TUJM Tribhuvan University Journal of Microbiology

ORIGINAL RESEARCH

Integrative Analysis of Community-Level Determinants of Pediatric Diarrhea in the Peri-Urban area of Kathmandu

Hemanta Khanal[1, 2], Kajol Jha[1], Binesh Thapaliya[3], Santosh Adhikari[4], Ram Hari Chapagain[5], Rajat Dhakal[6], Dev Raj Joshi[1], Reshma Tuladhar[1*]

[1]Central Department of Microbiology, Tribhuvan University, Kirtipur, Nepal;

[2]Central Campus of Technology, Dharan, Sunsari, Nepal;

[3]Tokha Chandeshwori Hospital, Tokha, Kathmandu, Nepal

[4]Shankharapur Hospital, Jorpati, Kathmandu, Nepal;

[5]Kanti Children's Hospital, Maharajgunj, Kathmandu, Nepal;

[6]Centre for Infectious Diseases and Microbiology, Public Health, WSLHD, New South Wales, Australia

***Corresponding author:** Dr. Reshma Tuladhar, Associate Professor, Central Department of Microbiology, Tribhuvan University, Kirtipur, Nepal Email: reshma.tuladhar@cdmi.tu.edu.np / resutu@gmail.com

ABSTRACT

Objectives: This study aimed to identify community-level environmental and behavioral determinants associated with acute pediatric diarrhea among children under five years of age in peri-urban areas of Kathmandu Valley, Nepal.

Methods: A community-based cross-sectional study was conducted between May 2024 and October 2025 across three peri-urban community hospitals in Kathmandu Valley. A total of 550 children under five years of age presenting with acute diarrheal symptoms were enrolled following informed consent from guardians. Data on clinical presentation, environmental exposures, child-specific behaviors were collected using pretested semi-structured questionnaires and analyzed.

Results: Abdominal cramps (66.7%) and mucus in stool (64.2%) were the most commonly reported symptoms, while blood in stool (8.5%) and blood in urine (1.6%) were rare. Jar water was the predominant drinking water source (65.8%) and showed a strong association with vomiting and watery stool (χ^2, $p < 0.001$ for both). Multivariate logistic regression identified increasing age (adjusted OR = 1.32, 95% CI = 1.15–1.52) and putting toys in the mouth (adjusted OR = 2.02, 95% CI = 1.29–3.15) as significant, independent predictors of fever ($p \leq 0.002$). The model demonstrated a classification accuracy of 69.8% with marginal goodness-of-fit (Hosmer – Lemeshow, p = 0.045). Receiver operating characteristic (ROC) analysis indicated that age had the highest individual discriminatory power, whereas stool consistency and mucus in stool were poor predictors.

Conclusions: Pediatric diarrhea in peri-urban Kathmandu remains strongly influenced by child-specific behaviors and household water safety. Targeted interventions addressing hygiene practices, safe water handling and caregiver awareness are essential to reduce diarrheal morbidity in rapidly urbanizing settings.

Keywords: Pediatric diarrhea, Kathmandu Valley, community level determinants, hygiene behaviors

INTRODUCTION

Pediatric diarrhea remains a major global public health challenge, particularly among children under five years of age. Despite advances in sanitation and health care, diarrheal diseases are responsible for nearly half a million deaths annually, predominantly in low- and middle-income countries especially in South Asia and sub-Saharan Africa (World Health Organization, 2024). Besides mortality, recurrent diarrheal episodes lead to chronic malnutrition, growth delays, and cognitive

Date of Submission: November 30, 2025 **Date of Acceptance:** December 26, 2025

Published Online: December, 2025 **DOI:** https://doi.org/10.3126/tujm.v12i1.88393

impairment, perpetuating cycles of poverty and poor health across generations. In Nepal, diarrheal disease is ranked among the top five disease of childhood morbidity, with the highest incidence observed in children aged 6-23 months. The burden is further intensified during the monsoon season, when water quality and sanitation are compromised, leading to seasonal peaks in disease incidence (Ministry of Health and Population, 2023; Nepal Demographic and Health Survey, 2022). The persistence of diarrhea, which extends beyond pathogens, involves a complex environmental and behavioral determinant. Understanding these interconnected factors is essential for designing effective and context-specific interventions.

Kathmandu Valley, with its rapidly evolving mix of urban, peri-urban and rural lifestyles, highlights profound disparities in water access, sanitation facilities, and hygiene practices. These challenges are particularly pronounced in rapidly growing informal settlements and peri-urban areas, where high population density and inadequate infrastructure increase the vulnerability to diarrheal diseases. Although governmental and non-governmental initiatives have aimed to improve water, sanitation, and hygiene (WASH) infrastructure and promote healthy behaviors, progress has been uneven across regions and socioeconomic groups (Getahun and Adane 2021; UNICEF Nepal, 2021). Continued reliance on conventional drinking water sources that are frequently contaminated, coupled with irregular piped water supply in many regions, further exacerbates the risk of childhood diarrhea, especially during periods of heavy rainfall.

Despite the availability of effective, low-cost interventions such as oral rehydration therapy, acute diarrheal disease remains a leading cause of childhood morbidity and mortality in Nepal, with prevalence ranging from 11.9% to over 50%. The burden is exacerbated by significant geographic and socioeconomic disparities, with children from poorer households, those living in provinces such as Sindhuli, Karnali and Sudurpaschim (Far Western Nepal), and whose caregivers lack adequate knowledge or access to improved sanitation are affected (Ansari et al., 2011; KC et al., 2025). While community-based programs, have contributed to reductions in severe disease mortality, significant gaps persist, including limited maternal knowledge of dehydration signs and home management, treatment costs, and inconsistent access to preventive and curative services in remote areas (Ghimire et al., 2010, Thapa et al., 2023; Mishra et al., 2022).

