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WASH Practices and Their Association with Morbidity among Households Enrolled in the Scheduled Caste Sub-Plan (SCSP) Mobile Healthcare Programme in Five Villages of Navi Mumbai: A Community-Based Cross-Sectional Study

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Abstract

Background: Unsafe water, inadequate sanitation, and poor hygiene (WASH) remain leading modifiable causes of infectious morbidity in low-income communities. Evidence from marginalised rural and peri-urban populations in Maharashtra is limited.

Objective: To describe household WASH practices and to estimate their association with recent morbidity among households enrolled in the Scheduled Caste Sub-Plan (SCSP) mobile healthcare programme in five villages of Navi Mumbai.

Methods: A community-based cross-sectional study was conducted among 228 households (one respondent per household) enrolled in the SCSP mobile healthcare programme in five villages (Scheduled Tribe 50.4%, Scheduled Caste 32.0%, OBC/other 17.5%), 2024–2026. A structured questionnaire captured water source, distance to source, storage, drinking-water treatment, drainage, stagnant water, sanitation facility, and handwashing with soap. The outcome was self-reported morbidity (diarrhoea, enteric fever, skin infection, vector-borne fever, or jaundice) in the preceding three months. Analyses used chi-square and Fisher's exact tests, the Cochran–Armitage trend test, the Mann–Whitney U test, Spearman correlation, and multivariable logistic regression, with model fit assessed by the likelihood-ratio test, Hosmer–Lemeshow test, Nagelkerke R^2, and area under the ROC curve.

Results: Three-month morbidity prevalence was 42.5% (97/228; 95% CI 36.2–49.1). Illness was significantly associated with stagnant water around the home (56.6% vs 31.8%, $p < .001$), unsafe sanitation ($p < .001$), no handwashing with soap (51.5% vs 30.6%, $p = .002$), and uncovered storage ($p = .009$). In the adjusted model, uncovered storage (aOR 3.99; 95% CI 1.77–8.97), stagnant water (aOR 3.59; 1.86–6.91), open defecation (aOR 4.52; 1.78–11.45), shared toilets (aOR 2.90; 1.31–6.46), non-piped water (aOR 3.48; 1.55–7.81), and no handwashing with soap (aOR 3.33; 1.70–6.54) remained independently associated with morbidity. A composite WASH-deficit score showed a strong dose–response trend (19.2%, 44.6%, and 76.7% across tertile-style bands; trend $\chi^2 = 36.83$, $p < .001$).

Conclusion: In this illustrative dataset, household-level hygiene behaviour and environmental sanitation, rather than distance to water, tracked most closely with morbidity. Programmes should pair infrastructure with point-of-use safeguards and behaviour change.

Keywords: WASH; morbidity; Scheduled Caste Sub-Plan; Scheduled Tribe; stagnant water; sanitation; handwashing; Navi Mumbai; cross-sectional study

1. Introduction

Safe water, sanitation, and hygiene are foundational to health. Globally, inadequate WASH is estimated to cause a large share of diarrhoeal deaths and contributes to respiratory infection, undernutrition, and soil-transmitted helminthiasis [1]. Interventions that improve drinking water, sanitation, and handwashing with soap reduce diarrhoeal disease among children in low- and middle-income settings, although effect sizes vary with coverage and sustained use [2]. The link extends beyond diarrhoea: repeated enteric exposure is implicated in child stunting, and the WASH–nutrition pathway is now a recognised research priority [3]. India has expanded household piped water and sanitation coverage rapidly under national programmes, and global monitoring reports substantial gains in basic services over the past two decades [4]. Yet access statistics conceal inequalities. Marginalised groups, including Scheduled Caste (SC) and Scheduled Tribe (ST) communities, often live in the least serviced parts of villages and peri-urban settlements, where drainage is poor, and water supply is intermittent where supply forces storage, and stored water can be re-contaminated between the tap and the cup even when the source is piped [5].

