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BACTERIOLOGICAL PROFILES OF FOOD SAMPLES FROM STREET VENDORS ALONG OTOLO DUMP SITE IN NNEWI NORTH

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Abstract: Food safety remains a critical public health challenge globally, particularly in developing regions where street food vending is widespread and often unregulated. This study evaluated the bacteriological quality of street-vended foods near the Otolo dumpsite in Nnewi North Local Government Area, Anambra State, Nigeria, where environmental contamination poses a significant risk to food safety. Adopting a cross-sectional descriptive design, the study collected and analyzed ten food samples, including beans, plantain, yam, akara (fried bean cakes), and okpa (steamed bean pudding), from local vendors. Samples were aseptically packaged, transported to the Microbiology laboratory of Technology Incubation Centre, Onitsha-Okigwe Expressway, Nnewi and subjected to microbiological analysis to identify bacterial isolates and assess contamination levels. The results revealed significant bacterial contamination across all food samples, with the highest total bacterial count recorded in beans. Identified pathogens included *Escherichia coli*, *Salmonella typhi*, *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Enterobacter* spp., and *Bacillus subtilis*. The presence of fecal coliforms further indicated poor hygiene practices among vendors, likely due to the use of contaminated water and unsanitary food handling conditions. Statistical analysis using descriptive methods showed no significant relationship between bacterial isolates and the type of food sample ($p = 0.952$), suggesting that contamination was primarily driven by external factors such as environmental exposure, improper food handling, and proximity to the dumpsite. These findings underscore the severe public health risks associated with consuming street-vended foods in areas with poor sanitation. To address these risks, the study recommends comprehensive hygiene training for vendors, stricter enforcement of food safety regulations, and the relocation of vending sites to cleaner environments with access to potable water and waste disposal facilities. Additionally, regular microbial monitoring of street foods and public awareness campaigns on food safety practices are essential to reduce contamination and prevent foodborne illnesses. This study highlights the urgent need for targeted interventions by policymakers, public health authorities, and community stakeholders to improve food safety standards and protect consumer health in high-risk settings.

Keywords: Bacterial contamination, Environmental, Fecal coliforms, Food safety, Public health.

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Introduction

Street vended food is defined according to Food and Agriculture Organization (FAO) as 'ready to eat foods and beverages prepared and sold by vendors especially in streets and similar public places for immediate consumption without further processing or preparation. Though the street vended food plays an important role both economically and socially in meeting food demands in urban people, microbiologically contaminated street food is considered a global problem, which is liable to be a significant contributor to the transmission of food borne diseases (Amare *et al*., 2019).

Food safety is a major public health concern worldwide, particularly in developing regions where street food vending is common. Street food, defined as ready-to-eat food and beverages prepared and sold by vendors in public places, plays a significant role in meeting the nutritional needs of urban populations (Ma *et al*., 2019). However, food sold on the streets is often prepared under unsanitary conditions and exposed to environmental contaminants, raising concerns about its microbiological quality and the associated health risks (Ma *et al*., 2019). Street food vendors in proximity to waste dump sites are particularly vulnerable to contamination. Dump sites harbor a wide range of microorganisms, including potentially pathogenic bacteria that can be transferred to food through air, water, and direct contact (Baye *et al*., 2024). The presence of bacteria such as *Escherichia coli*, *Salmonella spp*., and *Staphylococcus aureus* in food poses a significant health risk, as these pathogens are known to cause

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foodborne illnesses (Elbehiry *et al*., 2023; Odo *et al*., 2021). Given that many people rely on street food as an affordable and convenient meal option, especially in low-income communities, these risks are heightened.

The bacteriological profile of food refers to the presence, types, and concentrations of bacterial organisms found within a food item. Understanding these profiles is crucial for evaluating food safety, as certain bacteria are known to cause foodborne illnesses that pose significant health risks (Makinde *et al*., 2023). Street-vended foods, particularly in areas near waste disposal sites, are often subject to various forms of contamination, including exposure to airborne bacteria from decomposing waste, direct contact with contaminated surfaces, and inadequate hygiene practices by food handlers. Bacteriological profiling involves isolating and identifying bacteria in food samples to determine their presence and concentration. Common pathogenic bacteria that are frequently identified in street food include *Escherichia coli, Staphylococcus aureus, Salmonella spp.,* and *Shigella spp.* (Elbehiry *et al*., 2023; Odo *et al*., 2021), among others. Each of these pathogens can cause a range of symptoms, from mild gastrointestinal discomfort to severe and life-threatening infections, depending on the individual's health and the bacterial load consumed (Bintsis, 2017).

