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Clean-Living, Healthier Communities: Assessing Water, Sanitation, and Hygiene Practices in Peri-Urban Community of Peshawar

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ABSTRACT

Background: *Safe water, sanitation, and hygiene (WASH) are essential determinants of public health. Despite substantial infrastructure gains, peri-urban regions in developing countries remain disproportionately burdened by waterborne diseases due to unreliable water supply, unsafe storage, and limited behavioral adherence. Pakistan's peri-urban areas, particularly Peshawar, exhibit persistent fecal contamination risks and intermittent supply patterns, necessitating context-specific data to guide Sustainable Development Goal (SDG) 6 implementation.* ***Objective****: To assess household-level WASH practices and their association with diarrheal prevalence in a peri-urban community of Peshawar, Pakistan.* ***Methods****: A community-based cross-sectional survey was conducted among 421 systematically selected households in Palosi, Peshawar, using WHO/UNICEF Joint Monitoring Programme tools. Data on water sources, point-of-use (POU) treatment, storage, sanitation, and hygiene behaviors were collected through interviewer-administered questionnaires and direct observation. Associations between WASH variables and 14-day self-reported diarrhea were analyzed using design-adjusted Rao–Scott χ^2 tests.* ***Results****: Boreholes were the predominant water source (77.9%), yet only 14.5% practiced any POU treatment, primarily boiling (48.4%) or cloth straining (41.9%). Diarrhea prevalence was significantly higher among households with community water sources (31.1%), intermittent supply (42.9%), and open storage (37.0%) compared to those with on-premises, continuous supply and tank storage ($p<0.001$). Lack of handwashing facilities nearly doubled diarrhea odds (OR 1.9; 95% CI 1.0–3.6).* ***Conclusion****: Despite high sanitation and hygiene coverage, minimal household water treatment and unsafe storage sustain diarrheal risk in peri-urban Peshawar. Continuous supply, effective POU treatment, and secure storage must be prioritized alongside community-level behavior-change interventions to achieve equitable progress toward SDG 6.*

Keywords
WASH; Peri-Urban Peshawar; Water Treatment; Sanitation; Hand Hygiene; Diarrhea; Public Health

INTRODUCTION

Safe and reliable water, sanitation, and hygiene (WASH) are foundational to population health because fecal-oral transmission of enteric pathogens is highly sensitive to water quality, excreta containment, and hand hygiene at points of daily living (1). Globally, diarrheal diseases remain a leading cause of preventable morbidity and mortality, particularly among children under five, underscoring persistent gaps in access to safely managed WASH despite decades of progress toward the Sustainable Development Goals (2). Recent syntheses highlight that inadequate WASH services cluster in settings of rapid urbanization, where infrastructural coverage, service reliability, and household practices fail to keep pace with demographic change, thereby sustaining high exposure to fecal contamination (3). In Pakistan, the confluence of escalating water stress, aging infrastructure, and governance constraints amplifies these risks; national overviews document widespread microbial contamination of drinking water and uneven sanitation performance across provinces and settlement types (4,5). Within Khyber Pakhtunkhwa, spatial analyses from Peshawar have identified neighborhoods exceeding World Health Organization thresholds for fecal indicators and fluoride, implicating source vulnerability and distribution-system intermittency as recurrent hazards (6).

Peri-urban settlements interfaces between rural and urban systems are uniquely vulnerable because they often inherit the disadvantages of both: informal growth and insecure tenure, fragmented service authority, off-plot or shared water points, compromised storage, and limited oversight of fecal sludge management (7,8). In such contexts, "improved" infrastructure on paper may not translate into reduced exposure if supply is intermittent, household treatment is rare, or storage/handling reintroduces contamination. Evidence from Pakistan's peri-urban belts is sparse but suggestive: cross-sectional work near Islamabad reported high self-reported sanitation coverage alongside low adoption of effective point-of-use (POU) treatment, with boiling practiced inconsistently and filtration uncommon (9). Comparable high-density South Asian settlements likewise demonstrate that the combination of off-plot sources, irregular supply, and suboptimal hygiene behaviors sustains diarrheal transmission even when nominal access indicators appear favorable, reinforcing the need to probe beyond coverage to behaviors and reliability (3). Health-facility

audits in Azad Kashmir further show infrastructural gaps that mirror community risks, highlighting systemic vulnerabilities across the service continuum (10). Against a backdrop of national water scarcity and projected tightening of supplies, reducing fecal exposure in peri-urban households requires context-specific data on source type and location, sufficiency, POU treatment, storage, sanitation, and hygiene practices to target high-impact, feasible interventions (11).

