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Full Length Research Article

PREVALENCE, DETERMINANTS, AND CLINICAL CORRELATES OF NOROVIRUS GASTROENTERITIS AMONG CHILDREN IN PLATEAU STATE, NIGERIA

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ABSTRACT
Norovirus is a public health challenge, particularly among children. This study investigated the prevalence, determinants, and clinical correlates of norovirus infection among children aged five years and below in Plateau State, Nigeria. A cross-sectional design involving the collection of watery-stool samples from 200 children attending selected health facilities in the state. They were analyzed for norovirus using real-time polymerase chain reaction. After obtaining parental consent, a structured questionnaire was used to collect socio-demographic and risk-factor information regarding infection. The overall prevalence of norovirus was 8.5% (17/200). Infection occurred more in the males (12.0%) (p=0.106). The 20-29 months age group had the highest infection rate (16.0%) (p=0.596). Children in Plateau-North had a higher infection rate (19.2%) than in other zones. Children residing in urban areas had higher infection rates (17.9%) (OR=5.3, 95% CI=1.9-15.1, p=0.002). Children without fever and vomiting had rates of 12.4% and 10.2%, respectively, and there were no cases among those with these symptoms. Abdominal pain in children was higher (OR=12.4, 95% CI=2.8-55.8, p=0.001). Children who received hospitalization, unboiled water, tap water, and stream water appear to be more vulnerable, with 14.9% (p=0.021), 10.3% (p=0.162), 26.7% (p=0.001), and 38.5% (p=0.002), respectively. Infected children from parents with formal education had more infections (p=0.018). Analysis of the geno-group showed that Geno-group G1 was 4 (22.2%), while GII was 13 (77.8%). Treatment of drinking water is recommended to reduce disease transmission, and further epidemiological studies are advocated.

Keywords: Gastroenteritis, Norovirus, Children, Infection, Health

INTRODUCTION

Norovirus is a virus of public health concern globally, as it is a leading cause of gastroenteritis, especially among children. The virus from the family "*Caliciviridae*" is an RNA virus and measures about 7.5-7.7 kb in length (Rani *et al*., 2021). The round virus is composed of a viral capsid surrounding the viral genome. The genome of the virus has three open reading frames: ORF1, which encodes the non-structural proteins of the virus, and ORF2 and ORF3, which encode the major and minor structural proteins, respectively. The non-structural protein of the virus is made up of six components, which include p48, NTPase, p22, VPg, protease, and RNA-dependent RNA polymerase [RdRp]. VPg acts as a primer during protein synthesis, while p22 and p48 are involved in viral translation. The RdRp is a transcriptase enzyme that catalyzes the synthesis of a new RNA genome (Yunus, 2021).
The virus is primarily contracted from infected persons (person-to-person), through contaminated food and water, or through contact with contaminated surfaces. Children may ingest dirt from their surroundings while playing or by coming into contact with contaminated surfaces. This makes them more susceptible to the virus. The symptoms of this infection primarily include diarrhea, fever, vomiting, and abdominal pain (Lanrewaju *et al*., 2022). Of this, diarrhea is the most apparent symptom, characterized by the passage of watery stools three or more times beyond the typical frequency (Ugboko *et al*., 2020). Frequent passage of watery stool can lead to complications of dehydration and even death. Complications can lead to frequent visits to health clinics by children and even hospitalization.
The symptoms of Norovirus gastroenteritis resemble those of other enteric illnesses, complicating the differentiation of Norovirus infections from other enteric illnesses. Hence, laboratory diagnosis of samples for the virus infection is an important means of detecting the virus. Serological diagnosis via antibody detection of viral antigens and molecular diagnosis using Polymerase Chain Reaction (PCR) are the primary methods for virus detection (Malik *et al*., 2019). The PCR was applied in this study due to its high specificity and sensitivity.
Norovirus infection poses a significant public health issue due to its documented high morbidity and mortality rates in children, particularly in low-resource environments(Hasan *et al*., 2021). In Plateau State, children do report to clinics with gastroenteritis, and cases of late presentation can result in death. There is limited documentation of the burden of infection among children, and the associated risk factors are poorly studied. Information on the clinical correlates of the infection is limited, creating a gap in effective management.
Knowledge from this can provide insight into the burden of infection among children. In addition, studying the determinants of the infection provides information on the practices and environmental factors that predispose children to the infection. Hence, this study aims to determine the prevalence, determinants, and clinical correlates of the infection among children during hospital visits in Plateau State, Nigeria.

