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Household Practices and Environmental Conditions Associated with Diarrhea Occurrence in School-Age Children of Karachi: A Cross-Sectional Study

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ABSTRACT

Background: Diarrheal disease remains a leading cause of morbidity in low- and middle-income countries. Whereas most research focuses on children under five, the burden in school-age children (5–15 years) is poorly characterized. This study examined the frequency of diarrhea in this age group in Karachi, Pakistan, and explored associations with household hygiene practices and environmental conditions.

Methods: A cross-sectional study was conducted across 30 randomly selected clusters in Karachi between October 2018 and March 2019. One child aged 5–15 years per household was enrolled using systematic sampling. A modified version of the Multiple Indicator Cluster Survey (MICS) questionnaire was administered to mothers. Univariate and multivariate logistic regression were used to identify predictors of diarrhea in the past two weeks.

Results: Among 241 enrolled children (mean age 10 years), 79 (32.8%) had diarrhea in the preceding two weeks. The majority of households had improved sanitation (80.9%), water available for handwashing (95.9%), and soap present (93.4%). In multivariate analysis, renting the household dwelling was the only independent predictor of diarrhea (adjusted OR 2.32, 95% CI 1.04–5.18, p = 0.041).

Conclusions: Diarrhea prevalence of 32.8% in school-age children is substantial. Household tenure a proxy for socioeconomic stability and residential mobility emerged as the primary modifiable predictor. Expanded longitudinal studies are needed in this under-researched age group, with particular attention to socioeconomic determinants and residential mobility.

Keywords: *diarrhea; school-age children; household practices; WASH; Karachi; Pakistan; hygiene; sanitation*

INTRODUCTION

Globally, an estimated 4 billion cases of diarrhea occur each year, causing approximately 1.8 million deaths, the majority among children under five years of age in low- and middle-income countries (LMICs) [1]. Beyond early childhood, diarrheal disease accounts for roughly 2.8 billion episodes among older children, adolescents, and adults [2]. Despite this substantial burden, school-age children (5–15 years) represent a largely understudied population; most epidemiological and intervention research has focused on the under-five age group, where mortality is highest.

In Pakistan, access to an improved drinking water source exceeds 93%, yet only 8% of households employ an appropriate point-of-use water treatment method [3]. A community-based study in Karachi found a peak-season diarrhea prevalence of approximately 32% [4]. Known risk factors include unsafe drinking water, inadequate sanitation, and poor hygiene, alongside household-level determinants such as maternal education, household crowding, and socioeconomic status [5,6].

Children aged 5–15 years' experience greater environmental independence compared to younger children: they attend school, play outdoors, and eat outside the home, creating distinct exposure pathways for enteric pathogens. Understanding the determinants of diarrhea in this group is therefore critical for the design of targeted interventions. This paper reports findings from a cross-sectional study examining the relationship between household hygiene practices, environmental water and sanitation conditions, and diarrhea occurrence in school-age children in Karachi.

BACKGROUND

Global Burden of Diarrheal Disease

The Global Burden of Disease (GBD) Study 2015 estimated that diarrhea caused over 1.3 million deaths worldwide and ranked as the fourth leading cause of death in children under five. Although mortality has declined substantially since 1990 driven in part by scale-up of oral rehydration therapy and rotavirus vaccination reductions in morbidity have lagged behind [7]. Sub-Saharan Africa and South Asia bear a disproportionate share of this burden; half of all diarrheal deaths in children and adolescents are concentrated in five countries: India, Democratic Republic of Congo, Pakistan, Nigeria, and Ethiopia [8].

Among older children (5–9 years), intestinal infectious disease ranks as the second leading cause of death globally, driven primarily by high mortality in South and Southeast Asia [9]. Diarrheal disease also contributes substantially to undernutrition and growth faltering: each day of diarrheal illness is associated with measurable decrements in height-for-age and weight-for-age z-scores [10].

Water, Sanitation, and Diarrhea

Contaminated drinking water, inadequate sanitation, and poor hygiene practices are the primary drivers of diarrheal transmission. Intermittent water supply (IWS) prevalent across LMICs is associated with microbial contamination during pipeline pressure losses and during household storage between supply cycles [11]. A matched cohort study in urban India found that, although continuous piped supply was not associated with overall diarrhea reduction, it was linked to lower rates of typhoid and severe waterborne illness among lower-income households [12].

Access to improved sanitation reduces diarrhea risk in young children by up to 36% [13]. The Global Enteric Multicenter Study (GEMS) found that sharing a toilet facility with three or more households significantly increased moderate-to-severe diarrhea (MSD) risk at multiple sites in Africa and South Asia [13]. Lack of latrine ownership (AOR 2.43), lack of home-based water treatment (AOR 2.25), improper disposal of infant feces (AOR 3.35), and lack of improved water sources (AOR 1.98) have all been independently associated with childhood diarrhea in LMICs [14].

