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Original Article

Prevalence of Skin and Gastrointestinal Infections Associated with Contaminated Water in Coastal Sindh: A Cross-Sectional Study

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ABSTRACT

Background: Water-borne diseases are still a significant preventable cause of morbidity in low-income coastal communities. The reliance on unprotected surface water sources is associated with gastrointestinal and skin infections in coastal areas of Sindh, Pakistan. The purpose of this study was to evaluate the prevalence of these infections and the relationship between them and drinking water sources and sanitation facilities for coastal populations.

Methods: It was a descriptive cross-sectional study conducted in coastal districts of Badin, Thatta and Sujawal, recruited 385 participants by convenience sampling. Questionnaire-based data were gathered on sociodemographic factors, water consumption habits, sanitation facilities and self-reported infections. Gastrointestinal symptoms that fulfilled the WHO criteria and dermatological symptoms from water contacts were defined as outcome measures. The data were analyzed by descriptive statistics and Chi-square test ($p<0.05$) through IBM SPSS version 26.

Results: 67.8% of participants reported gastrointestinal infections, with diarrhea being the most frequently reported symptom (48.8%). Skin infections were reported by 50.9%, mainly rashes and pruritus (34.3%). Gastrointestinal and skin infections were seen concurrently in 37.4% of the participants. There were significant relationships between gastrointestinal infections and the sources of primary drinking water ($\chi^2=32.84$, $p<0.001$) and drinking water source and skin infections ($\chi^2=22.61$, $p<0.001$), especially among users of canal or drain water.

Conclusion: The residents of coastal Sindh showed a high prevalence of gastrointestinal and skin infections, which were strongly linked to the use of unprotected water sources and poor sanitation. There is an urgent need to improve access to safe water, sanitation and promote hygiene.

Keywords: *Diarrhea, Gastrointestinal Diseases, Public Health, Skin Diseases, Water Borne Diseases*

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INTRODUCTION

Clean drinking water is a prerequisite for good health, but polluted water is one of the largest preventable causes of morbidity and mortality globally1. Gastrointestinal infections, including diarrhea, cholera, typhoid and dysentery are the most common water-borne diseases, causing millions of deaths every year, particularly in children under 5 years old in low and middle income countries[1,2]. In addition to enteric disease, quantitative microbial risk assessments have shown that pathogenic bacteria such as Escherichia coli, Salmonella spp., Shigella spp., Campylobacter, and Vibrio cholerae are widely distributed in drinking water sources and that they pose serious health risks to populations that are exposed, particularly in areas with inadequate water treatment and sanitation[3].

It is evident that Pakistan is one of the most water stressed countries in the world and the quality of drinking water has been deteriorating consistently in the county due to the increasing population, rapid industrialization, agricultural runoff, and old sanitation system[2,4]. It is a fact that about 80% of all the diseases and nearly 40% of all deaths in the country are due to unsafe water consumption[4]. High prevalence of diarrhea, typhoid fever, dysentery and hepatitis, as well as cholera have been reported in several provinces such as Khyber Pakhtunkhwa and Punjab and are linked to contaminated water sources[5,6,7]. The challenge is further amplified during flooding events: following the catastrophic 2022 monsoon floods, over 1.5 million suspected cases of priority waterborne diseases were reported nationally, with Sindh Province alone contributing the highest burden approximately 692,673 cases across 23 districts.[8] District-level data from flood-affected areas of Khairpur Mirs documented a simultaneous surge in malaria, diarrhea, dysentery, cholera, typhoid, skin diseases, and hepatitis among affected communities, underscoring the multi-disease burden imposed by contaminated floodwater[9].

Sindh Province, particularly its coastal belt, represents a setting of compounded vulnerability. Coastal communities depend heavily on surface water from canals, tidal creeks, and open drains, many of which carry high microbial loads and chemical pollutants[10]. In addition to high microbial levels, groundwater in several coastal and riverine districts of Sindh has arsenic levels much higher than the limits set by the World Health Organization (WHO), thus also presenting a chemical health risk[10]. Microbiological risk assessment studies in Sindh found that approximately half of school water samples were contaminated with multiple pathogens and that southern Sindh carried the highest risk of infection, with children in Karachi exhibiting the greatest annual probability of illness due to *Campylobacter* (70%) and Rotavirus (22.6%)[1]. Poor water, sanitation, and hygiene (WASH) conditions have been independently associated with increased risk of gastrointestinal illness and skin disease in community settings[3,11], while rural drinking water assessments in similar resource-limited settings confirm that sanitation coverage and water treatment practices remain critically inadequate[11,12].