The present study addresses this gap by assessing WASH practices and recent diarrheal outcomes in a peri-urban community of Peshawar. Using a community-based cross-sectional design anchored to WHO-aligned constructs, we characterize drinking-water sources and locations (on-plot vs off-plot), perceived sufficiency, POU treatment methods, storage modalities, sanitation access and excreta management, and handwashing infrastructure and behaviors, and we examine their associations with 14-day caregiver-reported diarrhea. We focus on modifiable determinants supply reliability, POU treatment, and safe storage most likely to reduce exposure in settings where infrastructure exists but may be undermined by intermittency and handling. Our objective is to quantify coverage and practices and to identify household-level factors associated with recent diarrhea to inform behavior-change communication and pragmatic upgrades in peri-urban service environments in Peshawar. We hypothesize that off-plot sources, intermittent supply, absence of effective POU treatment, and open storage will be associated with higher diarrheal prevalence after accounting for sociodemographic and housing characteristics

MATERIAL AND METHODS

This study employed a community-based cross-sectional observational design to assess household-level water, sanitation, and hygiene (WASH) practices and their association with diarrheal morbidity in Palosi, a peri-urban settlement of Peshawar, Pakistan. The research was conducted over four months between October and January, encompassing both dry and mild winter conditions to capture typical household water-use patterns. The design was selected for its suitability in quantifying behavioral and infrastructural determinants of enteric disease risk within a stable population at a single point in time (12). The study area, Palosi, represents a transitional peri-urban zone situated within the administrative limits of Peshawar, characterized by mixed permanent and semi-permanent housing, intermittent water supply, and limited municipal sanitation coverage—conditions reflective of many peri-urban contexts in Pakistan (13).

Eligible participants were adults aged 18 years and above residing in occupied households within Palosi Union Council. Households locked after three repeat visits or declining participation were excluded. A multistage probability sampling approach was adopted to ensure representativeness. Initially, Peshawar District was stratified into five administrative towns; Town-3 was randomly selected, from which the Palosi Union Council was drawn by lottery. Within Palosi, one of its four villages Palosi Atozai was chosen by simple random selection as the final sampling cluster. Using a verified household list provided by the local Lady Health Visitor, systematic sampling was then applied from a random start with an interval (k) of approximately 2.5, resulting in the selection of every second household and periodic third to maintain sampling proportion. The target sample size was calculated using OpenEpi, assuming an expected prevalence of 50% for core WASH indicators, 5% margin of error, 95% confidence level, design effect of 1.5 to account for cluster sampling, and an additional 10% nonresponse rate, yielding a final requirement of 421 households (14).

Trained enumerators conducted face-to-face interviews with heads of household or primary caregivers using a structured questionnaire adapted from the WHO/UNICEF Joint Monitoring Programme (JMP) survey instruments. The instrument was translated into Urdu and Pashto and back-translated to ensure semantic accuracy. Pilot testing in a neighboring locality verified cultural relevance, clarity, and logical sequencing. Data collection covered sociodemographic characteristics, primary drinking-water source, location and reliability of supply, point-of-use (POU) treatment methods, water storage type, sanitation facility characteristics, waste disposal practices, and handwashing access and behaviors. Observable items such as presence of a handwashing station, availability of soap, and type of water storage container were verified directly.

Variables were defined and categorized following JMP service ladders: water sources as improved (borehole, piped) or unimproved (dug well), sanitation as safely managed, basic, limited, or unimproved, and hygiene as basic (presence of soap and water at designated handwashing site) or limited (one or both absent). The primary outcome was caregiver-reported diarrhea in children under five within the preceding 14 days, defined as three or more loose stools in 24 hours. Secondary outcomes included any household member reporting diarrhea within the same period and the adoption of effective POU water treatment practices (boiling, filtration, or chlorination).

