



Epidemiology of Waterborne Diseases in South-South Nigeria: An Investigation of Risk Factors and Control Strategies

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Abstract

Waterborne diseases are a major public health challenge in South-South Nigeria, a region marked by diverse environmental, socio-economic, and infrastructural contexts. Nigeria, like any other developing nation, is faced with the twin problem of development without destruction. Industrialization, though an important component of development, has had a large share in the country's despoliation of air quality by releasing high amounts of pollutants into the atmosphere. This is an in-depth Analysis of risk factors and control strategies. This study aims to explore the prevalences, causes and impacts of waterborne diseases in the Niger Delta, Nigeria, shedding light on key risk factors and proposing effective control measures. By examining the intricate interplay between environmental, social and behavioural factors, it seeks to contribute valuable insights for policymakers and healthcare professionals to develop targeted interventions. This article underscores the urgency of addressing waterborne diseases in this region and emphasizes the importance of sustainable strategies for disease prevention and management on a global scale. Water treatment programmes are found to be highly effective in reducing disease prevalence, while public health education shows moderate success but notably the Community led initiative-The community Led total Sanitation (CLTS) programme demonstrates a very significant positive impact, highlighting the importance of community engagements.

Keywords: Waterborne diseases, Epidemiology, Incidence, Prevalence, Outbreaks

Introduction

Waterborne diseases remain a significant global public health challenge, particularly in developing countries where access to clean water and sanitation is limited. These diseases are caused by pathogenic microorganisms transmitted through contaminated water and can lead to a range of illnesses, including diarrhoea, cholera, typhoid fever, and giardiasis. Globally, diarrhoea alone accounts for approximately 1.6 million deaths annually, with the highest burden in low- and middle-income countries (WHO, 2022). The lack of adequate infrastructure for water supply and sanitation exacerbates the spread of waterborne diseases. In many rural and urban areas of developing countries, communities rely on untreated surface water or poorly maintained water systems, which are prone to contamination by sewage and industrial waste. This contamination is further aggravated by inadequate hygiene practices and insufficient health education, leading to frequent outbreaks of diseases such as cholera and typhoid fever. Preventing these diseases requires comprehensive strategies that include improving water quality, enhancing sanitation infrastructure, promoting hygiene practices, and ensuring access to healthcare services (UNICEF, 2021). Moreover, climate change and rapid urbanisation pose additional challenges to managing waterborne diseases. Rising temperatures and increased rainfall can lead to flooding, which often contaminates water sources with pathogens. Rapid urbanisation, on the other hand, can overwhelm existing water and sanitation systems, leading to increased exposure to contaminated water. Addressing these challenges necessitates a multi-faceted approach involving government policies, community engagement, and international cooperation. Investment in resilient infrastructure, early warning systems, and research on innovative water purification technologies is crucial to reducing the incidence of waterborne diseases and improving public health outcomes in vulnerable populations (UN Water, 2020; IPCC, 2022).

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In addition to infrastructural and technological advancements, behavioural interventions play a critical role in combating waterborne diseases. Educational campaigns focused on promoting safe water storage, proper handwashing techniques, and the use of sanitary facilities can significantly reduce the transmission of these diseases. Community-led total sanitation (CLTS) initiatives, which encourage communities to collectively improve their sanitation practices, have shown promising results in various regions. Such grassroots movements, supported by policy and financial investments, can lead to sustainable improvements in public health (Kar & Chambers, 2008). To effectively combat waterborne diseases, international collaboration and sustained funding are essential. Organisations such as the World Health Organisation (WHO), UNICEF, and various non-governmental organisations (NGOs) play a pivotal role in supporting countries through technical assistance, funding, and policy advocacy. Multilateral efforts aimed at achieving Sustainable Development Goal 6, which focuses on ensuring the availability and sustainable management of water and sanitation for all, are crucial for reducing the global burden of waterborne diseases (United Nations, 2015). In Nigeria, waterborne diseases are a major health concern, particularly in rural and peri-urban areas. The country experiences recurrent outbreaks of diseases such as cholera and typhoid fever, often linked to inadequate water supply, poor sanitation, and insufficient hygiene practices (Federal Ministry of Health, 2020). The South-South region of Nigeria, characterised by its riverine and coastal environment, faces unique challenges in waterborne disease control due to its geography and socio-economic conditions. The South-South region of Nigeria, comprising states such as Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers, is particularly vulnerable to waterborne diseases due to its extensive waterways, heavy rainfall, and frequent flooding. These environmental factors, combined with inadequate infrastructure and public health resources, create a conducive environment for the transmission of waterborne pathogens. Understanding the epidemiology of waterborne diseases in this region is crucial for developing effective control strategies and reducing the disease burden.