Research has shown that foodborne diseases are among the leading causes of illness and death in Nigeria and other developing countries, with bacterial infections playing a substantial role (Ifeadike *et al*. 2012). In light of the increasing prevalence of foodborne diseases and the potential for environmental contamination near dump sites, understanding the bacteriological profile of food sold in such areas is crucial. This study seeks to examine the bacterial contaminants present in food samples collected from street vendors near the Otolo dump site. The findings aim to provide insight into the public health risks associated with street-vended foods in this setting and inform policies and interventions that promote food safety among vulnerable populations.

Methodology

Research Design

This study adopts a cross-sectional descriptive design aimed at assessing the bacteriological profiles of food samples collected from street vendors near the Otolo dump site in Nnewi North LGA, Anambra State. A cross-sectional approach is suitable for examining the current state of bacterial contamination in street-vended foods within this specific area, as it allows for the collection of data from multiple samples at a single point in time.

Study Area

The study was conducted in the vicinity of the Otolo dump site, located in Nnewi NorthLocal Government Area (LGA) of Anambra State, Nigeria. The Otolo dump site is a major waste disposal location serving surrounding communities, and its presence poses significant environmental and health challenges due to the accumulation of various types of waste, including domestic, industrial, and organic refuse. The area around the dump site hosts a number of street vendors who sell ready-to-eat food items to local residents and passersby. This location presents a unique context for examining food contamination risks, as vendors operating near waste sites are exposed to airborne particles, pests, and potential microbial contaminants that can transfer to food.

Population of study

The population of this study consists of 10 street food vendors operating near the Otolo dump site in Nnewi North West Local Government Area (LGA) of Anambra State, Nigeria, and the ready-to-eat food items they sell. This population includes vendors who sell various types of food commonly found in street markets, such as snacks, fruits, grilled meat, and other prepared meals. These vendors are typically informal food handlers who may lack access to proper facilities for food storage, hygiene, and sanitation, increasing the risk of contamination. This study will focus on vendors who are consistently stationed within a defined radius of the Otolo dump site, as they are likely to experience higher exposure to environmental contaminants.

Sample Size Determination

The sample size for this study will be determined using Taro Yamane's formula for finite population sampling, which is suitable for a population of known size. The formula is given as:

n = {N}/{1 + N(e)^2}

Where:

n= sample size

N= total population size

e = margin of error (typically 0.05 for 95% confidence level)

Since the exact population of vendors is the study Area is known.

N= 10

n = {N}/{1 + N(e)^2}

n = {10}/{1 + 10(0.05)^2}

= {10}/{1 + 0.025}

= {10}/{1.025}

= 9.7

≈10

Approximately, 10 vendors was used for this study. 1 samples will be taken from each vendor.

A total of 10 samples was used for this study.

Sampling Techniques

The sampling technique used in this study was random sampling to ensure that each street vendor operating near the Otolo dump site has an equal chance of being selected for the study. This method is appropriate for obtaining a representative sample of vendors and the food items they sell, minimizing bias in the selection process. A list of street vendors operating around the Otolo dump site was compiled. This may involve direct observation or consultation with local authorities or community leaders to identify active food vendors in the area. From this list, vendors will be selected using a simple random sampling technique.

Food samples were collected from the selected vendors. The types of food sampled will vary, including snacks, fruits, grilled meats, and ready-to-eat meals, to ensure a comprehensive analysis of bacterial contamination across different food types. A standard procedure for sample collection will be followed to avoid contamination. Each sample will be properly labeled, packed, and transported to the laboratory under hygienic conditions.

Sample Collection and Transportation

The process of sample collection and transportation was carefully designed to maintain the integrity of the food samples and minimize the risk of contamination before laboratory analysis.

Food samples will be collected from the selected street vendors around the Otolo dump site. A variety of food types will be sampled, including snacks, fruits, grilled meat, and ready-to-eat meals, to cover a broad spectrum of street-vended foods. A total of 2 to 3 food samples per vendor was collected to account for variability between food items sold by the same vendor.

