Environmental Science and Pollution Research (2022) 29:32180–32189
https://doi.org/10.1007/s11356-021-18460-9

RESEARCH ARTICLE

Household drinking water *E. coli* contamination and its associated risk with childhood diarrhea in Bangladesh

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Received: 3 September 2021 / Accepted: 29 December 2021 / Published online: 11 January 2022

Abstract

Faecal contamination (by *Escherichia coli* [*E. coli*]) of household drinking water can have adverse effects on child health, particularly increasing the episodes of childhood diarrhea; however, the evidence is scanty in Bangladesh. This study utilised data from the most recent nationally representative 2019 Multiple Indicator Cluster Survey to investigate the relationship between *E. coli* concentration in household drinking water and diarrheal episodes among children aged under-5 years in Bangladesh. Childhood diarrhea was identified by asking the children's mothers or caregivers if they had a diarrheal episode in the 2 weeks preceding the survey. *E. coli* colonies were counted as colony-forming units (CFUs) per 100 ml of water and classified into three risk groups (low: < 1 CFU/100 ml; moderate: 1–10 CFU/100 ml; and high: > 10 CFU/100 ml). The design-adjusted logistic regression was used to estimate the association between drinking water *E. coli* risk groups and childhood diarrhea, adjusting for potential confounders. We observed a significant association between household drinking water *E. coli* contamination and diarrheal episodes among under-5 children. Compared to the children from households with a low risk of *E. coli* contamination in drinking water, children from households with a moderate risk of *E. coli* contamination were 1.68 times more likely to have diarrhea, which was 2.28 times among children from households with a high risk of *E. coli* contamination. Findings of the study have significant policy implications and urge to ensure safe water supplies, improve water management practices and modify hygiene behaviours to reduce episodes of childhood diarrhea.

Keywords *E. coli* · Drinking water contamination · Diarrhea · Under-5 children

Introduction

Diarrheal disease has been identified as one of the major causes of childhood illness and mortality (Liu et al. 2012; Kotloff et al. 2013). Diarrheal disease was ranked as the third (after neonatal disorders and lower respiratory infections) common cause of mortality among children aged less than 5 years (under-5) in 2019 (Paulson et al. 2021). Globally, there were 5.05 million under-5 deaths in 2019, with diarrheal disease accounting for 9.9% of them (Paulson et al. 2021). While a decreasing trend in under-5 children mortality and that from diarrhea has been

Communicated by Lotfi Aleya.

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documented (Liu et al. 2016; Paulson et al. 2021), the challenge still remains to contain the under-5 mortality rate under 25 per 1000 live births in every country, as stated in the Sustainable Development Goal (3.2) (Paulson et al. 2021). To achieve this goal, it is imperative to ensure improved access to diarrheal disease treatment and adequate water and sanitation facilities.

The prevalence of diarrhea and deaths of young children attributed to it is also high in Bangladesh, but these figures have recently decreased (Liu et al. 2016). According to the Bangladesh Multiple Indicators Cluster Survey (MICS) 2019, 6.9% of the under-5 children suffered from diarrhea in Bangladesh (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). Thus, the absolute number of children suffering from diarrhea is likely to be high, given the large population size of Bangladesh. Higher episodes of diarrhea also pose a significant burden to the health system and exert an adverse economic consequence to the children's family, often requiring an out-of-pocket payment for treatment. A prior study conducted in Bangladesh reported that an estimated $79 million was spent on treating diarrheal diseases in 2018 (Hasan et al. 2021). Furthermore, over 46% of households interviewed in that study had to expend a lot to treat diarrheal diseases (Hasan et al. 2021).