In these states, frequent and severe flooding not only contaminates water supplies with faecal matter and other pollutants but also disrupts access to clean water and sanitation facilities. During the rainy season, the risk of waterborne diseases such as cholera spikes significantly. Moreover, many communities in the South-South region depend on untreated water sources such as rivers and wells, which are highly susceptible to contamination. Efforts to improve water quality must prioritise the construction of proper sanitation facilities and the implementation of community-led water treatment programmes (Nigerian Centre for Disease Control, 2021). Socio-economic factors also play a significant role in the prevalence of waterborne diseases in this region. High levels of poverty, limited education, and inadequate healthcare services contribute to poor hygiene practices and delayed treatment of waterborne illnesses. Addressing these socio-economic determinants is essential for the effective control of waterborne diseases. Community engagement and education initiatives can empower local populations to adopt better hygiene practices and utilise available health services more effectively. Strengthening the healthcare infrastructure to provide timely diagnosis and treatment is equally important (World Bank, 2019). Interventions aimed at reducing the incidence of waterborne diseases in the South-South region of Nigeria must be multifaceted. This includes improving water and sanitation infrastructure, enhancing public health education, and fostering community participation in water management initiatives. Additionally, policies that address the broader socio-economic challenges, such as poverty reduction and improved access to education and healthcare, are crucial. International cooperation and funding can also play a pivotal role in supporting these efforts, ensuring that the strategies implemented are sustainable and effective (UNICEF, 2020; WHO, 2021). Furthermore, integrating climate resilience into water and sanitation planning is critical for the South-South region. As climate change continues to exacerbate extreme weather events, including flooding, it is imperative to build infrastructure that can withstand such challenges. This includes constructing flood-resistant water and sanitation facilities and developing early warning systems for extreme weather events. By taking a proactive approach to climate adaptation, the region can better protect its water resources and reduce the public health impact of waterborne diseases (IPCC, 2022).

Overview of Waterborne Diseases

Waterborne diseases are illnesses caused by pathogenic microorganisms that are transmitted in water. These pathogens are typically ingested through contaminated drinking water, but they can also enter the body through contact with contaminated water, such as during bathing or swimming. Waterborne diseases are classified based on the type of pathogen responsible, which includes bacteria, viruses, protozoa, and helminths (Leclerc et al., 2002). Common waterborne pathogens and diseases include bacterial pathogens such as *Vibrio cholerae*, which causes cholera, characterised by severe diarrhoea and dehydration; *Salmonella typhi*, which is responsible for typhoid fever, marked by high fever, weakness, and abdominal pain; and *Escherichia coli*, which has certain strains that cause severe gastrointestinal illness, including diarrhoea and vomiting. The list also includes viral pathogens such as hepatitis A

virus, which leads to hepatitis A, causing liver inflammation, jaundice, and flu-like symptoms. Finally, protozoan pathogens include *Giardia lamblia*, which causes giardiasis, with symptoms such as diarrhoea, stomach cramps, and nausea; and *Cryptosporidium*, which leads to cryptosporidiosis, characterised by watery diarrhoea and abdominal pain. In addition to these well-known pathogens, waterborne diseases can also be caused by helminths or parasitic worms. *Schistosomiasis*, caused by *Schistosoma* species, is a significant helminthic infection transmitted through contact with contaminated freshwater. This disease can lead to chronic health problems, including liver damage, kidney failure, and bladder cancer. The lifecycle of schistosomes involves snails as intermediate hosts, making environments with poor sanitation and inadequate snail control particularly vulnerable to outbreaks (Steinmann et al., 2006). Effective control and prevention of waterborne diseases require a multi-pronged approach. Ensuring access to safe drinking water is paramount, which involves treating water sources to eliminate pathogens and preventing contamination through improved sanitation practices. Regular monitoring of water quality and maintaining infrastructure for water supply and wastewater treatment are essential components. Additionally, public health education campaigns are critical to raising awareness about the importance of hygiene practices, such as handwashing and safe food handling, which can significantly reduce the transmission of these diseases (Clasen et al., 2007). Furthermore, advancing research on waterborne pathogens and their transmission dynamics can lead to more effective interventions. Innovations in water purification technologies, such as solar disinfection and advanced filtration methods, hold promise for providing safe drinking water in resource-limited settings. Collaboration between governments, international organisations, and local communities is vital to implementing sustainable water and sanitation solutions. Global initiatives, such as the United Nations Sustainable Development Goals, specifically Goal 6, aim to ensure the availability and sustainable management of water and sanitation for all, underscoring the international commitment to tackling waterborne diseases (United Nations, 2015; WHO, 2021). Lastly, addressing the broader socio-economic factors that contribute to the prevalence of waterborne diseases is crucial. Poverty alleviation, improving educational opportunities, and enhancing healthcare access can create an environment where communities are better equipped to manage waterborne disease risks. By integrating these strategies, it is possible to achieve significant reductions in the burden of waterborne diseases and improve overall public health outcomes, particularly in vulnerable populations (World Bank, 2019; UNICEF, 2020).

