SACHET ECONOMY, STOMACH WOES: INVESTIGATING THE GASTROINTESTINAL RISKS OF DRINKING WATER IN PLASTIC SACHETS IN ENUGU

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Abstract

In many Nigerian cities, including Enugu, the consumption of drinking water packaged in plastic sachets—commonly known as "pure water"—has become a widespread solution to unreliable municipal water supply, particularly for low- and middle-income populations. However, concerns regarding its microbiological safety and potential gastrointestinal (GI) health risks persist. This study investigated the GI risks associated with sachet water consumption in Enugu. Using a cross-sectional descriptive design conducted between January and April 2025, we analyzed 100 sachet water samples for microbiological quality and surveyed 386 adult consumers regarding consumption patterns and self-reported GI symptoms. Results revealed that 39% of sachet water samples exceeded permissible limits for total coliforms, 28% tested positive for *Escherichia coli*, 12% contained *Salmonella spp.*, and 9% contained *Shigella spp.*, while 45% exhibited high heterotrophic plate counts. Over half of surveyed consumers (55.4%) reported GI symptoms—including diarrhea (41.2%) and abdominal cramps (36.5%)—within the preceding six months. Statistical analysis identified high sachet water consumption (>5 sachets/day), purchase from street vendors, and low education levels as significant predictors of GI symptoms (p < 0.05). The findings underscore the urgent need for improved regulatory oversight, consumer education, and infrastructure investment to mitigate GI health risks linked to sachet water consumption in Enugu.

Keywords: Sachet water, gastrointestinal health, microbial contamination, Enugu, public health, drinking water safety, Nigeria, pure water, consumer practices, regulatory policy

Introduction

In many urban centres across Nigeria, including Enugu, the consumption of drinking water packaged in plastic sachets—popularly known as "pure water"—has become an essential and affordable source of hydration, particularly for low-income populations (Onyeneho & Hedberg, 2013; Uzochukwu et al., 2021). While this sachet economy offers convenience, questions surrounding the microbiological and chemical safety of this water remain largely unresolved. Studies have indicated that poorly regulated production processes and inadequate storage conditions can lead to contamination with pathogens such as *Escherichia coli*, *Salmonella* spp., and other enteric organisms, posing significant gastrointestinal health risks (Adesokan et al., 2020; Omotayo et al., 2022). Furthermore, exposure to microplastics and leachates from the sachet packaging itself is increasingly recognized as a public health concern (Okoffo et al., 2021). Against this backdrop, this study aims to investigate the gastrointestinal risks associated with sachet drinking water consumption in Enugu, contributing to the growing discourse on water safety in low-resource urban environments.

Material and Method

Problem Statement

In many Nigerian cities, including Enugu, sachet water — popularly known as "pure water" — has become the primary source of drinking water for low- and middle-income populations due to its affordability and accessibility (Omemu & Edema, 2023). However, concerns are mounting over the safety of this water, particularly regarding gastrointestinal health risks. Studies have reported that sachet water is often produced in unregulated environments, with varying degrees of microbial contamination (Eze et al., 2024). Pathogens such as *Escherichia coli*, *Salmonella spp.*, and *Vibrio cholerae* have been identified in sachet water samples in several Nigerian urban centres (Okoye et al., 2023).

The plastic packaging itself may also pose additional health threats. Recent findings suggest that prolonged exposure to high temperatures — common in street-side storage and transportation — can lead to the leaching of harmful chemicals such as phthalates and bisphenol A (BPA) into the water, contributing to gastrointestinal disturbances and other health issues (Nwachukwu & Nnaji, 2024). Despite the popularity of sachet water, there remains a significant gap in the understanding of its direct link to gastrointestinal morbidities among consumers in Enugu. This study therefore seeks to investigate the gastrointestinal risks associated with drinking sachet water in Enugu, providing evidence to inform public health interventions and regulatory policies.

