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Burden of Multidrug-Resistant *Escherichia coli* in Pigs Slaughtered in Uganda and Its Implication on Veterinary Public Health

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Abstract

Antimicrobial resistance by bacteria and other microbes has become a global public and animal health threat. In this cross-sectional study, assessed the abattoir workers' practices regarding pork handling and we investigated antimicrobial susceptibility patterns of *Escherichia coli* isolated from pigs brought for slaughter at Wambizzi, Uganda's main pig abattoir. Rectal swabs were collected from a total of 176 live pigs prior to slaughter. Additionally, 24 swabs were taken from the abattoir floor environment. The collected swabs were cultured for the detection and isolation of *E. coli* followed by antibiotic susceptibility tests. Regarding pork handling practices, absence of hand washing facilities was observed and none of the workers cleaned/disinfected their equipment between slaughters while slaughters took place on the unhygienic floors of the inspection room. Overall, high prevalence (85.1%) of multi-drug resistant *E. coli* was detected in pigs received from all the regions of Uganda. Swine *E. coli* isolates exhibited high resistance against erythromycin (87.4%) and the least resistance against ciprofloxacin at 2.3%. At regional level, *E. coli* isolates from the central region of Uganda showed higher prevalence of multidrug resistant *E. coli* isolates as follows; amoxicillin (30.4%, *p*-value = 0.007), erythromycin (34.8%, *p*-value = 0.002), streptomycin (40.7%), ciprofloxacin (100%), oxytetracycline (31%) and sulphamethoxazole-trimethoprim (42.9%). Furthermore, multidrug-resistant *E. coli* was also confirmed in the immediate environment where pigs were gathered and slaughtered. From these environmental isolates, the highest resistance was confirmed against erythromycin (100%), whereas no isolates showed resistance against ciprofloxacin. The observed practices coupled with the presence of multidrug-resistant *E. coli* in the slaughterhouses presents a possible risk of pork contamination with multidrug-resistant *E. coli* presenting a potential risk of causing foodborne

illnesses among pork consumers in Uganda. The current findings could justify active surveillance of antimicrobial resistance among food animals and provides basis for monitoring the quality of pork products to ensure food safety.

Keywords

Escherichia coli, Antimicrobial Resistance, Pigs, Abattoir, Pork, Practices

1. Introduction

Antimicrobial resistance (AMR) refers to the persistent growth of microbes in the presence of antimicrobial drugs which are known to be active against them [1]. Antimicrobial resistance is not only a global public health threat but also an animal health threat. It is reflected in at least 2 million resistant infections and at least 23,000 deaths in the United States and 25,000 deaths annually [2]. AMR development in animals is influenced by the rational and irrational use of antimicrobials for a variety of purposes, for example therapeutic, regular prophylactic treatments, and as growth promoters in food-producing animals [2] [3].

Livestock has been reared extensively as a source of food and income. Their intensive production is to meet the continuously increasing demand for livestock products driven by human population growth and urbanization [4]. The annual per capita consumption of pork in Uganda was estimated to be 3.4kg in 2015 [5]. The pig population increased to 5.1 million in 2018 to keep up with the high pork consumption in the country [6]. The majority of the pigs in Uganda are kept under an extensive production system by smallholder pig farmers; other pigs are kept under intensive and semi-intensive production systems mainly for commercial purposes [7] [8].

The poor biosecurity due to poor pig production systems, disease challenges like swine fever, salmonellosis, dysentery, and colibacillosis that affect pig health and the entire piggery industry in Uganda. To prevent and control these diseases, pig farmers irrationally use antimicrobials in feed, water or injectable antibiotics without seeking professional advice [3] [4].

Recent reports have showed a rise in antimicrobial resistance, mainly attributed to the irrational drug use and treatment, prophylaxis and as feed additives. [2]. Normal intestinal flora like *Escherichia coli (E. coli)* and enterococci are used to monitor the development of antimicrobial resistance in animals [3]. The prevalence and degree of AMR in these bacteria are good indicators of selective pressure in the antibiotics used in the animals [9]. When animals excrete, they contaminate the environment, other animals and humans *[9]*. Farm, abattoir workers, veterinarians, and those in close contact with these animals may easily get infected with resistant bacteria [2]. The resistant bacteria in these animals can be transferred to humans through the consumption of meat, through water, mud and manure used as fertilizer [2].

