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Risk Factors Associated with Vibrio Cholerae Mimics from Diarrhoea Stool and Drinking Water Samples in Internally Displaced Persons (IDP) Camps Within North Central Nigeria

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Abstract- ***Cholera continues to pose a significant public-health challenge in sub-Saharan Africa, particularly within Internally Displaced Persons (IDP) camps where inadequate water, sanitation, and hygiene (WASH) conditions amplify transmission risks. Diagnostic challenges arise when non-cholera pathogens exhibit phenotypic characteristics similar to Vibrio cholerae, resulting in "V. cholerae mimics" that impede accurate outbreak detection. This study investigated the risk factors associated with the presence of V. cholerae mimics in diarrhoeal stool and drinking water samples collected from IDP camps in North-Central Nigeria. A prospective case-control, event-driven study design was employed, involving diarrhoeic patients and drinking water sources across Benue, Nasarawa, and Plateau States. Standard bacteriological methods were used for isolation and presumptive identification, and structured questionnaires were used to assess socio-demographic, environmental, and behavioral risk factors. Bivariate analysis was conducted using odds ratios (ORs) with 95% confidence intervals (CIs). Findings showed that older age groups (≥60 years), female sex, and lower educational levels exhibited higher odds of positive mimics. Environmental factors such as reliance on dam water, open defecation, inadequate shelter, and prolonged stay in camps were associated with increased risk. Behavioral factors—including poor handwashing, lack of access to soap, and limited healthcare—were also significantly associated with the presence of mimics. These findings highlight the complex interaction between sanitation infrastructure, population vulnerability, and diagnostic limitations. Strengthening WASH systems, improving diagnostic capacity, and enhancing public-health surveillance in IDP settings are essential to minimizing misclassification and improving cholera control strategies***

Keywords: Cholera, IDP Camps, Risk Factors, Vibrio Cholorae Mimics

I. INTRODUCTION

Cholera remains an important and persistent public-health threat in sub-Saharan Africa, where inadequate water, sanitation and hygiene (WASH) infrastructures and humanitarian crises converge to create high-risk environments for transmission (World Health Organization, 2024). Internally displaced persons (IDP) camps concentrate susceptible populations under conditions—overcrowding, interrupted water supply, open defecation and limited waste management—that repeatedly precipitate or amplify cholera outbreaks (Ngwa et al., 2020; World Health Organization, 2024). In these settings, public-health responses are complicated by diagnostic uncertainty: routine culture methods (e.g., sucrose-fermenting colonies on TCBS agar with oxidase positivity) can yield isolates that phenotypically resemble Vibrio cholerae but belong to other taxa (so-called "V. cholerae mimics"), producing false-positive presumptive identifications and complicating surveillance and outbreak control (Baron, Chevalier, & Lesne, 2007).

Environmental persistence of *V. cholerae* and related vibrios is driven by multiple reservoirs and survival strategies—biofilms, association with planktonic organisms and seasonal dynamics—that link aquatic sources to human infection risk (Lutz, Erken, Noorian, Sun, & McDougald, 2013). At the same time, non-O1/non-O139 *V. cholerae* and other vibrios are increasingly recognized as causes of sporadic gastroenteritis and clinically significant diarrhoeal disease that may be mistaken for classical cholera in low-resource laboratories (Zhang, Alter, & Fleischmann, 2024). These taxonomic and phenotypic overlaps have practical consequences in IDP camps where rapid, accurate laboratory confirmation is essential for targeting WASH interventions, reactive vaccination and case management.

Despite documented cholera events in Nigerian displacement settings (e.g., Borno State), few studies have systematically assessed risk factors that distinguish true V. cholerae infections from culture-positive mimics in matched diarrhoeal stool and drinking-water samples from IDP camps (Ngwa et al., 2020). Understanding those risk factors environmental (source and storage of water, seasonal rainfall), behavioural (open defecation, handwashing practices), and laboratory-related (diagnostic algorithms and reliance on biochemical presumptive tests) is critical to reduce misclassification, improve outbreak detection and optimise resource allocation. This study therefore investigates risk factors associated with *V. cholerae*-like isolates recovered from diarrhoeal stool and drinking water in IDP camps in North-Central Nigeria.

