

## The association between water, sanitation and hygiene (WASH) conditions and drowning in Bangladesh

Jagnoor Jagnoor, Medhavi Gupta, Kamran Ul Baset, Daniel Ryan, Rebecca Ivers and Aminur Rahman

### ABSTRACT

The present study investigated associations between water, sanitation and hygiene (WASH) factors and fatal and non-fatal drowning events in Bangladesh. Here, we report findings from a large household survey (89,700) conducted in Barisal Division of Bangladesh. Univariate analyses showed that the use of surface water rather than piped water was associated with an increased risk of both fatal and non-fatal drowning events. Additionally, increased risk of non-fatal drowning events was associated with shared toilet facilities, lack of toilet facilities and non-cemented flooring such as bamboo and wood. The WASH measures reduce the need to access exposure to open water, thus reducing drowning events.

**Key words** | Bangladesh, drowning, hygiene, risk factors, sanitation, water

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### INTRODUCTION

Previous works have largely overlooked possible associations between water, sanitation and hygiene (WASH) conditions with the incidence of fatal and non-fatal drowning. While the World Health Organization estimated that 74% of drowning events in low- and middle-income countries was attributable to environmental or occupational factors, which comprises a variety of causes including the lack of lifeguards and boating regulations (Meddings *et al.* 2014). Limited analysis has been conducted to date to understand how specific WASH facilities, such as drainage coverings and access to piped water, may influence the risk of drowning.

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This paper aimed to explore how WASH-related variables in Barisal Division, Bangladesh were associated with drowning. Bangladesh experiences a particularly high rate of drowning, causing 43% of deaths for children aged 1–4 (Meddings *et al.* 2014). Variable and poor WASH infrastructure may present a particular risk in this region (Hyder *et al.* 2014). Overall, Bangladesh has made considerable progress in WASH infrastructure. By 2015, Bangladesh achieved the Millennium Development Goal (MDG) of halving the number of people accessing unimproved water, increasing the number of people with access to contamination-free water from unshared sources (World Bank 2018). Additionally, the World Bank (2018) estimated that 63% of the population now has access to improved sanitation facilities that are not shared and have provisions for suitable disposal of waste. However, remote areas in Bangladesh are still left

behind in this growing trend of national sanitation development. It is estimated that less than half of the population in the Barisal Division on the south coast of Bangladesh has access to improved sanitation. This region is prone to frequent disasters aggravated by climate change, and requires more resilient WASH infrastructure to ensure the long-term health of its people in the face of flooding and cyclones. Hence, it is valuable to understand how WASH factors in the Barisal region are related to drowning, given the greater risk of disaster and vulnerability in this region.

## METHODS

Data were collected from 89,700 households in a cross-sectional survey across all districts of the Barisal Division, comprising 385,127 population from October 2016 to January 2017. Respondents (head of the household or an adult member of the household) were asked to identify cases of fatal drowning in the last two years and non-fatal drowning within their household in the last year. Multi-stage cluster sampling was used. Details of the data collection have been previously reported (Jagnoor *et al.* submitted).

Questions for data collection were adapted from the validated Bangladesh Demographic Health Survey (BDHS), which is used to determine health outcomes and other socio-economic indices across Bangladesh. Questions relating to WASH were extracted for the study. The tools were adapted to be used for electronic data capture.

The variables for analysis were modified to group together certain response options from the BDHS questionnaire. (See Supplementary materials Tables S1 and S2, available with the online version of this paper, outlining the grouping of BDHS responses against variables for analysis where they differed from the original BDHS survey.) A univariate analysis was used to identify significant associations between the variables and drowning events. Multivariate analyses were also conducted on variables with sufficient sample size of drowning events. Separate analyses for fatal and non-fatal drowning events were conducted.

Free and informed consent of the participants was obtained. The study was approved by the appropriate Committee for the Protection of Human Participants, The

University of Human Research Ethics Committee, NSW, Australia, approval number 2016/606, dated 8th September 2016. Ethics approval was also sought from the CIPRB Ethical Review Committee, Bangladesh, and granted 8th August 2016, memo number CIPRB/ERC/2016/12.

## RESULTS

Drowning presents a large burden to mortality and morbidity in Bangladesh. Our survey findings reported three times higher mortality rate in Barisal (37.9/100,000 population) as compared to national drowning mortality rates (11.7/100,000 population) (Rahman *et al.* 2016).