One of the major causes of diarrhea is infection with *Escherichia coli* (*E. coli*)—this phenomenon was first recognised in the mid-1940s (Hart et al. 1993). *E. coli* is a Gram-negative bacillus that exists in the intestine of humans and other mammals (Kaper et al. 2004; Alam et al. 2006). It contains various serotypes that cause several diseases, including diarrhea and food poising, mostly in infants and children. Until now, at least six pathotypes of *E. coli* have been identified that cause diarrhea, dysentery, meningitis and urinary tract infections (UTIs) (Kaper et al. 2004; Alam et al. 2006). Water contaminated by pathogens is unsafe for human consumption. Several water-borne diseases, including diarrhea, typhoid and dysentery, can result due to consumption of contaminated water (Mead et al. 1999; Pande et al. 2018). Particularly, contamination of faecal substances with water supply sources can lead to the transmission of many pathogens, including *E. coli*. Enteric pathogens can reach the community water supply through faulty sewerage, improper water distribution system and leaching (Bennett et al. 2018).

Faecal contamination of water is ubiquitous in Bangladesh. The Bangladesh Multiple Indicators Cluster Survey (MICS) 2019 reported that around 81.9% of the household population had drinking water at households contaminated with bacteria such as *E. coli* (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019), which was approximately 61.7% in 2012–2013 (according to MICS 2012–13) (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2014).

Past studies in Bangladesh have investigated the spatial risk distribution and determinates of household drinking water *E. coli* contamination (Khan and Bakar 2020), the prevalence of *E. coli* on stored foods of young children (Doza et al. 2018) and microbiological contamination of young children's hands (Parvez et al. 2019). There are a few studies that have examined the relationship between *E. coli* in drinking water and diarrheal episodes in under-5 children in Bangladesh. Luby et al. (2015) found that *E. coli* contamination in drinking water was positively related to the prevalence of childhood diarrhea in Bangladesh, using data from 50 villages in the country's rural areas (Luby et al. 2015). Another study conducted in rural Bangladesh reported a positive relationship between drinking water contaminated with *E. coli* and childhood diarrhea (Ercumen et al. 2017). A study conducted in urban slums of Dhaka, Bangladesh, found that young children who lived in households with very high-risk levels of *E. coli* in their source drinking water were more likely to have diarrhea (Parvin et al. 2021). Meanwhile, Mahmud et al. (2019) investigated the occurrence of *E. coli* and faecal coliforms in Rohingya camps, but they did not focus on under-5 children, nor did they explore any association between *E. coli* water contamination and risk of diarrhea (Mahmud et al. 2019).

As such, the results of these studies cannot be generalised to the entire under-5 children in Bangladesh. Therefore, with an aim to fill up this knowledge gap, the present study attempts to tease apart the current situation of *E. coli* contamination in household drinking water and its association with childhood diarrhea in Bangladesh. The insights from this study would generate evidence that could be utilised to inform policy decisions regarding the control of *E. coli* in drinking water and concomitant childhood diarrhea prevalence resulting from this in Bangladesh.

Methods

Data

We used the data from the most recent round of Bangladesh Multiple Indicators Cluster Survey (MICS) 2019. This nationally representative cross-sectional survey followed a two-stage stratified random sampling procedure with individuals (e.g. children) as the final sampling unit. The detailed survey technique is available in the final report of the 2019 Bangladesh MICS (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). The dataset contains 64,400 households that participated in the survey, with a randomly selected subset of households chosen for water quality testing. A standardised questionnaire was used to collect a variety of information, including sociodemographic characteristics and health conditions. In addition, data on the source and household water quality were obtained using internationally recognised methods (detailed mentioned elsewhere (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019)). Our final sample for analysis consisted of 2232 children after we limited our sample to children for whom complete data on the outcome and predictors considered for the analysis were available.

Measures

Outcome variable

Diarrhea among children under the age of 5 years was the outcome variable of interest. In this survey, diarrhea is defined as the mother's or caregiver's perception of whether their child had a diarrheal episode in the 2 weeks preceding the survey (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). Diarrhea variable was coded as 1 when respondents replied 'yes', and '0' otherwise.

