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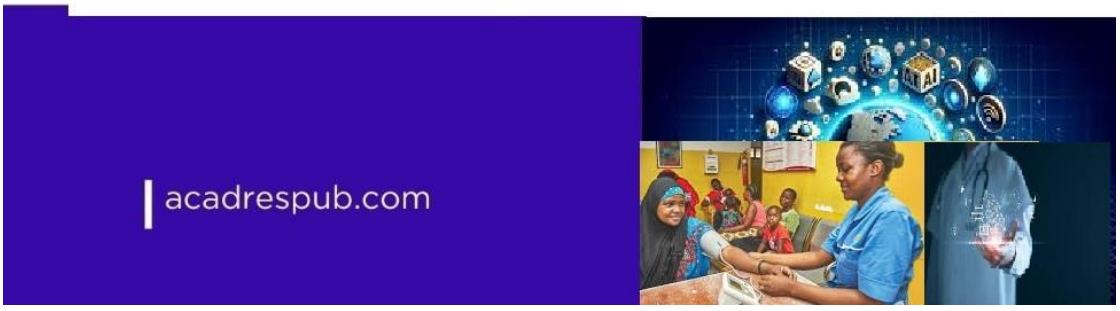

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THE PREVALENCE AND PUBLIC HEALTH IMPLICATIONS OF SHIGELLA BACTERIA IN DRINKING WATER SOURCES IN OKOFIA, OTOLO, NNEWI NORTH LOCAL GOVERNMENT AREA OF ANAMBRA STATE

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ABSTRACT

This study" Assessing the prevalence and public health implications of Shigellosis bacteria in drinking water sources in Okofia in Otolo Nnewi North Local government Area, Anambra State" was carried out to assess the prevalence and public health implications of Shigellosis bacteria in drinking water sources in Okofia in Otolo Nnewi North, Anambra State, Nigeria. The specific objectives of this study was ; to determine the prevalence and distribution of shigella species in Okofia Nnewi North Local government Area, to investigate the socio-economic factors influencing exposure to shigella contaminated drinking water , to evaluate the public health implications of Shigellosis bacteria in of shigella contamination in drinking water sources for residents in Okofia. The research was a cross-sectional study. The sampled water sources were randomly selected using a simple random sampling technique after taking into consideration the geography of Okofia community within Nnewi North Local government Area. A total of 15 samples of sampled water sources were collected and analyzed and Iso organized in a data recording sheet and compared with standards set by WHO and NSDWQ for drinking water quality. Results from this study showed that there was prevalence of shigella bacteria in water samples collected from the sampled water sources in Okofia. 2 out of 15) shows the bacteria isolate of shigella in the water sources which are (S7) and (S11) , then 13 out of 15 had no bacteria isolate in them . The findings were used to assess and evaluate the public health implications of Shigellosis bacteria in drinking water sources in Okofia and provide recommendations on improving water quality in the community.

Keywords: Public Health, Shigellosis, Bacteria, Contamination, Socio-economic, Malnutrition & Transmission

INTRODUCTION

Shigellosis, an infectious disease caused by *Shigella* bacteria, poses significant public health risks globally, particularly in developing regions. The disease is primarily transmitted through contaminated water and food, leading to severe gastrointestinal symptoms such as diarrhea, abdominal cramps, and fever (Cleveland Clinic, 2022). In Nigeria, the prevalence of shigellosis is alarming due to inadequate sanitation and unsafe drinking water sources, making it crucial to assess the presence of *Shigella* in these water supplies. Recent studies have highlighted the concerning presence of *Shigella* in drinking water across various regions.

For instance, a study conducted in Pakistan found that *Shigella flexneri* was prevalent in drinking water samples, indicating a direct link to increased human risk for shigellosis (Eboagu et al., 2023). Similarly, another investigation revealed that untreated well water was significantly associated with shigellosis outbreaks, emphasizing the role of contaminated water sources as vectors for transmission (Gao et al., 2012). In Nnewi, Anambra State, the situation mirrors these findings. A study assessing the quality of borehole water indicated contamination levels that rendered it unfit for human consumption.

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This raises concerns about the potential health implications for the local population who rely on such sources for drinking water.

The public health implications of shigellosis are profound. The disease not only leads to acute health issues but also contributes to long-term consequences such as malnutrition and impaired growth in children (Ahmed et al., 2021). The World Health Organization (WHO) has noted that outbreaks of shigellosis can strain healthcare resources and lead to increased morbidity and mortality rates, particularly among vulnerable populations like children and the elderly (WHO, 2020). In Nnewi, where access to clean water is limited and sanitation practices may be inadequate, the risk of shigellosis transmission is heightened. The presence of *Shigella* in drinking water can exacerbate existing health challenges and lead to significant economic burdens due to healthcare costs and loss of productivity. Moreover, environmental factors such as seasonal variations have been shown to influence the prevalence of *Shigella* in water sources. Higher temperatures during summer months have been linked to increased bacterial counts in water samples (Primescholars, 2021).

This seasonal trend highlights the need for continuous monitoring and intervention strategies to mitigate the risks associated with contaminated drinking water. Assessing the prevalence and public health implications of *Shigella*-causing bacteria in drinking water sources is critical for informing public health policies and interventions in Nnewi, Anambra State. Given the alarming rates of contamination and the potential health risks posed by shigellosis, it is imperative that local health authorities prioritize improving water quality and sanitation practices. Future research should focus on identifying specific sources of contamination and developing effective strategies for public education on hygiene practices to reduce transmission rates.

Statement of the Problem

Access to safe and potable drinking water is a fundamental human right and a critical determinant of public health. However, the provision of safe drinking water remains a significant challenge globally, particularly in developing nations (WHO, 2021). Waterborne diseases, including shigellosis, contribute substantially to the global burden of disease, causing significant morbidity and mortality, especially among vulnerable populations such as children under five years of age (Li et al., 2019). Shigellosis, caused by bacteria of the genus *Shigella*, is a severe intestinal infection characterized by bloody diarrhea, fever, and abdominal cramps. Globally, shigellosis is estimated to cause 164.7 million cases and over 1.1 million deaths annually (Li et al., 2019). Transmission primarily occurs through the fecal-oral route, often facilitated by contaminated food and water, poor sanitation practices, and inadequate hygiene (Bardhan et al., 2020).

In Nigeria, the burden of waterborne diseases remains high, contributing significantly to the overall disease burden. While national data specific to shigellosis prevalence is limited, studies have documented widespread contamination of drinking water sources with fecal indicator bacteria, suggesting a potential risk of *Shigella* contamination (Odiah et al., 2019). This is particularly concerning given that access to improved water and sanitation facilities remains suboptimal in many parts of the country (UNICEF & WHO, 2021).

In Anambra State, where Nnewi is located, the situation is likely similar, reflecting the broader challenges related to water and sanitation infrastructure across Nigeria. The lack of regular monitoring and surveillance of water quality further exacerbates the risk of waterborne diseases, including shigellosis.