Despite the well-documented burden of waterborne disease in Pakistan, existing research has predominantly focused on enteric infections in non-coastal regions, with limited attention to the unique environmental, occupational, and sanitation conditions of coastal Sindh. The co-prevalence of skin infections and gastrointestinal illness attributable to contaminated water two disease categories known to co-occur in populations with heightened water contact remains largely uncharacterized in coastal Sindh[5,7]. There is therefore a pressing need for rigorous cross-sectional epidemiological evidence from coastal Sindh to quantify the prevalence of both skin and gastrointestinal infections associated with contaminated water exposure, identify associated socio-demographic and environmental risk factors, and generate data to inform targeted public health interventions.

METHODOLOGY

Study Design and Setting

This descriptive cross-sectional study was conducted across three coastal districts of Sindh, Pakistan: Badin, Thatta, and Sujawal. These districts were purposively selected on the basis of their coastal geography, documented dependence on unprotected water sources. The study was carried out over a period of twelve months, from October 2024 to September 2025.

Sample Size

The sample size was calculated using Open Epi version 3.0 software at a 95% confidence interval and a 5% margin of error. The reference prevalence was derived from Ali et al. (2023), which reported a prevalence of diarrhoea as 17% and skin diseases as 8% among flood-affected populations of district Khairpur Mirs, Sindh, Pakistan[9]. These two prevalence values were combined to obtain an estimated prevalence of 25%, which was used as the basis for sample size estimation. A final sample size of n = 289 participants was determined.

$$n = Z^2 \times p \times (1 - p) / d^2$$

Where Z = 1.96 (at 95% confidence), p = 0.25 (combined prevalence of gastrointestinal and skin infections), and d = 0.05 (margin of error). Participants were selected through non-probability convenience sampling from community health centers, basic health units (BHUs), and residential areas across the three study districts.

Selection Criteria

Residents aged 18 years and above who had been residing in the coastal districts of Badin, Thatta, and Sujawal for a minimum period of six months prior to the study and who used local water sources including canal or surface water, hand pumps, tube wells, or unpiped ground water for drinking or domestic purposes were included. Participants who gave written informed consent were enrolled. People who had been diagnosed with chronic non-water exposure dermatologic disease, such as psoriasis, congenital ichthyosis, had undergone gastrointestinal surgery, or had moved to the study area less than 6 months prior were excluded from the study.

Data Collection Procedure

Ethical approval was obtained from the Ethical Review Committee of DHQ Civil Hospital Thatta (IRB Protocol Number: DHQ-CH-012-24) and data collection was started after the approval. Written informed consent was taken from all participants before they were enrolled and the nature, voluntary nature and confidentiality of the study was explained to participants in both Sindhi and Urdu.

The trained field investigators administered a pre-tested questionnaire for data collection on the following variables: (i) sociodemographic characteristics such as age, gender, district of residence, educational level and monthly household income; (ii) primary drinking water source, and method of water storage; (iii) water treatment practices (boiled, filtered, chemically disinfected, or not treated); (iv) sanitation and hygiene practices (latrine access, handwashing behavior); and (v) history of gastrointestinal or skin infections in the previous 3 months.

Gastrointestinal infections were confirmed when a person reported having one or more of the following symptoms: diarrhea, vomiting, abdominal cramps, nausea or dysentery, according to the WHO case definitions for waterborne enteric illness. Skin infections were evaluated by self-reported rashes, skin sores, dermatitis, boils, and itching of the skin that occurred at the same time or immediately after being in water. An attempt was made to obtain clinical confirmation of disease episodes by using medical records or the Basic Health Units (BHUs) registers, if available, to support participant-reported disease episodes. The water sources observed and reported were classified into piped water supply, canal or surface water, hand pump or tube well, or bottled water.

Statistical Analysis

IBM SPSS Statistics 26 was used to enter and analyze the data. Categorical variables like demographic characteristics, type of water source, sanitation practices and disease prevalence were tabulated and presented as frequencies and percentages. The correlation between the type of water source, sanitation and incidences of skin and gastrointestinal infection was assessed by Chi-square test. A p value of < 0.05 was considered significant.

RESULTS

A total of 289 community residents from three coastal districts of Sindh Badin (n = 97, 33.6%), Thatta (n = 101, 35.0%), and Sujawal (n = 91, 31.5%) completed the study. Most participants were male (56.7%) with the age group of 31-45 years being the age group with the highest representation (40.5%). The participants were predominantly uneducated (60.9%) or had received only primary education (40.6%) while 44.3% had an income of less than PKR 20,000 per month in their household. Demographic and socioeconomic characteristics presented in Table 1.