MATERIALS AND METHODS

Study Area

The study was carried out in Plateau State (9°10 '0" N and 9°45'0" E), located in the North-Central region of Nigeria. There are 17 Local Government Areas (LGAs) in the state, spread across the three senatorial zones of Plateau North, Plateau Central, and Plateau South (Figure 1). The state covers a total area of about 30,913 km^2(Selowo *et al*., 2021). Plateau State is bounded in the Northeast by Bauchi State, North-West by Kaduna State, South-

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West by Nasarawa State, and South-East by Taraba State.

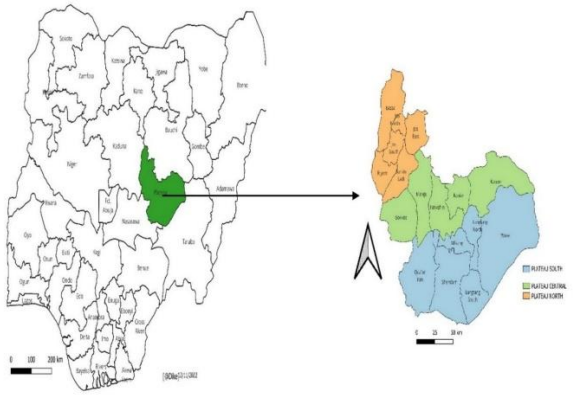

Figure 1: Map of Plateau State, Nigeria, showing the Study Sites (self-generated using QGIS)

Study Population
Children aged 5 years or younger presenting with gastroenteritis during a hospital visit were selected for this study.

Case Definition
The following case definitions were applied in this study:
Acute Gastroenteritis (AGE) is any child five years and below who passes loose stool for 14 days or less from the date of onset of the stooling.

A. Inclusion and Exclusion Criteria
The Inclusion criteria were.

Any child five years and below presenting with gastroenteritis, 14 days or less from the date of onset of the stooling, and who visited the selected health facilities during the study.

The Exclusion criteria were.

Any child aged 5 years or below presenting with gastroenteritis for more than 14 days and visiting the selected health institutions during the study period.

Sample Size Determination
The sample size for this study was determined in accordance with previous epidemiological studies of Norovirus in Nigeria (Osazuwa *et al*., 2020). This was determined using the formula:

$$n=\frac{t2\times p(1-p)}{m2}$$

Where.
n =number of samples
t^2= Standard normal deviation at 95% (1.96)
p= prevalence from previous studies of 11% (0.11) (Osazuwa *et al*., 2020)
m= Allowable error of 5% (0.05)
Therefore, n= $(1.96)^2$ x 0.11x 0.89 / $(0.05)^2$ =150

To enhance representativeness and improve statistical power, a sample size of 200 children was selected in this study.

Sampling Technique
This study was a cross-sectional hospital-based study. The selected children were clustered within Plateau North, South, and Central senatorial zones in the state. In each cluster (senatorial zone), a random sampling method was used to select a particular LGA and two health facilities in that selected LGA. This includes Kuka and Kalong Primary Health Centers in Shendam LGA for Plateau South senatorial zone, Kullingning and Koplok Primary Health Centers in Panshin LGA for Plateau Central senatorial zone, and Random Bingham University Teaching Hospital and Our Lady of Apostles Hospital (OLA Hospital) in Jos North LGA for Plateau North senatorial zone. Children with gastroenteritis were purposively selected during their visits to the selected health facilities until the sample size was reached.

