



Antibiotics Susceptibility Profile of *Listeria* species Isolated from Untreated Abattoir Wastewater in Akinyele, Ibadan, Nigeria and Its Implication on Public Health

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Authors' contributions

This work was carried out in collaboration between all authors. Authors OIF and OEF designed the study and the protocol. Authors OIF and AGR managed literature search, data acquisition and wrote the first draft. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: The demand for meat to meet the need of increasing human population has led to increase in the abattoir activities. Untreated abattoir wastewaters which may constitute a public health threat due to the possibility of transmission of pathogens to humans are constantly being discharged into water bodies. *Listeria* is an emerging pathogen that is commonly associated with food infection and has been found to survive in water.

Aim: This study was carried out to determine the occurrence and antibiotic resistant pattern of *Listeria* species isolated from abattoir wastewater in Akinyele, Ibadan.

Materials and Methods: Wastewater samples were collected from the slaughter slab and drainage channels between May and June, 2015. *Listeria* species were isolated using *Listeria* Selective Agar Base with *Listeria* Selective Supplement and identification of the isolates was done using conventional methods. Antimicrobial susceptibility testing was carried out using the Kirby-Bauer disk diffusion assay using single antibiotic disks including ampicillin, streptomycin, chloramphenicol, amoxicillin/clavulanate, ceftriazone, cloxacillin, ciprofloxacin, ofloxacin, tetracycline and

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trimethoprim/sulfamethoxazole.

Results: A total of 82 *Listeria* spp. were isolated comprising 58.5% and 41.5% from the slaughter slab and drainage respectively; all the isolates were resistant to ampicillin while 86.6%, 68.3% and 65.5% were resistant to ceftriaxone, amoxicillin/clavulanate and tetracycline respectively. In addition, 12.2% of the total isolates were resistant to a combination of six antibiotics (ampicillin, tetracycline, amoxicillin, ceftriazone, streptomycin, and trimetoprim/sulfamethoxazole) while only one isolate was resistant to eight or more antibiotics.

Conclusion: This study revealed that the Akinyele abattoir wastewater is a potential medium for the transmission of multi-drug resistant bacteria to humans. Hence, adequate measures should be put in place for the treatment of the abattoir wastewater before discharge into the environment.

Keywords: *Listeria* species; antibiotics resistance; abattoir wastewater; emerging pathogen.

1. INTRODUCTION

Listeria is an emerging pathogen which is commonly associated with food borne infection [1]. Out of the eight generally recognized species that includes the following: *L. monocytogenes*, *L. ivanovii*, *L. seeligeri*, *L. innocua*, *L. welshimeri*, *L. grayi*, *L. marthii* and *L. rocourtiae* [2,3], only *L. monocytogenes* and *L. ivanovii* are both humans and animals pathogens while *L. ivanovii* cause disease mostly in ruminants animals, others are regarded as nonpathogenic [2,4]. However, there have been reported cases of human infection as a result of *L. ivanovii*, *L. seeligeri*, *L. innocua* and *L. welshimeri* [5-7]. For instance, *L. innocua* has been reported to be occasionally associated with encephalitis in ruminants [8]. *L. monocytogenes*, the etiologic agent of listeriosis continues to be a pathogen with significant impact in the public economy all over the world because of the food safety concern [9]. The pathogen has also been reported to be responsible for infections such as meningitis, encephalitis and septicemia in immune-compromised individuals, abortion in pregnant women and neonatal infections with lethality around 20%-30% of all cases [7,10].

While *Listeria* is reported to be responsible for several food borne outbreaks in the developed world, little is known about such outbreak in the developing countries [10,11]. Although, food is the primary route of transmission of *Listeria* infections, studies have shown that this pathogen is able to survive in water and that wastewater is a potential reservoir for *Listeria* species and possible source of its transmission [1,12-14]. Transmission of this pathogen via wastewater has a serious public health implication especially in the developing world in which the greater percentage of the population depends on surface water for drinking and other domestic purposes.