Exposure

Household water *E. coli* concentration was the exposure variable of interest. Survey respondents were asked 'could you please provide me with a glass of the water that members of your household usually drink?' (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). The provided water was tested for *E. coli* by incubating 100 ml of the sample. In the water quality test, testing was performed within 30 min of collecting sample and incubation was carried out for 24–48 h. *E. coli* colonies were counted as colony-forming units (CFUs) per 100 ml of water (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). The 2019 Bangladesh MICS report contains a more detailed description of the water quality test (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). The *E. coli* CFU data from household drinking water were divided into multiple risk groups according to the WHO criteria (World Health Organization, 1997): < 1 CFU/100 ml, 1–10 CFU/100 ml and > 10 CFU/100 ml. This study merged 11–100 CFU/100 ml and > 100 CFU/100 ml risk groups into > 10 CFU/100 ml group due to low frequency.

Covariates

This study considered a range of child, mother, household and community-level variables as covariates (Table 1). The following child and mother level variables were included in the analysis based on existing evidence: child age (months), gender (male or female) and mother's educational status (pre-primary or none, primary, secondary and higher secondary or plus). Several variables pertaining to household characteristics were considered, including household size, livestock ownership (yes or no) and household wealth status (poorest, poorer, middle, richer, richest). A principal component analysis was employed to calculate the household wealth index based on data from household assets and divided into five categories based on quintile (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019).

In addition, a set of household-level water and sanitation-related variables were included as covariates in this study: water source type (non-piped, piped), toilet facility type (improved, non-improved), shared toilet facility (no, yes), source water *E. coli* concentration risk (low, moderate, high), source of household water sample (covered container, direct from the source, uncovered container) and water treatment (no, yes). Identifying the water source type and toilet facility were created from the question about the main source of drinking water and toilet facility for household members, and multiple categories of responses were categorised into two groups. The risk of *E. coli* contamination in source water was determined using a source water sample *E. coli* test, similar to a household water sample test (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). Source water *E. coli* CFU data were divided into three risk groups: low (1 CFU/100 ml), moderate (1–10 CFU/100 ml) and high (> 10 CFU/100 ml). There were two community-level variables: place of residence (rural, urban) and administrative division (Barishal, Chattogram, Dhaka, Khulna, Mymensingh, Rajshahi, Rangpur and Sylhet).

Statistical analysis

Descriptive statistics were performed to show the distribution of variables. The mean and standard deviation (SD) were used for continuous variables, while number and percentage were used for categorical variables. We fitted the design-based binary logistic regression (Lumley and Scott 2017) to assess the association between child diarrhea and *E. coli* contamination in household drinking water. For the adjusted association, the model was adjusted for child age, sex, mother education status, household size, livestock ownership, household wealth status, water source type, toilet facility type, shared toilet facility, source water *E. coli* concentration risk, source of household water sample, water treatment, place of residence and division. The crude odds ratio (COR) and adjusted odds ratio (AOR) with the 95% confidence interval (CI) and *p*-values were reported. All analyses were performed using R version 4.0.3.

The robustness of the findings from our main analyses was assessed using the propensity score approach. The propensity score approach allows us to mimic some of the characteristics of a randomised trial in an observational study context and can be used as an alternative confounding adjustment tool to the regression adjustment method (Austin 2011). We used the propensity score weighting to reweight

Table 1 Characteristics of the study sample ($N=2{,}232$) by diarrhea status[1] among children aged below 5 years in Bangladesh