Once the antimicrobial resistance has developed in animals, it impacts negatively animal health and may also be associated with resistant infections in humans who consume products from these animals [2]. Antimicrobial resistance leads to treatment failure in the piggery industry and losses through pig mortalities [1]. None the less, there is scanty information recorded about antimicrobial resistance in animals [3]. The purpose of the study was therefore, to determine the antimicrobial susceptibility patterns of *Escherichia coli* isolated from pigs brought for slaughter at Wambizzi abattoir and assess the practices of the abattoir workers concerning pork handling and waste management throughout the slaughter process.

2. Materials and Methods

2.1. Study Area

The study was carried out in Wambizzi abattoir located in Nalukolongo, Rubaga division Kampala city. The abattoir is located at N 0.294484˚, E 32.542500˚ [10]. The abattoir is fenced with a wall on one side and barbed wire on the other side. The abattoir is under the management of the manager, two meat inspectors and around 30 workers. The slaughter houses are permanent structures but the holding area was made of temporary structures. The abattoir receive pigs from all the regions of the country, but most pigs came from the central region of Uganda. The pigs usually arrive in trucks in evening hours with the pig traders. The pigs are marked on their bodies according to the trader's identification and then placed in holding pens. They are slaughtered according to the demand of pork and other products like pig fat. The average number of pigs slaughtered was between 71 and 80 per day. Slaughter process usually starts at 5:00am. It involves killing, bleeding, scalding, hair removal, hoisting to hangar, removal of feet, evisceration, cleaning of carcass and weighing carcass. Pig traders privately operating from Wambizzi also use the facility to slaughter their pigs and have their meat inspected and stamped to meet the requirements in the formal market place. After slaughter, the carcasses are inspected by the Kampala City Council Authority (KCCA) meat inspectors and carcass graded according to its fitness for human consumption. There is also another room, beside the bleeding area, where the intestines are cleaned from. The small intestines and the stomach are cleaned and packed for sale.

2.2. Study Design

This was a cross sectional study which aimed at determining the antibiotic susceptibility patterns of *Escherichia coli* which was isolated from abattoir environmental samples and fecal samples obtained from the pigs brought for slaughter at Wambizzi abattoir. It involved sample and data collection using fecal swabs and a standard checklist respectively. The fecal and environmental (floor) swabs were cultured for bacterial (*E. coli*) growth, isolation and antibiotic susceptibility tests conducted on randomly selected *E. coli* isolates. A standard

checklist was developed in accordance with the guidelines from Uganda National Bureau of Standards for all slaughter houses and was used to observe the practices of the abattoir workers during the slaughter of pigs brought for slaughter until the carcass was ready for sale.

2.3. Sample Size and Sample Collection from Pigs

A total of 200 sample swabs (176 pig samples and 24 abattoir floor samples) were collected. With the help of the abattoir workers, the selected pig was restrained. While wearing examination gloves, cotton swabs containing 70% ethanol were used to disinfect the perineum. A rectal swab was picked and labelled according to the identification mark on the animal. The identification mark on the pig body was used to find out about the district of origin of the pigs from the abattoir manager and the pig traders.

2.4. Sample Collection from the Abattoir Floor

Floors of the pig holding rooms which were actively being used during the study period were also swabbed at five different points. The floors were swabbed in a way that three points in a diagonal line were swabbed starting from one corner, to the center and then proceeded to the next corner in line using one swab. Other three points were also swabbed in another diagonal line. The center of each holding room was swabbed twice and two swabs were used per holding room. The swabs were labelled according to numbers given per holding room and all the swabs collected were stored in an ice box with ice packs at 2˚C - 8˚C. After sample collection, the samples were rushed to the laboratory at Makerere University for analysis within 6 to 24 hours of samples collection.

2.5. Data Collection

A standard checklist was used to assess the pork handling practices during the slaughter process. Systematic random sampling was used in such a way that the slaughter process of every 10th pig was carefully observed, from the time of decapitation up to when it is dressed as pork ready for sale. The checklist of good practice according to UNBS standards for all slaughter places included all the key points to be noted by the abattoir workers during the slaughter process. Observation was done and a clear judgment was selected among the options written down.