Most of the surface water is negatively impacted as they are constantly receiving wastewater that is untreated or not properly treated from operations like the abattoir [15,16].

The continuous drive to increase meat production to meet the ever increasing protein demand of the increasing world population goes along with pollution problem [17,18]. Abattoir wastewater generated during the slaughtering activities are of great concern because like other discharged sewage, they eventually enter natural bodies of water like ground water, streams, rivers, lakes and oceans [19,20]. These water bodies are used by humans for different purposes especially for drinking and recreation; such usage has been implicated in the transmission of pathogens to humans [21,22]. Previous reports has shown that bacteria exists either as free-living or attached cells [23] in other to resist the action of disinfection and enhance their ability to develop resistance to antimicrobial agents [1]. More so *Listeria* has been reported to be resistant to antimicrobial agents which were as a result of certain resistance genes that encode proteins and act to either inhibit or reduce the effect of the antimicrobials on the pathogen [1,24].

Reports have shown that the mortality rate of *Listeria* infections is as high as 50% among the foodborne pathogens [10], an indication that Nigerian public is vulnerable because of the high HIV/AIDS prevalence in the country coupled with the rate of drug and alcohol abuse just like some other low income countries [1,25]. However, only limited information on the prevalence and possible outbreak of listeriosis in Nigeria is available. More importantly, *Listeria* is not considered as a waterborne pathogen despite reports in literature that it is well established in water supply chain [12,14]. The first prevalence study of *Listeria* was a serological study, but the

first isolation was in 1969 [26,27] in a female adult with leptomeningitis being treated with chloramphenicol and prednisone. The first neonatal listeriosis from which *L. monocytogenes* was isolated was from a 2-day old baby who developed *Listeria meningitis* after the contact with the mother. [28]. Since then the pathogen has been isolated from neonatal septicemia patients in the country [29,30]. *Listeria monocytogenes* was also reported to be prevalent in cattle and other animals characterised by still birth, abortion and nervous signs before death [31].

Resistance of *Listeria* spp. to antimicrobial agents has been reported, the most common among clinical isolates is to chloramphenicol and ampicillin [26]. A high level of resistance to clindamycin, daptomycin, fluoroquinolone and to third- and fourth-generation cephalosporins was observed in a study on *Listeria* spp. isolated from humans and slaughterhouse [32]. In another study, some strains of *L. monocytogenes*, *L. innocua*, *L. seeligeri*, and *L. welshimeri* were found to be resistant to oxacillin, clindamycin and daptomycin which are widely used in hospitals for the treatment of Gram-positive infections [33]. The indiscriminate discharge of untreated abattoir wastewater into the environment may portend grave danger to the health of the public because the wastewater may harbour pathogens with high level of antibiotics resistance and even multiple drug resistant organisms capable of cross-infecting human and cattle due to increasing evidence that the use of antimicrobial in animals selects for resistant pathogens [34]. In Nigeria, there is a need to investigate emerging waterborne pathogen that is being overlooked or not investigated though they have tendency to survive and be distributed in water supply chain [1]. This study was carried out to determine the prevalence of *Listeria* species in untreated abattoir wastewater as well as determine the profile of the isolated strains to selected antibiotics.

2. MATERIALS AND METHODS

2.1 Study Site

The study site was a commercial abattoir located in Akinyele-Ibadan, Oyo State, Nigeria. Ibadan is the largest city in West Africa [35] with land size covering an area of 240 km², and a human

population of about 3 million. The city is located on geographic grid reference longitude 3° 5' E and latitude 7° 20' N [36].

2.2 Sample Collection

Wastewater samples were aseptically collected into sterile polythene bottles from slabs where animals are being slaughtered and also from the drainage channel which is about 15 meters away from the slab. The samples were transported immediately to the laboratory in ice packs for microbiological analyses. Samples were collected bi-weekly over a period of six weeks (May and June, 2015).