Ethical Approval
This was obtained from the Jos University Teaching Hospital, with certificate no: JUTH/DCS/IREC/127/XXXI/651. Permission was obtained from the heads of the selected health facilities, and verbal assent was obtained from each child's parent or guardian before sample collection.

Data Collection and Sample Analysis
A questionnaire was designed to collect socio-demographic and risk-factor variables associated with Norovirus infection. Two hundred fecal samples from children with acute gastroenteritis aged 5 years or younger who presented to the selected health facilities during the period were collected. Each sample was collected in a leak-proof, well-labeled universal container. This was immediately placed in an icebox at 2-8 °C before being taken to the laboratory for storage at -70 °C prior to analysis. Ten percent (10%) fecal suspension was prepared by adding 1ml (1000µl) of liquid stool to 9ml (9000µl) of Phosphate Buffer Saline (PBS) in an Eppendorf tube, vortexed for 30 seconds, and centrifuged at 5000×g for 30 seconds for nucleic acid extraction method (Feghoul *et al*., 2016). One hundred and forty microliters of the supernatant of the fecal samples were vortexed and used for viral nucleic acid extraction using the QIAamp Viral RNA Mini Kit (Qiagen, Heiden, Germany) according to the manufacturer's instructions. Qualitative real-time Reverse Transcriptase Polymerase Chain Reaction (RT-qPCR) was used to detect Norovirus. The Biosphere Norovirus GI-II Detection Kit (AGW-ABNGD1) was used according to the manufacturer's instructions. The Biosphere kit can also detect the Norovirus genogroups G1 and GII.
Five µL of the sample extract and 20 µL of PCR master mix were added to 1.5 ml cryovial PCR tubes. The final volume for each reaction was 25 µL. The PCR master mix, already prepared, contains precise volumes of Taq DNA Polymerase, reverse transcriptase, PCR buffers, dNTPs, and a probe, along with forward and reverse primers for each reaction. The content of the tubes was amplified using a 7500 CFX96 Deep Well Dx System real-time PCR thermocycler (Bio-Rad, Hercules, CA, USA). The amplification conditions were set as follows: reverse transcription at 50ºC for 20 minutes, denaturation at 95ºC for 15 minutes, followed by 45 cycles of amplification (95ºC for 10 seconds, 60ºC for 1 minute, and extension at 72ºC for 30 seconds (Fang *et al*., 2021). Positive samples were identified by a rising light signal or amplification, indicating the presence of the virus. All samples were screened for the presence of Norovirus and the determination of the Geno-groups.

Data Analysis
The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 21 (IBM, USA). Descriptive analysis of norovirus cases was conducted. The correlation between exposure variables (determinants) and outcome variables (norovirus infection) was established. A p-value of less than or

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equal to 0.05 was considered statistically significant at 95% confidence interval. The data were appropriately presented in tables.

RESULTS

The overall prevalence of Norovirus infection was 8.5% (17/200). The gender distribution showed that males had a higher prevalence of 12.0% (11/92) while females had 5.6% (6/108) (p=0.106). The age distribution of infection showed that children aged 20-29 months had the highest prevalence, at 16.0%, with an odds ratio of 3.6 compared to other age groups (p=0.596). The children living in the urban and rural areas had infection prevalence of 19.0% and 4.2%, respectively. There was a statistically significant association between children's rural-urban residence and infection (p=0.002). The senatorial zone of the child's residence showed that Plateau North had the highest prevalence at 19.2%, followed by Plateau Central at 7.4%, while Plateau South had the lowest prevalence at 3.2% (p=0.005).

Seasonality of Norovirus infection showed that infection occurred more in the wet season than in the dry season, with prevalence of 9.3% and 7.6%, respectively. It was 0.8 times lower in the dry season compared with the wet season (p=0.677) (Table 1).