Hygiene Practices

Handwashing with soap remains one of the most cost-effective interventions for reducing diarrheal disease. A cohort study in Brazil found that children from households with predominantly unhygienic behavior had a 2.2-fold higher diarrhea prevalence compared to those in mainly hygienic households (95% CI 1.7–2.8) [15]. The WHO endorses point-of-use water treatment and handwashing as priority practices for reducing contaminated-water-attributable diarrhea [16]. Yet in Pakistan, despite relatively high soap availability in urban areas, safe handwashing practices remain inconsistent [3].

Gap in Evidence for School-Age Children

The vast majority of diarrhea studies in LMICs focus on children under five, where case fatality is highest. School-age children are considerably more mobile and environmentally independent, yet the literature on this age group is sparse. Children aged 5–15 are influenced by school environments, peer behaviors, and community-level sanitation in ways that differ fundamentally from the household-centric risk profile of infants and toddlers. This study aims to address this gap.

METHODS

Study Design and Setting

This was a cross-sectional study conducted in Karachi, Pakistan's largest urban center with an estimated population exceeding 15 million. Karachi comprises five administrative districts and includes both planned residential areas and approximately 702 informal squatter settlements (katchi abadis) housing 40–61% of the urban population [17,18]. Data collection took place between October 2018 and March 2019.

Sampling

Two-stage cluster sampling was employed. In the first stage, 30 enumeration blocks were randomly selected from the Pakistan Bureau of Statistics sampling frame of approximately 7,500 blocks. Within each selected block, a line listing of 50 households was conducted. In the second stage, 8 households per cluster were randomly selected. One child aged 5–15 years per household was enrolled; in households with multiple eligible children, the Kish selection method was applied. For refusals, the next household was approached.

Sample Size

Sample size was calculated using WHO sample size software based on an odds ratio of 1.9 (baseline prevalence 10%), 5% significance level, 80% power, and 4% margin of error, yielding a minimum of 217 participants. The final sample comprised 241 children.

Eligibility Criteria

Inclusion: Children aged 5–15 years residing in selected households.

Exclusion: Households where the family had resided for fewer than 6 months; children with chronic debilitating conditions (congenital anomalies, immunosuppressive therapy, gluten enteropathy); families not present at time of visit; refusal to participate.

Data Collection

Interviews were conducted with the child's mother using a structured questionnaire adapted from the Multiple Indicator Cluster Survey (MICS) tool, translated into Urdu and back-translated into English. The questionnaire covered: household sociodemographic characteristics; water source, storage, and treatment; sanitation facility type and sharing; handwashing practices and resources; and diarrheal illness in the preceding two weeks.

Outcome Variable

The primary outcome was diarrhea occurrence in the past two weeks, defined as three or more loose or liquid stools per day (WHO definition) [1].

Exposure Variables

Household practice variables included: availability of water and soap at handwashing location, handwashing frequency, type of handwashing area, and point-of-use water treatment. Environmental variables included: primary drinking water source (piped, borehole/well/tanker/drum, or bottled), water storage location, toilet type (improved vs. unimproved per WHO/UNICEF JMP definitions), and sanitation sharing arrangement. Covariates included maternal education, household head education, ethnicity, home ownership, household wealth index, house construction quality, and area type (urban/rural).

Statistical Analysis

Data were analyzed using SPSS version 21. Descriptive statistics were generated for all variables. Chi-square tests were used for categorical associations and independent-sample t-tests for continuous variables. Variables significant at $p < 0.05$ in univariate analysis were entered into a multivariate logistic regression model adjusting for key confounders (maternal education, household wealth index, home ownership, area type, household head education, ethnicity, house construction quality). Results are reported as odds ratios (OR) and adjusted odds ratios (AOR) with 95% confidence intervals.

Ethics

Ethical approval was obtained from the Ethical Review Committee of the Aga Khan University. Written informed consent was obtained from all participants. Confidentiality was maintained throughout. Households with diarrheal illness were counseled on treatment and prevention; those requiring medical attention were referred to nearby public-sector tertiary care facilities.

RESULTS

Participant Characteristics

A total of 241 children were enrolled, with a mean age of 10 years (range 5–15). The majority of households were located in urban areas (91.3%). Table 1 summarizes sociodemographic characteristics.

