Journal of Medical Science, Biology, and Chemistry (JMSBC)

ISSN: 3079-2576 (Online)

Volume 2 Issue 1, (2025)

https://doi.org/10.69739/jmsbc.v2i1.661

https://journals.stecab.com/jmsbc

Published by
Stecab Publishing

Review Article

Norovirus in under 5 Children in Nigeria: History, Current Epidemiology and Future Trends

*[1]Olusola Bamidele Ojo, [2]Gbolahan M. Abideen

About Article

Article History

Submission: May 04, 2025
Acceptance : June 12, 2025
Publication : June 23, 2025

Keywords

Diarrhea, Gastroenteritis, Nigeria, Norovirus, Seroprevalence, Under 5 Years of Age

About Author

[1] Anse Boileau Health Centre, Department of Community Health, Health Care Agency, Ministry of Health, Seychelles

[2] Gbagada General Hospital, Lagos, Nigeria

Contact @ Olusola Bamidele Ojo
ojoolusola302@gmail.com

ABSTRACT

Diarrhea is a principal cause of mortality in children, particularly those under the age of 5 years. Globally, roughly 444, 382 children die yearly due to acute gastroenteritis. Human noroviruses are the dominant cause of gastroenteritis in children under 5, killing 200,000 yearly out of 677 million cases. In Nigeria, the real burden of human noroviruses remains unknown due to inadequate research. In this regard, we conducted a narrative analysis of past works on human noroviruses in children from 2010 to 2023. We discovered a prevalence rate of human norovirus- associated gastroenteritis ranged from 3.0% to 37.6% between Lagos and Kano. We found out Lagos had the maximum seroprevalence rate of 37% between 2010 and 2023, and Kano had the third highest prevalence of 21%. We ascribed the high seroprevalence rate of human norovirus infections in Lagos and Kano to high population density and the concomitant overstretching of WASH facilities. We acknowledge the overarching sequelae of poverty to the causation of acute gastroenteritis in resource-mismanaged climes such as Nigeria. Hence, we claim that one out of ten children of under-5 age are prone to human norovirus-associated gastroenteritis in Nigeria. A study of this caliber exposes the threat of human norovirus infections in Nigeria. It reinforces the call for heightened community education, prompt management, and enhanced government intervention in the fight against acute gastroenteritis in under 5 children including human-norovirus associated gastroenteritis.

Citation Style:
Ojo, O. B., & Abideen, G. M. (2025). Norovirus in under 5 Children in Nigeria: History, Current Epidemiology and Future Trends. *Journal of Medical Science, Biology, and Chemistry, 2*(1), 157-164. https://doi.org/10.69739/jmsbc.v2i1.661

1. INTRODUCTION

Diarrheal disease is a leading cause of mortalities in children under 5 years of age. It ranks third after preterm birth complications and pneumonia (WHO Child Mortality Under 5, 2022). It is also a significant cause of malnutrition, poor development, and stunted growth in children (WHO Child Mortality Under 5, 2022). Every year roughly 443, 382 children die due to diarrheal-related illnesses globally (WHO Diarrheal disease, 2024). Most of these diarrheal episodes are due to viral, bacterial, and parasite infections. Viral diarrheal are more predominant in children, particularly those under 5 years. Many causative agents such rotavirus, astrovirus, and norovirus have been implicated in the causation of diarrhea in children below the age of 5 years (Rahouma *et al.*, 2011). Human noroviruses are the leading cause of gastroenteritis worldwide, and the second leading cause of diarrhea in under 5 children after rotavirus (Afework *et al.,* 2022). They have been responsible for the majority of acute cases of diarrhea with significant mortalities in recent times. For instance, about 200,000 deaths are recorded yearly out of 677 million cases of human norovirus associated gastroenteritis (Pires *et al.,* 2015). In Lower- and Middle-Income Economies (LMIC) including Nigeria, epidemiological data about gastroenteritis due to human noroviruses is lacking and sometimes inadequate to evaluate the threat of the virus. The significance of noroviruses regarding the causation of diarrheal in children and immunocompromised individuals is often relegated to the footnotes of rotaviruses. Nevertheless, the burden of human noroviruses in children and in the immunocompromised subjects is significant worldwide, with a disproportionate burden in poor-resource climes. Therefore, this review intends to assess the burden and distribution of norovirus infections in contemporary Nigeria.

