Escherichia coli *O157:H7 and* Salmonella *species isolated from Ducks and Indigenous chickens in live-bird Markets in Ibadan, Oyo State, Nigeria*

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Summary
This study investigated the occurrence of *Escherichia coli* O157:H7 and *Salmonella* spp. and their antimicrobial susceptibility from ducks and indigenous chickens in major live-bird markets at Ibadan, Oyo State, Nigeria. Thirty-one cloacae samples were each collected from both ducks and indigenous chickens, in three different sample locations for a total of 186 cloaca swab samples. Isolation of *Escherichia coli (E. coli)* was done using MacConkey agar and Sorbitol MacConkey agar selective for *E. coli* O157:H7, while serological latex agglutination test kit was used to confirm isolates. Rappaport Vassiliadis and Xylose Lysine Deoxycholate agar were used for *Salmonella* spp. Antibiotic susceptibility was determined using the disc diffusion method and interpreted using the CLSI 2020 standards. Data were analyzed using descriptive statistics and Fisher's exact test ($p \leq 0.05$). *Escherichia coli* O157:H7 was confirmed in 31 samples (16.7%). *E. coli* isolates showed high resistance (90.3-93.5%) to cefuroxime, cefixime, ceftazidime, and amoxicillin, while they were highly susceptible to ofloxacin (96.8%) and gentamycin (80.7%). *Salmonella* was confirmed in 24 samples (12.9%). *Salmonella* showed 100% resistance to cefuroxime, cefixime ceftazidime, and amoxicillin, but was highly susceptible to gentamycin (91.7%) and nitrofurantoin (66.7%). No statistically significant association ($p<0.05$) was observed between the occurrence of *E. coli* O157 and *Salmonella* within the three live-bird markets. This study reveals that *E. coli* and *Salmonella* spp. occur in ducks and indigenous chickens from major live bird markets in Ibadan, Oyo state with antimicrobial susceptibility. Findings from this study underscores the need for further studies on these pathogenic organisms from ducks in Nigeria because there is paucity of data on this species of poultry that may serve as reservoir for these zoonotic organisms.

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Introduction

Escherichia coli O157:H7 is the most widely known Shiga-toxin or verotoxin producing organism. It may cause severe illnesses from simple bloody diarrhea to hemorrhagic colitis (HC), hemolytic uremic syndrome (HUS), and thrombotic thrombocytopenic purpura in humans (Thomas and Elliott 2013; Atnafie *et al*., 2017; Erickson *et al*., 2019). The organism was incriminated in an outbreak from an unknown source in March 2021 affecting several people in seven states of the United States (CDC, 2021). Enterohemorrhagic O157:H7 is mainly transmitted to humans by the consumption of contaminated food and water, or by direct contact with animals, their feces, and contaminated soil. Person-to-person transmission can contribute to disease spread during outbreaks; however, humans do not appear to be a maintenance host for this organism (Ahn *et al*., 2009).

Salmonella spp. is one of the most important food-borne pathogens. It was the most frequently reported causative agent in bacterial food-borne disease outbreaks and has caused the highest number of deaths due to food-borne illnesses in the European Union in 2017 (EFSA and ECDC, 2018). Poultry meat has been identified as one of the most important sources (FAO and WHO, 2009) of human infections. As the consumption of poultry meat is increasing every year, prevention of *Salmonella* spp. contamination in the poultry meat production chain remains very important. Poultry and poultry meat can become contaminated with *Salmonella* spp. during the entire poultry production chain, that is from the breeder farm, production farm, transportation, slaughterhouse, and retail (Hardie *et al., 2019*; Shang *et al., 2019*).