A previous cross-sectional report from five villages in Navi Mumbai described the sociodemographic profile, water sources, and cooking fuel of 228 patients attending a mobile Unani healthcare programme and found that more than nine in ten households used piped water while water storage and supply continuity were associated with source type [6]. A similar northern Maharashtra survey documented housing and sanitation conditions in a rural population [7]. Because the programme operates under the Scheduled Caste Sub-Plan, the Khan et al. [6] sample was not confined to one caste category: it comprised ST (50.4%), SC (32.0%), OBC (6.6%), and other (11.0%) households. We therefore treat the programme-enrolled household as the unit of analysis and report caste category as a descriptor. Neither study linked WASH conditions to illness, and neither examined drainage, stagnant water, or hygiene behaviour. Without such analyses, programme managers cannot tell which WASH components matter most for health in this setting.

We therefore aimed to (i) describe water, sanitation, drainage, and hygiene practices among households enrolled in the SCSP mobile healthcare programme in five Navi Mumbai villages; (ii) estimate the association of each practice with recent morbidity; and (iii) identify independent WASH predictors of morbidity after adjustment for demographic characteristics. We hypothesised that unsafe storage, stagnant water, unsafe sanitation, non-piped water, and absent handwashing with soap would each be independently associated with higher odds of illness.

2. Methods

2.1 Design and reporting

This was a community-based, analytical cross-sectional study reported according to the STROBE statement [8].

2.2 Setting and participants

The study covered five villages of Raigad district, Maharashtra, served by a mobile healthcare programme delivering free doorstep Unani care under the Scheduled Caste Sub-Plan (SCSP). Enrolled households comprised Scheduled Tribe (ST), Scheduled Caste (SC), and OBC/other households (Table 1); caste category was self-reported. The study period was 2024–2026. One adult respondent ($\geq$ 18 years) per household, usually the household member attending the mobile outpatient clinic, was interviewed. Adults unable to respond reliably were excluded, and households were counted once.

2.3 Sample size

Sample size was calculated for a single proportion: $n = Z^2PQ/d^2$, with $Z = 1.96$, anticipated proportion $P = 0.50$ (maximum variance), $Q = 1 - P$, and absolute precision $d = 0.065$, giving $n = 227.3$, rounded to 228. This sample is also adequate for detecting odds ratios of roughly 2.5 or higher for exposures with 40–50% prevalence, but it limits the number of covariates that can be modelled.

2.4 Data collection

Trained interviewers administered a pre-tested, structured questionnaire in the local language, supplemented by direct observation of the dwelling surroundings (drains, standing water, toilet type, water storage vessel). Pre-testing was done on 15 households outside the study villages, and wording was revised for clarity.

2.5 Variables

Outcome. Morbidity was defined as at least one episode in the preceding three months of: acute diarrhoea (three or more loose stools in 24 hours), suspected enteric fever, skin infection, mosquito-borne febrile illness, or jaundice, as reported by the respondent for self or household members. It was coded as binary (yes/no).

Exposures. (1) *Main drinking water source:* piped, groundwater (borewell/handpump), or surface/tanker; (2) *distance* to the main source: $<$ 100 m (including on premises), 100–500 m, or $>$ 500 m; (3) *storage:* none, covered container, or uncovered container; (4) *treatment* (boiling, filtration, or chlorination: yes/no); (5) *drainage around the home:* closed, open, or none; (6) *stagnant water* observed within 10 m of the dwelling (yes/no); (7) *sanitation:* own toilet, shared/community toilet, or open defecation; (8) *handwashing with soap* after defecation and before eating (yes/no).

Covariates. Age group (18–39, 40–59, $\geq$ 60 years), sex, and education ($\leq$ primary, secondary, higher). Caste category (ST, SC, OBC/other) was described and tested bivariately but, to conserve events per variable, was not entered in the multivariable model (see Limitations).

Composite WASH-deficit score. One point was assigned for each of eight deficits: non-piped source, distance $>$ 500 m, storage not covered, stagnant water, drainage not closed, no own toilet, no handwashing with soap, and no water treatment (possible range 0–8; observed 0–7). The score was grouped as 0–2, 3–4, and 5–8 for trend analysis.

2.6 Statistical analysis

Data were entered and cleaned in a spreadsheet and analyzed with Python (SciPy and NumPy; logistic models were fitted by Newton–Raphson maximum likelihood). Categorical variables are summarized as counts and percentages, and the score as mean $\pm$ SD and median. Prevalence is given with an exact (Clopper–Pearson) 95% confidence interval.