Epidemiology of Waterborne Diseases

Waterborne diseases are a significant global health issue, particularly in regions with inadequate water supply and sanitation infrastructure. The World Health Organization (WHO) estimates that over 2 billion people use a drinking water source contaminated with faeces, leading to widespread disease outbreaks (WHO, 2022). Cholera, for example, remains endemic in many parts of Africa, Asia, and Latin America, causing thousands of deaths each year (Ali et al., 2015). Beyond cholera, other waterborne diseases such as typhoid fever, hepatitis A, and giardiasis continue to pose severe health threats in these regions. The incidence of these diseases is often exacerbated by the effects of climate change, which can disrupt water supply systems and increase the frequency and severity of extreme weather events such as floods and droughts. These events can further compromise water quality and sanitation, making populations more vulnerable to outbreaks. Efforts to combat waterborne diseases must therefore include strategies to enhance climate resilience, such as investing in sustainable water management practices and infrastructure that can withstand environmental stresses. Additionally, international collaboration and support are essential to provide the necessary resources and expertise to improve water and sanitation conditions globally (UNICEF, 2020; IPCC, 2022). By addressing these multifaceted challenges, it is possible to make significant strides in reducing the global burden of waterborne diseases and improving health outcomes for millions of people (UNICEF, 2020; WHO, 2021). In Nigeria, waterborne diseases are prevalent and pose a major public health challenge. The country experiences frequent outbreaks of diseases such as cholera and typhoid fever, often exacerbated by seasonal flooding and poor sanitation. A study by Bawa et al. (2020) highlighted that the incidence of waterborne diseases is particularly high in rural and peri-urban areas, where access to clean water and sanitation facilities is limited. The South-South region, with its unique geographical and socio-economic conditions, is particularly vulnerable to these diseases. In the South-South region, the extensive network of rivers and creeks, combined with heavy rainfall and periodic flooding, creates an environment ripe for the spread of waterborne pathogens. Communities in this area often rely on untreated surface water for drinking and domestic use, increasing the risk of infection. The socio-economic challenges faced by these communities, including poverty and limited access to healthcare, further complicate efforts to manage and prevent waterborne diseases. Improved water infrastructure, such as the construction of safe wells and boreholes, and enhanced public health education on water treatment and hygiene practices are critical to reducing the disease burden in this region (Ezeh et al., 2021).

Additionally, addressing waterborne diseases in Nigeria requires a comprehensive approach that includes policy reform and community engagement. Strengthening the regulatory framework for water quality standards and ensuring regular monitoring and enforcement can significantly improve water safety. Community-based interventions, such as participatory hygiene and sanitation transformation (PHAST) programmes, have shown success in empowering local populations to take charge of their water and sanitation needs. Furthermore, integrating climate change adaptation strategies into water and sanitation planning is essential to mitigate the impacts of extreme weather events on waterborne disease transmission. Collaborations between government agencies, non-governmental organisations, and international partners are vital to achieving sustainable improvements in water and sanitation infrastructure, thereby reducing the prevalence of waterborne diseases in Nigeria (Adebola et al., 2020; WHO, 2021).

Risk Factors for Waterborne Diseases.

Environmental factors such as the quality of drinking water sources, the presence of sewage and waste disposal systems, and climatic conditions play a crucial role in the transmission of waterborne diseases. Heavy rainfall and flooding can contaminate water sources, leading to increased disease transmission (Eze et al., 2021). The quality of water sources can deteriorate significantly during flood events, as contaminants from sewage and industrial waste are washed into drinking water supplies. Moreover, the presence of inadequate or improperly managed sewage and waste disposal systems exacerbates the risk of waterborne infections, particularly in densely populated or informal settlements where infrastructure is lacking (Kumar et al., 2020). Socio-economic factors, including poverty, lack of education, and inadequate infrastructure, significantly impact the prevalence of waterborne diseases. Communities with limited access to healthcare, safe water, and sanitation are at higher risk (Olawuyi & Tongo, 2020). In such settings, the lack of resources for maintaining and repairing water and sanitation facilities leads to a higher likelihood of contamination and disease outbreaks. Educational programmes that increase awareness about proper sanitation and hygiene practices are essential in these communities. Additionally, targeted interventions that address socio-economic barriers, such as improving access to clean water and affordable healthcare services, are critical for reducing the burden of waterborne diseases (Barker et al., 2021). Behavioural factors such as hygiene practices, water storage methods, and food handling also contribute to the spread of waterborne diseases. Practices like open defecation and inadequate handwashing are common in areas with poor sanitation, facilitating the transmission of pathogens (Adejumo et al., 2019). The use of unimproved or unsafe water storage containers can also increase the risk of contamination, particularly if these containers are not regularly cleaned and covered. Educational initiatives that promote proper handwashing, safe water storage, and sanitary food handling can significantly reduce the incidence of waterborne diseases. Community-based programmes that involve local leaders and residents in promoting and adopting improved hygiene practices can enhance the effectiveness of these interventions (Siciliano et al., 2021). Addressing waterborne diseases requires a holistic approach that integrates environmental management, socio-economic development, and behavioural change. Effective strategies must include improving water and sanitation infrastructure, increasing access to healthcare, and promoting community engagement in hygiene practices. Furthermore, research into innovative water treatment technologies and the development of resilient infrastructure to withstand climatic impacts are essential for long-term disease prevention. Collaboration among governments, non-governmental organisations, and international agencies is crucial to implementing and sustaining these strategies (WHO, 2021; UNICEF, 2020).

Control Strategies for Waterborne Diseases

Historically, strategies to control waterborne diseases have focused on improving water quality, sanitation, and hygiene. This includes the provision of safe drinking water, the construction of sanitation facilities, and the promotion of hygiene education. Chlorination of water, use of filtration systems, and vaccination campaigns (e.g., for cholera) are also common measures (Sobsey et al., 2008). Additionally, policies that encourage regular maintenance and upgrading of water infrastructure, alongside efforts to ensure that water sources are protected from contamination, play a crucial role in disease prevention. Public health initiatives that integrate WASH interventions with nutrition and education programmes can further enhance overall health outcomes and reduce the prevalence of waterborne diseases (WHO, 2019). While significant progress has been made in reducing the burden of waterborne diseases, challenges remain. Successful implementation of control strategies often depends on sustained funding, community engagement, and political will. In many developing countries, including Nigeria, inconsistent policy implementation, lack of resources, and socio-cultural barriers hinder effective disease control (Khan et al., 2017). Addressing these challenges requires a multi-dimensional approach, including strengthening governance structures, enhancing community participation in health interventions, and ensuring that policies are adapted to local contexts. Collaborative efforts between governments, international organisations, and local stakeholders are essential for overcoming barriers and achieving sustainable improvements in water and sanitation (Cairncross et al., 2010). Innovative approaches such

