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Assessing water, sanitation and hygiene (WASH) practices and their association with diarrhoea in under-five children in urban Chandernagore: Community-based evidence from a small municipal corporation in Hooghly District of West Bengal, India

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ABSTRACT

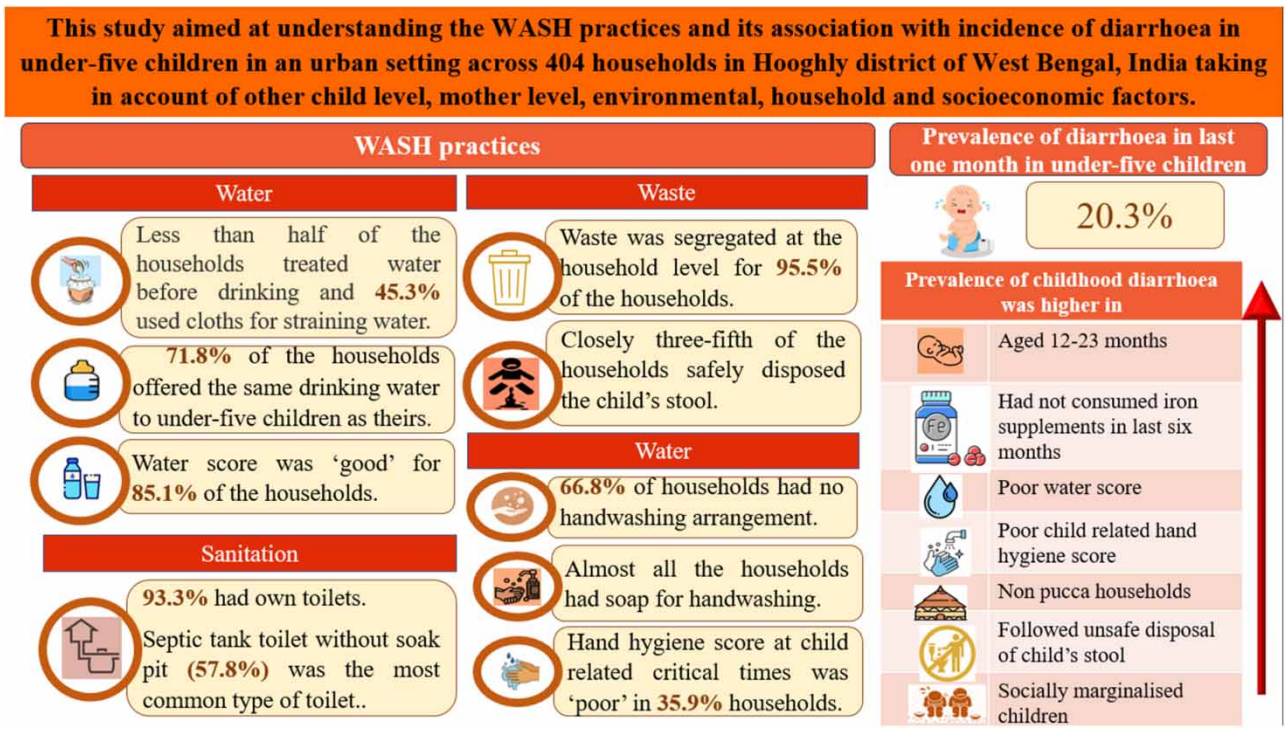
The study aims to understand the relationship of childhood diarrhoea (under-five children) with water, sanitation and hygiene factors in the light of other contextual factors in an urban setting in the district of Hooghly in West Bengal, India. This primary study was carried out by SIGMA Foundation, Kolkata from 4 to 24 January 2023 across 404 households having at least one under-five child. The findings suggested that the water score was 'good' in 85.1% of the households whereas the hand hygiene score was 'good' in 14.6% of households. More than 90% of the households had piped water supply. Less than half of them treated water before consumption among which 45.3% used cloths for straining water; 59.2% of the caregivers followed safe disposal of child's faeces; 66.8% of households had no handwashing arrangement, and 30.5% had taps and wash basins for handwashing; 20.3% of the under-five children had suffered from diarrhoea in the last month before the survey and its prevalence was higher in children aged 12–23 months. Multivariate results suggested diarrhoea prevalence was lower in households that were pucca and had good water and hand hygiene scores, lower in children that had received iron fortification and whose caregivers followed safe child's stool disposal.

Key words: childhood diarrhoea, India, urban, WASH factors

HIGHLIGHTS

- Occurrence of diarrhoea in under-five children was linked to WASH practices in the urban setting of the Hooghly district of West Bengal, India.
- Although most of the households had piped water supply, proper sanitation facilities and waste segregation, their handwashing practices at child-related critical times were not adequate.

GRAPHICAL ABSTRACT



1. INTRODUCTION

Diarrhoea, a preventable disease, is a significant population health hazard and ranks as the second leading common cause of death among children under the age of five (WHO 2017). In developing countries, on average, a child under the age of five years experiences three episodes of diarrhoea each year (Black *et al.* 2010). In response to this pressing issue, sustainable development goal (SDG)-3 targets to end preventable deaths of under-five children by 2030.

Previous research has identified a complex interplay of higher incidence of diarrhoeal disease among under-five children in low- and middle-income countries and is associated with a multifaceted mix of many sociodemographic, environmental and behavioural factors. Socioeconomic factors such as children's age, place of residence, type of household, maternal education and household economic condition are key predictors of diarrhoeal incidence in under-five children (Mohammed & Tamiru 2014; Sarker *et al.* 2016; Asfaha *et al.* 2018; Zedie & Kassa 2018; Melese *et al.* 2019; Paul 2020; Vijayan & Ramanathan 2020; Saha *et al.* 2022). Moreover, positive behavioural practices, including appropriate breastfeeding nutritional status, and proper hygienic practices have been associated with a significant reduction in childhood diarrhoea (Simiyu 2010; Badowski *et al.* 2011; Jayalakshmy *et al.* 2011; Kumar & Subitha 2012; Gupta *et al.* 2015; Kumari *et al.* 2021; Solomon *et al.* 2021). However, the incidence of diarrhoea did not significantly vary in underweight or stunted under-five children with well-nourished children (Anand *et al.* 1994; Jayalakshmy *et al.* 2011). Additionally, factors such as birth weight and immunization coverage have been identified as crucial predictors of diarrhoea incidence in children under five (Stanly *et al.* 2009; Lakshminarayanan & Jayalakshmy 2015; Dhami *et al.* 2020).

