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Food safety and hygiene knowledge, attitudes and practices in street restaurants selling chicken in Ouagadougou, Burkina Faso

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Introduction: Chicken is the most commonly consumed animal source food in street restaurants in Burkina Faso. In most of these restaurants, slaughtering, processing, and cooking practices are carried out under poor hygienic conditions.

Methods: A cross-sectional survey using a semi-structured interview was carried out to assess food safety knowledge, attitude, and hygienic practices of food handlers in street restaurants selling chicken in Burkina Faso's capital, Ouagadougou. One hundred chicken restaurants were randomly selected, and food handlers were interviewed.

Results and discussion: Most restaurants served eat-in and takeaway chicken (66%); the remaining 34% were takeaway only; restaurants served grilled, flamed or roasted chicken. Only 11% of the food handlers had training on food hygiene and safety. Half the outlets were not regularly inspected by the authorities. Less than half (40%) slaughtered their own chickens at the restaurant: of these 85% bled chickens on bare earth. About 80% cleaned the bleeding surface immediately after slaughter with water but only 20% used water with either soap or disinfectant detergent. Eighty-two percent of them used the same cloth during slaughtering and food preparation stages. Many used the same knife in all stages of the slaughtering process. Two-thirds kept carcasses unrefrigerated at ambient temperature until cooking started. Around a quarter buried slaughter waste on-site whereas 20% disposed of it on the street near the restaurant. Only 20% had taken steps to improve food safety, and about 80% of food handlers stated that cleanliness and hygiene were not important to their customers when choosing where to eat. Almost half (42%) the food handlers continued to work when they were ill. The poor standards of hygiene observed are typical for street food and small-scale eateries in LMICs in Sub Saharan Africa. An integrated approach is required to improve the situation, including staff training, introduction of food-grade equipment and appropriate technology, behavior-change approaches, as well as worker and consumer awareness campaigns on good food safety practices. However, significant, sustained improvement in food safety will also require major upgrading of infrastructure and facilities including power and water supply, and cold chain.

KEYWORDS

poultry, restaurants, food handlers, food safety, Burkina Faso

1 Introduction

Across the world chicken is a widely consumed animal source food and poultry value chains are an important source of income and nutrition, particularly in low- and middle-income countries (LMICs) where production and consumption are increasing rapidly (Wong et al., 2017). However, poultry products are among those most often implicated in foodborne disease (FBD) outbreaks resulting in severe disease burden and economic losses (Thung et al., 2016; Hoffmann et al., 2017; Li et al., 2019; Mezali et al., 2019; Mpundu et al., 2019; Sapp et al., 2022; van Wagenberg and Havelaar, 2023).

The World Bank has estimated that the economic cost of FBD in LMICs at \$95.2 billion per year from lost human capital (productivity), with additional costs of treating FBD at least \$15 billion (Jaffee et al., 2019; Grace, 2023). These financial burdens are highest in larger, middle-income nations such as South Africa, Nigeria, and Egypt, but are also significant in other countries. African countries bear a greater *per capita* burden of foodborne diseases than other LMICs (Havelaar et al., 2015; Grace, 2023). This high burden has been linked to poor food handling and sanitation practices, inadequate food safety regulations, lack of financial resources to invest in safer equipment, and inadequate food-handler education; factors that jeopardize the health and nutritional status of the most vulnerable groups in those countries (Grace, 2015; Hoffmann et al., 2019). Given that most foods in LMICs are purchased in informal, traditional food systems, much the burden of FBD in LMICs is also linked to these markets (Havelaar et al., 2022).

In Burkina Faso, the poultry sector is important and growing. More than 98% of the poultry produced and consumed in the country comes from traditional systems (Schneider et al., 2010; Dione et al., 2021). The demand for poultry products in the country outstrips supply and is likely to expand with growth in population, income, and urbanization (Hoffmann et al., 2019). With this increase, the FBD burden will likely increase, unless measures are taken.

In 2017 it is estimated that at least 400,000 people, or 1 out of 50 in the total population of Burkina Faso fell ill from consuming poultry meat contaminated with *Campylobacter* spp. and non-typhoidal *Salmonella* spp., resulting in a loss of 42,600 Disability Adjusted Life Years (DALYs: one lost DALY is the equivalent of one lost year of healthy life) (Havelaar et al., 2022). The economic costs associated with just three foodborne diseases in Burkina Faso were substantial (3.0% of Gross National Income (GNI)) (van Wagenberg and Havelaar, 2023).

Chicken is the primary animal source food consumed in Ouagadougou street restaurants, with consumption in this setting being part of day-to-day life, and greater than home consumption. More than three quarters of poultry is consumed at street restaurants (called 'maquis') (Somda et al., 2018). In most of these restaurants, slaughtering, processing and cooking practices are carried out with poor hygienic conditions, leading to concern among market actors and consumers (Dione et al., 2021). Most customers are men or young women, with ready-to-eat chicken taken back to the home for the family. In Ouagadougou chicken was consumed on most days by middle- and high-income men, with low-income households only consuming chicken at special celebrations every few months.

However, major hygiene issues have been identified in these outlets. Poultry products on sale in Ouagadougou are heavily

contaminated with diarrheagenic *Escherichia coli*, *Salmonella* spp. and *Campylobacter* spp. Cross-contamination is common during food processing and preparation, increasing the risk of consumer exposure to agents of FBD (Kagambèga et al., 2018; Somda et al., 2018).

Food handlers can be a major source of food contamination, particularly for ready-to-eat food, such as that served in restaurants or sold for takeaway (Ncube et al., 2020). To develop interventions to improve chicken restaurant food safety we must better understand the hygienic status, worker knowledge and perceptions towards food safety. This study was performed as part of the Pull-Push project¹ to identify options for interventions to improve food safety, that could then be further investigated.

2 Materials and methods

2.1 Survey instrument and questionnaire administration

A questionnaire was developed and uploaded to note-pad mobile devices installed with open data kit (ODK) software. Trained enumerators collected data from 100 randomly selected restaurants, interviewing owners or employees. The questionnaire consisted of several questions grouped into three major sections. The first part covered background information of the participant and their working environment (demographic, regulatory, sources of live chickens, and other relevant information). The next section covered process hygiene, focusing on the participants' slaughtering, personal hygiene, and cooking practices. The last section of the questionnaire was on personal knowledge and perception of participants towards food safety in general, and chicken handling in particular. Prior to the study, the questionnaire was piloted with 8 food handlers.