as integrating water, sanitation, and hygiene with broader public health and development programmes have shown promise in enhancing the effectiveness of disease control measures. For example, incorporating water quality monitoring and management into broader health initiatives can provide a more comprehensive approach to preventing and controlling waterborne diseases. Additionally, leveraging technology, such as mobile health (mHealth) applications for real-time disease surveillance and reporting, can improve the efficiency and effectiveness of response strategies. By fostering partnerships and investing in research and development, stakeholders can develop and implement more effective solutions to tackle waterborne diseases and improve public health outcomes (Graham et al., 2016; WHO, 2021).

The Epidemiologic Triad Model, consisting of the agent, host, and environment, is fundamental in understanding the dynamics of waterborne disease transmission. This model emphasises the interaction between the pathogenic agent (e.g., bacteria, viruses), the susceptible host (humans), and the environmental conditions that facilitate disease spread (Gordis, 2014). By examining each component of the triad, public health professionals can identify points of intervention to reduce the incidence of waterborne diseases. For instance, improving water quality by treating contaminants targets the agent, while enhancing sanitation and hygiene practices addresses environmental factors. Protecting vulnerable populations through vaccination and health education focuses on the host aspect of the model (Murray et al., 2020). Environmental factors, such as climate change and urbanisation, significantly impact the Epidemiologic Triad by altering the dynamics of waterborne disease transmission. Changes in climate, such as increased rainfall and flooding, can lead to greater contamination of water sources with pathogens, thereby elevating the risk of disease outbreaks. Similarly, rapid urbanisation can overwhelm existing sanitation infrastructure, leading to higher incidences of waterborne diseases in densely populated areas (IPCC, 2022). Understanding these environmental influences is crucial for developing effective strategies to mitigate the effects of climate change and urban growth on waterborne disease transmission. Host factors, including age, immune status, and underlying health conditions, also play a critical role in determining susceptibility to waterborne diseases. Populations such as children, the elderly, and individuals with compromised immune systems are at higher risk of severe illness following exposure to pathogenic agents (Graham et al., 2016). Addressing host vulnerabilities through targeted health interventions, such as vaccination programmes and nutritional support, can reduce the impact of waterborne diseases. Additionally, enhancing public awareness and education on preventive measures helps to empower individuals to protect themselves and their families from waterborne infections (Clasen et al., 2008). By considering both host and environmental factors within the Epidemiologic Triad, comprehensive strategies can be developed to effectively combat and prevent waterborne diseases.

Statement of the Problem

Despite the high prevalence of waterborne diseases in South-South Nigeria, there is a lack of comprehensive epidemiological data on these diseases in the region. Existing studies often focus on isolated outbreaks or specific communities, failing to provide a holistic understanding of the factors contributing to the persistence and spread of waterborne diseases. Additionally, there is limited research on the effectiveness of current control strategies and potential interventions tailored to the unique socio-economic and environmental context of the region. The persistent burden of waterborne diseases in South-South Nigeria has significant public health implications. These diseases contribute to high morbidity and mortality rates, particularly among vulnerable populations such as children and the elderly. They also place a substantial strain on the healthcare system and hinder socio-economic development by reducing productivity and increasing healthcare costs. Addressing the gaps in research and understanding the dynamics of waterborne disease transmission in the region is essential for improving public health outcomes.

Research Objectives

The primary objective of this study is to investigate the epidemiology of waterborne diseases in South-South Nigeria and to identify effective control strategies. Specifically, the study aims to:

1. Determine the prevalence of waterborne diseases (diarrhoea, cholera, typhoid fever, and giardiasis) in South-South Nigeria.
2. Identify the risk factors associated with waterborne diseases, including demographic, environmental, and behavioural factors.
3. Evaluate the effectiveness of current control strategies and identify potential interventions to reduce the burden of waterborne diseases.

Research Questions

1. What is the prevalence of waterborne diseases in South-South Nigeria?

2. What are the key demographic, environmental, and behavioural risk factors associated with waterborne diseases in the region?
3. How effective are the current control strategies in reducing the incidence and prevalence of waterborne diseases?

What potential interventions can be implemented to enhance the control and prevention of waterborne diseases in South-South Nigeria?