Optimistically, reported diarrheal cases in Nepal have declined threefold over the past decade, largely attributed to improvements in WASH practices and reductions in open defecation (MOHP, 2022). However, evidence suggests that contamination of water sources remains widespread, and children's behaviors, and feeding practices continue to play a critical role in the incidence of diarrhea (Bhandari et al., 2020; Dhimal et al., 2021). Continued efforts to ensure safe drinking water and public awareness are essential to sustain this progress.

Existing research in Nepal has predominantly relied on hospital-based surveillance data and pathogen identification, offering limited insights into community level determinants within rapidly urbanizing settings like Kathmandu valley. Consequently, there is a lack of robust evidence on the interplay between household hygiene practices, animal exposure, childcare practices, and environmental conditions at the community level. Addressing this knowledge gap is vital for informing locally tailored and effective prevention strategies. This study aims to assess community-level determinants of pediatric diarrhea in Kathmandu Valley, generating evidence to support targeted public health interventions and contribute to Nepal's ongoing efforts to reduce childhood morbidity and mortality from diarrheal diseases.

METHODS

Ethical Approval: Ethical clearance was obtained from the Institutional Review Committee of the Nepal Health Research Council (NHRC), Kathmandu, Nepal (Ref. No. 1504). Written informed consent was obtained from the parents or legal guardians of all participating children prior to enrollment, ensuring voluntary participation.

Study design and setting: A community-based cross-sectional study was conducted across three strategically selected community hospitals located in the peri-urban areas of the Kathmandu Metropolitan City ring road: Gokarneshwar Hospital, Gokarna; Tokha Chandeshwori Hospital, Tokha; and Shankharapur Hospital, Jorpati. These hospitals primarily serve semi-rural and peri-urban populations and were selected to

capture diarrheal disease determinants in communities transitioning from rural to urban settings. Although participant recruitment occurred in hospitals, the catchment populations of these facilities represent defined community settings, allowing assessment of community-level environmental and behavioral factors associated with pediatric diarrhea. Data and samples collection were conducted over an 18-month period from May 2024 to October 2025.

Sample size: The sample size was calculated using Cochran's formula, assuming a 40% prevalence of pediatric diarrhea based on prior study (Sangma and Rasania, 2025), a 5% margin of error, and a 95% confidence level, with a 50% inflation factor (design effect [DEFF] = 1.5) to account for non-response and to ensure adequate statistical power for subgroup analyses, resulting in a final target sample size of 550 children.

Study participants and sample collection: Children under 60 months of age presenting clinically suspected acute diarrhea were enrolled from the outpatient departments or emergency units of the participating hospitals. Eligible cases were identified by attending pediatricians, who introduced the study to the guardians. After obtaining written informed consent, participants were enrolled consecutively. A pretested semi-structured questionnaire was administered by trained pediatricians to ensure uniformity and data reliability.

Data collection: Pediatricians collected data at the time of clinical evaluation and sample collection. The questionnaire collected detailed information on sociodemographic factors (age, gender), clinical features of diarrhea and medical history, vaccination status, environmental and behavioral factors, including household conditions, child-specific habits and hygiene practices at home and in the community, and recent travel history.

Data management and statistical analysis: Data from the semi-structured questionnaires were entered into Microsoft Excel, followed by data cleaning, validation, and consistency checks. Descriptive statistics were used to summarize participant characteristics, while chi-square tests and multivariable logistic regression were applied to assess associations between community-level factors and diarrheal outcomes. A p-value of <0.05 was considered statistically significant. All analyses were conducted using Linux-based R software (version 4.3.2).

RESULTS

Study population

A total of 550 children aged 1-60 months with clinically suspected acute diarrhea were enrolled from peri-urban community hospital settings at outside ring-road in Kathmandu Valley. Any one of the following key symptoms: acute diarrhea lasting at least one day, lose or watery stool, or a frequency of three or more defecations within a 24-hour period, abdominal cramps and mucus and/or blood in stool, was considered during enrollment. Males were predominant (60.4%) and the most represented age group was 13 - 24 months (30.7%), followed by 7 – 12 months (19.8%). The majority of participants (70.5%) were from Gokarneshwar Hospital **(Table 1).**

Table 1: Sociodemographic characteristics of the study population

Categories		Gender		Total (%)
		M	F	
Study centers	Gokarneshwar Hospital	220	168	388 (70.5)
	Shankharapur Hospital	57	20	77 (14)
	Tokha Hospital	55	30	85 (15.5)
Age group (months)	below 6	35	22	57 (10.4)
	7 to 12	66	43	109 (19.8)
	13 to 24	110	59	169 (30.7)
	25 to 36	48	43	91 (16.5)
	37 to 48	41	22	63 (11.5)
	48 to 60	32	29	61 (11.1)
Total		**332 (60.4%)**	**218 (39.6%)**	**550 (100)**

Clinical presentation and vaccination status

Semi-formed stool was the most frequently reported consistency (57.5%), followed by watery stool (35.3%) **(Figure 1)**.