Improved sanitation and hygienic practices can avert 3,61,000 deaths annually in under-five children (WHO 2016). These practices also yield a substantial economic return, with an average of four dollars in profit for every dollar invested (Whittington 2015). Earlier research has demonstrated that safe disposal of children's faeces, handwashing with soap and water at critical times and safe treatment and storage of drinking water are effective ways in reducing diarrhoeal diseases (WHO 2017). Factors leading towards childhood diarrhoea are compounded by a lack of easy access to clean water and awareness towards WASH practices (Shrestha *et al.* 2013; Bin Mohanna & Al-Sonboli 2017; Getachew *et al.* 2018; Musoke *et al.* 2018; Yaya *et al.* 2018; Edward *et al.* 2019; Melese *et al.* 2019; Solomon *et al.* 2021). Diarrhoea also contributes to 54–65% of all deaths due to inadequate access to safe drinking water (35%), poor sanitation (31%) and poor hygiene (12%).

This subsequently culminates in 829,000 deaths annually in low- and middle-income countries (Prüss-Ustün *et al.* 2019). Figure 1 presents a conceptual framework based on these findings.

Despite numerous interventions and schemes to control diarrhoeal deaths in India, childhood diarrhoea prevails at an alarming rate in the country. It is responsible for 13% of deaths in under-five children claiming the lives of an estimated 300,000 children in India annually (Million Death Study Collaborators 2010). According to the National Family Health Survey (2019–2021), the prevalence of diarrhoea in under-five children with a reference of 2 weeks prior to the surveys stands at 9.2%, with a burden of 6.2% in the urban areas (IIPS & ICF 2020). The prevalence of diarrhoea is higher in the central and eastern regions of the country, particularly in rural areas (Ghosh *et al.* 2021).

A previous study delineated that between 1990 and 2017, improvements in sanitation and increased access to safe water led to a 21.8% reduction in diarrhoea mortality rates in India (Troeger *et al.* 2020). While several small-scale studies have been conducted in rural areas to understand factors associated with childhood diarrhoea, only a handful of studies have focused on urban settings and their association with WASH-related factors (Qazi *et al.* 2015; Mohd & Malik 2017; Patel *et al.* 2020; Wani *et al.* 2022). Considering this, our study aims to investigate WASH practices and their association with the incidence of diarrhoea in children under five in a small Municipal Corporation town in the Hooghly district of West Bengal, India, while accounting for other factors related to children, mothers, the environment, households and socioeconomic conditions.

2. DATA AND METHODS

This current study is based on a primary survey conducted by SIGMA Foundation, Kolkata with the mothers (aged between 18 and 44 years) of under-five children in the urban areas of Chandernagore Municipal Corporation (CMC) located in

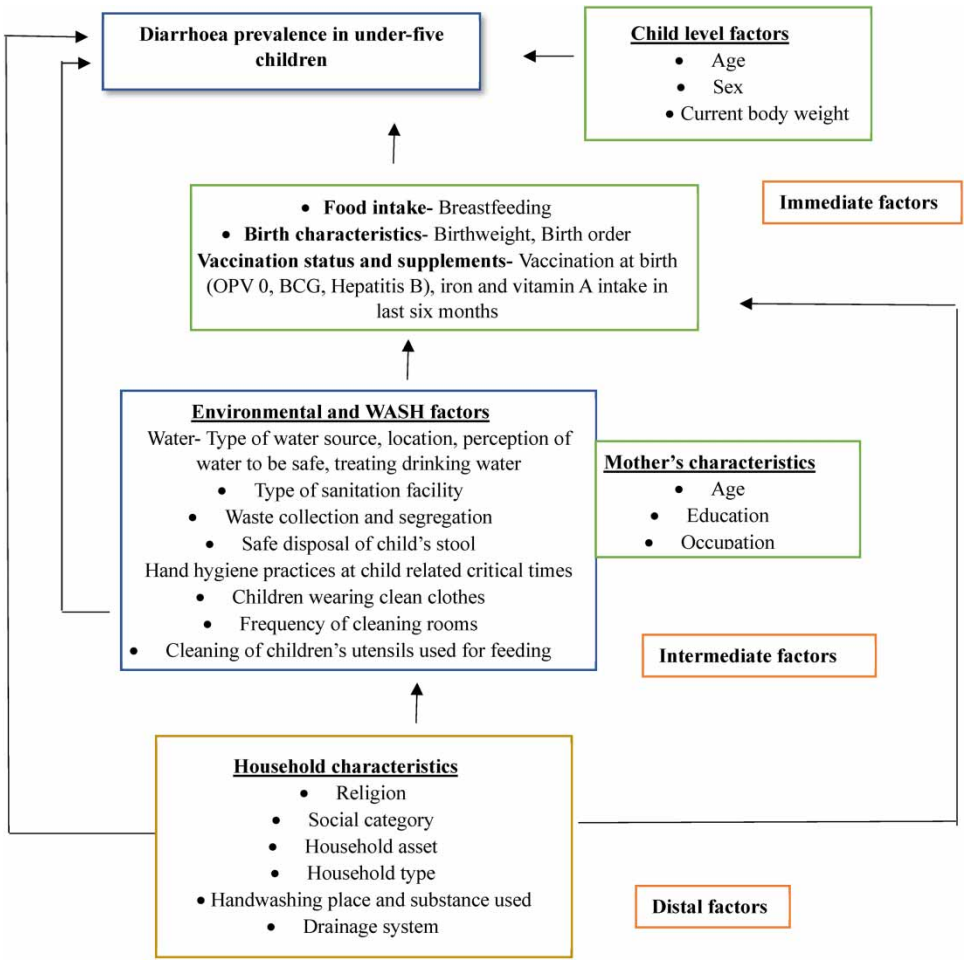


Figure 1 | Conceptual framework to determine the predictors of diarrhoea in under-five children.

Chandannagar subdivision of Hooghly district, West Bengal. SIGMA Foundation, Kolkata which is a not-for-profit organization working extensively on various domains such as social and economic development, child rights and protection, health and nutrition (including perinatal health, adolescent health), education, poverty alleviation and livelihood, WASH (Water, Sanitation and Hygiene) and governance. For more information, the link can be accessed (https://sigma.foundation/).

2.1. Study area and study period

The fieldwork for this cross-sectional study was conducted between 4 and 24 January 2023 in CMC which is in the Chandannagar subdivision of Hooghly district, West Bengal which is a small Municipal Corporation with a total of 33 wards. In this context, CMC is called a small Municipal Corporation based on its geographic area, administrative structure and population served, which are all lower than most of the remaining six municipal corporations in West Bengal (Government of West Bengal 2023).