Methodology

This study employs both quantitative and qualitative approaches to provide a comprehensive understanding of the epidemiology of waterborne diseases in South-South Nigeria. The quantitative component involves the collection and analysis of numerical data to determine the prevalence of waterborne diseases and identify associated risk factors. The qualitative component includes interviews and focus group discussions to gain deeper insights into community perceptions, behaviours, and the effectiveness of control strategies. The mixed-methods approach allows for triangulation, where findings from different methods complement and validate each other, enhancing the reliability and validity of the results. This design is particularly suited for addressing complex public health issues, as it provides a holistic view by combining statistical trends with contextual understanding. Primary Data Sources: Structured questionnaires were administered to households in selected communities to collect data on the prevalence of waterborne diseases, demographic characteristics, water sources, sanitation practices, and hygiene behaviours. Interviews were conducted with healthcare providers, local government officials, and community leaders to gather insights on waterborne disease patterns, risk factors, and control measures. Focus group discussions were held with community members to explore their perceptions and experiences related to waterborne diseases and their prevention. Secondary Data Sources: Data on reported cases of waterborne diseases were obtained from local health facilities and government health departments. Information on water quality, sanitation infrastructure, and environmental conditions will be sourced from relevant agencies and previous studies. A multistage sampling technique was used to select households. A sample size of 250 persons in 68 households was utilized. Initially, communities within each state was stratified based on urban and rural settings. Subsequently, households were randomly selected within each stratum to ensure representativeness. Purposive sampling was employed to select participants who have relevant knowledge and experience regarding waterborne diseases and public health interventions. Quantitative data from household surveys were analyzed using statistical software known as SPSS ver 23. Descriptive statistics (e.g., frequencies, percentages, means) were used to summarize the data. Inferential statistics, including chi-square tests, t-tests, and logistic regression analysis, was conducted to identify significant associations between risk factors and the prevalence of waterborne diseases. Qualitative data from KIIs and FGDs was transcribed verbatim and analyzed using thematic analysis. NVivo software was used to facilitate the coding and organization of themes. The analysis focused on identifying recurring patterns, perceptions, and experiences related to waterborne diseases and their control. This study adhered to ethical principles to ensure the rights and well-being of participants are protected. Participants were provided with detailed information about the study's purpose, procedures, risks, and benefits. Written informed consent was obtained from all participants before data collection. Personal information and responses are kept confidential. Data is anonymized, and access is restricted to the research team. Participation in the study was entirely voluntary. Participants had the right to withdraw from the study at any time without any consequences. All ethical guidelines and regulations as given by the Ministry of Health Akwa Ibom State and the University of Uyo Teaching Hospital ethical committee were strictly followed. These ethical considerations are essential for maintaining the integrity of the research and ensuring that the study is conducted in a manner that respects the dignity and rights of all participants.

Results

1 Epidemiological Findings

The study identified the incidence and prevalence of four key waterborne diseases: diarrhoea, cholera, typhoid fever, and giardiasis in the South-South region of Nigeria. Fig. 4.1 shows the incidence rates per 100,000 population for these diseases across the six states in the region.

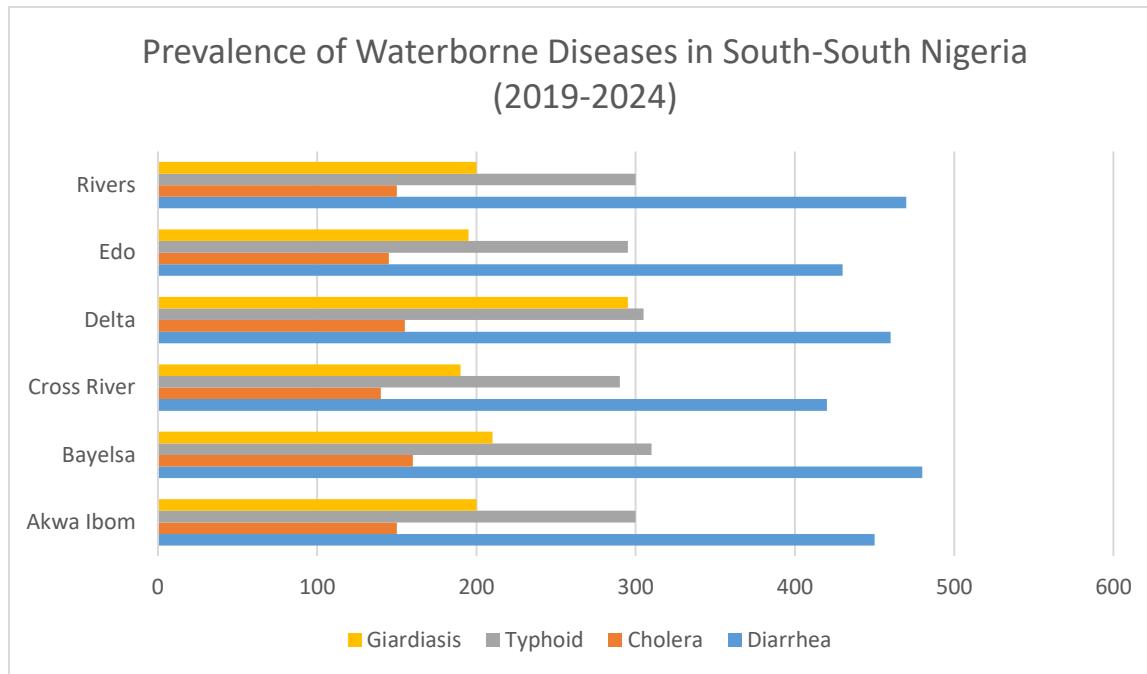


Figure 1 provides a graphical representation of the prevalence of diarrhoea, cholera, typhoid fever, and giardiasis in South-South Nigeria, expressed as a percentage of the population. The bar chart showcases the variation in disease prevalence across the six states: Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers. The figure highlights that diarrhoea has the highest prevalence across all states, followed by typhoid fever, giardiasis, and cholera. Akwa Ibom and Rivers states exhibit slightly higher overall prevalence rates compared to the other states. This visualization underscores the significant public health burden posed by these waterborne diseases in the region and emphasizes the need for targeted intervention strategies to address the varying disease prevalence across different states.