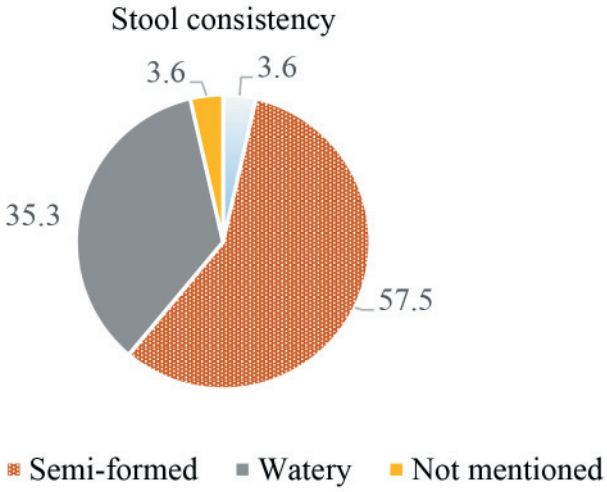

Figure 1: Stool consistency

Abdominal cramp was the most common clinical symptom (66.7%), followed by mucus in stool (64.2%). Fever and vomiting were reported in 27.8% and 20.5% of cases respectively. Blood in stool was uncommon, with only 8.5%, and blood in urine was rare (1.6%) (**Table 2a**). Regarding vaccination status, rotavirus vaccine coverage was the highest (73.2%), followed by typhoid (43.5%) and cholera vaccines (24.9%) (**Table 2b**).

Table 2a: Patients clinical symptoms and medical history

Clinical Symptoms and Medical History	Yes (%)	No (%)	Not mentioned (%)
Blood in stool	47 (8.5)	481 (87.5)	22 (4)
Mucus in stool	353 (64.2)	174 (31.6)	35 (4.2)
Fever	153 (27.8)	362 (65.8)	35 (6.4)
Nausea	82 (14.9)	413 (75.1)	55 (10)
Vomiting	113 (20.5)	409 (74.4)	28 (5.1)
Muscle ache	113 (20.1)	415 (75.5)	24 (4.4)
Abdominal cramp	367 (66.7)	159 (28.9)	24 (4.4)
Blood in urine	9 (1.6)	516 (93.8)	25 (4.6)
Prior antibiotic therapy	46 (8.4)	468 (85.1)	36 (6.5)

Table 2b: Vaccination Status

Vaccine taken	Yes (%)	No (%)	Not mentioned (%)	Didn't Know (%)
Typhoid vaccine	239 (43.5)	271 (49.2)	39 (7.1)	1 (0.2)
Rota vaccine	403 (73.2)	106 (19.3)	39 (7.1)	2 (0.4)
Cholera vaccine	137 (24.9)	365 (66.3)	40 (7.3)	8 (1.5)

Diarrhea Onset and Defecation Frequency

Most children (60.2%) presented within 1-2 days of symptoms onset, indicating predominantly acute cases. Defecation frequency was highest at 2 episodes per day (34.4%), while 11.8% reported more than 5 daily episodes. Only 4.4% experienced symptoms lasting over 5 days, suggesting most cases were self-limiting **(Table 3)**.

Table 3: Diarrhea onset and frequency of defecation

Factors	Response in questionnaires	Frequency (%)
Symptoms/Diarrhea appeared since (days)	1 Day	129 (23.5)
	2 Days	202 (36.7)
	3 Days	113 (20.5)
	4 Days	44 (8)
	5 Days	18 (3.3)
	More than 5 Days	24 (4.4)
	Not mentioned	20 (3.6)

Factors	Response in questionnaires	Frequency (%)
Frequency of defecation	1 time a day	40 (7.3)
	2 times a day	189 (34.4)
	3 times a day	114 (20.7)
	4 times a day	77 (14)
	5 times a day	42 (7.6)
	More than 5 times a day	65 (11.8)
	Not mentioned	23 (4.2)

Behavioral and environmental determinants

Frequent oral exploratory behavior was observed, with 63.3% of children putting fingers in their mouth and 32.7% placing toys in their mouth. Hand hygiene practices were suboptimal, as only 20% of caregivers reported that children always washed their hands after returning home. Environmental exposures risks were relatively low: 85.3% of households reported no pets or cattle, and reports of animal diarrhea (0.7%), recent travel to endemic areas (2.2%), diarrhea among family members (2.9%), and diarrhea in neighbors (0.4%) were uncommon (**Table 4** and **Table 5**).

Table 4: Child behaviors and hygiene practices

Child-specific behaviors and hygiene practices				
Child behaviors	**Yes (%)**	**No (%)**	**Not mentioned (%)**	**Sometimes (%)**
Finger in mouth	348 (63.3)	140 (25.5)	53 (9.6)	9 (1.6)
Crawling of child	144 (26.2)	296 (53.8)	106 (19.3)	9 (1.6)
Toys in mouth	180 (32.7)	314 (57.1)	55 (10)	1 (.02)
Hand washing when back to home from out	110 (20)	244 (44.4)	54 (9.8)	142 (25.8)

Table 5: Potential source exposure history

Potential source exposure history	Yes (%)	No (%)	Not mentioned (%)	Not noticed (%)
Pets/cattle at home	25 (4.5)	469 (85.3)	56 (10.2)	--
Diarrhea in pets/cattle	4 (0.7)	490 (89.1)	56 (10.2)	--
Recent travel history	12 (2.2)	483 (87.8)	55 (10)	--
Diarrhea in family	16 (2.9)	480 (87.3)	54 (9.8)	
Diarrhea in neighbors	2 (0.4)	483 (87.8)	54 (9.8)	11 (2)