Compared to the rest of Bangladesh, the Barisal Division has one of the greatest populations of lower-income households. Over 50% of the population is in the bottom two quintiles of wealth (National Institute of Population Research and Training (NIPORT) *et al.* 2008). Figure 1 shows the distribution of socio-economic status (SES) scores in the Barisal Division in rural and urban areas derived using BDHS methodology. The figure demonstrates that rural areas have a larger share of households with low SES scores below 0.

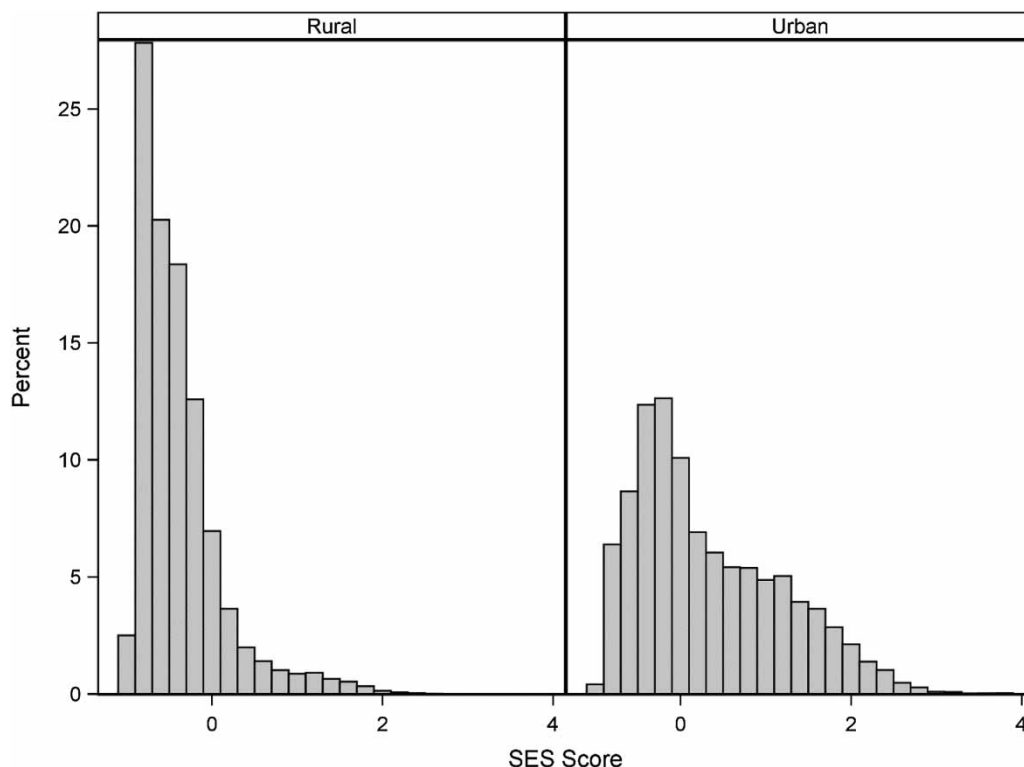
### Fatal drowning

#### WASH variables

Households who accessed surface water for their daily needs were found to be exposed to a greater risk of fatal drowning compared to those accessing piped water. Additionally, those who share water sources with other households are more at risk of a fatal drowning event than those who had access to private water sources. Please see Table 1 for statistical results of analysis.

#### Socio-economic variables

Demographically, households which did not have ownership of a transportation asset, such as a bicycle, vehicle or motorcycle, were at higher risk of fatal drowning than those who had ownership of these assets. Please see Table 1 for statistical results of analysis.



**Figure 1** | Socio-economic index scores in the Barisal Division.

## Non-fatal drowning

### WASH variables

As with fatal drowning, there was a greater probability of non-fatal drowning incidents in households that accessed surface water compared to piped water. This finding was corroborated by the multivariate analysis (Figure 2). Similarly, households which do not share their toilet facilities with other households have a reduced risk of non-fatal drowning compared to those who share toilet facilities. Specifically, compared to no toilet facilities, flush toilets and pit latrines were associated with a lower level of risk. Please see Table 2 for statistical results of analysis.