2.1.1. Background of Chandernagore municipality

Chandannagar was established as a French colony in 1673 and the city had become independent of French Rule in 1948. It is located by the side of the Hooghly River, 37 km away from Kolkata. At present, CMC is governed by the West Bengal Municipal Corporation Act, 2006. CMC is one of the seven municipal corporations spread over an area of 22.03 km^2 and divided into 33 wards. Each ward elects its own ward councillor, who elects the Mayor and other Council Members who govern the city. The total population of CMC as per the latest Census was 166,867 (Census of India 2011). The total slum population of CMC is around 36,979, which is around 22.16% of the total population of the city (Census of India 2011). Herein, slum refers to a densely populated, impoverished and often overcrowded area with a city or an urban area characterized by substandard housing, inadequate living conditions and lack of basic amenities and services. Like any other urban local body (ULB) which refers to a form of local government or local authority that is responsible for governing and managing urban areas such as cities or towns, CMC has several public health issues many of which are preventable with good WASH practices and taking other precautionary measures. The city was affected more during the COVID-19 pandemic as compared to the rest of the state. While the total persons infected by COVID-19 and the number of deaths in West Bengal was 2.18 million and 21,531[1], respectively, the corresponding figures of CMC are 6,667 and 188, respectively[2]. Thus, taking the population for the year 2011, the incidence of people who suffered from COVID in West Bengal (population 9.13 billion) and CMC comes to 2.35 and 3.99, respectively. The death rate per million population was 2.3.6 and 11.3, respectively, in West Bengal and CMC. Therefore, such cities are less equipped with emergency responses to epidemics/other public health emergencies.

2.1.2. Sampling strategy

For this primary study, quantitative data were collected from the households distributed across all 33 wards of CMC, the numbers of which were selected based on probability proportional to the size sampling (PPS) technique from each ward (see Supplementary Information).

2.1.3. Sample size

Based on the population size of 166,867 (Census of India 2011) in CMC and taking population proportion as 50%, 95% confidence interval with a 5% margin of error, the sample size for the quantitative survey would be 384. However, data were collected from some extra households and those with good quality were retained. For this current household study, the sample size of the households was 404.

2.1.4. Development of survey tools

A structured questionnaire was developed for the quantitative interviews with the mothers at the household level which consisted of close-ended questions. All the survey tools were developed by the SIGMA Foundation. The tools were pre-tested in the field and the changes were made based on the findings of the pre-test survey. The survey tools were developed in English and upon finalization were translated to Bengali.

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[1] https://www.mygov.in/corona-data/covid19-statewise-status

[2] Data collected from Health Officer, CMC on 16.11.2022

2.1.5. Data management and analysis

The field data were collected using computer-assisted personal interviews (CAPI) and stored electronically which were regularly monitored and data cleaning was administered in the case of illogical answers or missing data. KoboCollect software (https://www.kobotoolbox.org/) was used for conducting the interviews with the mothers. For the data analysis, the software Stata 16 was used. Descriptive analysis, bivariate analysis, specific tests, and computing of specific indices were administered in the study. For the multivariate analysis, binary logistic regression was used for the purpose.

2.2. Variables used in the study

2.2.1. Dependent variable

The primary dependent variable of the study was the prevalence of diarrhoea (Yes = 1, No = 0) in under-five children in the last one month prior to the survey. The World Health Organization (WHO) definition of diarrhoea was used in this study (WHO 2005). Acute diarrhoea was defined as the passage of three or more abnormally loose, watery stools in 24 h and lasting up to 14 days and chronic diarrhoea was defined as lasting more than 14 days along with those symptoms.

2.2.2. Independent variables

Table 1 presents the details of the variables used in the study. The variables were selected based on the conceptual framework proposed in Figure 1. The independent variables were classified as **Immediate factors, Intermediate factors** and **Distal factors**. The **Immediate factors** consisted of (i) Child-level factors, such as age, sex and current body weight and (ii) Food intake (breastfeeding initiation and current breastfeeding practices), birth characteristics such as birth weight and birth order, vaccination received at birth (BCG vaccine for tuberculosis, Hepatitis B and Oral poliovirus (OPV 0) were considered) and supplements such as iron and Vitamin A received in the last six months. If a child received all three vaccines at birth, it was classified as 'received all' else 'did not receive all'.

The **intermediate factors** consisted of Environmental and WASH factors and Mother's characteristics. The Environment and WASH factors were based on water, sanitation, hygiene and waste issues. The water factor was studied based on the following variables: (i) water source, (ii) location of water source, (iii) mode of water storage, (iv) perception of drinking water to be safe for consumption, (v) treatment of drinking water, (vi) method of treating drinking water, (vii) storage of drinking water, (viii) storage container having a lid to cover it, (ix) storage container having a big enough opening to dip a cup, (x) whether children drink the same water as other family members. The sanitation facility consisted of the type of toilet present in the household. For understanding the hygiene factor, the following were used: (i) handwashing with soap and water at child-related critical times in the last 24 h, (ii) frequency of cleaning rooms in which the child stayed the maximum in the last 24 h, (iii) frequency of clothes changed by the child in the last 24 h, (iv) frequency of cleaning utensils used for feeding children and (v) substance used for cleaning utensils used for feeding children. For the child-related critical times, handwashing before feeding, after cleaning the child's bottom and before cooking was considered. For understanding the waste factor, (i) waste collection by whom, (ii) frequency of waste disposal, (iii) waste segregated at home was used. Further, the mode of safe disposal of a child's stool (based on the last time the child passed stool) was also studied. A child's stool was considered safely disposed of if was put/rinsed into a toilet or latrine or if the child used a toilet/latrine. It was considered unsafe if the stool was put/rinsed in a drain or ditch, left in the open or thrown in the garbage.

The mother-level factors that were included were her age, highest educational qualification and occupation.

The **distal factors** that were considered in the study were the household-level factors such as (i) religion, (ii) social category, (iii) household asset, (iv) household type, (v) handwashing facility and substance used for handwashing, (vi) drainage system and (vii) monthly per capita expenditure of the household.

2.3. Asset index

An index was created based on the availability of different assets possessed by the sampled households which are as follows: Electricity, Radio/Transistor, Television, Refrigerator, Ordinary Mobile Phones, Smart Phones, Computer (Desktop/Laptop), Bicycle, Motorcycle, Air conditioner/cooler and four-wheeler. For constructing the index, a value of '1' was given if the item mentioned above was present and '0' otherwise. The total score was summed up and divided by the total number of indicators so that our index lay between 0 and 1. The asset index was classified as 'high' if the score was above 0.7, 'medium' if the score was between 0.5 and 0.7 and 'low' if the score was below 0.5.