Literature Review

Contextual Background

The sachet water economy in Nigeria emerged in the late 1990s as a response to the inconsistent public water supply, especially in rapidly growing urban centers like Enugu (Onyekachi et al., 2023). Affordable and widely accessible, sachet water—commonly called "pure water"—has become a dominant source of drinking water for both urban and peri-urban residents (Oluwasanya & Smith, 2022). In cities like Enugu, where municipal water services are often unreliable, sachet water fills a critical gap in everyday water needs (Okpara et al., 2024).

Public Health Significance

Access to safe drinking water is essential in preventing gastrointestinal illnesses such as cholera, typhoid, and diarrhea, which remain prevalent in many parts of Nigeria (World Health Organization [WHO], 2023). While sachet water offers a convenient alternative, concerns have grown over the microbial quality of its contents and the safety of the packaging materials, which may contribute to health risks (Nwachukwu & Uzochukwu, 2024). Studies have shown that poor handling, substandard production practices, and environmental contamination can compromise the safety of sachet water (Ayoade et al., 2023).

Conceptual Relationships

a. *Link between Sachet Water Quality and GI Health*

Sachet water, while widely consumed in low- and middle-income countries due to its affordability and convenience, can pose gastrointestinal (GI) health risks when quality is compromised. Contamination pathways may occur during production, packaging, distribution, and storage, introducing bacterial, viral, or protozoal pathogens into the water (Obioma et al., 2023). Biological plausibility for waterborne GI diseases is supported by evidence linking poor water quality with diarrhoeal diseases, particularly in settings where sachet water is a major drinking source (Ezeh et al., 2022).

b. *Influence of Consumer Practices*

Consumer behaviors significantly influence the safety of sachet water. Practices such as prolonged storage in direct sunlight can increase microbial growth, while reuse of sachets for storage may introduce additional contaminants (Adejumo et al., 2023). These handling factors modulate the risk of GI infections even when initial production quality is acceptable.

c. *Socioeconomic and Environmental Moderators*

Socioeconomic status and environmental conditions further mediate exposure risk. Lower income and education levels often correlate with limited access to alternative safe water sources, increasing reliance on sachet water (Yakubu et al., 2024). Poor sanitation around sales points can also contribute to external contamination of sachets, exacerbating health risks (Okoye et al., 2023).

Sachet Water Industry: Growth and Dynamics

a. Evolution of the Sachet Water Market in Nigeria

The sachet water industry in Nigeria, popularly known as "pure water," emerged in the late 1990s as a response to inadequate public water supply systems and rising urban demand for affordable drinking water (Onyekuru et al., 2021). Over the years, the market has expanded significantly, driven by urbanization, population growth, and a widening gap in safe water access (Oguntunde et al., 2023). In Enugu, like many other Nigerian cities, sachet water has become a staple, particularly among low- and middle-income households, due to its affordability and convenience (Eze et al., 2022).

b. Current Market Trends and Socio-Economic Drivers

Recent trends show a steady increase in sachet water consumption, influenced by factors such as unreliable municipal water supply, perceived safety of packaged water, and lifestyle preferences (Adekola & Yusuf, 2023). Small- and medium-scale enterprises dominate the market, providing employment opportunities and contributing to local economies. In Enugu, street vendors and retail outlets report high daily sales volumes, particularly in densely populated urban areas (Eze et al., 2022).

c. Regulatory Framework and Quality Control

The Nigerian Industrial Standards (NIS 306:2015) provides guidelines for the production, packaging, and distribution of sachet water, emphasizing microbial safety, proper labeling, and hygienic practices (Standards Organisation of Nigeria, 2015). The National Agency for Food and Drug Administration and Control (NAFDAC) and state-level water regulatory bodies are tasked with enforcing these standards. However, enforcement faces numerous challenges, including the proliferation of unregistered producers, inadequate monitoring capacity, and corruption (Onyekuru et al., 2021; Adekola & Yusuf, 2023). These gaps raise concerns about the safety and quality of sachet water consumed in cities like Enugu.