### Socio-economic variables

Demographically, households which did not have ownership of a transportation asset were at higher risk of non-fatal drowning than those who had ownership of these assets. This finding was corroborated by the multivariate

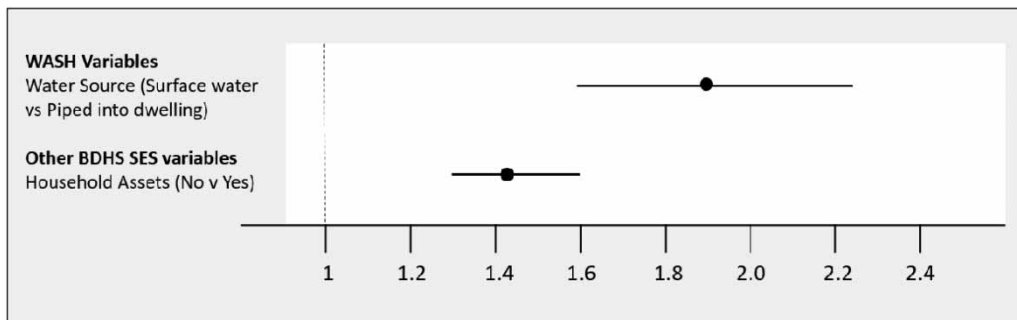
analysis. Additionally, compared to those who use wood as a cooking fuel, there was a greater risk of non-fatal drowning for those who used agricultural crop, dung or other, while those who used LPG were at lower risk of non-fatal drowning. Participants who received microfinance or banks loans were also registered with low scores for risk of non-fatal drowning events. Further, household flooring and building materials also lowered the risk of non-fatal drownings. Please see Table 2 for statistical results of analysis.

## DISCUSSION

This report aimed to investigate how WASH conditions may be associated with fatal and non-fatal drowning events in Bangladesh. This was the first analysis to investigate the relationship between WASH variables and drowning events in a lower-income country (LIC). A total of 89,700 households was included in the univariate analysis.

**Table 1** | Univariate analysis of fatal drowning

Covariate	Effect	OR	LCL	UCL	Univariate p-value
<i>WASH variables</i>					
Water source	Surface water vs Piped into dwelling	2.14	1.35	3.39	0.0013
Location of water source	Outside property vs Own property	0.84	0.61	1.14	0.2743
Shared water sources	Not shared vs Shared	1.84	1.08	3.14	0.0246
Toilet type	Flush toilet vs No facility or other	0.88	0.21	3.66	0.8479
	Pit latrine vs No facility or other	0.78	0.20	3.13	
Shared toilets	No vs Yes	0.96	0.50	1.83	0.9040
<i>Other BDHS socio-economic variables</i>					
Household assets	No vs Yes	<b>1.42</b>	<b>1.06</b>	<b>1.91</b>	0.0192
Cooking fuel source	Crop vs Wood	0.14	0.02	1.01	0.0448
	Dung vs Wood	2.00	0.78	5.13	
	LPG vs Wood	0.53	0.08	3.56	
	Other vs Wood	1.77	0.86	3.61	
Transport asset	A bicycle vs None	0.79	0.46	1.38	0.0889
	A motorcycle or motor scooter vs None	1.63	0.75	3.51	
	Rickshaw/Van vs None	0.67	0.19	2.35	
	Motorised vehicle vs None	2.30	1.19	4.46	
Floor material	Other vs Cemented/Ceramic	1.19	0.59	2.41	0.3879
	Palm/Bamboo/Wood Planks vs Cemented/Ceramic	0.32	0.04	2.64	
Wall type	Bamboo vs Tin/Plywood				
	Bricks/Cement vs Tin/Plywood	0.88	0.42	1.85	
	Cardboard/Cane/Palm/Trunks vs Tin/Plywood	1.61	0.62	4.16	
	Other vs Tin/Plywood	0.71	0.13	3.85	
Loan received	No vs Yes	0.79	0.58	1.08	0.1322

**Figure 2** | Multivariate analysis of non-fatal drowning.

The findings support the hypothesis that improving access to WASH may reduce drowning hazards and other exposure risks involved. Both fatal and non-fatal drowning

events were associated with accessing surface water for household needs, such as unprotected wells, open ponds and rain water. These bodies of water have been identified