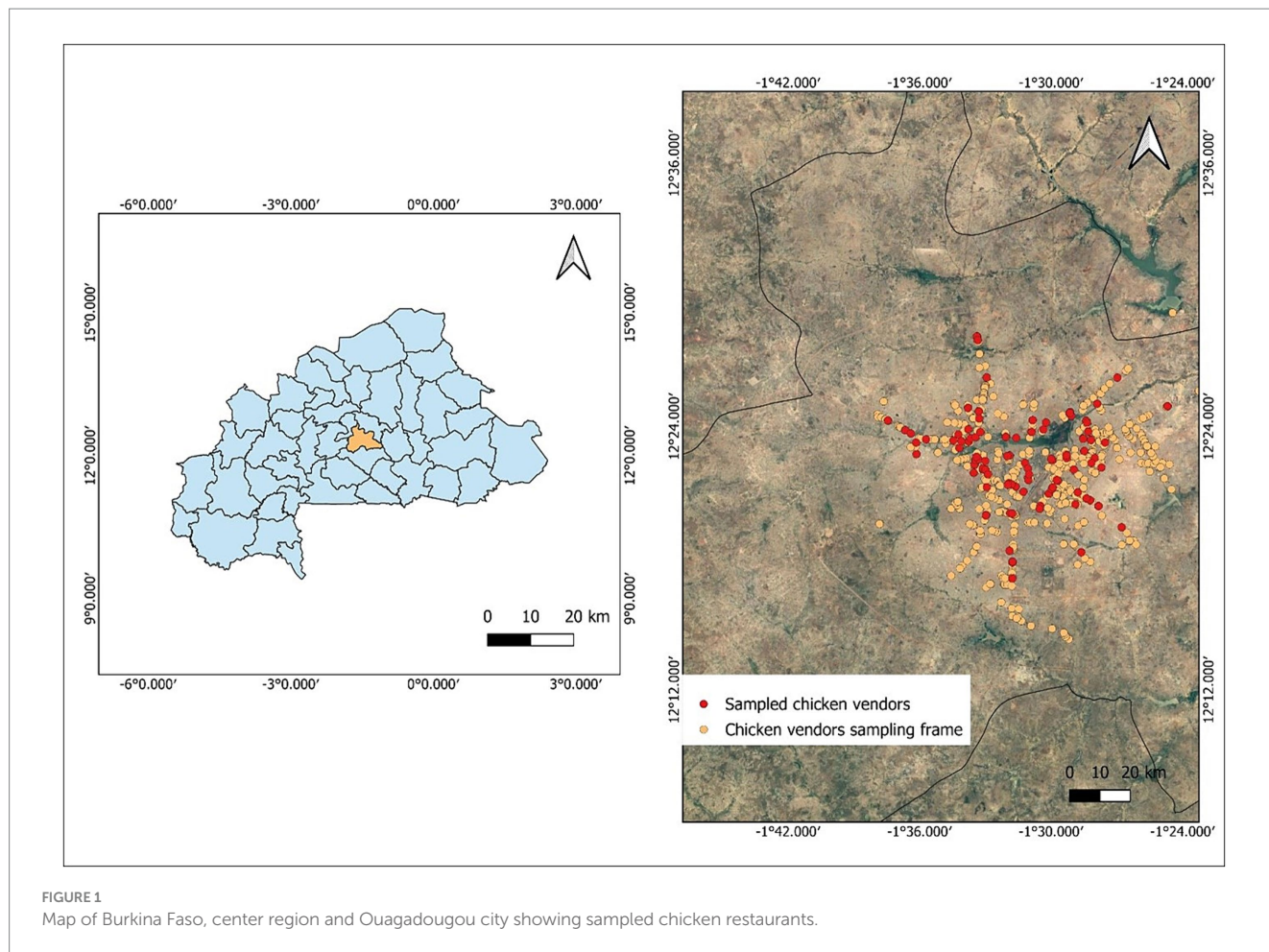
Each enumerator had a list of chicken vendors to visit with reserve outlets to replace those who did not consent to the survey or were unreachable. Enumerators clarified the objective of the work and consent was obtained from each participant.

2.2 Study area, sampling and sample size

The study was carried out in Ouagadougou, the capital of Burkina Faso. The sample size calculation was conservatively based on the outcome parameters which required the largest sample size, that is binary outcomes with a proportion of 50%, requiring 95% confidence intervals (CI) with 10% absolute precision either side of the estimate (Lemeshow et al., 1990). The required sample size was 97 outlets, which was rounded up to 100 to account for failings in data collection.

First, the city's main roads were georeferenced, and a route was established for trained enumerators. The enumerators then surveyed

¹ "Pull-Push" Urban food markets in Africa: Incentivizing food safety using a pull-push approach.



this route, recording the location of each eligible chicken restaurant. Outlets located along medium and main roads throughout the city were mapped to create a sampling frame ($n=622$). From this sampling frame, outlets were randomly selected (Figure 1).

2.3 Data management and analysis

Once collected, data was exported to MS excel where it was cleaned, checked, and prepared for analysis. The findings were summarized with descriptive statistics using STATA version 17. Data were presented in tables (frequencies and proportions) and graphs.

3 Results

3.1 Background information of participants and the restaurants

Of 100 participants, 93% were men, while 7% were women. Forty-eight percent were restaurant employees, the rest being owners or their relatives working at the outlet. Among the outlets visited, 41% were restaurants with seating but no permanent structure, 25% were restaurants with seating and a permanent structure, 22% were

takeaways with no building or structure, and 11% were takeaways with a structure but no seating.

Only 11% of the respondents had previous training on food safety and related topics; 47% were not regularly inspected by the authorities. Just under a third of participants reported the presence of animals around the outlets, mostly chickens, goats, pigs, and cats (Table 1).

3.2 Price, source of carcass and live chicken markets

Restaurants slaughtered chickens themselves, and/or others bought carcasses from other slaughterers. Twenty-two percent of the restaurants purchased chicken carcasses, while 55% relied on other enterprises for slaughtering chickens. Of those who got chicken carcasses from other suppliers (purchased or slaughtered by another enterprise), 36 (62%) had only one supplier, while 18 (31%) had two suppliers and four (7%) had 3–4 suppliers. About 40 (40%) of the restaurants slaughtered chicken themselves, and most of these perform on-site slaughter (85%). Of those who slaughtered chicken themselves, about half of the restaurants got live chickens from a middleman who kept the chickens for a short period, the next most common source was urban markets and after that village markets. The average price of a chicken is 3,479 XOF, equivalent to 6 USD as of March 2021 exchange rate. On average establishments sell 83 servings per day and more than

TABLE 1 Background data of respondents and characteristics of restaurants.