2.6. Laboratory Sample Processing and Analysis

At the laboratory, each swab was first pre-enriched in 1ml of peptone water to increase the population of microorganisms on the swab. Pre-enrichment lasted between 1 - 2 hours. After pre-enrichment, the fecal swabs were inoculated onto Mac Conkey agar plates. A sterile wire loop was used to streak on each plate, starting from the corner where the swab was inoculated and moving towards the center. The plates were then incubated at 44˚C for 16 to 24 hours. The colonies

observed on the plates, which were suspected to be *E. coli* were raised, dry with complete margins and were pink. Significant colonies were picked and sub cultured on fresh MacConkey agar plates, while streaking each plate with three samples and then incubated at 44˚C for 16 - 24 hours to obtain pure colonies. Gram stain and other biochemical tests of Methyl red, Indole test and Citrate (MIC) were carried out on every sub cultured sample to confirm the isolate as *E. coli*.

2.7. Biochemical Tests

A colony was identified as *E. coli* if it tested positive for Indole and Methyl, and negative for citrate. The colonies of *E. coli* also stained negative with gram stain.

2.8. Storage of Pure *E. coli* Isolates

Colonies of confirmed *E. coli* isolates were picked using a sterile wire loop and incubated in sterile Brain Heart Infusion (BHI) at 37˚C for 24 hours. Each confirmed *E. coli* sample was incubated in 1 ml of BHI. After incubation, 700 µl of the broth culture were picked using a pipette and added to 300 µl of sterile glycerin in cryovials. The broths were then stored under −8˚C for 24 hours and later transferred to −20˚C.

2.9. Antibiotic Sensitivity Tests

A total of 100 pure *E. coli* isolates were randomly selected. The isolates came from the floors of the abattoir houses including holding sties, slaughter and inspection (13), Western region (12), Eastern region (29), Northern region (14) and central region (32) were picked and antibiotic susceptibility tests carried out on them. The selected isolates were picked from the cryovials using sterile wire loops and regrown on fresh MacConkey agar plates. They were incubated for 16 - 24 hours at 44˚C. Significant colonies were picked and dissolved in sterile normal saline to make a solution. The solution's turbidity was compared with 0.5% Mac Farland solution.

The solution was spread on labelled sterile plates of Mueller Hinton agar using a sterile swab, putting one sample per Mueller Hinton agar plate. Representative drugs from the six commonly used antibiotics in pig medicine were used to test their clearance of *E. coli* cultured. Erythromycin, streptomycin, oxytetracycline, amoxicillin, ciprofloxacin and sulfamethoxazole-trimethoprim discs were transferred to the streaked Mueller Hinton agar plates and the plates were incubated for 24 hours at 37˚C. After the incubation, the diameter of the zones of clearance of *Escherichia coli* by individual drug discs were measured in mm using a ruler. The zones of clearance around the drug disks were used to classify the antibiotics as resistant, susceptible and intermediate depending on the diameter of clearance.

2.10. Data Processing and Analysis

The collected checklist data was entered in Microsoft excel and then analyzed

with SPSS to generate descriptive statistics. A *p*-value of ≤0.05 was considered significant at 95% confidence interval. The descriptive statistics were presented as frequencies and percentages in a tabular format. The laboratory results were presented in a tabular form in Microsoft Excel spreadsheet version 2013 and then analyzed. The diameter of zone of clearance obtained was compared with the manufacturer's instructions and directions to classify isolates into the three categories (resistant, intermediate and susceptible). Graphs and tables were used to present the antibiotic susceptibility results of swine *E. coli* across the regions of Uganda.

2.11. Ethical Consideration

The study was approved by the research ethics committee of college of veterinary medicine animal resources and biosecurity. Ethical principles and professional code of conduct were fully observed during the implementation of the study. Permission was sought from relevant authorities at Wambizzi abattoir before undertaking the study. The samples and relevant information in accordance to the sampled animals were obtained from the manager of Wambizzi Cooperative Society abattoir.