Human noroviruses are highly virulent, non-enveloped RNA viruses possessing a single-stranded RNA genome Norovirus belong to the class caliciviridae, composed of 10 subgroups with GI and GII predominantly responsible for acute watery diarrhea in humans (Atmar *et al.,* 2008). Other subgroups have been implicated in the gastroenteritis of felines, canines, bovines, and other animals (Soma *et al.,* 2015). Noroviruses possess extensive mutagenic capacities with new norovirus strains and new variants evolving almost every 2-3 years (Karst *et al.,* 2014; Green, 2013). Norovirus causes gastroenteritis in all ages, however, children under 5 are more prone to developing severe watery stooling, vomiting, and concomitant dehydration that could lead to mortality. The normal incubation period in healthy people is between 12 and 48 hours (Brown *et al.,* 2017). Healthy adults have a limiting infection with minor manifestations of watery diarrhea and occasional nausea and vomiting, which they usually recover from without much morbidity. However, children and the immunocompromised such as those living with HIV, or those taking anticancer therapy are prone to having severe episodes of stooling and vomiting, usually leading to severe dehydration, electrolyte imbalance, and shock, which could lead to death.

1.1. Image depicting a Norovirus

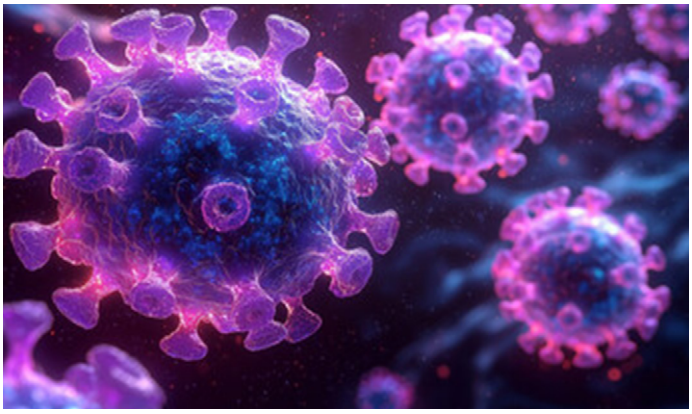

Figure 1. Norovirus under a microscope with glowing spherical particles
Source: Adobe Stock Image

1.2. Image depicting Organ affected by Norovirus

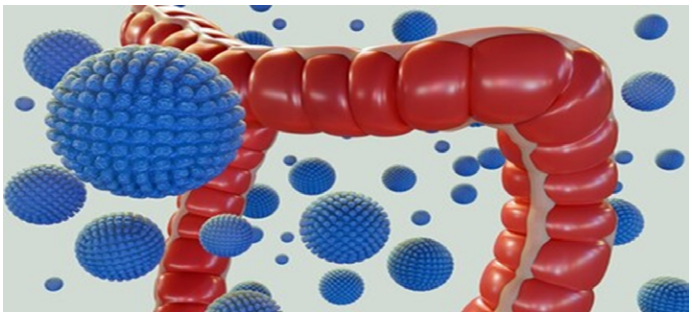

Figure 2. 3D rendering of human large intestine and scattered norovirus particles
Source: Adobe Stock Image

1.3. Routes of contracting Norovirus and manifestations in children

Figure 3. Routes of contracting Norovirus
Source: Shutterstock

1.4. Routes of contracting Norovirus

Figure 4. Norovirus COVID virus prevention
Source: Adobe Stock Image

2. LITERATURE REVIEW

Human noroviruses have also been implicated in asymptomatic and chronic gastroenteritis in immunocompromised subjects (Green, 2013). Noroviruses are highly resistant to environmental elements and can survive on tables, door handles, utensils, and other fomites for a long period. Noroviruses are hard to eradicate in the environment, they usually resist hot and cold weather conditions, and most antiseptics (Seitz *et al.,* 2011). They are transmitted through the fecal-oral route, and they have been incriminated to cause sporadic epidemics of diarrhea in confined spaces such as child care and elderly care homes, cruise ships, military barracks, and prison facilities (Sdiri-Loulizi, 2021). It is the dominant pathogen linked to gastroenteritis resulting from semi-cooked seafood and contaminated food handlers (Mohammad *et al.*, 2020). Contaminated sea food such as oysters, crabs, and some vegetables could spread noroviruses and trigger epidemics (Mohammad *et al.*, 2020). Outbreaks could be deadly and control rely specifically on early diagnosis, prompt treatment of fluid loss, control of nausea and vomiting, as well as the use of zinc in children as well as effective hand hygiene through the use of sanitizer or disinfectants (Karst *et al.,* 2014). Swift enactment of infection control measures remains the pillar of norovirus epidemic management.