2.3 Isolation and Identification of *Listeria* species

Listeria species were isolated using the method described by Akano et al. [37]. The wastewater samples analysis was done using the *Listeria* Selective Agar Base (Oxoid) which was prepared according to manufacturers' instruction and supplemented with a vial of *Listeria* Selective Supplement. Serial dilutions of the abattoir wastewater samples were done and standard pour plate technique was used by plating out 1 ml of the appropriate dilution on the *Listeria* selective media. The plates were then incubated at 35°C for 24-48 hrs. Typical colonies of *Listeria* species, gray coloured isolates with dark background, were sub-cultured on *Listeria* Selective Agar media to obtain pure isolates. Identification of *Listeria* strains were carried out in accordance with standard methods of identification of bacteria of medical importance through microscopy, Gram staining and biochemical tests.

2.4 Antibiotics Susceptibility Test of the Isolates

The antibiotics susceptibility test for the *Listeria* isolates was done using the standard disk diffusion technique based on the recommendation of Clinical Laboratory Standards Institute [38] on Mueller-Hinton agar. The antibiotics used were obtained from Oxoid, U.K. and include: Ampicillin (10 µg), streptomycin (10 µg), chloramphenicol (30 µg), amoxicillin/clavulanate (30 µg), ceftriazone (30 µg), cloxacillin (5 µg), ciprofloxacin (10 µg), ofloxacin (5 µg), tetracycline (25 µg) and trimethoprim/sulfamethoxazole (25 µg).

Colonies of 18-24 hour old culture was picked and suspended in a tube containing sterile normal saline (0.85% NaCl) and the turbidity adjusted to 0.5 McFarland standards. With the aid of a sterile swab stick, the suspension was uniformly spread over already prepared Mueller Hinton agar plates and with the aid of sterile forceps, the antibiotics were placed carefully on the plates which were inverted and incubated at 37°C for 18-24 hours. After the incubation period, the zones of inhibition were measured, recorded and compared/interpreted to the CLSI standards [38].

3. RESULTS

A total of 82 *Listeria* spp. were recovered from the Akinyele abattoir wastewater samples and comprises of 48 (58.5%) and 34 (41.5%) from the slaughter slab and the drainage respectively (Table 1). The identification showed that 22 (26.8%) were *Listeria monocytogenes*; 15 (18.3%) were *L. ivanovii*, 17 (20.7%) were *L. innocua* while 28 (34.2%) belongs to other *Listeria* species. From the slaughter slab, the highest was *L. monocytogenes* (17.1%) while from the drainage, it was other *Listeria* sp. (18.3%) (Table 1).

The results of the antibiotic susceptibility test showed that all the isolates (100%) were resistant to ampicillin. However, all the *L. monocytogenes* (100%) and *L. ivanovii* (100%) were susceptible to ofloxacin while all the other *Listeria* species were susceptible to ciprofloxacin. Furthermore, resistance of the isolates to ceftriaxone (86.6%), amoxicillin (68.3%) and tetracycline (65.5%) was high. Among the isolates that were resistant to ceftriaxone, the highest was from other *Listeria* spp. (92.9%), followed by *L. monocytogenes* (90.9%), *L. innocua* (82.4%) and *L. ivanovii*. (73.3%) while among the different isolates that showed resistant to amoxicillin, the highest was among the other *Listeria* spp. (85.7%), followed by *L. innocua* (70.6%) then *L. monocytogenes* (63.6%) and *L. ivanovii* (40%). More so resistance to tetracycline was 71.4% (other *Listeria* species), 70.6% (*L. innocua*), 60.0% (*L. ivanovii*) and 59.1% (*L. monocytogenes*).