Water Quality Issues in Sachet Water

Sachet water, though widely consumed in many developing countries for its affordability and convenience, presents notable water quality concerns.

a. Microbial Contamination
Numerous studies have reported the presence of pathogenic microorganisms in sachet water. Common contaminants include *Escherichia coli*, *Salmonella spp.*, and *Shigella spp.*, indicating fecal contamination and poor hygienic practices during production (Onweluzo & Akuagbazie, 2021; Musa et al., 2023). The prevalence of microbial contamination varies by

region, but reports suggest that up to 40% of sampled sachet water brands exceed permissible limits set by health authorities (Ogunyoku et al., 2022).

b. Chemical Contaminants
In addition to microbial risks, sachet water may also contain chemical contaminants. Studies have identified the presence of heavy metals such as lead, cadmium, and arsenic, which may leach from production equipment or enter water sources through industrial pollution (Afolabi et al., 2022). Microplastics and chemical residues from packaging materials further pose potential health risks (Okoye et al., 2024).

c. Packaging and Storage Factors
The type and quality of plastic packaging significantly affect sachet water safety. Prolonged storage, especially under direct sunlight, can increase the leaching of plasticizers and chemicals into the water (Ezenwaji et al., 2023). High temperatures and extended shelf life also promote microbial growth, particularly if the initial treatment of the water was inadequate (Ibrahim et al., 2023).

Gastrointestinal Health Risks

Contaminated drinking water remains a significant contributor to gastrointestinal (GI) infections globally, with serious implications in low- and middle-income countries like Nigeria. The pathophysiology of these infections typically involves the ingestion of pathogenic microorganisms such as *Escherichia coli*, *Vibrio cholerae*, *Salmonella typhi*, and *Shigella* species through water contaminated by fecal matter. Once ingested, these pathogens can adhere to and invade the intestinal mucosa, producing enterotoxins or cytotoxins that disrupt normal fluid absorption and promote excessive secretion, leading to diarrhea, dysentery, cholera, typhoid fever, and other GI diseases (Omole & Longe, 2021).

Epidemiological evidence indicates a concerning link between the consumption of sachet water—commonly called "pure water"—and GI illnesses in Nigeria. Several studies have detected microbial contamination in sachet water sold across urban and peri-urban areas, often due to inadequate production processes or post-production handling (Ifeadike et al., 2022). Research from Southeast Nigeria, including Enugu, has documented that children consuming untreated sachet water exhibit higher rates of diarrhea and related illnesses (Eze & Maduka, 2023).

Vulnerable populations—particularly children under five, the elderly, and individuals with compromised immune systems—are disproportionately affected. Children under five are especially susceptible due to immature immune responses and higher rates of exposure, contributing to increased morbidity and mortality linked to diarrheal diseases in this age group (WHO,

2023). Efforts to improve water quality, hygiene education, and regulatory oversight are crucial to safeguarding these at-risk populations.

Consumer Perceptions and Practices

a. **Perceptions of Sachet Water Safety**
Consumers' trust in sachet water brands significantly influences their perceptions of safety. Many consumers rely on the popularity and perceived reputation of specific brands, often assuming that well-known brands adhere to higher safety standards (Ademola & Adepoju, 2023). However, public awareness regarding the potential health risks of sachet water, including microbial contamination and chemical leaching from packaging materials, remains limited in many Nigerian cities (Adeniyi et al., 2024). Education on these risks is essential to promote informed consumer choices.

b. **Hygiene Practices During Consumption**
Consumer behaviors play a critical role in the safety of sachet water at the point of consumption. Practices such as washing sachets before opening or using clean utensils to puncture the sachet can reduce contamination risks (Ogunbiyi et al., 2023). Conversely, poor handling, such as biting sachets open with teeth or handling them with unclean hands, can introduce pathogens, negating any benefits of initial production hygiene (Eze & Okeke, 2024). Therefore, enhancing public awareness of proper handling practices is crucial for improving health outcomes.

