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Informal and formal meat marketing in Ibadan, Nigeria: public health implications from microbial assessment

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Abstract

Introduction: *informal food marketing is predominantly practiced in developing countries as it solves major social and economic challenges through the provision of employment and easily accessible food products at relatively inexpensive prices. However, such products often escape effective health and safety regulations which*

relatively characterize formal marketing, thus posing threats to public health. ***Methods:*** *we conducted a cross-sectional microbial assessment of randomly collected raw meats (n=224) sold at selected informal (n=112) and formal (n=112) meat markets in Ibadan, south-western Nigeria for Listeria monocytogenes, Staphylococcus aureus, Escherichia coli and Salmonella spp. using standard protocols. Isolates were evaluated for antibiogram patterns by Kirby-Bauer Assay and data analysed using descriptive statistics and logistic regression.* ***Results:*** *overall, 75.5%, 65.2%, 61.6%, and 46.9% of the 224 samples were positive for S. aureus, L. monocytogenes, Salmonella spp, and E. coli, respectively. Significantly higher prevalences were obtained from the informal markets for S. aureus (OR=9.43; 95%CI: 0.05-0.24), L. monocytogenes (OR=9.35; 95%CI: 0.06-0.21), Salmonella spp (OR=10.00; 95%CI: 0.05-0.19) and E. coli (OR=12.99; 95%CI: 0.04-0.15) than the formal markets. The pathogens exhibited total resistance against half of the 14 antibiotics studied, with the least resistance to ciprofloxacin and ofloxacin.* ***Conclusion:*** *the significantly higher microbial contamination in meats from informal markets and associated high antibiotic resistance level portends serious public health implications of informal meat marketing. Since informal food marketing also characterizes other developing sub-Saharan African countries, synergy among local and international stakeholders to step up health and safety policies towards regulating activities at informal food markets is urgently required.*

Introduction

Food safety is a global concern over the years considering the fact that everyone at one time or the other has ever experienced food borne illness [1]. Food product handling plays a key role in such food-borne illnesses. Most foodborne diseases are attributable to the consumption of fresh, perishable foods sold in informal markets [2]. Such diseases are likely to increase in low- and middle-income countries considering massive increases in the consumption of risky foods such as livestock and fish products [3]. In sub-Saharan Africa, most livestock products such as meats are sold in informal markets which are often unlicensed and where effective health and safety regulations are lacking [4,5]. The sector is therefore accessible to anyone without formal certification or regulations. Besides, informal markets are characterized with lack of electricity, clean potable water, waste disposal and sanitation facilities [6,7]. The settings are sometimes dusty and muddy and/or could sometimes be flooded due to poor roads [8]. Such an environment exposes food to contamination, thus increasing the risk of foodborne illnesses [8].

According to Food and Agriculture Organization of the United Nations [9], most foods prepared in informal markets are in open-air public spaces either on foot or from mobile outlets, fixed outlets or removable outlets without enclosed space. This therefore portends increasing tendencies for meat contamination with ultimate compromise of consumers´ health and safety. As reported, more than 91 million persons fall ill due to food-borne pathogens with 137,000 deaths recorded each year in Africa [1]. The situation is more worrisome in developing countries like Nigeria with high poverty and unemployment rates, where most traders lack sufficient funds for medical care or formal education and qualifications required to work in the formal industry [5]. Such unregulated markets usually sell products at lower prices than formal markets since they are usually untaxed, are closer and more accessible to consumers. However, such products from informal markets face rising standards concerns for safety and quality.

Nigeria is currently witnessing increasing informal food marketing system due to inadequate employment. This situation tends to encourage untrained hands who in most cases are ignorant of the basic essential hygiene requirements for food handling and processing system. Worse still, the informal sector actors have been remarkably neglected in agri-food chain interventions in developing countries particularly Nigeria [2]. Moreover, the role of informal food marketing in

the prevailing or rising food-borne pathogens circulating in the country remains largely uninvestigated. This study was therefore aimed at assessing the magnitudes of microbial contaminations of raw meat sold at informal and formal meat markets in Ibadan for *Listeria monocytogenes, Staphylococcus aureus, Escherichia coli* and *Salmonella spp*. towards providing baseline data for policy decision making.