Clinical correlates showed that children without fever had a higher prevalence (12.4%), and there was no statistically significant association between fever and infection (p=0.103). Also, children without vomiting had a higher prevalence of 10.2%, with no statistically significant association (p=0.081). While children with abdominal pain had a higher prevalence of 17.9% and, there was a statistically significant association between abdominal pain and Norovirus infection (p=0.001). There were 12.4 times the odds of infection in children with abdominal pain compared to those without it. Children who stooled within 3 days of the onset of gastroenteritis had a prevalence of 9.7%, while those who stooled after 3 days of gastroenteritis had no record of Norovirus infection. Duration of stooling was not statistically associated with the infection (p=0.140) (Table 1).

Table 1: Norovirus infection in relation to Socio-Demographics and Clinical Symptoms among children aged five years and below in Plateau State, Nigeria

Variable	Number of Children Examined (%)	Number Positive	Prevalence (%)	Odd Ratio (95% Confidence Interval)	p-value
Gender					
Female	108(54.0)	6	5.6	1	0.106
Male	92(46.0)	11	12.0	2.3(0.8-6.5)	
Age-group (Months)					
≤ 9	20(10.0)	1	5.0	1	0.596
10-19	22(11.0)	1	4.5	0.9(0.1-15.5)	
20-29	25(12.5)	4	16.0	3.6(0.4-35.3)	
30-39	41(20.5)	2	4.9	1.0(0.1-11.4)	
40-49	43(21.5)	3	7.0	1.4(0.1-14.6)	
≥ 50	49(24.5)	6	12.2	2.7(0.3-23.6)	
Type of Residence					
Rural	142(71.0)	6	4.2	1	*0.002
Urban	58(29.0)	11	19.0	5.3(1.9-15.1)	
Senatorial Zone					
Plateau Central	53(27.0)	4	7.4	1	*0.005
Plateau North	51(26.0)	10	19.2	3.0(0.9-10.2)	
Plateau South	94(47.0)	3	3.2	0.4(0.1-1.9)	
Season					
Wet	108(54.0)	10	9.3	1	0.677
Dry	92(46.0)	7	7.6	0.8(0.3-2.1)	
Clinical Symptoms					
Fever					
Absent	137(68.5)	17	12.4		0.103
Present	63(31.5)	0	0.0		
Vomiting					
Absent	167(83.5)	17	10.2		0.081

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Present	33((16.5)	0	0.0		
Abdominal Pain					
Absent	116((58.0)	2	1.7	1	*0.001
Present	84(42.0)	15	17.9	12.4(2.8-55.8)	
Duration of Stooling					
≤3 Days	176(88.0)	17	9.7		0.140
>3 Days	24(12.0)	0	0.0		
Total	**200(100.0)**	**17**	**8.5**		

Children admitted to the hospital due to viral infection had a prevalence of 14.9%. Hospital admission was associated with the infection (p=0.021). Among children who had unboiled water, a higher infection rate of 10.3% was recorded, but this was not statistically associated with infection (p=0.162). The kinds of water that children took and were studied include stream, tap, Borehole, and sachet water. Children who took tap water had a higher prevalence of 26.7% (p=0.001). Those who took borehole water had a lower prevalence of 7.9% (p=0.709). Those who took water from the stream had a higher prevalence of 38.5% (p=0.002), whereas those who used sachet water had a higher prevalence of 9.5% (p=0.861).

Children with the infection from mothers/caregivers with formal education had a higher infection rate of 12.2%, while those mothers/caregivers with no formal education had 2.6% infection rate. Educational status was statistically associated with the infection (p=0.018).