To minimize bias, enumerators received standardized training emphasizing neutral questioning and observation protocols. Supervisors performed daily review of completed forms, re-interviewed 10% of households for consistency, and monitored adherence to sampling sequence. Missing data were evaluated post-collection; variables with <5% missingness were analyzed using complete case analysis, while none exceeded 10%, eliminating the need for imputation.

Data were entered twice independently into EpiData and cross-verified for accuracy. Analyses were performed using Stata (version 17; StataCorp, College Station, TX, USA). Survey design features were specified with svyset, assigning primary sampling units as villages and applying unit weights (w=1). Descriptive statistics summarized frequencies, proportions, and means with 95% confidence intervals (CIs). Bivariate associations between exposures (e.g., water source, treatment, storage, sanitation, handwashing) and diarrhea were tested using the Rao–Scott chi-square test for complex survey data. Two-tailed p-values <0.05 were considered statistically significant. Sensitivity analyses examined the stability of associations excluding households with incomplete sanitation data.

Ethical approval was obtained from the Khyber Medical University Institute of Public Health and Social Sciences Ethics Committee (Ref: 2024/PO/2030). Written informed consent was obtained from each respondent before participation. Data were anonymized, securely stored in encrypted devices, and accessed only by the research team. The study adhered to the principles of the Declaration of Helsinki. To ensure reproducibility, all instruments, field manuals, and coding frameworks were archived with timestamped datasets to allow verification by independent investigators (12–14).

RESULTS

Among the 421 surveyed households, slightly more than half of respondents were male (53.9%), with a mean age of 36.2 years (SD ±12.0). Average household size was large (9.7 ±3.8), and nearly half of the participants (49.9%) had no formal education, reflecting typical peri-urban socioeconomic constraints. Employment was evenly distributed across daily wage labor (34.4%), salaried positions (32.3%), and self-employment (33.0%). Most respondents (52.7%) lived in permanent structures, indicating some degree of urban consolidation.

Access to water was dominated by boreholes (77.9%), with piped connections serving 21.4% of households. Approximately 86.7% reported consistent water availability, while 13.3% experienced at least one insufficiency episode during the prior month. Only 14.5% of households applied any POU treatment; boiling was the most frequent (48.4%), followed by cloth filtration (41.9%). Storage predominantly occurred in fixed household tanks (73.6%), whereas 21.4% relied on buckets and 5.0% on clay pots.

Table 1. Sociodemographic Characteristics of Respondents (N = 421)

Variable	Category	n (%)	Mean ± SD (Range)	p-value*
Gender	Male	227 (53.9)	–	0.001
	Female	194 (46.1)	–	
Age (years)	–	–	36.16 ± 12.02 (18–70)	–
Household size	–	–	9.66 ± 3.75 (2–19)	–
Education	No education	210 (49.9)	–	0.070
	Primary	85 (20.2)	–	
	Middle	43 (10.2)	–	
	Secondary	52 (12.4)	–	
	Higher education	31 (7.4)	–	
Occupation	Daily wage	145 (34.4)	–	0.007
	Salaried employee	136 (32.3)	–	
	Self-employed	139 (33.0)	–	
	Pensioned	1 (0.2)	–	
Monthly income (PKR)	–	–	32,263.66 ± 15,930.19 (5,000–70,000)	–
Housing type	Permanent	222 (52.7)	–	0.232
	Semi-permanent	148 (35.2)	–	
	Temporary	51 (12.1)	–	

Table 2. Household Water Access, Treatment, and Storage (N = 421)