Methods

Study design and setting: this cross-sectional study was carried out in Ibadan, south-western Nigeria over a period of four months (September - December 2019). Ibadan is the largest city by geographical area in the country and one of the country´s most populous cities with over three million people. The city accommodates a major cattle market as well as a central abattoir which supplies meat to the teeming population in the city and the neighboring environments. The abattoir is connected to major markets formally designated by the government for the sales of meat. However, in addition to these formal meat markets, the city is characterized with increasing informal meat marketing ranging from open-air public space marketing to mobile open, street meat hawking. Raw meats are sold on wooden materials with crevices that could harbor dirt and pathogens. These materials are often unwashed despite exposure to dusty, unhygienic environments. Worse still, the informal meat marketers are mostly untrained in meat hygiene. Thus, such meats may serve as a vehicle for microbial transmission to meat consumers.

Study population, sample size and sampling technique: the study population comprised informal and formal meat markets in Ibadan, south-western Nigeria. A pilot survey was conducted among the 11 Local Government Areas (LGAs) in Ibadan to determine the proportions of informal meat markets in the areas, since there was no prior documented report on the same. Following the survey, four of the LGAs were purposively chosen: Ido, Ibadan North and Ibadan South-east, being LGAs with highest informal meat markets; and Ibadan North as well as Akinyele, respectively hosting the major and one of the small-sized formal meat markets. Based on reported prevalences in food animals and products: 5.4% for *S. aureus*[10], 3.39% for *E. coli* [11], 8.5% for *Salmonella* [12] and 5.1% for *L. monocytogenes* [13]; the highest prevalence of 8.5% was used in calculating the sample size, giving a minimum sample size of 132 samples. Considering the mobile nature of the population of meat marketers in the informal markets, a snowball sampling technique was employed in the LGAs to select the participants every other day in the week. An initial potential participant was located, who then provided information on locating the next potential participant. The purpose of the study was explained to each potential participant and were told that participation was voluntary without any attached penalty for refusal to participate. This process was repeated until the sample size was reached. However, those who declined participation were excluded from the study. On alternate days of the week at the formal market, a simple random sampling technique was used to select the participants by choosing one of every five meat sellers in the markets following the linear patterns of the organization of their meat shops. Corresponding numbers of participants obtained at the informal markets were serially selected per time of visit at the formal markets each alternate day.

Collection of samples was done in the morning hours of the day at the different market sites. Meat swab samples were aseptically collected from the raw meats of consenting participants using sterile swabs by rolling the swabs against the sampled items. Following a simple random sampling technique, a sterile cotton tipped swab (2x3cm) fitted with shaft, was first soaked in an approximately 10ml of buffered peptone water (BPW; Oxoid, Hampshire, UK) and subsequently rubbed horizontally and vertically several times on the meat surface. The swab samples were

aseptically collected in duplicates from a 2 cm2 area of at least two different sites on the meat per participant, stored in the transport medium and packaged in a cooler containing ice packs. The samples were thereafter transported to the Food and Meat Hygiene Laboratory of the Department of Veterinary Public Health and Preventive Medicine, University of Ibadan, Nigeria for processing.

