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Research Article

Assessment of Parasitic Contamination and Associated Hygienic Practices in Local and Modern Restaurants across Selected Local Government Areas of Kaduna State, Nigeria

***Suzie Nathan[1], Ishaya Auta Kato[1,2], Balarabe-Musa B.[3], Solomon Bitrus[1], and Japheth Ishaya Auta[4]**

[1]Department of Biological Sciences, Faculty of Life Sciences, College of Computing, Engineering, and Sciences, Kaduna State University, Kaduna, Nigeria
[2]Department of Biotechnology, Faculty of Sciences, Federal University of Applied Sciences, Kachia, Kaduna, Nigeria
[3]Department of Biological Sciences, University of Abuja, Federal Capital Territory, Nigeria
[4]Department of Biochemistry, Faculty of Life Sciences, College of Computing, Engineering, and Sciences, Kaduna State University, Kaduna, Nigeria
****Corresponding Author's email*: suzienathan101@gmail.com; Phone: +234 802 398 2297**

ABSTRACT
Bacterial contamination of food-handling environments remains an important public health concern. This study evaluated parasitic 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. Parasitological investigations were performed using standard microscopic examination techniques to detect and identify intestinal parasites. The findings revealed a substantially higher prevalence and diversity of intestinal parasites in local restaurants than in modern restaurants. *Cryptosporidium* spp. recorded the highest prevalence with 18 (60%) occurrences in local restaurants within Igabi LGA, followed by 15 (50%) occurrences in Kaduna North and 12 (40%) occurrences in Kaduna South. *Giardia lamblia* occurred in 14 (46.6%) samples from Igabi and 12 (40%) samples from Kaduna North local restaurants, while *Entamoeba* spp. were detected in 11 (36.6%) and 10 (33.3%) samples from Igabi and Kaduna North, respectively. Helminthic parasites including *Ascaris* spp. (8; 26.6%), *Ancylostoma* spp. (4; 13.3%), *Fasciola hepatica* (3; 10%), and *Echinococcus granulosus* (2; 6.6%) were detected at lower frequencies, predominantly in local restaurants. Overall, Igabi LGA recorded the highest parasitic burden, whereas Chikun LGA had the lowest prevalence. Inadequate hygiene, poor environmental sanitation, and contaminated water sources contributed significantly to parasitic contamination in the local restaurants. Improved hygiene and sanitation practices are recommended to reduce parasite transmission.

Keywords: *Cryptosporidium spp.*; Food handlers; Food safety, Kaduna State; *Giardia lamblia;* Intestinal parasites; Public health; Restaurant hygiene

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INTRODUCTION

Foodborne parasitic infections remain a significant public health concern worldwide, particularly in low- and middle-income countries where poor sanitation, inadequate access to potable water, weak food safety systems, and poor food handling practices facilitate parasite transmission (World Health Organization [WHO], 2022, 2023; Food and Agriculture Organization [FAO] and WHO, 2022; Ryan *et al*., 2021). Although bacterial pathogens account for a substantial proportion of reported foodborne disease outbreaks, intestinal parasites continue to contribute significantly to diarrhoeal diseases, malnutrition, anaemia, impaired physical and cognitive development, and increased morbidity, especially among children, pregnant women, and immunocompromised individuals (Fletcher *et al*., 2012, Efstratiou *et al*., 2017; WHO, 2022; FAO and WHO, 2022). Food handlers, contaminated utensils, food-contact surfaces, and washing water have been recognized as important vehicles for the transmission of protozoan cysts, oocysts, and helminth eggs to consumers, making food hygiene a critical component of food safety and disease prevention (Todd *et al*., 2008; Uga *et al*., 2010 ; WHO, 2023).

Among the most important foodborne parasites are *Giardia lamblia*, *Cryptosporidium* spp., *Entamoeba histolytica*, *Ascaris lumbricoides*, hookworms (*Ancylostoma* spp.), and *Fasciola hepatica*, all of which have been associated with contaminated foods, unsafe water, poor environmental sanitation, and inadequate personal hygiene among food handlers (Fletcher *et al*., 2012; Ryan *et al*., 2021; Tefera *et al*., 2021; WHO, 2022). These parasites are primarily transmitted through the faecal–oral route via contaminated hands, improperly cleaned utensils, untreated water, contaminated vegetables, and inadequately sanitized food preparation environments (Uga *et al*., 2010; Efstratiou *et al*., 2017; Obaid, 2022). Consequently, routine parasitological surveillance of food handlers and food-contact environments is essential for preventing foodborne parasite transmission, improving food hygiene, and protecting public health (Yeshanew *et al*., 2021; WHO, 2023).