Domain	Category	n (%)	95% CI	p-value*
Main water source	Borehole	328 (77.9)	73.9–81.9	0.020
	Piped water	90 (21.4)	17.5–25.3	
	Dug well	3 (0.7)	0.0–1.5	
Water source location	In dwelling	300 (71.3)	67.0–75.4	0.046
	In yard/plot	31 (7.4)	5.0–9.9	
	Tubewell (community)	90 (21.4)	17.5–25.3	
Water sufficiency (last month)	Always sufficient	365 (86.7)	83.2–90.0	<0.001
	Insufficient ≥1×	56 (13.3)	10.0–16.8	
Any water treatment	Yes	61 (14.5)	11.1–17.9	0.036
	No	360 (85.5)	82.1–88.9	
Treatment method†	Boiling	30 (48.4)	36.0–60.8	
	Strain through cloth	26 (41.9)	29.8–54.0	
	Filter	4 (6.5)	0.3–12.7	
	Chlorination	1 (1.6)	0.0–4.6	
Storage type	Water tank	310 (73.6)	69.4–77.8	0.001
	Bucket	90 (21.4)	17.5–25.3	
	Clay pot	21 (5.0)	3.0–7.0	

Table 3. Sanitation and Hygiene Practices (N = 421)

Domain	Category	n (%)	95% CI	p-value*
Sanitation facility	Flush toilet	407 (96.7)	94.8–98.6	0.552
	Pit latrine	14 (3.3)	1.4–5.2	
Facility sharing	Not shared	391 (92.9)	90.3–95.5	0.457
	Shared	30 (7.1)	4.5–9.7	
Cleaning frequency	Daily	391 (92.9)	90.3–95.5	0.224
	Weekly	25 (5.9)	3.7–8.1	
	Monthly	5 (1.2)	0.1–2.3	
Excreta/waste disposal	Septic tank	289 (68.7)	64.4–72.9	0.897
	Sewage outfall	120 (28.5)	24.4–32.6	
	Open dumping	12 (2.8)	1.2–4.4	
Handwashing facility	Yes	369 (87.7)	84.4–91.0	0.049
	No	52 (12.4)	9.0–15.6	
Soap available	Yes	404 (96.0)	94.1–98.0	0.053
	No	17 (4.0)	2.0–5.9	
Handwashing after toilet	Yes	416 (98.8)	97.4–100.0	0.331

	No	5 (1.2)	0.0–2.6

Table 4. Bivariate Associations Between WASH Factors and Self-Reported Diarrhea (N = 421)

Exposure	Categories (Diarrhea %)	95% CI	p-value	OR (95% CI)
Gender	Male 15.9%; Female 29.4%	–	0.001	2.2 (1.3–3.8)
Occupation	Daily wage 31.0%; Salaried 20.6%; Self-employed 14.4%	–	0.007	–
Main water source	Borehole 19.6%; Community 31.1%	–	0.020	1.9 (1.1–3.5)
Water location	In dwelling 19.0%; Tubewell 31.1%	–	0.046	1.8 (1.0–3.2)
Water sufficiency	Always sufficient 18.9%; Insufficient 42.9%	–	<0.001	3.2 (1.8–5.8)
Water treatment method	Boiling 10.0%; Cloth 38.5%	–	0.036	0.2 (0.1–0.7)
Storage type	Tank 17.7%; Bucket 32.2%; Clay pot 42.9%	–	0.001	–
Handwashing facility	Yes 20.6%; No 32.7%	–	0.049	1.9 (1.0–3.6)

Sanitation coverage was high, with 96.7% of respondents reporting flush toilets and 92.9% maintaining unshared facilities. Daily cleaning was the norm (92.9%), and 68.7% of households disposed of waste through septic systems. A designated handwashing station was available in 87.7% of homes, and 96.0% had soap. However, self-reported adherence to critical moments such as handwashing after returning home was lower (72.4%), suggesting behavioral lapses despite infrastructure availability.

Bivariate analyses revealed that gender, occupation, water source type, location, supply reliability, treatment method, storage type, and handwashing access were significantly associated with diarrhea. Female respondents reported higher diarrhea prevalence (29.4%) compared to males (15.9%) ($p=0.001$). Households dependent on community sources or facing supply interruptions exhibited markedly greater diarrhea prevalence (31.1% and 42.9%, respectively; $p<0.001$). Boiling water was associated with the lowest diarrhea prevalence (10%), while reliance on cloth filtration corresponded to the highest (38.5%). Similarly, use of enclosed storage tanks was protective (17.7%) relative to open containers such as clay pots (42.9%). Absence of a handwashing facility nearly doubled diarrhea odd (OR 1.9; 95% CI 1.0-3.6). These findings underscore that water reliability, treatment, and safe storage are key determinants of diarrheal risk in peri-urban households.