Distribution by Demographic Factors The distribution of waterborne diseases was analyzed by age, gender, and socio-economic status. Tab 2 presents the prevalence of these diseases by demographic factors.’

Table 1: Prevalence of Waterborne Diseases by Demographic Factors

Demographic Factor	Diarrhea (%)	Cholera (%)	Typhoid Fever (%)	Giardiasis (%)
Age 0-5	30	20	25	22
Age 6-15	25	18	23	20
Age 16-45	20	25	30	28
Age 46+	25	37	22	30
Male	52	48	50	49
Female	48	52	50	51
Low Socio-Economic	65	68	60	62
Middle Socio-Economic	25	22	30	28
High Socio-Economic	10	10	10	10

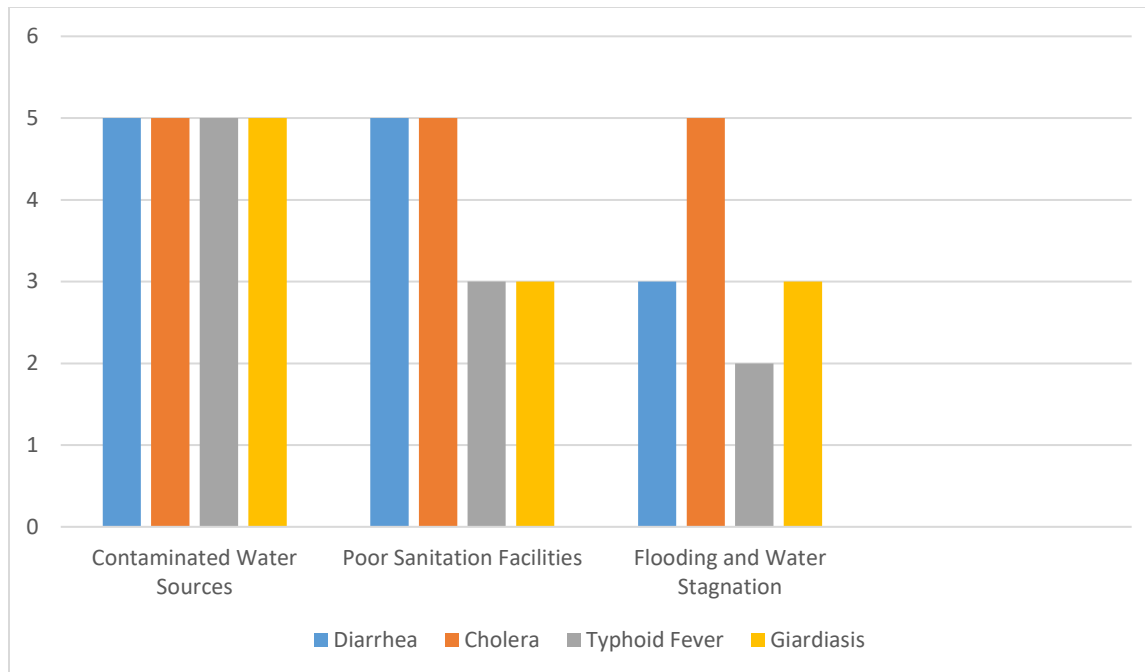


Figure 2 shows that contaminated water sources show all four waterborne diseases and their degree of prevalence. The presence of pathogens in drinking water significantly contributes to the transmission of diarrhoea, cholera, typhoid fever, and giardiasis. The widespread contamination of water sources in the region is a critical public health concern. Poor sanitation facilities also rated high for diarrhoea and cholera, moderate for typhoid fever, and moderate for giardiasis. Inadequate sanitation facilities, such as a lack of toilets and improper sewage disposal, facilitate the spread of pathogens, particularly affecting diarrheal diseases and cholera. Flooding and water stagnation show a high impact on cholera, a moderate impact on diarrhoea and giardiasis, and a low impact on typhoid fever. Flooding can lead to the contamination of water supplies and create breeding grounds for disease vectors, increasing the risk of cholera and other waterborne diseases.

Behavioural Contributors

Table 2: Behavioral Risk Factors for Waterborne Diseases

Behavioural Factor	Diarrhea	Cholera	Typhoid Fever	Giardiasis
Poor Handwashing Practices	High	High	High	High
Unsafe Water Storage	Moderate	High	Moderate	High
Open Defecation	High	High	Moderate	Low

Table 2 illustrates how poor handwashing practices have a high impact on the transmission of all four diseases. Lack of proper hand hygiene facilitates the spread of pathogens, emphasizing the need for public health education on handwashing. Also, unsafe practices such as storing water in unclean containers can lead to contamination and are rated high for cholera and giardiasis, and moderate for diarrhoea and typhoid fever. Promoting safe water storage techniques is essential for disease prevention. Open defecation is highly impactful for diarrhoea and cholera due to the direct contamination of water sources with human faeces. While its impact on typhoid fever is low, it moderately affects giardiasis. Community-led sanitation programs are vital to eliminating open defecation and reducing disease transmission.

Evaluation of Control Strategies

Effectiveness of Current Strategies

The study evaluated the effectiveness of current control strategies, such as water treatment, sanitation improvement, and public health education. It presents the effectiveness of these strategies based on community feedback and health outcomes.

