Food Safety Knowledge, Hygienic Practices, Environmental Conditions, and Microbial Contamination Among Food Vendors in Abuja, Nigeria: A Cross-Sectional Mixed-Methods Study

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ABSTRACT

Background: Food safety is a global health challenge, especially in low-and middle-income countries where informal food vending predominates.

Objectives: The study assessed food safety knowledge, hygienic practices, and their correlates, including socio-demographic, environmental, and microbiological factors, among food vendors in four major urban markets in Abuja, Nigeria.

Methods: A cross-sectional, mixed-methods study of 320 food vendors was conducted across four Abuja markets. The research tools used were questionnaires, observation checklists, and microbial tests on food, water, and surfaces, conducted using ISO-accredited methodological protocols. data using descriptive statistics, chi-square tests, Pearson correlations, and ANOVA at $p < 0.05$.

Results: Around 64% of sampled food vendors had food safety knowledge, but only 48% observed good hygiene practices, 43% had reliable potable water, and 34% wore protective gear. Food samples exceeded aerobic plate count limits in 38%, with Escherichia coli in 29% and Staphylococcus aureus in 33%. Knowledge was positively correlated with hygienic practices ($r = 0.68$, $p < .01$), whereas hygiene was negatively correlated with microbial loads ($r = -0.56$, $p < .01$). Contamination varied significantly across markets ($F = 4.21$, $p = .008$).

Conclusion: Vendor knowledge, hygienic practices, and environmental health interact to shape food safety in Abuja markets. Awareness alone falls short without facilities and enforcement. Therefore, vendor training, regular inspections, adequate water supplies, and waste-disposal facilities are needed to improve food safety in Abuja markets.

Keywords: Food safety, vendors, knowledge, practice, microbiological analysis, environmental hygiene, Abuja markets, cross-sectional study

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INTRODUCTION

Food safety is an important global public health issue that affects human health and economic development. The World Health Organization (WHO) estimates that over 600 million people fall ill, and 420,000 die each year as a result of eating contaminated food.[1] The dimension of the problem deepens in low-and middle-income countries (LMICs), where the safety of food in informal markets is undermined by weak regulatory systems, poor infrastructure, and unhygienic practices.[2-5]

In Nigeria, this threat is intensified by rapid urban growth, rural-urban migration, poor hygiene standards, and poor marketplace infrastructure.[6,7] Informal food vendors and open market vendors are instrumental in meeting the nutritional needs of urban populations. However, unhygienic conditions, poor waste management, and erratic food safety regulation and enforcement are associated factors for foodborne diseases.[8,9]

Food safety practices involve several activities and behaviours aimed at preventing food contamination, from production to consumption. These activities include hygiene, food handling and preparation, waste disposal, pest control, and compliance with regulatory measures.[10-12] Previous studies have reported low adherence to food safety practices among open-market vendors in Nigeria.[13-15]

Despite existing regulations and awareness campaigns, foodborne diseases continue to be common in Abuja and other Nigerian cities. Outbreaks of typhoid fever, cholera, and diarrhoeal diseases have often been associated with improper handling of street food.[4,16] The situation is worsened by inadequate food vendor training, limited inspections by environmental health officers, and inadequate waste management infrastructure. Research in similar urban environments shows that even when vendors have theoretical knowledge of hygiene, this does not necessarily translate into safe practice due to economic constraints, behavioural factors, and a lack of enabling infrastructure.[8] Consequently, microbial contamination of food, water, and utensils remains widespread, putting consumers at risk of illness from contamination with a range of pathogens, including E. coli, Staphylococcus aureus, Salmonella spp., and total coliforms.[13]

The most frequented markets in Nigeria's Federal Capital Territory (FCT), Abuja, are Wuse, Garki, Karu, and Dutse markets. Thousands of vendors prepare and sell food to hundreds of thousands of consumers each day. The combination of high ambient temperatures, poor sanitation infrastructure, and inconsistent regulatory oversight creates an ideal environment for food contamination. A systematic assessment of food-safety knowledge, practices, and microbial loads in these markets is necessary to develop evidence-based interventions that protect consumers and strengthen public health surveillance.