In Nigeria, the food service sector comprises both formal modern restaurants and informal local restaurants that provide affordable meals for a large proportion of the urban population. While modern restaurants generally operate under relatively better hygienic conditions with greater regulatory oversight, local restaurants often face challenges including inadequate sanitation facilities, poor access to potable water, ineffective waste disposal systems, overcrowded food preparation areas, and inconsistent food safety monitoring (FAO, 2022; Nigeria Centre for Disease Control [NCDC], 2023; WHO, 2023). These conditions increase the likelihood of contamination of food handlers, food-contact surfaces, utensils, and washing water with intestinal parasites, thereby posing significant public health risks to consumers (Grace, 2015; WHO, 2023). In many developing countries, the informal food sector continues to expand rapidly because of increasing urbanization and changing dietary patterns, making effective food safety surveillance increasingly important (Odeyemi*et al*., 2020; (FAO and WHO, 2022).

Previous studies conducted in Nigeria, Ethiopia, Ghana, Sudan, and other developing countries have consistently reported the occurrence of intestinal parasites among food handlers, with *Giardia lamblia*, *Entamoeba histolytica*, *Cryptosporidium* spp., and *Ascaris lumbricoides* being among the most frequently isolated organisms (Alemu *et al*., 2019; Tefera *et al*., 2021; Tiruneh *et al*., 2021; Gizaw *et al*., 2022). Similar studies have demonstrated that poor hand hygiene, inadequate environmental sanitation, lack of periodic medical screening, low educational status, and inadequate food safety knowledge are significant risk factors associated with parasitic contamination among food handlers (Alemu *et al*., 2019; Gizaw *et al*., 2022; Obaid, 2022). However, most previous investigations have focused primarily on food handlers or specific food items, with limited comparative assessment of parasitic contamination associated with food handlers and food-contact environments in both local and modern restaurants. This knowledge gap is particularly evident in Kaduna metropolis, where rapid urbanization, increasing patronage of restaurants, and inadequate food safety surveillance have heightened concerns regarding foodborne parasitic infections (NCDC, 2023; WHO, 2023).

Comparative assessment of parasitic contamination in local and modern restaurants is therefore essential for identifying contamination sources, evaluating hygiene practices, and generating evidence to support effective public health interventions. Such information will strengthen routine surveillance programmes, guide food safety education for food handlers, improve compliance with hygiene regulations, and support policy development aimed at reducing foodborne parasitic infections (FAO and WHO, 2022; WHO, 2023). Therefore, this study

comparatively assessed parasitic 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.

MATERIALS AND METHODS

Study Area

The study was conducted in Kaduna Metropolis, Kaduna State, Nigeria, covering four selected Local Government Areas (LGAs): Igabi (10.8060°N, 7.7144°E), Kaduna North (10.3500°N, 7.2500°E), Kaduna South (10.4631°N, 7.4138°E), and Chikun (10.3150°N, 7.2740°E). These LGAs comprise both urban and peri-urban communities with a high concentration of local and modern restaurants, making them suitable for comparative assessment of bacterial and parasitic contamination (Kaduna State Bureau of Statistics, 2022).

