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Research Paper

Status of drinking water, sanitation facilities, and hygiene in West Bengal: evidence from the National Family Health Survey of India (NFHS), 2019–2021

Chandan Roy *, Vishwambhar Prasad Sati, Amit Biswas and Saurav Kumar

Department of Geography and Resource Management, Mizoram University, Aizawl 796004, Mizoram, India
*Corresponding author. E-mail: chandan96.roy@gmail.com

CR, 0000-0001-6246-4263

ABSTRACT

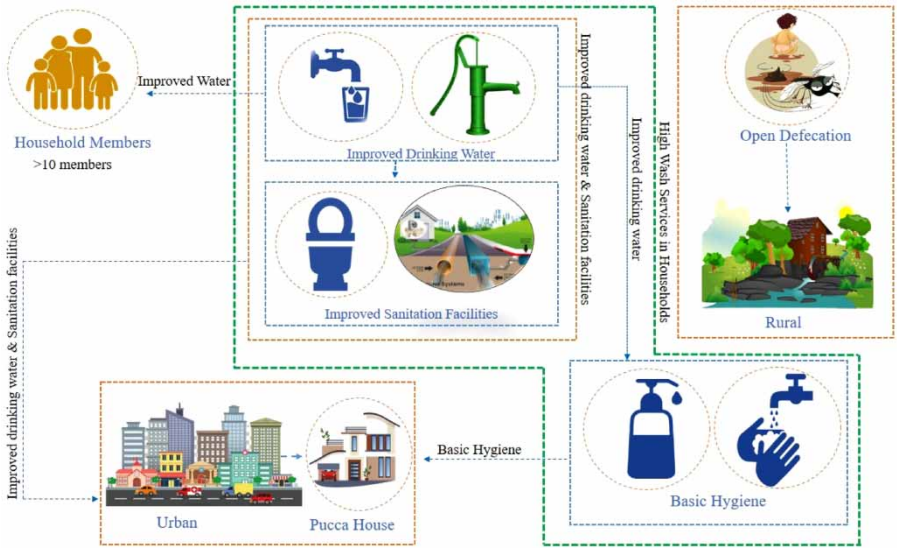
Access to safe drinking water and sanitation are essential fundamental rights for every citizen of a country. It is an important indicator of quality of life. Inadequate access to WASH services harms children under five and adolescent girls. This study examines the status of WASH services in West Bengal. A comprehensive assessment of WASH services was conducted using data from the fifth round of the National Family Health Survey. Data were statistically analyzed using Stata V. 14.1 software. A multivariate ordinal logistic regression model was applied to examine the association between experimental and explanatory variables. Furthermore, adjusted odds ratios, significance levels, and confidence intervals were provided for each dummy variable. The study found that only 33.69% of households in West Bengal have access to improved sources of drinking water. Moreover, only 74.35% of households have access to hygienic sanitation facilities within their premises, while 14.60% still practice open defecation. However, urban, Pucca, and non-nuclear households have better access to clean water, sanitation, and hygiene. The study also reported that drainage facilities are lacking in the state. Finally, the study recommends some policy measures to improve the access of WASH services in the state.

Key words: multivariate regression, NFHS-5, open defecation, quality of life, WASH services, West Bengal

HIGHLIGHTS

- People in non-nuclear households in cities have better access to WASH services.
- Kolkata is ranked top in combined WASH services.
- Purulia is the worst-performing district in terms of WASH services.
- West Bengal's rural residents continue to practice open defecation.
- The prevalence of diarrhea among children is higher in rural areas.

GRAPHICAL ABSTRACT



INTRODUCTION

Access to WASH (water, sanitation, and hygiene) is a powerful tool for improving people's quality of life. Poor and vulnerable groups, particularly children under the age of five and adolescent girls, have less access to improved WASH services (Hutton & Chase 2017). The UN General Assembly has declared that access to better water and sanitation is a fundamental right for all people. To live a dignified life, everyone should have access to sanitary facilities and clean water. Besides, poor WASH services are harmful to human health (UN-Water n.d.; WHO WASH Strategy 2018-2025 2018, pp. 2018–2025). It is estimated that more than 2.6 billion people lack access to adequate sanitation, resulting in an estimated 10% disease burden (Mara *et al.* 2010). A lack of improved drinking water and sanitation facilities places children in the neonatal age group at an increased risk of death. Due to improved WASH services, the life expectancy of newborns (0–28 days) and under 5 year olds (0–4 years) increases significantly (Ezeh *et al.* 2014). Moreover, improved drinking water and sanitation facilities contribute to the decline of maternal mortality rates (MMRs) (Cheng *et al.* 2012).