Background	Category	N	%
Gender	Male	93	93%
	Female	7	7%
Role	Employee	48	48%
	Owner	37	37%
	Owner's relation working at outlet	14	14%
	Other	1	1%
Type of outlet	Restaurant with seating but no permanent building	41	41%
	Restaurant with seating and permanent building	25	25%
	Take-away with no building or seating, cooking on the street	22	22%
	Take-away with a building but no seating	12	12%
Inspected by authorities	Yes	53	53%
	No	47	47%
Received food safety related training	Yes	11	11%
	No	89	89%
Roaming animals near the outlet	Yes	30	30%
	No	70	70%
Type of animal roaming near the outlet	Chicken	13	22.4%
	Goat	11	19%
	Pig	10	17.2%
	Cat	10	17.2%
	Dog	8	13.8%
	Sheep	4	6.9%
	Cattle	1	1.7%
	Other poultry (not chicken)	1	1.7%

300 raw chickens per week. On average participants reported that 67% of customers who visited the outlets were male. Age-wise, more than 50% of customers were between the ages of 21–60 (Figure 2).

3.3 Operational hygiene and food safety practices from collection to consumption of chicken carcass at the restaurants

3.3.1 Collection of chicken and carcass

About 30 (75%) restaurants which slaughtered chickens kept live chickens at the outlet, but they did not keep chickens for many days before slaughter, on average 1.4 days, with 2.5 days a typical maximum. Around 92% of outlets claimed not to slaughter sick birds. In 97.5% of restaurants, chickens had access to feed immediately before slaughter. Restaurants, which slaughtered their birds in another establishment, commonly used plastic bags (43%) and sacks (17%) to carry carcasses to the restaurant. It took on average 30 min and a maximum of 2 h from when a chicken was slaughtered until they received the carcass. During this time, most of the restaurants (89%) transported carcasses at ambient temperature. After receiving chicken carcasses, they kept them on average for a minimum of 2.5 days, most likely for 3.5 days and maximum of 5.5 days until cooking. Only about 19 and 14% of them kept chicken carcasses in a

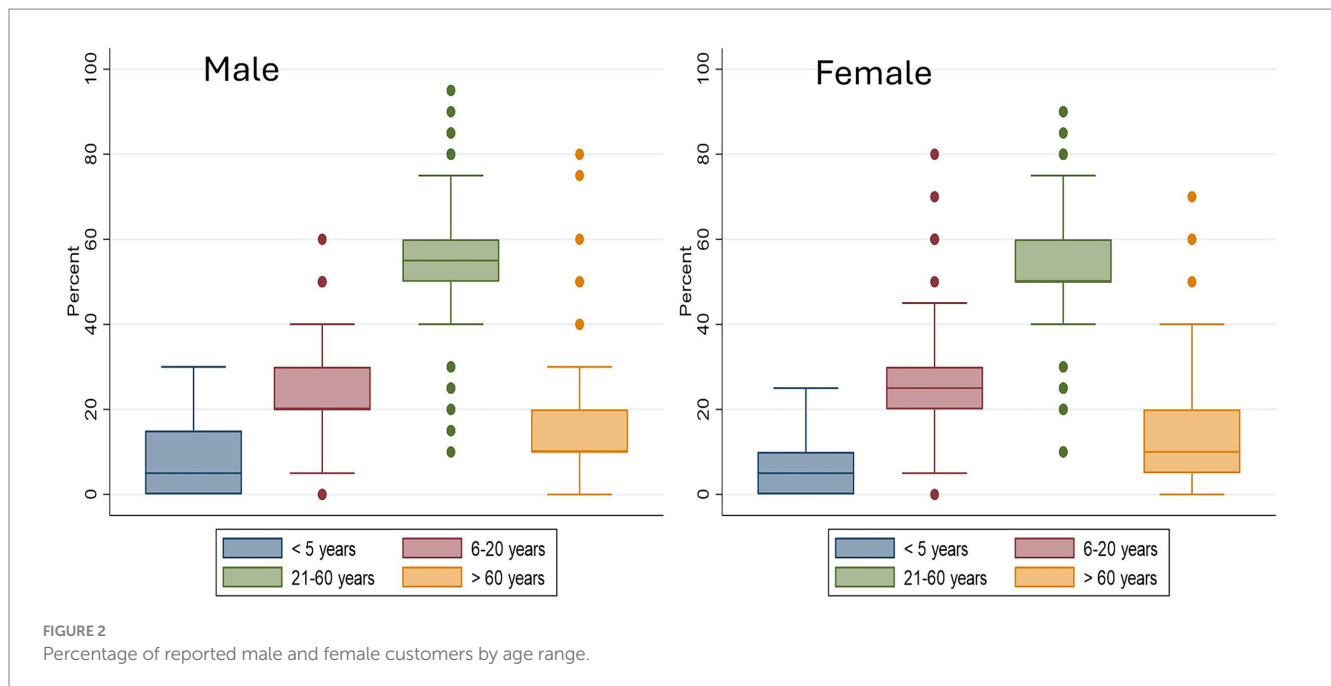
refrigerator or freezer, respectively. The rest kept carcasses in a container or open air at ambient temperature.

3.3.2 Slaughtering/bleeding process

Most restaurants, 34 (85%) which slaughtered chicken performed slaughtering at the site where they prepared and sold food (Table 2). As a bleeding surface, most used bare earth, followed by cement and ceramic (Table 3). About 80% of outlets cleaned the bleeding surface immediately with water but only 8 (20%) used either soap or disinfectant-detergent (Table 4).

3.3.3 Scalding and plucking process

Following bleeding, chickens were scalded. An average of 24 chickens were slaughtered and scalded in one batch. An average of 16.5 liters of water was used in the scald tank and about 10 outlets shared the same scald water. Typically, around 17 chickens were scalded in the scald water before the water was changed. About 58% of the outlets which slaughtered chickens themselves changed scalding water for every batch of birds (Table 4). Respondents said they hot water to defeather the chickens and knew the proper temperature mainly from when the water starts to boil, and vapor appears. Most of them plucked chickens on wood and plastic surfaces. Most used disinfectant-detergent and sanitizer to clean the plucking surface (Table 3).



