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Research Article

Comparative Assessment of Bacterial Contamination and Associated Food Safety Risks among Local and Modern Restaurants in Selected Local Government Areas of Kaduna State, Nigeria

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ABSTRACT
Food safety is a fundamental aspect of public health. This study assessed bacterial contamination associated with food handlers and food-contact environments in selected local and modern restaurants across Kaduna metropolis, Kaduna State, Nigeria. The study was conducted within four Local Government Areas (LGAs): Igabi, Chikun, Kaduna North, and Kaduna South. A total of 240 samples, comprising hand swabs, utensil swabs, and hand-washing water, were collected from selected restaurants using standard aseptic procedures. Microbiological analyses were carried out using standard culture, morphological, and biochemical identification techniques. The results revealed significantly higher bacterial contamination in local restaurants compared to modern restaurants across all sampled LGAs. Total *Salmonella-Shigella* count (TSSC), Total *Escherichia coli Count* (TECC), and Total Coliform count (TCC) in several local restaurant samples exceeded the WHO permissible limits, particularly in hand swabs and hand-washing water samples. The highest TSSC (2.515×10^{-1} CFU/ml) and TECC (3.364×10^{-1}CFU/ml) were recorded in Kaduna North local restaurants, while the highest TCC (2.214×10^{-1} CFU/ml) was also observed within the same LGA. Most modern restaurant samples recorded either no detectable bacterial growth or values within acceptable WHO limits. Identified bacterial isolates included *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Escherichia coli*, *Klebsiella* spp., *Salmonella* spp., *Shigella* spp., *Pseudomonas* spp., *Listeria* spp., and *Clostridium* spp., indicating poor hygiene practices and environmental contamination. The study concludes that local restaurants pose greater microbiological risks due to inadequate hygiene, poor sanitation, and potentially contaminated water. Potable water supply, sanitation, medical screening of food handlers, and stricter hygiene regulations are recommended to reduce foodborne disease risks.

Keywords: Bacterial contamination; Food handlers; Food-contact surfaces; Food safety; Kaduna State; Public health; Restaurants

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INTRODUCTION

Food safety is a fundamental aspect of public health that aims to prevent food contamination during production, preparation, handling, and distribution. Despite advances in food safety regulations and food processing technologies, foodborne diseases remain a major global health concern, particularly in low- and middle-income countries where inadequate sanitation, poor hygiene practices, and weak regulatory systems facilitate the transmission of foodborne pathogens (Newell *et al*., 2010, Grace, 2015; Food and Agriculture Organization [FAO], 2022; World Health Organization [WHO], 2023). The WHO estimates that approximately 600 million people develop foodborne illnesses annually, resulting in about 420,000 deaths worldwide, with children under five years bearing a disproportionate burden (WHO, 2023; FAO and WHO, 2022). Bacterial pathogens constitute one of the leading causes of these illnesses, making continuous monitoring of food safety practices an important public health priority (Havelaar *et al*., 2015).

Bacterial contamination of foods and food-contact environments is primarily associated with pathogenic organisms such as *Escherichia coli*, *Salmonella* spp., *Shigella* spp., *Staphylococcus aureus*, *Listeria monocytogenes*, and *Clostridium* spp., which are responsible for gastroenteritis, typhoid fever, food poisoning, and other severe infections (Newell *et al*., 2010; WHO, 2023; Centers for Disease Control and Prevention [CDC], 2024). These microorganisms are commonly transmitted through contaminated hands of food handlers, utensils, preparation surfaces, water, and cross-contamination between raw and cooked foods (Mensah *et al*., 2002; Todd *et al*., 2007). Poor personal hygiene, inadequate sanitation, improper food storage, and ineffective cleaning practices further increase the risk of bacterial contamination and foodborne disease outbreaks (Todd *et al*., 2007; Grace, 2015; FAO and WHO, 2022).