II. MATERIALS AND METHODS

Description of the Study Area

The study was carried out in internally displaced persons (IDP) camps located in Benue, Nasarawa, and Plateau States within North Central Nigeria. Geographically, the region lies between latitudes 7°10'–10°10' N and longitudes 7°10'–11°10' E. North Central Nigeria, also known as the Middle Belt, is ethnically diverse and highly agrarian, with an estimated population of about 20 million people. Benue State has an estimated population of 5.7 million, Nasarawa State recorded 189,835 people in the 2006 census, and Plateau State also has significant agricultural and mining activities. Recurrent farmer–herder conflicts over land and water resources have resulted in large-scale displacement in all three states, with nearly 500,000 displaced in Benue alone as of 2023. Similar conflicts in Nasarawa and Plateau have displaced thousands, forcing many into IDP camps. These camps face challenges such as overcrowding, inadequate sanitation, and limited access to potable water, conditions that heighten vulnerability to waterborne diseases, including cholera. Poor hygiene, water scarcity, and reliance on contaminated water sources further worsen diarrheal disease outbreaks.

Study Design

A prospective cohort, event-driven design with longitudinal environmental sampling was used to determine the prevalence, distribution, and determinants of *Vibrio cholerae* mimics in stool and water samples. The design enabled monitoring of diarrhea cases as they occurred and assessment of associated environmental and demographic risk factors.

Study Population

The study population comprised diarrheic patients of all ages residing within IDP camps across the three states.

Sample Size

Sample size followed an event-driven approach, determined by the number of diarrhea episodes and available control participants during the study period. Monthly samples from proximal drinking water sources were also obtained following ethical approval.

Inclusion Criteria

All diarrheic patients who provided informed consent (or assent from guardians) were included. Diarrhea was defined as passage of three or more watery stools within 24 hours. Some non-diarrheic individuals were recruited as controls.

Exclusion Criteria

Individuals without diarrhea who were not selected as control participants were excluded.

Data Collection

A structured questionnaire was administered to obtain socio-demographic information and risk-factor data. Interpreters were trained to ensure accurate communication. Odds ratios and confidence intervals were used to identify associated risk factors.

Ethical Clearance

Ethical approval was obtained from State Emergency Agencies and Benue State University Teaching Hospital, Makurdi.

Experimental Design

A case-control, event-driven sampling framework was used. Diarrhea stool samples and drinking water samples were collected from all study sites and processed for laboratory analysis.

Sample Collection

Stool Samples

Stool samples from diarrhea cases were collected in leak-proof Cary-Blair containers and transported on ice to the BSUTH microbiology laboratory.

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Water Samples

One-liter water samples were aseptically collected from drinking sources in sterile bottles and transported immediately for analysis.

Culture of Stool and Water Samples

Stool samples were enriched in alkaline peptone water (APW) for 6–8 hours and cultured on TCBS agar at 37°C for 24 hours. Water samples underwent membrane filtration using 0.45 µm filters, followed by enrichment in APW and culturing on TCBS agar. Yellow colonies were sub-cultured on nutrient agar for characterization.

Isolation and Characterization of Vibrio Species

Presumptive Vibrio isolates (yellow colonies) were subjected to Gram staining to identify Gram-negative curved rods and tested for oxidase activity using oxidase strips. A purple color within 10 seconds indicated a positive oxidase reaction.

Data Analysis Techniques

Bivariate analysis was conducted to determine the crude association between potential risk factors and the presence of Vibrio cholerae mimics in stool or water samples. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated.

III. RESULT

Table 1. Demographic Risk Factors associated with the presence of mimics of *Vibrio cholerae*

Variable	Category	N	n	OR	95% CI (Lower - Upper)
Age Group (years)	0-9	335	10	1.00	0.41 - 2.43
	10-19	299	5	0.55	0.19 - 1.64
	20-29	109	2	0.61	0.13 - 2.82
	30-39	61	1	0.54	0.07 - 4.31
	40-49	38	1	0.88	0.11 - 7.06
	50-59	47	2	1.44	0.31 - 6.80
	60-69	51	3	2.03	0.54 - 7.64
	≥70	35	2	1.97	0.41 - 9.37
Sex	Male	394	7	1.00	0.35 - 2.88
	Female	581	19	1.87	0.78 - 4.49
Educational Level	Non-formal	468	21	1.00	0.54 - 1.86
	Primary Education	313	3	0.21	0.06 - 0.70
	Secondary Education	146	1	0.15	0.02 - 1.10
	Higher Education	48	1	0.45	0.06 - 3.44

N= Total number of respondents; n= Respondents with positive mimics OR =Odd Ratio, CI=Confidence Interval

Table 2. Environmental Risk Factors Associated with Presence of mimics of *Vibrio cholerae*

Category	N	N	Odds Ratio	95% (Low)	95%CI (High)
Drinking water Source					
Well	285	8	0.03	0.01	0.06
River	150	7	0.05	0.02	0.11
Borehole	235	4	0.02	0.01	0.05
Water tank	40	0	0.00	0.00	0.00
Dam	30	4	0.15	0.05	0.47
Stream	235	3	0.01	0.00	0.04
Fecal Disposal Methods					
Open defecation	691	17	0.03	0.02	0.04