Household Environment and behavioral risk factors

More than half of households had cemented floors (57.2%), while jar water was the predominant drinking source (65.8%). Approximately one-third of children (34.4%) consumed no food outside the home during the preceding week, whereas kindergarten canteens were a common source of outside food (20.4%). Missing responses ranged from 10 to 15.8% across environmental variables **(Table 6).**

Table 6: Distribution of household environment and behavioral risk factors

Risk Factors	Response in questionnaires	Frequency (%)
Floor of house	Carpeted	114 (26.2)
	Cemented	315 (57.2)
	Muddy	34 (6.2)
	Others	2 (0.4)
	Not mentioned	55 (10)
Child food from outside (within a week)	Home only	93 (16.9)
	Breastfeeding only	8 (1.5)
	Hotel	17 (3.1)
	Kindergarten Canteen	112 (20.4)
	Junk foods	4 (0.6)
	Sometimes	35 (6.4)
	No	189 (34.4)
	Others	5 (0.9)
	Not mentioned	87 (15.8)

Risk Factors	Response in questionnaires	Frequency (%)
Drinking water type	Boiled water	78 (14.2)
	Breastfeeding only	12 (2.2)
	Filtered water	12 (2.2)
	Jar water	362 (65.8)
	Natural resource	3 (0.5)
	Tap water	27 (4.9)
	Deep well water	1 (0.2)
	Not mentioned	55 (10)

Association between stool consistency with gender and fever

Fever prevalence increased with worsening stool consistency, from formed stool (15.0%) to semisolid (25.3%) to watery stool (36.1%). This association was stronger in males. The relationship between stool consistency and fever was statistically significant across gender (p<0.0001), with moderate-to-large effect sizes (Cramer's V= 0.535). Missing stool data corresponded with missing fever data, indicating a documentation gap (**Table 7**).

Table 7: Association of stool consistency with genders and fevers

Stool consistency	Fever in Female			Fever in Male			*p*-value
	Yes	No	Not mentioned	Yes	No	Not mentioned	
Formed	2	5	--	1	12	--	Both genders and overall (0.0001)
Semisolid	31	95	6	49	129	6	
Watery	23	46	--	47	75	3	
Not mentioned	--	--	10	--	--	10	
Total	**56**	**146**	**16**	**97**	**216**	**19**	

Fecal characteristics and abdominal cramp

Abdominal cramps were significantly more common among children with blood in stool (70.2%) and mucus in stool (75.6%) compared to those without these features. Strong associations were observed between abdominal cramp and blood in stool (χ^2 = 525.2, p = 0.0001), as well as mucus in stool (χ^2 = 522.940, p = 0.0001) (**Table 8**).

Table 8: Association between blood and mucus in stool and abdominal cramp

Fecal characteristics		Abdominal Cramp				Total	*p*-Value
		Yes	No	Not mentioned	Not noticed		
Blood in stool	Yes	33	14	--	--	47	x^2 = 525.2 *p*-Value = 0.0001
	No	334	145	1	1	481	
	Not mentioned	--	--	22	--	22	
Mucus in stool	Yes	267	84	1	1	353	x^2 = 522.940 *p*-Value = 0.0001
	No	99	75	--	--	174	
	Not mentioned	1	--	22	--	23	

Vaccination status by age group

Vaccination coverage increased with age, peaking in the 13-24 month age group. Significant associations were observed between age and rotavirus vaccines (χ^2 = 57.257, p < 0.001) and typhoid vaccines (χ^2 = 102.635, p < 0.001). No significant age-based association was observed for cholera vaccination (χ^2 = 17.580, p=.0.285), with remained low (19.3%-32.3%) across all ages (**Table 9**).

Table 9: Association between age group and vaccination status

Age (months)	Rota vaccine		Typhoid vaccine		Cholera vaccine	
	Yes	No/don't know/others	Yes	No/don't know/others	Yes	No/don't know/others
below 6	26	31	7	50	11	46
7 to 12	79	30	24	85	28	81
13 to 24	130	39	79	90	35	134
25 to 36	71	20	46	45	27	64
37 to 48	50	13	36	27	18	45
48 to 60	47	14	47	14	18	43
Total	**403**	**147**	**239**	**311**	**137**	**413**
	x^2 = 57.257, p = .0001		x^2 = 102.635, p < .001		x^2 = 17.580, p = 0.285	

Defecation frequency and pet animal exposure

Most households reported no pets or cattle (84.5%), and animal diarrhea was rare. Although statistically significant associations were observed between defecation frequency and pet ownership (χ^2 = 206.71, p < 0.001, Cramer's V = 0.43) and animal diarrhea (χ^2 = 207.03, p < 0.001, Cramer's V = 0.43), interpretation is limited due to moderate effect sizes (Cramer's V = 0.43) and a high proportion of cells with expected counts below five. The significance appears largely driven by missing data pattern rather than biologically meaningful relationships (**Table 10**).

Table 10: Child defecation frequency in relation to household animal presence and animal diarrheal illness

Frequency of defecation per day (times)	Pets/cattle at home			Diarrhea in pets/cattle		
	Yes	No	Not mentioned	Yes	No	Not mentioned
1	4	32	4	1	35	4
2	6	165	18	2	169	18
3	5	98	11	--	103	11
4	4	72	1	--	76	1
5	3	39	--	--	42	--
More than 5	3	62	--	1	64	--
Not mentioned	--	1	22	--	1	22
p-Value: 0.0001				*p*-Value: 0.0001		

Drinking water source as a determinant of vomiting and watery diarrhea

Type of drinking water is strongly associated with vomiting (χ^2 = 217.74, p = 0.0001) and stool consistency (χ^2 = 350.11, p = 0.0001). Jar water and boiled water accounted for the majority of vomiting and watery stool cases, suggesting potential contamination or handling related risks (**Table 11**).