In Nigeria, rapid urbanization has led to increased dependence on commercially prepared foods from both modern restaurants and informal local food vendors. Modern restaurants generally operate under better sanitary conditions with greater regulatory oversight and trained personnel, whereas local restaurants often function within environments characterized by inadequate water supply, poor waste disposal, limited sanitation facilities, and inconsistent food safety monitoring (FAO, 2022; Nigeria Centre for Disease Control [NCDC], 2023; WHO, 2023). Although local restaurants provide affordable meals for a large proportion of the urban population, these operational conditions may increase the likelihood of bacterial contamination during food preparation and handling (Mensah *et al*., 2002; Grace, 2015).

Several studies in Nigeria and other developing countries have reported the isolation of pathogenic bacteria including *Escherichia coli*, *Salmonella* spp., *Staphylococcus aureus*, *Shigella* spp., and *Klebsiella* spp. from ready-to-eat foods, food handlers, utensils, and food-contact surfaces, indicating persistent deficiencies in hygiene and sanitation (Mensah *et al*., 2002; Odeyemi *et al*., 2020). Likewise, recurrent outbreaks of cholera, typhoid fever, and other enteric diseases in northern Nigeria further emphasize the need to strengthen food safety surveillance and hygiene compliance within food service establishments (NCDC, 2023; WHO, 2023; CDC, 2024). These findings highlight the critical role of food handlers and environmental hygiene in preventing foodborne bacterial infections (Todd *et al*., 2007; FAO and WHO, 2022).

Kaduna metropolis is one of the rapidly expanding urban centres in northwestern Nigeria, with an increasing number of both formal and informal food establishments. However, routine monitoring of food handlers and food-contact environments remains inadequate, particularly within the informal sector. Although modern restaurants are generally expected to maintain higher hygiene standards, food safety lapses may still occur, while local restaurants are often more vulnerable to contamination due to environmental and infrastructural limitations (NCDC, 2023; WHO, 2023). Despite the public health significance of foodborne bacterial infections, comparative studies evaluating bacterial contamination associated with food handlers and food-contact environments in both local and modern restaurants within Kaduna metropolis remain limited. Therefore, this study comparatively assessed bacterial contamination associated with food handlers and food-contact environments in selected local and modern restaurants across four Local Government Areas of Kaduna metropolis, Kaduna State, Nigeria. The findings will provide baseline information for improving food hygiene practices,

strengthening food safety regulations, and reducing the burden of foodborne bacterial diseases among consumers (FAO and WHO, 2022; WHO, 2023).

MATERIALS AND METHODS

Study Area

The study was conducted in Kaduna metropolis, Kaduna State, northwestern Nigeria, covering four selected Local Government Areas (LGAs): Igabi (10.8060°N, 7.7144°E), Chikun (10.3150°N, 7.2740°E), Kaduna North (10.3500°N, 7.2500°E), and Kaduna South (10.4631°N, 7.4138°E). These LGAs comprise a mixture of urban and peri-urban communities with numerous local and modern restaurants, making them suitable for assessing bacterial contamination associated with food handlers and food-contact environments.

Igabi Local Government Area

Igabi LGA is characterized by a tropical wet-and-dry climate with a mean annual temperature of approximately 27.8°C (WorldClim, 2023). Agriculture remains the predominant economic activity, particularly maize cultivation and livestock feed production, alongside increasing commercial and food service activities that support the growing urban population (Kaduna State Bureau of Statistics, 2022).

Chikun Local Government Area

Chikun LGA occupies approximately 4,466 km² with its administrative headquarters at Kujama and a population of 372,272 according to the 2006 national census (National Population Commission, 2006). The area experiences a tropical savannah climate with distinct wet (May–September) and dry (October–April) seasons and average temperatures ranging from 25°C to 33°C (WorldClim, 2023). Agriculture, small-scale industries, and commercial activities constitute the major economic activities within the LGA (Kaduna State Bureau of Statistics, 2022).

Kaduna South Local Government Area

Kaduna South LGA is predominantly urban, with a tropical savannah climate characterized by wet and dry seasons and average annual temperatures of 25–33°C (WorldClim, 2023). The economy is driven by commerce, transportation, small-scale manufacturing, food vending, and informal trading, resulting in a high concentration of food service establishments (Kaduna State Bureau of Statistics, 2022).