Lack of access to WASH services kills many people in low- and middle-income developing countries. Children under the age of five are particularly at risk due to poor handwashing habits (Dery *et al.* 2019; Mourad *et al.* 2019). In India, regional disparities exist between states, and sanitation facilities are extremely limited, especially in states such as Assam, Bihar, and Madhya Pradesh. Although Haryana has made significant progress over the years, Assam, Rajasthan, and Maharashtra are still struggling to meet their targets (Agarwal & Saha 2021). About 90% of urban households in India have improved access to drinking water facilities, and 77% of them have access to drinking water on their premises. Meanwhile, 90% of households have improved sanitation facilities, and 60% have improved garbage collection systems (Patel *et al.* 2020). The cluster of districts in central and eastern India has a higher level of WASH poverty (Ghosh *et al.* 2022).

Sabud *et al.* (2020) reported that in West Bengal, stunted and underweight children are highly associated with families with low WASH scores. According to Mukhopadhyay *et al.* (2020), the groundwater in Murshidabad Lalbagh Municipality is highly contaminated with arsenic and iron, posing serious health concerns. Furthermore, the groundwater in Murshidabad district is heavily contaminated with arsenic (As) and iron (Fe), which have a direct impact on human health (Das *et al.* 2021). A lack of access to safe drinking water, inadequate sanitation facilities, and improper handwashing practices in the home can have serious health implications. Despite this, many districts of West Bengal suffer from contaminated drinking water, containing various substances, posing a serious health risk to people. The diseases like diarrhea, skin diseases, anemia, water-related diseases, and fever are highly correlated with unimproved water and unhygienic sanitation facilities, as well as poor handwashing habits. In addition, previous studies show that people living in the district located in the Gangetic delta are at particularly high risk of drinking arsenic-contaminated water, creating a major public health concern

in the long run (Chakraborti *et al.* 2018). Therefore, it is critical to provide clean drinking water, access to improved sanitation facilities, and awareness of hygiene at the household level. This will enable us to achieve SDG 6 by 2030.

Several studies have been conducted on the availability of WASH services in India (Patel *et al.* 2020; Saroj *et al.* 2020; PALO *et al.* 2021). Few studies are also conducted on the state of WASH services in West Bengal. However, these studies are very limited, old and cover only a few districts of West Bengal. This study is empirical, unique and covers all the districts of the state. Therefore, it will help to assess the current state of WASH services in the state of West Bengal. It will also investigate how various socio-economic and demographic factors are associated with households' access to improved drinking water and sanitation facilities. The results of this study will fill gaps in the existing literature and pave the way for future studies. Moreover, future research should be focused on examining the rural–urban heterogeneity of access to drinking water, sanitation, and hygiene behavior at the micro level (Figure 1).

STUDY AREA

West Bengal is the eastern state of India, sharing a land border with Bangladesh from the east, Sikkim, and Bihar from the north, and Jharkhand from the west. The latitudinal and longitudinal extent of West Bengal is 21°25′24″ N–27°13′15″ N and 88°48′20″ E–89°53′40″ E, respectively. There are 23 districts and 5 divisions, with approximately 68.13% of the population living in rural areas and 31.87% living in urban areas. Furthermore, it is India's fourth-largest state by population (over 91 million) and 13th-largest by area (88,752 km^2). The topography is hilly and undulating in the north and plain in the center and south. Lateritic soil is found in the west, a Gangetic alluvial plain in the east, and a coastal alluvial region in the south. In West Bengal, districts like Malda, Murshidabad, Hooghly, North 24 Parganas, South 24 Parganas, and Kolkata are highly contaminated with arsenic (Chakraborti *et al.* 2009; Mazumder & Dasgupta 2011). For this study, the author (s) considered all districts of West Bengal, however, data were not available for Darjeeling, Alipurduar, and Jhargram (Figure 2). Besides, 18,161 households were considered for this study.

Figure 1 | Photographs of drinking water sources and sanitation facilities in West Bengal. (a) Household tap water connection, (b) unhygienic sanitation facility, (c) villagers fetching drinking water from India Mark II hand pump, and (d) a woman cleaning kitchen utensils.