Sample processing: the duplicate swab samples were pooled together and were processed within three hours of collection. Preparatory to processing the samples, the glass-wares were washed thoroughly and sterilized in Hot Air Oven at 100°C for 20 min. The collected swab samples in the broth media were incubated at 37°C for 18 to 24 hours. The samples were thereafter plated on Mannitol salt agar for *Staphylococcus aureus, Listeria*selective agar for *L. monocytogenes, Salmonella-Shigella* agar for *Salmonella* and Eosin-Methylene blue agar for *E. coli*. They were incubated at 37°C for another 18 to 24 hours, but up to 24 to 48 hours for *Listeria* plates because of the relatively slow growth of this organism. Following incubation, the growths typical of the different pathogens on the respective media were harvested and aseptically sub-cultured and incubated to obtain pure colonies. The pure culture was then transferred into nutrient agar slants for preservation prior to the biochemical tests. Identification of the organisms was done following conventional biochemical methods previously described [14]. Briefly, Gram staining, haemolysis on 5% sheep blood agar, coagulase, catalase, sugar fermentation (mannitol, glucose, xylose and arabinose) and pigmentation (mannitol salt agar) were used to identify *Staphylococcus aureus*. On the other hand, the use of conventional biochemical methods including Gram staining, catalase, aesculin, triple sugar iron (TSI) reaction, urease, sugar fermentation tests (lactose, sucrose, mannitol and xylose) and haemolysis on 5% sheep blood agar was employed to identify Listeria monocytogenes. Likewise, TSI agar test and urease test were conducted to identify Salmonella isolates, while *E. coli* was identified following urease production, voges proskauer, catalase, methyl red, motility, carbohydrate fermentation, indole production and citrate utilization tests.

Antibiotic Sensitivity Test (Kirby-Bauer Assay): antibiotic susceptibility testing was conducted following the Kirby-Bauer disc-diffusion test as earlier described [15]. Briefly, 3mL of sterile normal saline was used to emulsify an inoculum of each pure bacterial isolate. The density was thereafter adjusted to 0.5 McFarland standard. The mixture was then inoculated onto the Mueller-Hilton Agar (MHA) plates (Oxoid, England) using a sterile cotton swab dipped into the standardized suspension of bacterial cultures and the plates were left to dry. Antibiotic discs and were placed onto MHA plates. The discs contained Ampicillin (10ug), Ceftazidime (30ug), Cefuroxime (30ug), Gentamicin (10ug), ciprofloxacin (5ug), of Loxacin (5ug), Augmentin (30ug), Nitrofurantoin (300ug), Cotrimoxazole (25ug), Chloramphenicol (10ug), Cloxacillin (5ug), Erythromycin (5ug), Streptomycin (10ug), Tetracycline (10ug) (antibiotic Becton Dickinson and Company, Sparks, USA). Thereafter, the plates were incubated aerobically at 37°C for 24 h. The zone of inhibition was measured in millimeters. The zone diameters were interpreted as susceptible, intermediate and resistant on the basis of the critical points recommended by Clinical and Laboratory Standards Institute [15] in accordance with standards. *L. monocytogenes*ATCC7644, *S. aureus* ATCC 25923, *Enterococcus faecalis* ATCC 29212 and *Escherichia coli* ATCC 25922 were used as reference strains.

Ethical consideration: the protocols of the study were approved by the University of Ibadan Animal Care and Use Research Ethics Committee (UI-ACUREC) with the approval number: UI-ACUREC/057-0621/10.

Data analysis: data were analyzed using STATA 12. Frequencies and percentages were calculated accordingly to determine the prevalence of each foodborne pathogen. The relationships between outcome variable (prevalence of the different foodborne pathogens) and market types were

determined by conducting univariate binary logistic analysis and multivariate logistic regression analysis. The presence and strength of the associations between variables was determined by computing Odds ratios (OR) and 95% Confidence Intervals (CIs) were calculated to investigate the statistical significance. Values of $P < 0.05$ were considered significant.

Results

Of the projected sample size of 264 samples, only a total of 224 meat swab samples comprising 112 each from both informal and formal markets were collected due to non-cooperation of the potential participants, mostly at informal markets. This gives a 15.2% non-response rate. Of these, 65.2%, 75.5%, 46.9% and 61.6% were respectively positive for *L. monocytogenes, S. aureus, E. coli* and *Salmonella spp*. Based on meat market types, significantly higher proportions of 87.5%, 92.9%, 75.0% and 85.7% were positive for *L. monocytogenes, S. aureus, E. coli* and *Salmonella spp*. From the informal market than 42.9%, 58.0%, 18.8% and 37.5%, respectively from the formal market (Table 1). The varying prevalences of these pathogens across different sampling locations of the informal and formal meat markets are shown in Table 1. Bivariate analysis revealed that the prevalence of the pathogens was significantly associated with the market types (p=0.000; Table 2). Overall, multivariate logistic regression showed that the meat from informal markets were about 9, 9, 13 and 10 times, respectively, more likely to be contaminated with *L. monocytogenes* (OR=9.35; CI: 0.06-0.21; p =0.000), *S. aureus* (OR=9.43; CI: 0.05-0.24; p = 0.000), *E. coli* (OR=12.99; CI: 0.04-0.15; p =0.000) and *Salmonella spp.* (OR=10.00; CI: 0.05-0.19; p =0.000), than from the formal market (Table 3).