There is a paucity of appropriate literature in sub-Saharan Africa to estimate the epidemiological data on norovirus infections. In Lagos, Ayolabi *et al.* (2010) discovered a prevalence rate of 32 .4% between November 2007 and January 2008. While from June 2010 to January 2011, in Ile-Ife, Japhet *et al.* (2012) computed a prevalence rate of 25.5% in children under 5 years. In recent years, the epidemiology data about human noroviruses has been varied and often inconclusive for adequate analysis. In 2015, Babalola *et al.* (2015) derived a prevalence rate of 8 % in Ondo State while Imade & Eghafona highlighted a prevalence of 3.0% in children under 5 years in Edo State. In 2019, different researchers also arrived at dissimilar results. For example, Arowolo *et al.* (2019) arrived at 5.1% prevalence rate in children under 5 years in Ogun State while Afolabi *et al.* (2019) and Japhet *et al.* (2019) computed a prevalence rate of 3.0 % and 10.7% in Kwara and Osun respectively. Likewise in 2023, Chigor *et al.* (2023) calculated a prevalence rate of 8.3% in Nsukka, Enugu State and Abubakar *et al.* (2023) estimated a prevalence of 21% in Kano. In Ogun State, Ogunbiyi *et al.* (2023) derived a prevalence rate of 6 % in children under 5 years of age. While noting that the discrepancies in previous results might be due to variations in sample size, testing mechanisms, and geographical peculiarities, it is expedient to have an average prevalence value for national health planning and policy formulation. Therefore, it is imperative to harmonize these studies to compute more reliable epidemiological data that could reveal the true burden of norovirus infections in Nigeria. In this light, this review article sets out to calculate the average prevalence rate and expose the true state of human norovirus infections in Nigeria. By this research, we aim to raise community awareness about human norovirus infections. We advocate for heightened government intervention regarding the prompt management of acute gastroenteritis including norovirus-associated infections in vulnerable countries including Nigeria.

3. METHODOLOGY

The study deploys a descriptive analysis of relevant articles from major databases, to look for past studies regarding human norovirus in Nigeria. We searched major search engines such as Google Scholar, PubMed, Embase, Directory of Open African Journals, and Web of Science. We set up a research question, 'how prevalent is norovirus in Nigeria? To refine our search, the study used keywords such as 'norovirus in Nigeria', 'human norovirus in Nigeria', 'human norovirus epidemiology', 'prevalence of human norovirus in Nigeria', 'human norovirus infections', and 'norovirus gastroenteritis'. We narrowed our search and included relevant articles from 2010 to 2025. Our articles in Nigeria and related articles in the sub-Saharan clime were included in our search and analysis. The studies were assessed repeatedly in three consecutive steps to determine their suitability. In step 1, we assessed articles based on the information presented in the title and abstract. When the abstract was available, the study was further evaluated for full text. The full texts of the articles selected for step 2 were read for their eligibility and adequacy for data extraction. In step 3, we sourced and analyzed relevant data from selected articles. Some relevant articles from the references of the analysed articles in Step 3 were also included and analysed via snowballing. Subsequently, we deploy a narrative review of sourced data to highlight the epidemiological attributes and compute the prevalence rate of human norovirus infections in contemporary Nigeria. Research focusing broadly on other strains of human noroviruses except GI and GII and their management were excluded from this review article. This study highlights an overview of human noroviruses, their mutagenic properties, and clinical characteristics by concentrating on updating the reader on recent advances and controversies. Information from sources other than peer-reviewed journals has been evaluated but was not considered to add indispensable new information, so is not featured in this review article. In other words, non -peer review articles were not used in this review. Our work is a narrative review deploying descriptive data analysis, and hence it is not registered with PRISMA as it is the norm with systemic review or meta- analysis.

History of Noroviruses

Human noroviruses were the first viral agents attributed to gastroenteritis (Kapikian *et al.*, 1972). It was initially described as ''winter vomiting disease' in 1929 due to its high occurrence during winter and the prevalence of vomiting as its primary clinical manifestation (Caul, 1995). However, human norovirus, initially known as Norwalk virus was identified in stool specimens in 1968, after an outbreak in an elementary school in Norwalk, Ohio in the US. Roughly half of the students presented with nausea, vomiting, and low-grade fever (Caul, 1995). In this index outbreak, nausea and vomiting were the predominant symptoms compared to other clinical features. Among the cases, 98% had nausea, 93% vomited, 38% had watery stooling, and 34% had a fever. Secondary cases developed in 32% of those who had contacts with the students, ascertaining the 48 hours incubation period (Robilotti *et al.,* 2015). All the affected students recovered in 24 hours without any co- morbidity.

In sub-Saharan Africa, in 1993, the first outbreaks of human norovirus-induced gastroenteritis were recorded in South Africa (Taylor *et al.,* 1993). There were two successive epidemics attributed to Hawaii (GII.1) and Norwalk (GI.1) strains. Epidemiological studies done in 1996 and 1999 revealed relatively high seropositivity of IgG antibodies against the model human norovirus (GI. II) ,55.5% and 94.4% respectively in South Africa, Angola, Zimbabwe, Mozambique and Namibia (Smit *et al.,* 1999). Although human noroviruses have been identified as a dominant cause of gastroenteritis in Nigeria, seroprevalence studies started gaining prominence from the first decade of the 21st century. In 2010 and 2012, some studies discovered a seroprevalence of 32.4% and 25.5 % respectively in the southwestern geopolitical zone of the country (Ayolabi *et al.*, 2010; Japhet *et al.,* 2012). Nigeria lacks adequate epidemiological data on human noroviruses as the emphasis has been mainly directed towards rotavirus-induced gastroenteritis in children. Since 2010, however, a handful of research regarding human noroviruses and its concomitant infections in children, specifically, those under 5 years and in immunocompromised subjects have been done in Nigeria.