Table 11: Association between drinking water type, vomiting and stool type

Types of drinking water	Vomiting			Types of stool			
	Yes	No	Not mentioned	Formed	Semisolid	Watery	Not mentioned
Boiled Water	31	47	--	1	13	64	--
Breastfeeding	1	11	--	--	8	4	--
Deep well	1	--	--	--	--	1	--
Filtered Water	5	7	--	--	2	10	--
Jar Water	58	299	5	9	266	87	--
Natural Resource	3	--	--	1	--	2	--
Tap Water	10	17	--	--	11	16	--
Not mentioned	4	28	23	9	16	10	20
***p*-Value**	**x^2 = 217.74, *p*-value= 0.0001**			**x^2 = 350.11, *p*-value= 0.0001**			

Predictors of fever

Multivariable logistic regression analysis was conducted among 148 complete cases to identify predictors of fever among children with diarrhea. The model was statistically significant (χ^2 (4) = 34.621, p < 0.001) and explained approximately 9.8% of the variance in fever occurrence (Nagelkerke R^2 = 0.098). The Hosmer–Lemeshow test indicated a borderline poor model fit (χ^2 (7) = 14.375, p = 0.045), suggesting that the model's predictions deviated from the observed outcomes. The overall classification accuracy was 69.8%. Age and putting toys in the mouth were strong, significant predictors of fever (p < .001 and p = 0.002, respectively). A one-unit increase in age category increased the odds of fever by 32.1%, and children who placed toys in their mouth had twice the odds of developing fever (aOR = 2.02). Vomiting showed a marginal association (p = 0.079), while stool consistency was not a significant predictor (**Table 12**).

Table 12. Logistic regression analysis of factors associated with fever

Predictor variable	B	SE	Wald	df	*p*-value	Adjusted OR	95% CI for OR
Age Category	0.279	0.072	14.854	1	0.0001	1.321	1.147 - 1.523
Toys in Mouth	0.701	0.227	9.526	1	0.002	2.017	1.292 - 3.148
Stool Consistency	0.111	0.232	0.231	1	0.631	1.118	0.710 - 1.760
Vomiting	0.434	0.247	3.085	1	0.079	1.544	0.951 - 2.505
Constant	-1.916	0.243	62.112	1	0.0001	0.147	—

Model χ^2 (df = 4) = 34.621, Cox & Snell R^2 = 0.070, Nagelkerke R^2 = 0.098, Overall Classification Accuracy = 69.8%, $p < .001$, Hosmer–Lemeshow p-value = 0.045

B = Regression coefficient, SE = standard error of the regression coefficient, df: degree of freedom, CI: Confidence Interval, OR: Odds Ratio

ROC curve analysis confirmed age as the strongest single predictor of fever, followed by putting toys in the mouth. Vomiting demonstrated moderate predictive value, whereas stool consistency and mucus in stool showed minimal discrimination (AUC ≈ 0.50), aligning with their non-significance in the adjusted model (**Figure 2**).

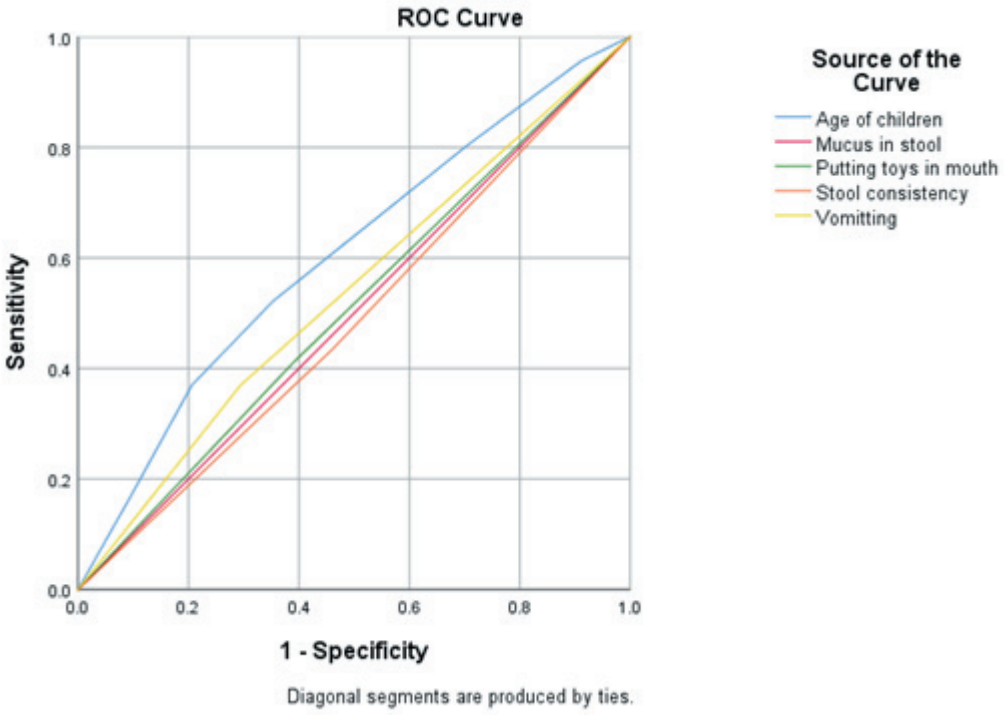

Figure 2: Receiver operating characteristic (ROC) curves comparing the diagnostic accuracy of individual clinical and behavioral predictors for fever