Table 1 | Variables used in the study

Variables	Categories and values assigned
Child level factors	
Age	Below 12 months – 1; 12–23 months – 2; 24–59 months – 3
Sex	Female – 1; Male – 2
Current body weight	Underweight – 1; Not underweight – 2
Child-related immediate factors	
Prevalence of diarrhoea in children in the last one month	No – 0; Yes – 1
Number of episodes of diarrhoea in the last one month	1, 2, 3 +
Duration of ailment during last episode	Upto 2 days – 1; 3–4 days – 2; Beyond 4 days – 3
Iron consumption in last six months	No – 0; Yes – 1
Vitamin A consumption in last six months	No – 0; Yes – 1
Birth order	1, 2 +
Vaccinations received at birth	Did not receive all – 0; Received all – 1
Initiation of breastfeeding after birth	Immediately/within an hour – 1; After more than 1 h – 2
Currently breastfeeding	No – 0; Yes – 1
Mother-level factors	
Age of mother	18–24 years – 1; 25–34 years; 35–44 years – 3
Highest educational level of mother	Upto primary – 1; Upto secondary – 2; Upto higher secondary – 3; More than higher secondary – 4
Occupation of mother	Housewife – 1, Working – 2
WASH-related factors	
Water score	Good – 1; Poor – 2
Water source	Piped water – 1; Street stand post – 2; Others (Bottled water, Protected well, Tubewell) – 3
Location of water source	In own dwelling – 1; In own yard/plot – 2; Elsewhere – 3
Mode of water storage	Underground storage – 1; Overhead storage – 2; Bucket/mug/jug/bottles, etc. = 3
Perception of drinking water to be safe for consumption	No – 0; Yes – 1
Drinking water treated	No – 0; Yes – 1
Method of treating drinking water	Boiling – 1; Non-electric filter – 2; RO/UV filter – 3; Straining through cloth – 4
Storage of drinking water	No – 0; Yes – 1
Storage container having lid to cover it	No – 0; Yes – 1
Storage container having big enough opening to dip a cup	No – 0; Yes – 1
Whether children drink same water as other family members	No – 0; Yes – 1; Child is yet to start drinking water – 3
Sanitation facility	Pit toilet – 1; Septic tank – 2; Don't know – 99
Hand hygiene score	Good – 1; Fair – 2; Poor – 3
Washed hands at child-related critical times	Not washed – 0; Used only water – 1; Used soap/hand sanitizer – 2
Waste score	Good – 1; Poor – 2
Waste collection by whom	Collected by Urban local body (ULB) – 1; Garbage is dumped/thrown away – 2
Frequency of waste collected	Daily – 1; Alternate days – 2; Weekly – 3
Waste segregated at home	No – 0; Yes – 1
Safe disposal of child's stool	No – 0; Yes – 1

(*Continued.*)

Table 1 | Continued

Variables	Categories and values assigned
Frequency of cleaning utensils used for feeding children	Always – 1; Not always – 2
Substance used for cleaning utensils used for feeding children	Sterilized/boiled – 1; Used dishwasher – 2; Wipe with damp/dry clothes – 3
Frequency of room cleaning	1–2 times – 1, 3–4 times – 2; 4 + times – 3
Frequency of clothes changed of the baby	1–3 times – 1; More than 4 times – 2
Household-level factors	
Type of household	Pucca – 1; Non-pucca (Semi pucca and Kutcha) – 2 A 'Pucca house' is a term used in South Asian countries, particularly colloquial to India, which refers to a house or building that is constructed using permanent and durable materials such as bricks, concrete, cement, stone or other solid building materials. These houses have proper foundations, walls and roofs, providing a higher level of stability, strength and longevity compared to temporary structures ('non-pucca houses'). 'Kutcha houses' are makeshift or temporary structures made from less durable materials such as mud, thatch or bamboo. 'Semi pucca houses' refers to a dwelling that has characteristics of both pucca (a permanent and durable structure) and kutcha houses (a temporary or less sturdy structure)
Handwashing arrangement	No arrangement/at water source – 0; Tap water/Basin – 2; Others (Tubewell) – 3
Drainage system	Unimproved – 1; Improved – 2
Religion	Hindu – 1; Muslim – 2
Social category	Others – 1; Other backward classes (OBC) – 2; Scheduled caste/tribe (SC-ST) – 3 'Other Backward Classes' refers to a social category in India that are considered socially or educationally disadvantaged or backward compared to other groups. Scheduled caste and Scheduled tribe refer to two social categories that have been historically disadvantaged and marginalized in India
Asset index	Low – 1; Medium – 2; High – 3
Monthly per capita expenditure (MPCE)	Below INR 8,000 – 1, INR 8,000 – 10,000 – 2; INR10,000–15,000 – 3; INR 15,000 and above – 4
Availability of soap and alcohol-based hand sanitizer	None – 0; Only soap – 1; Only alcohol-based hand sanitizer – 2; Both – 3

2.4. Water, waste and hygiene scores

2.4.1. Water score

A variable on water factor was created based on the availability of four different factors associated with it viz., water source, location of water source, whether perceives drinking water to be safe for consumption and whether does something to make the water safe for drinking. All of these indicators were binary in nature. A score of '1' (one) was given for the water source being piped water supply and '0' otherwise. A score of '1' (one) was given for the location of water to be inside the dwelling or yard/plot and '0' otherwise. A score of '1' (one) was given if drinking water was perceived to be safe and '0' otherwise. A score of '1' (one) was given if the drinking water was treated and '0' otherwise. The water score varied from 0 to 4. It was classified as 'good' if the score was 3–4 and 'poor' if the score was 0–2.

2.4.2. Waste score

A variable on waste factor was created based on the frequency of waste collection, managing solid waste in households and waste segregation at home. All of these indicators were binary in nature. A score of '1' (one) was given if the garbage was collected by the ULB and '0' otherwise. A score of '1' (one) was given if the garbage was segregated at the household level and '0' otherwise. A score of '1' (one) was given if the garbage was collected on a daily basis and '0' otherwise. The waste score varied from 0 to 3. It was classified as 'good' if the score was 3 and 'poor' if the score was 0–2.

2.4.3. Hand hygiene score

A variable on hand hygiene practices at child-related critical times (before cooking, before feeding and after cleaning child's bottom) was created based on the handwashing practices (not washing hands, washing hands with only water, washing hands with soap and water) in the last 24 h prior to the survey. A score of '2' was given if handwashing was done with soap and water at each of the three selected critical times, and a score of '1' was administered if handwashing was done with only water at each of the three selected critical times and '0' if handwashing was not done. The hand hygiene score varied from 0 to 9. It was classified as 'good' if the score was 7–9, 'fair' if the score was 5–6 and 'poor' if the score was 0–4.

2.5. Multivariate analysis

A binary logistic regression was run to understand the predictors of the prevalence of diarrhoea in under-five children in the last one month. The dependent variable was the prevalence of diarrhoea in under-five children in the last one month (1 = Yes, 0 = No). Various child-level variables, Environment and WASH-level variables, mother-level factors and household-level factors were included as the independent variables.

3. FINDINGS

3.1. Sociodemographic and household characteristics

The present study involved 404 mothers having under-five children (0–59 months). As shown in Table 2, the highest proportion of them belonged to the age group 25–34 years (63.4%), 37.6% of the mothers had completed up to Secondary education, 18.3% had completed up to Higher Secondary whereas 33.9% had completed education beyond Higher Secondary.

3.2. Demographic characteristics of the under-five children

Around one-third of the sampled under-five children were below age one year, whereas nearly one-fifth were between four and five years old. The sample constituted 51.2% of males and 48.8% of females. More than half of the children in the age groups below six months and 4–5 years were females (Figure 2).