Table 1. Sociodemographic Characteristics of Study Participants (n = 241)

Characteristic	n	%
Number of children per household		
0–2 children	54	22.4
3–5 children	187	77.6
Maternal education		
No education	90	37.3
Up to matriculation	80	33.2
Higher education	71	29.5
Ethnicity		
Urdu-speaking	100	41.5
Sindhi/Baluchi	59	24.5
Other	82	34.0
Home ownership		
Own	171	71.0
Rent	70	29.0
Household head education		
No formal education	73	30.3
Up to matriculation	93	38.6
Higher education	75	31.1
Household wealth index		
Low	83	34.4
Middle	73	30.3
High	85	35.3

Maternal education at or above matriculation was reported by 62.7% of respondents. The largest ethnic group was Urdu-speaking (41.5%), followed by other ethnicities (34.0%) and Sindhi/Baluchi (24.5%). Most households were owner-occupied (71.0%) and located in permanent structures with finished roofing (80.9%) and flooring (88.0%).

Water, Sanitation and Hygiene Conditions

Table 2 presents water and sanitation characteristics. Most households had improved toilet facilities (80.9%) and unshared facilities (90.5%). Water was available for handwashing in 95.9% of households and soap was present in 93.4%. The predominant soap type was bar soap (90.5%). Most households did not use any water purification method (85.1%); no household reported boiling as a purification practice. Piped water was the primary drinking water source for 68.9% of households. Drinking water appeared clear in 88.0% of cases and had a sweet taste in 91.3%.

Table 2. Water and Sanitation Characteristics (n = 241)

Characteristic	n	%
Improved toilet facility	195	80.9
Unshared toilet facility	218	90.5
Water available for handwashing	231	95.9
Soap available for handwashing	225	93.4
No water purification method used	205	85.1
Primary water source: piped	166	68.9
Primary water source: bore/well/drum/tanker	48	19.9
Primary water source: bottled water	27	11.2
Water storage in premises	237	98.3
Water appearance: clear	212	88.0

Diarrhea Prevalence and Treatment

Diarrhea in the preceding two weeks was reported for 79 children (32.8%). Fever in the past two weeks was reported in 49.0% of respondents. ORS was administered during diarrheal episodes in 70.5% of cases. The majority of caregivers sought treatment from private healthcare providers (60.2%). Allopathic treatment (tablet/syrup/injection) was used in 26.6% of episodes; traditional remedies in 73.4%. Weight loss was reported in 17.0% of children with diarrhea.

Stratified Analysis

In stratified analysis, diarrhea was significantly associated with ethnicity ($p = 0.022$), home ownership ($p = 0.015$), and household head education ($p = 0.020$). Sindhi/Baluchi ethnicity was associated with lower diarrhea prevalence (18.6%) compared to Urdu-speaking (35.0%) and other

ethnicities (40.2%). Among renters, 44.3% reported diarrhea compared to 28.1% of homeowners. Sanitation facility type, water availability, soap availability, and sharing of toilet facilities were not significantly associated with diarrhea in stratified analyses (Table 3).

Table 3. Stratified Analysis: Diarrhea in Past Two Weeks by Key Characteristics (n = 241)

'Yes' and 'No' columns refer to the presence or absence of diarrhea in the preceding two weeks.

Characteristic	Yes (n)	Yes (%)	No (n)	No (%)	p
Home ownership: Own	48	28.1	123	71.9	0.015
Home ownership: Rent	31	44.3	39	55.7	
Ethnicity: Urdu	35	35.0	65	65.0	0.022
Ethnicity: Sindhi/Baluchi	11	18.6	48	81.4	
Ethnicity: Other	33	40.2	49	59.8	
Toilet type: Improved	66	33.8	129	66.2	0.468
Toilet type: Unimproved	13	28.3	33	71.7	
Shared toilet: Yes	8	34.8	15	65.2	0.830
Shared toilet: No	71	32.6	147	67.4	

Univariate and Multivariate Analysis

In univariate analysis, significant predictors of diarrhea were: home rental (OR 2.04, 95% CI 1.14–3.63, p = 0.016); Sindhi/Baluchi ethnicity vs. Urdu-speaking (OR 0.43, 95% CI 0.20–0.92, p = 0.030); and household head education up to matriculation vs. no education (OR 2.49, 95% CI 1.26–4.91, p = 0.009).

Following multivariate logistic regression adjusting for area type, drinking water source, handwashing area, and ORS use household rental remained the sole significant independent predictor of diarrhea (AOR 2.32, 95% CI 1.04–5.18, p = 0.041). No hygiene, sanitation, or water-quality variable reached significance in the adjusted model (Table 4).

Table 4. Multivariate Logistic Regression: Predictors of Diarrhea in the Past Two Weeks

AOR = adjusted odds ratio; CI Lower/Upper = 95% confidence interval bounds.