Table 2: Prevalence of Norovirus Infection in Relation to Risk Factors among Children Aged Five Years and Below in Plateau State, Nigeria

Variable	Number of Participants Examined (%)	Number Positive	Prevalence (%)	Odd-Ratio (95% Confidence Interval)	p-value
Type of Hospital Service					
Inpatient	67	10	14.9	1	*0.021
Outpatient	133	7	5.3	0.3(0.1 0.9)	
Source of Drinking Water					
Boiled	55	2	3.6	1	0.162
Not Boiled	145	15	10.3	3.1(0.7-13.8)	
Tap Water					
No	170	9	5.3	1	*0.001
Yes	30	8	26.7	6.5(2.3-18.6)	
Borehole					
No	74	7	9.5	1	0.709
Yes	126	10	7.9	0.8(0.3-2.3)	
Stream					
No	187	12	6.4	1	*0.002
Yes	13	5	38.5	9.1(2.6-32.2)	
Sachet Water					
No	179	15	8.4	1	0.861
Yes	21	2	9.5	1.2(0.2-5.4)	
Education of Caregivers					
Informal	77	2	2.6	1	*0.018
Formal	123	15	12.2	5.2(1.2-23.4)	

*Statistically significant at 95% confidence intervals (P<0.05)

Multivariate analysis was conducted to identify predictors of the infection among associated risk factors, revealing that the senatorial zone, rural-urban residence, hospitalization, children exposed to stream water, and the educational status of mothers of children with the infection were not statistically correlated with the infection (p-value > 0.05). In contrast, children who consumed tap water and presented to the clinics with abdominal pain were statistically associated with the infection, with p=0.049 and p=0.003, respectively (Table 3).

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Table 3: Multivariate Logistic Regression between Predictor Variables and Norovirus Infection among Children in Plateau State, Nigeria

Variables	Adjusted Odd Ratio (POR)	Confidence Interval (95%)		P-Value
Senatorial Zone				
(North vs Central)	0.4	0.0	3.6	0.396
(South vs Central)	0.2	0.0	1.3	0.087
Residence				
(Rural vs Urban)	2.9	0.5	18.0	0.134
Abdominal Pain				
(Absent vs Present)	13.8	2.5	77.1	*0.003
Hospitalization				
(Inpatient/Outpatient)	0.4	0.1	1.6	0.288
Tap Water				
(No/Yes)	5.0	1.0	25.2	*0.049
Stream Water				
(No/Yes)	3.7	0.2	61.5	0.364
Education of Caregivers				
(Informal/Formal)	1.8	0.8	4.2	0.177

*Statistically significant at 95% confidence intervals (p<0.05)

Of the 18 positive samples observed in this study, Geno-group 1 (G1) accounted for 4 (22.5%), while Geno-group 2 (GII) accounted for 14 (77.8%). Distribution of the genogroups among children across the senatorial zones showed that Plateau North had GI and GII, with 4 (40.0%) and 6 (60.0%), respectively. GII was the only genogroup found in Plateau South and Plateau Central, with 3 (100.0%) and 4 (100.0%) cases, respectively (Table 4).

Table 4: Distribution of Geno-Groups of Norovirus in Children in Plateau State, Nigeria

Source	Senatorial Zone	Frequency (%)	GI (%)	GII (%)
Children	Plateau Central	4(22.3)	0(0.0)	4(100.0)
	Plateau North	10(55.6)	4(40.0)	6(60.0)
	Plateau South	3(16.7)	0(0.0)	3(100.0)
Total		17(100.0)	4(23.5)	13(76.5)

DISCUSSION

The prevalence and distribution of Noroviruses among children aged 5 years and below in Plateau State, North-central region of Nigeria, were 8.5% (17/200). A similar study in Ogun State, South-west Nigeria, showed a lower prevalence (5.1%) than that reported in this study (Arowolo *et al*., 2019). The finding from this study is slightly higher than the 8.3% reported in Nsukka, South-eastern Nigeria (Chigor *et al*., 2023). However, other similar studies reported higher prevalence rates: 10.3% in Ibadan (Afolabi et al., 2019) and 11.1% in Edo State, Nigeria (Osazuwa et al.). The finding from this study was lower than the prevalence of the infection in other African countries, where a prevalence of 36.2% was reported in Ghana (Lartey et al., 2020), 30.5% in Egypt (El-Sayed-Zaki et al., 2019), and 28.8% in Sudan (Tatay *et al*., 2019). The differences in prevalence between this study and others may be due to geographic location, sample size, the age of the recruited children, and the diagnostic methods employed. However, this study has provided baseline information on the burden of Norovirus infection among children ≤ 5 years in Plateau State, North-central Nigeria. This indicates that the infection is a major pathogen of viral gastroenteritis among children in this region.