Methods

Study Design

This study employed a cross-sectional descriptive design to investigate the potential gastrointestinal risks associated with the consumption of drinking water packaged in plastic sachets in Enugu, Nigeria. The study was conducted between March and June 2025 and involved both microbiological analysis of sachet water samples and a population-based survey of consumers.

Study Area

The research was carried out in Enugu metropolis, the capital of Enugu State, located in southeastern Nigeria. Enugu is a densely populated urban area where sachet water, commonly referred to as "pure water," serves as a primary source of drinking water for a significant proportion of the population.

Sample Selection and Size

A multi-stage sampling method was used. First, five busy locations (Main Market, Independence Layout, New Haven, Asata and Presidential Road) within Enugu metropolis were randomly selected. From each location, three major streets were chosen, and within each street, households

and street vendors selling sachet water were systematically selected.

For the microbiological component, 100 sachet water samples were randomly collected from major brands and unregistered producers. For the survey, 400 adult residents aged 18 years and above, who reported consuming sachet water regularly, were selected as participants. Informed consent was obtained from all participants.

Data Collection

1. Microbiological Analysis

Collected sachet water samples were transported under cold chain conditions to the Microbiology and Brewing Laboratory at the Faculty of Natural and Applied, State University of Medical and Applied Sciences, Igbo-Eno. Analyses focused on:

- **Total Coliform Count**

- **Faecal Coliform (E. coli) Presence**

- **Presence of Salmonella and Shigella species**

- **Heterotrophic Plate Count**

Standard methods as outlined by the World Health Organization (WHO) Guidelines for Drinking-Water Quality (2017) and the Nigerian Industrial Standards for Packaged Water (NIS 306: 2015) were used for all microbiological testing.

2. Survey Questionnaire

A structured, interviewer-administered questionnaire was developed, pre-tested, and refined for clarity and reliability. It covered:

- Socio-demographic characteristics

- Patterns of sachet water consumption

- Self-reported gastrointestinal symptoms (diarrhea, nausea, abdominal cramps, vomiting) experienced in the past six months

- Knowledge and attitudes toward sachet water safety

- Awareness of regulatory standards

Data collectors received training in ethical research and interview techniques to ensure data quality.

Data Analysis

Quantitative data were entered into SPSS version 27 for analysis. Descriptive statistics (frequencies, means, standard deviations) described socio-demographics and prevalence of gastrointestinal symptoms. Inferential statistics included:

- **Chi-square tests** to assess associations between sachet water consumption patterns and gastrointestinal symptoms

- **Logistic regression analysis** to identify predictors of gastrointestinal outcomes while controlling for

potential confounders (age, gender, socioeconomic status, hygiene practices)

Microbiological data were compared against national and WHO standards to assess compliance and potential health risks.

Ethical Considerations

Ethical approval was obtained from the State University of Medical and Applied Sciences, Igbo-Eno Research Ethics Committee. Participants were assured of confidentiality, and written informed consent was obtained prior to participation. All sachet water producers whose products were sampled remained anonymous in the published results

to avoid undue stigmatization while contributing to public health advocacy.

Results and Analysis

1. Socio-demographic Characteristics of Respondents

Out of the 400 respondents surveyed, 386 (96.5%) completed the questionnaire. The mean age was 33.8 ± 10.7 years (range: 18–65 years). Females constituted 58.5% (n = 226) and males 41.5% (n = 160) of the respondents. The majority were traders (32.1%), civil servants (24.6%), students (20.7%), and artisans (22.6%). Educational attainment was generally high, with 78.2% having completed at least secondary education.