Live Bird Markets (LBMs) are termed as a place where live birds are sold to customers (Oloso, 2019). In Nigeria, about 90% of poultry product marketing is done by sales of live birds with less than 2% comprising processed or frozen chickens. An estimate that over 2 million live birds are sold daily in LBMs across Nigeria highlights the position of live bird markets in control of avian diseases (Muhammed, 2008). The high concentration and interaction of a wide variety of birds coming from different sources make LBMs a high-risk area for disease transmission (Choi *et al.*, 2005). These processes involve the collection of chickens from multiple households who own few numbers of marketable ages, then mixed at various densities starting from the village markets to the big terminal markets that lead to the spread of infection across a long distance. In addition, multiple species of birds in confined spaces in LBMs create a stressful condition, cross-infection, and increased surface contamination (Mai *et al*., 2004).

The spread of zoonotic pathogens such as *Salmonella* spp. and *Escherichia coli* O157:H7 poses threat to public health, as they may be transferred to humans through the food chain (Lim *et al*., 2010; Chang *et al*., 2012) and also antimicrobial resistance (AMR) of *E. coli* and *Salmonella* spp. is a worldwide health concern (Peterson and Kaur, 2018). Different organizations such as the Centers for Disease Control and Prevention (CDC), Infectious Diseases Society of America, World Economic Forum, and the World Health Organization (WHO) have declared antibiotic resistance as a global public health concern (Michael *et al*., 2014; Spellberg *et al*., 2016). This study, therefore, investigated the occurrence of *E. coli* O157:H7 *Salmonella* spp. and their antimicrobial susceptibility in ducks and indigenous chickens from major live bird markets in Ibadan, Oyo state, Nigeria.

Materials and Methods

Collection of Samples

Three LBMs located in Shasha, Molete, and Bode areas of Ibadan, Oyo State, Southwest Nigeria were used for this study. The sample size was determined as described by Thrusfield, (2005). Using a prevalence of 11.4% from previous study from roadside LBMs in Zaria, Kaduna State, Nigeria (Ejeh *et al*., 2017) and an absolute error of 5%, the sample size was calculated to be 155, plus 10% non-responsive samples gave a total of 186 samples.

One hundred and eighty-six (186) cloacae swab samples were collected; 62 birds per LBMs, 31 each from chicken and duck. Adequate precaution was taken to avoid contact between cotton swab tips and the surrounding of the anus to avoid cross-contamination. All samples were properly labeled and transported on ice to the Bacteriology Laboratory of the Department of Veterinary Microbiology, University of Ibadan, for bacteriological analysis.

Escherichia coli O157 Identification and Isolation

Samples were pre-enriched using 9mls of buffered peptone water (Lab M, UK) and incubated at 37°C for 24 hours. After which, 0.1ml of the pre-enrichment broth was inoculated onto prepared plates of MacConkey agar (Oxoid, UK) and incubated at 37°C for 24 hours. Pink, round, medium sized-colonies taken to be *E. coli* were sub-cultured onto Sorbitol MacConkey agar, SMAC, (Oxoid, UK) and incubated at 37°C for 24 hours. Colorless colonies (non-sorbitol fermenter) were purified by sub-culturing onto freshly prepared Sorbitol MacConkey agar. The purified isolates were used for further analyses;

Gram staining, catalase test, indole test, citrate test, sugar fermentation, and triple sugar iron test, which were performed for *E. coli* identification. Serological latex agglutination test using *E. coli* O157 antiserum (Oxoid, UK), was used for confirmation (according to manufacturer's instruction)

Salmonella spp. Identification and Isolation

Samples were pre-enriched using 9mls of buffered peptone water (Lab M, Heywood, UK) and incubated at 37 ºC for 24 hours. After which 0.1ml of the pre-enrichment broth was inoculated onto 10mls of Rappaport Vassiliadis (Oxoid, Hampshire, UK), for selective enrichment of *Salmonella* and incubated at 37 ºC for 24 hours. A loopful from Rappaport Vassiliadis was inoculated onto Xylose Lysine Deoxycholate, XLD, (Oxoid, UK) agar, which was incubated at 37 ºC for 24 hours. The presumptive isolates that appeared pinkish, with or without small transparent black centers to predominantly black colonies were subcultured on Xylose Lysine Deoxycholate to obtain a pure culture. The purified isolates were used for further identification; Gram staining, catalase test, indole test, citrate test, sugar fermentation, and triple sugar iron test were performed for *Salmonella* identification.