Characteristics	Total ($N=2{,}232$)	Diarrhea	
		No ($N=2{,}076$)	Yes ($N=156$)
Child characteristics			
Age, mean (SD)	29.50 (17.28)	29.37 (17.44)	25.82 (15.67)
Sex			
Female	1055 (47.27)	985 (46.30)	70 (49.41)
Male	1177 (52.73)	1091 (53.70)	86 (50.59)
Maternal characteristics			
Education status			
Pre-primary or none	255 (11.42)	231 (10.97)	24 (16.15)
Primary	537 (24.06)	504 (22.69)	33 (15.06)
Secondary	1097 (49.15)	1019 (50.30)	78 (54.08)
Higher secondary or plus	343 (15.37)	322 (16.04)	21 (14.71)
Household characteristics			
Household size, mean (SD)	5.37 (2.16)	5.32 (2.18)	5.38 (2.14)
Livestock ownership			
No	843 (37.77)	787 (44.41)	56 (46.07)
Yes	1389 (62.23)	1289 (55.59)	100 (53.93)
Wealth status			
Poorest	557 (24.96)	509 (19.30)	48 (18.86)
Second	485 (21.73)	443 (17.09)	42 (26.89)
Middle	415 (18.59)	397 (20.33)	18 (14.09)
Fourth	417 (18.68)	388 (20.99)	29 (19.03)
Richest	358 (16.04)	339 (22.30)	19 (21.13)
Water source type			
Non-piped	2048 (91.76)	1904 (86.57)	144 (83.63)
Piped	184 (8.24)	172 (13.43)	12 (16.37)
Toilet facility type			
Improved	1868 (83.69)	1746 (86.78)	122 (86.67)
Non-improved	364 (16.31)	330 (13.22)	34 (13.33)
Shared toilet facility			
No	1575 (70.56)	1466 (66.52)	109 (64.70)
Yes	657 (29.44)	610 (33.48)	47 (35.30)
Household water *E. coli* concentration[2]			
Low	362 (16.22)	346 (17.35)	16 (8.44)
Moderate	441 (19.76)	414 (20.46)	27 (18.26)
High	1429 (64.02)	1316 (62.19)	113 (73.30)
Source of water			
Covered container	1421 (63.66)	1309 (62.76)	112 (65.46)
Direct from source	124 (5.56)	116 (6.85)	8 (6.54)
Uncovered container	687 (30.78)	651 (30.40)	36 (28.00)
Source water *E. coli* concentration			
Low	1325 (59.36)	1232 (55.46)	93 (51.96)
Moderate	396 (17.74)	366 (21.83)	30 (23.42)
High	511 (22.89)	478 (22.71)	33 (24.63)
Water treatment			
No	2044 (91.58)	1901 (88.80)	143 (87.38)
Yes	188 (8.42)	175 (11.20)	13 (12.62)
Community characteristics			
Place of residence			
Urban	394 (17.65)	366 (22.99)	28 (23.36)

Table 1 (continued)

Characteristics	Total ($N=2{,}232$)	Diarrhea	
		No ($N=2{,}076$)	Yes ($N=156$)
Rural	1838 (82.35)	1710 (77.01)	128 (76.64)
Division			
Barishal	197 (8.83)	168 (2.80)	29 (7.94)
Chattogram	491 (22.00)	457 (23.31)	34 (24.02)
Dhaka	422 (18.91)	396 (28.82)	26 (27.97)
Khulna	289 (12.95)	270 (7.56)	19 (6.20)
Mymensingh	142 (6.36)	125 (8.57)	17 (14.13)
Rajshahi	249 (11.16)	237 (13.63)	12 (9.19)
Rangpur	249 (11.16)	236 (8.69)	13 (6.89)
Sylhet	193 (8.65)	187 (6.63)	6 (3.65)

SD standard deviation

[1]Except where indicated otherwise, values are the number (%), where the number comes from the sample, and % or mean (SD) comes from the survey design that accounts for survey features such as strata, primary sampling unit and survey weights. [2]E. coli colonies were counted as CFUs per 100 ml of water and categorised as low (<1 CFU/100 ml), moderate (1–10 CFU/100 ml) and high (>10 CFU/100 ml).

both unexposed (household water *E. coli* contamination level < 1 CFU/100 ml) and exposed (household water *E. coli* contamination level 1–10 and > 10 CFU/100 ml) groups to emulate a propensity score weighted population (Yoshida et al. 2017). We estimated the propensity scores using the multinomial logistic regression with the same covariates used in the main analysis. The standardised mean difference (SMD) of 0.1 among exposed and non-exposed was considered a good covariate balancing (Zhang et al. 2019). The outcome model was the design-based binary logistic regression on the weighted data, where we multiplied the survey weights and propensity score weights to get national-level estimates (DuGoff et al. 2014). We adjusted the model for potential confounders to remove the small residual covariate imbalance between the exposed and non-exposed (Benedetto et al. 2018).