Antibiogram patterns of tested microbial isolates: all the isolates obtained exhibited total resistance to seven of the 14 antibiotics used, including Ampicillin (10ug), Ceftazidime (30ug), cefuroxime (30ug), Cotrimoxazole (25ug), Chloramphenicol (10ug), Cloxacillin (5ug) and Erythromycin (5ug) (Table 3). With respect to total resistance to most of the antibiotics used, *E. coli* from both formal and informal meat markets were resistant to all the antibiotics except 75% each from formal market that were susceptible to only ciprofloxacin and Ofloxacin (Table 4).

Discussion

Consumer health problems have been linked to meat contaminations, with such products implicated in several outbreaks and recall cases from marketplaces. The present study investigated the microbial burden of meat sold at informal and formal meat markets in Ibadan, south-western Nigeria. The study revealed a significantly higher heavy microbial contamination of meats from informal than formal meat markets in Ibadan. These findings are in agreement with some representative reports on hazards in fresh foods from a range of studies on food in informal markets in Nigeria and other international communities. For instance, ILRI [16] reported that only 2% of meat sampled from informal markets in Nigeria complied with standards, while another report showed that only 6% of pork sampled from informal markets in Nagaland, India complied with standards [17]. Similarly, ILRI [18] found that 0% of milk samples sold in informal market in Assam, Kenya complied with standards. These findings underscore the report that most foodborne disease is the result of consumption of fresh, perishable foods sold in informal markets [19]. The higher microbial loads observed in meat samples from informal markets compared to those from formal markets in this study might be as a result of the higher exposure levels of the meat from the informal markets to potential contaminants since most of such markets are often located directly close to dusty, untarred roads. Besides, the rate of human hand contacts with meat from informal markets is often unprecedentedly higher given its exposure to the majority of passers-by who might or might not eventually buy the meat. In addition, most of the meats in the informal markets are sold on open air,

unhygienic environment which makes the meat to be prone to microbial contamination. It is equally of importance to note that since regulations are not often applied in informal markets, laxities regarding proper meat handling hygiene might abound.

Moreover, the heavy microbial loads observed in meat in this study is indicative of meat with poor quality and short shelf-life which portends risk of exposure of consumers to meat-borne diseases. This is of serious public health concern since most meat consumers do not observe strict hygiene measures when handling meat. Hence, the possibility of spreading the organisms far and wide through the usual bargaining habits of touching and palpating the meat severally when attempting to buy is high. Our findings are similar to previous reports from elsewhere showing heavy bacterial contamination of meat [20,21]. Generally, the detection and isolation of *E. coli, Listeria monocytogenes, Salmonella spp*. as well as *Staphylococcus aureus* from raw meat samples from both formal and informal meat markets in this study is suggestive of poor, quality control in the processing and handling of meat in the study area. A previous report showed that most meat handlers are not trained in the art of food and meat handling hygiene [22]. Unhygienic dressing of carcasses on the killing floor characterizes meat processing in most developing countries including Nigeria, leading to contamination of carcasses and consequent isolation of pathogenic microorganisms from the meat as well as the slaughtering facilities [23]. Also, the hands of food handlers have been shown to be vectors in the spread of foodborne disease, mainly because of poor personal hygiene.