3.3.4 Evisceration

The majority of outlets performed evisceration on a table and in a container/bowl. The surface of table/bowl was most commonly made of wood followed by plastic. Around 43% of the outlets washed the evisceration surface with only water (Table 4), the rest using soap and disinfectants to clean the evisceration surface (Table 3). Half of the outlets washed the area of evisceration every day, but the mean was every two and half days.

3.3.5 Carcass processing

After slaughter, a carcass was placed in a bowl or on a table made of plastic or wood for further processing and kept for an average of 15 min. Respondents most commonly cut carcasses on the table, followed by in a bowl made of wood and plastic. These cutting surfaces were cleaned with soap and disinfectant-detergent. Other animals often came in contact with carcass processing surfaces, especially cats, dogs and livestock (Table 5). All respondents said they washed carcasses with water after slaughter. But 20% of them do not change the wash water for every slaughter batch and changed the wash water a minimum of once a day and a maximum of 3 times a day. When washing chicken carcasses, an average of 15 liters of water are used with on average 12 chicken carcasses washed before the water is changed.

The majority (53%) of the outlets stored carcasses at ambient temperature. Plastic bags and sacks were commonly used as carcass carrying material.

3.3.6 Frozen chicken

Only 2% of outlets bought frozen chicken, and 25 and 24% owned a freezer or fridge on their site, respectively.

Around 25% washed the frozen carcasses with water only before cooking. In addition, 90% washed the working area before cooking the carcass. Furthermore, 69% had access to electricity but reported power cuts every 3 days on average with power cuts lasting 6 h on average (Table 6).

3.3.7 Chicken preparation and cooking

Before cooking, respondents used on average 15 liters of water to wash the carcasses; there was a gap of 20 min between slaughter time and cooking time on average. After chicken was prepared, it took typically 15 min until it is served.

Workers typically washed chicken preparation surfaces at the start and end of the shift. Only a few of them washed in between meals. They used soap and disinfectant detergents to clean the chicken preparation surface (Table 7). Cooks knew when chicken was well cooked primarily by the appearance of the meat's surface and by stabbing the meat (Supplementary Table S1).

Grilled, flamed and roasted chicken were the most common dishes sold. But 43% of outlets sold raw/uncooked chicken for customers to cook at home as well. Grilled chicken was cooked over direct heat, either on a grill or a grill pan and used no other cooking medium. It was typically seasoned with herbs, spices, or marinades and cooked until the exterior was charred or marked with grill lines. Flamed chickens are processed and sold as street foods. Locally bred chickens, known as "poulet bicyclette," are traditionally processed into flamed chickens by direct exposure to burned charcoal and wood flame. Roasted chicken are cooked in front of or over a fire or bed of coals or cooked in the oven as well. About 17% of the outlets sold dishes with raw tomatoes and 7% sold with salads (Table 8).

3.3.8 Personal hygiene and workplace

Most of the participants cleaned knives and hands during slaughter and cooking with clean water, and nearly 93% of them used cleaning products, like soap, as well. Just under half of them used the same knife in all stages of the slaughtering process. Similarly, more than 80% used the same cloth for slaughtering and food preparation (Table 9). About 95% of them claimed they have access to the required amount of water, and 100% reported access to clean water. The primary water source of the restaurants was the main public water supply, and a few of them used water from boreholes.

TABLE 2 Source of chicken, transport, slaughter and live bird information.

Outlet Practices	Yes	%	No	%
Purchase chicken carcass	22	22%	78	78%
Obtained chicken carcasses from other enterprises	55	55%	45	45%
Transport carcass at ambient temperature (Of the outlets that outlets that obtained chicken carcasses from other enterprises)	49	89%	6	11%
Outlet performs chicken slaughter	40	40%	60	60%
The source of the live chickens for outlets that slaughter				
From an urban market	10	25%	30	75%
From a village market	6	15%	34	85%
From a middleman who has kept the chickens for a short period	20	50%	20	50%
From a middleman who brings birds directly from farm to the outlet	4	10%	36	90%
Rear their own chicken	2	5%	38	95%
Perform onsite slaughter	34	85%	6	15%
Store live chickens at the outlet	30	75%	10	25%
Use disinfectant to clean chicken pens/cages	15	43%	20	57%

Most cleaned knives at the beginning and the end of the day as well as before slaughtering a batch of chickens and after slaughtering a batch. Outlets used mostly soap and disinfectant-detergents to clean knives. The majority of slaughterers claimed to wear clean clothes and aprons during slaughtering of chicken. About 28% of them wore both a clean apron and a fabric resembling an apron while working, depending on their availability (Supplementary Table S2). Most respondents washed their hands at the beginning and the end of the day, and before slaughtering a batch and after slaughtering a batch (Supplementary Table S3). Slaughter waste was mostly buried on the site, thrown away in the street or collected in trash cans (Table 5).

3.3.9 Facility hygiene

Animals did come in contact with food preparation surfaces in about quarter of the restaurants but the majority (78%) of them have no animal control plan. Moreover, 66% of them also did not control flies. About 27% of respondents reported they did not have adequate toilet facilities (Table 10).

Most restaurants used private toilets near their site or private toilets far from their restaurants. Among the animals that come and contact the chicken cooking surface, cats in 22 premises (81.5%) and dogs in 19 premises (70.4%) accounted for the highest number. Among the control measures used for these animals, fencing was most common. From those who employ fly control measures, fly spray and glass windows were used (Table 11).

3.4 Food safety perception and knowledge

About 80% of respondents thought that cleanliness and hygiene were not important to their customers when they choose where to eat chicken. Only about 20% of them had adopted an activity to improve the hygiene and safety of food in their restaurant recently. More than 80% of them were not aware of customers becoming sick from eating tomatoes and chicken. About 90% of them

understood the importance of temperature in storing food (Table 12).

When they felt sick, 42% of outlet respondents reported they did not go to work, 21% worked but washed their hands thoroughly, and 19% washed their hands more thoroughly and minimized food handling (Figure 3). Only 27% of the restaurants received a complaint about their food. Their most frequently encountered customer complaints were the cost (37%) and taste (25.7) of a chicken.