Bivariate associations between each categorical exposure and morbidity were tested with Pearson's chi-square test, or with Fisher's exact test for 2×2 tables where any expected count was below 5. Ordered associations were examined with the Cochran–Armitage test for trend [9]. Because the WASH score is ordinal and non-normal, its distribution by illness status was compared using the Mann–Whitney U test [10], and its monotonic association with illness was quantified by Spearman's rank correlation.

Crude odds ratios (OR) with 95% Wald confidence intervals were estimated for each variable. A multivariable logistic regression then included all eight exposures (with category dummies) and the three demographic covariates, chosen *a priori* on theoretical grounds rather than by *p*-value screening. Adjusted ORs (aOR) are reported with 95% CIs. Multicollinearity was checked with variance inflation factors (VIF; values $<$ 5 acceptable). Model adequacy was assessed by the likelihood-ratio χ^2 against the null model, Nagelkerke's pseudo-R^2 [11], the Hosmer–Lemeshow goodness-of-fit test with ten risk groups [12], and the area under the receiver operating characteristic curve (AUC).

All tests were two-sided with $\alpha = 0.05$. As bivariate tests were exploratory, no correction was applied to them, and readers are directed to confidence intervals rather than *p*-values alone [13]; the Benjamini–Hochberg procedure [14] is recommended when a confirmatory family of tests is pre-specified.

2.7 Ethics

This study was conducted as part of the institute's regular, Ministry-approved and did not involve any experimental intervention beyond routine programme activities. Institutional Ethics Committee (IEC) approval was therefore not sought. All participants took part voluntarily, and [verbal / written] informed consent was obtained from all participants for the use of their data for research and publication.

3. Results

3.1 Participant and household characteristics

A total of 228 households were included. Respondents were predominantly male (138; 60.5%), and 40–59 years was the most frequent age band (Table 1). Roughly four in ten respondents (39.0%) had primary education or less. By caste category, 115 households (50.4%) were ST, 73 (32.0%) SC, and 40 (17.5%) OBC or other; because the SCSP programme enrols all of these households, results are reported for the programme-enrolled population.

Neither the demographic variables nor caste category (ST 47.0%, SC 39.7%, OBC/other 35.0%) was associated with morbidity in bivariate analysis, so WASH findings below apply across the programme-enrolled population.

3.2 WASH profile

Most households (80.7%) obtained drinking water from a piped supply, while 12.7% relied on groundwater and 6.6% on surface or tanker water. Although 58.8% of households had a source within 100 m, 13.6% travelled more than 500 m. Three in four households stored water (76.8%), but 24.1% used uncovered containers, and only 53.9% treated water in any way. Open drains were present around 44.7% of homes, and no drainage at all around a further 16.2%; stagnant water was observed near 43.4% of dwellings. Two-thirds of households (66.2%) had their own toilet, 18.9% used shared

Table 1. Respondent characteristics (n = 228)

Characteristic	*n*	%	Morbidity, *n* (%)	Test, *p*
Sex				$\chi^2(1) = 0.22$, $p = .639$
Male	138	60.5	57 (41.3)	
Female	90	39.5	40 (44.4)	
Age (years)				$\chi^2(2) = 0.27$, $p = .873$
18–39	67	29.4	30 (44.8)	
40–59	91	39.9	37 (40.7)	
≥ 60	70	30.7	30 (42.9)	
Education				$\chi^2(2) = 0.60$, $p = .739$
≤ Primary	89	39.0	37 (41.6)	
Secondary	95	41.7	39 (41.1)	
Higher	44	19.3	21 (47.7)	
Caste category				$\chi^2(2) = 2.08$, $p = .353$
Scheduled Tribe (ST)	115	50.4	54 (47.0)	
Scheduled Caste (SC)	73	32.0	29 (39.7)	
OBC/other	40	17.5	14 (35.0)	