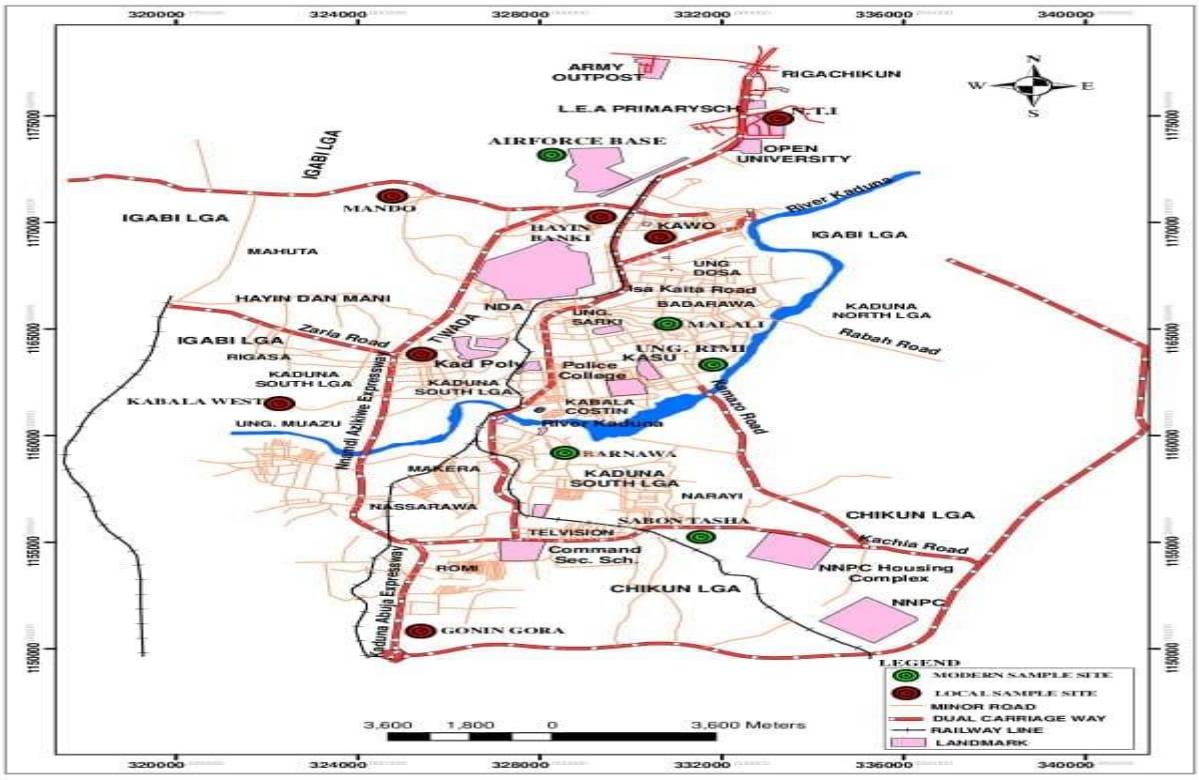

Figure 1: Map of Kaduna Metropolis Showing Study Area
Source: Google Maps, 2025; https://www.google.com/maps

Study Design

This study employed a descriptive cross-sectional design to evaluate parasitic contamination associated with food handlers and food-contact environments in selected local and modern restaurants within Kaduna metropolis, Kaduna State, Nigeria. A simple random sampling technique was used to select the study LGAs and participating food establishments (Setia, 2016).

Study Population

The study population comprised food handlers from selected local and modern restaurants in four Local Government Areas (Igabi, Chikun, Kaduna North, and Kaduna South). Three local and three modern restaurants were randomly selected from each LGA. Samples collected for parasitological analysis included hand swabs, utensil swabs, and handwashing water obtained aseptically from food handlers (World Health Organization [WHO], 2023).

Sample Size, Collection and Handling

Sample Size

A total of 240 samples comprising hand swabs, utensil swabs, and handwashing water were collected from selected local and modern restaurants across the four LGAs to enable comparative assessment of parasitic contamination.

Collection of Sample

Hand swabs, utensil swabs, and handwashing water samples were collected aseptically using sterile cotton swabs and sterile sample bottles following standard parasitological sampling procedures (Mensah *et al*., 2002). Samples were transported in ice-cooled containers to the laboratory and processed within two

hours of collection to preserve sample integrity (Todd *et al*., 2010; WHO, 2017).

Parasitological Analysis

Parasitological examination was performed using direct wet mount and formalin–ether concentration techniques following standard laboratory protocols for the detection and identification of intestinal protozoa and helminths (Uga *et al*., 2010; Gizaw *et al*., 2022; Obaid, 2022).

Ethical Considerations

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

Data Analysis

Data were analyzed using descriptive statistics with Microsoft Excel. The prevalence of parasitic contamination was expressed as frequencies and percentages and compared between local and modern restaurants across the selected LGAs.

RESULTS

Prevalence of Parasitic Species Identified in Selected Local and Modern Restaurants across Four LGAs of Kaduna Metropolis

Tables 1-4 present the prevalence of parasitic species identified from hand swabs, utensil swabs, and hand-washing water collected from local and modern restaurants across Igabi, Chikun, Kaduna North, and Kaduna South LGAs.