Collection Procedure

A sterile, clean container or packaging material (such as plastic bags or containers) were used to collect each food sample. The samples will be taken directly from the food being served to customers to accurately represent the bacteriological quality of the food that is most likely to be consumed. Each sample will be labeled with the vendor's identification number, food type, and the time and date of collection. A detailed log of each sample, including the vendor's name and the type of food collected, was maintained. To prevent cross-contamination, collection tools (e.g., gloves, forceps, and containers) will be sterilized before use, and new gloves will be worn for each sample collection. Samples will be handled as minimally as possible to avoid external contamination, and all collection were conducted in hygienic conditions.

Transportation

After collection, food samples was transported to the laboratory as soon as possible, ideally within 2-3 hours, to ensure that bacterial contamination levels are accurately reflected. Samples will be placed in coolers with ice packs to maintain a temperature that slows down bacterial growth during transportation. Each cooler was labeled with the sample collection details to ensure proper tracking. Samples will be transported under chain-of-custody conditions to ensure that they are not tampered with and that all information is accurately recorded. The laboratory will be notified ahead of time regarding the arrival of the samples to ensure immediate analysis.

Sample Storage upon Arrival

Upon arrival at the Technology Incubation Centre, Okigwe-Nnewi Road laboratory, samples were stored in a refrigerator if there is any delay in processing, samples will be stored at appropriate temperatures to prevent bacterial growth or degradation until analysis can begin.

Laboratory Analysis

The laboratory analysis focused on isolating, identifying, and quantifying bacterial contaminants in the food samples collected from street vendors near the Otolo dump site. The procedures included microbiological culture, biochemical tests, and quantitative analysis to determine bacterial load.

Microbiological Culture and Isolation

Sample Preparation:

Each food sample was homogenized in sterile saline or buffered peptone water to create a uniform solution for testing. A series of dilutions will be prepared to enable accurate bacterial counting.

Plating and Incubation:

Aliquots from each dilution was plated on selective and differential media, such as MacConkey agar, nutrient agar, and mannitol salt agar, to allow for the growth of different bacterial types. Plates will be incubated at 37°C for 24-48 hours, depending on the type of bacteria being cultured.

Colony Counting

After incubation, colonies on the plates were counted to determine the bacterial load in terms of colony-forming units (CFU) per gram of food. Counts from various dilutions will be averaged to get an accurate measure of contamination levels.

Biochemical Identification of Bacteria

Gram Staining:

A gram stain was performed on colonies to classify bacteria as gram-positive or gram-negative, which helps narrow down potential bacterial species.

Biochemical Tests:

Catalase Test: This test will determine if bacteria produce catalase, differentiating Staphylococcus species (positive) from Streptococcus (negative).

Oxidase Test: This test helps to identify Pseudomonas species and differentiate them from Enterobacteriaceae.

Indole, Methyl Red, Voges-Proskauer, and Citrate (IMViC) Tests: These tests help to identify members of the Enterobacteriaceae family, such as *E. coli* and Klebsiella species.

Coagulase Test: This test was used to identify *Staphylococcus aureus*, a common contaminant in street food.

Quantitative Analysis of Bacterial Load

Determination of Bacterial Load:

Bacterial counts from colony-forming units (CFUs) will be calculated to estimate the concentration of bacteria in each food sample. CFU counts will be expressed in CFU/g to quantify contamination levels and assess if they exceed acceptable food safety limits. Bacterial counts will be compared across different types of food (e.g., fruits, snacks, and cooked foods) to identify if certain food types are more prone to contamination.

Quality Control

Positive and Negative Controls

Positive control samples with known bacterial strains and negative controls (sterile media) were included in each test run to ensure reliability and accuracy.

Sterility Checks

All media and equipment were checked for sterility to prevent cross-contamination and false results.

Method of Data Analysis

The data collected in this study were analyzed using both descriptive and inferential statistical methods, Data will be organized according to the objectives of the study. Data generated from the study was reviewed, tallied and presented in tables with frequencies and percentages.. All statistical analyses will be performed using SPSS and results will be considered significant at

a p-value of <0.05. The results will guide conclusions and recommendations on food safety and public health interventions.

Ethical Considerations

Ethical principles were strictly adhered to throughout this study to ensure that the research is conducted responsibly and respectfully.