Therefore, this study aimed to assess food safety knowledge and practices and to identify predictors, including socio-demographic and environmental factors, as well as microbiological contamination, among food vendors in four major markets in Abuja, Nigeria.

Methods

Study Area: The study was conducted in the four central markets located in the FCT, Abuja (Wuse, Garki, Karu, and Dutse markets). Abuja, situated in the north-central region of Nigeria, is the capital city and a growing commercial hub, with a population of over 4 million.[17] These markets attract a diverse range of food vendors and large consumer populations each day, with a volume of ready-to-eat (RTE) foods. These four markets had varying levels of infrastructural development, food vendor densities, and regulatory surveillance within the FCT, enabling the researchers to create a map of food safety hazards across different urban market environments.

Research Design: A cross-sectional mixed approach was used. Questionnaires and observational checklists provided data from food vendors. Laboratory microbiological analyses were also performed on samples from vendors' food, water, and surfaces. The use of these different approaches ensured a holistic assessment of behavioural, environmental, and microbial data for food safety evaluation.

Study Population: The study population comprised all registered and unregistered food vendors across the four selected markets in Abuja. Vendors included food vendors who prepared and sold cooked food, pastries, grilled meat, soups, rice-based dishes, and beverages.

Sample Size Determination: The sample size was calculated through the Cochran formula for cross-sectional studies (Ahmed, 2024)[18]:

$n = \mathbf{Z}^2 p(1-p) / d^2$

Where:

Z = 1.96 (95 % confidence level),

p = 0.5 (assumed proportion of vendors practicing safe food handling),

d = 0.05 (margin of error).

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$n = [Z^2 \times p(1-p)] / d^2 = [1.96^2 \times 0.5(1-0.5)] / 0.05^2 = 384$

Finite population correction applied for N≈1200 vendors → final n=320 (+10% non-response).

The total vendor population across the four markets was estimated at approximately 1,200 by the market authorities, based on earlier vendor surveys in related Nigerian urban contexts that often-included hundreds to over a thousand respondents. This estimate was used for determining the sample size.[12,19] Adding 10% for non-response and incomplete questionnaires produced a final sample size of 320 food vendors.

Sampling Technique: Markets were first stratified by location. Within each stratum, systematic random sampling was used, selecting every fourth stall until the quota was met (Table 1).

Table 1: Sample Size Distribution

Market	Estimated Vendors	Sample Size
Wuse	300	80
Garki	350	90
Karu	250	70
Dutse	300	80
Total	1200	320

Inclusion and Exclusion Criteria

- Inclusion criteria: Vendors selling prepared food and willing to participate.
- Exclusion criteria: Raw produce vendors, pre-packaged food vendors, and those not present on the data collection day.

Data Collection Instruments: Three instruments were used in the study:

1. Structured questionnaire to collect data on demographics, knowledge, attitudes, and food-safety practices.
2. Observation checklist to observe environmental conditions, sanitation, and hygiene behavior.
3. Laboratory analysis template to observe and document microbiological results for food, water, and surface samples.

All tools were adapted from validated WHO and FAO food safety assessment frameworks and modified for the local context.

The attitude component of the questionnaire consisted of 8 Likert-scale items assessing vendors' perceptions of foodborne disease severity and susceptibility, the benefits of hygienic practices, and perceived barriers to compliance. Responses ranged from 1 (strongly disagree) to 5 (strongly agree). Higher scores indicated more positive attitudes toward food safety.

Validity and Reliability: The instruments were reviewed by experts in environmental health and food microbiology to ensure content validity. A pilot study was conducted with 20 vendors at Nyanya Market (outside the study sites). Cronbach's alphas for the questionnaire sections on knowledge and practices were 0.83 and 0.79, respectively, indicating high internal consistency.