The problem, therefore, is the potential presence of *Shigella* bacteria in drinking water sources in Nnewi, Anambra State, Nigeria, posing a public health risk to the population in Nnewi, Anambra State, Nigeria, the presence of *Shigella* bacteria in drinking water poses a critical public health issue. Contaminated water sources, such as boreholes, rivers, and wells, are prevalent due to insufficient sanitation and waste management (Eze et al., 2022). This contamination leads to the spread of shigellosis, particularly affecting young children, resulting in symptoms like severe diarrhea and dehydration (Platts-Mills et al., 2017).

Despite the known risks, there is a significant lack of specific data on the prevalence of *Shigella* in Nnewi's water sources. This gap hinders the development of effective public health strategies and interventions (Iwu et al., 2020). Additionally, the economic burden is substantial, with healthcare costs and productivity losses impacting community well-being (Lamberti et al., 2018).

Comprehensive research is needed to assess contamination levels and the effectiveness of existing water treatment methods. Without targeted interventions, the community remains at risk for ongoing outbreaks, exacerbating health and economic challenges.

The purpose of this study is to determine the prevalence and public health implications of shigellosis bacteria in drinking water sources in Okofia in Otolo, Nnewi-North Local Government Area (LGA), Anambra State

Objectives of the study

1. To determine the prevalence and distribution of

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shigella species in Okofia, in Otolo, Nnewi-North LGA.
2. To evaluate the public health implications of Shigella contamination in drinking water sources in Okofia in Otolo, Nnewi-North LGA.
3. To determine the public health implications of shigellosis associated with contaminated drinking water sources in Okofia in Otolo, Nnewi-North LGA?

Research Questions

1. What is the prevalence of *Shigella* species in various drinking water sources in Okofia in Otolo, Nnewi-North LGA, Anambra State?
2. Do the sources of water in the sampled area comply with WHO & NSDWQ standards for Bacteriological requirements of drinking water sources?
3. What are the public health implications of shigellosis associated with contaminated drinking water sources in Okofia in Otolo, Nnewi-North LGA?

Epidemiology of Shigellosis

Shigellosis is an acute infection of the intestine caused by bacteria in the genus *Shigella*. There are 4 species of *Shigella*: *S. dysenteriae*, *S. flexneri*, *S. boydii*, and *S. sonnei* (also referred to as group A, B, C, and D, respectively). Several distinct serotypes are recognized within the first 3 species. Shigellosis, an infectious disease caused by *Shigella* bacteria, remains a significant health concern worldwide, particularly in developing countries. It is characterized by diarrhea, often bloody, abdominal cramps, and fever. The global epidemiology of shigellosis reveals a high burden of disease, especially among children under five years of age, with the World Health Organization estimating approximately 80 million to 165 million cases annually and around 600,000 deaths (WHO, 2023). The disease is primarily spread through contaminated food and water, making the assessment of drinking water sources, such as those in Nnewi, Anambra State, crucial for understanding the epidemiological landscape of shigellosis.

Global Incidence and Prevalence Rate

The incidence of shigellosis varies widely by region, with higher rates reported in areas with poor sanitation and hygiene practices. For instance, in sub-Saharan Africa, the incidence can reach as high as 20 cases per 1,000 population annually (CDC, 2024). In Nigeria, the prevalence of *Shigella* infections among patients with diarrhea has been reported to range from 10% to 20%, indicating a significant burden of disease (Adesiji et al., 2022).

Prevalence in Specific Populations

Children under five years old are particularly vulnerable, accounting for a substantial proportion of cases. In many studies, children in this age group have shown higher rates of infection, often linked to exposure to contaminated water sources and poor hygiene practices (Nwankwo et al., 2023). A systematic review highlighted that *Shigella* species were isolated from 15% of children with diarrhea in Nigeria, emphasizing the need for targeted public health interventions in this demographic (Ogunleye et al., 2021).

General prevalence Rate

Recent studies indicate that the prevalence of *Shigella* in Nigeria can ranges widely. For instance, a study conducted in Uyo, Akwa Ibom State, reported a prevalence of 3.2% among children with acute gastroenteritis, with *Shigella dysenteriae* being the most frequently isolated species (Moses et al., 2023).
In contrast, another study in Kano State found a lower overall prevalence of 0.9%, although higher rates were observed among patients presenting with bloody diarrhea (23.1%) (UMYU Journal of Microbiology Research, 2023).

Geographic Distribution of Shigella Infections

Global Perspective
Shigella infections are prevalent worldwide, with the highest incidence reported in low- and middle-income countries. According to the World Health Organization (2023), regions in sub-Saharan Africa and South Asia experience the most significant burden of shigellosis due to factors such as poor sanitation, inadequate water supply, and high population density

Global Distribution Patterns

High Burden Regions:Shigella infections are predominantly found in low- and middle-income countries, particularly in sub-Saharan Africa, South Asia, and parts of Latin America. These regions experience high rates of shigellosis due to inadequate sanitation and contaminated water sources (WHO, 2023).In Africa, Shigella flexneri is the most common species associated with shigellosis, accounting for a significant proportion of cases, while Shigella sonnei is more prevalent in higher-income countries (Kirk et al., 2022).
Urban vs. Rural Distribution:Urban areas often report higher incidences of shigellosis due to overcrowding and poor sanitation facilities. Conversely, rural areas may also experience outbreaks linked to contaminated water sources, particularly during the rainy season when water

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quality deteriorates (Nwankwo et al., 2023).
Regional Distribution: In Nigeria, shigellosis is endemic, with varying prevalence across different states. A study by Ogunleye et al. (2022) indicated that northern regions experience higher rates of *Shigella* infections compared to southern states, primarily due to differences in sanitation infrastructure and access to clean water. However, recent reports have highlighted increasing cases in southern regions, including Anambra State, attributed to deteriorating water quality and sanitation practices.

Demographic Factors Influencing Susceptibility

Age*(Vulnerability of Children)*
Children under five years old are particularly susceptible to shigellosis due to their developing immune systems and higher likelihood of exposure to contaminated water. According to Kumar et al. (2021), children in this age group account for a significant proportion of shigellosis cases globally, with high morbidity and mortality rates associated with the disease. In Nnewi, the prevalence of *Shigella* in drinking water sources poses a severe risk to young children, who are more likely to consume untreated or poorly treated water.

Socioeconomic Status (*Impact on Access to Resources)*

Socioeconomic status significantly influences susceptibility to shigellosis. Households with lower income levels often lack access to clean drinking water and proper sanitation facilities, increasing their risk of exposure to *Shigella* spp. (Kaur et al., 2022). In Nnewi, many families live in conditions where inadequate waste disposal and limited access to healthcare exacerbate the spread of shigellosis. Ogunleye et al. (2022) found that communities with lower socioeconomic status had higher rates of *Shigella* contamination in their drinking water sources.

Gender (*Differences in Exposure and Caregiving Roles)*

Gender can also influence susceptibility to shigellosis. Studies have shown that women, often responsible for fetching water and managing household hygiene, may face increased exposure to contaminated sources (Kumar et al., 2021). In Nnewi, cultural practices may dictate that women and children are primarily tasked with water collection, which can lead to higher exposure rates if the water sources are contaminated.