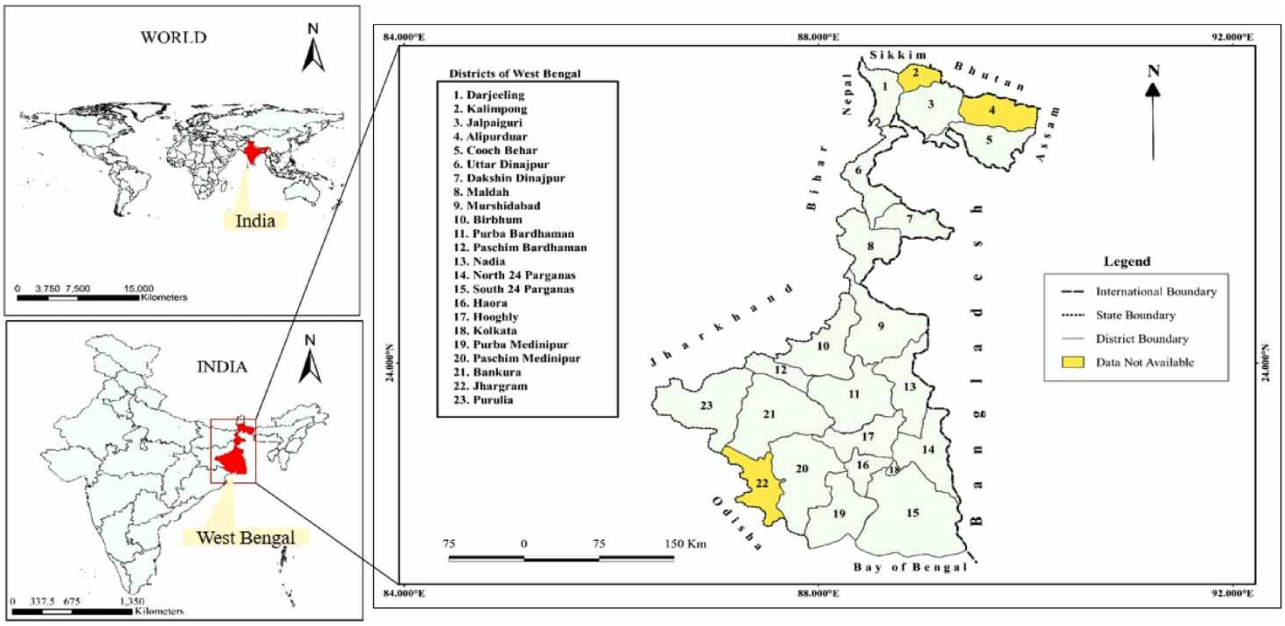


Figure 2 | Location map of the study area.

METHODOLOGY

Data source

Data were gathered from the fifth round of NFHS (NFHS-5). This is a two-stage cross-sectional stratified sampling survey that uses a probability proportional to size (PPS) method. Similarly, CAPI (computer-assisted personal interviews) were used in the survey to collect information about women, men, children, couples, and households. This survey involves 636,699 households across the country. However, the authors only considered 18,161 households of West Bengal (after exclusion of missing variables) for the study.

Variable descriptions

Experimental variables

Improved access to water sources and sanitation facilities were considered experimental variables. In addition, improved water sources and sanitation facilities were coded as 1, and unimproved water sources and sanitation facilities were coded as 0 (Table 1).

Table 1 | Definition of improved and unimproved facilities (WHO/UNICEF Joint Water Supply and Sanitation Monitoring Programme 2018)

Service	Improved	Unimproved
Drinking water sources	Piped water, boreholes or tube wells, protected dug wells, protected springs, rainwater, and packaged or delivered water.	Unprotected dug well, unprotected spring, river, dam, lake, pond, stream, canal, and irrigation canal.
Sanitation facilities	Flush/pour flush to piped sewer systems, septic tank, pit latrines, ventilated improved latrines, pit latrines with slabs, and composting sanitation.	Pit latrines without slabs or platforms, hanging latrines or bucket latrines, shared sanitation facilities, and open defecation.
Time to get water	Drinking water from improved sources, with a collection time of <30 min for a round trip including queuing.	Drinking water from unimproved sources, with a collection time >30 min for a round trip including queuing.
Handwashing facilities	Availability of handwashing facilities on premises including soap and improved water.	Availability of handwashing facilities on premises without soap and water, and unimproved water.

Explanatory variables

The gender of the household head, educational level, Wealth Index, household members, place of residence, current marital status, time to fetch water (round trips), house types, and house structure were the main explanatory variables for this study. In addition, some variables were classified/coded into different categories. The household members variables (hv009) were coded into four groups: 1 member households coded as 0, 2–5 members households coded as 1, 6–10 members households coded as 2, and >10 members households coded as 3. Similarly, marital status (hv115_01) was coded as: 0 for unmarried, 1 for married, 2 for widowed, 3 for divorced, and 4 for separated. Moreover, the time to fetch water in a round trip (hv204) was coded as 1 for less than 30 min and 0 for more than 30 min.

Statistical analysis

The statistical analysis was performed using Stata V. 14.1 software. Data were arranged in a categorical rank-ordered cluster or hierarchical structure. An ordered logistic model was used for the analysis (Grilli & Rampichini 2021). The lower values from Model II and Model I indicated that adding new variables continued to improve the goodness of fit for the combined model (Model III). Deviance was used to calculate the total variations caused by different types of variables. An adjusted odds ratio (AOR) has been calculated with a 95% confidence interval (CI). The first dummy variable in each group was considered a reference category. For the statistical significance test, the Likelihood Ratio Test (syntax: lrtest) was used to compare each model to the final model (Model III). The results of the lrtest showed that all models were statistically significant at $p < 0.001$. In addition, the Pearson chi-square (syntax: chi2) test was applied to test the statistical significance of the analysis.