The current overall prevalence of 65.2% of *L. monocytogenes* from informal and formal markets in this study is lower than 95.8% reported in chicken in Ibadan [24]. This notwithstanding, the obtained prevalence is unacceptable and could have resulted from the unhygienic handling practices of meat handlers and processors. As reported, contamination usually arises from unwholesome contacts of meat with excretions from skin, mouth and nose of the meat processors [25,26]. It also suggests likely cross contamination of raw processed meat by improperly cleaned and disinfected processing environment. This finding concurs with similar reports [27,28] which put processing as a major hazard of cross contamination. The presence of *S. aureus* also agrees with the report of cross contamination from meat handlers during processing, since it is a normal flora of the skin [29]. This also agrees with previous reports of isolation of *S. aureus* from meats [30-31]. *S. aureus* is recognized as one of the major foodborne pathogens in fresh and ready-to-eat products and it´s responsible for various infections around world [32]. This pathogen could grow at temperature between 15°C and 45°C and at NaCl concentrations as high as 15% [33]. It multiplies quickly at room temperature to produce toxins that cause illness. Our findings are therefore of public health concern considering the poor food handling practices that could enhance the multiplication of this pathogen which characterizes most food handlers [22].

The prevalence of 46.9% of *E. coli* in this study is higher than 43.4% earlier reported in Ibadan [34] as well as 11.1% and 16% from Osogbo [35] and Calabar metropolis [36], respectively. This difference might be as a result of the fact that meats from these other studies were frozen poultry meat; more so, abattoir meat processing is more often characterized with poorer unhygienic activities that put the meat in the present study at a higher risk of contamination. The high prevalence of *E. coli* in this study is also similar to the report by Gibbons *et al*. [37] which indicated 90.9% prevalence in raw meat. These findings coupled with poor food handling practices in the study area therefore portend serious health hazards to the public, considering possible contamination with other raw food items during food preparation. The rate of *E. coli* obtained is indicative that meats obtained from the study area were unfit for human consumption in accordance with criterion of recommended limits by foreign food agencies. Although the species of *E. coli* obtained in this study

were not characterized, *E. coli*O157 has been commonly reported in Nigeria and is recognized as a major causative agent of enterohemorrhagic *E. coli* (EHEC) infection which has been categorized as a category III notifiable disease under the Infectious Diseases Control Law in industrialized countries of the world such as Japan [38]. *Salmonella spp* isolated from the meats sampled in this study is also a pathogenic organism of public health significance and concerns. The isolation of *Salmonella spp*. is of practical impact as it might have contaminated the meats as a result of poor handling by meat sellers. *Salmonella* species such as *Salmonella* typhi is a bacterium that causes typhoid fever (enteric fever), an acute, life-threatening febrile illness [39]. The disease is a cause for concern and a major public health problem in developing countries (Asia, Africa); especially in Nigeria due to poor sanitary conditions and lack of or inadequate potable water [40]. It is mainly transmitted through food or drink or water, contaminated with urine or faeces of infected people or a chronic carrier [39,40].

Further, the level of antibiotic resistance exhibited by most of the foodborne pathogens isolated in this study calls for serious public health attention. Antibiotics are commonly used around the world to cure diseases caused by bacteria, but as the World Health Organisation and other international bodies have pointed out; the global increase in antibiotics resistance is a rapidly worsening problem [41]. Since antibiotics are also an essential part of modern medicine as prophylactic treatment, rising resistance of bacteria presents even more of a danger. As observed in this study, all the isolates exhibited total resistance to Ampicillin (10ug), Ceftazidime (30ug), Cefuroxime (30ug), Cotrimoxazole (25ug), Chloramphenicol (10ug), Cloxacillin (5ug) and Erythromycin (5ug). In a study on the emergence of a new antibiotic resistance mechanism in India, Pakistan and the UK [42], 36 isolates of *Escherichia coli*. This is in line with the observation in this study as the *E. coli* isolates were resistant to all, but ciprofloxacin and ofloxacin among the antibiotics used. In a study on the characterization of antimicrobial resistance of foodborne *Listeria monocytogenes* [43]; resistance to linezolid, ciprofloxacin, ampicillin and rifampicin, trimethoprim/sulphamethoxazole, vancomycin and tetracycline was observed among some of the isolates. Gomba *et al*. [44] in their study also revealed that the *Salmonella* isolates assessed were mostly resistant to most of the antibiotics. On the other hand, the majority of the *S. aureus* strains in this present study were susceptible to ciprofloxacin, ofloxacin and gentamicin. This is similar to the observation of Bernard *et al*. [45] in their study to determine the antibiotic sensitivity of *S. aureus* strain responsible for community-acquired skin infections where only 0.5% of isolated strains showed resistance to gentamicin. This indicates that resistance of *S. aureus* to gentamicin may still be generally low.