3.3. WASH indicators

3.3.1. Water

Table 3 presents different parameters of water indicators in the surveyed households. Nine in 10 households were connected with a piped water supply. While every ninth household used buckets, mugs, jugs and bottles to store water, 37.6% of the households had an overage storage for storing water. Nearly half of all the respondents thought that the water available to them was safe for consumption without any treatment. Thereby, less than half of them treated the water coming from the source before consumption. Of them, 45.3% used cloths for straining the water and 30.8% used an reverse osmosis/ultraviolet (RO/UV) filter before drinking the water and 90.1% of the households stored the drinking water before consumption. Nearly three-fourths of the households gave the same water to drink to the under-five children as consumed by them. Based on the scoring, the water score was 'good' for 85.1% of the households and 'poor' for the remaining 14.9%.

3.3.2. Sanitation

Out of the 404 surveyed households, 93.3% (377 households) had their own toilets whereas the remaining households shared toilets with other households (6.4%) or used community toilets (0.3%) (Figure 3). Among households having their own toilet, the most common type of toilet was septic tank toilets without soak pits (57.8%) followed by septic tank toilets with soak pits (34.8%).

3.3.3. Waste disposal

Out of the surveyed 404 households, waste was collected by the ULB in 99% of the households on a daily basis. Waste was segregated at the household level for 95.5% of the households. As per the computed waste score, it was 'good' for 94.3% of the households and 'poor' for 5.7%. As per Figure 4, almost three-fifths of the households safely disposed of the child's stool (based on the last time the child passed stool) of which the children majorly used the toilet or latrine themselves.

Table 2 | Sociodemographic and household characteristics of mothers

Background variables	Frequency (*N*)	Percentage
Mother-level characteristics		
Age of the mother		
18–24 years	107	26.4
25–34 years	256	63.4
35–44 years	41	10.2
Highest educational level of mother		
Up to primary	41	10.1
Up to secondary	152	37.6
Up to higher secondary	74	18.3
More than higher secondary	137	33.9
Occupation of mother		
Housewife	372	92.1
Working	32	7.9
Household characteristics		
Religion		
Hindu	368	91.1
Muslim	36	8.9
Social category		
Scheduled Caste/Scheduled Tribe (SC-ST)	76	18.8
Other Backward Classes (OBC)	54	13.4
Others	274	67.8
Household type		
Kutcha	15	3.7
Semi pucca	57	14.1
Pucca	332	82.2
Monthly per capita expenditure (MPCE)		
Below INR 8,000	114	28.2
INR 8,000–10,000	90	22.3
INR 10,000–15,000	120	29.7
INR 15,000 and above	80	19.8
Asset index		
Low	80	19.8
Medium	224	55.4
High	100	24.8
N	**404**	**100**

3.3.4. Hygiene practices

3.3.4.1. Availability of handwashing substances. Figure 5 shows the handwashing place and substance used for washing hands in the surveyed households. While 66.8% of the households had no arrangement for washing hands, 30.5% had an arrangement of tap and wash basin for handwashing; 52.7% of the households had only soap available at home whereas 45.8% had both soap and alcohol-based hand sanitizer.

Figure 6 presents the handwashing practices of mothers/caregivers at child-related critical times in the last 24 h. More than fourth-fifths of the mothers washed their hands with soap and water before feeding children, and half of them did so after

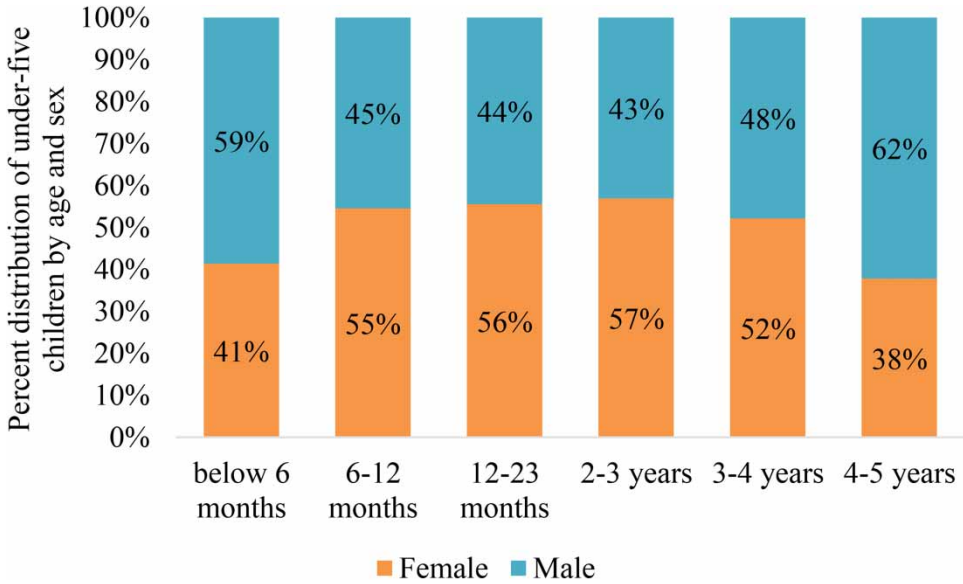

Figure 2 | Age and sex distribution (in %) of the under-five children.

cleaning the child's bottom. However, two-fifths of them washed their hands with soap and water before cooking. Overall, the hand hygiene score at the child-related critical times was 'poor' for 35.9% of the mothers/caregivers and 'good' for 14.6% of the mothers/caregivers (Figure 7).

3.3.4.2. Cleaning of utensils used for feeding children in the last 24 h. Almost all the mothers/caregivers cleaned the utensils in the last 24 h which they used for feeding children. While 70.7% of them used a dishwasher to clean the utensils, 26.7% sterilized/boiled them whereas the others wiped them with damp or dry clothes.

3.3.4.3. Frequency of cleaning rooms in which the child spent most of the time in the last 24 h. It was observed that 40.4% of the mothers or primary caregivers in the surveyed households cleaned the room once in the last 24 h in which the under-five child spent the maximum time. On the other hand, 42.1% of households cleaned twice whereas 17.5% cleaned thrice or more.

3.3.4.4. Frequency of changing clothes of the child in the last 24 h. While 22% of the children changed clothes twice in the last 24 h, 41.1% changed clothes 3–4 times and 36.9% changed clothes more than four times in the last 24 h. Almost all the children changed and wore fresh clothes.

3.3.5. Prevalence of diarrhoea in under-five children

Out of the 404 under-five children sampled, 20.3% had experienced at least one episode of diarrhoea in the month preceding the survey. While the occurrence of diarrhoea did not significantly differ between male and female under-five children, it varied significantly across different age groups (χ^2 value = 21.2, $p < 0.01$). Figure 8 illustrates this variation in diarrhoea incidence over the past month. Among children aged 12–23 months, 33.3% had experienced at least one episode of diarrhoea. This was followed by 20% of children in the age group 6–12 months and 17.7% of children aged 2–3 years. Notably, a higher percentage of female under-five children (30%) had suffered from at least two episodes of diarrhoea compared to their male counterparts (14.3%), as indicated in Table 4. However, the duration of the last diarrhoea episode was longer for males than females. Specifically, 57.5% of females experienced diarrhoea episodes lasting up to 2 days, while 38.1% of males endured episodes lasting beyond 4 days.