Current Epidemiology of Norovirus in Nigeria, 2010-2023

As initially highlighted, there is a dearth of epidemiological studies describing the burden of human norovirus infections in Nigeria. We collated epidemiological data from relevant works on human norovirus infections in under 5 children in Nigeria from 2010 to 2023. Table (1) depicts the epidemiological attributes of human noroviruses between 2010 and 2023.

Table 1. Epidemiological studies on Human norovirus in Nigeria between 2010 and 2023 (under 5 years)

Year of Study	Total number tested	Positive Human Norovirus sample	Prevalence Rate (%)	Location	Detection Method	Source
2010	161	60	37.3	Lagos	EIA	Ayolabi *et al.* (2010)
2012	55	14	25.5	Osun	RT-PCR	Japhet *et al.* (2012)
2015	50	4	8	Ondo	EIA	Babalola *et al.* 2015
2015	223	8	3.6	Edo	ICT	Imade & Eghafona, (2015)
2016	600	40	6.7	Taraba Bornu, Bauchi	EIA	Oyinloye *et al.* (2016)
2019	175	9	5.1	Ogun	RT- PCR	Arowolo *et al.* (2019)
2019	135	4	3.0	Kwara	ICT	Afolabi *et al.* (2019a)
2019	103	11	10.7	Osun	RT- PCR	Japhet *et al.* (2019)
2019	100	11	11.0	Kwara	ICT	Afolabi *et al.* (2019b)
2020	405	45	11.1	Delta Edo Bayelsa	RT-PCR	Osazuwa (2021)
2022	65	7	10.8	Ibadan	RT- PCR	Maina *et al.* (2022)
2023	120	10	8.3	Enugu	ICT	Chigor *et al.* (2023)
2023	200	42	21	Kano	RT-PCR	Abubakar *et al.* (2023)
2023	100	6	6	Ogun	RT- PCR	Ogunbiyi *et al.* (2023)
Total	2492	271	10.9			

EIA – Enzyme immunoassay; RT-PCR – Reverse Transcriptase Polymerase Chain Reaction; ICT – Immunochromatographic Test

Table (1) depicts the previous studies on norovirus infections in children below 5 years from 2010 to 2023. It shows that southwest geopolitical states such as Lagos, Oyo, Ogun, Osun, and Ondo had the lion's share of the human norovirus epidemiological studies. The highest frequency of studies was undertaken in 2019 (4), closely followed by the 2023 studies (3). Gross analysis reveals wide variations in the samples of under-5 children tested, which might be due to the social, cultural, and geographical variations of the country. The peak number of children tested (600) was in the northeastern states of Taraba, Borno, and Bauchi in 2016, while the lowest number of samples (50) tested was in Ondo in 2015. Lagos state had the highest number of human noroviral positive samples. Out of 161 under 5 children tested, 61 showed positivity for human norovirus through EIA. Therefore, Lagos had the highest human norovirus seroprevalence 37.5% between 2010 and 2023, while Kwara had the lowest prevalence rate of 3.0% within the same time frame. Other states in the southwestern zone also had a comparatively high prevalence rate for human norovirus among children below 5 years. Osun had a rate of 25.5% in 2012 and 10.7% in 2019, while Ibadan in Oyo state had a prevalence rate of 10.8% in 2022. In the northwestern geopolitical zone, Kano State had the second highest positive samples (42) after Lagos with the third highest seropositivity rate of 21%. Overall, between 2010 and 2023, the prevalence rate spanned from 3.0% to 37.3 %. There were 271 positive samples from a total sample of 2,492, with a pooled prevalence rate of 11%. Regarding the methods of evaluating human norovirus in the samples, RT-PCR was the most deployed (50%) during 2010 and 2023. It is the most reliable and recommended method of testing for noroviruses. Other tests such as ICT and EIA dominated the other 50%.

4. RESULTS AND DISCUSSION

In our study, Lagos had the highest seroprevalence of norovirus at 37.3 % between 2010 and 2023. This might be due to the geographical and socio-political contexts. Lagos is the economic epicenter of the country; it is cosmopolitan in context, and the sixth-largest economy in Africa (Lagos State Government, 2025). It has the highest population of people in Nigeria despite being the smallest regarding the land space (Lagos State Government, 2025; Kenneth, 2024). Hence, it has the highest population density in the country. This population density occasions the overstretching of water, sanitation, and hygiene infrastructure (WASH) which leads to incessant cholera outbreaks (Ojo & Gbolahan, 2025), and other acute gastroenteritis including norovirus-induced variants, specifically in the under-5 children. The high seroprevalence of human norovirus in Osun and other southwestern states might also be attributed to ineffective WASH facilities and the overriding influence of poverty (Ojo & Gbolahan, 2025). This predisposes to malnutrition which facilitates gastrointestinal infections including human norovirus-induced infections, particularly in children. In the northwestern zone of the country, our review shows a 21 % prevalence rate in Kano State from 2010 to 2023. Kano is the next most occupied state in the country and shares the same population dynamics with Lagos (Ojo & Gbolahan, 2025; Kenneth, 2025). Its high population density, some unplanned urban settings, and the overstretching of WASH facilities might be attributed to its comparatively high human norovirus prevalence rate.