Informed Consent: All participating street vendors were fully informed about the study's objectives, procedures, potential risks, and benefits.

Confidentiality: Personal information about the vendors and the location of their stalls were kept confidential. Data will be anonymized, and results will be reported in aggregate form to prevent identifying individual vendors or their businesses.

Results

Table 4.1: Isolation and Biochemical Identification of Bacterial Species Present in Food Samples from Street Vendors Near the Otolo Dump Site in Nnewi, North LGA Anambra State.

ISOLATE	Morphology	Gram stain	Urease	Methyl Red	Indole	VP	Citrate	Catalase	Oxidase	Coagulase	Glucose	Mannitol	Maltose	Identification
1	Cocci	+	-	+	-	-	-	-	+	-	+	-	+	*Streptococcus pyogenes*
2	Cocci	+	-	+	-	-	-	+	-	+	+	+	+	*Staphylococcus aureus*
3	Rods	-	-	+	+	-	-	+	-	-	+	-	-	*Escherichia coli*
4	Rods	-	-	+	-	-	-	+	-	-	+	-	+	*Salmonella typhi*
5	Rods	-	-	-	-	+	+	+	-	-	+	-	+	*Enterobacter*
6	Rods	+	-	-	-	+	-	+	+	-	+	-	+	*Bacillus subtilis*
7	Cocci	+	+	-	-	+	-	+	-	-	+	-	+	*Staphylococcus epidermidis*

The table above shows the bacteria identified from the food samples from street vendors near the Otolo dump site in Nnewi, North LGA Anambra State.

Table 4.2: The Bacterial Load, Types and Contamination Levels in Food Samples from Street Vendors Near the Otolo Dump Site in Nnewi, North LGA Anambra State.

PARAMETER TESTED/100g	TBC (cfu/g)	Total Coliform (cfu/g)	Feacal coliform (MPN/g)
A	1.8×10^7	2×10^5	0
B	1×10^4	0	0
C	5.0×10^8	6.2×10^6	0
D	1.04×10^7	0	0
E	6.0×10^5	0	0
F	1.2×10^6	2×10^5	0
G	6.0×10^5	0	0
H	4×10^5	0	0
I	8.4×10^6	3×10^6	2.4×10^6
J	4.0×10^7	1.6×10^6	0

A: First beans vendor, B: Beans and rice from first vendor, C: Second beans vendor, D: Rice/stew, E: First akara vendor, F: Secon akara vendor, G: Uncut Okpa, H: Cut Okpa, I: Beans and plantain first vendor, J: Beans and yam from second vendor.

The table above shows the bacterial load, the type of bacteria and the contamination levels in the food samples sold by street vendors near the Otolo dump site in Nnewi North LGA Anambra state.

Table 4.3: The Bacterial Species Isolated from Various Food Samples from Street Vendors Near the Otolo Dump Site in Nnewi, North LGA Anambra State.

PARAMETER TESTED/100g	ISOLATE
A	*Staphylococcus epidermidis*
	Staphylococcus epidermidis
	Streptococcus pyogenes
	Enterobacter
B	*Staphylococcus epidermidis*
C	*Staphylococcus epidermidis*
	Enterobacter
D	*Staphylococcus epidermidis*
E	*Staphylococcus aureus*
	Streptococcus pyogenes
F	*Staphylococcus epidermidis*
	Enterobacter spp
G	*Staphylococcus epidermidis*
H	*Staphylococcus aureus*
	Streptococcus pyogenes
I	*Staphylococcus epidermidis*
	E. coli
	Salmonella typi
	Enterobacter
J	*Staphylococcus epidermidis*
	Bacillus subtilis
	Enterobacter

A: First beans vendor, B: Beans and rice from first vendor, C: Second beans vendor, D: Rice/stew, E: First akara vendor, F: Secon akara vendor, G: Uncut Okpa, H: Cut Okpa, I: Beans and plantain first vendor, J: Beans and yam from second vendor.

The table above shows the different bacterial species that was isolated from the various food samples gotten from street vendors near the Otolo dump site in Nnewi North LGA Anambra state.