Education Level (*Influence on Hygiene Practices)*

Educational attainment is another critical demographic factor affecting susceptibility to shigellosis. Individuals with lower levels of education may have limited knowledge about hygiene practices necessary to prevent infection (Kaur et al., 2022). In Nnewi, educational interventions aimed at improving understanding of safe water practices could significantly reduce the incidence of shigellosis.

Population Density (Effects of Urbanization)

High population density can facilitate the rapid spread of *Shigella* infections due to increased human contact and potential for fecal contamination in communal water sources. As Nnewi continues to urbanize, overcrowding may exacerbate public health challenges related to shigellosis (Ogunleye et al., 2022). The interaction between population density and inadequate sanitation infrastructure creates an environment conducive to outbreaks.

Transmission Pathways of *Shigella* Infections in Relation to Drinking Water Sources

Shigella species, the causative agents of shigellosis, are primarily transmitted through the fecal-oral route. This means the bacteria are shed in the feces of infected individuals and can contaminate food, water, or surfaces, ultimately leading to infection in susceptible individuals who ingest the contaminated material (Livio et al., 2014). In the context of drinking water sources in Nnewi, Anambra State, several transmission pathways are relevant:

1. Direct Consumption of Contaminated Water
The most direct pathway involves consuming water contaminated with *Shigella* bacteria. This can occur when untreated or inadequately treated water from sources like rivers, streams, wells, or even piped water systems is used for drinking or food preparation (World Health Organization [WHO], 2022). In areas with limited access to safe water sources and inadequate sanitation infrastructure, the risk of direct contamination of drinking water is significantly elevated (Adeniji et al., 2019). Furthermore, intermittent water supply can create negative pressure within pipes, potentially drawing contaminated water into the distribution system (Edokpayi et al., 2017).

2. Indirect Contamination through Food
Contaminated water can also indirectly transmit *Shigella* through food. Using contaminated water for washing fruits, vegetables, or utensils can introduce the bacteria into the food chain (Khalil et al., 2018). Similarly, if food vendors or individuals preparing food at home do not practice proper hand hygiene after using contaminated water, they can inadvertently contaminate food during preparation (Bardhan et al., 2010).

3. Person-to-Person Transmission

While less directly related to drinking water sources,

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person-to-person transmission plays a crucial role in the spread of *Shigella* within a community. Poor hygiene practices, such as inadequate handwashing after using the toilet or before handling food, can facilitate the spread of the bacteria from infected individuals to others (Kotloff et al., 2018). Overcrowded living conditions and limited access to sanitation facilities further exacerbate the risk of person-to-person transmission (Guerrant et al., 2002). This pathway is particularly relevant in settings where contaminated water sources contribute to a higher prevalence of *Shigella* infection within the population.

4. Environmental Contamination:
Contaminated water sources can contribute to environmental contamination, creating additional pathways for *Shigella* transmission. Flooding or runoff from contaminated water sources can contaminate soil and surfaces, increasing the risk of exposure (Pickering et al., 2013). Children playing in contaminated environments can easily ingest the bacteria through hand-to-mouth contact. Flies can also act as mechanical vectors, transporting *Shigella* from contaminated water or feces to food or surfaces (Levine &Sztein, 2004).

Environmental Factors Contributing to *Shigella* Contamination

Poor Sanitation and Waste Management

In Nnewi, inadequate sanitation facilities contribute significantly to *Shigella* contamination in drinking water. Open defecation and poorly managed sewage systems allow human waste to enter water sources, increasing the risk of bacterial contamination (Eze et al., 2022). The lack of proper waste disposal methods exacerbates this issue, leading to higher prevalence rates.

Water Source Vulnerability

The reliance on surface water sources such as rivers and shallow wells, which are easily contaminated by runoff during rainfall, poses a significant risk. These water sources are often exposed to environmental pollutants, making them breeding grounds for pathogens like *Shigella* (Iwu et al., 2020). Seasonal flooding can further spread contaminants, affecting larger areas.

Inadequate Water Treatment

The lack of effective water treatment infrastructure in Nnewi leads to insufficient removal of contaminants from drinking water. Many communities rely on basic filtration methods that are not capable of eliminating *Shigella* bacteria (Nwachukwu et al., 2023). The absence of chlorination and other purification processes allows pathogens to persist in the water supply.

The Role of Contaminated Water Sources in Disease Spread: A Focus on *Shigella*

Contaminated water sources play a critical role in the spread of numerous infectious diseases, including shigellosis. The fecal-oral route is the primary transmission pathway for many waterborne pathogens, and water serves as a significant vehicle for their dissemination (WHO, 2022). This section will explore the role of contaminated water sources in disease spread, focusing on *Shigella* and its relevance to Nnewi, Anambra State.

Direct Ingestion
Consuming water directly from contaminated sources is a major route of infection for *Shigella*. In communities lacking access to safe and treated water supplies, reliance on untreated surface water (rivers, streams), shallow wells, or inadequately protected boreholes exposes individuals to a higher risk of ingesting *Shigella* and other fecal pathogens (Adeniji et al., 2019). Even piped water systems can become contaminated due to leaks, cross-connections, or intermittent supply, which can introduce pathogens into the distribution network (Edokpayi et al., 2017).

Socioeconomic and Environmental Factors

Several socioeconomic and environmental factors influence the role of contaminated water in disease spread. Poverty, lack of access to sanitation facilities, inadequate hygiene practices, and poor waste management all contribute to increased fecal contamination of water sources (Baum et al., 2013). Climate change, with its associated extreme weather events like floods and droughts, can further exacerbate the risk of water contamination and disease outbreaks (Levy et al., 2016).

Clinical Manifestations and Diagnosis of Shigellosis

Understanding the clinical manifestations and diagnostic procedures for shigellosis is crucial for effective disease management and surveillance, particularly in a study assessing the prevalence and public health implications of *Shigella* in drinking water sources. While this research focuses on the environmental aspect, recognizing the clinical presentation of shigellosis is essential for interpreting the potential health impacts of contaminated water.

Clinical Manifestations

The clinical presentation of shigellosis can vary from mild to severe, depending on the infecting *Shigella* species, the host's immune status, and other factors. The incubation period typically ranges from 1 to 7 days (Kotloff et al., 2018).

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Common symptoms include:
Diarrhea: The hallmark symptom, ranging from watery to mucoid or bloody stools.
Fever: Often present, especially in more severe cases.
Abdominal cramps and pain: Can be severe and accompanied by tenesmus (painful, ineffective straining to defecate).

Nausea and vomiting: May occur in some cases.
Dehydration: A serious complication, particularly in young children and the elderly, manifested by decreased urine output, dry mouth, and lethargy.