During slaughter and food preparation stages, about quarter to a half of outlet staff think clean hands (45%), clean surfaces (45%), clean water for washing (40%), avoiding contaminating carcasses with gut contents (40%), and clean equipment (23%) were important practices to ensure chicken safety (Supplementary Tables S4, S5). Furthermore, they think that clean surfaces (77%), clean hands (44%) and clean knife/equipment (37%) were important to ensure chicken is safe during cooking (Supplementary Table S6). Respondents also reported food appearing clean (43%), food appearing fresh (33%), the origin of the food (from a producer they trust) (17%), and the stall's appearance (7%) were the top hygiene concerns of their customers.

4 Discussion

Chicken meat can be contaminated with foodborne pathogens at various points along the supply chain including production, transport, slaughter, and meat processing and handling, posing significant health risks to consumers (Prachantasena et al., 2016; Thung et al., 2016; Kagambèga et al., 2018; Perez-Arnedo and Gonzalez-Fandos, 2019; Sun et al., 2021). In this study, we found that hygienic practices, perceptions and knowledge of workers in restaurants and takeaways selling chicken in Ouagadougou were poor, sometimes strikingly poor, with food routinely prepared in unhygienic environments with inadequate facilities and practices.

Most restaurants sold food in the street without permanent buildings, while only a quarter had a permanent site and building,

TABLE 3 Chicken bleeding, plucking and evisceration surface and cleaning.

Questions	Response category	N	%
Surface type where the chickens were bled	Earth	34	85%
	Cement	2	5%
	Cloth	1	2.5%
	Plastic	1	2.5%
	Ceramic	2	5%
Reported ways of judging temperature of scalding water	Starts to boil with water vapor	15	40%
	Starting to boil	3	7.5%
	Heating time and others	1	2.5%
	Starting to boil, water vapor and heating time	2	5%
	Starting to boil, water vapor, heating time, and the bubbles on the surface of the pot	4	10%
	Starting to boil, water vapor and, the bubbles seen on the surface of the pot	1	2.5%
	It's starting to boil, water vapor and heating time	2	5%
	Water vapor	3	7.5%
	The bubbles on the surface of the pot	2	5%
	Heating time	2	5%
	Others (do not use water)	4	10%
Type of surface material for feather plucking	Wood	18	45%
	Plastic	16	40%
	Metal	2	5%
	Earth	2	5%
	Cement	2	5%
What else was used to wash plucking surface in addition to water	Disinfectant-detergent	14	73.7%
	Sanitizer	4	21.1%
	Other (Omo)	1	5.3%
Evisceration places	Table	29	72.5%
	Container/bowl	10	25%
	Other	1	2.5%
Evisceration surface materials	Earth	1	2.5%
	Cement	2	5%
	Metal	2	5%
	Plastic	9	22.5%
	Wood	26	65%
Detergent to clean evisceration surface	Soap	13	56.5%
	Soap and other	1	4.4%
	Soap, disinfectant-detergent and sanitizer	1	4.4%
	disinfectant	6	26.1%
	disinfectant-detergent and sanitizer	1	4.4%
	sanitizer	1	4.4%

mainly serving grilled, flamed and roasted chicken. Outdoor food markets are exposed to environmental contaminants, and are often dusty and windy making good hygiene a challenge (Oguttu et al., 2014; Campos et al., 2015). Permanent buildings are easier to clean and protect food from animals and dust.

The majority of restaurants lacked adequate toilet facilities with inadequate handwashing, critical for hygiene. Human faecal-oral transmission is a key pathway for foodborne pathogen spread, including via contaminated food after unhygienic handling. Half of the outlets visited had not been regularly inspected by authorities to

TABLE 4 Status of operational hygiene during slaughtering and subsequent processing stages.

Slaughtering practices	Yes		No	
	N	% (95% CI)	N	%
Chickens have access to feed immediately before slaughter	39	97.5% (86.8–99.9)	1	2.5%
Slaughtered sick birds for consumption	3	7.5% (1.6–20.3)	37	92.5%
Often slaughter birds for immediate consumption as chicken is ordered	34	85% (70–94.3)	6	15%
Wash surface after bleeding with water	32	80% (64.4–90.9)	8	20%
Wash the carcass after every slaughtering batch	32	80% (64.3–90.9)	8	45%
Scald water was changed for every slaughter batch	23	57.5% (40.9–72.9)	17	42.5%
Wash the evisceration surface with only water	17	42.5% (27–59.1)	23	57.5%

enforce and promote good food safety practices. Furthermore, most had not received any training on food safety or good hygiene. Studies indicate that educational campaigns on food safety and hygienic practices influence people's perception and knowledge of the subject (Adesokan et al., 2015; McFarland et al., 2019). Moreover, the presence of roaming live animals like chickens, goats, pigs and cats near the outlets, contributes to pathogen contamination (Pouokam et al., 2017; Heredia and García, 2018).

In most restaurants which do their own slaughtering, chickens had access to feed immediately before slaughter. Feed withdrawal 6 to 10 h before slaughter reduces the feed content in the digestive tract. This helps prevent gut contents spillage during carcass evisceration and contamination during processing (Xue et al., 2021).

4.1 Process hygiene (hygienic practices)

Some restaurants regularly slaughtered sick chickens for human consumption, which should not be done because sick birds are sources of foodborne zoonoses, this also reflects the poor health and welfare that birds are subjected to (Khamesipour et al., 2018). The surface where birds are slaughtered was often bare earth, making adequate cleansing a challenge or impossible, and the majority of outlets used only water to wash blood contaminated environments, when detergent or sanitizer/disinfectant are required to remove pathogen contamination (Singh et al., 2020). Furthermore, almost half of the outlets did not clean the surfaces used for bleeding after each batch of birds, cleaning only at the end of the day. This greatly increases the risk of contamination.

After bleeding, plucking was performed using hot water for scalding in equipment made of plastic and metal. Although some did not change the scalding water after every batch of birds and cleaned the tank with disinfectant-detergent, the majority did, which is a good practice because the tank is among the initial points where carcasses can be contaminated. Environmental contaminants like *E. coli*, *Staphylococcus aureus*, *Pseudomonas* spp., *Acinetobacter* spp. and many other organisms have been implicated in contaminating the carcass at plucking due to favourable temperatures (Zweifel and Stephan, 2012; Barbut, 2016; Song et al., 2021). Evisceration was performed on a table, or a bowl made of plastic or metal, and more than half of the restaurants used tap water and soap to clean the evisceration surface. Among the stages of chicken processing, evisceration is a key stage where carcasses can be contaminated with gut microbiota and environmental contaminants from the working environment unless proper hygienic measures are implemented (Schets et al., 2017; Perez-Arnedo and Gonzalez-Fandos, 2019).