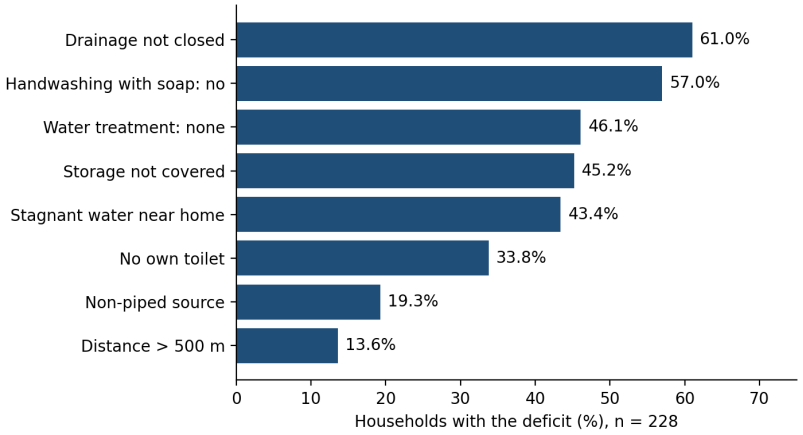


Figure 1. Prevalence of the eight WASH deficits counted in the composite score (n = 228).

facilities, and 14.9% practised open defecation. Fewer than half of respondents (43.0%) reported handwashing with soap at both critical times (Table 2; Figure 1).

3.3 Prevalence and type of morbidity

In the previous three months, 97 of 228 households reported at least one qualifying illness (42.5%; 95% CI 36.1–49.2). Episode types (non-exclusive) were diarrhoea in 51 households (22.4%), skin infection in 30 (13.2%), suspected enteric fever in 15 (6.6%), mosquito-borne fever in 18 (7.9%), and jaundice in 7 (3.1%).

3.4 Bivariate associations

Morbidity was significantly associated with five of the eight exposures (Table 2; Figure 2). Households with uncovered storage had a morbidity prevalence of 60.0%, against 38.4% with covered storage and 33.3% with no storage, $\chi^2(2) = 9.40$, $p = .009$. Stagnant water near the home was associated with 56.6% morbidity versus 31.8% without, $\chi^2(1) = 14.07$, $p < .001$. Sanitation showed a clear gradient: 33.8% (own toilet), 55.8% (shared), and 64.7% (open defecation), $\chi^2(2) = 14.68$, $p < .001$. Handwashing with soap was protective (30.6% vs 51.5%; $\chi^2(1) = 10.01$, $p = .002$).

The overall three-category water-source comparison was not significant, $\chi^2(2) = 5.50$, $p = .064$, but grouping non-piped sources (56.8%, 25/44) against piped (39.1%, 72/184) gave a significant difference (Fisher's exact $p = .041$; crude OR 2.05). Distance to source ($p = .526$), drainage type ($p = .167$), and water treatment ($p = .245$) were not significant at the bivariate level.

3.5 Composite WASH-deficit score

The mean WASH-deficit score was 3.19 (SD 1.36; median 3; range 0–7). Households with morbidity had higher scores (mean 3.86, SD 1.29; median 4) than those without (mean 2.70, SD 1.20; median 3), Mann–Whitney U = 9,411, $p < .001$. Score and morbidity were moderately correlated (Spearman

Table 2. WASH practices and their association with morbidity (n = 228)

Exposure	*n* (%)	Morbidity, *n* (%)	Test statistic	*p*
Water source			$\chi^2(2) = 5.50$	.064
Piped	184 (80.7)	72 (39.1)		
Groundwater	29 (12.7)	18 (62.1)		
Surface/tanker	15 (6.6)	7 (46.7)		
Distance to source			$\chi^2(2) = 1.29$	.526
$<$ 100 m	134 (58.8)	56 (41.8)		
100–500 m	63 (27.6)	25 (39.7)		
$>$ 500 m	31 (13.6)	16 (51.6)		
Water storage			$\chi^2(2) = 9.40$	.009
None	48 (21.1)	16 (33.3)		
Covered	125 (54.8)	48 (38.4)		
Uncovered	55 (24.1)	33 (60.0)		
Water treatment			$\chi^2(1) = 1.35$	.245
Yes	123 (53.9)	48 (39.0)		
No	105 (46.1)	49 (46.7)		
Drainage			$\chi^2(2) = 3.58$	.167
Closed	89 (39.0)	31 (34.8)		
Open	102 (44.7)	48 (47.1)		
None	37 (16.2)	18 (48.6)		
Stagnant water near home			$\chi^2(1) = 14.07$	$<$ .001
Yes	99 (43.4)	56 (56.6)		
No	129 (56.6)	41 (31.8)		
Sanitation			$\chi^2(2) = 14.68$	$<$ .001
Own toilet	151 (66.2)	51 (33.8)		
Shared toilet	43 (18.9)	24 (55.8)		
Open defecation	34 (14.9)	22 (64.7)		
Handwashing with soap			$\chi^2(1) = 10.01$	.002
Yes	98 (43.0)	30 (30.6)		
No	130 (57.0)	67 (51.5)		