Igabi Local Government Area (IGB)

Igabi LGA recorded the highest prevalence and diversity of parasitic contamination among the four study areas. Eight parasitic species were identified in both local and modern restaurants. Local restaurants consistently exhibited higher contamination than modern restaurants. *Cryptosporidium* spp. was the predominant parasite, occurring in 18 (60.0%) samples from local restaurants and 13 (43.3%) samples from modern restaurants. This was followed by *Giardia lamblia* [14 (46.6%) and 6 (20.0%)], *Entamoeba* spp. [11 (36.6%) and 4 (13.3%)], and *Ascaris* spp. [8 (26.6%) and 6 (20.0%)] in local and modern restaurants, respectively. Lower occurences were observed for *Balantidium coli*, *Ancylostoma* spp., *Fasciola hepatica*, and *Echinococcus granulosus*. Overall, the results indicate a substantial parasitic burden in Igabi, particularly within local restaurants.

Table1: Morphology of parasite species identified from local and modern Restaurants in Igabi LGA (IGB) of Kaduna Metropolis

Parasite species	Microscopic morphological Description	Occurrence and Concurrence (N=60 n=30)		
		LR (30)	MR (30)	Total (60)
Balantidium coli	Protozoan:Largeovalandthick-walled cyst and Trophozoites.	6 (20)	3 (10)	9 (15)
Entamoeba sp	Protozoan:Roundcyst nuclei	11 (36.6)	4 (13.3)	15 (25)
Giardia lamblia	Protozoan:ovalcystwithnuclei inside flagellated	14 (46.6)	6 (20)	20 (33.3)
Fasciola hepatica	Helminths: large operculated egg	3 (10)	2 (6.6)	5 (8.3)
Ancylostoma sp	Helminths:Ovalthin-shelled egg with segmented embryo:	4 (13.3)	2 (6.6)	6 (10)
Ascaris sp	Helminths: Oval egg,rough thick shell	8 (26.6)	6 (20)	14 (23)
Echinococcus granulosus	Helminths: Ovalegg rough thick shell mammilated shell	2 (6.6)	2 (6.6)	4 (6.7)
Cryptosporidium sp	Helminths:Largeoval with thick ciliated wall	18 (60)	13 (43.3)	31 (51.7)

N=60

Keys: LR=Local Restaurant; MR=Modern Restaurant; KS=Kaduna South
N=Total number of samples in the entire study; n=number of samples per LGA

Chikun Local Government Area (CHK)

Chikun LGA recorded the lowest prevalence of parasitic contamination among all the study areas. Only four parasitic species were detected, namely *Balantidium coli*, *Entamoeba* spp., *Giardia lamblia*, and *Cryptosporidium* spp., all occurring at very low frequencies. Local restaurants recorded one (3.3%) occurrence each of *Balantidium coli*, *Giardia lamblia*, and *Cryptosporidium* spp., while *Entamoeba* spp. was detected in two (6.6%) samples. No helminth parasites (*Ascaris* spp., *Ancylostoma* spp., *Fasciola hepatica*, and *Echinococcusgranulosus*) were detected in either local or modern restaurants. Likewise, no parasitic contamination was observed in modern restaurants except for the absence of all identified species. These findings suggest comparatively better hygienic conditions and a lower risk of foodborne parasitic transmission within Chikun LGA.

Kaduna North Local Government Area (KN)

Kaduna North LGA demonstrated a relatively high prevalence of parasitic contamination, second only to Igabi. *Cryptosporidium* spp. was the most prevalent

parasite, occurring in 15 (50.0%) samples from local restaurants and 13 (43.3%) samples from modern restaurants. *Giardia lamblia* was also frequently detected, with 12 (40.0%) and 9 (30.0%) occurrences in local and modern restaurants, respectively. *Entamoeba* spp. was identified in 10 (33.3%) local restaurant samples and 3 (10.0%) modern restaurant samples. Lower prevalences were recorded for *Balantidium coli* [3 (10.0%) and 1 (3.3%)], *Fasciola hepatica* [2 (6.6%) and 3 (10.0%)], and *Ancylostoma* spp. [1 (3.3%)] in local restaurants. *Ascaris* spp. occurred only in local restaurants [5 (16.6%)], while *Echinococcusgranulosus* was not detected in either restaurant category. Overall, local restaurants harboured greater parasitic contamination than modern restaurants, although modern restaurants also exhibited relatively high occurrences of *Cryptosporidium* spp. and *Giardia lamblia*.