Table 1. Demographic and Socioeconomic Characteristics of the Participants (n = 289)

Variable	Category	Frequency n (%)
Gender	Male	164 (56.7%)
	Female	125 (43.3%)
Age Group (years)	18–30	84 (29.1%)
	31–45	117 (40.5%)
	46–60	65 (22.5%)
	>60	23 (8.0%)

District	Badin	97 (33.6%)
	Thatta	101 (35.0%)
	Sujawal	91 (31.5%)
Education Level	No formal education	95 (32.9%)
	Primary level	81 (28.0%)
	Secondary level	73 (25.3%)
	Higher / graduate	40 (13.8%)
Monthly Household Income (PKR)	<20,000	128 (44.3%)
	20,000 – 40,000	107 (37.0%)
	>40,000	54 (18.7%)

Hand pumps and tube wells were the most commonly used primary drinking water source (45.3%), followed by canal or drain water (35.3%). The majority of participants (58.5%) consumed water without any form of treatment prior to use. Half of the participants stored water in open, uncovered containers (50.9%). Open defecation was reported by 37.4% of participants, and one-quarter (25.3%) rarely or never practiced handwashing with soap. Water source and sanitation characteristics was summarized in Table 2.

Table 2. Drinking Water Source, Treatment Practices, and Sanitation Conditions (n = 289)

Variable	Category	Frequency n (%)
Primary Drinking Water Source	Canal / drain water	102 (35.3%)
	Hand pump / tube well	131 (45.3%)
	Piped supply	38 (13.2%)
	Bottled water	18 (6.2%)
Water Treatment Practice	No treatment	169 (58.5%)
	Boiling	56 (19.4%)
	Filtration	43 (14.9%)
	Chemical disinfection	21 (7.3%)
Water Storage Method	Open containers	147 (50.9%)
	Covered containers	142 (49.1%)
Access to Latrine	Yes	181 (62.6%)
	No (open defecation)	108 (37.4%)
Handwashing with Soap	Always (before/after meals)	88 (30.4%)
	Sometimes	128 (44.3%)
	Rarely / Never	73 (25.3%)

The overall prevalence of gastrointestinal infections was 67.8% (n = 196). Diarrhea was the most frequently reported gastrointestinal condition (48.8%), followed by vomiting or nausea (30.1%), dysentery (23.9%), typhoid fever (11.8%), and cholera (6.2%). The overall prevalence of skin infections was 50.9% (n = 147). Among individual presentations, rashes or pruritus were most common (34.3%), followed by boils or furuncles (21.5%), contact dermatitis (18.7%), fungal skin infections (16.3%), and scabies (10.7%). Co-occurrence of both gastrointestinal and skin infections was observed in 37.4% (n = 108) of all participants, while 18.7% (n = 54) reported neither condition. Prevalence data detailed in Table 3.

Table 3. Prevalence of Gastrointestinal and Skin Infections among Study Participants (n = 289)		
Infection Category	**Specific Condition**	**Frequency n (%)**
Gastrointestinal Infections	**Overall prevalence**	**196 (67.8%)**
	Diarrhea	141 (48.8%)
	Vomiting / Nausea	87 (30.1%)
	Dysentery	69 (23.9%)
	Typhoid fever	34 (11.8%)
	Cholera	18 (6.2%)
Skin Infections	**Overall prevalence**	**147 (50.9%)**
	Rashes / Pruritus	99 (34.3%)
	Boils / Furuncles	62 (21.5%)
	Contact dermatitis	54 (18.7%)
	Fungal skin infection	47 (16.3%)
	Scabies	31 (10.7%)
Co-occurrence of GI + Skin	**—**	**108 (37.4%)**
Neither infection reported	**—**	**54 (18.7%)**

A statistically significant association was observed between the primary drinking water source and both gastrointestinal infections ($\chi^2 = 32.84$, df = 3, $p < 0.001$) and skin infections ($\chi^2 = 22.61$, df = 3, $p < 0.001$). Participants relying on canal or drain water reported the highest prevalence of both gastrointestinal infections (86.3%) and skin infections (69.6%). In contrast, participants using piped water supply and bottled water demonstrated substantially lower rates of both gastrointestinal infections (42.1% and 33.3%, respectively) and skin infections (31.6% and 38.9%, respectively). The results show that there is a distinct gradient in risk of infection based upon water source quality, with unprotected surface water posing the highest risk. Details given in Table 4.