**Table 2** | Univariate analysis of non-fatal drowning

Covariate	Effect	OR	LCL	UCL	Univariate p-value
<i>WASH variables</i>					
Water source	Surface water vs Piped into dwelling	1.94	1.57	2.40	<0.0001
Location of water source	Outside property vs Own property	1.14	1.01	1.29	0.0319
Shared water sources	Not shared vs Shared	1.18	0.89	1.57	0.2363
Toilet type	Flush toilet vs No facility or other	0.33	0.23	0.48	<0.0001
	Pit latrine vs No facility or other	0.51	0.36	0.71	
Shared toilets	No vs Yes	0.62	0.53	0.73	<0.0001
<i>Other BDHS socio-economic variables</i>					
Household assets	No vs Yes	1.54	1.39	1.72	<0.0001
Cooking fuel source	Crop vs Wood	1.76	1.32	2.34	<0.0001
	Dung vs Wood	1.70	1.34	2.14	
	LPG vs Wood	0.35	0.22	0.55	
	Other vs Wood	1.19	1.04	1.37	
Transport asset	A bicycle vs None	0.83	0.72	0.95	<0.0001
	A motorcycle or motor scooter vs None	0.96	0.80	1.14	
	Rickshaw/van vs None	1.37	1.16	1.61	
	Motorised vehicle vs None	1.19	0.97	1.46	
Floor material	Other vs Cemented/Ceramic	2.06	1.75	2.42	<0.0001
	Palm/Bamboo/Wood Planks vs Cemented/Ceramic	2.39	1.40	4.09	
Wall type	Bamboo vs Tin/Plywood	1.80	0.80	4.03	<0.0001
	Bricks/Cement vs Tin/Plywood	0.57	0.48	0.67	
	Cardboard/Cane/Palm/Trunks vs Tin/Plywood	1.15	0.83	1.59	
	Other vs Tin/Plywood	1.33	0.88	1.99	
	Stone vs Tin/Plywood	0.70	0.31	1.57	
Loan received	No vs Yes	0.80	0.97	0.80	0.0086

as environments in which drownings occur in LICs (Tyler *et al.* 2017). These findings suggest that there is potential to reduce drownings in LICs through work to improve WASH and that reduced drowning risk may be considered a positive outcome of WASH programmes that reduce reliance on surface water. As such, there is a need for those working in the drowning prevention and WASH sectors to acknowledge and utilise the potential to prevent drownings through WASH, particularly as Sustainable Development Goal 6 focuses efforts on access to safe and clean water and reducing child mortality.

Additionally, a number of WASH factors were found to be associated with non-fatal drowning, including shared toilet facilities, lack of toilet facilities and non-cemented flooring such as bamboo and wood. Brick and cement

walls were found to be protective against non-fatal drowning. The results corroborate with findings that few shared toilet facilities in Bangladesh have regular maintenance and repair work performed (Nelson *et al.* 2014), which may present an increased risk to drowning events as users use faulty and dangerous toilet platforms. Furthermore, a household survey of 1.17 million individuals in Bangladesh by Rahman *et al.* (2017) found that 66% of drowning events occurred in ponds, which are the primary water source for homes without a private supply of water. Similarly, in our results, 56% of drownings in Bangladesh have been found to occur while washing or bathing (data not shown). These results together highlight that while safe drinking water is an essential WASH factor to health and safety, greater gains in injury prevention can be made with investment in

safe and sustainable access to water for everyday activities such as bathing and washing.

A caveat with these findings is that the factors associated with fatal and non-fatal drowning are also associated with low socio-economic status, such as living in wooden structures and sharing water and sanitation facilities. Low socio-economic households are also more likely to live near open water such as rivers and ponds, and work in the fishing industry (National Institute of Population Research and Training (NIPORT) *et al.* 2008; Islam 2011; Rahman *et al.* 2013). These lifestyle factors may be contributing to the increased risks of drowning found in addition to WASH factors. An indicator of this is our observation that people who have access to loans and microfinance opportunities to potentially increase income (Mahjabeen 2008; Habib & Jubb 2015) have demonstrated a reduced rate of non-fatal drowning cases.

### Limitations

First, smaller sample sizes for some variables such as floor type and unshared toilet sources, particularly in fatal drownings, reduced statistical power and hence ability to find associations. A larger sample size may be required to identify further associations between fatal drowning and WASH characteristics. Second, the study did not measure specific WASH factor contributors to drowning, such as whether poor toilet facilities or lack of indoor water supply played a role in the event. However, our findings did suggest that those who do not have access to water in their homes may be at greater risk while accessing water in ponds and pools, especially while washing or bathing. Further research is required to determine the extent to which WASH factors contribute to drowning, as opposed to being indicators for drowning risk due to lifestyles led by poorer households.