Kaduna North Local Government Area

Kaduna North LGA forms part of the metropolitan core of Kaduna State and experiences a tropical savannah climate with temperatures ranging from 25°C to 33°C (WorldClim, 2023). The area is highly urbanized and serves as an administrative, commercial, and business hub, hosting numerous formal and informal restaurants, markets, and food outlets that contribute significantly to the local economy (Kaduna State Bureau of Statistics, 2022).

Study Design

This study employed a descriptive cross-sectional design to evaluate bacterial contamination associated with food handlers and food-contact environments in selected local and modern restaurants across Kaduna Metropolis, Kaduna State, Nigeria. The study involved field sample collection and laboratory-based microbiological analyses to determine bacterial contamination levels and identify bacterial isolates using standard microbiological techniques (Setia, 2016; American Public Health Association [APHA], 2022). A simple random sampling technique was used to select the study LGAs and participating restaurants (Taherdoost, 2016).

Study Population

The study was conducted in four selected LGAs (Igabi, Chikun, Kaduna North, and Kaduna South). Three local restaurants and three modern restaurants were randomly selected from each LGA. Samples comprised hand swabs from food handlers, utensil swabs, and hand-washing water collected aseptically from the selected restaurants following standard microbiological procedures (World Health Organization [WHO], 2023).

Sample Size, Collection and Handling

Sample size

A total of 240 samples were collected from the four LGAs to enable comparative assessment of bacterial contamination between local and modern restaurants. The samples consisted of hand swabs, utensil swabs, and hand-washing water collected using standard microbiological sampling procedures to ensure representative sampling and minimize contamination (APHA, 2022; WHO, 2023).

Collection of samples

Hand-washing water samples were aseptically collected into sterile sampling bottles according to standard microbiological procedures (Centers for Disease Control and Prevention [CDC], 2002; APHA, 2022). Hand and utensil swabs were collected using sterile cotton swabs moistened with sterile distilled water and transported immediately to the laboratory in insulated ice boxes for analysis. All samples were

processed within 2 hours of collection to maintain microbial integrity (Mensah *et al*., 2002; Atlas, 2004; Todd *et al*., 2010).