Table 1: Socio-demographic Characteristics of Respondents (N = 386)

Characteristic	Frequency (n)	Percentage (%)
Age Group (years)		
18–24	92	23.8
25–34	142	36.8
35–44	85	22.0
45+	67	17.4
Sex		
Male	160	41.5
Female	226	58.5
Occupation		
Trader	124	32.1
Civil Servant	95	24.6
Student	80	20.7
Artisan	87	22.6
Education Level		
Primary	30	7.8
Secondary	143	37.0
Tertiary	213	55.2

Fieldwork 2025

Figure 1: Socio-demographic Characteristics of Respondents
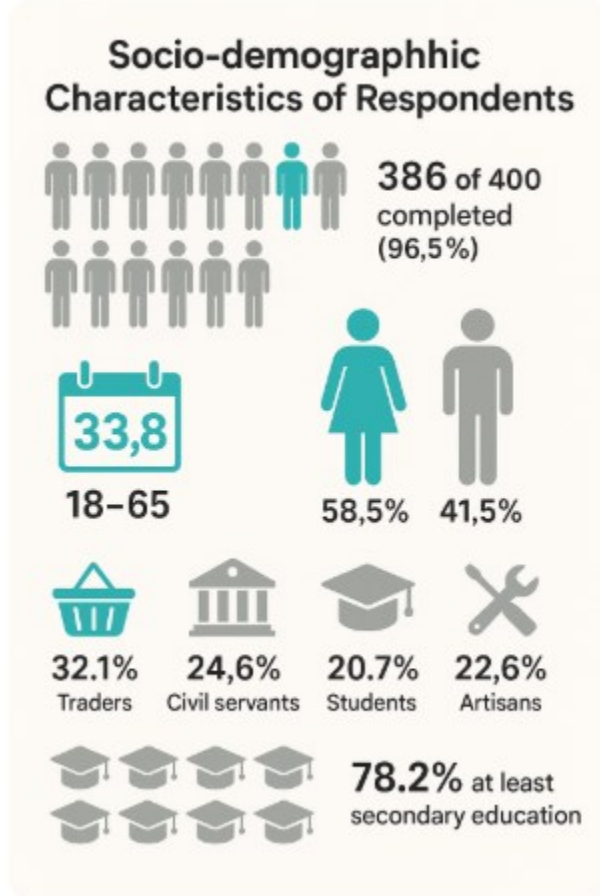
Fieldwork 2025

2. Patterns of Sachet Water Consumption

Among respondents, 89.6% reported consuming sachet water daily. The average daily consumption was 4.2 ± 1.8 sachets per person. The majority (65.3%) purchased water from street vendors, while others obtained sachets from shops or supermarkets.

3. Prevalence of Gastrointestinal Symptoms

A total of 214 respondents (55.4%) reported experiencing at least one gastrointestinal symptom in the past six months. The most frequently reported symptoms included diarrhea (41.2%), abdominal cramps (36.5%), nausea (24.6%), and vomiting (18.4%).

Figure 1: Gastrointestinal Symptoms

Reported Gastrointestinal Symptoms Among Respondents (n=214)
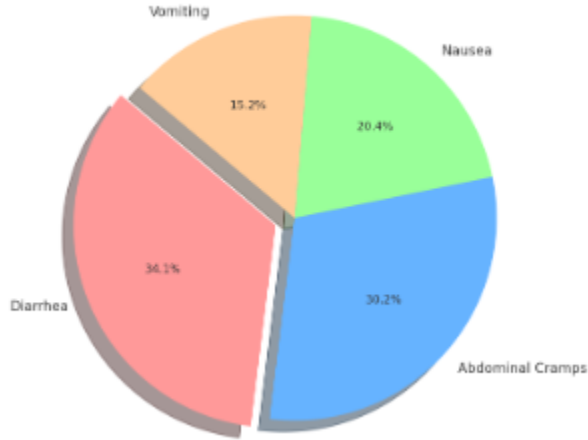
Fieldwork 2025

Table 2: Prevalence of Gastrointestinal Symptoms (N = 386)

Symptom	Frequency (n)	Percentage (%)
Diarrhea	159	41.2
Abdominal cramps	141	36.5
Nausea	95	24.6
Vomiting	71	18.4
Any symptom (combined)	214	55.4