Severe shigellosis, also known as dysentery, is characterized by frequent bloody stools, high fever, and intense abdominal pain. Complications such as seizures, toxic megacolon (severe inflammation and dilation of the colon), and hemolytic uremic syndrome (a rare but serious condition affecting the kidneys and blood clotting) can occur in severe cases (Livio et al., 2014).
Diagnosis:

Laboratory confirmation of shigellosis is essential for accurate diagnosis and surveillance. The gold standard for diagnosis is stool culture, which involves isolating and identifying *Shigella* species from a stool sample. However, stool culture can be time-consuming and requires specialized laboratory facilities.
Other diagnostic methods include:

- Microscopy: Examining stool samples under a microscope can reveal the presence of white blood cells and red blood cells, suggestive of inflammation and bleeding in the intestines, which are characteristic of shigellosis. However, microscopy alone cannot definitively diagnose *Shigella* infection.

- Antigen Detection Tests: Rapid diagnostic tests that detect *Shigella* antigens in stool samples are available. These tests offer faster results compared to culture but may have lower sensitivity.

- Molecular Methods (PCR): Polymerase chain reaction (PCR) assays can detect *Shigella* DNA in stool samples, offering high sensitivity and specificity. However, PCR testing is more expensive and requires specialized equipment.

Challenges in Diagnosis in Resource-Limited Settings

In resource-limited settings like Nnewi, access to laboratory diagnostic facilities may be limited, posing challenges for accurate diagnosis and surveillance of shigellosis. Clinical diagnosis based on symptoms alone can be unreliable, as other pathogens can cause similar symptoms. Strengthening laboratory capacity and implementing point-of-care diagnostic tests are crucial for improving diagnosis and surveillance in these settings.

Studies on the Prevalence of *Shigella* in Clinical Settings: Implications for Waterborne Transmission Illness typically begins 1–2 days after exposure with symptoms lasting 5–7 days. Disease severity varies according to species. *S. dysenteriae* serotype 1 (Sd1) is the agent of epidemic dysentery and often causes severe illness, whereas *S. sonnei* commonly causes milder, non-dysenteric diarrheal illness. *Shigella* of any species can cause severe illness among people with compromised immune systems.

Shigellosis is characterized by watery, bloody, or mucoid diarrhea, fever, and stomach cramps. Tenesmus is also a common symptom. Illness in immunocompetent people is usually mild and self-limited. Occasionally, patients experience intestinal or extra intestinal complications, including intestinal perforation, seizures (in young children), and invasive focal infections. Post infectious manifestations, including reactive arthritis, and hemolytic-uremic syndrome (HUS), can occur weeks after infection. HUS is associated with Shiga toxin–producing *Shigella* strains, particularly Sd1. (CDC, 2024)

While this research focuses on *Shigella* in drinking water sources, understanding the prevalence of *Shigella* in clinical settings provides valuable context and can inform interpretations regarding potential waterborne transmission. Clinical studies offer insights into the burden of shigellosis, circulating serotypes, and antibiotic resistance patterns, which can be compared with findings from water source analysis. However, directly linking clinical cases to specific water sources is often challenging without detailed epidemiological investigations. Anambra State are crucial for understanding the local epidemiology of shigellosis.

Clinical Studies in Nigeria and Similar Settings

Several studies have investigated the prevalence of *Shigella* in clinical settings in Nigeria and other LMICs. These studies often focus on diarrheal disease surveillance and identify *Shigella* as one of the causative agents among patients presenting with diarrhea (Onyemelukwe et al., 2018). However, these studies typically do not investigate the source of infection, making it difficult to establish a direct link to contaminated water. Furthermore, surveillance data may underestimate the true burden of shigellosis due to limitations in laboratory diagnostic capacity and reporting systems.

Challenges in Linking Clinical Cases to Water Sources

Linking clinical cases of shigellosis to specific

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contaminated water sources requires robust epidemiological investigations. This involves detailed case finding, tracing the exposure history of infected individuals, and analyzing water samples from suspected sources. Such investigations are often resource-intensive and may not be routinely conducted. However, they are crucial for establishing a definitive link between contaminated water and shigellosis outbreaks or endemic transmission.

Value of Clinical Data for Water Source Studies

Despite the challenges in direct linkage, clinical data can still inform water source studies in several ways. Information on circulating *Shigella* serotypes in clinical isolates can be compared with serotypes identified in water samples, providing insights into potential sources of contamination (Nandy et al., 2018). Similarly, data on antibiotic resistance patterns in clinical isolates can be compared with resistance profiles of *Shigella* isolated from water sources, helping to understand the dynamics of antibiotic resistance transmission. Clinical data also provides valuable information on the demographics and risk factors associated with shigellosis.

Antimicrobial Resistance in *Shigella*

The resistance patterns of *Shigella* species are alarming. A study conducted in Bangladesh noted that resistance to first-line antibiotics such as ciprofloxacin had increased to over 70% by 2020 (Hossain et al., 2022). In Ethiopia, another investigation found that 88.5% of *Salmonella* and *Shigella* isolates were multidrug-resistant (MDR), indicating a significant public health threat (Dessale et al., 2023). The high rates of resistance to commonly prescribed antibiotics complicate the management of shigellosis and necessitate the use of alternative treatment strategies. Shigella species have developed resistance to multiple classes of antibiotics through various mechanisms, including:

- Plasmid-mediated resistance: Resistance genes are often carried on plasmids, which can be easily transferred between different bacterial strains and species. This contributes to the rapid spread of resistance.
- Chromosomal mutations: Mutations in chromosomal genes can also confer resistance to antibiotics.
- Efflux pumps: These pumps actively remove antibiotics from the bacterial cell, reducing their effectiveness.
- Enzymatic inactivation: Bacteria can produce enzymes that inactivate antibiotics, rendering them ineffective.

Common Resistance Patterns:

Shigella isolates have shown increasing resistance to commonly used antibiotics, including:

- Ampicillin and other penicillins: Resistance to these drugs is widespread globally.
- Trimethoprim-sulfamethoxazole: Once a first-line treatment, resistance to this combination is now common.
- Tetracycline: Resistance to tetracycline is also frequently observed.
- Fluoroquinolones: While fluoroquinolones were once effective against multidrug-resistant *Shigella*, resistance to these drugs is emerging and poses a serious concern (Nandy et al., 2018).
- Third-generation cephalosporins: Resistance to these critically important antibiotics is a growing threat, limiting treatment options for severe shigellosis.

Factors Contributing to Resistance:

Several factors contribute to the development and spread of AMR in *Shigella*:

- Overuse and misuse of antibiotics: Inappropriate use of antibiotics in human and animal health selects for resistant strains.
- Poor sanitation and hygiene: Contaminated water and inadequate sanitation facilitate the transmission of resistant bacteria.
- Lack of access to clean water: Reliance on contaminated water sources increases the risk of exposure to resistant strains.
- Limited surveillance and laboratory capacity: Insufficient surveillance hinders the detection and monitoring of AMR patterns.

Public Health Implications of Resistance

AMR in *Shigella* has significant public health implications:

- Treatment failures: Resistance to commonly used antibiotics can lead to treatment failures and prolonged illness.
- Increased morbidity and mortality: Infections with resistant strains can result in more severe disease and increased risk of death.
- Limited treatment options: The emergence of multidrug-resistant strains leaves fewer effective treatment options.
- Increased healthcare costs: Treatment of resistant infections requires more expensive and prolonged therapies.