RESULTS

Access and coverage of WASH facilities in West Bengal

The availability of safe drinking water, the location of water sources, sanitation facilities, and wastewater drainage facilities are all key indicators of WASH services. In West Bengal, access to and coverage of improved drinking water sources within household premises were observed in 33.93% of households. Furthermore, 74.35% of households have access to improved sanitation within their premises, while 14.88% of households have access to improved sanitation facilities outside of their dwellings. Besides, 43.78% of households have drinking water sources inside their premises, whereas 56.22% have drinking water sources outside their premises (elsewhere). 35.40% of households have access to sanitation facilities within their dwellings, however, 6.81% have access to a sanitation facility elsewhere (outside their premises). Moreover, 37.41% of households have access to drainage facilities (both open and closed) in their dwellings (Table 2).

Status of households' WASH services

Household access to drinking water, sanitation facilities, and shared sanitation are presented in Table 3. Purba Barddhaman (97.69%) had the highest access to improved drinking water, followed by Bankura (97.36%) and Birbhum (97.17%), while Darjeeling (86.98%) had the lowest access to improved drinking water. Kolkata (95.96%) had the highest access to improved sanitation facilities, however, Purulia (34.68%) had the lowest access to improved sanitation facilities. Maldah had the highest access (25.26%) to water within dwellings, followed by Koch Bihar (24.62%) and Jalpaiguri (19.98%). The results showed that water fetching time was less than 30 min in 12 districts. Besides, Hugli (98.48%) had the largest number of households that had access to improved water in less than 30 min, followed by Kolkata (97.87%) and Paschim Medinipur (97.84%). Furthermore, it was noted that Purulia (21.20%) had the highest prevalence of open defecation, followed by Bankura (11.89%) and Birbhum (11.53%). However, North 24 Parganas (0.40%) had the lowest prevalence of open defecation, followed by Darjeeling (1.00%) and Purba Medinipur (1.16%). Kolkata (6.73%) had the highest share of sanitation facilities, followed by South 24 Parganas (8.01%) and Haora (6.73%). The district of North 24 Parganas (96.02%) had the highest availability of water at handwashing facilities, followed by Koch Bihar (94.65%) and Nadia (96.22%). But Purulia (37.77%) had the lowest availability of water at handwashing facilities. Additionally, the availability of soap or detergent in households was the greatest in Kolkata (78.50%), followed by North 24 Parganas (70.99%) and Darjeeling (68.84%), whereas Purulia had the lowest facilities in terms of all WASH key indicators.

Socio-economic and demographic factors affecting household access to improved drinking water

In West Bengal, 93.30% of households have access to improved sources of drinking water (Table 4). The results showed that female-headed households were 6% less likely to have access to improved sources of drinking water in comparison

Table 2 | Access to and coverage of WASH facilities in households of West Bengal

Improved sources of drinking water				**Location of drinking water**	
Within Premises (33.69%)		*Outside Premises (3.22%)*		*Within Premises (43.78%)*	
Public tap	5.20%	Protected Spring	0.38%	In own dwelling	13.42%
Tube well or bore well	27.35%	Piped to neighbor	2.46%	In own yard/plot	30.36%
Protected well	0.62%	River/Dam/Lake/Ponds/Canal/Stream	0.38%	Elsewhere	56.22%
Packaged water	0.52%				
Types of improved sanitation facilities				**Location of Sanitation facilities**	
Sanitation Within Premises (74.35%)		*Sanitation outside of Premises (14.88%)*		*Within Premises (93.19%)*	
Flush or pour flash		Open defecation	14.60%	In own dwelling	35.40%
		Other	0.28%	In own yard/plot	57.79%
Piped sewer	2.78%			Elsewhere	6.81%
Septic tank	34.54%				
Pit latrine	23.87%			**Types of drainage facilities**[a]	
Other	0.12%				
				Open and closed (37.41%)	
Pit latrine					
				Closed drainage	11.19%
Ventilated improved	1.14%			Open drainage	26.22%
Slab or ventilated	10.24%			Drain to soak the pit	3.24%
Without a slab or open pit	1.66%			No drainage	59.36%

Note: [a]Types of drainage facilities (open and closed) are considered as WASH parameters.

to male-headed households. Compared with households with no education level, primary 30%, secondary 31%, and higher educational status 28% were less likely to have access to improved sources of drinking water. Furthermore, in comparison with the poorest households, poorer 11%, middle-income 47%, richer 70%, and richest households 68% were less likely to have access to improved sources of drinking water. Compared with 1-member households, the likelihood of access to improved sources of drinking water was 1.06 times for 2–5-member households, 1.22 times for 6–10-member households, and 1.69 times for more than >10-member households. The households in urban areas were 1.37 times more likely to have access to improved sources of drinking water in comparison to rural households. As compared with unmarried-headed households, married households were 1.21 times more likely to have access to improved drinking water, widowed households were 1.35 times more likely, and separated households were 1.10 times more likely to have access to improved sources of drinking water. Female-headed divorced households were 29% less likely to have access to improved sources of drinking water. Compared with households with access to improved sources of drinking water within 30 min, those with access to improved sources of drinking water after 30 min were 89% less likely to have improved sources of water. Households that were semi-Pucca and Pucca were 1.43 times, and 1.40 times more likely to have access to improved sources of water than Kachha households. Moreover, non-nuclear households were 1.14 times more likely to have access to improved sources of drinking water compared with nuclear households (Table 5).