Antibiotics Sensitivity Testing

Confirmed *E. coli* O157 and purified *Salmonella* spp. isolates were tested for their susceptibility to antimicrobial agents using the agar disc diffusion method (CLSI, 2020). Commercially available Gram-negative antibiotics multi-disc from Abtek, Liverpool, UK, was used; comprising of ceftazidime (30 µg/disc), cefuroxime (30 µg/disc), gentamicin (10µg/disc), cefixime (5 µg/disc), ofloxacin (5 µg/disc), amoxicillin (30 µg/disc), nitrofurantoin (5 µg/disc) and ciprofloxacin (30 µg/disc). The antibiotic discs were placed on Muller Hilton agar plates previously seeded with an overnight culture of the test organisms using a sterile cotton swab and incubated at 37 ºC for 24 hrs, after which zones of inhibition were measured and interpreted accordingly.

Statistical Analysis

The IBM® SPSS® Statistical Software (SPSS) was used for data analysis. Fisher's Exact test was used to determine the statistically significant association of the prevalence of *Salmonella* spp. and *E. coli* O157 in ducks and indigenous chickens because the numbers within the two by two categories from our result had values lower than 5, using confidence levels (CL) of 95% and $p \leq 0.05$.

Results

A total of 156 (83.9%) *Escherichia coli* isolates were obtained from 186 cloacae swab samples of these, 75 (80.7%) were from ducks and 81 (87.1%) indigenous chickens from three live bird (Shasha, Molete and Bode) markets in Ibadan. Eighty-seven (46.7%) of the 156 isolates were non-sorbitol fermenters, of which 57 (30.7%) samples showed distinct *E. coli* characteristics with biochemical test, while 31 (16.7%) were serologically identified as *Escherichia coli* O157:H7 (Table I). There was no statistically significant association (p=0.14) in the occurrences of *E. coli* O157 in the three live-bird markets (p>0.05). A total of 40 (21.5%) *Salmonella* spp. isolates were obtained from 186 cloacae swab samples. Of these, 25 (26.9%) ducks and 15 (16.1%) indigenous chickens from three live bird (Shasha, Molete and Bode) markets in Ibadan. Thirty-three (17.7%) of the 40 isolates were recorded on further purification on Xylose Deoxycholate agar. Using biochemical test, *Salmonella* was confirmed in 24 (12.9%) samples (Table II).

Table I. *E. coli* O157 isolation in ducks and indigenous chickens in Oyo State, Nigeria.

Sample Source (live-bird markets)	Number of samples		Presumptive *E. coli* MacConkey agar (MAC)		Presumptive *E. coli* O157 Sorbitol MacConkey agar (SMAC)		Biochem Test *E. coli* O157		Serology *E. coli* O157:H7	
	Ducks	Indigenous chickens	Ducks	Indigenous chickens	Ducks	Indigenous chickens	Ducks	Indigenous chickens	Ducks	Indigenous chickens
Molete	31	31	23	27	13	13	7	8	3	2
Shasa	31	31	27	30	11	18	6	14	4	11
Bode	31	31	25	24	16	16	13	9	7	4
TOTAL	**93**	**93**	**75**	**81**	**40**	**47**	**26**	**31**	**14**	**17**
OVERALL TOTAL	**186**		**156**		**87**		**57**		**31**	

Table II. *Salmonella species* isolation in ducks and indigenous chickens in Oyo State, Nigeria.

Sample Source (live-bird markets)	Number of samples		*Salmonella* Spp Xylose Lysine Deoxycholate (XLD)		*Salmonella* Spp (XLD) Purification		Biochemical test *Salmonella* Spp	
	Ducks	Indigenous chickens	Ducks	Indigenous chickens	Ducks	Indigenous chickens	Ducks	Indigenous chickens
Molete	31	31	7	6	7	4	5	3
Shasa	31	31	15	7	12	5	8	5
Bode	31	31	3	2	3	2	1	2
TOTAL	**93**	**93**	**25**	**15**	**22**	**11**	**14**	**10**
OVERALL TOTAL	**186**		**40**		**33**		**24**	

There was no statistically significant association (p= 0.72) in the occurrences of *Salmonella* in the three live-bird markets (p>0.05).