The infection rate by gender showed that males had a higher prevalence of infection (10.2%) than females (5.6%) (OR=2.3, 95% CI=0.8-6.5, p=0.106). This is consistent with findings from other researchers who reported a higher prevalence among males than among females (El-Sayed-Zaki et al.; Osazuwa *et al*., 2023). A study noted that males are at greater risk of acquiring the infection than females (Dias *et al*., 2022). The greater susceptibility of males to Norovirus infection may stem from physiological and immunological factors, as females tend to respond more effectively to infectious pathogens than males (Migliore *et al*., 2021).

The age distribution of Norovirus infection in this study was highest in the 20-29 months age group (16.0%) (p=0.596). This is contrary to a study reporting that younger children (16-20 months) had the highest Norovirus infection rate among age groups (Maina *et al*., 2022). Our finding is consistent with a report in which older children (greater than 2 years) had a higher prevalence than younger

children (less than 2 years) (Ogunbiyi *et al*., 2023). Children in the 20-29 months category are mostly toddlers and are more likely to put contaminated objects in their mouths, which can lead to infection. Also, the children in this category can easily move around and contaminate their hands, resulting in fecal-oral transmission of infectious particles.

The infection, by senatorial zone, showed that children residing in the Plateau North Senatorial Zone had the highest prevalence compared to those from other Senatorial Zones (p=0.005). Additionally, children in urban areas had more infections than those in rural areas (p=0.002). This is consistent with another study in which Norovirus infection in urban areas was higher than in rural areas (El-Sayed-Zaki *et al*., 2019). The higher prevalence in urban areas could be attributed to poor sanitation systems among urban dwellers, inadequate hygiene practices, and housing conditions (such as overcrowding), which may facilitate high transmissibility of the virus among children in the study area (Chipeta *et al*., 2022).

Seasonal variation showed that infection occurred more frequently in the wet season than in the dry season, with prevalence of 9.3% and 7.6%, respectively (p=0.677). This is consistent with the report from the Niger-Delta, Nigeria, where more Norovirus infections were recorded in the wet season than in the dry season (Favor). This could be a result of children's exposure to contaminated water during rainfall. A researcher suggested that monitoring seasonal Norovirus variation could provide early warning of seasonal Norovirus infections and outbreaks (Donaldson *et al*., 2022).

The clinical correlates of Norovirus infection studied were fever, vomiting, and abdominal pain. Children without fever had a higher prevalence of Norovirus, at 12.4% (p=0.003). Children without vomiting had a higher Norovirus prevalence of 10.2% (p=0.081). This is consistent with findings in which children without fever and/or vomiting as presenting symptoms had a higher proportion of Norovirus infection (12.9%) compared to those presenting with these symptoms (Ogunbiyi *et al*., 2023). Children with absence or fewer symptoms of fever and vomiting were the least common among children with Norovirus gastroenteritis in a study (Carlson *et al*., 2024). Asymptomatic individuals may also excrete the virus and unknowingly transmit it to others. This undermines efforts to interrupt transmission. However, the findings of this study were not consistent with those from studies in which children presenting with fever and vomiting were predominantly infected (El Sayed Zaki *et al*., 2019; Lartey *et al*., 2020).