Socio-economic and demographic factors affecting household access to improved sanitation facilities

The proportion of households that had access to improved sanitation facilities was 82.75% in West Bengal (Table 4). Female-headed households were 1.12 times more likely to have access to improve sanitation facilities compared with male-headed households. As compared with households having no education, households with primary education, secondary education, and higher education were 1.36, 1.41, and 1.39 times more likely to have access to improved sanitation, respectively. Compared with the poorest households, poorer 4.52, middle-income 13.57, richer 62.14, and richest $3.18 \times 10^{+08}$ times more likely

Table 3 | Present status of households' WASH services

Districts	Access to improved water	Access to improved sanitation	Access to water in own dwelling	Time to get water (<30 min)	Prevalence of open defecation	Households shared sanitation facilities	Water at the handwashing facilities	Availability of soap
Alipurduar	NA	NA	NA	NA	NA	NA	NA	NA
Bankura	97.36%	59.18%	13.97%	96.04%	11.89%	3.16%	52.73%	34.11%
Birbhum	97.17%	66.01%	11.13%	97.60%	11.53%	3.99%	57.51%	32.47%
Dakshin Dinajpur	91.96%	87.50%	8.85%	93.75%	3.49%	3.33%	91.95%	55.16%
Darjiling	86.98%	95.70%	15.50%	95.29%	1.00%	3.19%	89.07%	68.84%
Haora	91.81%	95.24%	9.37%	94.57%	1.57%	6.73%	85.63%	61.22%
Hooghly	96.26%	91.24%	17.30%	98.48%	1.85%	5.17%	75.39%	47.29%
Jalpaiguri	91.43%	85.19%	19.95%	96.33%	4.78%	4.37%	91.05%	63.96%
Jhargram	NA	NA	NA	NA	NA	NA	NA	NA
Kalimpong	NA	NA	NA	NA	NA	NA	NA	NA
Koch Bihar	96.16%	93.56%	24.62%	94.58%	1.49%	6.45%	94.65%	59.72%
Kolkata	93.15%	95.96%	16.92%	97.87%	1.24%	8.67%	91.55%	78.50%
Maldah	90.82%	86.30%	25.62%	92.22%	3.90%	7.67%	79.11%	46.62%
Murshidabad	93.39%	88.45%	13.66%	96.52%	2.89%	6.17%	82.93%	41.92%
Nadia	88.02%	92.99%	7.26%	89.94%	1.20%	4.96%	92.62%	60.51%
North Twenty-Four Parganas	90.50%	95.74%	7.65%	93.78%	0.40%	4.82%	96.02%	70.99%
Paschim Barddhaman	94.70%	82.64%	11.22%	96.17%	5.90%	2.98%	65.59%	48.24%
Paschim Medinipur	97.00%	70.14%	7.73%	97.84%	8.96%	3.40%	81.38%	45.07%
Purba Barddhaman	97.69%	82.70%	18.21%	97.69%	4.86%	6.59%	72.05%	47.31%
Purba Medinipur	94.52%	86.63%	9.16%	94.92%	1.16%	5.13%	67.63%	34.74%
Purulia	88.12%	34.68%	4.95%	89.31%	21.20%	1.60%	37.77%	18.30%
South Twenty-Four Parganas	94.99%	93.86%	6.46%	96.02%	1.53%	8.01%	76.48%	52.20%
Uttar Dinajpur	94.51%	74.51%	18.44%	97.25%	9.16%	3.61%	86.43%	40.34%

NA, Data not available.

to have access to improved sanitation facilities. Compared with households with 1 member, households with 2–5 members, 6–10 members, and more than 10 members were 0.97, 0.92, and 0.66 times less likely to have access to improved sanitation facilities. Urban households were 1.08 times more likely to have access to improved sanitation facilities compared with rural households. As compared with unmarried-headed households, married-headed households were 1.22 times more likely to have access to improved sanitation, and widowed households were 1.35 times more likely to have access to improved sanitation. Furthermore, divorced and separated households were 29 and 13% less likely to have an access to improved sanitation facilities. Compared with households with access to improved sources of drinking water within 30 min, those with access to improved sources of water after 30 min were 36% less likely to have access to improved sanitation. Households that were semi-Pucca and Pucca were 1.43 times, and 1.40 times more likely to have access to improved sanitation than Kachha households. In addition, non-nuclear households were 1.14 times more likely to have access to improved sources of sanitation facilities than nuclear households (Table 6).