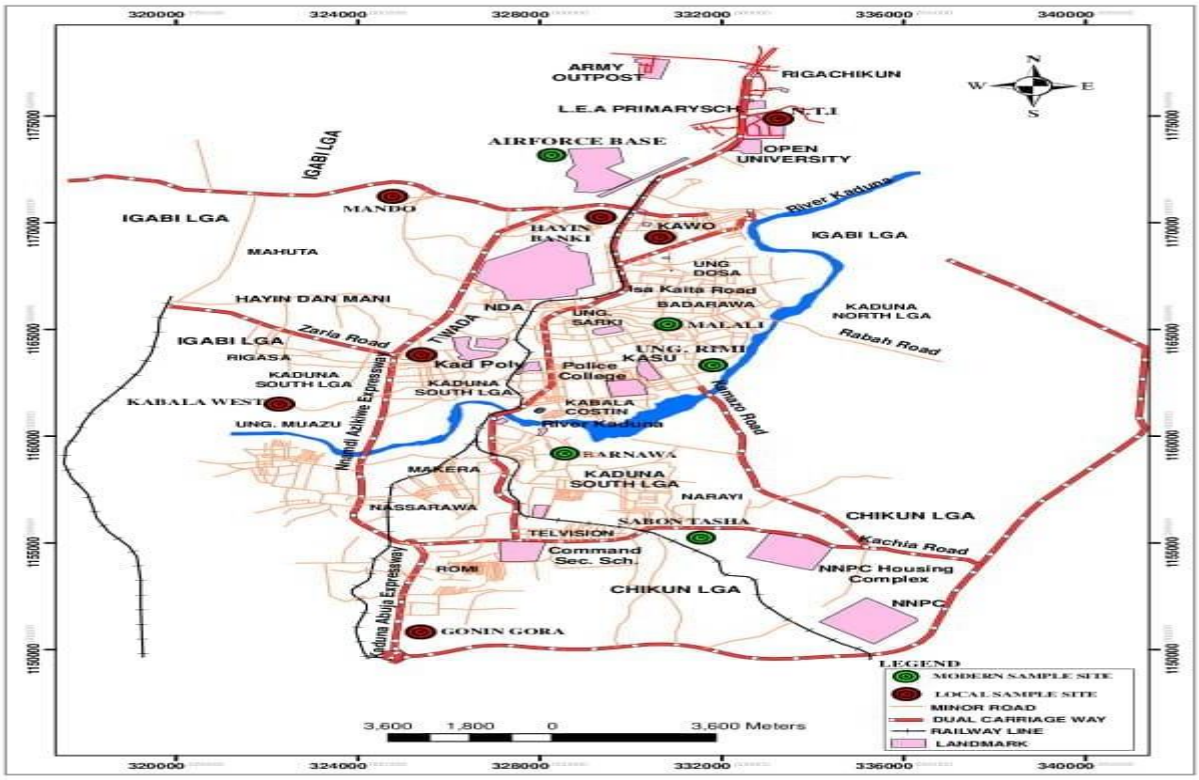

Figure 1: Map of Kaduna Metropolis Showing Study Area
Source: Google Maps, 2025; https://www.google.com/maps

Microbiological Analysis

Serial dilution

Serial dilution of samples was performed using sterile physiological saline following standard microbiological procedures to obtain countable bacterial colonies for enumeration (APHA, 2022; International Organization for Standardization [ISO], 2021).

Bacterial inoculation and enumeration

The pour plate technique was employed for bacterial enumeration using Nutrient Agar, MacConkey Agar, Eosin Methylene Blue (EMB) Agar, and *Salmonella–Shigella* Agar. Inoculated plates were incubated at 37°C for 24-48 hours, after which bacterial colonies were enumerated and expressed as colony-forming units per millilitre (CFU/mL) (APHA, 2022; WHO, 2023).

Bacterial isolation and identification

Distinct bacterial colonies were purified by repeated subculturing to obtain pure isolates. Identification was based on colony morphology, Gram staining characteristics, and standard biochemical tests, including catalase, coagulase, oxidase, indole, citrate utilization, urease, triple sugar iron (TSI), methyl red, Voges–Proskauer, and motility tests, following established clinical microbiology procedures (Beveridge, 2001; Cheesbrough, 2006; American Society for Microbiology, 2022).

Informed Consent

Informed consent was obtained from all participating food handlers before collection of samples. Participation was voluntary, and confidentiality of all participants and restaurants was maintained throughout the study in accordance with established ethical research guidelines (WHO, 2023).

Data Analysis

Data were analysed using descriptive statistics and presented in tables and charts using Microsoft Excel 2021. Bacterial counts were expressed as colony-forming units per millilitre (CFU/mL), while frequencies and percentages were used to summarize the occurrence and distribution of bacterial isolates among the sampled restaurants (Microsoft Corporation, 2021; Setia, 2016).

RESULTS

Bacterial counts from hand swabs, utensil swabs, and hand-washing water collected from selected local

and modern restaurants in Igabi Local Government Area

Table 1 shows the average bacterial counts from hand swabs, utensil swabs, and hand-washing water collected from selected local and modern restaurants in Igabi Local Government Area. The Total *Salmonella–Shigella* count (TSSC) was detected in both restaurant types but was consistently higher in local restaurants than in modern restaurants, with all recorded values exceeding the WHO permissible limit (≤1.0 × 10^{-2} CFU/mL). In contrast, Total *Escherichia coli* count (TECC), Total Coliform Count (TCC), and Total Faecal Coliform count (TFCC) were either not detected or remained within the WHO acceptable limits in all samples. The Total Heterotrophic Plate Count (THPC) was within the recommended WHO limit across both restaurant categories.