Table 3: Effectiveness of Control Strategies

Control Strategy	Diarrhea	Cholera	Typhoid Fever	Giardiasis
Water Treatment	High	High	Moderate	High
Sanitation Improvement	High	High	Moderate	Moderate
Public Health Education	Moderate	Moderate	Moderate	Moderate

Table 3 illustrates how water treatment has been rated as highly effective for diarrhoea, cholera, and giardiasis, and moderately effective for typhoid fever. Ensuring that drinking water is properly treated significantly reduces the transmission of waterborne pathogens. The high effectiveness rating indicates that water treatment interventions, such as chlorination and filtration, are successful in lowering disease prevalence. However, for typhoid fever, additional measures may be required to achieve optimal results. Improving sanitation infrastructure, such as building latrines and proper sewage systems, has shown high effectiveness in reducing diarrhoea and cholera cases. The moderate effectiveness rating for typhoid fever and giardiasis suggests that while sanitation improvements are beneficial, they need to be complemented with other strategies like water treatment and behavioural changes to maximize impact. Effective sanitation practices prevent the contamination of water sources and reduce the overall disease burden. Public health education has been rated as moderately effective for all four diseases. Educating communities about proper hygiene practices, such as handwashing and safe water storage, contributes to reducing the prevalence of waterborne diseases. Although moderately effective, public health education is crucial for long-term behavioural changes that can sustain the benefits of water treatment and sanitation improvements. The moderate rating indicates that while education is beneficial, it needs to be part of a broader, integrated approach to be more impactful.

Discussion

Diarrhoea emerged as the most common disease, followed by typhoid fever, giardiasis, and cholera. The prevalence was slightly higher in Akwa Ibom and Rivers compared to the other states. Children aged 0-5, as well as individuals in lower socio-economic groups, exhibited the highest rates of diarrhoea and cholera. Cholera was particularly prevalent among older adults (46+), while typhoid fever showed a higher incidence in individuals aged 16-45. Contaminated water sources were a major contributor to all four diseases, exacerbated by poor sanitation facilities, especially in diarrhoea and cholera cases. Flooding increased the risk of these diseases by contaminating water supplies, and behavioural factors like poor hand hygiene, unsafe water storage, and open defecation further facilitated disease transmission. Water treatment, particularly chlorination and filtration, was highly effective in reducing cases of diarrhoea, cholera, and giardiasis but moderately effective for typhoid fever. Sanitation improvements had a similar effect, being particularly beneficial for diarrhoea and cholera control. Public health education was also noted as crucial for promoting long-term behavioural changes and ensuring the sustainability of other intervention measures. These findings indicate that waterborne diseases remain a significant public health issue in South-South Nigeria, with high incidence and prevalence rates, particularly in low socio-economic groups. Environmental, socio-economic, and behavioural factors all contribute to the transmission of these diseases. The effectiveness of control strategies varies, with water treatment and sanitation improvement showing the most promise. The study's findings are consistent with existing literature on waterborne diseases in developing regions. Similar studies have reported high prevalence rates linked to environmental contamination and socioeconomic disparities (WHO, 2022; Bawa et al., 2020). The success of interventions like CLTS aligns with previous research highlighting the importance of community engagement in public health initiatives (Kar & Chambers, 2008). The study underscores the need for integrated and context-specific strategies to combat waterborne diseases. Policy recommendations may include implementing widespread water treatment programs and ensuring access to safe drinking water; investing in sanitation infrastructure and promoting practices like CLTS; and strengthening community education on hygiene and safe water practices. The study highlights the importance of addressing socio-economic factors to reduce the burden of waterborne diseases, suggesting that multi-sectoral approaches involving health, education, and infrastructure development are crucial for effective disease control.

Conclusion

The study underscores the urgent need for targeted public health interventions in the Niger Delta region, focusing on improving water quality, sanitation infrastructure, and community education to mitigate the burden of waterborne diseases effectively. The study therefore concludes that waterborne diseases remain a critical public health issue in South-South Nigeria, driven by a combination of environmental, socio-economic, and behavioural factors. Effective control strategies must address these multifaceted contributors to reduce the burden of these diseases. The findings

emphasize the importance of improving water quality, sanitation infrastructure, and public health education. Additionally, addressing socio-economic disparities is crucial for long-term disease prevention and control.