The above findings notwithstanding, this study had some limitations. First, only few selected informal and formal meat markets in Ibadan were studied; nation-wide study might give more elaborate insights into the microbial burden associated with informal meat marketing. However, Ibadan where the study was carried out is the largest city by geographical area in the country and one of the country´s most populous cities with over three million people. Hence, the findings might be typical of the country´s situation. Second, a 100% response rate was not obtained due to non-cooperation of some potential participants. This, however, might not grossly affect the outcome of this study considering the 84.8% response rate obtained from the potential participants.

Conclusion

This study shows that meat contamination with important foodborne pathogens was significantly higher in informal than formal meat markets in Ibadan, southwestern Nigeria; thus, reiterating the role of unregulated, informal food marketing in food safety concerns in Nigeria. The results portend serious public health concerns to meat consumers, considering the fact that the less privileged and

poor to average people often constitute the majority of the prospective meat buyers in the informal markets. The meat samples processed in this study all had high levels of microbial contamination including *L. monocytogenes, S. aureus, E. coli* and *Salmonella spp*. This is suggestive of the poor hygienic practices which characterize meat handling, processing and distribution in the country. The high level of antibiotic resistance exhibited by most of the foodborne pathogens isolated is a matter of grave concern to the health of animals as well as meat consumers. The observations in this study might not be limited to Nigeria alone, but also typical of most developing African countries, characterized with proliferation of unregulated informal food markets. Hence, there is need for synergy among relevant stakeholders at both local and international levels to institute regulatory measures on informal meat marketing in order to checkmate practices that could undermine the safety of food. Measures such as judicious use of antibiotics are required to lower the resulting widespread resistance exhibited by food pathogens.

What is known about this topic

- *Listeria, Salmonella, Escherichia and Staphylococcus spp. are common food pathogens;*
- *Meats as veritable substrate for microbial growth;*
- *Poor antibiotic stewardship is prevalent among livestock owners.*

What this study adds

- *Meats from informal markets have significantly higher microbial loads than those from formal markets;*
- *Proliferation of informal food markets in developing countries, if unregulated constitutes threat to public health;*
- *Informal markets play a major role in food safety, and antibiotic resistance spread to man.*

Competing interests

The authors declare no competing interests.

Authors' contributions

HKA conceptualized and designed the study; HKA and OCO were involved in the collection and processing of samples; HKA and VOA analysed the data; HKA, OCO and VOA wrote and revised the first draft of the manuscript. All authors read and approved the final version of the manuscript.

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Tables

Table 1: prevalence of foodborne pathogens in raw meat samples from informal and formal meat markets in Ibadan, south-western Nigeria

Table 2: bivariate analysis of the prevalence of foodborne pathogens between meat from informal and formal markets in Ibadan, south-western Nigeria

Table 3: multivariate logistic regression analysis of the prevalence of foodborne pathogens between meat from informal and formal markets in Ibadan, south-western Nigeria

Table 4: percentage susceptibility of foodborne pathogen isolates obtained from raw meat from formal and informal meat markets in Ibadan, south-western Nigeria

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Table 1: prevalence of foodborne pathogens in raw meat samples from informal and formal meat markets in Ibadan, south-western Nigeria