Respondents indicated that they used the same knife in all slaughtering stages and the same person slaughtered, prepared and cooked the meat wearing the same clothes or apron. There should be clear separation between "dirty" stages of this process, where handler, environment and equipment contamination are likely, and stages involving handling of carcasses and meat. Handling of live birds and slaughter waste in particular should be separated, but there is also a need to reduce contamination between other steps, e.g., slaughter, defeathering, evisceration and carcass preparation.

Wearing the same clothes, and using the same uncleaned knives, with limited hand washing will transfer pathogens along the slaughter line and food preparation areas. Many only washed knives and hands at the start and end of the day, creating massive cross contamination of carcasses. Previous studies have demonstrated that the risk of contamination increases when restaurant staff wear dirty clothing while working. Poor personal hygiene can also facilitate the transmission of pathogens through food to humans. Restaurant personnel can act as mechanical vectors for *Salmonella* cross-contamination from raw chicken, vegetables, or the environment through utensils or other tools (Mensah et al., 2002; Cardinale et al., 2005).

Slaughter waste disposal facilities were lacking in the restaurants, and a significant number of vendors disposed slaughter waste in the streets. Slaughter waste is highly contaminated and must be separated from the slaughter environment and disposed of safely in a manner which is financially sustainable, feasible, socially and legally acceptable, and environmentally friendly (Abdel-Shafy and Mansour, 2018).

4.2 Chicken preparation and cooking

Various unhygienic practices were reported after slaughtering and during cooking and serving. Again, some restaurant workers cleaned kitchen utensils and their hands with only water, without any detergents. Even cleaning with detergent and hot water results in low reduction in microbial contamination, and disinfectants or sanitizers should be used (Scott et al., 1984). A study showed, thorough disinfection of the kitchen and utensils was linked to a reduced risk of *Salmonella* contamination (Cardinale et al., 2005). Washing hands with water and soap is an effective way to eliminate pathogens that may be present on hands (Centers for Disease Control and Prevention (CDC), 2021). Cross-contamination can occur when food workers touch other utensils, kitchen surfaces, or prepare other foods after handling raw chicken without properly washing their hands with soap and water (Bruhn, 2014). A recent quantitative microbial risk

TABLE 5 Places to put carcass immediately after slaughter, dressing and transport.

Items	Response	N	%
Where carcasses were placed immediately after slaughter and dressing	Container/bowl	18	45%
	Table	16	40%
	Others (fence, dish, On the grill)	6	15%
Surface materials where carcasses were placed immediately after slaughter	Plastic	14	35%
	Wood	19	47.5%
	Cement	1	2.5%
	Metal	5	12.5%
	Others (fence)	1	2.5%
Places of slaughter waste disposal	Buried on-site	10	25%
	In the street	8	20%
	Municipal rubbish	2	5%
	Trash bin	18	45%
	Other (downstream)	2	5%
Carcass cutting surface after slaughter	Table	31	77.5%
	Container/bowl	7	17.5%
	Other	2	5%
Materials for butchering surfaces	Wood	27	67.5%
	Plastic	9	22.5%
	Metal	1	2.5%
	Other	3	7.5%
Butchering surface cleaned with detergents	Soap	16	61.5%
	disinfectant-detergent	8	30.8%
	Sanitizer	1	3.9%
	Others	1	3.9%
Animals come into contact with slaughter surfaces	Yes	14	35%
	No	26	65%
Animals that come into contact with slaughter surfaces	Cats only	4	28.6%
	Cats and dogs	6	42.9%
	Cats, dogs and livestock	1	7.1%
	Dogs only	2	14.3%
	Dogs and others	1	7.1%
Store carcass after receiving until cooking	In container at ambient temperature	31	53.5%
	In refrigerator	11	18.9%
	In freezer	8	13.8%
	In open air at ambient temperature	8	13.8%
Carcasses carrying materials during transport to outlet	Plastic bag	25	43.1%
	Plastic bag and sack	11	18.9%
	Sack	10	17.2%
	Sack and others	1	1.7%
	Plastic box	1	1.7%
	Plastic box and plastic bag	1	1.7%
	Plastic bag and others	1	1.7%
	Others	8	13.8%

TABLE 6 Information on frozen chicken.

Outlet Practices	Yes	%	No	%
Buy frozen chicken	2	2%	97	97%
Own freezer on-site	25	25%	74	74%
Own fridge on-site	24	24%	75	75%
Wash frozen carcass with only water	25	25%	74	74%
Surfaces washed before chicken preparation	89	90%	10	10%
Have electricity supply	69	69.7%	30	30.3%

TABLE 7 Timing when they wash chicken preparation surface, and detergents used.

Questions	Response	N	%
Timing when they wash chicken preparation surface	Start of shift	33	33.3%
	Start of shift and end of shift	38	38.4%
	Start of shift, end of shift and during shift between dishes	16	16.2%
	Start of shift and during shift between dishes	1	1%
	End of shift	3	3%
	During shift between dishes	2	2%
	Other	6	6.1%
Product used to clean chicken preparation surface	Wash with just water, without any additional product	25	25.3
	Soap used	48	64.9%
	Soap and disinfectant-detergent	5	6.8%
	Soap, disinfectant-detergent and sanitizer	1	1.4%
	Disinfectant-detergent	17	22.9%
	Other	3	4.1%
Chicken preparation surface material	Metal	24	24.2%
	Plastic	15	15.2%
	Wood	44	44.4%
	Tarpaulin	5	5.1%
	Other (Ceramics)	11	11.1%

assessment study revealed that combining interventions at restaurants (improved hand washing plus designated kitchen utensils with improved cooking) resulted in a 75% risk reduction in pathogen contamination in Burkina Faso (Ssemenda et al., 2024).