Antibiotics susceptibility of *E. coli* O157 and *Salmonella* Isolates

The antibiotic susceptibility profile of *E. coli* O157 (31) and *Salmonella* (24) isolates to the eight antibiotics is shown in Table III and Table IV, respectively.

Table III. Antibiotic susceptibility of *E. coli* O157 isolated in ducks and indigenous chickens in Oyo State, Nigeria.

Antimicrobial class	Antimicrobial agent	Disk Potency	Number of Isolates, T=31		
			Sensitive [n (%)]	Intermediate [n (%)]	Resistance [n (%)]
Cephalosporins (2nd Generation)	Cefuroxime	30µg	1 (3.2)	1 (3.2)	29 (93.5)
Cephalosporins (3rd Generartion)	Cefixime	5µg	2 (6.5)	0 (0.0)	29 (93.5)
	Ceftazidime	30µg	2 (6.5)	0 (0.0)	29 (93.5)
Penicillins	Augmentin	30ug	2 (6.5)	1 (3.2)	28 (90.3)
Aminoglycoside	Gentamycin	10µg	25 (80.7)	1 (3.2)	5 (16.1)
Floroquinolone	Ciprofloxacin	5µg	10 (32.3)	13 (41.9)	8 (25.8)
	Ofloxacin	5µg	30 (96.8)	0 (0.0)	1 (3.2)
Nitrofuran	Nitrofurantoin	300µg	18 (58.1)	1 (3.2)	12 (38.7)

Table IV. Antibiotic susceptibility of *Salmonella* Spp.

Antimicrobial class	Antimicrobial agent	Disk Potency	Number of Isolates, T=24		
			Sensitive [n (%)]	Intermediate [n (%)]	Resistance [n (%)]
Cephalosporins (2nd Generation)	Cefuroxime	30µg	0 (0.0)	0 (0.0)	24 (100)
Cephalosporins (3rd Generartion)	Cefixime	5µg	0 (0.0)	0 (0.0)	24 (100)
	Ceftazidime	30µg	0 (0.0)	0 (0.0)	24 (100)
Penicillins	Augmentin	30ug	0 (0.0)	0 (0.0)	24 (100)
Aminoglycoside	Gentamycin	10µg	22 (91.7)	0 (0.0)	2 (8.3)
Floroquinolone	Ciprofloxacin	5µg	1 (4.2)	18 (75.0)	5 (20.8)
	Ofloxacin	5µg	Interpretative break point not available		
Nitrofuran	Nitrofurantoin	300µg	16 (66.7)	2 (8.3)	6 (25.0)

Escherichia coli O157 showed very high resistance to 4 (90.3-93.5%) of the antibiotics tested, specifically to the Cephalosporins: cefuroxime, cefixime and ceftazidime, and also to amoxicillin.

Intermediate susceptibility to ciprofloxacin (41.9%), while it was highly susceptible to ofloxacin (96.8%) and gentamycin (80.7%), then nitrofurantoin (58.1%), (Figure 1 and 2).

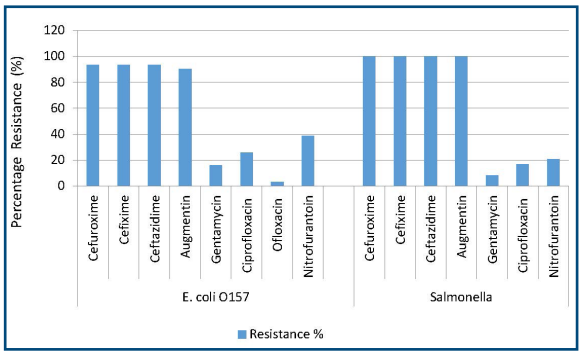

Figure 1. *Antibiotics resistance pattern of* E. coli *and* Salmonella *spp. isolated in ducks and indigenous chickens in Oyo State, Nigeria.*