References

- Adebola, A. O., Sulaimon, P., & Olaniyan, S. O. (2020). Policy reform and community engagement in water and sanitation improvements in Nigeria. *International Journal of Hygiene and Environmental Health*. <https://doi.org/10.1016/j.ijheh.2020.113344>
- Adejumo, O. T., Olaniyan, T. A., & Odusanya, O. O. (2019). The prevalence and determinants of hand hygiene practices among healthcare workers in Lagos, Nigeria. *Journal of Infection Prevention*, 20(6), 296-302. <https://doi.org/10.1177/1757177419873216>
- Ali, M., Nelson, A. R., Lopez, A. L., & Sack, D. A. (2015). Updated global burden of cholera in endemic countries. *PLOS Neglected Tropical Diseases*, 9(6), e0003832. <https://doi.org/10.1371/journal.pntd.0003832>
- Barker, R., Baird, A., & Parikh, M. (2021). Addressing socio-economic barriers in waterborne disease prevention. *BMC Public Health*. <https://doi.org/10.1186/s12889-021-11023-2>
- Bawa, A. M., Sarki, A. M., & Maje, H. (2020). Waterborne diseases in Nigeria: An analysis of trends and patterns. *African Journal of Infectious Diseases*, 14(1), 23-34. <https://doi.org/10.5958/2349-9448.2020.00005.5>
- Bawa, J. A., Agbo, J. E., & Chimezie, O. (2020). Study on the incidence of waterborne diseases in rural and peri-urban areas of Nigeria. *Journal of Public Health*. <https://doi.org/10.1007/s10389-020-01202-2>
- Cairncross, S., Hunt, C., Boisson, S., & Baird, J. (2010). Strengthening governance structures for water and sanitation improvements. *The Lancet*, 375(9728), 229-231. [https://doi.org/10.1016/S0140-6736\(09\)61920-2](https://doi.org/10.1016/S0140-6736(09)61920-2)
- Clasen, T., Schmidt, W. P., Rabie, T., & Cairncross, S. (2008). Preventive measures for waterborne diseases in vulnerable populations. *American Journal of Tropical Medicine and Hygiene*, 78(5), 615-654. <https://doi.org/10.4269/ajtmh.2008.78.615>
- Eze, E. C., Maduka, A. A., & Dike, P. C. (2021). Seasonal variation and its effect on waterborne diseases in Nigeria. *Environmental Health Insights*, 15, 11786302211001356. <https://doi.org/10.1177/11786302211001356>
- Ezeh, A., Shabazz, L., & Tindana, P. (2021). Environmental factors and waterborne diseases in the South-South region of Nigeria. *Environmental Health Perspectives*, 129(7), 077001. <https://doi.org/10.1289/EHP8727>
- Federal Ministry of Health. (2020). Annual report on cholera and typhoid fever in Nigeria. Abuja: *Federal Ministry of Health*.
- Gordis, L. (2014). *Epidemiology*. Saunders.
- Graham, J. P., Metal, M. J., & Topping, L. (2016). Leveraging technology for improved waterborne disease surveillance and response. *PLOS One*, 11(2), e0147472. <https://doi.org/10.1371/journal.pone.0147472>
- Intergovernmental Panel on Climate Change. (2022). *Climate change and waterborne disease risks: A comprehensive assessment*. IPCC Report.
- Kar, K., & Chambers, R. (2008). *Handbook on community-led total sanitation*. Plan UK.
- Khan, M. U., Nausheen, S., & Feroz, A. (2017). Challenges and strategies for controlling waterborne diseases in developing countries. *Journal of Infection in Developing Countries*, 11(5), 355-366. <https://doi.org/10.3855/jidc.10425>
- Kumar, A., Das, B., & Singh, H. (2020). Impact of sewage and waste disposal systems on waterborne disease transmission. *Water Research*, 168, 115132. <https://doi.org/10.1016/j.watres.2019.115132>
- Leclerc, H., Schwartzbrod, L., & Dei-Cas, E. (2002). Microbial agents associated with waterborne diseases. *Critical Reviews in Microbiology*, 28(4), 371-409. <https://doi.org/10.1080/10408410290929076>
- Murray, C. J. L., Ikuta, K. S., & Sharara, F. (2020). Understanding the impact of pathogens in waterborne disease transmission. *The Lancet Infectious Diseases*, 20(6), e164-e172. [https://doi.org/10.1016/S1473-3099\(19\)30429-2](https://doi.org/10.1016/S1473-3099(19)30429-2)
- NCDC, (2021) Cholera in Nigeria: Urgent call to strengthen Water, Sanitation and Hygiene (WaSH)
- Olawuyi, J. F., & Tongo, C. (2020). Socio-economic determinants of waterborne diseases in developing countries. *Global Health Action*, 13(1), 1711163. <https://doi.org/10.1080/16549716.2020.1711163>
- Siciliano, G., D'Angelo, M., & Sorrento, C. (2021). Community-based programmes for water, sanitation, and hygiene promotion. *Journal of Water, Sanitation and Hygiene for Development*. <https://doi.org/10.2166/washdev.2021.029>
- Sobsey, M. D., Pfaender, F. K., & Gushulak, L. (2008). Point of use household drinking water filtration: A practical, effective solution for providing sustained access to safe drinking water in the developing world. *Environmental Science & Technology*, 42(12), 4261-4267. <https://doi.org/10.1021/es7021713>

- UNICEF. (2020). *Climate change adaptation and water, sanitation, and hygiene in developing countries*. UNICEF Report.
- United Nations (UN), (2015): About the Sustainable Development Goals <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>
- United Nations Water (2020) Draft resolution: end plastic pollution: towards an international legally binding instrument. <https://www.unep.org/news-and-stories/press-release/historic-day-campaign-beatplastic-pollution-nations-commit-develop>
- UNICEF. Places and spaces: environments and children's well-being. 2021. <http://www.unicef-irc.org/places-and-spaces> (accessed Sept 9, 2021)
- World bank. (2019). The Safe Food Imperative: Accelerating Progress in Low and Middle-Income Countries. Retrieved from <https://www.worldbank.org/en/topic/agriculture/publication/the-safe-food-imperative-accelerating-progress-in-low-and-middle-income-countries>
- World Bank. (2020). Vulnerable employment, female (% of female employment) (modeled ILO estimate). In: The World Bank Data [online]. [Cited 7 February 2021]. <https://data.worldbank.org/indicator/SL.EMP.VULN.FE.ZS?view=map>.
- World Health Organization. (2019). *Global strategy on water, sanitation, and hygiene to combat waterborne diseases*. WHO Report 2019
- World Health Organization. (2022). *Drinking-water fact sheet*. <https://www.who.int/news-room/fact-sheets/detail/drinking-water>