Market type	**Location**	**Total samples collected**	**Prevalence of foodborne pathogens Number (%)**			
			L. monocytogenes	*S. aureus*	*E. coli*	*Salmonella spp*
Informal	Ido	32	32 (100.0%)	30 (93.8%)	12 (37.5%)	16 (50.0%)
	Ibadan south-east	32	28 (87.5%)	26 (81.3%)	24 (75.0%)	32 (100.0%)
	Ibadan North	48	38 (79.2%)	48 (100.0%)	48 (100.0%)	48 (100.0%)
Sub-total		112	98 (87.5%)	104 (92.9%)	84 (75.0%)	96 (85.7%)
Formal	Akinyele	50	12 (24.0%)	23 (46.0%)	3 (6.0%)	12 (24.0%)
	Ibadan North	62	36 (58.1%)	42 (67.7%)	18 (29.0%)	30 (48.4%)
Sub-total		112	48 (42.9%)	65 (58.0%)	21 (18.8%)	42 (37.5%)
Total		224	146 (65.2%)	169 (75.5%)	105 (46.9%)	138 (61.6%)

Table 2: bivariate analysis of the prevalence of foodborne pathogens between meat from informal and formal markets in Ibadan, south-western Nigeria

Foodborne pathogens	**Market type**	**Number contaminated (%)**	**Number uncontaminated (%)**	**X^2, p-value**
L. monocytogenes	Informal	98 (87.5%)	14 (12.5)	49.17, 0.000
	Formal	48 (42.9%)	64 (57.1%)	
S. aureus	Informal	104 (92.9%)	8 (7.1%)	36.65, 0.000
	Formal	65 (58.0%)	47 (42.0%)	
E. coli	Informal	84 (75.0%)	28 (25.0%)	71.15, 0.000
	Formal	21 (18.8%)	91 (81.2%)	
Salmonella spp	Informal	96 (85.7%)	16 (14.3%)	55.04, 0.000
	Formal	42 (37.5%)	70 (62.5%)	

Table 3: multivariate logistic regression analysis of the prevalence of foodborne pathogens between meat from informal and formal markets in Ibadan, south-western Nigeria						
Foodborne pathogens	**Market type**	**Number contaminated (%)**	**Number uncontaminated (%)**	**OR**	**CI**	**P-value**
L. monocytogenes	Informal	98 (87.5%)	14 (12.5%)	9.35	0.06-0.21	0.000
	Formal	48 (42.9%)	64 (57.1%)	1	1	
S. aureus	Informal	104 (92.9%)	8 (7.1%)	9.43	0.05-0.24	0.000
	Formal	65 (58.0%)	47 (42.0%)	1	1	
E. coli	Informal	84 (75.0%)	28 (25.0%)	12.99	0.04-0.15	0.000
	Formal	21 (18.8%)	91 (81.2%)	1	1	
Salmonella spp	Informal	96 (85.7%)	16 (14.3%)	10.00	0.05-0.19	0.000
	Formal	42 (37.5%)	70 (62.5%)	1		

Table 4: percentage susceptibility of foodborne pathogen isolates obtained from raw meat from formal and informal meat markets in Ibadan, south-western Nigeria								
Market types	**Formal**				**Informal**			
Pathogens	*S. aureus* (n=22)	L. monocytogenes (n=14)	*Salmonella* (n=14)	*E. coli* (n=4)	*S. aureus* (n=10)	*L. monocytogenes* (n=6)	*Salmonella* (n=4)	*E. coli* (n=2)
Antibiotic	%	%	%	%	%	%	%	%
Ciprofloxacin (5ug)	100.0	100.0	78.6	75.0	100.0	100.0	100.0	0.0
Ofloxacin (5ug)	100.0	100.0	71.4	75.0	100.0	100.0	100.0	0.0
Augmentin (30ug)	81.8	0.0	0.0	0.0	80.0	0.0	0.0	0.0
Nitrofurantoin (300ug)	0.0	71.4	0.0	0.0	0.0	83.3	0.0	0.0
Ampicillin (10ug)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ceftazidime (30ug)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cefuroxime (30ug)	0.0	0.0	0.0	0.0	60.0	0.0	0.0	0.0
Gentamicin (10ug)	0.0	64.3	0.0	0.0	0.0	66.7	0.0	0.0
Cotrinazole (25ug)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Chloramphenicol (10ug)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cloxacillin (5ug)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Erythromycin (5ug)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Streptomycin (10ug)	68.2	0.0	28.6	0.0	0.0	0.0	0.0	0.0
Tetracycline (10ug).	36.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0