We computed an average prevalence rate of 11% for human norovirus infections from 2010 to 2023. This is slightly higher though consistent with the recent research in 2024. The researchers computed a seroprevalence rate of 10 % for human norovirus infections in Nigeria (Chigor *et al.,* 2024). The marginal difference might be due to the upgraded nature of this review, which incorporated additional studies on human noroviruses in the Nigerian context. Comparatively with similar contexts, our prevalence range of 3.0% to 37.3% slightly aligns with previous studies in sub-Saharan climes, which computed a prevalence range of 4.6% to 32.4% with an average prevalence rate of 13.6% (Munjita, 2015; Mans *et al.,* 2016). This might be due to the similarities in geographical, social, political, and economic peculiarities shaping the epidemiology of infectious diseases. Specifically in Ghana, a recent study highlighted an average prevalence of 36.2 % between 2008 and 2017 in children under 5 years (Lartey *et al.*, 2020). It is consistent with the upper limit of the prevalence range of our findings (37.2%). Our value is also consistent with high average prevalence values in countries such as Cameroon, Burkina Faso, Libya, and Madagascar (Abugalia *et al.*, 2011; Papaventsis *et al.*, 2007; Ayukekbong *et al.*, 2011; Huynen *et al.,* 2013). However, there is a variation of our average prevalence of 11% with the global average prevalence of human norovirus infections of 18% due to environmental variations, disparities in samples and testing methods, and seasonal variation of human norovirus infections, particularly in the temperate climes (Lartey *et al.,* 2020; Ahmed *et al.,* 2014). Nevertheless, our pooled prevalence is not far from the average prevalence of human norovirus infections of 12.6% in the sub-Saharan contexts due to similar idiosyncrasies (Munjita, 2015).

5. CONCLUSION

Human norovirus is a significant cause of gastroenteritis globally. It is the second principal cause of gastroenteritis in children after rotavirus worldwide. In sub-Saharan clime and other LMICs including Nigeria, the real burden of human norovirus-associated gastroenteritis remains largely unknown because of the scantiness of data and inadequate government efforts. By deploying narrative analysis of relevant articles on human noroviruses in the Nigerian context, we compute and describe the current epidemiological attributes of human norovirus-associated gastroenteritis in children under 5 years. We discovered that the prevalence rate of human norovirus-associated gastroenteritis ranged from 3.0% to 37.6%, with an average prevalence rate of 11%, and Lagos had the highest prevalence rate of 37.6% between 2010 and 2023. We attributed the high prevalence rate of human norovirus infections in Lagos and Kano to high population density and the concomitant overstretching of WASH facilities while acknowledging the overriding impacts of poverty to the causation of acute gastroenteritis in resource- mismanaged climes such as Nigeria. Hence, we maintain that one out of ten children of under 5 years is vulnerable to human norovirus-associated gastroenteritis in Nigeria.

While a pooled prevalence value of 11% seemed moderate, we should not forget the wide variation in the prevalence of norovirus infections. By deploying our values, roughly two out of five children are vulnerable to human norovirus-induced gastroenteritis in Lagos and one out of five in Osun and Kano. Due to the inadequacies of total samples in some of the studies, we believe there is an unmet gap regarding norovirus-associated infections in Nigeria. There should be heightened community engagement and education for mothers regarding the threat of gastroenteritis induced by norovirus. Regular health promotions regarding the common clinical features of chest infections and acute gastroenteritis should be instituted across the tertiary, secondary, and, specifically primary health levels. Mothers should be educated about the warning signs of acute gastroenteritis to prevent unwarranted mortalities occasioned by rotavirus and norovirus in under 5 children. For example, loose or watery stools more than 7 times in an infant per day are a cause for concern, inability to suck breast, and weakness are dangerous signs necessitating swift intervention in a health facility.