Table 4. Association Between Primary Drinking Water Source and Gastrointestinal and Skin Infections (n = 289)						
Water Source	**GI Infected n (%)**	**Chi Square**	**p-value**	**Skin Infected n (%)**	**Chi Square**	**p-value**
Canal / drain water	88 (86.3%)	*χ^2=32.84 (3),*	*p< 0.001*	71 (69.6%)	*χ^2=22.61*	*p< 0.001*
Hand pump / tube well	86 (65.6%)			57 (43.5%)		
Piped supply	16 (42.1%)			12 (31.6%)		
Bottled water	6 (33.3%)			7 (38.9%)		

DISCUSSION

In the present study, high prevalence of waterborne infection was found among the residents of three coastal districts of Sindh, the prevalence of gastrointestinal infection was 67.8%, skin infection was 50.9% and 37.4% of the participants had both skin and gastrointestinal infection. Such results are in line with the situation of gastrointestinal and infectious diseases found in Thatta district by the population-representative illness survey conducted by Malik et al.[13], which reported high rates of gastrointestinal and infectious diseases in a population with 75% adult illiteracy rate, 81% rural dwelling and restricted access to health care facilities, with thatta being ranked 22nd among 23 districts in the Human Development Index, Sindh.

These structural determinants are reflected in the demographic profile of our cohort, where 44.3% of participants were earning less than PKR 20,000 per month and more than 60% of the participants had only primary education or no education at all. The demographic profile of our cohort, accounted by 44.3% of people earning less than PKR 20,000 per month and more than 60% of people having no education or primary education, is a plausible socioeconomic explanation for the persistently high infection burden observed in this coastal setting.

Hydrochemical evidence within the study area supports the statistically significant link between use of canal or drain water and gastrointestinal (86.3%) and skin infections (69.6%). In a thorough national water quality assessment, Kumar et al. recorded arsenic levels as high as 1,400 micrograms per litre (µg/L) in ground water from Sindh and found that bacteriological contamination caused by faecal coliforms was rampant in all the provincial water sources[14]. In the district of Sanghar, Sindh, a hydrochemical study revealed that 31.7% of the groundwater samples were unsuitable for drinking and 20% of groundwater samples showed high restriction for drinking purpose due to saline intrusion, suggesting multi-hazard contamination in tube well sources too[15]. A chemical study and multivariate analysis of groundwater in Sanghar district, Sindh also showed that water samples were contaminated by a number of hazardous substances such as chromium, lead, nickel, cadmium, and arsenic in significant proportion and it was concluded that the groundwater source is facing multi-hazard contamination in significant proportions[16]. These findings explain why hand pump and tube well users in our cohort still recorded substantially higher infection rates than piped or bottled water consumers, reflecting endemic multi-source contamination across coastal Sindh water infrastructure.

The skin infection prevalence of 50.9%, dominated by rashes or pruritus (34.3%), boils (21.5%), and contact dermatitis (18.7%), is consistent with the dermatological burden reported in Sindh during flooding events. Manzoor and Adesola documented approximately 143,870 confirmed skin disease cases at medical centers across southern Sindh during the 2022 monsoon floods, attributing them to direct contact with contaminated floodwater causing wound infections, dermatitis, and conjunctivitis[17]. Notably, our study was conducted outside acute flooding periods yet skin infection prevalence approached the magnitude observed during the 2022 disaster, suggesting that chronic exposure to contaminated canals and open drains generates a persistent dermatological disease burden in coastal Sindh largely independent of acute flood events. A comparative analysis by Faruqui and Khan in remote Sindh reinforced this finding, demonstrating markedly elevated rates of contact-transmitted and waterborne infections in post-flood phases and emphasizing contaminated water environments as ongoing breeding grounds for skin and enteric pathogens[18].

The inadequate WASH practices documented in this cohort are a major driver of the observed infection burden. Palo and Kanungo reported an adjusted odds ratio of 3.79 (95% CI: 1.23–11.70) for acute illness among rural participants consuming surface water compared to tube well water, in a population where approximately 40% practiced open defecation, closely paralleling the 37.4% open defecation rate and 25.3% inadequate handwashing rate in our cohort[19]. The finding that 58.5% of participants consumed untreated water and 50.9% stored water in open, uncovered containers further compounds post-collection contamination risk. These converging WASH deficits create the faecal-oral and contact transmission conditions that sustain both gastrointestinal and dermatological disease at the community level, consistent with the dual-burden pattern observed in our study population.