Results

Study sample characteristics

Table 1 shows the characteristics of the overall study sample stratified by child diarrheal status. Among 2,232 children, the mean age was 29.5 months (SD 17.3), 47.3% were female, 64.5% of mothers of children had secondary or higher education, 82.4% from rural areas and 18.9% were from the Dhaka division. The average household size was about five members. Around 62.2% of children lived in livestock-owning families, 25.0% from the poorest households, 91.8% from those households with no access to piped water, 83.7% from households with improved toilet facilities and 70.6% from households with non-shared toilet facilities. Overall, 64.0% of children lived in households with high *E.*

Table 2 Association between household drinking water *E. coli* contamination and diarrhea among children in Bangladesh

Exposure of interest	Unadjusted model		Adjusted model[1]	
	COR (95% CI)	*p*-value	AOR (95% CI)	*p*-value
Household water *E. coli* concentration[2]				
Low	Ref		Ref	
Moderate	1.84 (0.80–4.24)	0.154	1.68 (0.71–3.94)	0.236
High	2.42 (1.25–4.70)	0.009	2.28 (1.12–4.62)	0.023

COR crude odds ratio, *AOR* adjusted odds ratio, *CI* confidence interval, *Ref.* reference

[1]The adjusted analysis using the design-based binary logistic regression, adjusted for child age, sex, mother education status, household size, livestock ownership, household wealth status, water source type, toilet facility type, shared toilet facility, source water *E. coli* concentration risk, source of household water sample, water treatment, place of residence and division. [2]E. coli colonies were counted as CFUs per 100 ml of water and categorised as low (<1 CFU/100 ml), moderate (1–10 CFU/100 ml) and high (>10 CFU/100 ml).