Table 1: Average Bacterial counts (CFU/1ml selected Restaurants obtained from Igabi Local Government Area, Kaduna State

Counts (CFU/1 mL)	N	Local restaurants sample Type			Modern restaurants sample type			WHO (CFU/ml)
		HS	US	HW	HS	US	HW	
TSSC	**30**	1.706×10^{-1}	3.95×10^{-2}	1.579×10^{-1}	3.0×10^{-2}	3.0×10^{-2}	1.48×10^{-1}	$\leq1.0\text{x}10^{-2}$
TECC	**30**	0.00	0.00	0.00	0.00	0.00	0.00	$0.1\text{x}10^{-2}$
TCC	**30**	$<0.1\text{x}10^{-2}$	$<0.1\text{x}10^{-2}$	$<0.1\text{x}10^{-2}$	0.00	0.00	0.00	$0.1\text{x}10^{-2}$
THPC	**30**	$\leq1.0\text{x}10^{2}$	$\leq1.0\text{x}10^{2}$	1.704×10^{-1}	$\leq1.0\text{x}10^{2}$	$\leq1.0\text{x}10^{2}$	$\leq1.0\text{x}10^{2}$	$\leq1.0\text{x}10^{2}$
TFCC	**30**	0.00	0.00	0.00	0.00	0.00	0.00	$0.1\text{x}10^{-2}$

Keys: TSSC=Total *Salmonella Shigella* count; TECC=Total *E. coli* count; TCC=Total coliform count; TFCC=Total faecal coliform count; THPC=Total heterotrophic plate count; HS=Hand swab; US=Utensil swab; HW=Hand washing water; SN=Sample number; N=Total number of samples in the study

Bacterial counts obtained from hand swabs, utensil swabs, and hand-washing water collected from selected local and modern restaurants in Chikun LGA

Table 2 presents the average bacterial counts obtained from hand swabs, utensil swabs, and hand-washing water collected from selected local and modern restaurants in Chikun LGA. The Total *Salmonella–Shigella* count (TSSC) was detected only in local restaurant samples, with hand-washing water recording the highest count (3.6 × 10^{-2} CFU/mL), while hand and utensil swabs remained within the WHO permissible limit. No *Salmonella–Shigella* was detected in any of the modern restaurant samples. The Total *Escherichia coli* count (TECC) was detected only in local restaurants, with the highest count observed in hand-washing water (2.226 × 10^{-1} CFU/mL), followed by hand swabs (1.238 × 10^{-1} CFU/mL), both exceeding the WHO permissible limit (0.1 ×10^{-2} CFU/mL). Total Coliform count (TCC) was not detected in any sample, while the Total Heterotrophic Plate Count (THPC) remained within the WHO acceptable limit across all samples. The Total Faecal Coliform Count (TFCC) in local restaurants was at the WHO permissible limit (0.1 × 10^{-2} CFU/mL) but was absent in modern restaurants.

Bacterial counts obtained from hand swabs, utensil swabs, and hand-washing water collected from selected local and modern restaurants in Kaduna North Local Government Area

Table 3 shows that local restaurants in Kaduna North LGA recorded substantially higher bacterial contamination than modern restaurants. The Total *Salmonella–Shigella* Count (TSSC), Total *Escherichia coli* Count (TECC), and Total Coliform Count (TCC) in local restaurant hand swabs, utensil swabs, and hand-washing water all exceeded the WHO permissible limits, with the highest counts generally observed in hand-washing water. In contrast, all corresponding bacterial counts in modern restaurants were within the WHO acceptable limits. The Total Heterotrophic Plate Count (THPC) remained within the recommended limit in both restaurant categories, while the Total Faecal Coliform Count (TFCC) was at the WHO permissible limit across all samples.

Bacterial counts obtained from hand swabs, utensil swabs, and hand-washing water collected from selected local and modern restaurants in Kaduna South Local Government Area

Table 4 presents the mean bacterial counts obtained from hand swabs, utensil swabs, and hand-washing water collected from selected local and modern restaurants in Kaduna South Local Government Area. The Total *Salmonella–Shigella*Count (TSSC) and Total *Escherichia coli* Count (TECC) were higher in local restaurants than in modern restaurants, with the highest counts recorded in hand-washing water, exceeding the WHO permissible limits. In contrast, modern restaurant samples recorded bacterial counts within the acceptable WHO limits. The Total Coliform

Count (TCC) remained at the WHO permissible limit in both restaurant categories, while the Total Heterotrophic Plate Count (THPC) was within the recommended limit across all samples. Total Faecal Coliform Count (TFCC) was not detected in any of the samples.