DISCUSSION

The study focused on a high-risk pediatric population, with children aged 13–24 months constituting the largest proportion of cases. This age group is widely recognized as vulnerable to diarrheal disease due to increased mobility, and frequent oral exploratory behaviors. Although a substantial proportion of participants were recruited from a single, potentially limiting generalizability across diverse geographic settings, the use of stringent clinical inclusion criteria ensured enrollment of children with active, symptomatic diarrheal illness, enhancing the clinical relevance of the findings. Despite a reported 70.7% decline in under-five diarrheal mortality in Nepal between 2005 and 2015, diarrhea remains a significant public health burden, with millions of cases and thousands of deaths annually. While expanded use of ORS and zinc supplementation has contributed to reductions in mortality, persistent gaps in preventative WASH infrastructure, child-specific exposure risks, and food safety continue to drive high disease incidence (GBD 2017; Getahun and Adane 2021).

This study highlights critical community-level determinants of pediatric diarrhea in peri-urban Kathmandu, a setting increasingly vulnerable to climate-sensitive health threats. The high prevalence of oral exploratory behaviors, combined with suboptimal hand hygiene practices, reflects well established fecal-oral transmission pathways that are exacerbated by inadequate WASH conditions. The strong associations between commonly used drinking water sources (particularly jar and boiled water), and clinical outcomes such as watery stool and vomiting raise concerns regarding post-treatment contamination during water storage and distribution. These findings

emphasize that access to improved water source alone is insufficient without concurrent attention to safe handling practices and household hygiene, particularly in rapidly urbanizing peri-urban environments.

Vaccination coverage patterns further support critical preventive gaps. While rotavirus vaccination coverage was relatively high, coverage for typhoid and cholera vaccines remained low. In Nepal, rotavirus vaccine is routinely administered in early infancy, whereas typhoid vaccine is typically given at 15 months and cholera vaccines mainly during outbreaks. Low typhoid and cholera vaccine uptake likely reflects a combination of supply constraints, access barriers, and limited parental awareness (Lawrence et al., 2025). Reports of early rotavirus vaccination may reflect documentation errors, misattribution of sibling vaccination status, or reporting inaccuracies under high clinical workloads (Paul et al., 2022). These findings highlight the need for improved vaccination record-keeping and caregiver education to ensure effective immunization coverage.

Although direct exposure to pets was reported infrequenty in this study, the role of zoonotic transmission warrants careful consideration. Numerous studies from Nepal and South Asia have demonstrated that domestic animals can serve as reservoirs for enteric pathogens such as *Campylobacter*, *Salmonella*, *Cryptosporidium*, *Giardia*, and diarrheagenic *E. coli*, which are transmitted to children, with evidence of genetically similar strains circulating between humans and animals (Heyworth et al., 2006; Klous et al., 2016; Delahoy et al., 2018; Shrivastava et al., 2020; Khan et al., 2023; Tumwebaze et al., 2025). Approximately 10% of caregivers in this study reported uncertainty regarding animal exposure or animal diarrhea, indicating limited awareness and surveillance at the community level. This knowledge gap likely leads to underestimation of zoonotic transmission risks and obscures the true contribution of animal fecal contamination to diarrheal disease burden in peri-urban settings.

Clinically, the strong association between blood or mucus in stool and abdominal cramps, observed in this study highlights the frequent co-occurrence of these symptoms in acute diarrheal illness. Compared with reports from rural Nepal, India and Kenya, the overall prevalence of severe symptoms such as abdominal cramping appeared lower, potentially reflecting improved healthcare access and health-seeking behavior in peri-urban Kathmandu. Consistent with previous studies, pathogens such as *Shigella* spp and *Entamoeba histolytica* have been commonly implicated in similar clinical presentations, supporting the importance of hand hygiene, safe water handling, and sanitation as key preventive measures against acute diarrhea (Aggarwal et al., 2016; Njuguna et al., 2016; Taneja and Mewara 2016; Rai et al., 2018).

The association between drinking water sources and gastrointestinal symptoms observed in this study further emphasizes the role of environmental contamination in pediatric diarrhea. The higher frequency of vomiting and watery stool among children consuming boiled and jar water was suggested contamination during storage or handling. However, breastfeeding and use of filtered water were associated with better outcomes. These findings are consistent with studies from Nepal, India, and Ethiopia, demonstrating that unsafe water and poor handling significantly increase diarrheal risk (Lakew et al., 2016; Mitkari et al., 2019; Getahun and Adane, 2021; Shrestha et al., 2021; Zulfiana et al., 2021; Mebrahtom et al., 2022; Merid et al., 2023). Ensuring safe water, proper handling, and strengthening caregiver education on water safety and hygiene practices remains essential for reducing diarrhea transmission.

Multivariable regression analysis identified increasing age and putting toys in mouth as significant predictors of fever among children with diarrhea. The strong effect of age corroborates national evidence identifying children aged 12–24 month as the most vulnerable group. A key behavioral predictor putting toys in the mouth highlights a direct transmission pathway often overlooked in large demographic surveys that emphasize broad determinants like sanitation and household wealth. These findings suggest that while socioeconomic conditions establish baseline risk, immediate child behaviors play a critical role in triggering febrile illness in high-risk age groups (Pathak et al., 2019; Li et al., 2020; Thapa et al., 2023).

CONCLUSION

This study provides a comprehensive characterization of acute diarrheal illness among children under five years of age in peri-urban Kathmandu Valley. The burden is highest among children aged 13–24-month and is driven by a combination of developmental behaviors, inadequate hygiene practices, unsafe water handling, and gaps in vaccination coverage.