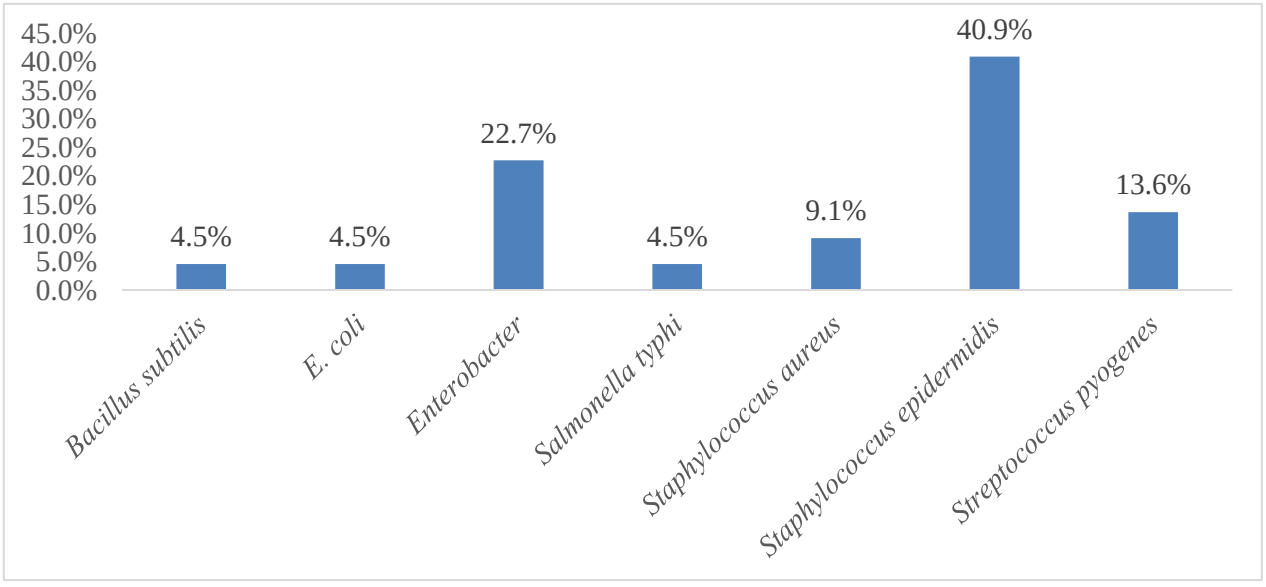

Figure 4.1: A Bar Chart Showing the Prevalence of Bacterial Species Isolated from Various Food Samples from Street Vendors Near the Otolo Dump Site in Nnewi, North LGA Anambra State.

HYPOTHESIS TESTING

Hypothesis 1

Ho There is no significant relationship between the bacteria isolated and the food samples sold by street vendors near the Otolo dump site**.**

H_1 There is a significant relationship between the bacteria isolated and the food samples sold by street vendors near the Otolo dump site**.**

Table 4.4: Crosstabulation between the bacteria isolated and the food samples sold by street vendors near the Otolo dump site.

Isolates	A	B	C	D	E	F	G	H	I	J	Total
Bacillus subtilis	0	0	0	0	0	0	0	0	0	1	**1**
E. coli	0	0	0	0	0	0	0	0	1	0	**1**
Enterobacter	1	0	1	0	0	1	0	0	1	1	**5**
Salmonella typhi	0	0	0	0	0	0	0	0	1	0	**1**
Staphylococcus aureus	0	0	0	0	1	0	0	1	0	0	**2**
Staphylococcus epidermidis	2	1	1	1	0	1	1	0	1	1	**9**
Streptococcus pyogenes	1	0	0	0	1	0	0	1	0	0	**3**
Total	**4**	**1**	**2**	**1**	**2**	**2**	**1**	**2**	**4**	**3**	**22**

Test: Chi Square test

Alpha level: 0.05

$X^2 = 38.215$

P-value = 0.949

Decision: Since the p value was greater than the 0.05, the null hypothesis was **accepted** and the alternate hypothesis was **rejected**. Therefore, there is no significant relationship between the bacteria isolated and the food samples sold by street vendors near the Otolo dump site**.**

Discussion

The study identified several bacterial species from food samples collected near the Otolo dumpsite in Nnewi North LGA, including *Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Salmonella typhi, Streptococcus pyogenes Enterobacter sp.*, and *Bacillus subtilis*. The high prevalence of *Staphylococcus epidermidis* (41%) aligns with previous studies that reported this bacterium as a common contaminant in food due to poor handling practices (Afolabi et al., 2020). *Staphylococcus aureus* (9%) was also isolated, known for producing heat-stable toxins that cause foodborne illnesses, particularly when vendors fail to maintain adequate hygiene standards (Oluwafemi & Simisaye, 2020). The presence of *E. coli* and *Salmonella typhi* is particularly concerning, as these are indicators of fecal contamination and poor sanitation. Similar findings were reported by Chukwuocha et al. (2021), where E. coli was prevalent in food samples collected near waste sites in southeastern Nigeria, indicating the use of contaminated water during food preparation.