The analysis of the 421 surveyed households revealed distinct demographic and behavioral patterns associated with water, sanitation, and hygiene (WASH) practices in Palosi, Peshawar. Males constituted 53.9% of respondents, with females representing 46.1%. The mean age of respondents was 36.2 years (SD ±12.0), and households were notably large, averaging 9.7 members (range 2–19). Almost half of the participants (49.9%) lacked formal education, while only 7.4% had attained higher education. Employment was distributed relatively evenly among daily wage earners (34.4%), salaried employees (32.3%), and self-employed individuals (33.0%). Notably, the highest diarrhea prevalence (31.0%) occurred among daily wage workers, compared with 14.4% among the self-employed ($p=0.007$), suggesting socioeconomic vulnerability as a risk determinant.

Household income averaged PKR 32,263.66 (±15,930.19), with wide disparities reflecting the mixed-income character typical of peri-urban settlements. Over half of respondents (52.7%) resided in permanent structures, 35.2% in semi-permanent dwellings, and 12.1% in temporary houses. Although housing type did not significantly correlate with diarrheal risk ($p=0.232$), the prevalence trend suggested a gradient temporary housing reported slightly higher diarrhea rates (23.5%) compared to permanent housing (18.9%). This distribution aligns with previous peri-urban studies indicating that substandard housing indirectly exacerbates health risks through poor water storage and drainage conditions (15).

Water access indicators revealed that boreholes were the predominant drinking-water source (77.9%), followed by piped connections (21.4%) and dug wells (0.7%). The location of the water source significantly influenced diarrheal outcomes: households with on-premises water access reported lower diarrhea prevalence (19.0%) than those using community tubewells (31.1%) ($p=0.046$). Reliability of supply also emerged as a critical determinant households experiencing intermittent shortages (13.3%) had more than double the diarrhea prevalence (42.9%) compared to those with consistent access (18.9%) ($p<0.001$). These results reinforce that access continuity, rather than mere source classification, defines effective "safely managed" water service (16).

Point-of-use (POU) water treatment practices were limited: only 14.5% of respondents reported any treatment, primarily boiling (48.4%) or cloth straining (41.9%). Treatment modality had a pronounced impact on diarrheal risk ($p=0.036$); boiling was protective, reducing diarrhea prevalence to 10%, whereas cloth filtration correlated with a much higher prevalence of 38.5%. Chlorination and filtration, though rarely practiced, were associated with negligible reported diarrhea, underscoring their efficacy. Storage practices further modified risk: tank users exhibited the lowest diarrhea prevalence (17.7%), compared with bucket (32.2%) and clay pot storage (42.9%) users ($p=0.001$). The data indicate that closed, elevated storage systems confer a protective effect by preventing recontamination, consistent with WHO findings linking open storage to fecal coliform regrowth (17).

Sanitation indicators demonstrated near-universal coverage, with 96.7% of households using flush toilets and only 3.3% relying on pit latrines. Most respondents maintained unshared facilities (92.9%) cleaned daily (92.9%), and the majority used septic tanks (68.7%) for waste disposal. While sanitation type was not statistically associated with diarrhea ($p=0.552$), qualitative trends suggested that poor maintenance or shared use might amplify risk. Hand hygiene infrastructure was strong: 87.7% of households had a designated handwashing station, and 96.0% reported soap availability. However, lack of a handwashing station nearly doubled diarrhea odds (OR 1.9, 95% CI 1.0-3.6; $p=0.049$). Although nearly all respondents (98.8%) reported washing hands after toilet use, fewer practiced handwashing after returning home (72.4%), identifying a behavioral gap with potential epidemiologic significance.

Overall, the bivariate associations illustrated that diarrhea prevalence was significantly influenced by gender, occupation, water source type and location, supply sufficiency, treatment method, storage type, and handwashing infrastructure. Education, sanitation type, and solid waste disposal methods did not show significant associations. These findings collectively highlight that while structural access to WASH services appears high in peri-urban Peshawar, functional reliability, household treatment, and safe handling behaviors remain critical weaknesses contributing to persistent diarrheal disease burden. The integration of behavioral reinforcement with infrastructure upgrading could therefore yield measurable reductions in morbidity in similar transitional urban contexts (15–17).