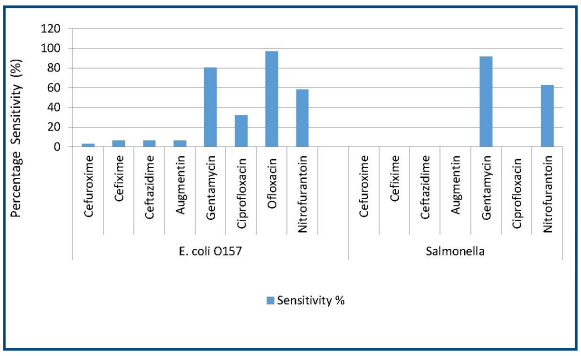

Figure 2. *Antibiotics sensitivity pattern of* E. coli *and* Salmonella spp. isolated in ducks and indigenous chickens in Oyo State, Nigeria.

Salmonella showed 100% resistance to four of the antibiotics tested; specifically, to the Cephalosporins; cefuroxime cefixime and ceftazidime and also to amoxicillin. It also showed high intermediate susceptibility to ciprofloxacin (75%) while it was highly susceptible to gentamycin (91.7%) and nitrofurantoin (66.7%), (Figure 1 and 2).

Majority of *E. coli* O157 and *Salmonella* strains showed resistance to at least two antimicrobial agents.

Muti-drug resistance (defined as to be non susceptible to at least three or more classes of antimicrobial tested) was highest for *E. coli* O157 (77.5-80.4%), and observed in cefuroxime-cefixime-ceftazidime-amoxicillin antibiotics, while *Salmonella* spp. had 100% multidrug resistance to the same group of antibiotics. Multi-drug resistance was lowest, 0% for *E. coli* O157 and 4.2% for *Salmonella* spp. to gentamycin-amoxicillin-nitrofurantoin-ciprofloxacin combination (Table V).

Table V. Resistance and Multi-drug Resistance Pattern of *E. coli* O157 and *Salmonella* spp. isolated in ducks and indigenous chickens in Oyo State, Nigeria.

Antibiotics	Number of resistance *E. coli* O157 isolates (%)		Number of resistance *Salmonella* isolates (%)	
	Duck	Indigenous chicken	Duck	Indigenous chicken
CAZ	12 (38.7)	17 (54.8)	14 (58.3)	10 (41.7)
CRX	13 (41.9)	16 (51.6)	14 (58.3)	10 (41.7)
CXM	13 (41.9)	16 (51.6)	14 (58.3)	10 (41.7)
AUG	13 (41.9)	15 (48.4)	14 (58.3)	10 (41.7)
NIT	9 (29.0)	3 (9.7)	5 (20.8)	1 (4.2)
CPR	4 (12.9)	4 (12.9)	2 (8.3)	3 (12.5)
GEN	1(3.2)	4 (12.9)	2 (8.3)	0 (0)
OFL	0 (0)	1 (3.2)	0 (0)	0 (0)
AUG-NIT	9 (29.0)	2 (6.5)	5 (20.8)	1 (4.2)
AUG-CPR	4 (12.9)	4 (12.9)	2 (8.3)	3 (12.5)
AUG-GEN	1 (3.2)	4 (12.9)	2 (8.3)	0 (0)
GEN-CPR	0 (0)	1 (3.2)	1 (4.2)	0 (0)
AUG-NIT-CPR	2(6.5)	2 (6.5)	1 (4.2)	0 (0)
NIT-AUG-GEN	1 (3.2)	0 (0)	2 (8.3)	0 (0)
GEN-AUG-CPR	0 (0)	1 (3.2)	1 (4.2)	0 (0)

Key: CAZ– Ceftazidime CRX – Cefuroxime GEN– Gentamycin CXM– Cefixime
OFL- Ofloxacin AUG- Augmentin NIT- Nitrofuratoin CPR–Ciprofloxacin