3. Results

3.1. Demographics and Background Characteristics

A total of 200 samples were obtained of which 24 samples were obtained from the floors of the holding sites and houses and 176 samples were pigs (Table 1). 50% of the pigs sampled were females and the other 50% were both uncastrated and castrated males combined. All the 200 samples were analyzed for the presence of *E. coli* but only 170 (85%) turned positive on MacConkey agar plates and biochemical tests.

3.2. Pork Handling Practices at Wambizzi Abattoir

From the observational checklists of every 10th pig sampled that was slaughtered, the following findings were noted. The lairage lacked wash points, beddings, a drainage system and the floor was made of soil which was quite difficult to clean. Similarly, the bleeding area lacked a drainage system, wash points and appeared unhygienic. However, the bleeding area was well separated from the lairage area. Protective wear such as gumboots and over coats were used by all those working within the bleeding area (appendix; Table A1(a)). Compared to the lairage and bleeding area, the inspection area had a functioning drainage system. However, it appeared unhygienic with the floor flooded with blood and other trimmings coupled with absence of disinfection points and proper containers for carrying pork. The rest of the practices within the inspection area complied with the standard practice (Appendix; Table A1(b)). Although the pork handling area had disinfection units, the area fell short of the minimum hygiene standards expectations (Appendix; Table A1(c)).

Table 1. Key background characteristics.

Category	Variables	Frequency (%)
Samples (N = 200)	Rectal swab samples	176 (88.0%)
	Floor swabs	24 (12.0%)
Sex of pigs sampled (N = 176)	Males and castrates	88 (50.0%)
	Female	88 (50.0%)
Bacterial culture results (N = 200)	*E. coli* positive	170 (85.0%)
	E. coli Negative	30 (15.0%)

3.3. Antibiotic Susceptibility of Swine *E. coli* Isolates

The highest antibiotic resistance of *E. coli* isolates was observed against macrolides (erythromycin at 87.4%) followed by oxytetracycline (85.1%). The least *E. coli* resistance was confirmed against fluoroquinolones (ciprofloxacin at 2.3%) after 24 hours of incubation (Figure 1). On the other hand, *E. coli* isolates were majorly susceptible to ciprofloxacilin (86.2%) followed by streptomycin (54.0%), sulfamethoxazole-trimethoprim (52.9%) and amoxicillin (50.6%).

3.4. Antibiotic Susceptibility of Swine *E. coli* Isolates at Regional Level

At regional level, there was multi-drug resistance observed in all the four regions of the country against the six classes of the antibiotics used. The central region had the highest burden of multidrug resistant *Escherichia coli* isolates with resistance confirmed on all the 6 classes of drugs used. Resistance to amoxicillin was higher in Eastern (30.4%) and Central (30.4%) than in Northern (26.1%) and western (2.2%) regions. Resistance to erythromycin, streptomycin and oxytetracycline was highest in the central region at 34.8%, 40.7% and 31.0% respectively. Only two isolates in the central region showed resistance to ciprofloxacin (100%) and 42.9% resistance was seen in isolates from the central region towards Sulphamethoxazole-trimethoprim (Table 2). The antibiotic Susceptibility profiles of *E. coli* isolates was significantly different across regions for amoxicillin (p-value = 0.007) and erythromycin (p value = 0.022). The prevalence of multi drug resistant isolates of *Escherichia coli* against the six classes of the antibiotics used was 85.1% (N = 87).

3.5. AMR Profile for *E. coli* Isolated from the Floor of the Abattoir and the Holding Sties

Thirteen *E. coli* isolates from the floors of holding sties and the slaughter areas were subjected to antibiotic sensitivity tests. The isolates showed highest resistance against erythromycin (100%) followed by oxytetracycline (76.9%). There was no resistance observed against ciprofloxacin in all the isolates (Figure 2). The isolates were largely susceptible to sulphamethoxazole-trimethoprim, streptomycin and amoxicillin at 76.9%, 61.5% and 53.8% respectively.