Data Collection Procedures: The data were collected over a period of 3 weeks in December 2025. Trained research assistants administered questionnaires (interviewer-administered) in English, Hausa, and Pidgin. Observations were conducted during peak trading times (8 a.m.–2 p.m.). Food, water, and surface samples were collected aseptically using sterile containers, labelled, packed in ice boxes, and transported within 2 hours to a certified private microbiology laboratory in Abuja for analysis.

Microbiological Analysis: Sample Types and Quantity; In total, there were 960 samples: 320 food, 320 water, and 320 surface samples (hands, utensils, and tables). Each vendor provided one food sample, one water sample, and one surface sample.

Laboratory Methods

All analyses were conducted at an established ISO 9001-certified private laboratory in accordance with international standards (Table 2).

Microbial Parameter	Cultured Medium	ISO Reference	Incubation	Acceptable Limit
Aerobic Plate Count (APC)	Nutrient Agar	ISO 4833-1:2013	37 °C for 48 h	$\leq 1 \times 10^5$ CFU/g
Total Coliforms	MacConkey Agar	ISO 4832:2006	37 °C for 24 h	$\leq 10^2$ CFU/g
Escherichia coli	Eosin Methylene Blue Agar	ISO 16649-2:2001	37 °C for 24 h	Absent
Staphylococcus aureus	Mannitol Salt Agar	ISO 6888-1:2021	37 °C for 24 h	$\leq 10^2$ CFU/g
Salmonella spp.	Xylose Lysine Deoxycholate (XLD) Agar	Pre-enrichment and selective enrichment in compliance with ISO 6579-1:2017	37 °C for 24 h	Absent

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Colony-forming units (CFU) were counted using a digital colony counter. Values were expressed as CFU/g or CFU/ml and compared to values accepted by WHO and the National Agency for Food and Drug Administration and Control (NAFDAC) 2025.[20] Though ISO standards specify selective media for enumeration, equivalent culture media commonly used in accredited laboratories were employed in accordance with the testing laboratory's standard operating procedures.[21] Acceptable microbiological limits were interpreted in accordance with WHO guidelines for ready-to-eat foods and NAFDAC food safety regulations.

Quality Control

Each batch of cultures included positive and negative controls. All media was sterilized at 121 °C for 15 minutes. Samples for duplicate plating were randomly selected. Standard operating procedures were followed for calibration and waste disposal.[21]

Data Management and Analysis

Quantitative data were recorded and cleaned in Microsoft Excel, then imported into SPSS version 25. Descriptive statistics (frequencies, percentages, means, and standard deviations) were computed to summarise the variables.[22] Inferential analyses included:

- Chi-squared test for associations between categorical variables;
- ANOVA for comparing mean microbial counts across markets;
- Pearson correlation to test relationships between hygiene scores and microbial loads.

All tests were performed at the 95% confidence level, with significance set at $p < 0.05$.

Ethical Considerations

Ethical approval was granted by the FCT Health Research Ethics Committee (FHREC/2025/01/506/22-12-25). Market management authorities provided permission. Informed consent was obtained from all participants, with an explanation of the study purpose and confidentiality. Personal identifiers were removed from the data sets.

Study Limitations

Laboratory analyses were limited to selected microbial indicators; viral or chemical contaminants were not investigated. Self-reported practices may be subject to social desirability bias. The cross-sectional design limits causal inference. Additionally, the absence of a longitudinal component to evaluate changes in practice over time has limited the study's strength. Finally, the lack of multivariate analysis (e.g., logistic regression) limits the study's ability to identify independent predictors of poor practices and microbial contamination.