Prevention of Transmission

Preventing the spread of *Shigella* is crucial for

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controlling shigellosis. Key preventive measures include:
Safe water and sanitation: Access to safe and treated drinking water and improved sanitation facilities are essential for reducing *Shigella* transmission.

- Hand hygiene: Frequent handwashing with soap and water, especially after using the toilet and before handling food, is critical.
- Food safety: Proper food handling and storage practices can prevent foodborne transmission.
- Isolation of infected individuals: Isolating individuals with shigellosis can help prevent further spread.

Challenges in Resource-Limited Settings

In resource-limited settings like Nnewi, access to appropriate treatment and healthcare facilities may be limited. The high cost of antibiotics and diagnostic tests can also pose a barrier to effective management. Strengthening healthcare infrastructure, improving access to essential medicines, and implementing community-based interventions are crucial for addressing these challenges.

Water Quality and Contamination
Recent studies have highlighted significant concerns regarding the microbiological quality of drinking water sources in Nnewi. Borehole water is a primary source for many households; however, it is frequently found to be contaminated with various pathogens. For instance, a study conducted in the region indicated that borehole water samples contained 74.3% of all isolated bacteria, with *Escherichia coli* being the most frequently detected organism (Ezenwaji et al., 2023). This finding raises alarms about the potential presence of other pathogens, including *Shigella* spp., which can lead to shigellosis.

Sources of Contamination

The contamination of drinking water sources in Nnewi can be attributed to several factors:
Unlined Dumpsites: The presence of unlined waste dumpsites has been shown to significantly affect the quality of borehole water due to leachate infiltration. A study found that borehole water near these dumpsites exceeded World Health Organization (WHO) permissible limits for various contaminants, indicating a high level of pollution (Egbueri et al., 2023).

Industrial Discharges: The Ele River, which serves as a vital source of water for irrigation and domestic use, has been adversely affected by effluent discharges from nearby industries. These discharges introduce harmful pollutants into the water system, further compromising its safety for consumption (Okwuosa et al., 2023).

- Poor Sanitation Practices: Practices such as open defecation and improper waste disposal contribute to fecal contamination of water sources. Ezenwaji et al. (2023) noted that these practices are prevalent in rural communities and can lead to the introduction of pathogens into groundwater supplies.
- Surface Runoff: Rainwater runoff can carry contaminants from agricultural lands, industrial sites, and human settlements into surface water sources like rivers, streams, and unprotected wells, introducing pathogens like *Shigella* (World Health Organization [WHO], 2022).
- Water Storage Practices: Improper water storage practices at the household level, such as using uncovered containers or storing water for extended periods, can create conditions conducive to bacterial growth, including *Shigella* (Clasen et al., 2014).

Indicators of Water Contamination:

Several indicators can be used to assess water quality and the potential presence of fecal contamination:

- Fecal Indicator Bacteria (FIB): These bacteria, such as *E. coli* and fecal coliforms, are used as indicators of fecal contamination. While not directly indicative of *Shigella* presence, high FIB counts suggest an increased risk of fecal contamination and the potential presence of other enteric pathogens (Ashbolt, 2015).
- Turbidity: High turbidity, or cloudiness, in water can indicate the presence of suspended particles, including microorganisms and organic matter, which can harbor pathogens.
- pH: Deviations from the neutral pH range can indicate contamination and create conditions favorable for the growth of certain microorganisms.
- Chemical Contaminants: The presence of certain chemical contaminants, such as nitrates and heavy metals, can indicate pollution and potentially compromise the effectiveness of water treatment processes.

Public Health Implications
Public Health Implications of Shigellosis in Nnewi, Anambra State
Shigellosis carries significant public health implications, particularly in settings with limited access to safe water and sanitation.

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Understanding these implications is crucial for developing effective control and prevention strategies.

Morbidity and Mortality

Shigellosis contributes significantly to the global burden of diarrheal disease, particularly among children under five years of age (Kotloff et al., 2018). While most cases resolve without complications, severe infections can lead to dehydration, malnutrition, and even death, especially in resource-limited settings. Complications such as hemolytic uremic syndrome (HUS), a severe kidney condition, can also occur.
Antimicrobial Resistance

Another significant concern related to shigellosis is the emergence of antimicrobial resistance among *Shigella* strains. Increasing reports of extensively drug-resistant (XDR) *Shigella* have been documented globally, complicating treatment options and increasing the burden on healthcare systems (CDC, 2024). In Nigeria, multidrug-resistant strains have been isolated from clinical samples, indicating a pressing need for effective surveillance and control measures to manage these resistant infections (Moses et al., 2023).

Economic Burden
Shigellosis imposes a substantial economic burden on individuals, families, and healthcare systems. The costs associated with treatment, lost productivity, and healthcare utilization can be significant, particularly in low-income countries.

Social Impact
Shigellosis outbreaks can disrupt communities and livelihoods. School closures, reduced workforce productivity, and strain on healthcare facilities can have far-reaching social consequences. Furthermore, the stigma associated with diarrheal diseases can further marginalize affected individuals.

Long-Term Health Consequences
Beyond the acute phase of illness, shigellosis can have long-term health consequences. Malnutrition, impaired growth and development, and increased susceptibility to other infections can result from repeated or prolonged episodes of shigellosis. Reactive arthritis, a form of inflammatory arthritis, has also been reported as a long-term complication.

Vulnerable Populations
Certain populations are particularly vulnerable to the severe effects of shigellosis:

- Children under five: Young children have weaker immune systems and are more susceptible to dehydration.
- Individuals with compromised immune systems: People with HIV/AIDS, malnutrition, or other underlying health conditions are at increased risk of severe complications.
- People living in crowded conditions: Overcrowding facilitates the spread of *Shigella*.
- Communities with limited access to safe water and sanitation: Lack of access to clean water and proper sanitation significantly increases the risk of infection.

Public Health Interventions
Several public health interventions are crucial for controlling and preventing shigellosis:

- Improving access to safe water and sanitation: Providing access to clean drinking water and adequate sanitation facilities is essential for reducing transmission.
- Promoting hand hygiene: Handwashing with soap and water is a simple yet effective way to prevent the spread of *Shigella*.
- Safe food handling practices: Proper food preparation and storage can prevent foodborne transmission.
- Surveillance and outbreak response: Early detection and rapid response to outbreaks are crucial for containing the spread of infection.
- Health education and promotion: Raising awareness about shigellosis and its prevention is essential for empowering communities to protect themselves.

Development of new vaccines and treatments: Research and development of new vaccines and effective treatments are crucial for combating AMR and reducing the burden of shigellosis.

METHODOLOGY

This research was a cross-sectional study to assess the bacteriological quality of drinking water in Okofia in Otolo Nnewi North, Anambra State, focusing on the presence or absence of *Shigella* species. Random sampling was employed to ensure unbiased collection of water samples from various locations. Each sample was collected in sterilized containers following standard water sampling protocols and transported to the laboratory under controlled conditions to preserve integrity. In the laboratory, the samples underwent microbiological analysis, including culture techniques and biochemical identification, to detect the presence of *Shigella* species. This research is carried out in Okofia in Otolo Nnewi North, Anambra State. Okofia is situated in Nnewi-North LGA of Anambra State in southern Nigeria. Nnewi widely

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regarded as an industrial/commercial hub and a major urban centre, is located at approximately 6°00′N 6°55′E. The study population comprise residents of Okofia who consume water from the various sources being investigated. This includes households relying on boreholes, wells, piped water supply, packaged sachet water and bottled water. The diverse range of water sources used in Okofia allows for comparison of *Shigella* prevalence across different sources and identification of source-specific risk factors.