Immediately after slaughter, respondents commonly put chicken carcasses in bowls made of plastic and on wooden tables at ambient temperature. The average time between when a chicken was slaughtered and when respondents received the carcass was 30 min, similar to another Sub-Saharan Africa study (Rwanda) (Niyonzima et al., 2018). The duration of carcass transportation under ambient temperature correlates with proliferation of *Salmonella* initially present on the carcasses, since the generation/doubling time for *Salmonella* at optimal temperature conditions (35–37°C) is known to be 25 min (Delhalle et al., 2009). Previous studies have reported bacterial growth during transportation of carcasses when temperature control was inadequate (Lo Fo Wong et al., 2002; Niyonzima et al., 2015). Keeping chicken carcasses at the proper temperature of 4°C immediately after slaughter is one of the most important steps a food handler can take to prevent growth of microorganisms that cause foodborne illness (WHO, 2006). However, only 50% of outlets had a freezer or fridge on-site, while the rest kept carcasses at room

temperature; only 70% had access to electricity. Keeping chicken carcasses without a cold chain for extended periods leads to pathogenic microorganisms proliferation to unsafe levels, thereby posing a health risk to consumers (Alonso-Hernando et al., 2013).

Some of the restaurants sold chicken dishes with salad or tomatoes. As salads are not heated before consumption they are a high-risk food, vulnerable to pathogen cross-contamination. Studies have shown that chicken cross-contamination with *Salmonella* occurs frequently with vegetables that are not properly cleaned and disinfected (Mosupye and von Holy, 2000; Cardinale et al., 2005).

Animals such as cats and dogs were in contact with cooking and food preparation areas, with flies a regularly occurring issue with no measures to control this. This is a major concern (Nazari, 2017; Khamesipour et al., 2018).

4.3 Knowledge and perception towards chicken safety

Similar to their hygienic practices, knowledge and perception of food safety amongst outlet staff was limited. Surprisingly the majority

TABLE 8 Food types sold and cooking practice.

Questions	Response	N	%
Type of dish sold	Grilled/braised chicken	54	54%
	Flamed chicken	15	15%
	Roasted chicken	12	12%
	Oven baked backed chicken	5	5%
	Other (Chicken soup, garlic chicken, flesh chicken etc.)	14	14%
Chicken servings sold	Whole chicken	94	94%
	Half chicken	3	3%
	Quarter chicken	2	2%
	Other (1/5)	1	1%
Sell uncooked chicken	Yes	43	43%
	No	57	57%
Sell dishes with salad	Yes	7	7%
	No	92	92%
Use the same knife to prepare salad and chicken	Yes	4	57%
	No	3	43%
Is salad prepared on the same surface as chicken	Yes	0	0%
	No	7	100%
Sell dishes with tomato	Yes	17	17%
	No	83	83%
Of those who sell dishes with tomato, do they store tomatoes in a fridge?	Yes	3	17.7%
	No	14	82.3%
Store raw meat with tomatoes	Yes	3	17.7%
	No	14	82.3%

TABLE 9 Hygienic practices at the restaurants.

Practices	Yes		No	
	N	%	N	%
Hands washed before cooking	39	97.5%	1	2.5%
Hands washed with soap or disinfectant	36	92.3%	3	7.7%
Food prepared in a separate area from slaughter	23	57.5%	17	42.5%
Knife washed in fresh, clean water	37	92.5%	3	7.5%
The same knife is used for all stages of slaughter	19	47.5%	21	52.5%
The person who slaughters the chicken also prepares food	28	70%	12	30%
Use only water to wash hands (without soap or disinfectant)	19	47.5%	21	52.5%
Use only water to wash knife (without soap or disinfectant)	21	52.5%	19	47.5%
Wash hands with fresh, clean water	37	92.5%	3	7.5%
Wash carcasses with water after slaughter	13	33.3%	26	66.7%
Wear the same clothes for slaughtering and preparing food	23	82%	5	18%
Animals come into contact with slaughter surfaces	14	35%	26	65%
Any control measure used for animals	9	22.5%	31	77.5%

believed cleanliness and hygiene were not important to their customers when choosing where to eat. Also, more than 80% of staff had not heard of foodborne diseases associated with eating chicken or tomato. This underscores the need to educate vendors. If their reports of

consumer lack of concern are accurate, this should also be addressed. Consumer awareness campaigns, using mass-media and the involvement of key influencers, have potential to empower consumers to consistently pay attention to their own food safety behaviours while

TABLE 10 Hygienic practices and facilities in the restaurants (N = 100).

Question items	Yes	%	No	%
Animal contact with food preparation surfaces	27	27%	73	73%
Fly control	34	34%	66	66%
Access to adequate toilet	73	73%	27	27%
Measures taken to control animals	22	22%	78	78%
Outlet workers pay for toilet access	3	3%	97	97%
Water availability to wash hands after using the toilet	80	80%	20	20%

TABLE 11 Types of toilets accessible by the outlet and animal proximity and their control (N = 100).

Hygiene questions	Response category	N	%
Outlet toilet facilities	Market or public toilet only	2	2%
	Outside only/Open air	5	5%
	Private toilet at outlet	48	48%
	Private toilet not at the outlet	44	44%
	Others	1	1%
Animals contact food preparation surface at night	Cats only	6	22%
	Dogs only	2	7.4%
	Cats and rats	1	3.7%
	Rats and dogs	1	3.7%
	Dogs and birds	1	3.7%
	Cats and dogs	12	22%
	Rats, cats and dogs	1	3.7%
	Cats, dogs and livestock	2	7.4%
	Others	1	3.7%
Animal control measures	Fencing only	12	54.6%
	Fencing and others	2	9.1%
	Fencing and trap	1	4.6%
	Others	7	31.8%
Fly control measure	Use fly spray	10	29.4%
	Other insect killers	2	5.9%
	Fly tape	6	17.7%
	Use fly spray, other insect killers and fly tape	1	2.9%
	Others	15	44%

purchasing foods, and those of the retailer, leading to enhancing food safety at the informal markets (Madjdian et al., 2024).

The study also found that 42% of workers still go to work when they are ill with a stomach upset and diarrhoea, a major risk for infecting the customers. Many disease outbreaks could be prevented by ensuring that food workers do not work while they are sick. But obviously there are financial pressures working against this, for the worker and outlet.