RESULTS

Socio-Demographic Characteristics

Table 3: Socio-Demographic Characteristics and Food Safety Knowledge and Practices of Food Vendors (n = 320)

Variable	Category	Frequency (%)
Gender		
	Female	246 (76.9)
	Male	74 (23.1)
Age (years)		
	<25	38 (11.9)
	25–34	118 (36.9)
	35–44	104 (32.5)
	≥45	60 (18.7)
Education		
	No formal	32 (10.0)
	Primary	68 (21.3)
	Secondary	150 (46.9)
	Tertiary	70 (21.8)
Years of Experience		
	<2	38 (11.9)
	2–5	126 (39.4)
	6–10	94 (29.4)
	>10	62 (19.3)
Food Safety Knowledge		
	Adequate	205 (64.1)
	Inadequate	115 (35.9)
Food Safety Practice		
	Good	153 (47.8)
	Poor	167 (52.2)

Note. Market subgroups showed no significant differences, $\chi^2(3) = 4.2–7.8, p > .10$

All of the 320 targeted vendors were enrolled, yielding a 100% response rate (Table 3). Females dominated at 76.9%, reflecting gendered patterns in Nigerian informal food vendors. Age distribution tilted toward the economically active (working) age group: 36.9% aged 25-34 years, 32.5% aged 35-44 years, 11.9% under 25 years, and 18.7% aged ≥45 years. Most of the vendors had secondary school education (46.9%), followed by primary (21.3%), tertiary (21.8%), and no formal education (10%). Most respondents had several years of

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experience in food vending: 39.4% with 2–5 years, 29.4% with 6–10 years, 19.3% with over 10 years, and 11.9% with under 2 years.

Food-Safety Knowledge and Practices

Food safety knowledge among vendors was 64.1% (Table 3). However, good hygienic practices lagged behind at 47.8%. Pearson correlation revealed a robust positive association ($r = 0.68$, 95% CI [0.61–0.74], $p < .001$); normality test (Shapiro-Wilk $p = 0.12$).

The cut-off scores were based on Bloom's taxonomy and adapted from similar Knowledge, Attitude, and Practice (KAP) studies among food vendors. Scores ≥60% were categorized as adequate or good, while scores <60% were classified as inadequate or poor.[13,18] Knowledge scores ranged from 0–20 (mean = 13.4 ± 3.2), with vendors scoring ≥12 being considered to have adequate knowledge. Hygienic practice scores ranged from 0 to 25 (mean = 12.1 ± 4.5). Vendors with scores ≥ 13 were considered to exhibit good practices.

Environmental Hygiene Indicators of the Vending Areas

Table 4: Environmental Hygiene Indicators Observed in the Selected Markets (n = 320)

Variable	Observed "Yes" n (%)
Access to potable water	138 (43.1)
Covered waste bin present	170 (53.1)
Evidence of rodent activity	126 (39.4)
Market drainage functional	162 (50.6)
Vendor wearing protective clothing	108 (33.8)
Separate storage for raw and cooked food	124 (38.8)

Spearman's rank correlation, a nonparametric measure, was used for skewed data in this table.

Table 4 summarises the key environmental-sanitation indicators from the observation checklist. The checklist revealed inconsistent sanitation indicators: potable water at 43.1%, covered bins at 53.1%, functional drains at 50.6%, raw/cooked separation at 38.8%, protective gear at 33.8%, and pests at 39.4%. Hygiene scores were inversely correlated with total microbes (Spearman's rank correlation, $\varrho = -0.52$, $p = .032$). Inter-rater $\varkappa = 0.85$ confirmed observation fidelity.

Microbiological Quality of Samples

Table 5: Microbiological Quality of Food Samples

Microbial Indicator	Positive Samples (%)	Mean ± SD (CFU/g or ml)	WHO/NAFDAC Limit
Aerobic Plate Count (APC)	38 %	$2.8 \times 10^5 \pm 0.9 \times 10^5$	$\leq 1 \times 10^5$
Total Coliforms	41 %	$3.1 \times 10^3 \pm 0.7 \times 10^3$	$\leq 10^2$
Escherichia coli	29 %	$1.6 \times 10^3 \pm 0.5 \times 10^3$	Absent
Staphylococcus aureus	33 %	$2.2 \times 10^3 \pm 0.6 \times 10^3$	$\leq 10^2$
Salmonella spp.	17 %	Detected	Absent

Note. Analyses per ISO 4833-1:2013. Practice scores inversely correlated with total microbial load, Pearson $r = -0.56$, 95% CI [−0.64, −0.47], $p < .001$. Duplicate plating CV < 15%.

