomial regression analysis. The present study suggests, the issue of safe disposal of child faeces, which has received insufficient attention so far, should be given more importance. Stronger emphasis on the environmentally safe disposal of child faeces in national sanitation policy and in implementation and monitoring of sanitation programs is therefore strongly recommended. In addition, policies should emphasis on ongoing monitoring after the intervention period to encourage community members to maintain safe behaviours.

## Author contribution statement

NCD: Conceived, conducted study; interpretation of data; manuscript writing.

MP: Data analysis, interpretation of data, manuscript writing.

MRI: Data analysis, interpretation of data, manuscript writing.

SKM: Interpretation of data.

DL: Conceived, reviewed and edited.

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## Conflicts of interest

The authors declare no conflict of interest.

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## Appendix A. Supplementary data

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