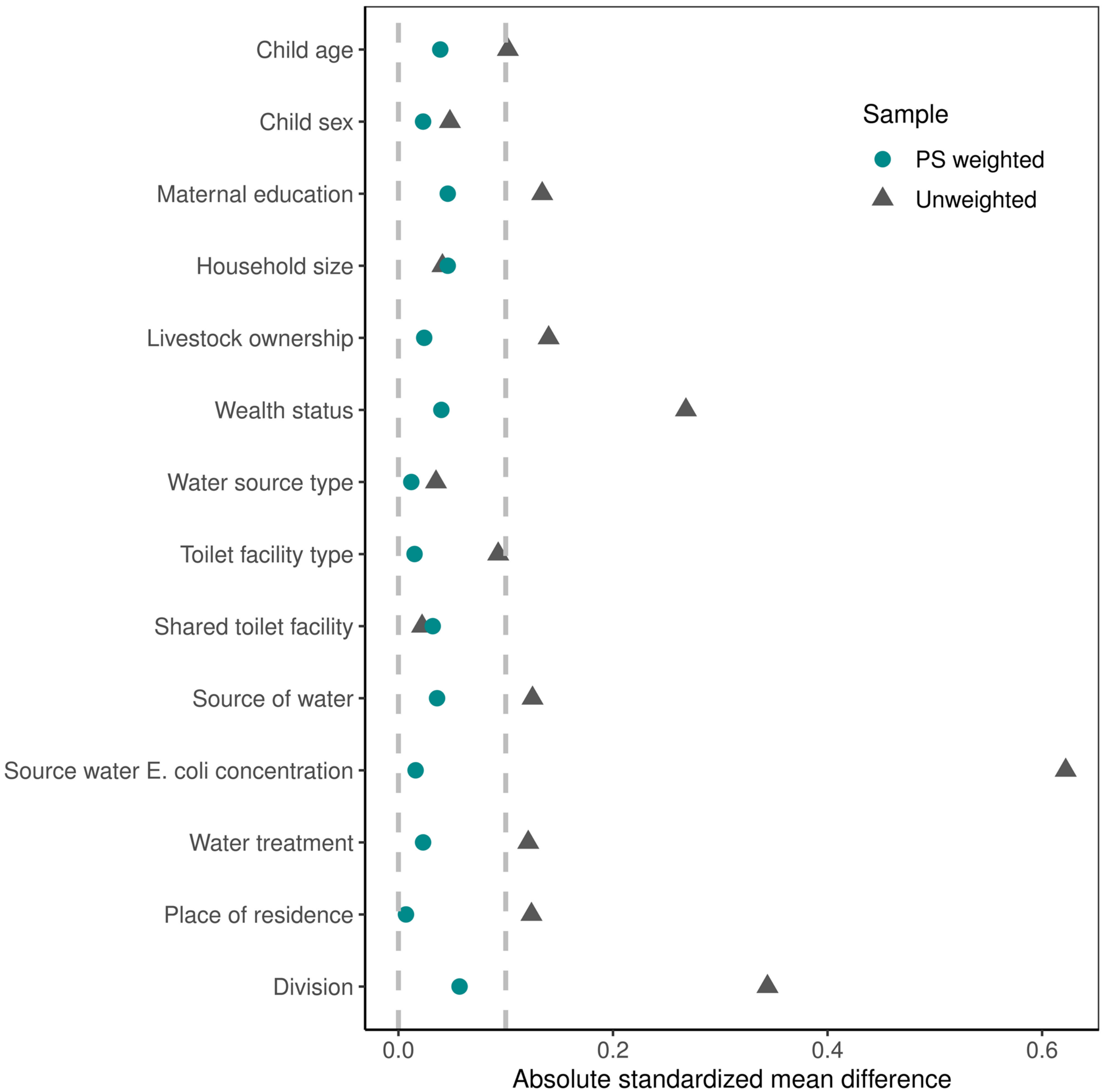

Fig. 1 Absolute standardised mean differences (SMD) between low, moderate and high household water *E. coli* concentration in unweighted and propensity score (PS)–weighted samples

coli contamination in drinking water. Approximately 59.4% of children from those households with low *E. Coli* contamination in the source water, 63.7% and 91.6%, respectively, from households where water samples were obtained from a covered container and not treated. Furthermore, the proportion of children from the household with high water *E. coli* concentration was comparatively higher among those who had diarrhea.

Association between household water E. coli contamination and childhood diarrhea

Table 2 shows the crude and adjusted association between household water *E. coli* concentration and diarrhea among children in Bangladesh. In crude analysis, > 10 CFU/100 ml risk group *E. coli* contamination in drinking water was associated with 2.42 times higher odds of diarrhea than < 1 CFU/100 ml risk group *E. coli* contamination in household drinking water (COR: 2.42; 95% CI: 1.25–4.70). After adjusting the model for potential confounders and risk factors, we observed 2.28 times the odds of diarrhea among those children from > 10 CFU/100 ml risk group *E. coli* contamination in water than those from < 1 CFU/100 ml (AOR: 2.28; 95% CI: 1.12–4.62). The odds of diarrhea was 68% higher among those children from 1 to 10 CFU/100 ml *E. coli* risk in drinking water than < 1 CFU/100 ml. However, the association was not statistically significant (AOR: 1.68; 95% CI: 0.71–3.94).