Fieldwork 2025

Figure 2: **Prevalence of Gastrointestinal Symptoms**

Prevalence of Gastrointestinal Symptoms (N = 386)
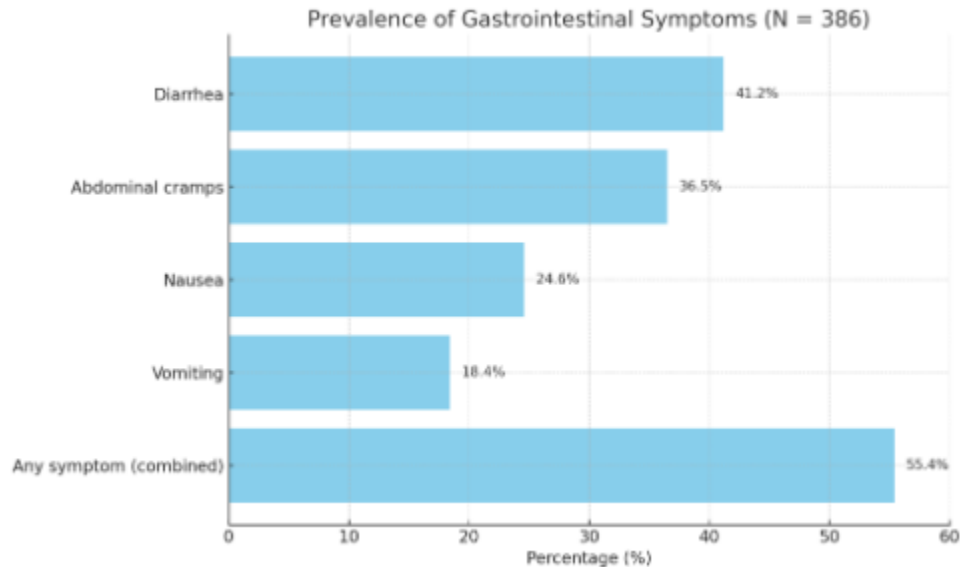
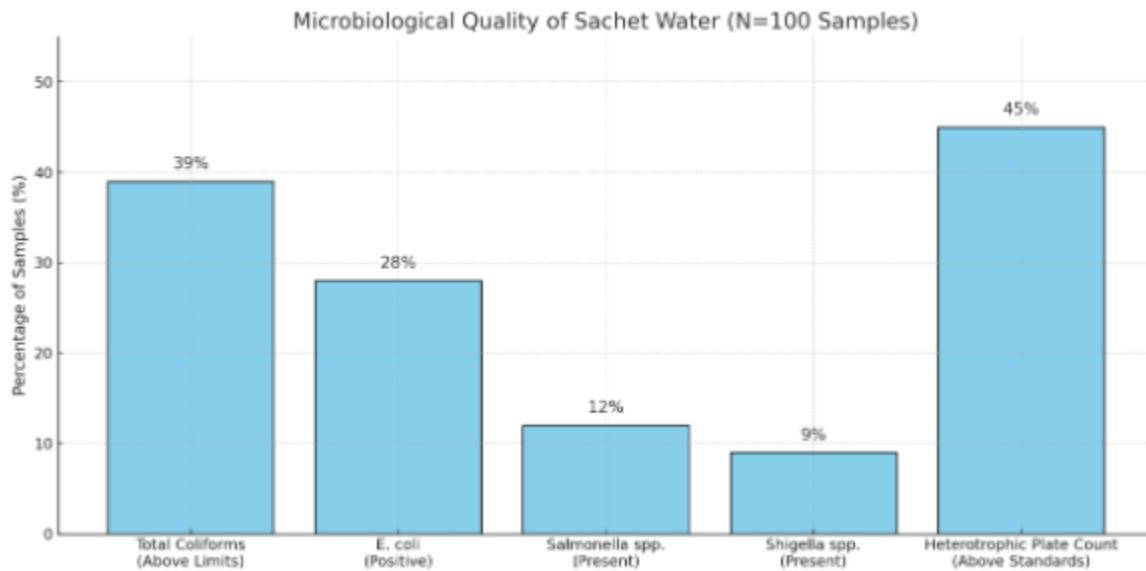*Fieldwork 2025*

4. Microbiological Quality of Sachet Water

Out of 100 sachet water samples analyzed:

- 39% exceeded permissible limits for total coliform counts.
- 28% tested positive for *E. coli*.
- 12% contained *Salmonella* spp.
- 9% contained *Shigella* spp.
- 45% had heterotrophic plate counts above NIS/WHO standards.