3.3.6. Association between diarrhoea in under-five children and WASH score, waste score and hand hygiene score

It was observed that a higher prevalence of diarrhoea in under-five children was associated with lower scores of WASH parameters (Figure 9). The prevalence of diarrhoea in under-five children in the last one month varied from 35% in households

Table 3 | Water source, storage and treatment practices of drinking water in the surveyed households

Water indicators	*N*	Percentage
Water source		
Piped water	368	91.9
Street stand post	20	5.0
Others	16	4.0
Location of water source		
In own dwelling	247	63.3
In own yard/plot	122	31.3
Elsewhere	21	5.4
Mode of water storage[a]		
Underground storage	81	20.1
Overhead storage	152	37.6
Bucket/mug/jug/bottles, etc.	378	93.6
Perception of drinking water to be safe for consumption		
No	201	49.8
Yes	203	50.2
Drinking water treated		
No	203	50.2
Yes	201	49.8
Method of treating drinking water		
Boiling	17	8.5
Non-electric filter	31	15.4
RO/UV filter	62	30.8
Straining through cloth	91	45.3
Storage of drinking water		
No	40	9.9
Yes	364	90.1
Storage container having lid to cover it		
No	1	0.3
Yes	363	99.7
Storage container having big enough opening to dip a cup		
No	72	19.8
Yes	292	80.2
Whether children drink same water as other family members		
No	50	12.4
Yes	290	71.8
Child is yet to start drinking water	64	15.8
Water score		
Poor	60	14.9
Good	344	85.1

[a]Based on multiple choice responses.

with 'poor' water scores to 18% in households with 'good' water scores. The corresponding figure for the prevalence of diarrhoea were 26% in households with a 'poor' waste score as compared to 20% in households with a 'good' waste score. In similar lines, households with mothers following 'poor' hand hygiene practices at child-related critical times were more likely to have a higher prevalence of diarrhoea in under-five children than those with 'good' hand hygiene scores (28 vs 7%).

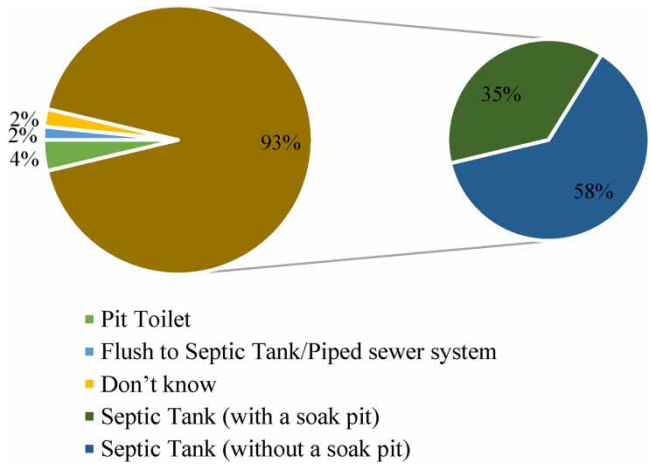

Figure 3 | Sanitation facility (in %) in the surveyed households.

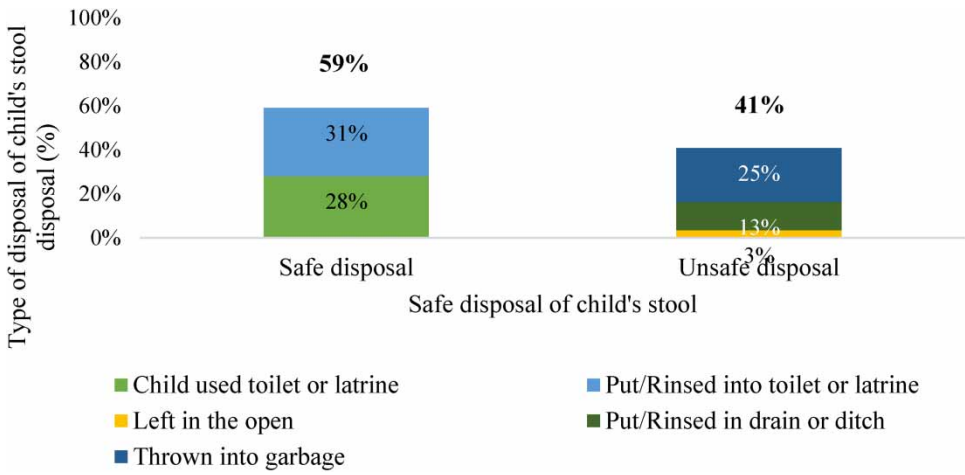

Figure 4 | Disposal of child's stool during the last time when child passed stool.

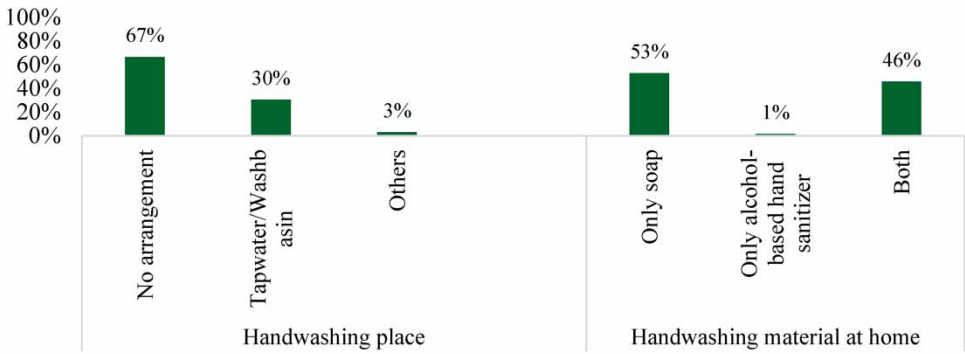

Figure 5 | Handwashing place and handwashing material available at the surveyed households.

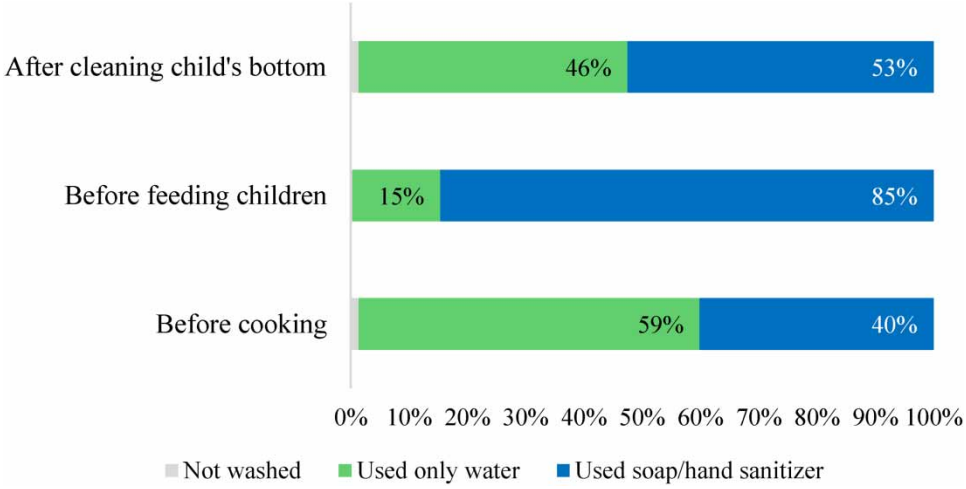

Figure 6 | Handwashing practices of mothers/caregivers at child-related critical times in the last 24 h.