While rotavirus vaccination uptake is encouraging, persistently low typhoid and cholera coverage represents a missed opportunity for prevention. Contamination of commonly used water sources, including jar and boiled water, remains a significant risk factor. Although reported direct animal exposure was low, limited awareness suggests that zoonotic transmission risks may be underestimated. Addressing pediatric diarrhea in peri-urban Nepal will require integrated interventions that combine WASH improvements, strengthened immunization programs, and targeted caregiver education focused on child-specific behaviors and household hygiene.

ACKNOWLEDGMENTS

This research was supported by Excellence Research Grant (ERG-1) provided by Research Directorate, Tribhuvan University, Nepal and Research Fellowship by Nepal Academy of Science and Technology (NAST), Khumaltar, Nepal. We are grateful to the staff of Gokarneshwar, Tokha Chandeshwori, and Shankharapur Hospitals, and the Central Department of Microbiology for their invaluable support.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

REFERENCES

Aggarwal, P., Uppal, B., Ghosh, R., Prakash, S. K., Chakravarti, A., & Rajeshwari, K. (2016). True prevalence of shigellosis in Indian children with acute gastroenteritis: Have we been missing the diagnosis? *International Journal of Research in Health Sciences*, 16(1), 11–16. https://doi.org/10.29011/IJRHS-16-001

Ansari, M., Izham, M. I., & Pathiyil, R. S. (2011). A survey of mothers' knowledge about childhood diarrhoea and its management among a marginalised community of Morang, Nepal. *Australasian Medical Journal*, 4(9), 474–479. https://doi.org/10.4066/AMJ.2011.821

Bhandari, D., Bi, P., Sherchand, J. B., Dhimal, M., & Hanson-Easey, S. (2020). Assessing the effect of climate factors on childhood diarrhoea burden in Kathmandu, Nepal. *International Journal of Hygiene and Environmental Health*, 223(1), 199–206. https://doi.org/10.1016/j.ijheh.2019.09.002

Delahoy, M. J., Wodnik, B., McAliley, L., Penakalapati, G., Swarthout, J., Freeman, M. C., & Levy, K. (2018). Pathogens transmitted in animal feces in low- and middle-income countries. *International Journal of Hygiene and Environmental Health*, 221(4), 661–676. https://doi.org/10.1016/j.ijheh.2018.03.005

Dhimal, M., Bhandari, D., Dhimal, M. L., Kafle, N., Pyakurel, P., Mahotra, N., Akhtar, S., Ismail, T., Dhiman, R. C., Groneberg, D. A., Shrestha, U. B., & Müller, R. (2021). Impact of climate change on health and well-being of people in Hindu Kush Himalayan region: A narrative review. *Frontiers in Physiology*, 12, 651189. https://doi.org/10.3389/fphys.2021.651189

GBD Diarrhoeal Diseases Collaborators. (2017). Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoeal diseases: A systematic analysis for the Global Burden of Disease Study 2015. *The Lancet Infectious Diseases*, 17(9), 909–948. https://doi.org/10.1016/S1473-3099(17)30276-1

Getahun, W., & Adane, M. (2021). Prevalence of acute diarrhea and water, sanitation, and hygiene (WASH) associated factors among children under five in Woldia Town, Amhara Region, northeastern Ethiopia. *BMC Pediatrics*, 21(1), 227. https://doi.org/10.1186/s12887-021-02668-2

Ghimire, M., Pradhan, Y. V., & Maskey, M. K. (2010). Community-based interventions for diarrhoeal diseases and acute respiratory infections in Nepal. *Bulletin of the World Health Organization*, 88(3), 216–221. https://doi.org/10.2471/BLT.09.065649

Heyworth, J. S., Cutt, H., & Glonek, G. (2006). Does dog or cat ownership lead to increased gastroenteritis in young children in South Australia? *Epidemiology and Infection*, 134(5), 926–934. https://doi.org/10.1017/S0950268806006078

Khan, B., Channo, A., Rehman, R., Qazi, A. H., Akbar, H., Zaynub, N., Ali, H., Soomro, K., & Hassan, M. (2023). Animals to human transmission of intestinal diseases: A review of the mechanism and factors involved. In S. Altaf, A. Khan, & R. Z. Abbas (Eds.), *Zoonosis* (Vol. 4, pp. 29–45). Unique Scientific Publishers. https://doi.org/10.47278/book.zoon/2023.136

Klous, G., Huss, A., Heederik, D. J. J., & Coutinho,

R. A. (2016). Human–livestock contacts and their relationship to transmission of zoonotic pathogens: A systematic review of literature. *One Health*, 2, 65–76. https://doi.org/10.1016/j.onehlt.2016.03.001

K.C., R., Tiwari, P., Pahadi, S., Chalise, N., K.C., P., & K.C., S. (2025). Assessment of mothers' knowledge and practices regarding oral rehydration solution in Sindhuli District, Nepal. *Cureus*, 17(3), e89120. https://doi.org/10.7759/cureus.89120

Lakew, G., Yirsaw, A. N., Bogale, E. K., Andarge, G. A., Getachew, D., Getachew, E., et al., (2024). Diarrhea and its associated factors among children aged under five years in Madagascar, 2024: A multilevel logistic regression analysis. *BMC Public Health*, 24(1), 2910. https://doi.org/10.1186/s12889-024-20374-3