The bacterial loads observed in the food samples ranged significantly, with the highest total bacterial count (TBC) of 5.0 x 10^8 CFU/g in beans from the second vendor. This value exceeds the acceptable microbial load for ready-to-eat foods as stipulated by food safety guidelines (WHO, 2020). Foods like akara and okpa exhibited relatively lower bacterial loads, suggesting that frying may reduce microbial contamination, a finding supported by Nyachuba et al. (2019). However, these foods still harbored Staphylococcus spp., highlighting the risk of post-cooking contamination due to inadequate handling or exposure to unhygienic environments.

Notably, fecal coliforms were detected in beans and plantain from the first vendor 2.4 x 10^6 MPN/g, indicating significant contamination likely caused by the use of untreated water or poor personal hygiene practices among vendors. Tessema et al. (2019) found similar trends in Ethiopian street foods, where fecal contamination was linked to the use of water sourced near waste sites.

The chi-square analysis revealed no significant relationship between the bacteria isolated and the type of food samples ($p = 0.952$). This finding suggests that bacterial contamination in street-vended foods near the Otolo dumpsite is not necessarily food-specific but rather influenced by external factors, such as environmental exposure and vendor practices. Similar conclusions were drawn by Quartey et al. (2019), who emphasized that the environment plays a more significant role than the food type in bacterial contamination.

The findings of this study highlight the significant public health risks associated with consuming food prepared and sold near dumpsites. Pathogenic bacteria such as Salmonella typhi and E. coli can cause severe gastrointestinal illnesses, particularly in vulnerable populations such as children and the elderly. Furthermore, the isolation of multidrug-resistant bacteria such as *Enterobacter sp*. and *Staphylococcus aureus* raises concerns about antimicrobial resistance, which complicates the treatment of foodborne infections (Osei-Tutu et al., 2020). The high microbial loads observed, particularly in beans and yam, tells the need for stringent food safety measures. Contamination from the Otolo dumpsite is likely exacerbated by the improper disposal of organic and medical waste, as previously reported by Iwegbue et al. (2020). Chukwuocha et al. (2021) reported similar bacterial species, including *Staphylococcus epidermidis* and *E. coli*, in street foods near dumpsites in southeastern Nigeria. Mosha et al. (2021) documented the presence of Salmonella spp. and Bacillus subtilis in food samples collected near open waste dumps in Tanzania, emphasizing the role of environmental exposure in food contamination.

However, this study uniquely identified variations in bacterial loads among different food types, highlighting the need for tailored interventions for high-risk foods such as beans and plantain sold along streets especially dumpsites.

Conclusion

This study revealed significant bacteriological contamination in street-vended foods sold near the Otolo dumpsite in Nnewi North LGA, Anambra State. The bacterial species isolated, including *Escherichia coli, Salmonella typhi, Staphylococcus aureus, and Enterobacter sp*., highlight the risks associated with poor hygiene practices, environmental exposure, and the use of contaminated water during food preparation. The high microbial loads observed in food samples such as beans and plantain exceed acceptable safety standards, emphasizing the need for urgent interventions to protect public health. The lack of a significant association between bacterial isolates and specific food types underscores the broader influence of external factors, particularly environmental contamination from the dumpsite. These findings align with previous studies that identified dumpsites as major contributors to foodborne illnesses due to bacterial contamination.

To mitigate these risks, it is essential to prioritize vendor education on food safety practices, implement stricter regulations on street food vending near waste sites, and provide access to clean water and sanitation facilities. Regular monitoring of microbial contamination and public awareness campaigns can further promote safer food consumption. Addressing these issues requires a collaborative effort between vendors, regulatory bodies, and public health authorities to ensure that street-vended foods remain a safe and sustainable source of nutrition for the population.

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