Discussion

In this study, the cloacal carriage of *E. coli* O157 and *Salmonella* spp. were investigated amongst indigenous chickens and ducks sold in three selected live-bird markets in Ibadan, Oyo State, Nigeria. *Escherichia coli* had a prevalence of 30.7% and *E. coli* O157, 16.7%. Isolation rate of *E. coli* O157 was higher in indigenous chicken (18.3%) than in ducks (15.1%), though there was no statistical degree of association in occurrence among the two poultry birds. The 16.7% prevalence of *E. coli* O157:H7 from this study is similar to reports from Aibinu *et al*., 2007 which reported 10% isolation from 50 cloacal samples of chicken in Lagos and 14.5% chicken samples in Ogun State. In addition, Ojo *et al*., 2009 confirmed *E. coli* O157:H7 strains in the faeces of poultry sampled from different farms in Nigeria. Also, Olatoye *et al*., 2012 reported 13% and 14% isolation of *E. coli* O157:H7 from Lagos and Ibadan poultry farms, respectively. Furthermore, 13.4% prevalence has been reported from chicken cloacal samples examined in eastern Ethiopia (Mude *et al*., 2017). The prevalence observed in this study is however higher compared to the 5.7% in local chicken from Zaria (Ejeh, *et al*., 2017) and 6.7% in strayed chicken from Calabar (Nfongeh *et al*., 2018).

Salmonella spp. had a prevalence of 12.9%, the isolation rate in ducks was 15.1% and 10.8% in indigenous chicken, suggesting that there was no significant difference in the occurrence of *Salmonella* spp. in the two poultry species. Our finding for *Salmonella* spp. occurrence in local chicken is similar to reports of 12% prevalence in local chickens along the roadside at Hanwa, Zaria, Nigeria (Ejeh *et al*., 2017). While it is lower compared to 59.1% prevalence from poultry cloacal swabs from Calabar, (Yhiller and Bassey, 2015) and 52.5%, from chicken cloacal samples from Owerri (Umeh and Enwuru, 2014), Nigeria. *Salmonella* spp. prevalence in ducks from this study is higher than (4.6% and 8.7%) prevalence reported in duck cloacal samples from Taiwan (Tsai and Hsiang, 2005) Mekong Delta, Vietnam (Tran *et al*., 2004), respectively but lower than the prevalence from duck cloacae content from Korea (20.7%) (Kim *et al*., 2016), from retail duck meat in Vietnam 22.3% of (Phan *et al*., 2005) from ducks from Dinajpur, Bangladesh (39,58%)(Rahman *et al*., 2016), from duck cloacal samples in Sichuan Province, China (43,5%) (Xinfeng *et al.,* 2020), from duck meat samples in South Korea (51,3%) (Yoon *et al*., 2014), from imported day-old duckling in Brazil (65,0%) (Ribeiro *et al*., 2003).

The variations in prevalence of *E. coli* and *Salmonella* spp. generally might be due to different sampling techniques, areas, time, and lack of strict hygiene measures among farms and live bird markets (Abah *et al*., 2017). The public health importance is the isolation of *E. coli* O157 and *Salmonella* spp. from this study with a prevalence of 16.7% and 12.9%, respectively in both duck and indigenous chicken in live bird markets. The presence of these pathogenic organisms predisposes live bird sellers as well as intermediaries having direct contact with birds to be at risk of occupational hazards (Ajetombi *et al*., 2010). Others at risk of infection include people who consume raw vegetables because wastes from poultry farms are used for irrigation and fertilizer in vegetable farms in Nigeria. Pathogenic *E. coli* from the gut can also contaminate chicken meat and thus may constitute serious public health problems (Ejeh *et al.,* 2017). A possible explanation for the high occurrence in indigenous chicken and ducks from LBMs in this study may be because live bird markets are high-risk areas for disease transmission due to high concentration and interaction of a wide variety of birds that come from different sources (Choi *et al*., 2005) and multiple species of birds that are kept together in a confined space and common practice of keeping ducks with indigenous chicken which increase the chance of spread of pathogenic organisms (Mai *et al*., 2004; Siraju *et al*., 2016).