Figure 3: **Microbiological Quality of Sachet Water**

Fieldwork 2025

Table 3: Microbiological Quality of Sachet Water Samples (N = 100)

Parameter	No. of Positive Samples	Percentage (%)
Total Coliforms (above limit)	39	39.0
E. coli	28	28.0
Salmonella spp.	12	12.0
Shigella spp.	9	9.0
Heterotrophic Plate Count (high)	45	45.0

Fieldwork 2025

Figure 4: Microbiological Quality of Sachet Water Samples

Microbiological Quality of Sachet Water Samples (N = 100)
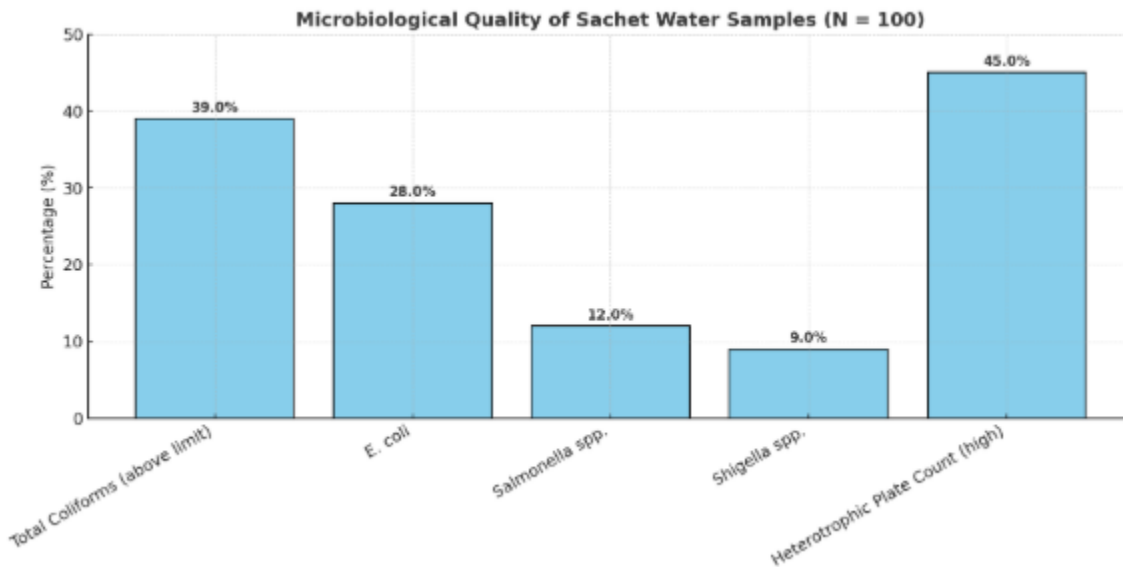
Fieldwork 2025

5. Association Between Sachet Water Consumption and Gastrointestinal Symptoms

Chi-square analysis showed a significant association between high sachet water consumption (>5 sachets/day) and reported gastrointestinal symptoms ($\chi^2 = 10.72$, $p = 0.001$).

6. Predictors of Gastrointestinal Symptoms

Logistic regression identified the following significant predictors of gastrointestinal symptoms:

- High sachet water consumption (OR = 2.43; 95% CI: 1.52–3.89; $p < 0.001$)
- Purchase from street vendors (OR = 1.95; 95% CI: 1.22–3.12; $p = 0.005$)
- Low education level (primary only) (OR = 1.68; 95% CI: 1.03–2.74; $p = 0.037$)

Discussion

This study revealed important insights into the potential gastrointestinal health risks associated with the consumption of sachet water in Enugu metropolis. The findings indicate that sachet water remains a primary source of drinking water for the majority of residents, with nearly 90% of respondents consuming it daily. This underscores the heavy dependence on sachet water in urban Nigerian settings, largely driven by affordability and accessibility, particularly for low- and middle-income populations.