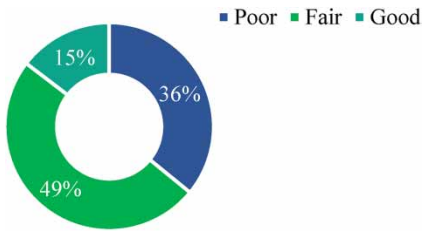

Figure 7 | Hand hygiene score.

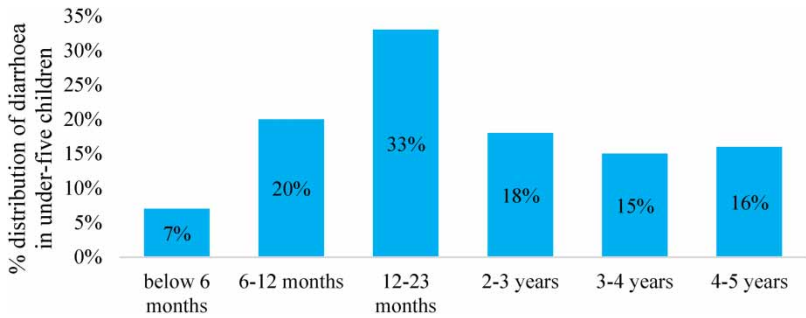

Figure 8 | Prevalence of diarrhoea (in %) in under-five children in the last one month prior to the survey.

Table 4 | Diarrhoeal episodes and duration of ailment during the last episode of in under-five children (in %) by age and sex

	Number of episodes			Duration of ailment during last episode				
Demographic variables	**1**	**2**	**3+**	**Upto 2 days**	**3–4 days**	**Beyond 4 days**		***N***
Age of children	Below 12 months*	81.3%	18.8%	0.0%	25%	43.8%	31.1%	16
	12–23 months	79.5%	15.4%	5.1%	51.3%	15.4%	33.3%	39
	24–59 months	74.1%	18.5%	7.4%	51.9%	11.1%	37%	27
Sex of children	Female	70%	22.5%	7.5%	57.5%	12.5%	30%	40
	Male	85.7%	11.9%	2.4%	35.7%	26.2%	38.1%	42

*The sample size is too small for any statistically valid interpretation.

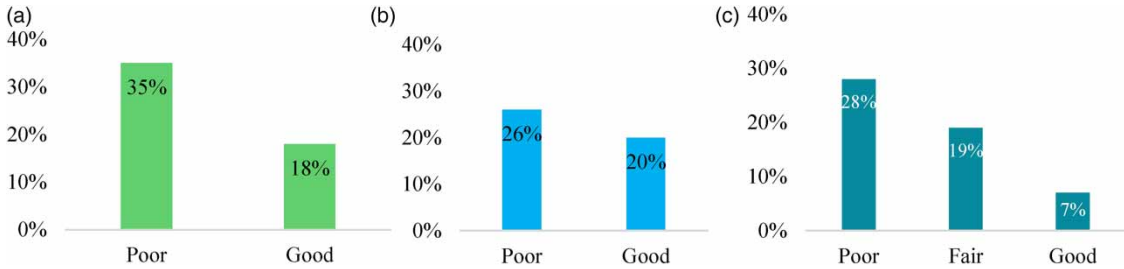

Figure 9 | Prevalence of diarrhoea in under-five children in the last one month by (a) water score, (b) waste score, (c) hand hygiene score.

3.3.7. Predictors of diarrhoea in under-five children based on multivariate analysis

Table 5 presents the result of logistic regression showing different child-level, mother-level, WASH-related and other household-level factors affecting the prevalence of diarrhoea in under-five children in the last one month. Compared to the other age groups of under-five children, those aged 12–23 months were more likely to suffer from diarrhoea in the last one month prior to the survey. Similarly, those who had consumed iron supplements in the last six months had lesser odds of getting diarrhoea. As for the WASH-related factors, high values of water and hand hygiene scores were negatively associated with higher diarrhoea prevalence in children. Moreover, diarrhoea prevalence was lower in households whose caregivers followed safe disposal of the child's stool. Prevalence of diarrhoea in under-five children was more common in non-pucca households. Children belonging to the Muslim community or from a Scheduled Caste/Scheduled Tribe (SC-ST) were more likely to suffer from diarrhoea.

4. DISCUSSION

The present study has examined the association between diarrhoea in under-five children and WASH factors, alongside various other contextual factors including sociodemographic, household, child and mother-level attributes in an urban setting. Previous cross-sectional studies have shown that the relationship between poor WASH infrastructure and WASH practices and childhood diarrhoea has a robust inverse association, However, most of these studies were either focused on rural settings or did not consider many distal factors. There is a gap in the existing literature, particularly in the urban settings with better health care facilities and better health access, examining the association between WASH-related factors and childhood diarrhoea which takes into control different child-level, mother-level, household-level factors as well as socioeconomic and distal factors.

With a reference period of the last one month prior to the survey, every fifth surveyed under-five children had suffered from diarrhoea during December 2022 and January 2023. Though its pattern varied with age, it did not follow any gender differentials. In fact, in tropical areas, Rotavirus diarrhoea is common throughout the year but its frequency increases during drier and cooler months (WHO 1992).

The study's findings revealed that approximately 85.1% of households had a 'good' water score, mainly because nearly 90% of them had access to piped water supply within their households or premises. However, only half of the respondents considered this water safe for drinking. It was also observed that the drinking water storage system was safe. Since the study was conducted in urban areas, nearly all households had access to improved sanitation facilities and received timely waste disposal collection by municipal authorities. Nevertheless, households with better indicators of water quality, as considered in this study, had a lower prevalence of diarrhoea among children.

One of the study endeavours was to establish a correlation between various hygienic practices of the mothers of under-five children with that of diarrhoeal prevalence in the children. However, less than three-fourths of the caregivers followed safe disposal of their child's faeces. Among the surveyed households, all had soap available at the time of the survey, but 66.8% lacked proper handwashing facilities. While over four-fifths of mothers washed their hands with soap and water before feeding their children, only around half did so after cleaning their child's bottom, and two-fifths did so before cooking. This suggests that only 15% of surveyed mothers received a 'good' hand hygiene score. Both bivariate and multivariate analyses revealed that children had higher odds of suffering from diarrhoea when there was a lack of proper hand hygiene practices.