DISCUSSION

The study showed that groundwater was the primary source of drinking water for the majority of households in West Bengal. Furthermore, access to improved sources of drinking water was the highest in Purba Bardhaman (97.69%) and the lowest in Purulia (88.12%). Meanwhile, 56.22% of households reported that their primary drinking water source was located 'elsewhere', and 59.36% reported that their premises lacked drainage facilities. According to the study, 14.60% of households

Table 4 | Socio-economic characteristics of the study participants of households in West Bengal

Variables	Categories	Frequency	%
Sources of drinking water	Improved water	16785	93.3
	Unimproved water	1206	6.7
Sanitation facilities	Improved sanitation	14,828	82.75
	Unimproved sanitation	3,090	17.25
Sex of household head	Male	15,063	84.07
	Female	2,855	15.93
The educational level of the household head	No education	4,912	27.45
	Primary	4,570	25.54
	Secondary	6,928	38.71
	Higher	1,487	8.31
Wealth Index	Poorest	6,350	35.48
	Poorer	4,637	25.91
	Middle	3,191	17.83
	Richer	2,425	13.55
	Richest	1,294	7.23
No. of household members	1	692	3.87
	2–5	14,122	78.91
	6–9	2,972	16.61
	>10	111	0.62
Place of residence	Rural	5,381	30.07
	Urban	12,516	69.93
Current marital status	Never married	472	2.64
	Married	15,214	85.03
	Widowed	2,047	11.44
	Divorced or separated	36	0.2
	Separated	123	0.69
Time to get drinking water	<30 min	16,630	95.31
	>30 min	818.00	4.69
Household types (defined NFHS 2 and 3)	Kachha	815	4.94
	Semi-Pucca	6,704	40.66
	Pucca	8,970	54.4
Household structure	Nuclear	10,267	58.84
	Non-nuclear	7,181	41.16

in the state still practice open defecation. As a result, households need WASH services in order to maintain their overall health and well-being (Kanyangarara *et al.* 2021). In India, open defecation is very common, especially in the eastern part of the country including West Bengal; and rural households lack access to clean drinking water, both of which pose serious health risks (Chaudhuri *et al.* 2018). In the study, it was found that Kolkata city had better access to and coverage of combined WASH services. Therefore, the city ranked top in WASH services, and higher performance was observed in SDG 6 (Sau 2017). Moreover, future studies should focus on the urban poor in order to accurately portray the state of WASH services in the city.

This study examined how sociodemographic variables influenced access to WASH services in West Bengal, including access to drinking water, sanitation, and hygiene. It is observed that lack of access to WASH services is negatively affecting the health of people in the state. Therefore, this study will be useful in highlighting the current state of WASH services in West Bengal to formulate micro-scale policies and programs.

Children and adolescent girls are more likely to contract fecal contamination from poor sanitation facilities. Poor WASH services also lead to a 10% burden of global diseases (Prüss-Üstün *et al.* 2008). While many people in rural areas of West Bengal died of diarrhea, the prevalence of open defecation may contribute to more fecal contamination and other diseases (Figure 3). Thus, access to hygienic sanitation facilities is essential. Bawankule *et al.* (2019) reported that children whose

Table 5 | The ordered logistics regression model of household-level variables on improved sources of drinking water in West Bengal

	Model I AOR (95% CI)	Model II AOR (95% CI)	Model III AOR (95% CI)
Sex			
Male®	1.00		1.00
Female	0.90 (0.74–1.11)		0.94 (0.75–1.18)
Education Level			
No Education®	1.00		1.00
Primary	0.70 (0.59–0.84)***		**0.70 (0.55–0.80)*****
Secondary	0.73 (0.62–0.86)***		**0.69 (0.57–0.82)*****
Higher	0.76 (0.60–0.97)**		0.72 (0.56–0.93)
Wealth Index			
Poorest®	1.00		1.00
Poorer	0.88 (0.74–1.04)***		0.89 (0.75–1.05)
Middle	0.52 (0.43–0.62)***		**0.53 (0.44–0.64)*****
Richer	0.28 (0.22–0.34)***		**0.30 (0.24–0.36)*****
Richest	0.29 (0.23–0.39)***		**0.32 (0.24–0.42)*****
Household Members			
1®	1.00		1.00
2–5	0.99 (0.75–1.36)		1.06 (0.74–1.50)
6–10	1.18 (0.84–1.69)		1.22 (0.82–1.81)
> 10	1.78 (0.73–4.32)**		1.69 (0.66–4.30)
Place of Residence			
Rural®	1.00		1.00
Urban	1.43 (1.23–1.65)***		**1.37 (1.18–1.61)*****
Current Marital Status			
Unmarried®	1.00		1.00
Married	1.23 (0.89–1.70)		**1.21 (0.86–1.71)****
Widowed	1.39 (0.96–2.03)		**1.35 (0.90–2.03)*****
Divorced	0.98 (0.28–3.33)		0.71 (0.21–2.42)
Separated	1.07 (0.50–2.22)		1.10 (0.50–2.40)
Time to Fetch Water			
< 30 min®		1.00	1.00
> 30 min		0.50 (0.38–0.66)***	**0.11 (0.06–0.14)*****
House Types#			
Kachha®		1.00	1.00
Semi-Pucca		1.21 (0.87–1.69)	**1.43 (1.02–2.00)****
Pucca		0.61 (0.44–0.83)***	1.40 (0.97–2.02)
House Structure			
Nuclear®		1.00	1.00
Non-Nuclear		1.16 (1.02–1.31)**	1.14 (0.99–1.31)
Model Fit Statistics	Model I	Model II	Model III
Log-likelihood	−4,777.45	−4,421.46	−4,283.85
Deviance	9,555.90	8,842.92	8,567.70