The role of health system strengthening in the fight against infectious diseases in LMICs could not be over-emphasized. Many health facilities lack the appropriate capacities to do RT-PCR for stool samples, especially in rural settings. In that context, the cause of several cases of acute gastroenteritis remains uninvestigated. Generally, to assess the true burden of human norovirus-associated gastroenteritis in Nigeria, at least 90 % of the children presenting with diarrhea should have their stools tested to ascertain the causation pathogen. It would enhance adequate assessment of the prevalence of the virus. There is no specific treatment for human norovirus-associated gastroenteritis or vaccine to combat the norovirus. The vast genetic and antigenic diversity with multiple co-circulating variants of different genotypes creates a challenge in formulating an appropriate vaccine. However, some vaccines are under clinical trials. Thus, symptomatic treatment is the mainstay of management. We advocate prompt rehydration orally via Oral Rehydration Salt (ORS) if the affected children can take oral and the effective monitoring of vital signs. Intravenous rehydration is non-negotiable in cases of severe weakness or dehydration to forestall shock and mortalities. Zinc therapy is an effective adjunct as it helps to improve intestinal absorption of water and electrolytes. Hence, it improves the treatment outcomes. In all, treatment of all cases of watery stooling and vomiting should be free across all government-owned health facilities in Nigeria. The provision of adequate WASH infrastructure, decongestion of cities like Lagos and Kano, and addressing the monstrous menace of multigenerational poverty are issues requiring urgent attention across all strata of government in Nigeria. In the foreseeable future, we hope this work will serve as a springboard for other engaging research regarding norovirus-induced infections in sub-Saharan regions, including Nigeria. Research highlighting the mutagenic properties of norovirus in detail is desirable in the post-modern era. It would enhance the swift production of vaccines to mitigate norovirus-based infections like rotavirus-induced infections.

LIMITATION

This article deploys narrative review of relevant articles on norovirus in under-5 Children in Nigeria. It is a descriptive study and might not be useful for causality or estimation of risk factors of norovirus in under -5 children in Nigerian context. In that regard, analytical and inferential research are desirable. Therefore, future works in that regards would be a welcome development, as our work serve as a springboard for other future descriptive , analytical or inferential studies on Norovirus infections in Nigeria.

REFERENCES

Abubakar, N. K., Hafiz, T. R., Kabuga, A. I., & Rogo, L. D. (2023). Molecular Detection of Human Norovirus among Children (0-5 Years) Attending Selected Hospitals in Kano Metropolis, Kano State, Nigeria. *Egyptian Journal of Medical Microbiology, 32*(3), 87-97.

Abugalia, M., Cuevas, L., Kirby, A., Dove, W., Nakagomi, O., & Nakagomi, T. (2011). Clinical features and molecular epidemiology of rotavirus and norovirus infections in Libyan children. *Journal of medical virology, 83*(10), 1849–1856. https://doi.org/10.1002/jmv.22141

Afework, D. T., Shumie, M. K., & Endalew, G. F. (2022).Pooled prevalence and genetic diversity of norovirus in Africa: a systematic review and meta-analysis. *Virology Journal, 19*(115). https://doi.org/10.1186/s12985-022-01835-w

Afolabi, O. F, Saka, A. O., Ojuawo, A., & Biliaminu, S. A. (2019). Serum zinc levels of hospitalized children with acute diarrhea differ by the isolated viruses. *International Journal of Health Sciences, 13*(5), 4–10.

Afolabi, O. F., Saka, A. O., & Ojuawo, A. (2019). Acute diarrhoea in hospitalized under-five children in Ilorin, Nigeria: Relationship between isolated enteropathogens and clinical outcome. *Nigerian Journal of Paediatrics, 46*(4), 182–188.

Ahmed, S. M., Hall, A. J., Robinson, A. E., Verhoef, L., Premkumar, P., & Parashar, U. D. (2014). Global prevalence of norovirus in cases of gastroenteritis: a systematic review and meta-analysis. *The Lancet. Infectious diseases, 14*(8), 725–730. https://doi.org/10.1016/S1473-3099(14)70767-4

Arowolo, K. O., Ayolabi, C. I, Lapinski, B., Santos, J. S., & Raboni, S. M. (2019). Epidemiology of enteric viruses in children with gastroenteritis in Ogun State, Nigeria. *Journal of Medical Virology, 91*(6), 1022–1029. https://doi.org/10.1002/jmv.25399

Atmar, R. L., Opekun, A. R., Gilger, M. A., Estes, M. K., Crawford, S. E., & Neill, F. H. (2008). Norwalk virus shedding after experimental human infection. *Emerging Infectious Diseases,* 14, 1553-1557. https://doi.org/10.3201/eid1410.080117

Ayolabi, C. I., Ojo, D. A., Armah, G. E., & Mafiana, C. F. (2010). Detection and partial characterization of norovirus among

children with acute gastroenteritis in Lagos, Nigeria. *International Journal of Medicine and Medical Sciences, 2*(7), 216–221.