The high prevalence of diarrhea (48.8%), dysentery (23.9%), and typhoid fever (11.8%) in this cohort reflects the enteric pathogen exposure documented in Sindh water sources. The microbial risk assessment conducted by Ahmed et al. across ten districts of Sindh primary schools estimated a 70% annual probability of Campylobacter infection and a 22.6% annual probability of Rotavirus illness for children consuming school water in southern Sindh, driven by documented faecal coliform contamination in both groundwater and surface water sources[20]. In the present study, the same observations have been made in the context of the adult coastal community, which revealed that the level of pathogen exposure in the water source area in Sindh results in a significant level of enteric disease at the community level for all age groups in the coastal districts. In the bacteriological study of drinking water in Badin district by Ali et al., they also found that there is a significant presence of faecal coliforms in the water sources in the coastal belt which is in line with the enteric infection gradient observed across the different water sources in our cohort[21]. In this setting, gastrointestinal and skin infections occurred concurrently in 37.4% of participants, highlighting multi-pathway modes of transmission of waterborne diseases. The communities having poor water and sanitation conditions are at higher risk of multiple co-occurring infectious diseases because water is a common source of transmission for various classes of infectious diseases[22], as it is observed that water sources are the common sources for the transmission of hepatitis B and hepatitis C virus. The co-occurrence pattern found in this cohort is thus a predictable consequence of chronic multi-route water exposure: enteric disease from ingestion of microbiologically contaminated water leads to dermatitis from contact with water contaminated by canals for domestic use, bathing, fishing and/or agricultural activities, and thus the observed dual burden pattern[23,25]. The climate-driven amplification of waterborne disease risk in coastal Sindh provides important context for interpreting the non-flood-period infection rates observed in this study. Faruqui and Khan demonstrated in remote Sindh communities that post-2022 flood phases corresponded to dramatic surges in malaria, hepatitis C, and other waterborne infections relative to pre-flood baselines, attributing these to floodwater mixing with sewage and agricultural drainage, contaminating canal and groundwater sources that communities continued to use for drinking and domestic purposes[18]. Manzoor and Adesola further documented that the 2022 floods displaced 2.3 million residents across Sindh and Balochistan and destroyed critical sanitation and water infrastructure, leaving a residual legacy of degraded source water quality that continues to elevate baseline infection risk in inter-flood periods[17]. The three coastal districts of this study, among the most severely flood-affected in Sindh, thus experience cyclical degradation of already fragile water infrastructure that compounds the chronic infection burden documented here.

There are a number of methodological weaknesses in this study that warrant mention. Disease ascertainment was performed by self-reported history of symptoms with the support of clinical record review if available, without routine laboratory confirmation of illness-causing pathogens, so that there is a potential for recall bias and misclassification of symptoms. The cross-sectional study design cannot establish causal association between water source exposure and occurrence of waterborne infections. Selection of recruited subjects from community health centers, basic health units, and residential areas could have also been a convenience sampling, which may have resulted in an overestimation of prevalence of the disease in comparison to the general population. Also, water quality testing at the household level is not done, which makes it difficult to directly attribute illness to exposure to any specific pathogen. A robust evidence base for causal attribution and targeted intervention design in this coastal population would be greatly enhanced by future longitudinal studies that included laboratory diagnosis and household water quality analysis and objective assessments of WASH infrastructure.

CONCLUSION

This cross sectional study shows a high clinically significant prevalence of gastrointestinal infection (67.8%) and skin infection (50.9%) among the residents of coastal Sindh, and more than one third of the respondents having a dual disease burden. The strongest determinants for both types of infection were primary drinking water source; canal and drain water consumers had a disproportionately high risk compared to piped or bottled water consumers. The lack of water treatment (58.5%) of water consumed, open defecation (37.4%) and poor hand hygiene (25.3%) places are a ‘convergent transmission environment' sustaining the observed infection burden regardless of acute flooding events. These results correspond to the regional hydrogeochemical evidence of widespread contamination of groundwater in coastal districts of Sindh and match with the national and international literature of the link between WASH deficits and waterborne disease burden in low-resource areas. The findings highlight the need of immediate public health interventions to increase access to safe piped water, improve sanitation access through increasing the coverage of latrine construction and hand washing promotion and implement community-level water treatment approaches (such as point of use chlorination, ceramic filtration) as an interim solution, in coastal Badin, Thatta and Sujawal districts. Coastal belt of Sindh should be regarded as a high-risk area of compounded infectious diseases that demands specific epidemiological surveillance, environmental health intervention as well as continuous investment in water, sanitation, and hygiene facilities for lowering the non-preventable morbidity burden as seen in this study.

Author Contributions
AS: Conception & design, Data Analysis and interpretation and Manuscript Writing.
NZ: Data Collection and Manuscript Writing.
AL: Conception & design, Data Collection, Critical Revision and Final Approval.
IK: Data Analysis and interpretation, Critical Review and Final Approval.

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Data Availability
Data will be available on request

Ethics approval
Not applicable

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