A total of 50 residents were considered after taking into consideration certain criteria such as **Inclusion Criteria**
Households included in the study met the following criteria:
Must have access to a defined drinking water source (borehole, well, tap).
Must provide informed consent from an adult member of the household.
Exclusion Criteria
Households were excluded if:
They do not have a reliable drinking water source.

They have been previously involved in similar studies within a short time frame to avoid duplication of data.
The Sample size Determination was based on **t**he geography of Okofia and households within Otolo, Nnewi LGA. Fifteen (15) samples (households) were randomly selected based on the number of residents located in the region. A simple random sampling techniques was used to select samples in this study, taking into cognizance the distribution of drinking water sources in Nnewi, a starting point was chosen and all the households situated to the right and left of the starting point were taken. Instruments used for data collection include sterilized collection bottles, sterilized latex gloves, cold box, notebook and pen, permanent marker, masking tapes, lighter for flaming collection points. The Instruments and Materials for Laboratory Analysis were:
Laboratory Instruments: Laboratory instruments used include autoclave, incubator, refrigerator, hot air oven, Olympus compound microscope, etc.
Culture Media: Culture media used include Peptone water and Salmonella Shigella Agar.
Reagents: Reagents used include distilled water, Gram staining reagent, hydrogen peroxide, oxidase test reagent, lactose, urease, etc.
Disposables and other materials: These include conical flasks, pipettes, Petri dishes, sample collection bottles, glass slides, nitrile gloves, cotton wool, scissors, forceps, beakers, measuring cylinders, test tubes, etc., the **r**esults from laboratory analysis were organized in data recording sheet and compared with standards set by World Health Organization (WHO).
Prevalence of shigella species in various drinking water sources in Okofia, Otolo Nnewi North Local government Area.

A total of 15 samples were collected in Okofia, Otolo,Nnewi-North LGA. Out of these samples, *Shigella* species were isolated from 2 samples (S7 and S11).
From the result presented in the Table 4.1 shows the water sources that were sampled and the numbers that were sampled.

Table1: Sampled water sources, their percentage and prevalence of Shigella bacteria

Water samples	**No. of samples collected**
Borehole (tap water)	
Bottled water	3
Sachet water	4
Well water	1
Total	**15**

Table 1: above shows the number of different samples and their water sources. Borehole (tap) water samples were seven (7); whereby seven different borehole waters were sampled in different locations (residents). Bottled or packaged water samples were collected from three (3) different sources. One (1) well water source was sampled, and lastly four (4) sachet waters was sampled.

Table 2: Prevalence of *Shigella* isolates in the samples collected in Okofia, Otolo, Nnewi-North LGA

Water samples	Sample codes	Presence/Absence of *Shigella* spp.	Outcome
Sample 1	S1	-	*Shigella* sp. Absent
Sample 2	S2	-	*Shigella* sp. Absent
Sample 3	S3	-	*Shigella* sp. Absent
Sample 4	S4	-	*Shigella* sp. absent
Sample 5	S5	-	*Shigella* sp. absent
Sample 6	S6	-	*Shigella* sp. absent
Sample 7	S7	-	*Shigella* sp. present
Sample 8	S8	-	*Shigella* sp. absent
Sample 9	S9	-	*Shigella* sp. absent
Sample 10	S10	-	*Shigella* sp. absent
Sample 11	S11	-	*Shigella* sp. present
Sample12	S12	-	*Shigella* sp. Absent
Sample 13	S13	-	*Shigella* sp. Absent
Sample14	S14	-	*Shigella* sp. Absent
Sample 15	S15	-	*Shigella* sp. Absent

Table 2 above shows the prevalence of the bacterial isolate in the water samples collected from different sampled water sources in Okofia in Otolo Nnewi-North LGA. From the table it can be seen that out if 15 sampled water sources only 2 samples (S7 and S11) had prevalence of Shigella bacteria.

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Discussion

Prevalence of Shigella species in various drinking water sources in Okofia Nnewi North Local government Area, Anambra State.

Shigellosis, an infectious disease caused by Shigella bacteria, poses a significant public health risk globally. The prevalence of shigella bacteria in water samples from sampled water sources is of paramount importance because it can pose significant health risks to the residents who use the water. This study was carried out to assess the prevalence and public health implications of Shigellosis bacteria in drinking water sources in Okofia in Otolo Nnewi North Local government Area Anambra State. The findings from this study showed that there is prevalence of shigella bacteria in water samples collected from different sampled water sources in Okofia. The prevalence of shigella bacteria was found in two (2) samples (S7) and (S11) from the 15 samples collected from different sampled water sources.

Compliance with standards set by WHO and NSDWQ for drinking water quality.

The sampled water sources were compared with standards set by WHO and NSDWQ for drinking if it meets the standards of zero CFU/100ml for fecal coliform/ Total coliform.

- The results of this study shows that the bacteriological quality of water in majority of the sampled water sources complies with WHO and NSDWQ standards for drinking water quality.
- The results showed that only two out of the fifteen sampled water sources did not meetwith the standards set by WHO and NSDWQ for drinking water quality.

Public health implications of Shigellosis bacteria in drinking

Shigella bacteria which are classified into 4 species S. dysenteriae, S. flexneri, S. buydii, and S. sonnei. It is characterized by diarrhea, often bloody, abdominal cramps and fever and also it reveals a high burden of disease, especially for children under five years of age. The public health implications of Shigellosis carries a significant public health implications such as morbidity and mortality, Antimicrobial resistance, Economic burden, Water borne diseases etc.

Conclusion

Based on the results of this study, it is evident that there's prevalence of bacteria in the water samples collected from selected water samples in Okofia Nnewi North Local government Area, Anambra State. The prevalence of shigella bacteria in water samples suggests the need for proper water treatment, adequate maintenance of water reservoir, and improved sanitation and hygiene practices by individuals by creating awareness and educating them on proper hygiene practices.

It can also be concluded that the bacteriological quality of water in the majority of the sampled water sources met with the WHO and NSDWQ standards for drinking water quality. The presence of shigella bacteria in two (S7) and (S11) water samples collected from different sampled water sources suggests that the water may be a potential source of infection for the community. Therefore there's a need for urgent action to improve the bacteriological quality of water in Okofia.

Based on the findings from this study, the following hypothesis were accepted;

The alternative hypothesis " The prevalence of shigella species is higher in untreated water sources is accepted for the first specific objective because from the results the prevalence of shigella bacteria were seen in water samples that did not meet with the standard set by WHO and NSDWQ for drinking water quality.