Characterization of the bacterial isolates recovered from local and modern restaurants across the selected Local Government Areas

Table 5 shows that eight bacterial species were identified from samples collected from selected local and modern restaurants across the four LGAs. The isolates comprised Gram-positive bacteria (*Staphylococcus aureus*, *Staphylococcus epidermidis*, and *Listeria* spp.) and Gram-negative bacteria (*Escherichia coli*, *Klebsiella* spp., *Salmonella* spp., *Shigella* spp., *Pseudomonas* spp., and *Clostridium* spp.). Identification was based on their colonial morphology, Gram reaction, cell morphology, and biochemical characteristics.

Table 2: Average Bacterial counts (CFU/1ml) in selected Restaurants obtained from Chikun Local Government Area, Kaduna State

Counts		Local restaurants sample Type			Modern restaurants sample type			WHO
(CFU/1 mL)	N	HS	US	HW	HS	US	HW	(CFU/ml)
TSSC	**30**	$\leq 1.0x10^{-2}$	$\leq 1.0x10^{-2}$	3.6×10^{-2}	0.00	0.00	0.00	$\leq 1.0x10^{-2}$
TECC	**30**	1.238×10^{-1}	$0.1x10^{-2}$	2.226×10^{-1}	0.00	0.00	0.00	$0.1x10^{-2}$
TCC	**30**	0.00	0.00	0.00	0.00	0.00	0.00	$0.1x10^{-2}$
THPC	**30**	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$
TFCC	**30**	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	0.00	0.00	0.00	$0.1x10^{-2}$

Keys: TSSC=Total *Salmonella Shigella* count; TECC=Total *E. coli* count; TCC=Total coliform count; TFCC=Total faecal coliform count; THPC=Total heterotrophic plate count; HS=Hand swab; US=Utensil swab; HW=Hand washing water; SN=Sample number; N=Total number of samples in the study

Table 3: Average Bacterial counts (CFU/1ml) in selected Restaurants obtained from Kaduna North Local Government Area, Kaduna State

Counts		Local restaurants sample type			Modern restaurants sample type			WHO
(CFU/1 mL)	N	HS	US	HW	HS	US	HW	(CFU/ml)
TSSC	**30**	2.474×10^{-1}	3.66×10^{-2}	2.515×10^{-1}	$\leq 1.0x10^{-2}$	$\leq 1.0x10^{-2}$	$\leq 1.0x10^{-2}$	$\leq 1.0x10^{-2}$
TECC	**30**	3.04×10^{-2}	4.44×10^{-2}	3.364×10^{-1}	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$
TCC	**30**	2.214×10^{-1}	6.16×10^{-2}	1.351×10^{-1}	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$
THPC	**30**	1.493×10^{-1}	4.34×10^{-2}	7.83×10^{-2}	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$
TFCC	**30**	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$

Keys: TSSC=Total *Salmonella Shigella* count; TECC=Total *E. coli* count; TCC=Total coliform count; TFCC=Total faecal coliform count; THPC=Total heterotrophic plate count; HS=Hand swab; US=Utensil swab; HW=Hand washing water; SN=Sample number; N=Total number of samples in the study.

Table 4: Average Bacterial counts (CFU/1ml) of selected Restaurants obtained from Kaduna South Local Government Area, Kaduna State

Counts (CFU/1 mL)	N	Local restaurants sample type			Modern restaurants sample type			WHO (CFU/ml)
		HS	US	HW	HS	US	HW	
TSSC	**30**	1.17×10^{-1}	3.73×10^{-2}	1.52×10^{-1}	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$
TECC	**30**	4.84×10^{-2}	$0.1x10^{-2}$	1.482×10^{-1}	0.00	0.00	0.00	$0.1x10^{-2}$
TCC	**30**	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$	$0.1x10^{-2}$
THPC	**30**	1.504×10^{-1}	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$	$\leq 1.0x10^{2}$
TFCC	**30**	0.00	0.00	0.00	0.00	0.00	0.00	$0.1x10^{-2}$