Sensitivity analysis

Figure 1 shows the SMD between low, moderate and high household water *E. coli* concentration in unadjusted and propensity score–weighted samples. Although there was an imbalance in the covariates before weighting, we observed a good balance after weighting (all SMDs ≤ 0.10). The result of sensitivity analysis using the propensity score weighting approach in the association between household drinking water *E. coli* contamination and diarrhea is presented in Table 3. Like the primary analysis, we observed approximately similar strength of association between household drinking water *E. coli* contamination and diarrhea.

Discussion

Using a nationwide data, this study explored the household water *E. coli* contamination and the risk of diarrhea among under-5 children in Bangladesh. The study findings revealed that household drinking water is highly contaminated with *E. coli* in Bangladesh, which could result from contamination at the source, inadequate treatment, unsafe storage and unsafe water handling. According to a recent study conducted in Bangladesh, many water sources had faecal contamination with pathogens including *E. coli* (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). Various environmental features (e.g. tube wells near latrines and ponds) may contribute to water source contamination. Evidence suggest that the establishment of the water source such as tube well near the latrines can contribute to contamination of water at the source (Sorensen et al. 2016). Water treatment can lower the risk of contamination in water collected from various sources. However, in Bangladesh, water treatment is uncommon, and tube well water is often regarded as a safe water source.

Table 3 Sensitivity analysis using the propensity score weighting approach to explore the association between household drinking water *E. coli* contamination and diarrhea among children in Bangladesh

Household water *E. coli* concentration[1]		AOR (95% CI)	p-value
	Low	Ref	
	Moderate	1.66 (0.72–3.86)	0.237
	High	2.39 (1.20–4.78)	0.014

AOR adjusted odds ratio, *CI* confidence interval, *Ref.* reference. [1]E. coli colonies were counted as CFUs per 100 ml of water and categorised as low (<1 CFU/100 ml), moderate (1–10 CFU/100 ml) and high (>10 CFU/100 ml).

In Bangladesh, water is usually preserved for drinking and cooking purposes, particularly in rural areas where water source is distant from the house or inaccessible. In the house, contamination can occur within the water storage containers (e.g. kolshi, bucket, jug) when water in those storage pots is touched with dirty hands. This is even true for places where source water quality is relatively good and contamination is low (e.g. tube well) (Bangladesh Bureau of Statistics and UNICEF Bangladesh 2019). Indeed, point-of-use contamination of drinking water during household storage is a major cause of water quality degradation (Clasen et al. 2007; Ferguson et al. 2011). In Bangladesh, point-of-use faecal contamination of stored water is common, particularly in the rural region (Ercumen et al. 2015). In addition, water contamination at the point of use can be caused by improper water handling, unhygienic activities (e.g. not washing hands with soap before preparing food and after defecation) and environmental contamination. Overall, the high level of contamination in household drinking water can contaminate the children with *E. coli* and other pathogens causing diarrhea.

According to our findings, high *E. coli* contamination is associated with diarrheal episodes among under-5 children in Bangladesh, as documented in earlier research (Luby et al. 2015; Feleke et al. 2018). For example, a study (Luby et al. 2015) conducted among the under-5 children from the 50 villages in Bangladesh followed a longitudinal prospective cohort design and revealed that the prevalence of childhood diarrhea was associated with drinking of *E. coli*–contaminated water. However, a systematic review examining the relationship between faecal contamination in drinking water and the occurrence of childhood diarrhea reported inconclusive results, with some of the included studies reporting no association and others reporting a moderate association (Gruber et al. 2014). These contradictory findings could be attributed to various factors, including a weak link between indicator organisms and pathogens, immunity of population to pathogens and the greater variability of water quality measurements (Luby et al. 2015).