Abdominal pain was another clinical symptom observed among children presenting to the health facilities and showed a higher prevalence of 17.9% (13/84) compared to those without abdominal pain (OR=12.4, 95%CI=2.8-55.8, p=0.002). A study equally reported a higher prevalence of Norovirus among children with abdominal pain (Ogunbiyi *et al*., 2023). Abdominal pain shares similar symptoms with infections caused by other enteric viruses (Hikita *et al*., 2023). This can lead to misdiagnoses of infection and poor case management. The cases of Norovirus in children with abdominal pain could lead to complications such as gastrointestinal hemorrhage (gross or occult blood in stool) (Lu *et al*., 2022).

Infection was observed to be higher (9.7%) among children who were stooling within 3 days of the onset of gastroenteritis, while no case of infection was found for those who were stooling more than 3 days after the onset of gastroenteritis (p=0.140). This could be a result of shedding of the virus as the disease progresses. A study noted that peak viral shedding occurs at the onset of gastroenteritis (2 to 5 days) but declines significantly thereafter (Cardemil *et al*., 2017).

Infection among children who used unboiled water was higher (10.3%) than among those who used boiled water (3.6%) (OR=3.1, 95% CI=0.7-13.8, p=0.162). A study found that drinking inadequately boiled municipal water was associated with Norovirus infection (Rajeevan *et al*., 2024).

The source of water for children in this study includes tap, stream, borehole, and sachet water. Children who drank tap water and stream water had a higher prevalence of Norovirus than those who did not, and these exposures were statistically associated with the infection (tap water, p=0.001; stream, p=0.002). However, exposure to borehole water was less prevalent (7.9%), whereas exposure to sachet water was more prevalent. Neither was associated with the infection (Borehole, p=0.709; sachet water, p=0.861). Studies have shown that the source of water a child drinks is statistically associated with Norovirus infection (Oyinloye *et al*., 2016; Ogunbiyi *et al*., 2023). A study also reported that 74% of cases of acute gastroenteritis were due to drinking unboiled tap water (Orysbayeva *et al*., 2022). Pollution of water sources, inadequate disinfection, and poor plumbing in premises could be the reason for contamination of the tap-water distribution system serving households, posing a risk of gastrointestinal illness linked to consumption of unsafe water (Hyllestad *et al*., 2024). Drinking water without boiling it does not preclude the absence of infectious particles, including Noroviruses. Hence, the findings from this study have reinforced the importance of boiling water before drinking it.

Infected children of mothers or caregivers with formal education had a higher rate of Norovirus infection (12.2%) than those from mothers without formal education (2.6%) (OR= 5.2, 95%CI=1.2-23.4, p=0.018). This is consistent with a study in which the prevalence of infection among parents of infected children with formal education was higher than among those with non-formal education (Oyinloye *et al*., 2016). The higher prevalence among parents of infected children with formal education could be as a result of mothers' long hours at work which could expose the children to longer hours of care in the hands of other people (neighbours, house-attendants, or family relatives) who probably have poor hygiene practices or have a care-free attitude which allows the child to pick up contaminated objects in the environment into their mouth (Ogunbiyi *et al*., 2023).

Multivariate regression analysis revealed that tap water and abdominal pain were the true predictor variables associated with Norovirus infection. Other variables studied were associated with the infection but were confounded by other variables. Thus, a change in the relationship between the predictor variable and the outcome (infection) was observed after multivariate analysis, which showed that they were not truly associated with infection.

Conclusion

This study has revealed that the prevalence of Norovirus was 8.5% among children under 5 years old presenting to the selected health facilities in Plateau State, Nigeria, with gastroenteritis. GII genogroup was the leading cause of gastroenteritis, especially among children in Plateau State. Statistical analysis showed that children residing in urban areas with fever and abdominal pain, and those who used tap water and Stream water as their water source, were associated with Norovirus infection. However, multivariate analysis revealed that children exposed to tap water and those who experienced abdominal pain were true predictors of Norovirus infection in the studied population.

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Competing interests.
The authors declare no competing interests.

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