Kaduna South Local Government Area (KS)

Kaduna South LGA exhibited a moderate prevalence of parasitic contamination. *Cryptosporidium* spp. was the predominant parasite, occurring in 9 (30.0%) samples from local restaurants and 12 (40.0%) samples from modern restaurants. *Giardia lamblia* was detected in 10 (33.3%) and 8 (26.6%) samples from local and modern restaurants, respectively, while *Entamoeba* spp. occurred in 9 (30.0%) local restaurant samples and 3 (10.0%) modern restaurant samples. Other parasites, including *Balantidium coli*, *Ancylostoma* spp., *Ascaris* spp., *Fasciola hepatica*, and *Echinococcus granulosus*, were detected at relatively low frequencies. Notably, *Ascaris* spp. and *Echinococcus granulosus* were detected only in local restaurants, whereas *Fasciola hepatica* and *Ancylostoma* spp. occurred at similarly low frequencies in both restaurant categories. Although parasitic contamination was generally higher in local restaurants, modern restaurants in Kaduna South showed a comparatively higher prevalence of *Cryptosporidium* spp., indicating that contamination may also occur within formal food establishments.

Table 2: Morphology of parasite species identified from local and modern Restaurants in Chikun LGA (CHK) of Kaduna Metropolis

Parasite species	Microscopic morphological Description	Occurrence and Concurrence (N=60)		
		LR (30)	MR (30)	Total (60)
Balantidium coli	Protozoan:Largeovalandthick-walled cyst and Trophozoites.	1 (3.3)	0 (0)	1 (1.7)
Entamoeba sp	Protozoan:Roundcyst nuclei	2 (6.7)	0 (0)	2 (3.3)
Giardia lamblia	Protozoan:ovalcystwithnuclei inside flagellated	1 (3.3)	0 (0)	1 (1.7
Fasciola hepatica	Helminths: large operculated egg	0 (0)	0 (0)	0 (0)
Ancylostoma sp	Helminths:Ovalthin-shelled egg with segmented embryo:	0 (0)	0 (0)	0 (0)
Ascaris sp	Helminths: Oval egg,rough thick shell	0 (0)	0 (0)	0 (0)
Echinococcus granulosus	Helminths: Ovalegg rough thick shell mammilated shell	0 (0)	0 (0)	0 (0)
Cryptosporidium sp	Helminths:Largeoval with thick ciliated wall	1 (3.3)	0 (0)	1 (1.7)

N=60

Keys: LR=Local Restaurant; MR=Modern Restaurant; KS=Kaduna South
N=Total number of samples in the entire study; n=number of samples per LGA

Table 3: Morphology of parasite species identified from local and modern Restaurants in Kaduna North LGA (KN) of Kaduna Metropolis

Parasite species	Microscopic morphological Description	Occurrence and Concurrence (N=60)		
		LR (30)	MR (30)	Total (60)
Balantidium coli	Protozoan: Largeovalandthick-walled cyst and Trophozoites	3 (10)	1 (3.3)	4 (6.7)
Entamoeba sp	Protozoan: Roundcyst nuclei	10 (33.3)	3 (10)	13 (21.7)
Giardia lamblia	Protozoan: ovalcystwithnuclei inside flagellated	12 (40)	9 (30)	21 (35)
Fasciola hepatica	Helminths: large operculated egg	2 (6.6)	3 (10)	5 (8.3)
Ancylostoma sp	Helminths: Ovalthin-shelled egg with segmented embryo:	1(3.3)	0 (0)	1 (1.7)
Ascaris sp	Helminths: Oval egg,rough, thick shell	5 (16.6)	0 (0)	5 (8.3)
Echinococcus granulosus	Helminths: Ovalegg rough thick shell mammilated shell	0 (0)	0 (0)	0 (0)
Cryptosporidium sp	Helminths: Largeoval with thick ciliated wall	15 (50)	13 43.3)	28 (46.7)

N=60

Keys: LR=Local Restaurant; MR=Modern Restaurant; KS=Kaduna South
N=Total number of samples in the entire study; n=number of samples per LGA

Table 4: Morphology of parasite species identified from local and modern Restaurants in Kaduna South LGA (KS) of Kaduna Metropolis

Parasite species	Microscopic morphological Description	Occurrence and Concurrence (N=60)		
		LR (30)	MR (30)	Total (60)
Balantidium coli	Protozoan:Largeovalandthick-walled cyst and Trophozoites.	2 (6.6)	0 (0)	2 (3.3)
Entamoeba sp	Protozoan:Roundcyst nuclei	9 (30)	3 (6.6)	12 (20)
Giardia lamblia	Protozoan:ovalcystwithnuclei inside flagellated	10 (33.3)	8 (26.6)	18 (30)
Fasciola hepatica	Helminths: large operculated egg	1 (3.3)	1 (3.3)	2 (3.3)
Ancylostoma sp	Helminths:Ovalthin-shelled egg with segmented embryo:	2 (6.6)	2 (6.6)	4 (6.7)
Ascaris sp	Helminths: Oval egg,rough thick shell	3 (10)	0 (0)	3 (5)
Echinococcus granulosus	Helminths: Ovalegg,rough, thick shell,mammilated shell	2 (6.6)	0 (0)	2 (3.3)
Cryptosporidium sp	Helminths:Largeoval with thick ciliated wall	9 (30)	12 (40)	21 (35)