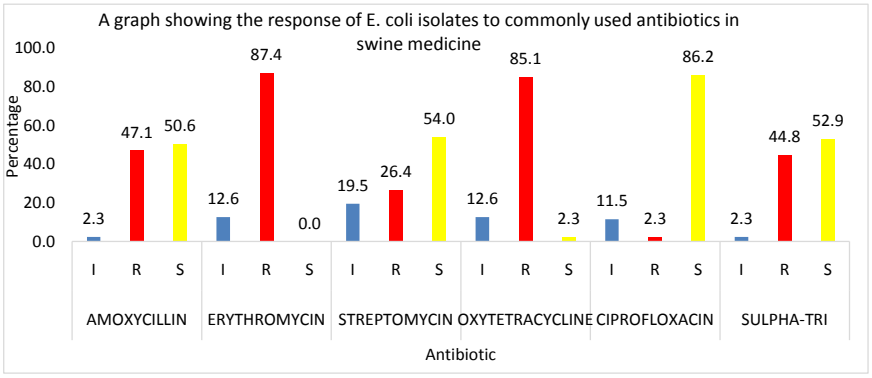

Figure 1. Overall antibiotic resistance of swine *E. coli*. *N* = 87. Key: I = Intermediate, R = Resistant, S = Susceptible.

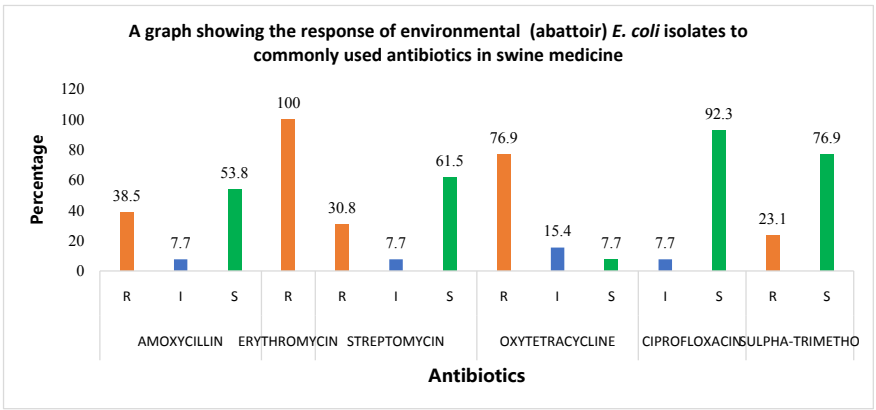

Figure 2. Antibiograms of *E. coli* isolates recovered from the abattoir floor samples. Key: I = Intermediate, R = Resistant, S = Susceptible.

Table 2. Antibiotic susceptibility profile of Isolates from all the four regions of Uganda and Wambizzi abattoir.

Antibiotic		Central	Eastern	Western	Abattoir	Northern	Total	p-value
Amoxicillin	**R**	**14 (30.4)**	**14 (30.4)**	**1 (2.2)**	**5 (10.9)**	**12 (26.1)**	**46**	**0.007**
	I	1 (33.3)	0 (0)	0 (0)	1 (33.3)	1 (33.3)	3	
	S	17 (33.3)	15 (29.4)	11 (21.6)	7 (13.7)	1 (2)	51	
Erythromycin	**R**	**31 (34.8)**	**26 (29.2)**	**8 (9)**	**13 (14.6)**	**11 (12.4)**	**89**	**0.022**
	I	1 (9.1)	3 (27.3)	4 (36.4)	0 (0)	3 (27.3)	11	
Streptomycin	**R**	**11 (40.7)**	**9 (33.3)**	**1 (3.7)**	**4 (14.8)**	**2 (7.4)**	**27**	**0.385**
	I	8 (44.4)	5 (27.8)	1 (5.6)	1 (5.6)	3 (16.7)	18	
	S	13 (23.6)	15 (27.3)	10 (18.2)	8 (14.5)	9 (16.4)	55	
Oxytetracycline	**R**	**26 (31)**	**25 (29.8)**	**9 (10.7)**	**10 (11.9)**	**14 (16.7)**	**84**	**0.428**
	I	4 (30.8)	4 (30.8)	3 (23.1)	2 (15.4)	0 (0)	13	
	S	2 (66.7)	0 (0)	0 (0)	1 (33.3)	0 (0)	3	
Ciprofloxacin	**R**	**2 (100)**	**0 (0)**	**0 (0)**	**0 (0)**	**0 (0)**	**2**	**0.687**
	I	6 (54.5)	2 (18.2)	1 (9.1)	1 (9.1)	1 (9.1)	11	
	S	24 (27.6)	27 (31)	11 (12.6)	12 (13.8)	13 (14.9)	87	
Sulphametho azole trimethoprim	**R**	**18 (42.9)**	**10 (23.8)**	**5 (11.9)**	**3 (7.1)**	**6 (14.3)**	**42**	**0.215**
	I	2 (100)	0 (0)	0 (0)	0 (0)	0 (0)	2	
	S	12 (21.4)	19 (33.9)	7 (12.5)	10 (17.9)	8 (14.3)	56	