Multiple antibiotics resistance was observed for both *E. coli* O157 and *Salmonella* spp.. There was 90.3%-100% resistance of *E. coli* O157 and *Salmonella* spp. to cefuroxime, ceftazidime, cefixime, and amoxicillin. This is similar to reports from other studies in poultry in Nigeria with *Salmonella* and *Escherichia coli* showing 100% resistance to amoxicillin (Adeyanju and Ishola, 2014; Gbadamosi *et al*., 2018). *Escherichia coli* O157 and *Salmonella* spp. were also resistant to gentamycin (16.1% and 8.3%), ciprofloxacin (25.8% and 20.8%), and nitrofurantoin (38.7% and 25%), respectively, this is in contrast with other studies from poultry in Nigeria that reported a greater (>70%) resistance for these antibiotics (Nfongeh *et al*., 2018; Gbadamosi *et al.,* 2018). In this study, *E. coli* O157 showed the highest sensitivity to ofloxacin (96.8%) and gentamycin (80.7%), while *Salmonella* spp. had the highest sensitivity to gentamycin (91.7%) and nitrofurantoin (66.7%). This is similar to the findings of Mohammad *et al*., 2014 and CVL report 2014/15 in poultry with 100% sensitivity for *E. coli* and *Salmonella* spp. to gentamycin; greater (>70%) sensitivity of *E. coli* O157 to gentamycin; Mude *et al*., 2017 (88.46%) and Altalhi *et al*., 2010 (71.7%) in Ethiopia, Bangladesh and Saudi Arabia, respectively.

The prevalence of antimicrobial-resistant pathogens and the high level of resistance to multiple antibiotics may be due to excessive and uncontrolled use of antibiotics in poultry which may be as a result of these antibiotics being freely available and readily affordable, or from the transfer of resistance gene(s) from another host in the same production environment (Swartz 2002; Hayes *et al.,* 2004; Levy

and Marshall 2004; Nelson *et al.,* 2007; USGAO 2011a; Salihu *et al*., 2014). It is worthy to note that there is no previously known prevalence of *E. coli* O157 and *Salmonella* spp. in ducks in Nigeria before this study.

Limitation

As at the time of compiling this report, there was non-availability of anti-sera and other reagents for further molecular characterization which was occasioned by recent global Coronavirus disease (COVID-19) pandemic, which resulted in our change of protocol.

Conclusions

The presence of these pathogenic organisms can cause serious infections that can result in gastroenteritis, hemorrhagic colitis, kidney failure, and sometimes death in humans, economic loss in the poultry agricultural sector through loss of production and high mortality. The LBMs can pose serious veterinary and public health risks to sellers, buyers, handlers, consumers, animals, animal health care providers and the environment.

Multiple antibiotic resistances observed to clinically relevant antimicrobials is worrisome, however, *E. coli* O157 was most susceptible to ofloxacin and gentamycin and *Salmonella* spp. to gentamycin. There is need for continuous education of local poultry farmers and retailers; on the standard of animal production and hygiene practices that allows prevention of pathogenic organisms in poultry and also on the dangers involved in exposure to the various pathogenic organisms that can be associated with poultry such as *E. coli* O157 and *Salmonella* spp.. There is need to legislate and enforce laws to limit the prescription, dispensing and administration of antibiotics and other drugs to only veterinarians for prophylactic and treatment purposes. In addition, animal health authorities should ban the use of antibiotics as growth promoters in Nigeria so as to curb the spread of antimicrobial resistance.

More studies should be carried out on the occurrence and antimicrobial resistance of pathogenic organisms in ducks in Nigeria because there is paucity of report on this matter. Also, studies involving serotype-specific AMR patterns and risk factors should be carried out as well as assessment of Avian Pathogenic *E. coli* (APEC) that has a negative impact on poultry health.

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