Keys: TSSC=Total *Salmonella Shigella* count; TECC=Total *E. coli* count; TCC=Total coliform count; TFCC=Total faecal coliform count; THPC=Total heterotrophic plate count; HS=Hand swab; US=Utensil swab; HW=Hand washing water; SN=Sample number; N=Total number of samples in the study

Table 5: Morphological and Biochemical Characteristics of Bacterial Isolates from Local and Modern Restaurants in the selected LGAs of this study

S/N	Colonial Morphological	GR	CM	Biochemical Characteristics							Organisms
				MO	CA	OX	IN	CO	MR	VP	
1	Produced raised and mucoid/yellowish colonies/zones on MSA; Pinkishsmoothsurfaceon MCA	+ve	Cocci	-	+	-	-	+	+	+	***Staphylococcus epidermidis***
2	Pinkish/mucoid/cloudy colonieson MCA,Green metallic sheen/slightly raisedandentireon EMB	-ve	Rods	+	+	-	+	-	+	+	***E.coli***
3	Round, greyishwhite, translucent andsmooth on NA,	+ve	Cocco id bacilli	+	+	-	-	-	+	-	***Listeriasp***
4	Yellowishcolonieson MSA and turning the medium yellowish	+ve	Cocci	-	+	-	-	-	-	+	***Staphylococcus aureus***
5	Pinkish/mucoidcolonies on MCA, very sticky/purple on EMB, greyish white dome and convex colonies on NA	-ve	Rods	-	+	-	-	+	-	+	***Klebsiella*sp**
6	Red-pinkishcolonieswith black centers on SSA	-ve	Rods	+	+	+	-	-	+	-	***Salmonella*sp**
7	Cleartransparentgrowth on SSA	-ve	Rods	-	+	-	-	-	+	-	***Shigella*sp**
8	Greenishraisedcolonies on NA, colourless on MCA	-ve	Rods	+	+	+	-	-	-	-	***Pseudomonas* sp**
9	Large,spreading,irregular and opaque growth with rough edges on NA	+ve	Rods	-	-	-	-	-	-	+	***Clostridium*sp**

Keys: GR=Gram reaction; CM=Cellular morphology; MO=Motility; CA=Catalase; OX=Oxidase CO=Coagulase; UR=Urease; MR=Methyl red; VP= Voges-Proskauer

DISCUSSION

The present study comparatively evaluated bacterial contamination associated with food handlers and food-contact environments in selected local and modern restaurants across four LGAs of Kaduna Metropolis. The findings showed consistently higher bacterial contamination in local restaurants than in modern restaurants, suggesting poorer hygiene practices, inadequate sanitation, and limited compliance with food safety regulations in local food establishments. This observation agrees with reports by the World Health Organization (WHO, 2023), the Food and Agriculture Organization (FAO and WHO, 2022), and the Centers for Disease Control and Prevention (CDC, 2024), which identify poor personal hygiene, contaminated food-contact surfaces, unsafe water, and inadequate environmental sanitation as major sources of foodborne bacterial contamination. Similar findings have also been reported among street food vendors and informal food establishments in Ghana, Nigeria, and other developing countries (Mensah *et al*., 2002; Oranusi *et al*., 2013; Rahman *et al*., 2016).

Among the bacterial indicators assessed, the Total *Salmonella–Shigella* count (TSSC) was consistently higher in local restaurants across all LGAs, with Kaduna North recording the highest counts. The elevated TSSC values, particularly in hand-washing water and hand swabs, may be attributed to poor hand hygiene, contaminated water sources, inadequate utensil sanitation, and cross-contamination during food preparation (Jay *et al*., 2005; Cheesbrough, 2006).

Salmonella and *Shigella* are major enteric pathogens responsible for salmonellosis, shigellosis, gastroenteritis, and other foodborne illnesses, and their detection above WHO permissible limits indicates an increased risk of disease transmission to consumers (WHO, 2023; CDC, 2024). Similar observations have been documented among food vendors in Nigeria, Ghana, and Ethiopia, where inadequate sanitation and poor hygiene practices contributed significantly to bacterial contamination of food-contact surfaces (Mensah *et al*., 2002; Oranusi *et al*., 2013; Gizaw *et al*., 2014).