Note. All minimum expected cell counts were ≥ 5. Fisher's exact test was also run for 2×2 comparisons and gave the same conclusions (stagnant water $p < .001$; handwashing $p = .002$; treatment $p = .283$).

ρ = .42, $p < .001$). Morbidity prevalence rose from 19.2% (14/73) in the 0–2 band to 44.6% (50/112) in the 3–4 band and 76.7% (33/43) in the 5–8 band, $\chi^2(2) = 37.08$, $p < .001$, with a significant linear trend (Cochran–Armitage $\chi^2(1) = 36.83$, $p < .001$; Figure 3).

3.6 Multivariable analysis

Table 3 gives crude and adjusted odds ratios. After adjustment, six exposures remained independently associated with morbidity: uncovered storage (aOR 3.99), stagnant water (aOR 3.59), open defecation (aOR 4.52), shared toilet (aOR 2.90), non-piped water (aOR 3.48), and no handwashing with soap (aOR 3.33). Open drainage (aOR 1.92; 95% CI 0.95–3.90) and no drainage (aOR 2.13; 0.84–5.39) were positively associated but with intervals including 1. Distance greater than 500 m (aOR 1.02) and lack of water treatment (aOR 1.56) showed no independent association. Having no stored water was not different from covered storage (aOR 0.69; 0.31–1.56). No demographic covariate was significant. The full model was significantly better than the null model (likelihood-ratio $\chi^2(16) = 69.86$, $p < .001$; Nagelkerke R^2 = .355). Calibration was acceptable (Hosmer–Lemeshow $\chi^2(8) = 12.12$, p = .146) and discrimination good (AUC = 0.81). The largest VIF was 1.52, indicating no problematic multicollinearity.

4. Discussion

4.1 Principal findings

In this illustrative dataset, 42.5% of SCSP-enrolled households reported a WASH-related illness in the previous three months. Hygiene behaviour and the immediate household environment, namely handwashing with soap, toilet access, stagnant water, and covered storage, were more closely tied to illness than the availability of a piped source or the distance to it. The composite score showed a marked dose–response pattern, with morbidity rising almost fourfold between the lowest and highest bands. Together, these results