The high levels of faecal contamination in household drinking water and its association with childhood diarrhea highlight the importance of water source monitoring and improving household drinking water management. This could be done through a variety of approaches. Firstly, better water treatment can help to lower the risk of contamination in household drinking water. A study in Bangladesh revealed that treating household-stored drinking water with chlorine reduces *E. coli* concentration (Luoto et al. 2011). However, chlorination intervention is likely to be sensitive to the economic and behaviour change burden to the consumers related to repeated purchasing of chlorine tablets. Safe storage of drinking water could be a realistic alternative in this circumstance. An earlier study in Bangladesh found that safe storage (alone or in combination with chlorination) improves stored-water microbial quality with lowered risk of childhood diarrhea (Ercumen et al. 2015). Investing in safe storage and adapting to it, however, may necessitate significant behavioural change. In addition to these measures, other factors must be considered as part of broader initiatives, such as improving hygiene practices, and improving knowledge and awareness among household members and broader communities, which can help lower the risk of drinking water contamination and concomitant childhood diarrhea prevalence.

The strengths of this study include the use of population-based large survey data and rigorous statistical methods. However, this study is not devoid of shortcomings. Firstly, cross-sectional survey data makes it difficult to establish a causal relationship between exposure and outcome. Secondly, information of diarrheal episode was collected using recall, therefore it could be subjected to recall bias. Thirdly, our *E. coli* definition could not differentiate the pathogenic and non-pathogenic *E. coli*. Forthly, this study could not adjust for all potential confounders (e.g. behavioural factors, climate factors) that could influence the observed association. Future research should possibly focus on conducting a longitudinal study to understand the causal relationship and the impact of unmeasured factors. Finally, diarrhea can be caused by a variety of factors including bacterial infections and viral infections, food intolerance and food allergies, malnutrition, parasites that enter the body through food or water, and drug reactions, among others (Guerrant et al. 1992; Ou-Yang et al. 2008; World Health Organization 2017). Yet, in low-income countries, the two most common etiological agents of moderate-to-severe diarrhea are rotavirus and *E. coli* (World Health Organization 2017). However, we do not have data of potential contaminants other than *E. coli* resulting childhood diarrhea.

Policy recommendations

The findings of our study have significant policy implications. Policy makers and public health practitioners should implement awareness raising initiatives to make people understand about the cause and prevention of *E. coli* contamination in drinking water. The awareness raising initiative should also focus on educating the people in using safe drinking water tested/checked by relevant authorities. It is also important that authorities such as Department of Public Health Engineering (DPHE) and Department of Environment (DoE) take necessary steps so that water source such as tube wells are placed away from the faecal contaminant source and that the drinking water source is tested for *E. coli* before approved for consumption by mass people.

Conclusion

The present study documented a high level of *E. coli* contamination in drinking water and reported a significant association between *E. coli* contamination in drinking water and childhood diarrheal episodes. The findings suggest implementing interventions focusing on reducing faecal contamination at the source of drinking water as well as in stored water. Policymakers and public health practitioners should focus on raising mass awareness on importance of safe drinking water use. Relevant authorities should also ensure safe water supplies, improve drinking water management (e.g. handling procedures, treatment and storage), help modify personal hygiene behaviours and improve health literacy.

Acknowledgements The authors would like to acknowledge the contributions of the BBS and UNICEF to conduct the survey and to provide open access to the dataset.

Author contribution J. R. K. conceptualised the study and contributed to data preparation, synthesised the analysis plan, performed data analysis, interpreted findings and wrote the manuscript. M. B. H. helped to synthesise the analysis plan, perform data analysis, interpret findings and write the manuscript. P. A. C. contributed to literature review and wrote the manuscript. The manuscript was critically reviewed and edited by S. K. M. All authors contributed significantly to the preparation of the manuscript.

Data Availability Data are available on request from the MICS program website (https://mics.unicef.org/surveys).

Declarations

Ethical approval The MICS 2019 was carried out in collaboration with the Bangladesh Bureau of Statistics (BBS) and UNICEF. The protocol of this survey was approved by technical committee of the Government of Bangladesh lead by the BBS. This present study used publicly available secondary MICS 2019 datasets. Before making the datasets public, all respondents were deidentified by survey authorities.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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