Food assays revealed figures exceeding acceptable limits (Table 5): 38% of samples had high APC levels, 41% had coliforms, 29% had E. coli, 33% had S. aureus, and 17% had Salmonella. Practices inversely predicted loads (Pearson $r = -0.56$, 95% CI [−0.64 to −0.47], $p < .001$; moderate-to-large effect), and Levene's test confirmed equal variances.

Market-Wise Comparison of Microbial Counts

Table 6: Market-Wise Comparison of Aerobic Plate Counts

Market	Mean APC (CFU/g)	% Above Limit
Wuse	2.5×10^5	34 %
Garki	3.1×10^5	44 %
Karu	2.9×10^5	41 %
Dutse	2.4×10^5	33 %

Note. One-way ANOVA: $F(3, 316) = 4.21$, $p = .008$, $\eta^2 = 0.038$. Tukey HSD: Garki was significantly higher than Dutse ($p = .012$).

APC varied significantly, with the Garki market highest (44%) and the Dutse market lowest (33%), while the Wuse and Karu markets were between -34% and 41%, respectively (Table 6). One-way ANOVA detected differences ($F(3, 316) = 4.21$, $p=.008$, $\eta^2=0.038$; small-moderate), with Tukey HSD pinpointing Garki > Dutse ($p=.012$).

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DISCUSSION

In this study, food vendors demonstrated good knowledge of food safety (over 64%), yet implementation (observed at 48%) remains a challenge, as reported by Fasinu et al. (2026) in some markets in Ikeja, Lagos, Nigeria.[23] This disconnect was also found in another study at Garki market in Abuja in 2017, where a lack of implementation of safety practices was associated with food poisoning.[23] Therefore, vendor awareness alone may not guarantee compliance, tracing the need for stringent regulatory support.[2,12,15,20,25] The similarity in the extent of overlap between the studies further supports the suggestion that infrastructural challenges pose an entrenched obstacle to food-safety compliance despite vendors' growing knowledge.

The finding of 40- 50% of vending sites lacking reliable potable water supply, covered waste-disposal facilities, and functioning drainage systems shows unacceptable infrastructure deficiencies, a common phenomenon across LMICs, which is associated with food contamination and subsequent foodborne diseases.[3] Microbiological testing in the study provided the objective evidence of the severity of some of these infrastructural issues.

A significant number of samples from ready-to-eat food products exceeded APC limits, and pathogenic organisms, including E. coli, S. aureus, and Salmonella spp., were recovered from their surfaces (38% high APC levels, 41% coliforms, 29% E. coli, 33% S. aureus, and 17% Salmonella). E. coli presence indicates faecal contamination, reflecting inadequate handler hygiene.[5,11,14,16,25] Similar contamination patterns have been documented in Nigerian urban markets.[23,26]

In this study, the Garki market showed significantly higher contamination than other sites ($p = 0.008$). This finding may be explained by very high population density, overcrowding, heavy foot traffic, inadequate sanitation facilities, and poor infrastructure at Garki market. These factors are associated with microbial accumulation and transmission.[25] The large volume of daily interactions between traders, customers, and goods increases the frequency of contact with potentially contaminated surfaces, thereby facilitating the persistence and spread of microorganisms. Similar observations have been reported in studies conducted in densely populated public markets where inadequate environmental sanitation and poor waste management practices were associated with increased microbial contamination of frequently touched surfaces.[23,26]

From the perspective of the Health Belief Model (HBM), the observed contamination levels may reflect gaps in health-related perceptions and preventive behaviours among market users.[27] Traders and visitors may have low perceived susceptibility to acquiring infections from contaminated environmental surfaces and may underestimate the potential severity of such infections. Limited access to handwashing facilities, inadequate water supply, time constraints, and the costs of maintaining hygienic practices may reduce adherence to recommended infection prevention measures. Increasing awareness of contamination risks and strengthening environmental sanitation measures may improve perceived benefits of preventive behaviours and promote healthier practices among market users.