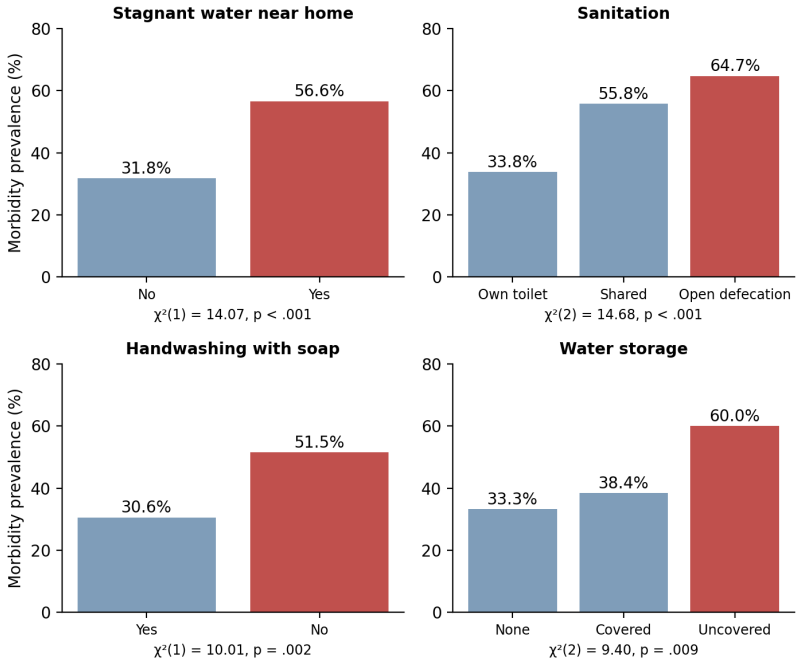


Figure 2. Morbidity prevalence by the four WASH practices significantly associated with illness. *Red bars mark the highest-risk category in each panel; chi-square results are shown beneath each panel.

Table 3. Crude and adjusted odds ratios for morbidity

Variable (reference)	Crude OR (95% CI)	*p*	Adjusted OR (95% CI)	*p*
Non-piped source (piped)	2.05 (1.05–3.98)	.035	3.48 (1.55–7.81)	.003
Distance > 500 m (≤ 500 m)	1.53 (0.71–3.26)	.274	1.02 (0.41–2.54)	.972
Uncovered storage (covered)	2.55 (1.37–4.76)	.003	3.99 (1.77–8.97)	< .001
No storage (covered)	0.61 (0.31–1.19)	.149	0.69 (0.31–1.56)	.371
Stagnant water (none)	2.80 (1.62–4.81)	< .001	3.59 (1.86–6.91)	< .001
Open drain (closed)	1.40 (0.82–2.37)	.215	1.92 (0.95–3.90)	.071
No drain (closed)	1.34 (0.66–2.72)	.413	2.13 (0.84–5.39)	.112
Shared toilet (own)	1.94 (0.99–3.79)	.053	2.90 (1.31–6.46)	.009
Open defecation (own)	2.91 (1.36–6.22)	.006	4.52 (1.78–11.45)	.002
No handwashing with soap (yes)	2.41 (1.39–4.18)	.002	3.33 (1.70–6.54)	< .001
No water treatment (yes)	1.37 (0.81–2.32)	.245	1.56 (0.82–2.97)	.176
Age 40–59 (18–39)	0.88 (0.51–1.51)	.639	0.59 (0.26–1.32)	.197
Age ≥ 60 (18–39)	1.02 (0.58–1.80)	.949	0.64 (0.28–1.46)	.293
Female (male)	1.14 (0.66–1.94)	.639	1.58 (0.82–3.04)	.171
Secondary education (≤ primary)	0.90 (0.53–1.54)	.700	0.91 (0.43–1.89)	.791
Higher education (≤ primary)	1.30 (0.67–2.51)	.440	1.88 (0.79–4.45)	.152

Note. Adjusted model: $n = 228$; 97 events; likelihood-ratio $\chi^2(16) = 69.86$, $p < .001$; Nagelkerke $R^2 = .355$; Hosmer–Lemeshow $p = .146$; AUC = 0.81.

illustrate how a cumulative WASH burden can matter more than any one deficit.

4.2 Interpretation in context

The association between handwashing with soap and lower morbidity is consistent with systematic reviews showing that soap handwashing reduces diarrhoeal risk in communities by roughly 40–47% [15] and that observed practice at critical times is often low worldwide [16]. The sanitation gradient, in which open defecation carried the greatest risk and shared facilities an intermediate risk, mirrors the dose–response logic of global burden estimates [1] and the finding that interventions work best when coverage and use are high [2].