The microbiological analysis highlighted significant safety concerns: 39% of sachet water samples had total coliform levels exceeding permissible limits, and 28% contained *E. coli* — a clear indicator of faecal contamination. The detection of *Salmonella*

and *Shigella* in some samples further indicates lapses in sanitary practices during production and distribution. These results are consistent with earlier reports on the compromised quality of sachet water in various Nigerian cities (Adekunle et al., 2021; Onuoha et al., 2022).

More than half of the respondents reported experiencing gastrointestinal symptoms within the past six months, with diarrhea and abdominal cramps being the most common complaints. The significant association between higher sachet water consumption and the prevalence of gastrointestinal symptoms reinforces the link between poor water quality and public health risks in this population. Notably, the odds of developing gastrointestinal symptoms were significantly higher among those purchasing sachet water from street vendors — likely due to improper storage and prolonged exposure to heat and sunlight, which can exacerbate bacterial growth (Nwachukwu et al., 2020).

The finding that lower educational attainment predicted higher odds of reporting gastrointestinal illness suggests that knowledge and awareness of water hygiene practices may play a protective role. These results call for targeted educational interventions alongside stronger regulatory enforcement.

Overall, the study highlights the urgent need to improve the quality control of sachet water production, enhance monitoring by regulatory bodies such as NAFDAC, and implement public health campaigns to raise consumer awareness on safe water handling and storage practices.

Conclusion

This study has demonstrated that sachet water consumed in Enugu metropolis poses considerable gastrointestinal health risks to the population. A significant proportion of sachet water samples failed to meet microbiological safety standards, and there is a clear link between consumption patterns and the occurrence of gastrointestinal symptoms among consumers.

Given the reliance on sachet water as a primary drinking source, urgent interventions are needed:

- Regulatory bodies must intensify routine inspections of sachet water producers and vendors.
- Producers must adopt stricter hygienic practices during packaging and distribution.
- Public health campaigns should educate consumers on safe handling and storage of sachet water.
- Investment in public potable water infrastructure is needed to reduce dependence on sachet water.

Without such efforts, the gastrointestinal disease burden in Enugu and similar urban centers may continue to rise, undermining public health gains.

Recommendations
Based on the study findings, the following recommendations are made to safeguard public health and improve the safety of drinking water in sachets in Enugu:

1. **Strengthen Regulatory Oversight**
   The National Agency for Food and Drug Administration and Control (NAFDAC), Standards Organisation of Nigeria (SON), and Enugu State Ministry of Health should enhance

routine inspection and enforcement of hygienic standards among sachet water producers and distributors.

2. **Mandatory Certification and Licensing**
Only registered producers who comply with good manufacturing practices and meet Nigerian Industrial Standards (NIS) for packaged water should be allowed to operate. Existing unlicensed producers should be identified and either brought into compliance or shut down.

3. **Periodic Microbiological Testing**
There should be mandatory periodic laboratory testing of sachet water for microbial contaminants. Test results should be publicly displayed or easily accessible to promote transparency.

4. **Training for Producers and Vendors**
Regular training workshops should be organized for sachet water producers,

,

packagers, and street vendors on hygienic handling, safe storage, and transportation practices.

5. **Public Awareness Campaigns**
The Ministry of Health and other stakeholders should implement targeted public education campaigns to raise consumer awareness on:

- The risks of consuming poorly stored sachet water
- Safe handling and storage practices (e.g., avoiding prolonged sun exposure)

6. **Improvement of Public Water Supply**
Government investment in improving public potable water infrastructure is critical to reducing dependence on sachet water, particularly in low-income urban areas.

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