N=60

Keys: LR=Local Restaurant; MR=Modern Restaurant; KS=Kaduna South

N=Total number of samples in the entire study; n=number of samples per LGA

DISCUSSION

The present study revealed considerable variation in the prevalence and distribution of parasitic species among selected local and modern restaurants across the four (LGAs) of Kaduna metropolis. Overall, local restaurants exhibited a higher prevalence and greater diversity of intestinal parasites than modern restaurants, suggesting that food handling practices, environmental sanitation, and hygiene standards may differ substantially between the two restaurant categories. The predominance of protozoan parasites, particularly *Cryptosporidium* spp., *Giardia lamblia*, and *Entamoeba* spp., further indicates that contaminated water, inadequate hand hygiene, and contaminated food-contact surfaces remain important routes of parasite transmission within food service establishments. These findings agree with previous reports that identified food handlers and contaminated food preparation environments as major reservoirs for the transmission of intestinal parasites in developing countries (Obaid, 2022; WHO, 2023).

Among the four LGAs, Igabi recorded the highest prevalence and widest diversity of parasitic species, with *Cryptosporidium* spp. being the most frequently detected parasite, followed by *Giardia lamblia* and *Entamoeba* spp. The high prevalence of these protozoan parasites, particularly in local restaurants, may be indicative of poor personal hygiene among food handlers, inadequate sanitation facilities, and possible use of contaminated water during food preparation and utensil washing. Protozoan parasites are well recognized for their ability to spread through the faecal–oral route, particularly in environments where access to potable water and effective sanitation is limited (Ryan *et al*., 2021). The occurrence of helminths including *Ascaris* spp., *Ancylostoma* spp., *Fasciola hepatica*, and *Echinococcusgranulosus*, although relatively lower, further suggests environmental contamination resulting from poor waste disposal practices and inadequate environmental hygiene. Similar observations have been reported among food handlers in Ethiopia, Sudan, and other sub-Saharan African countries, where poor hand hygiene, inadequate medical screening, and low levels of food safety awareness were significantly associated with intestinal parasitic infections (Alemu *et al*., 2019; Tiruneh *et al*., 2021).

In contrast, Chikun LGA exhibited the lowest parasitic contamination throughout the study. Only four protozoan parasites were detected at relatively low frequencies, while none of the helminth parasites were identified in either local or modern restaurants. The absence of *Ascaris* spp., *Ancylostoma* spp., *Fasciola hepatica*, and *Echinococcusgranulosus* may reflect comparatively improved sanitary conditions, better waste management systems, safer water sources, and greater adherence to hygienic food handling practices within the selected restaurants. Furthermore, the complete absence of parasites in modern restaurants within Chikun suggests relatively effective implementation of food safety measures compared with the other LGAs. Similar reductions in parasite prevalence have been associated with improved environmental sanitation, regular food handler training, and access to potable water in previous epidemiological studies (Uga *et al*., 2010; Obaid, 2022). Although the reasons for the lower contamination levels were not directly investigated in this study, the findings suggest that improved hygiene infrastructure may contribute substantially to reducing parasite transmission in food service environments.

Kaduna North LGA recorded the second-highest prevalence of parasitic contamination, with

Cryptosporidium spp., *Giardia lamblia*, and *Entamoeba* spp. accounting for most of the positive samples. Interestingly, relatively high occurrences of *Cryptosporidium* spp. and *Giardia lamblia* were observed not only in local restaurants but also in modern restaurants. This observation indicates that parasitic contamination is not exclusively associated with informal food establishments and that formal restaurants may also be vulnerable to contamination when food safety measures are inconsistently implemented. Protozoan parasites such as *Cryptosporidium* spp. produce environmentally resistant oocysts capable of surviving for prolonged periods in contaminated water and on food-contact surfaces, thereby facilitating their transmission despite routine cleaning practices (Ryan *et al*., 2021). The low prevalence of helminths and the absence of *Echinococcusgranulosus* in Kaduna North further suggest that contamination within this LGA was predominantly associated with waterborne protozoan parasites rather than soil-transmitted helminths. Comparable findings have been reported in studies where contaminated water supplies and inadequate hand hygiene were identified as important sources of protozoan transmission among food handlers (Efstratiou *et al*., 2017).