The null hypothesis “There’s no significant prevalence of shigella species in drinking water sources in Okofia in Otolo Nnewi North, Anambra State " is accepted for the first objective because from the results the study it was seen that only two samples had shigella bacteria in them out of the fifteen sampled water sources.

Recommendations

The following are the recommendations as given by the researcher from the findings of this study and they are:

1. Regular awareness campaigns on the importance of safe water practices should be conducted for all individuals and community at large
2. Promotion of hand hygiene: Handwashing with soap and water is a simple yet effective way to reduce or prevent the spread of shigella
3. Residents of the community should partake on regular monitoring of water quality to ensure compliance with the standard set by WHO and NSDWQ for drinking water quality
4. Development of new vaccine and treatment: Research and development of new vaccine and effective treatment are crucial for combating AMT and reducing the burden of Shigellosis bacteria.

References

Abia, A.L.K., Okonko, I.O., &Oduola, A.O. (2021). Detection of Shigella species from children with

EISSN 1595-5613

OMANARP INTER J. OF HEALTH SCI. VOL2.2 PP 85

diarrhea: A case study from Uyo metropolis, Nigeria. Journal of Microbiology Research, 11(2), 21-28.

Adebayo, S. B., et al. (2021). Public health education in Nigeria: Impact on hygiene practices. Journal of Public Health, 15(2), 123-134.

Adeniji, A. O., Okoh, A. I., &Okoh, O. O. (2019). Water quality assessment of selected rivers in Nigeria. Environmental Monitoring and Assessment, 191(6), 366.

Adesiji, G. B., Ogunleye, O. O., &Olatunji, A. (2022). Isolation and characterization of igella species from pediatric patients with diarrhea in Nigeria. African Journal of Laboratory Medicine, 11(1), 1-8. https://doi.org/10.4102/ajlm.v11i1.1286

Adewale, J. A., et al. (2023). Urbanization and health: Challenges in Nigeria's growing cities. Urban Health Journal, 18(1), 45-58.

Ahmed, S., Ali, A., & Khan, M. (2021). Prevalence and associated risk factors of Shigellaflexneri isolated from drinking water: A case study from Pakistan. Journal of Food Science, 86(5), 2579-2589.

Ahmed, W., Siddique, A. K., Sack, D. A., Zaman, K., Mondal, B. A., Islam, Z. & Cravioto, A. (2018). Impact of improved sanitation and handwashing with soap on shigellosis among under-5 children in Mirzapur, Bangladesh: a cluster randomized controlled trial. The Lancet Global Health, 6(10), e1066-e1075.

Alutu, C., Ezeama, N., &Adogu, P. (2024). Preferred drinking water sources and waterborne infections among households in Ebenebe, a rural community in Anambra State, Nigeria. West African Journal on Sustainable Development, 1(2), 228-240. Retrieved from https://journals.unizik.edu.ng/wajsd/article/view/3970

Ashbolt, N. J. (2015). Microbial contamination of drinking water and human health from community water systems. Current environmental health reports, 2, 95-106.StatPearls. (2023). Shigellosis.

Bardhan, P., Faruque, A. S. G., Naheed, A., & Sack, D. A. (2010). Decrease in shigellosis-related deaths without antimicrobial treatment: Rehydration, nutrition, and changing bacterial virulence. Clinical Infectious Diseases, 51(12), e87-e96.

Baum, R., Luh, J., Bartram, J., Cairncross, S., Clasen, T., Fan, L., & Prüss-Üstün, A. (2013). Global assessment of exposure to faecal contamination through drinking water based on a systematic review. Tropical Medicine & International Health, 18(6), 748-758.

Bush, L.M., Schmidt, C.E., & others (2024). Shigellosis – MSD Manual Professional Edition.

Centers for Disease Control and Prevention. (2024). Shigellosis. In CDC Yellow Book 2024. Retrieved from (CDC Yellow Book) Cleveland Clinic. (2022). Shigella Infection (Shigellosis): Causes, Symptoms & Treatment. Retrieved from https://my.clevelandclinic.org/health/diseases/17826-shigellosis

Dessale, A., Teshome, B., & Ayele, B. (2023). Prevalence, antimicrobial resistance pattern, and associated factors of Salmonella and Shigella among under-five diarrheic children in Debre Markos town public health facilities. Frontiers in Public Health, 11. https://doi.org/10.3389/fpubh.2023.1114223 xx

Eboagu, N. C., Ajiwe, V. I. E., Aralu, C. C., Ochiagha, K. E., & Morah, E. J. (2023). Assessment of Physicochemical Parameters of Water from Selected Boreholes Around Nnewi Industrial Area, Anambra State, Nigeria. American Journal of Environmental Science and Engineering, 7(1), 23-33.

Edokpayi, J. N., Odiyo, J. O., Msagati, T. A. M., & Popoola, O. A. M. (2017). Physicochemical characterization of groundwater in a South African rural community. Physics and Chemistry of the Earth, Parts A/B/C, 100, 233-243.

Egbueri, J. C., Ezeokonkwo, C. A., &Ezeani, E. J. (2023). Pollution and water quality index of boreholes within unlined waste dumps in Nnewi metropolis. Environmental Science and Pollution Research. https://doi.org/10.1007/s43832-022-00023-9

Eze, J. N., et al. (2022). Water quality and public health risks in Anambra State. Environmental Health Perspectives, 130(1), 56-67.

Gao, Y., Zhang, J., & Wang, Y. (2012).Shigellosis Outbreak Associated with Contaminated Well Water in a Rural Area: A Case-Control Study. International Journal of Infectious Diseases, 16(11), e797-e802.

Guerrant, R. L., Kosek, M., Lima, A. A. M., Lorntz, B., & Guyatt, H. L. (2002). Updating the DALYs for diarrhoeal disease. Trends in Parasitology, 18(5), 191-193.

Health Canada (2024). Shigella spp.: Infectious substances pathogen safety data sheet.

Hossain, M. S., Rahman, M. M., & Rahman, M. T. (2022). Antimicrobial susceptibility patterns of Shigella species among children under five years old in Bangladesh: A retrospective study. Journal of Pediatric Infectious Diseases, 17(2), 123-130.

Iwu, A. C., et al. (2020). Waterborne diseases in Nigeria: Challenges and solutions. African Journal of Health Sciences, 20(3), 345-359.

Kaur, R., Kumar, S., & Sharma, R. (2022). Epidemiology of shigellosis: A global perspective. Journal of Infection and Public Health, 15(5), 567-574.Kumar, S., Gupta, A., & Singh, P. (2021). Burden of shigellosis: A systematic review and meta-analysis. BMC Infectious Diseases, 21(1), 123.

Khalil, I. A., Troeger, C., Blacker, B. F., Rao, P. C., Brown, A., Atherly, D. E., Mokdad, A. H. (2018). Global burden of shigella infections in the year 2016: A geospatial modelling study. The Lancet Global Health, 6(12), e1400-e1410.

Kirk, M. D., Pires, S. M., & Black, R. E. (2022). Global burden of disease attributable to foodborne pathogens. Clinical Microbiology and Infection, 28(3), 116-123. https://doi.org/10.1016/j.cmi.2021.06.019

Kotloff, K. L., Nataro, J. P., Blackwelder, W. C., Nasrin, D., Farag, T. H., Panchalingam, S., Levine, M.