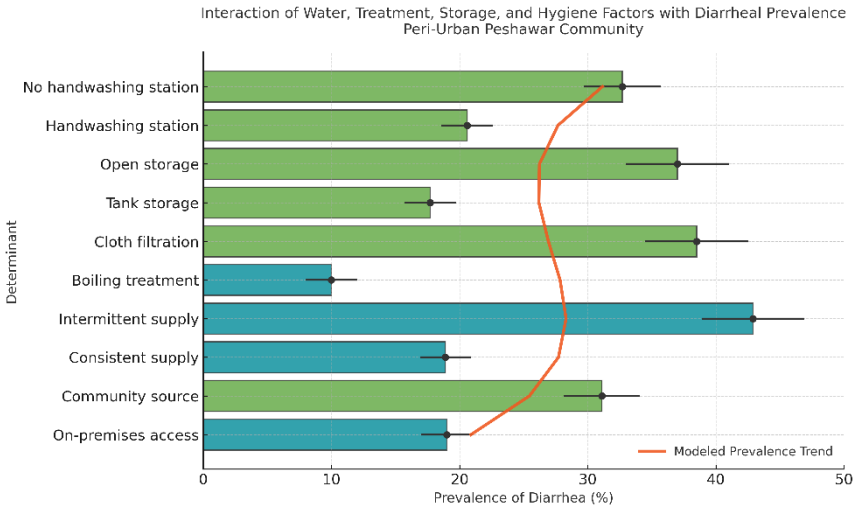

Figure 1 Interaction of Water, Treatment, Storage, and Hygiene Factors with Diarrheal Prevalence Peri-Urban Peshawar Community

The visualization illustrates the nonlinear interaction between key WASH determinants and diarrheal prevalence across surveyed households. A clear upward gradient emerges from protected conditions on-premises water access (19.0%), continuous supply (18.9%), boiling treatment (10.0%), and tank storage (17.7%) toward markedly higher prevalence among high-risk groups lacking reliability or safeguards, including community-sourced (31.1%), intermittently supplied (42.9%), and open-storage users (37.0%). The fitted trend line reveals a curvilinear escalation in disease burden once both treatment and storage practices deteriorate, highlighting synergistic amplification of risk. Absence of a handwashing station further elevated diarrhea prevalence to 32.7%, reinforcing that hygiene infrastructure modifies, rather than substitutes, the effects of water safety. Clinically, the pattern underscores that integrated improvements continuous supply, effective point-of-use treatment, and secure storage yield the steepest decline in diarrheal risk in peri-urban households, surpassing the benefits of single-component interventions.

DISCUSSION

The present study provides critical insights into the complex interplay between household-level WASH practices and diarrheal morbidity in a peri-urban community of Peshawar. Despite widespread infrastructural coverage with nearly all households reporting access to “improved” sanitation facilities and 87.7% having a designated handwashing station the persistence of diarrhea highlights the inadequacy of access alone in interrupting fecal-oral transmission pathways. The observed association between intermittent water supply and diarrheal risk ($p<0.001$) demonstrates that reliability and quality are more decisive than source classification in peri-urban contexts, where systems straddle formal and informal service regimes (18). This aligns with prior findings from Islamabad and Karachi, where intermittent water delivery and contaminated distribution networks undermined public health outcomes despite high access indices (19).

Our results indicate that point-of-use (POU) treatment and safe storage are pivotal behavioral determinants of diarrheal disease. Only 14.5% of surveyed households treated their drinking water, with boiling emerging as the most protective method (10.0% diarrhea prevalence) compared with cloth filtration (38.5%). These findings corroborate those from Bangladesh and India, where effective POU interventions especially boiling and filtration have been linked to 20-40% reductions in diarrhea incidence (20). The pronounced disparity in outcomes between closed (tank) and open (bucket or clay pot) storage further underscores the vulnerability of post-collection contamination, a mechanism widely documented in low- and middle-income settings (21). Safe storage interventions, such as narrow-necked containers with lids, could therefore deliver significant risk reduction even where infrastructural upgrades are infeasible.