Kaduna South LGA demonstrated a moderate burden of parasitic contamination, with *Cryptosporidium* spp., *Giardia lamblia*, and *Entamoeba* spp. remaining the predominant parasites. Although local restaurants generally exhibited higher prevalence of most parasite species, modern restaurants surprisingly recorded a higher prevalence of *Cryptosporidium* spp. than local restaurants. This finding may indicate contamination originating from common water sources, inadequately sanitized utensils, or infected food handlers rather than differences in restaurant type alone. Unlike many intestinal protozoa, *Cryptosporidium*oocysts possess remarkable environmental resistance and are capable of surviving many conventional disinfection procedures, making them particularly difficult to eliminate once introduced into food preparation environments (Ryan *et al*., 2021; WHO, 2023). Consequently, the occurrence of *Cryptosporidium* spp. within modern restaurants highlights the need for continuous monitoring of water quality and routine environmental sanitation irrespective of restaurant classification.

Across all four LGAs, protozoan parasites were considerably more prevalent than helminths, with *Cryptosporidium* spp. representing the predominant species detected throughout the study. This predominance corroborates previous reports indicating that protozoan infections constitute a significant proportion of foodborne parasitic diseases because of their efficient transmission through contaminated water, food, and infected food handlers (Efstratiou *et al*., 2017; WHO, 2023). The relatively lower prevalence of helminths such as *Ascaris* spp., *Ancylostoma* spp., *Fasciola hepatica*, and *Echinococcusgranulosus* may reflect improved interruption of soil-transmitted parasite life cycles within urban environments or reduced opportunities for environmental exposure compared with rural communities. Nevertheless, the detection of these helminths, particularly in local restaurants, remains a public health concern because their presence indicates faecal contamination and inadequate hygienic practices during food preparation.

The consistently higher prevalence of parasites observed in local restaurants across most LGAs further emphasizes the influence of food handling practices and environmental sanitation on food safety. Informal food establishments often operate under conditions characterized by limited access to potable water, inadequate waste disposal systems, overcrowded food preparation areas, and inconsistent regulatory oversight, all of which may facilitate parasite transmission (FAO, 2022; WHO, 2023). In contrast, the comparatively lower prevalence observed in most modern restaurants may be attributable to improved infrastructure, greater compliance with food safety regulations, and more frequent hygiene inspections. However, the occurrence of protozoan parasites in several modern restaurant samples demonstrates that compliance with hygiene standards alone may not completely eliminate contamination risks, particularly where water quality and food handler health are inadequately monitored.

Overall, the present findings reveal marked geographical differences in parasitic contamination within Kaduna Metropolis, with Igabi recording the highest contamination burden, followed by Kaduna North, Kaduna South, and Chikun. These variations likely reflect differences in sanitation infrastructure, water quality, environmental hygiene, and adherence to food safety practices across the selected LGAs. The findings underscore the importance of routine parasitological surveillance of food service establishments, periodic medical screening and deworming of food handlers, provision of safe and potable water, continuous food safety education, and strengthened enforcement of public health regulations. Implementation of these measures would substantially reduce the risk of foodborne parasitic

infections and improve consumer safety within both local and modern restaurant settings.

CONCLUSION

This study demonstrated that parasitic contamination was prevalent among food handlers and food-contact environments in selected restaurants across Kaduna Metropolis, with marked variations among the four Local Government Areas. Overall, local restaurants harboured a higher prevalence and greater diversity of intestinal parasites than modern restaurants, indicating comparatively poorer hygiene and sanitation practices. *Cryptosporidium* spp. was the most frequently detected parasite across the study areas, followed by *Giardia lamblia* and *Entamoeba* spp., while helminth parasites occurred at relatively lower frequencies. Igabi LGA recorded the highest parasitic burden, whereas Chikun LGA exhibited the lowest prevalence. The detection of these parasites in food-contact environments highlights the potential risk of foodborne parasitic infections among consumers and underscores the need for improved food safety and hygiene practices in both local and modern restaurant settings.