Variable	AOR	CI Lower	CI Upper	p-value
Home ownership: Own (ref.)	1.00	—	—	—
Home ownership: Rent	2.32	1.04	5.18	0.041
Area: Urban (ref.)	1.00	—	—	—
Area: Rural	0.96	0.20	4.70	0.959
Water source: Piped (ref.)	1.00	—	—	—
Water source: Bore/well/drum/tanker	0.66	0.26	1.67	0.374
Water source: Bottled water	0.45	0.04	4.59	0.497
Handwashing area: Washroom (ref.)	1.00	—	—	—
Handwashing area: Sink/tap/drum	0.71	0.21	2.45	0.588
Handwashing area: None	0.35	0.06	2.02	0.238
ORS use: No (ref.)	1.00	—	—	—
ORS use: Yes	0.71	0.27	1.88	0.491

DISCUSSION

This cross-sectional study found a two-week diarrhea prevalence of 32.8% among school-age children (5–15 years) in Karachi a figure comparable to peak-season estimates reported in younger children in the same city [4]. This finding underscores that diarrheal disease is not confined to the under-five age group and warrants dedicated research and programmatic attention in older children.

The most striking finding from the multivariable analysis is that household tenure renting vs. owning the dwelling was the only independent predictor of diarrhea (AOR 2.32). This association persisted after adjustment for sanitation, water quality, and handwashing variables, suggesting that rental status captures socioeconomic dimensions not fully reflected by the household wealth index. Renters in urban Karachi may be more likely to relocate frequently, exposing children to new microbial environments, or may inhabit lower-quality housing with suboptimal communal sanitation. Homeownership in low-income urban contexts often coincides with extended joint family structures, which may confer social support and greater attention to child health.

Despite the high prevalence of diarrhea, most standard WASH indicators performed poorly as predictors in the adjusted model. This is likely explained by the urban setting: improved sanitation coverage (80.9%), soap availability (93.4%), and piped water access (68.9%) were relatively high across the entire sample, limiting the statistical power to detect differences between exposure

groups. This 'ceiling effect' is consistent with findings from GEMS, where lack of sanitation was not a significant risk factor at sites with near-universal sanitation access [19].

The protective effect of Sindhi/Baluchi ethnicity seen in univariate analysis may reflect closely knit community networks with strong social capital and shared hygiene norms similar patterns have been noted in minority ethnic communities in South Asian cities. However, this variable did not remain significant after multivariate adjustment, suggesting confounding by socioeconomic or geographic factors.

The absence of a significant association between water purification and diarrhea likely reflects near-universal reliance on piped water and the fact that no household reported boiling as a treatment method. Easy access to bottled water and piped supply in urban Karachi may reduce motivation for home treatment, even though pipe network contamination during intermittent supply cycles remains a concern [20,11].

High ORS uptake (70.5%) and treatment-seeking behavior (69.7%) observed in this sample are encouraging from a public health standpoint, though the predominance of private-sector care (60.2%) among predominantly low-income households suggests financial barriers to public-sector utilization. Traditional treatments remained common (73.4%), consistent with patterns documented across Pakistan [21,22].

This study is the first to characterize the relationship between household practices, environmental conditions, and diarrhea specifically in the 5–15-year age group in Karachi. The two-stage cluster design and use of a validated MICS questionnaire strengthen the generalizability of findings to urban Karachi.

Several limitations should be noted. The cross-sectional design precludes causal inference. Data collection occurred during October–March, a period of relatively lower diarrhea transmission in Karachi; prevalence estimates may be conservative relative to the April–June peak season. The sample size of 241, while meeting minimum requirements, was not powered to detect small to moderate associations for subgroup analyses. Recall bias in caregiver reporting of two-week diarrhea prevalence is inherent to this methodology. Finally, the study does not capture individual-level behaviors outside the home including school environments, peer interactions, and street food consumption which are particularly relevant for the independence-seeking school-age group.

CONCLUSIONS

School-age children in Karachi experience a substantial burden of diarrheal disease, with a two-week prevalence of nearly one-third of the study population. Household rental status a marker of socioeconomic vulnerability and residential mobility was the sole independent predictor of diarrhea in multivariable analysis, while standard WASH indicators were not independently predictive, likely owing to relatively high baseline coverage in this urban sample.

These findings suggest that poverty-reduction interventions targeting housing insecurity may reduce diarrheal risk beyond what is achievable through WASH programs alone. Future research should employ prospective designs with larger samples, collect data during peak diarrhea season, and incorporate school-level and community-level exposures to capture the full range of risk factors relevant to this age group. Longitudinal studies examining migration, residential stability, and social support networks are particularly warranted.

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Data Availability Statement: The data supporting this study are available from the corresponding author upon reasonable request.

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