Lawrence, E., Metje, A., Matemba, C., & Powelson, J. (2025). Identifying context-specific drivers of routine childhood immunisation dropout in Mozambique and Malawi: A secondary thematic analysis of qualitative community-based participatory research data. *BMJ Open*, 15(11), e088305. https://doi.org/10.1136/bmjopen-2024-088305

Li, R., Lai, Y., Feng, C., Dev, R., Wang, Y., & Hao, Y. (2020). Diarrhea in under five year-old children in Nepal: A spatiotemporal analysis based on Demographic and Health Survey data. *International Journal of Environmental Research and Public Health*, 17(6), 2140. https://doi.org/10.3390/ijerph17062140

Mebrahtom, S., Worku, A., & Gage, D. J. (2022). The risk of water, sanitation and hygiene on diarrhea-related infant mortality in eastern Ethiopia: A population-based nested case-control. *BMC Public Health*, 22(1), 343. https://doi.org/10.1186/s12889-022-12735-7

Merid, M. W., Alem, A. Z., Chilot, D., Belay, D. G., Kibret, A. A., Asratie, M. H., Shibabaw, Y. Y., & Aragaw, F. M. (2023). Impact of access to improved water and sanitation on diarrhea reduction among rural under-five children in low and middle-income countries: A propensity score matched analysis. *Tropical Medicine and Health*, 51(1), 36. https://doi.org/10.1186/s41182-023-00511-5

Ministry of Health and Population, Department of Health Services, Epidemiology and Disease Control Division. (2022). *Cholera outbreak in Kathmandu Valley – 5 September 2022*. Retrieved from https://edcd.gov.np/uploads/news/pdf/6316cb3e7cb8b.pdf

Mishra, R., Acharya, A., Yadav, A. K., & Shreewastav, R. K. (2022). Diarrhoea among children under five years of age residing in a Village Development Committee: A descriptive cross-sectional study. *Journal of the Nepal Medical Association*, 60(250), 425–429. https://doi.org/10.31729/jnma.7322

Mitkari, K. K., Mankeshwar, R., & Haralkar, S. (2019). A study on hospitalized under five children presenting with acute diarrhoea. *Home Archives*, 10(1), 10.

Njuguna, C., Njeru, I., Mgamb, E., Langat, D., Makokha, A., Ongore, D., Mathenge, E., & Kariuki, S. (2016). Enteric pathogens and factors associated with acute bloody diarrhoea, Kenya. *PLoS ONE*, 11(8), e0160937. https://doi.org/10.1371/journal.pone.0160937

Pathak, P., Munsawaengsub, C., & Nanthamongkolchai, S. (2019). Predictive factors of diarrhea preventive practices by caretakers. *Journal of Nepal Health Research Council*, 17(2), 247–252. https://doi.org/10.33314/jnhrc.v0i0.1876

Paul, A. M., Nepal, S., Upreti, K., Lohani, J., & Rimal, R. N. (2022). The last stretch: Barriers to and facilitators of full immunization among children in Nepal's Makwanpur District, results from a qualitative study. *PLoS ONE*, 17(1), e0261905. https://doi.org/10.1371/journal.pone.0261905

Rai, S. K. (2018). Changing trend of infectious diseases in Nepal. In R. Adhikari & S. Thapa (Eds.), *Advances in experimental medicine and biology* (Vol. 1052, pp. 19–38). Springer. https://doi.org/10.1007/978-981-10-7572-8_3

Sangma, R. V. N., & Rasania, S. K. (2025). Prevalence of diarrhea among under-5 children and health-seeking behavior of mothers in a resettlement colony of Delhi, India: A community-based cross-sectional study. *Indian Journal of Community Medicine*, 50(4), 669–673. https://doi.org/10.4103/ijcm.ijcm_90_24

Shrestha, M. V., Choulagai, B. P., Joshi, T. P., Adhikari, S. R., & Pradhan, B. (2021). Factors associated with diarrheal disease among under five children in Godawari Municipality of Nepal: A cross-sectional study. *Journal of Health and Social Sciences*, 6(3), 269–280.

Shrivastava, A. K., Mohakud, N. K., Panda, S., Patra, S. D., Kumar, S., & Sahu, P. S. (2020). Major enteropathogens in humans, domestic animals, and environmental soil samples from the same locality: Prevalence and transmission considerations in coastal Odisha, India. *Epidemiology and Health*, 42, e2020034. https://doi.org/10.4178/epih.e2020034

Taneja, N., & Mewara, A. (2016). Shigellosis: Epidemiology in India. *Indian Journal of Medical Research*, 143(5), 565–576. https://doi.org/10.4103/0971-5916.187104

Thapa, B., Sapkota, S., & Hu, Y. (2023). Predictors of diarrhea among children under 24 months in Nepal: A multilevel analysis of multiple indicator cluster survey 2019. *PLoS ONE*, 18(6), e0287974. https://doi.org/10.1371/journal.pone.0287974

Tumwebaze, I. K., Krysan, M., Busienei, P. J., Simiyu, S., Mberu, B., Sewell, D. K., & Baker, K. K. (2025). Domestic animals and hygiene on infants' risk of contact and exposure to animal faeces in urban neighbourhoods in Kenya: A mixed methods cohort study. *One Health*, 21, 101217. https://doi.org/10.1016/j.onehlt.2025.101217

Zulfiana, Y., Fatmawati, N., & Herlina, S. M. (2021). Association between drinking water treatment and diarrhea among under-five years children. *Journal of Quality in Public Health*, 4(2), 72–76. https://doi.org/10.30994/jqph.v4i2.213