Table 5 | Result of logistic regression showing the predictors of diarrhoea in under-five children

Child level factors	Odds ratio	$P>z$	[95% conf. interval]	
Age				
Below 12 months	Reference			
12–23 months	5.7***	0	2.29	14.25
24–59 months	1.30	0.6325	0.45	3.69
Sex				
Female	Reference			
Male	0.96	0.899	0.51	1.81
Current body weight				
Underweight	Reference			
Not underweight	0.89	0.79	0.39	2.03
Child-related immediate factors				
Iron consumption in last six months				
No	Reference			
Yes	0.35***	0.003	0.17	0.71
Vitamin A consumption in last six months				
No	Reference			
Yes	1.65	0.276	0.66	4.14
Birth order				
1	Reference			
2 +	0.95	0.906	0.44	2.06
Vaccinations received at birth				
Did not receive all	Reference			
Received all	1.10	0.838	0.45	2.68
Initiation of breastfeeding after birth				
Immediately/within an hour	Reference			
After more than 1 h	1.28	0.48	0.65	2.53
Currently breastfeeding				
No	Reference			
Yes	0.58	0.228	0.24	1.4
Mother-level factors				
Age of mother				
18–24 years	Reference			
25–34 years	0.85	0.682	0.38	1.89
35–44 years	0.90	0.884	0.23	3.61
Highest educational level of mother				
Upto higher secondary	Reference			
More than higher secondary	0.88	0.754	0.41	1.92
Occupation of mother				
Housewife	Reference			
Working	0.41	0.275	0.08	2.02

(*Continued.*)

Table 5 | Continued

Child level factors	Odds ratio	$P>z$	[95% conf. interval]	
WASH related factors				
Water score				
Poor	Reference			
Good	0.40	0.039	0.17	0.96
Sanitation facility				
Septic tank	Reference			
Others	0.61	0.436	0.18	2.11
Hand hygiene score				
Poor	Reference			
Fair	0.63	0.189	0.32	1.25
Good	0.15***	0.003	0.04	0.53
Waste score				
Poor	Reference			
Good	0.82	0.77	0.22	3.08
Safe disposal of child's stool				
No	Reference			
Yes	0.53*	0.094	0.26	1.12
Frequency of room cleaning				
1–2 times	Reference			
3–4 times	1.67	0.728	0.09	29.94
4 + times	1.76	0.706	0.09	32.76
Frequency of clothes changed				
1–3 times	Reference			
More than 4 times	0.60	0.29	0.23	1.55
Household-level factors				
Type of household				
Pucca	Reference			
Non-pucca	3.15***	0.008	1.35	7.37
Handwashing arrangement				
No arrangement	Reference			
Tap water/Basin	0.88	0.731	0.42	1.84
Others	0.97	0.983	0.08	11.16
Drainage system				
Unimproved	Reference			
Improved drain	2.73	0.193	0.60	12.39
Religion				
Hindu	Reference			
Muslim	6.36***	0.005	1.73	23.39
Social category				
Others	Reference			
Other backward classes (OBC)	0.32*	0.069	0.09	1.09
Scheduled caste–scheduled tribe (SC-ST)	2.24*	0.054	0.99	5.08

(*Continued.*)

Table 5 | Continued

Child level factors	Odds ratio	$P>z$	[95% conf. interval]	
Asset index				
Low	Reference			
Medium	1.69	0.234	0.71	4.01
High	2.19	0.139	0.78	6.16

Note: ***, **, * denote *p* value to be significant at 1, 5 and 10%, respectively.

In addition to this, the study finds statistically significant associations between childhood diarrhoea and socioeconomic and demographic status and household infrastructure. Children living in non-pucca (less permanent) households, as well as those belonging to the Muslim community or Scheduled Caste/Scheduled Tribe (SC-ST) backgrounds, were more affected by diarrhoea during the reference period of the study. These findings align with several previous studies (Kuberan *et al.* 2015; Nandi *et al.* 2017; Kamath *et al.* 2018; Paul 2020). The study also established a negative association between iron fortification in the last six months and diarrhoea prevalence in them. Likewise, a few studies also found that iron fortification along with other micronutrients can cause modest improvements in diarrhoea prevalence (Baqui *et al.* 2003; Young *et al.* 2021).

4.1. Study limitations

The study findings should be discussed in the light of some limitations. First, this being a cross-sectional study, the findings derived from it should not be treated as causality. It simply emulates the association between childhood diarrhoea and its predictors. Second, the generalization of the study is restricted owing to the fact that it was conducted in a specific region. The findings derived from this study do not represent any macro picture as a whole. Third, the responses to WASH infrastructure activities as well as the diarrhoea prevalence were based on self-reported retrospective data. Fourth, this study did not take any water quality aspects into consideration as this was beyond the scope of the project. Last, diarrhoea-associated infections have a seasonal effect, capturing which was beyond the scope of the study.

5. CONCLUSION

The present study contributes to highlighting some contextual factors affecting the occurrence of diarrhoea in under-five children in an urban setting. It underscores the importance of WASH indicators, including poor water and hand hygiene scores and considers other contextual factors such as the child's age, household type, religion, social category and micronutrient fortification of the child as statistically significant risk factors for diarrhoeal diseases in under-five children. According to the study's results, it could serve as a foundation for government decision-making or inspire future research endeavours. This, in turn, may lead to targeted interventions designed to promote behavioural change and raise awareness among mothers about better hygienic practices. Also, technological advancements, such as rapid diagnostic tests, telemedicine and teleconsultation, health apps, improved sanitation and water treatment technologies, and so on should be promoted for easy and early identification of gastro-intestinal infections beyond regular pathogens for preventive and therapeutic actions for reducing diarrhoeal diseases.

5.1. Ethical standards

The current study was conducted by SIGMA Foundation, Kolkata which is a not-for-profit organization working extensively on various domains such as social and economic development, child rights and protection, health and nutrition (including perinatal health, adolescent health), education, poverty alleviation and livelihood, WASH (Water, Sanitation and Hygiene) and governance. For more information, the link can be accessed (https://sigma.foundation/). Ethical approval was sought from the internal review committee. Verbal informed consent was obtained from the participants before conducting the household interviews. The enumerators read out the informed consent form to make the respondents aware of the general objectives of the study. They also stated that participation in the study was voluntary and they could withdraw from the interview at any point of time or they could skip certain questions. Confidentiality in data handling was strictly maintained. The field investigators made sure to follow COVID-appropriate protocols during the field survey.

AUTHOR CONTRIBUTIONS

S.C. conceptualized the whole article, developed the methodology, investigated the process, rendered support in data curation and formal analysis, wrote the original draft; wrote the review and edited the article. D. M. conceptualized the whole article, developed the methodology, investigated the process, and rendered support in data curation. M. N. R. conceptualized the article, supervised the article, wrote the review and edited the article.

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICT OF INTEREST

The authors declare there is no conflict.

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