Ayukekbong, J., Lindh, M., Nenonen, N., Tah, F., Nkuo-Akenji, T., & Bergström, T. (2011). Enteric viruses in healthy children in Cameroon: viral load and genotyping of norovirus strains. *Journal of medical virology, 83*(12), 2135–2142. https://doi.org/10.1002/jmv.22243

Babalola, M. O., Odaibo, G. N., Olaleye, D. O., & Alonge, A. O. (2015). Enteric Adenovirus and Norovirus Gastroenteritis among Under-5 years Children in Owo, Ondo State, Nigeria. *Journal of Advances in Medicine and Medical Research, 9*(8), 1–9. https://doi.org/10.9734/BJMMR/2015/14082

Brown, J. R., Roy, S., Tutill, H., Williams, R., & Breuer J. (2017). Superinfections and relapses occur in chronic norovirus infections. *Journal of Clinical Virology, 96*, 44–48. https://doi.org/10. 1016/j.jcv.2017.09.009

Caul, E. O. (1995). Hyperemesis hiemis—a sick hazard. *Journal of Hospital Infection, 30*, 498-502. https://doi.org/10.1016/0195-6701(95)90054-3

Chigor, V. N., Chidebelu, P. E., Digwo, D. C., Chigor, C. B., Nwagwu, A. U., & Udeh, O. S. (2023). Assessment of the aetiology of acute gastroenteritis outbreaks in infants reveals rotavirus, noroviruses and adenovirus prevalence and viral coinfections in Nsukka, Nigeria. *Virus disease, 34*(2), 297–306. https://doi.org/10.1007/s13337-023-00821-2

Chigor, V. N., Digwo, D. C., Adediji, A., Chidebelu, P. E., Chigor, C. B., & Ugwu, K. O. (2024). Epidemiology of norovirus infection in Nigeria: a systematic review and meta-analysis. *Archives of virology, 169*(7), 138. https://doi.org/10.1007/s00705-024-06056-w

Green, K. Y. (2013). *Caliciviridae: the noroviruses, in Fields Virology.* D. M. Knipe and P. Howley, (Eds.). Lippincott Williams & Wilkins, Philadelphia, Pa, USA.

Huynen, P., Mauroy, A., Martin, C., Savadogo, L. G., Boreux, R., Thiry, E., Melin, P., & De Mol, P. (2013). Molecular epidemiology of norovirus infections in symptomatic and asymptomatic children from Bobo Dioulasso, Burkina Faso. *Journal of clinical virology: the official publication of the Pan American Society for Clinical Virology, 58*(3), 515–521. https://doi.org/10.1016/j.jcv.2013.08.013

Imade, P. E., & Eghafona, N. O. (2015). Viral Agents of Diarrhea in Young Children in Two Primary Health Centers in Edo State, Nigeria. *International journal of microbiology, 2015*, 685821. https://doi.org/10.1155/2015/685821

Japhet, M. O., Famurewa, O., Adesina, O. A., Opaleye, O. O., Wang, B., & Höhne, M. (2019). Viral gastroenteritis among children of 0-5 years in Nigeria: Characterization of the first Nigerian aichivirus, recombinant noroviruses and detection of a zoonotic astrovirus. *Journal of clinical virology, 111*, 4–11. https://doi.org/10.1016/j.jcv.2018.12.004

Japhet, M. O., Adesina., Famurewa, O., Svensson, L., & Nordgren, J. (2012). Molecular epidemiology of rotavirus and norovirus in Ile-Ife, Nigeria: high prevalence of G12P[8] rotavirus strains and detection of a rare norovirus genotype. *Journal of Medical Virology, 84*(9), 1489–1496.

Kapikian, A. Z., Wyatt, R. G., Dolin, R., Thornhill, T. S., Kalica, A. R., & Chanock, R. M. (1972). Visualization by immune electron microscopy of a 27-nm particle associated with acute infectious nonbacterial gastroenteritis. *Journal of Virology, 10*, 1075–1081.

Karst, S. M., Wobus, C. E., Goodfellow, I. G., Green, K. Y., & Virgin, H. W. (2014). Advances in norovirus biology. *Cell Host Microbe, 15*(6), 668-80. https://doi.org/10.1016/j.chom.2014.05.015

Kenneth. (2024). *Top ten smallest states in Nigeria by land area, 2025.* Accessed 30 May 2025. https://naijadetails.com/top-10-smallest-states-in-nigeria-by-land-area

Kenneth. (2025). *Facts About Kano State Population In 2025.* Accessed on 30 2025. https://naijadetails.com/kano-state

Lagos State. (2025). *Lagos State Government Official Website.* Assessed 30 May 2025. https://lagosstate.gov.ng/

Lartey, B. L., Quaye, O., Damanka, S. A., Agbemabiese, C. A., Armachie, J., & Dennis, F. E. (2020). Understanding Pediatric Norovirus Epidemiology: A Decade of Study among Ghanaian Children. *Viruses, 12*(11), 1321. https://doi.org/10.3390/v12111321

Maina, M. M., Faneye, A. O., Motayo, B. O., Nseabasi-Maina, N., & Adeniji, A. J. (2022). Human rotavirus VP4 and VP7 genetic diversity and detection of GII norovirus in Ibadan as Nigeria introduces rotavirus vaccine. *The Journal of international medical research, 50*(9), 3000605221121956. https://doi.org/10.1177/03000605221121956

Mans, J., Armah, G. E., Steele, A. D., & Taylor, M. B. (2016). Norovirus Epidemiology in Africa: A Review. *PloS one, 11*(4), e0146280. https://doi.org/10.1371/journal.pone.0146280

Mohammad, H. A., Madi, N. M., & Al-Nakib W. (2020). Analysis of viral diversity in stool samples from infants and children with acute gastroenteritis in Kuwait using Metagenomics approach. *Virology Journal. 17*(1),1–12.