(*Continued.*)

Table 5 | Continued

	Model I AOR (95% CI)	Model II AOR (95% CI)	Model III AOR (95% CI)
Likelihood Ratio Test (LRT)	LRT chi2 (2) = **987.24*****	LRT chi2 (16) = **275.22*****[@]	

Note: AOR, adjusted odds ratio; CI, confidence interval (Significance at *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$).
[®] Reference Category; Model I: Household-level six socio-economic variables; Model II: Three household-level variables; Model III: Combined all models.
[#] House types have been defined in NFHS-2 and NFHS-3.
[@] Likelihood Ratio Test (LRT) of Model II and Model III (Assumptions: Model I and II nested in Model III): The test excluded the house type's variable to maintain balance in sample sizes.
Bold values are significant at $p < 0.05$ and $p < 0.001$.

Table 6 | The ordered logistics regression model of household-level variables on improved sanitation facilities in West Bengal

	Model I AOR (95% CI)	Model II AOR (95% CI)	Model III AOR (95% CI)
Sex			
Male[®]	1.00		1.00
Female	1.01 (0.86–1.17)		1.12 (0.87–1.18)
Education Level			
No Education[®]	1.00		1.00
Primary	1.36 (1.22–1.51)***		**1.36 (1.23–1.51)*****
Secondary	1.41 (1.26–1.57)***		**1.41 (1.27–1.57)*****
Higher	1.36 (0.99–1.92)**		1.39 (0.99–1.93)
Wealth Index			
Poorest[®]	1.00		1.00
Poorer	4.52 (0.74–1.04)***		**4.52 (4.07–5.02)*****
Middle	13.54 (11.15–16.42)***		**13.57 (11.18–16.47)*****
Richer	61.53 (39.28–96.39)***		**62.14 (39.66–97.36)*****
Richest	$3.17 \times 10^{+08}$ ($2.65 \times 10^{+08}$–$3.80 \times 10^{+08}$)***		**$3.18 \times 10^{+08}$ ($2.65 \times 10^{+08}$–$3.80 \times 10^{+08}$)*****
Household Members			
1[®]	1.00		1.00
2–5	0.99 (0.84–1.24)		0.97(0.77–1.21)
6–10	0.97 (0.77–1.24)		0.92 (0.72–1.19)
> 10	0.72 (0.38–1.36)		0.66 (0.34–1.27)
Place of Residence			
Rural[®]	1.00		1.00
Urban	1.10 (0.93–1.24)***		**1.08 (0.93–1.25)*****
Current Marital Status			
Unmarried[®]	1.00		1.00
Married	1.19 (0.91–1.56)		1.22 (0.93–1.60)
Widowed	1.15 (0.85–1.55)		1.35 (0.85–1.55)
Divorced	0.73 (0.32–1.65)		0.71 (0.31–1.61)
Separated	0.87 (0.51–1.45)		0.87 (0.51–1.45)
Time to Fetch Water			
< 30 min[®]		1.00	1.00
> 30 min		0.50 (0.38–0.66)***	**0.64 (0.53–0.79)*****

(*Continued.*)

Table 6 | Continued

	Model I AOR (95% CI)	Model II AOR (95% CI)	Model III AOR (95% CI)
House Types[#]			
Kachha[®]		1.00	1.00
Semi-Pucca		1.21 (0.87–1.69)	**1.43 (1.02–2.00)****
Pucca		0.61 (0.44–0.83)***	1.40 (0.97–2.02)
House Structure			
Nuclear[®]		1.00	1.00
Non-Nuclear		1.16 (1.02–1.31)**	1.14 (0.99–1.17)
Model Fit Statistics	Model I	Model II	Model III
Log-likelihood	−6,626.85	−6,618.82	−6,507.01
Deviance	13,253.70	13,237.64	13,014.02
Likelihood Ratio Test (LRT)	LRT chi2 (2) = **23.88*****	LRT chi2 (16) = **3603.62***[@]	

Note: AOR, adjusted odds ratio; CI, confidence interval (Significance at *$p < 0.10$; **$p < 0.05$; ***$p < 0.001$).
[®] Reference Category; Model I: Household-level six socio-economic variables; Model II: Three household-level variables; Model III: Combined all models.
[#] House types have been defined in NFHS-2 and NFHS-3.
[@] Likelihood Ratio Test (LRT) of Model II and Model III (Assumptions: Model II nested in Model III): The test excluded the house type's variable to maintain a balance in sample sizes.
Bold values are significant at $p < 0.05$ and $p < 0.001$.