N = 100. Key: I = Intermediate, R = Resistant, S = Susceptible.

4. Discussion

This study revealed that the prevalence of multidrug resistant *E. coli* in pigs slaughtered at Wambizi Uganda's main abattoir was high. It was also observed that operational practices and facilities quality and design were generally inadequate with a high potential of predisposing pork to contamination with drug resistant *E. coli*. The absence of slaughter slabs in the slaughter houses presented a means of contamination of the carcass with the microorganisms especially the environmental *Escherichia coli* which demonstrated multi drug resistance towards the commonly used antibiotics [9] [10] [11] [12] [13]. The contaminated environment could therefore be a potential means of spread of multidrug resistant *E. coli* strains [1]. Failure to change water in the scalding saucepan during the slaughter process could increase the risk of cross contamination of all carcasses and as a result could lead to the transfer of these resistant bacteria on the carcasses from one point in the slaughter process to another [12]. Poor evisceration and polishing may increase pork contamination and could be a means of transmission of resistant bacteria to the abattoir workers and pork consumers [12].

The pork handling practices were generally below the recommended standards of practice as evidenced by the absence of hand washing facilities or any disinfectant. I addition, none of the abattoir workers cleaned their equipment after slaughter of any carcass before starting to slaughter another carcass. This could be a means of transfer of fecal pathogens especially drug resistant *E. coli* between carcasses in cases of poor evisceration of the first carcass.

The study also confirmed the presence of multi-drug resistant *Escherichia coli* among swine populations in all the four regions of Uganda. The Multi-drug resistance observed (85.1%) in this study is consistent with the previous report by [3]. High prevalence of multi drug resistant *E. coli* among swine population could present a serious threat to the piggery industry of Uganda due to high prevalence of diseases such as collibacillosis as previously reported [14]. The highest resistance was observed against erythromycin in all the four regions of Uganda as well as the immediate environment (holding sties and slaughter areas). In a similar study, findings showed that the high level of resistance was dominated by erythromycin at 85.4% and prevalence of multi drug resistant *E. coli* isolates among the 82 *E. coli* isolates from 96 pig farms was 57.3% [15]. The findings of this study are consistent with the findings of a study conducted by a team of researchers at Makerere University [16], who obtained samples from food animals such as chicken, pigs, cattle, goats and sheep and reported highest resistance against erythromycin at 96.0%, tetracycline at 61% and the least resistance was in ciprofloxacin at 6.5%. A retrospective study among 63 archived *E. coli* samples from poultry between 2012 and 2018 by [17] showed that multi drug resistance among 43 recovered *E. coli* samples was at 88.4%. Multidrug resistant bacteria has been reported in other livestock other than swine especially among dairy cattle [18] which points to the wide spread challenge of AMR in

Uganda's veterinary sector. The least resistance to fluoroquinolone could be attributed to their limited use since farmers most use tetracycline, penicillin and aminoglycosides [18].

Resistance to all the drugs was seen with isolates from the central region. The central region is the hub for commercial pig production with majority of pigs produced under intensive production system. The high prevalence of multidrug resistant *E. coli* in the central region could be attributed to the possibility of high antibiotic use for prophylaxis and feed additives in the central region compared to other parts of the country. Additionally, there are many veterinary drugs shops in the central which makes accessibility to drugs by farmer and veterinarians easy and cheaper. According to the study by [13], antimicrobials are purchased over the counter without any prescription. Heavy use of antibiotics in Uganda's livestock sector has been reported by Ugandan scholars [19] [20].