Correlation analyses revealed that knowledge positively predicted hygiene practices ($r = 0.68$; $p < 0.01$) and that hygiene practices inversely correlated with microbial contamination ($r = -0.56$; $p < 0.01$). These relationships confirm that knowledge supports behavioural change and that improved practices reduce the risk of contamination, even in environments with infrastructure limitations.[27]

Overall, the results of this study support the combined application of the KAP and Health Belief Model frameworks.[27] The models alone may not fully address the complexities of food-safety practices, as environmental factors are not specifically accounted for in either model. However, the models' integrated application provides a comprehensive analysis of the vendors' food-safety practices: food-safety knowledge and attitudes influence their behaviour, but environmental constraints and their enforcement ultimately govern the effectiveness of these behaviours in preventing food contamination.[28]

The consistency between this study's findings and those reported in other urban market settings in Nigeria enhances the external validity of the results.[28,29] Thus, it is likely that the food-safety problems documented in the selected markets in Abuja are not isolated cases but instead indicative of systemic problems in informal food-vending markets.

Implications for Practice, Policy, and Future Research

The findings of this study indicate that improving food safety in Abuja markets requires more than increasing vendor knowledge. Although knowledge levels were generally adequate, important gaps in hygienic practices and environmental sanitation remained. This suggests

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that training alone may be insufficient. Therefore, local health authorities, the Abuja Environmental Protection Board, and NAFDAC should institutionalize periodic food-hygiene training, certification, and regulatory monitoring.

Poor access to potable water, waste-disposal facilities, drainage systems, and covered storage containers highlights the need for infrastructural improvements. Government and market authorities should invest in basic sanitation facilities to support safe food-handling practices and reduce contamination risks.

The findings also support stronger food-safety surveillance. Routine inspections should include assessment of hygienic practices and periodic microbiological testing of ready-to-eat foods. A risk-based and phased implementation approach may improve efficiency and sustainability in resource-constrained settings.

Public awareness campaigns should promote consumer understanding of food hygiene and encourage patronage of compliant vendors. This may improve accountability and reinforce safe practices among food handlers.

Future studies should investigate other food contaminants, including chemical and viral hazards. Longitudinal and intervention studies are also needed to evaluate the effectiveness of training, infrastructure improvements, and regulatory measures in strengthening food-safety systems.

Limitations of the Study

The major limitations of this study need to be considered when interpreting the findings. First, the cross-sectional design precludes establishing causal relationships among the variables examined. Second, the microbiological analysis was limited to selected bacterial indicators and did not include assessment of viral or chemical contaminants, which may also contribute to foodborne disease burden. Third, the use of self-reported data may have introduced social desirability bias, resulting in the over-reporting of desirable food-handling practices. Nevertheless, these limitations do not diminish the value of the study, which provides a valid snapshot of food safety knowledge, practices, and microbiological quality of ready-to-eat foods in Abuja's informal markets. Notwithstanding these limitations, the study offers a valid snapshot of food safety in Abuja's informal markets.

Suggestions for Further Studies

Further research is needed to build on the findings of this study. Longitudinal studies should be conducted to assess the effectiveness and sustainability of food-safety training interventions among food vendors over time. Studies exploring consumers' perceptions of food-safety hazards in informal markets would also provide valuable insights into factors influencing food-purchasing behaviours and demand for safer food practices. In addition, future research should examine the role of vendor associations in promoting hygiene compliance, supporting food safety education, and facilitating adherence to regulatory standards in informal market settings.

CONCLUSION

Food safety in Abuja's informal markets was characterized by moderate vendor awareness, gaps in hygienic practices, and deficiencies in environmental sanitation. These findings underscore the importance of continuous vendor training, routine regulatory oversight, and improved water, sanitation, and waste-management facilities. A comprehensive approach is essential for strengthening food safety and protecting public health in informal market settings.

Declarations

Authors' contribution: All listed authors made substantial intellectual contributions to the manuscript, including conception, design, data analysis, drafting, critical revision, final approval, and accountability for the work, thereby confirming their authorship.

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