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Category	N	N	Odds Ratio	95% (Low)	95%CI (High)
Pit latrine	263	7	0.03	0.01	0.06
Flush toilet	21	2	0.11	0.02	0.48
Household range					
1-5	366	5	0.01	0.01	0.03
6-10	300	8	0.03	0.01	0.06
11-15	267	11	0.04	0.02	0.08
≥16	42	2	0.05	0.01	0.21
Type of shelter					
Temporal shelters	191	5	0.03	0.01	0.07
Self-constructed shelters	430	8	0.02	0.01	0.04
Occupied classroom	354	13	0.04	0.02	0.07
Duration of Stay in IDP Camps					
< 4 weeks	19	1	0.06	0.01	0.44
Months	256	6	0.02	0.01	0.05
Years	700	19	0.03	0.02	0.04

N= Total number of respondents; n= Respondents with positive mimics OR =Odd Ratio, CI=Confidence Interval

Table 3. Socio-economic and Behavioural Risk Factors Associated with the presence of bacteria mimics of *Vibrio cholerae*

Category	N	n	Odds Ratio (OR)	95% CI (Lower)	95% CI (Upper)
Handwashing					
Always	12	0	0.00	0.00	0.00
Most times	33	1	0.03	0.00	0.24
Sometimes	210	3	0.01	0.00	0.05
Rarely	720	22	0.03	0.02	0.05
Access to soap					
Yes	64	1	0.02	0.00	0.11
No	910	25	0.03	0.02	0.04
Diarrhoea Cases					
Yes	195	20	0.11	0.07	0.19
No	780	6	0.01	0.00	0.02
Access to healthcare					
Yes	302	5	0.02	0.01	0.04
No	673	21	0.03	0.02	0.05
Occupation					
Farmers	220	5	0.02	0.01	0.06
Traders	61	3	0.05	0.02	0.17
Civil servants	20	1	0.05	0.01	0.41
Others	674	17	0.03	0.02	0.04

N= Total number of respondents; n= Respondents with positive mimics OR =Odd Ratio, CI=Confidence Interval

finding that demographic factors significantly influence the odds of positive samples for *Vibrio cholerae*, indicating potential risk factors that warrant further investigation, this was also confirmed by the work done by Akyala *et al* (2014). Unlike the study conducted by Garbati et al. (2021) in which infection rate was high among young adults, individuals aged 60-69 (OR = 2.03, 95% CI: 0.54 - 7.64) and ≥70 (OR = 1.97, 95% CI: 0.41 - 9.37) had higher odds compared to young adults 30-39 age group (OR = 0.54, 95% CI: 0.07 - 4.31) with lower odds in their studies. By sex, females exhibited a higher risk of positive samples (OR = 562, 95% CI: 0.059–16.121) compared to males (OR = 1.869, 95% CI: 0.778–4.489), Akyala *et al* (2014) also gave the same report. Regarding educational levels, educational background influences the risk of infection, aligning with the findings of this research about the odds of positive samples based on education levels, individuals with primary education had lower odds (OR = 0.21, 95% CI: 0.06 - 0.70) compared to those with non-formal education (OR =1.00, 95% CI: 0.54 - 1.86) , except for the inconsistency observed with higher education (OR = 0.45, 95% CI: 0.06 - 3.44), but the confidence interval was wide, suggesting variability in the estimate, this agrees with the report of both Abdullahi and Ebele (2023) and Akyala *et al* (2014) which were consistent with this findings. For the association between environmental factors and positive cases, water source type is a significant factor in *Vibrio cholerae* and its bacteria culture mimics transmission as reported by Wolfe *et al* (2018), but in my findings, wells (OR = 0.03, 95% CI: 0.01–0.06), rivers (OR = 0.05, 95% CI: 0.02–0.11), and streams (OR = 0.01, 95% CI: 0.00–0.04) show low odds of positive outcomes, indicating minimal risk. Conversely, dams (OR = 0.15, 95% CI: 0.05–0.47) present a higher risk agreeing with the report by Wolfe *et al* (2018). Defecation practices such as open defecation (OR = 0.03, 95% CI: 0.02–0.04) are significantly associated with positive cases, suggesting poor sanitation as a key risk factor also. Housing conditions also influence outcomes, with temporal shelters (OR = 0.03, 95% CI: 0.01–0.07) and occupied classrooms (OR = 0.04, 95% CI: 0.02–0.07) showing elevated risks. Duration of stay in camps reveals consistent risk, particularly for individuals staying "Years" (OR = 0.03, 95% CI: 0.02–0.04). These findings underscore the impact of environmental and living conditions on disease prevalence as corroborated in a previous study by Usmani (2021). For various behavioral, health, socio-economic, and occupational factors associated with bacterial mimics of *Vibrio cholerae* infections, Handwashing behavior showed a significant association, with those who washed their hands rarely having higher odds (OR = 0.03, 95% CI [0.02, 0.05]) of infection compared to other groups, similar observations were made by Nwokoro et al. (2020). Access to handwashing soap reduced the odds of infection, with those lacking access showing higher odds (OR = 0.03, 95% CI [0.02, 0.04]).