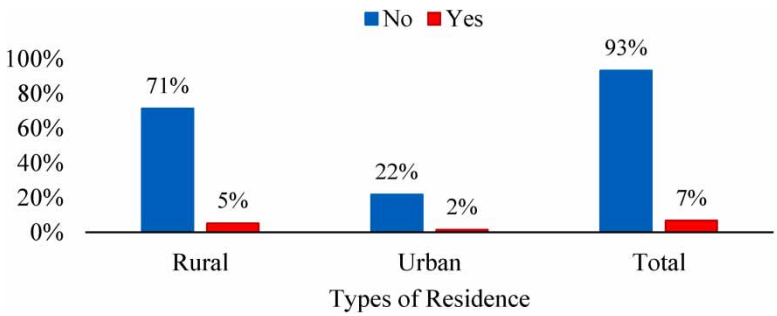


Figure 3 | The prevalence of diarrhea among children in West Bengal.

stools were disposed of in an unsafe manner and who did not have access to improved handwashing facilities were more likely to get bloody diarrhea. In order to tackle these serious problems, targeted public health interventions will be needed. Moreover, the state administration is running a project with various stakeholders to ensure access to improved WASH services in Purba Barddhaman, Bankura, and Hooghly. Moreover, it promotes hygiene among young girls and women, and its completion will improve the quality of life in the respective districts (PTI 2022). According to the results, Purba Bardhhaman (97.69%) had higher access to improved drinking water sources at the household level. This is due to the fact that the majority of the areas are located in medium to high groundwater potential zones. Meanwhile, Kolkata has the better sanitation and hygiene facilities due to 24-h access to water. In addition, the city also receives financial assistance from various government agencies to build new sanitation facilities. Purulia, however, ranked lowest in all key indicators of WASH (Asian Development Bank 2017; Kar *et al.* 2020), including a high prevalence of open defecation. Moreover, even urban areas in Purulia were far behind in achieving ODF status in the country (Purulia India's Only Urban Area yet to Achieve ODF Status 2021).

Furthermore, results showed that access to improved drinking water in the Nadia district was inadequate. A past study found that the majority of the area in Nadia district is contaminated with arsenic, which is affecting the quality of drinking water. Furthermore, the study also stated that prolonged exposure to arsenic causes skin lesions and adversely affects human health. Moreover, groundwater contamination with arsenic affects the quality of improved drinking water (Mazumder *et al.*

2010). In order to minimize the effects of arsenic in the district, the authors recommend the use of alternative sources such as potable water, rainwater harvesting, and deep tube wells.

In addition, results of the study revealed that Purulia ranked last in terms of access to water and soap for hand washing. In previous studies, it has been shown that access to water and soap is key to maintaining good health and preventing diarrhea and diarrhoeal diseases. Furthermore, these studies show that handwashing with plain water and soap reduced bacterial load by 8% (Burton *et al.* 2011). Therefore, handwashing awareness programs in the state are urgently needed. In order to address these issues, a micro-scale policy is necessary based on regional heterogeneity in West Bengal. As an additional measure, alternative sources of water (rainwater harvesting, potable water, and extra deep tube wells) can be used to minimize the effects of arsenic. On the other hand, the effects of arsenic on health can be minimized through public awareness and regular monitoring of shallow tube wells. Future studies should focus on access to and coverage of WASH services at a micro level in order to frame effective policies. Moreover, special attention is needed for Purulia district due to its low scores on combined WASH services.

CONCLUSION

Arsenic-contaminated drinking water, unhygienic sanitation facilities, and a lack of handwashing practices adversely affect human health. Therefore, improving access to WASH services is essential for people's health and well-being. The successful implementation of the Asian Development Bank's clean water project in arsenic, fluoride, and salinity-affected areas of West Bengal will help reduce health risks. The availability, affordability, and access to improved WASH services are all dependent on the successful and long-term implementation of various schemes. In order to achieve Sustainable Development Goal 6 (SDG 6) by 2030, it is imperative to effectively implement these ongoing schemes and collaborate with international and local authorities.

DATA AVAILABILITY STATEMENT

All relevant data are available from an online repository or repositories (https://dhsprogram.com/data/dataset/India_Standard-DHS_2020.cfm?flag=1).

CONFLICT OF INTEREST

The authors declare there is no conflict.

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