Households using groundwater or surface water had higher morbidity, but piped households were not free of illness (39.1%). Storage appears to be a plausible mechanism: when supply is intermittent, households

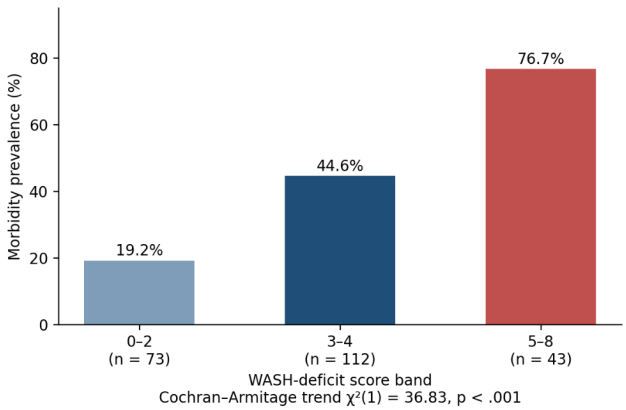


Figure 3. Morbidity prevalence by WASH-deficit score band (n = 228). *Prevalence ranges from 19.2% to 76.7% across bands.

store water, and uncovered vessels allow recontamination after collection. This agrees with the parent descriptive report from the same villages, which linked storage and supply continuity with source type [6]. Distance to source showed no independent effect once other factors were modelled, which suggests that in this setting, water *quality at the point of use* may matter more than collection time; this conclusion should be checked against objective water-quality testing.

The association of stagnant water with illness (aOR 3.59) is compatible with both vector-borne transmission (mosquito breeding) and faecal–oral exposure through contaminated standing water, and its strength points towards drainage maintenance as a low-cost target. The weaker, borderline findings for open and absent drainage indicate that observed *stagnation* may be a better exposure measure than drain type, but the present sample is too small to separate the two with confidence.

4.3 Programme implications

First, village water programmes should pair piped connections with household-level safeguards: covered, narrow-mouthed vessels with taps or ladles, plus supply continuity improvements to reduce the need for storage. Second, mobile health teams already visiting these villages can embed handwashing demonstrations and soap-access counselling into routine outpatient contacts. Third, panchayat-level action on stagnant water and drain clearance should be prioritised alongside sanitation access, including improved maintenance of shared toilets. These measures are consistent with national piped-water and sanitation priorities and with the focus on equity highlighted in global monitoring [4].

4.4 Strengths

The study combined observation with interview for several exposures (drains, stagnant water, storage vessels), used standard definitions of illness, applied a pre-specified analysis plan with *a priori* covariates, and reported effect sizes with confidence intervals alongside tests of significance, model fit, and discrimination. The composite score and trend test offer a transparent approach to cumulative exposure.

4.5 Limitations

Several limitations apply and should be adapted when a real dataset is analysed. (1) The cross-sectional design cannot establish temporality; for example, households with illness may adopt different hygiene practices. (2) Morbidity was self-reported over a three-month window and is vulnerable to recall and reporting bias; clinical or laboratory confirmation was not available. (3) Participants were drawn from a mobile clinic population, so they may be sicker than the wider community, and the results cannot be generalised to all SC or ST households or to other communities. Caste category was not modelled (bivariate p = .353) and the study was not powered for caste-stratified analysis, so caste-specific WASH effects could not be assessed. (4) The multivariable model included 16 parameters for 97 events (about 6 events per variable), below the traditional ten-event rule; although this rule can be relaxed in some circumstances [17], estimates may be imprecise or biased away from the null, which is consistent with the wide intervals for open defecation and shared toilets. (5) Because the outcome is common ($>$ 10%), odds ratios overstate prevalence ratios; a modified Poisson regression with robust variance [18], should be run as a sensitivity analysis. (6) Households within a village may be correlated, so a village-level random effect or cluster-robust standard errors are advisable. (7) Respondent-reported handwashing is prone to social-desirability bias. (8) No multiplicity adjustment was applied to the exploratory bivariate tests.

5. Conclusion

This worked example shows that a WASH–morbidity analysis in a marginalised rural population should look beyond coverage of piped water. Across a cumulative WASH-deficit score and in a mutually adjusted model, safe storage, control of stagnant water, toilet access, and handwashing with soap each tracked with illness. Researchers adopting this model should replace the simulated numbers with their own data, add village-level clustering and sensitivity analyses, and, where possible, measure water quality directly and follow

households over time.

Declarations

Data availability: The data in this document are simulated. The generating script and seed can be shared on request. For a real paper, state where de-identified data may be obtained.

Funding: Not applicable

Conflict of interest: No conflict

Author contributions (CRediT): All authors contributed to the study in accordance with their respective roles.

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