Diarrhea was strongly associated with infection, as individuals with diarrhea had significantly increased odds (OR = 0.11, 95% CI [0.07, 0.19]) this reinforces previous findings by Nwokoro et al. (2020) that diarrhea is a predisposing factor to *Vibrio cholerae* infection and other water borne diseases. Lack of access to healthcare services was another critical factor (OR = 0.03, 95% CI [0.02, 0.05]) with this study conforming to earlier study by Wahed (2013) in which access to health facilities is a major concern in resource limited areas. Among occupations, individuals in "Other" jobs exhibited relatively higher odds of infection (OR = 0.03, 95% CI [0.02, 0.04]). These findings underscore the importance of hygiene and healthcare access in mitigating infection risks.

IV. CONCLUSION

This study investigated the risk factors associated with *Vibrio cholerae* mimics isolated from diarrhoeal stool and drinking water samples in Internally Displaced Persons (IDP) camps within North Central Nigeria. The findings reveal that a substantial proportion of isolates exhibiting classical *V. cholerae* phenotypic characteristics—TCBS growth and oxidase positivity—were in fact non-cholera pathogens such as *Aeromonas* spp. and other enteric bacteria. This underscores the limitation of relying solely on conventional biochemical and culture-based identification methods in resource-limited settings, where misclassification may lead to inappropriate clinical management and underestimation of pathogen diversity.

The study further demonstrates that poor water sanitation, inadequate hygiene practices, overcrowding, and limited access to safe drinking water significantly increase the risk of acquiring these *V. cholerae* mimics. The detection of genetically diverse isolates in both stool and water

samples suggests ongoing environmental contamination and potential transmission pathways within the IDP camp environment. These findings highlight the urgent need for improved water quality surveillance, strengthened infection prevention and control (IPC) measures, and targeted health education among displaced populations.

Advanced molecular methods such as whole genome sequencing proved essential for accurate species-level identification, emphasizing the importance of integrating molecular diagnostics into routine public health investigations. Overall, this study contributes critical evidence on the epidemiology of *V. cholerae*–like pathogens in humanitarian settings and calls for coordinated interventions to mitigate the risks posed by non-cholera enteric bacteria that mimic cholera in standard laboratory procedures. Strengthening laboratory capacity and enhancing environmental sanitation remain vital strategies for protecting vulnerable populations and preventing future outbreaks.

V. RECCOMENDATION

Based on the findings of this study, several targeted interventions are recommended to reduce the prevalence of *Vibrio cholerae* mimics and associated diarrhoeal risks in IDP camps within North-Central Nigeria. First, WASH infrastructure must be strengthened, particularly through the provision of reliable and safe water sources. The higher risk associated with dam water highlights the need for improved water treatment, routine surveillance, and safer alternatives such as well-maintained boreholes. Sanitation facilities should be expanded, with efforts to eliminate open defecation by constructing and maintaining hygienic latrines that are accessible to all camp residents.

Second, hygiene-promotion programs should be intensified, focusing on regular handwashing with soap. Since inadequate hand hygiene and lack of access to soap significantly increased risk, humanitarian agencies and camp managers should ensure continuous supply of soap and incorporate behaviour-change communication targeted at adults and children.

Third, healthcare access must be improved through deployment of more health workers, mobile clinics, and early-warning surveillance systems to ensure timely detection, differentiation, and management of diarrhoeal diseases. Strengthening laboratory diagnostic capacity is essential to reduce misclassification of *V. cholerae* and its mimics, which can distort outbreak responses.

Fourth, environmental and structural improvements are needed, especially for households residing in temporary shelters or overcrowded classrooms, which were associated with higher infection odds. Relocation to more stable shelter units and decongestion of living spaces should be prioritized.

Lastly, targeted health education should be directed at high-risk demographic groups, particularly older adults, women, and individuals with low educational attainment. Community-based education on safe water storage, sanitation, and hygiene practices will further reduce the burden of diarrhoea and misidentified *Vibrio* species.

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