Regular medical screening of food handlers, continuous food safety and hygiene training, provision of safe water, and improved sanitation practices should be prioritized to reduce parasitic contamination in restaurants. Regulatory agencies should strengthen routine inspection and enforcement of food safety standards in both local and modern restaurants. In addition, public health awareness campaigns should be intensified, while further molecular-based studies are recommended to enhance the surveillance and epidemiological understanding of foodborne parasitic infections in Kaduna State.

REFERENCES

Alemu, G., Mama, M., Misker, D., and Haftu, D. (2019). Intestinal parasitic infection and associated factors among food handlers in Ethiopia: A systematic review and meta-analysis. *BMC Public Health,* **19**, 1315.

Efstratiou, A., Ongerth, J. E., and Karanis, P. (2017). Waterborne transmission of protozoan parasites: Review of worldwide outbreaks-An update 2011–2016. *Water Research,* **114**, 14–22.

Fletcher, S. M., Stark, D., Harkness, J., and Ellis, J. (2012). Enteric protozoa in the developed world: A public health perspective. *Clinical Microbiology Reviews*, **25**(3), 420–449.

Food and Agriculture Organization of the United Nations, and World Health Organization. (2014). *Multicriteria-based ranking for risk management of food-borne parasites*. Microbiological Risk Assessment Series No. 23. Rome, Italy: FAO/WHO.

Food and Agriculture Organization of the United Nations. (2022). *The state of food safety and quality*. Rome, Italy: FAO.

Gizaw, Z., Addisu, A., Dagne, H., Chanie, E. S., Yeshitila, Y. G., Tsegaye, B., and Aderaw, Z. (2022). Prevalence of intestinal parasites and associated factors among food handlers in food establishments in the Lidetasubcity of Addis Ababa, Ethiopia: An institution-based, cross-sectional study**.***BMJ Open,* **12**(7), e061688

Grace, D. (2015). Food safety in low- and middle-income countries. *International Journal of Environmental Research and Public Health,* **12**(9), 10490–10507.

Kaduna State Bureau of Statistics. (2022). Economic and agricultural report of Kaduna State. KSBS.

Mensah, P., Yeboah-Manu, D., Owusu-Darko, K., and Ablordey, A. (2002). Street foods in Accra, Ghana: How safe are they?*Bulletin of the World Health Organization,* **80**(7), 546–554.

Nigeria Centre for Disease Control. (2023). *National guidelines for food safety and food hygiene in Nigeria*. Abuja, Nigeria: Nigeria Centre for Disease Control.

Obaid, H. M. (2022). Laboratory diagnosis of intestinal parasites: Conventional and emerging techniques. *Journal of Parasitic Diseases,* **46**(2), 305–315.

Odeyemi, O. A., Sani, N. A., and Obadina, A. O. (2020). Food safety knowledge, attitudes and practices among food handlers in developing countries: A review. *Food Control,* **110**, 106947.

Ryan, U., Hijjawi, N., Feng, Y., and Xiao, L. (2021). *Cryptosporidium* species in humans and animals: Current understanding and research priorities. *Parasitology,* **148**(5), 537–559.

Setia, M. S. (2016). Methodology series module 3: Cross-sectional studies.*Indian Journal of Dermatology,* **61**(3), 261–264.

Tefera, T., Mebrie, G., and Feleke, D. (2021). Intestinal parasitic infections and associated factors among food handlers: A systematic review and meta-analysis. *Environmental Health Insights,* **15**, 1–13.

Todd, E. C. D., Greig, J. D., Bartleson, C. A., and Michaels, B. S. (2007). Outbreaks where food workers have been implicated in the spread of foodborne disease. Part 1: Description of the problem, methods, and agents involved. *Journal of Food Protection,* **70**(7), 1752–1761.

Uga, S., Hoa, N. T. V., Noda, S., Moji, K., Cong, L., Aoki, Y., Rai, S. K., and Fujimaki, Y. (2010). Parasite egg contamination of vegetables from a suburban market

in a developing country and associated public health risks. *Tropical Biomedicine,* **27**(3), 442–450.

World Health Organization. (2022). *Food safety*. Geneva, Switzerland: World Health Organization.

World Health Organization. (2023). *Food safety*. Geneva: World Health Organization. https://www.who.int/news-room/events/detail/2023/06/07/default-calendar/world-food-safety-day-2022-safer-food-better-healt

Yeshanew, S., Tadege, M., and Abamecha, A. (2021). Prevalence and associated factors of intestinal parasitic infections among food handlers in Mettu Town, Southwest Ethiopia. *Journal of Tropical Medicine* Article 6669734.