The Total *Escherichia coli* count (TECC) was detected mainly in local restaurant samples, particularly in Kaduna North, Kaduna South, and Chikun, whereas modern restaurants recorded little or no detectable growth. Since *E. coli* is widely recognized as an indicator of faecal contamination, its presence suggests poor personal hygiene, contaminated water, or inadequate handwashing practices among food handlers (Jay *et al*., 2005, APHA, 2022). Likewise, the Total Coliform count (TCC) was higher in local restaurants, further indicating poor environmental sanitation and ineffective cleaning of food-contact surfaces. Similar findings have been reported in studies assessing restaurant hygiene in developing countries, where inadequate sanitation facilities and poor compliance with food safety standards contributed to increased bacterial contamination (Rahman *et al*., 2016; FAO and WHO, 2022; WHO, 2023).

The Total Heterotrophic Plate count (THPC) remained within WHO acceptable limits in both restaurant categories, although relatively higher values were observed in some local restaurant samples. This suggests that while the general bacterial load was within acceptable limits, local restaurants harboured comparatively greater microbial contamination than modern restaurants (APHA, 2022). In contrast, the Total Faecal Coliform Count (TFCC) remained absent or within the WHO permissible limit in both restaurant categories, indicating limited recent faecal contamination despite the detection of other pathogenic bacteria (WHO, 2023; CDC, 2024).

The identification of *Staphylococcus aureus, Staphylococcus epidermidis, Escherichia coli, Klebsiella spp., Salmonella spp., Shigella spp., Pseudomonas spp., Listeria spp.,* and *Clostridium spp.* further demonstrates the microbiological diversity of contaminants present in the restaurant environments. The isolation of *Staphylococcus aureus* suggests contamination from food handlers, as the organism commonly colonizes human skin and nasal passages and is frequently associated with poor personal hygiene and improper food handling (Le Loir *et al*., 2003; Cheesbrough, 2006). Similarly, the presence of *Salmonella*, *Shigella*, and *E. coli* indicates faecal contamination and poor sanitary conditions, while *Listeria*, *Pseudomonas*, *Klebsiella*, and *Clostridium* species reflect environmental contamination, inadequate cleaning of food-contact surfaces, and poor storage conditions (Jay *et al*., 2005; Swaminathan and Gerner-Smidt, 2007; Ryan *et al*., 2014).

Overall, the lower bacterial counts observed in modern restaurants likely reflect better sanitation facilities, access to potable water, routine cleaning and disinfection of utensils, regular staff training, and greater compliance with food safety regulations (FAO and WHO, 2022; WHO, 2023). These findings underscore the need for continuous food safety education, regular microbiological surveillance, periodic medical screening of food handlers, and stricter enforcement of hygiene regulations, particularly in local restaurants, to reduce bacterial contamination and minimize the risk of foodborne diseases (Rahman *et al*., 2016; APHA, 2022; CDC, 2024).

CONCLUSION

This study demonstrated that bacterial contamination was significantly higher in local restaurants than in modern restaurants across the selected LGAs of Kaduna Metropolis. Pathogenic bacteria, including *Salmonella* spp., *Shigella* spp., *Escherichia coli*, *Staphylococcus aureus*, *Klebsiella* spp., *Listeria* spp., *Pseudomonas* spp., and *Clostridium* spp., were identified, with several bacterial counts exceeding the WHO permissible limits, particularly in local restaurants. These findings indicate inadequate hygiene and sanitation practices among food handlers and highlight the potential public health risk of foodborne bacterial infections.

Food handlers should receive regular training on proper hygiene and safe food handling practices. Routine microbiological surveillance and periodic medical screening of food handlers should be implemented, while access to safe potable water and effective sanitation facilities should be improved. In addition, regulatory agencies should strengthen the inspection and enforcement of food safety standards, particularly in local restaurants, to minimize bacterial contamination and protect public health.

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