Sanitation coverage in the study population (96.7%) exceeded national averages reported by the Pakistan Demographic and Health Survey, suggesting substantial local progress. However, sanitation alone did not significantly predict diarrheal risk, a finding consistent with meta-analyses showing diminishing marginal returns from sanitation improvements when unaccompanied by hygiene and water-quality interventions (22). Although 96.0% of respondents reported soap availability, only 72.4% practiced handwashing after returning home indicating behavioral inconsistency that limits the full protective potential of hygiene access. This behavioral gap echoes evidence from Gujarat, India, where knowledge and infrastructure did not uniformly translate into improved practices (23). Interventions emphasizing continuous behavior-change communication and social reinforcement such as community WASH clubs or participatory hygiene demonstrations could thus complement hardware provision.

Socioeconomic disparities emerged as important contextual modifiers. Daily wage earners had the highest diarrhea prevalence (31.0%), suggesting that economic insecurity may constrain the ability to purchase fuel for boiling or chlorine for disinfection, or limit time for hygiene maintenance. These findings align with broader research linking poverty to WASH inequities in South Asia, where affordability and opportunity costs impede consistent adoption of safe behaviors (24). Gender differences were also evident: women reported significantly higher diarrhea prevalence (29.4%) than men (15.9%), potentially reflecting differential exposure during caregiving or underreporting by males. Similar gendered exposure patterns have been reported in peri-urban Nigeria and Ghana (25).

From a mechanistic perspective, the data support a multifactorial model wherein diarrheal risk accumulates through overlapping deficits source unreliability, absence of treatment, and unsafe handling rather than single-factor failures. The nonlinear escalation in prevalence observed across these dimensions parallels the “multiple-barrier” concept in environmental health, reinforcing that partial compliance within the WASH chain cannot fully mitigate transmission. Behaviorally anchored interventions combining education, reliable supply, and affordable treatment technologies could therefore yield synergistic health benefits.

This study contributes novel evidence specific to Pakistan’s peri-urban contexts, a domain underrepresented in national surveillance. Strengths include a representative sample, standardized WHO/UNICEF-aligned measures, and field verification of observed variables, enhancing internal validity. However, several limitations merit consideration. The cross-sectional design precludes causal inference, and self-reported diarrhea may

be subject to recall and social desirability bias. Absence of microbiological water testing constrains direct linkage between exposure and contamination, while the focus on one peri-urban community limits generalizability. Future research should adopt longitudinal or quasi-experimental designs integrating environmental sampling, geospatial mapping of supply networks, and quantitative microbial risk assessment to establish causal pathways.

In public health terms, these findings underscore that peri-urban water safety hinges not solely on infrastructure expansion but on continuity, behavior, and safe storage. Interventions must be multisectoral linking municipal service reliability with community-based education and affordable household treatment options. Scaling such integrated WASH strategies could meaningfully advance Pakistan's progress toward Sustainable Development Goal 6 by addressing the behavioral and infrastructural inequities that sustain preventable diarrheal disease

CONCLUSION

In this peri-urban Peshawar community, diarrheal morbidity remained prevalent despite near-universal sanitation coverage and widespread handwashing infrastructure, primarily due to inconsistent water supply, inadequate point-of-use treatment, and unsafe household storage. Households using on-premises, continuously supplied water, practicing boiling or filtration, and maintaining enclosed tanks exhibited substantially lower diarrhea prevalence, underscoring that water reliability and post-collection safety are as critical as access. Socioeconomic vulnerability and behavioral inconsistency, particularly among daily wage earners and caregivers, further amplified risk. These findings highlight the need for integrated WASH interventions that combine infrastructure reliability with sustained behavior-change communication and affordable household treatment options. Strengthening continuous supply systems, promoting safe storage, and embedding hygiene reinforcement within community programming could significantly reduce diarrheal burden and advance Pakistan's progress toward achieving Sustainable Development Goal 6 on clean water and sanitation.

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