Furthermore, the retailers do not restrict to whom they sell the veterinary antibiotics and the buyers base on previous experience or the farmers' experience with a particular drug in purchasing it for use. This form of drug purchase could accelerate the development of antimicrobial resistance across almost all classes of antimicrobials in the central region of Uganda. Heavy use of antibiotics in Uganda's livestock sector has been reported by Ugandan scholars [19] [20].

5. Conclusion

The multidrug resistant *Escherichia coli* among pigs brought for slaughter in Uganda was confirmed with the highest resistance confirmed against erythromycin followed by tetracycline. At regional level, the isolates from pigs produced in the central region showed highest levels of multidrug resistance compared to other regions. Isolates from the abattoir houses showed similar results of antimicrobial resistance with environmental *E. coli* showing 100% resistance against erythromycin followed by tetracycline. Generally, the majority of the good pork handling practices were not followed by the abattoir workers during the slaughter process. Failure to follow recommended abattoir hygiene pork handling practices by the workers and the presence of multidrug-resistant *E. coli* in the slaughterhouses could present a possible risk of pork contamination with multidrug-resistant *E. coli* with a potential risk of causing antibiotic resistant foodborne illnesses among pork consumers in Uganda. The current findings could justify active surveillance of antimicrobial resistance among food animals and provides basis for monitoring the quality of pork products to ensure food safety.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Table A1. Summary of the pork handling practices at Wambizzi abattoir, central Uganda.

(a)

	Operational standards	Category (Yes/No)	Frequencies (N = 22)	Percentages (%)
Lairage	Dust and mud free?	Yes	0	0.0
		No	22	100.0
	Floor made of easy to clean materials?	No, Made of soil	22	100.0
	Presence of drainage system?	No	22	100.0
	Presence of wash points?	No	22	100.0
	Presence of beddings to minimize soiling of animals?	No	22	100.0
Bleeding area	Dust and mud free?	No, Flooded	4	18.2
		No, Floor has blood	18	81.8
	Bleeding area separated from dressing area?	Yes	22	100.0
	Is the killing area clean?	No	18	81.8
		No, Flooded	4	18.2
	Presence of drainage system?	Yes	22	100.0
	Presence of wash points?	No	22	100.0
	Workers with protective equipment?	Yes, Overalls and gumboots	22	100.0

(b)

	Operational standards	Category (Yes/No)	Frequencies (N = 22)	Percentages (%)
Inspection area	Mud and dust free?	No, Flooded	4	18.2
		No, Floor has carcass trimmings, hairs and water	18	81.8
	Workers with protective equipment?	Yes, Overalls and gumboots	22	100.0
	Presence of drainage system?	Yes	22	100.0
	Disinfection points with disinfectant?	No	22	100.0
	Proper evisceration to avoid pork contamination with intestinal contents?	No, Intestinal contents spilled over the meat during evisceration	3	13.6
		Yes	19	86.4
	Rails with hooks fixed 2 m above the floor to avoid meat touching the floor?	Yes	22	100.0
	Proper cleaning of the carcass?	No slaughter slab, carcass dehaired from the ground, and raised on hook, cleaned with tap water	22	100.0
	Are there containers for handling meat?	No, Carried on worker's back	22	100.0
	Is the slaughter area clean?	No	18	81.8
		No, Flooded	4	18.2

(c)

	Operational standards	Category (Yes/No)	Frequencies (N = 22)	Percentages (%)
Pork handling area	Is the pork handling area clean?	No, Flooded	4	18.2
		Yes, Slaughter slabs are clean	18	81.8
	Presence of a drainage system?	Yes	22	100.0
	Mud and dust free?	No	18	81.8
		No, Floor was flooded	4	18.2
	Presence of wash basins and disinfectants?	No	22	100.0
	Workers with protective equipment?	Yes, Overalls, overcoats and gumboots	22	100.0
Waste management	Are the stomach and intestinal contents disposed of properly and dried? (Composting)	Yes, Dried and sold as manure	22	100.0
	Are the inedible tissues, trimmings, waste and condemned meat disposed of properly? (incineration)	Yes	22	100.0