Munjita, S. M. (2015). Current Status of Norovirus Infections in Children in Sub-Saharan Africa. *Journal of tropical medicine, 2015*, 309648. https://doi.org/10.1155/2015/309648

Ogunbiyi, T., Ayolabi, C., Olukoya, D., Obi, C., & Adedoyin, D.A.(2023). Feaco- prevalence of enteric viruses in children under five in Ogun State, Nigeria; a one-year study. *Babcock University of Medicine Journal, 6*(2), 190-201.

Ojo, O. B., & Gbolahan, A. M. (2025). Contextualising cholera in Nigeria: Contemporary epidemiology, determinants and recommendations. *ISA Journal of Medical Sciences (ISAJMS), 2*(3), 57-68.

Osazuwa, F. (2021). *Sequencing of Norovirus in Southern, Nigeria: Prevalent Genotypes and Putative GII.4 Novel Recombinants among Children.* IntechOpen. https://doi.org/10.5772/intechopen.94389.

Oyinloye, S. O., Aminu, M., Ella, E. E., & Jatau, E. D. (2016). The prevalence and predisposing factors of norovirus and astrovirus infection among diarrheic children in north east, Nigeria. *Journal of Public Health Epidemiology, 8*(10), 204–210.

Papaventsis, D. C., Dove, W., Cunliffe, N. A., Nakagomi, O., Combe, P., Grosjean, P., & Hart, C. A. (2007). Norovirus infection in children with acute gastroenteritis, Madagascar, 2004-2005. *Emerging infectious diseases, 13*(6), 908–911. https://doi.org/10.3201/eid1306.070215

Pires, S. M., Fischer-Walker, C. L., Lanata, C. F., Devleesschauwer, B., Hall, A. J., & Kirk, M. D. (2015). Aetiology-specific estimates of the global and regional incidence and mortality of diarrhoeal diseases commonly transmitted through food. *PLoS ONE, 10*(12), e0142927. https://doi.org/10.1371/journal.pone.0142927

Rahouma, A., Klena, J. D., Krema, Z., Abobker, A. A., Treesh, K., & Franka, E. (2011). Enteric pathogens associated with childhood diarrhea in Tripoli-Libya. *American Journal Tropical Medical Hygiene, 84*(6), 886–891. https://doi.org/10.4269/ajtmh.2011.11-0116.

Robilotti, E., Deresinski, S., & Pinsky, B. A. (2015). Norovirus. *Clinical Microbiology Review, 28*(1), 134-64. https://doi.org/10.1128/CMR.00075-14

Sdiri-Loulizi, K., Hassine, M., Bour, J. B., Ambert-Balay, K., Mastouri, M., & Aho, L. S. (2021). Aichivirus IgG seroprevalence in Tunisia Parallels genomic detection and clinical presentation in children with gastroenteritis. *Clinical Vaccine Immunology, 17*(7), 1111–1116. https:// doi. org/10.1128/CVI.00059-10

Seitz, S. R., Leon, J. S., Schwab, K. J., Lyon, G. M., Dowd, M., & McDaniels, M. (2011). Norovirus infectivity in humans and persistence in water. *Applied Environmental Microbiology, 77*(19), 6884–6888. https://doi.org/10.1128/AEM.05806-11

Smit, T. K., Bos, P., Peenze, I., Jiang, X., Estes, M. K., & Steele, A. D. (1999). Seroepidemiological study of genogroup I and II calicivirus infections in South and southern Africa. *Journal of medical virology, 59*(2), 227–231. https://doi.org/10.1002/(sici)1096-9071(199910)59:2<227::aid-jmv17>3.0.co;2-8

Soma, T., Nakagomi, O., Nakagomi, T., & Mochizuki M. (2015). Detection of norovirus and Sapovirus from diarrheic dogs and cats in Japan. *Microbiology Immunology, 59*, 123–128.

Taylor, M. B., Schildhauer, C. I., Parker, S., Grabow, W. O., Xi, J., & Estes, M. K. (1993). Two successive outbreaks of SRSV-associated gastroenteritis in South Africa. *Journal of medical virology, 41*(1), 18–23. https://doi.org/10.1002/jmv.1890410105

WHO (2022). *Child Mortality Under 5.*

WHO (2024). *Diarrheal disease.* Accessed 17 May 2025. https://www.who.int/news-room/fact-sheets/detail/diarrhoeal-disease.