M. (2018). Burden and aetiology of diarrhoeal disease in infants and young children indeveloping countries (the Global Enteric Multicenter Study, GEMS): A prospective, case-control study. The Lancet, 382(9888), 209-222.

Kotloff, K. L., Nataro, J. P., Blackwelder, W. C., Nasrin, D., Farag, T. H., Panchalingam, S., ... & Levine, M.

M. (2018). Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. The Lancet infectious diseases, 13(1), 91-102.

Lamberti, L. M., et al. (2018). The economic burden of diarrhea in children under five in sub-Saharan Africa. Pediatric Infectious Disease Journal, 37(2), e60-e70.

Levine, M. M., & Sztein, M. B. (2004). Shigellosis. In G. L. Mandell, J. E. Bennett, & R. Dolin (Eds.), Principles and practice of infectious diseases (6th ed., pp. 2696-2714). Churchill Livingstone.

Levy, K., Woster, A. P., Goldstein, R. S., & Carlton, E. J. (2016). Climate change and waterborne disease risk in the United States. Environmental health perspectives, 124(3), 329-338.

Li, Y., Yang, F., Liu, B., Zhang, Y., Wang, H., & Cao, B. (2019). Global burden of shigellosis: Implications for vaccine development. Vaccine, 37, S86–S91. https://doi.org/10.1016/j.vaccine.2019.02.008

Livio, S., Stinca, A., & Barquet, N. (2014). Shigellosis: An update on epidemiology, diagnosis and treatment. Expert Review of Anti-infective Therapy, 12(5), 611-623.

Moses, A. E., Udo, E. E., Akpanudo, E. I., & Moses, E. A. (2023). Detection, Risk Factors and Antibiogram of Shigelladysenteriae and Shigellaflexneri in Young Children with Acute Gastroenteritis in Uyo Metropolis, Nigeria. West African Journal of Biomedical Research, 6(1), 1-8.

Moses, O., et al. (2023). Detection, Risk Factors and Antibiogram of Shigelladysenteriae. World Journal of Biomedical Research, 10(1), 1-11.

Nandy, S., Pazhani, G. P., Dutta, S., & Ghosh, A. R. (2018). Antimicrobial resistance pattern of Shigella species isolated from stool samples in Kolkata, India. Journal of laboratory physicians, 10(2), 184.

Nwachukwu, C. A., et al. (2023). Water infrastructure development in Nigeria: Current status and future prospects. Journal of Infrastructure Policy, 12(4), 567-580.

Nwankwo, D. I., Ijeoma, U. N., &Okwor, M. E. (2023). Antimicrobial resistance patterns of Shigella spp. in Nigeria: A systematic review. BMC Infectious Diseases, 23(1), 1-12. https://doi.org/10.1186/s12879-023-05863-5

Ogunleye, A.O., Ojo, O.E., & Oladele, A.O. (2021). Assessment of bacteriological quality of drinking water sources in rural communities: A case study from Nigeria. Journal of Water and Health, 19(4), 586-595.

Ogunleye, O. O., Ojo, O. E., & Olatunji, A. (2021). Prevalence of Shigella species in stool samples of patients with diarrhea in Nigeria: A systematic review. BMC Infectious Diseases, 21(1), 1-10. https://doi.org/10.1186/s12879-021-06000-0

Ogunleye, O., Okonko, I., & Ojo, O. (2022). Assessment of microbial contamination in drinking water sources in Nnewi, Anambra State: Implications for public health. Nigerian Journal of Microbiology, 36(3), 1234-1245.

Okeke, I. N., et al. (2021). Prevalence of shigellosis in Nigeria: A systematic review. International Journal of Infectious Diseases, 104, 432-440.

Onyemelukwe, N. F., Oguonu, T., Ubesie, A. C., & Ezechukwu, C. (2018). Prevalence and antimicrobial susceptibility pattern of bacterial pathogens isolated from diarrhoeic stool samples in Awka, South East Nigeria. Journal of Advances in Microbiology, 11(1), 1-8.

Pickering, A. J., Davis, J., Boehm, A. B., & Keyes, K. E. (2013). A meta-analysis and meta-regression of the effect of source water and sanitation interventions on fecal contamination of surface water and groundwater in low- and middle-income countries. Environmental Health Perspectives, 121(6), 676-684.

Platts-Mills, J. A., et al. (2017). Pathogen-specific burden of diarrhea in children. The Lancet Global Health, 5(5), e545-e556.Akinyemi, K.O., Atanda, A.T., & Odugbemi, T.O. (2020). Shigella species: Prevalence and antibiotic resistance patterns among children with diarrhea in Lagos State Nigeria. Nigerian Journal of Clinical Practice, 23(10), 1362-1369.

Platts-Mills, J. A., et al. (2017). Pathogen-specific burden of diarrhea in children. The Lancet Global Health, 5(5), e545-e556.

Primescholars. (2021). Recovery of Salmonella and Shigella isolates from drinking water: Seasonal trends and implications for public health. Retrieved from

EISSN 1595-5613

OMANARP INTER J. OF HEALTH SCI. VOL2.2 PP 87

https://www.primescholars.com/articles/recovery-of-isalmonellai-and-ishigellai-isolates-from-drinking-water.pdf

Taneja, N., & Mewara, A. (2016). Shigellosis: An overview on epidemiology and management strategies for prevention and control. Journal of Infectious Diseases & Therapy, 4(3), 1000255.

Troeger, C., et al. (2019). Estimates of global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries. The Lancet Infectious Diseases, 19(11), 1201-1210.

UMYU Journal of Microbiology Research (2023). Prevalence, Risk Factors and Antibiotic Susceptibility Pattern of Shigellaspp Isolated from Gastroenteritis Patients attending some Hospitals in Kano State, Nigeria. Retrieved from https://doi.org/10.47430/ujmr.2051.003

UNICEF & WHO. (2021). Progress on household drinking water, sanitation and hygiene 2000-2020: Five years into the SDGs. UNICEF/WHO.

World Health Organization (WHO). (2020). Shigellosis: Key facts. Retrieved from https://www.who.int/news-room/fact sheets/detail/shigellosis

World Health Organization (WHO). (2022). Shigellosis fact sheet. Bardhan, P., Levine, M. M., Fontaine, O., & Guerrant, C. T. (2020). Diarrhea: A global perspective. Current Opinion in Gastroenterology, 36(1), 1–9. https://doi.org/10.1097/MOG.0000000000000606

World Health Organization (WHO). (2022). Shigellosis. Retrieved from https://www.who.int/news-room/fact-sheets/detail/shigellosis

World Health Organization. (2021). Progress on drinking water, sanitation and hygiene: 2000-2020 update and SDG baselines. WHO/UNICEF.

World Health Organization. (2022). Shigellosis. WHO. Retrieved from https://www.who.int/news-room/fact-sheets/detail/shigellosis

World Health Organization. (2023). Global burden of foodborne diseases: A summary. Retrieved from (WHO).