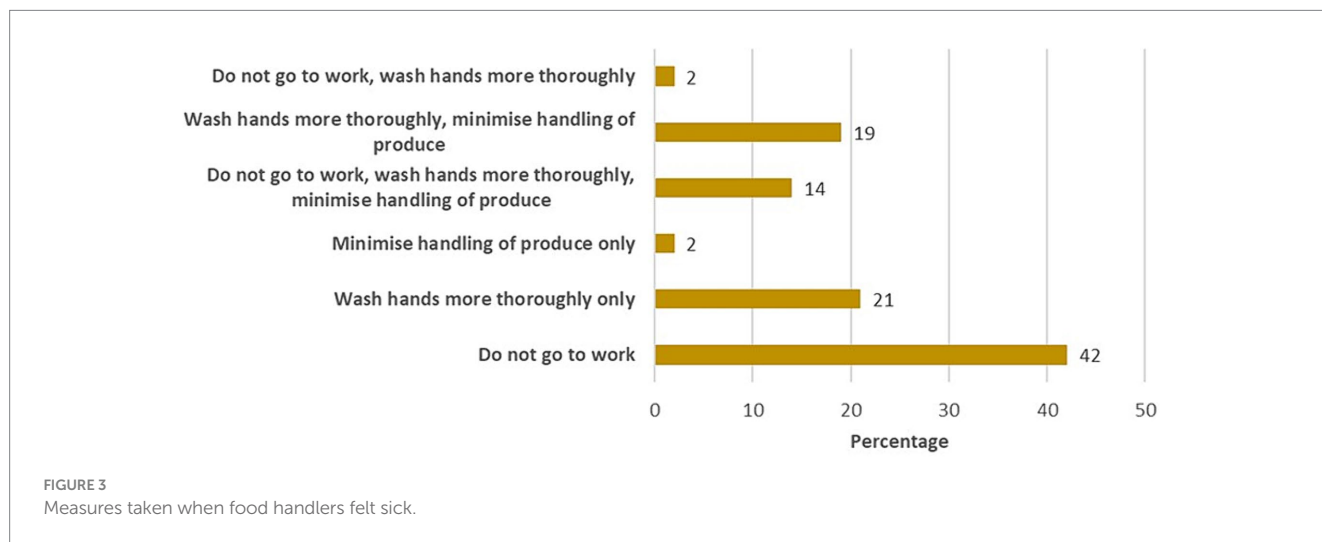
Clean water and detergents, standardized working tables, clean protective clothes, clean cooking areas and dining areas are among the minimum requirements to ensure the safety of customers from foodborne diseases (Osber et al., 2015; Bintsis, 2017). However, most of these minimum requirements were not met in the chicken outlets of Ouagadougou. Effective food safety and hygienic training should

focus on key behaviors that are directly linked to contamination and disease outcomes. Training combined with distribution of a food safety equipment to enable improved practices can be effective in delivering significant food safety behavior changes, and going beyond knowledge enhancement alone. For example, a chicken vendor training program in urban informal markets of Ouagadougou, Burkina Faso resulted in important behaviors to improve personal hygiene and several slaughtering and chicken preparation practices (Madjdian et al., 2024).

A limitation of this study was that the practices assessed were self-reported and social desirability bias may have led to over reporting good practices. If so, actual practices could be even worse. Despite these limitations, the results of this study remain valuable and

TABLE 12 Knowledge and perception of chicken outlet staff regarding chicken safety and hygiene in Ouagadougou (N = 100).

Questions	Yes		No	
	N	%	N	%
Do you think cleanliness and hygiene are important to your customers when choosing where to eat?	20	20%	80	80%
Do customers ever complain about the food?	27	27%	73	73%
What do they complain about? Quality	7	26%	20	74%
Cost	16	59.3%	11	40.7%
Taste	10	37%	17	63%
Cleanliness	0	0	27	100%
Hygiene	1	3.7%	26	96.3%
Other (Small portion and under cooked)	6	22%	21	78%
Do you think customers pay more for food from a place with improved food safety?	61	61%	39	39%
Have you heard about people becoming sick from eating chicken?	16	16%	84	84%
Have you heard about people becoming sick from eating tomato?	17	17%	83	83%
Is the temperature the food is kept at is important for food safety?	91	91%	9	9%
Is the water quality and cleanliness important for food safety?	97	97%	3	3%



representative, as the outlets were randomly selected, and the findings are consistent with other studies.

The results highlight the need to educate food vendors to improve food safety and hygiene knowledge and the need for equipment and infrastructure in order to allow safe food to be implemented. This is an extensive study to understand hygiene practices in one of the most important food chains of Ouagadougou and reflects handling practices of chicken and other foodstuffs in LMICs.

5 Conclusion

Like most street food outlets in Sub-Saharan Africa, chicken restaurants in Ouagadougou have poor levels of hygiene at all stages of food preparation. Restaurant workers lacked training and inspections by the authorities were limited. The working environment was contaminated, and seldom adequately cleaned, and stray animals

wandered around the slaughtering and cooking areas. Furthermore, cleanable surfaces and equipment, toilets, washing, power and clean water supply were lacking. Worker perceptions and knowledge of food safety and how to ensure food is safe were poor, and they did not consider food safety important to their customers. To improve this situation an integrated approach is needed, including worker and consumer educational campaigns on good food safety practices, introduction of easy to clean food-grade surfaces, and better equipment with cleaning and disinfection materials. Upgrading of infrastructure is required including buildings along with provision of clean water and establishment of a cold chain with freezers and power supply. Assuming much needed major investment in food outlet infrastructure is unlikely in the short to medium term in most LMICs, there is a need to identify easy to implement, but effective and sustainable food safety mitigation measures, to make the best of a bad situation, and minimize the ongoing deaths and disease burden resulting from the current food safety situation.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Ethics approval was obtained from the Institutional Research Ethics Committee of the International Livestock Research Institute (ILRI-IREC2019-36/1) and the national Ethical Committee for Health Research under reference 2020-10-220. Written informed consent from the participants was sought from the participants in this study in accordance with the national legislation and the institutional requirements.

Author contributions

BG: Formal analysis, Visualization, Writing – original draft, Writing – review & editing, Conceptualization, Methodology. MD: Conceptualization, Methodology, Supervision, Writing – review & editing. GI: Data curation, Investigation, Writing – review & editing, Conceptualization, Methodology. AA: Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. VL: Data curation, Investigation, Writing – review & editing. DG: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing. TK-J: Conceptualization, Funding acquisition, Methodology, Supervision, Writing – review & editing.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fsufs.2024.1448127/full#supplementary-material>

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