### CONCLUSIONS

This paper explored the relationships between WASH factors and drowning in a novel analysis. Although previous work has suggested that WASH variables may overall be related to drowning risk, this analysis provided insight into how individual WASH factors may contribute to drowning.

These findings provide compelling evidence that WASH variables may play a role in drowning risk, particularly in rural regions of LICs. Further research may provide further clarification on the causal nature of WASH variables in drowning events.

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### REFERENCES

- Habib, M. & Jubb, C. 2015 Poverty alleviation with microfinance: Bangladesh evidence. In: *Poverty Reduction Policies and Practices in Developing Asia* (A. Heshmati, E. Maasoumi & G. Wan, eds). Springer, Singapore, pp. 11–30.
- Hyder, A. A., Alonge, O., He, S., Wadhvaniya, S., Rahman, F., Rahman, A. & Arifeen, S. E. 2014 *Saving of children's lives from drowning project in Bangladesh*. *American Journal of Preventive Medicine* **47** (6), 842–845. DOI: 10.1016/j.amepre.2014.07.050.
- Islam, M. M. 2011 Living on the margin: the poverty-vulnerability nexus in the small-scale fisheries of Bangladesh. In: *Poverty Mosaics: Realities and Prospects in Small-Scale Fisheries* (S. Jentoft & A. Eide, eds). Springer, Dordrecht, The Netherlands, pp. 71–95.
- Jagnoor, J., Rahman, A., Cullen, P., Chowdhury, F. K., Lukaszuk, C., Baset, K. & Ivers, R. *Context of Water Related Disasters in Bangladesh: A Mixed Methods Study* (Submitted).
- Mahjabeen, R. 2008 *Microfinancing in Bangladesh: impact on households, consumption and welfare*. *Journal of Policy Modeling* **30** (6), 1083–1092. DOI: 10.1016/j.jpolmod.2007.12.007.
- Meddings, D., Hyder, A. A., Ozanne-Smith, J. & Rahman, A. 2014 *Global Report on Drowning: Preventing A Leading Killer*. World Health Organization, Geneva.
- National Institute of Population Research and Training (NIPORT), Mitra and Associates & Macro International 2008 *Bangladesh Demographic and Health Survey 2007: Key Findings*. NIPORT, Mitra and Associates & Macro International, Calverton, MD, USA.
- Nelson, K. B., Karver, J., Kullman, C. & Graham, J. P. 2014 *User perceptions of shared sanitation among rural households in Indonesia and Bangladesh*. *PLoS ONE* **9** (8), e103886. DOI: 10.1371/journal.pone.0103886.

- Rahman, M., Matsui, N. & Ikemoto, Y. 2013 Housing and household facilities. In: *Dynamics of Poverty in Rural Bangladesh* (P. M. M. Rahman, N. Matsui & Y. Ikemoto, eds). Springer, Tokyo, Japan, pp. 39–45.
- Rahman, A., Chowdhury, S., Mashreky, S., Linnan, M. & Rahman, A. K. M. F. 2016 *Bangladesh Health and Injury Survey (BHIS)*. Directorate General of Health Services and Centre for Injury Prevention, Bangladesh.
- Rahman, A., Alonge, O., Bhuiyan, A., Agrawal, P., Salam, S. S., Talab, A., Rahman, S. R. & Hyder, A. A. 2017 [Epidemiology of drowning in Bangladesh: an update](#). *International Journal of Environmental Research and Public Health* **14** (5), 488. DOI: 10.3390/ijerph14050488.
- Tyler, M. D., Richards, D. B., Reske-Nielsen, C., Saghafi, O., Morse, E. A., Carey, R. & Jacquet, G. A. 2017 [The epidemiology of drowning in low- and middle-income countries: a systematic review](#). *BMC Public Health* **17** (1), 413. DOI: 10.1186/s12889-017-4239-2.
- World Bank 2018 *Promising Progress: A Diagnostic of Water Supply, Sanitation, Hygiene, and Poverty in Bangladesh*. WASH Poverty Diagnostic, World Bank, Washington, DC, USA.

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