Moreover, resistance of the isolates to ofloxacin (6.1%), cloxacillin. (11.0%) and streptomycin (36.6%) was low (Table 2). Furthermore, the result of the antibiotypes (pattern of resistance to combination of antimicrobials) showed that the highest (12.2%) was to the combination of six

different drugs that included ampicillin, tetracycline, amoxicillin/ clavulanate, ceftriaxone, streptomycin and Trimethoprim/ sulfamethoxazole. Out of these, 25.0% *Listeria* sp. were resistant while it was 4.5% (*L. monocytogenes*), 6.7% (*L. ivanovi*) and 5.9% (*L. innocua*). In addition the result of this study also revealed that 9.6% of the resistant isolates exhibited resistance to a combination of four drugs including: Ampicillin, tetracycline amoxicillin and ceftriaxone with the highest (17.6%) being among the *L. innocua* followed by the *L. monocytogen* (13.6%) and other *Listeria* species but none of the *L. ivanovvi* showed resistance to the four antibiotic combination. Resistance to a combination of five drugs including ampicillin, tetracycline, amoxicillin/clavulanate, ceftriaxone and chloramphenicol was 7.3% which was among *L. monocytogenes* (13.6%) and other *Listeria* species (10.8%) while none of the *L. ivanovvi* and *L. innocua* showed resistant to the combination of the drugs. More so, the result of the study also showed that one (1.2%) isolates each among the other *Listeria* spp. showed resistant to eight or more antibiotics (Table 3).

4. DISCUSSION

Isolation of *Listeria* species from wastewater portending the organism as emerging pathogen associated with wastewater has been reported [39]. This organism has also been isolated from ruminant animals [40,41] and in 2008; strains of *L. monocytogenes* were isolated from broiler abattoir in Spain [42] and from pork products in India [9]. The highest occurrence of the isolates from this study which was *L. monocytogenes* (26.8%) followed by *L. innocua* (20.7%) and *L. ivanovii* (18.3%) is similar to the report of the study on pork and pork products where the occurrence of *L. monocytogenes* was higher than the other species [9]. However, the occurrence rate of these isolates was higher in this study compared to the same study; this may be because other animals including pigs are being slaughtered in the sampling site for this present study. This observation was not in agreement with another study carried out on animal faeces from the northern part of Nigeria in which the occurrence of *L. monocytogenes* was reported to be the least of all the *listerial* isolates [40].

The sensitivity of *L. monocytogenes* to ampicillin (0%), chloramphenicol (59.1%), streptomycin (59.1%) and trimethoprim/ sulfamethoxazole

(63.6%) in this study is not in agreement with the report of another study carried out on isolates from ready to eat food from South Africa in which all the isolates (100%) were reported to be sensitive to the combination of the four antibiotics [34]. However, the observation that all the *Listeria* isolates were fully sensitive (100%) to ciprofloxacin is the same with the report of Ndir et al. [34]. This observation is however higher but comparable to the 91% resistant reported in South Africa [1]. The reason for the slight difference may be as a result of the studied sample. While the present study was on abattoir wastewater, the later study was on municipal wastewater. Comparing the antibiotics resistance patterns of the *L. monocytogenes* form this study with the same strain in another study in the country, resistance to cloxacillin at the same concentration (5 µg) was much higher (80.7%) in the study [39] than the 4.5% in the present study. Resistance of the *L. monocytogenes* in this study was lower (63.6%) but comparable to the 77.4% in the other study [39]. The reason for the slight difference may be due to the different concentration of the antibiotics used in the studies which was 30 µg (present study) and 25 µg [39]. With the same drug concentration, resistance of *L. monocytogenes* to ampicillin (100%), chloramphenicol (36.4%) and streptomycin (40.9%) in this study was higher than the one reported by Enurah and his colleagues which was 64.5% (ampicillin), 1.2% (chloramphenicol) and 35.5% (streptomycin). Resistance to tetracycline in this study was 59.1% while it was 19.36% in the other study. However, the concentration used in this study was 30 µg while that reported in the latter study was 10 µg.

Also in another study carried out on the tissues of slaughtered cattle in a neighboring abattoir in Ibadan, all the *Listeria* isolates were reported to exhibit 100% resistance to all the antibiotics tested [41] which is not in agreement with the result of the present study except for resistance of the isolates to ofloxacin. The reason for this may be as a result of the samples studied and some of the concentration of the antibiotics used which was higher in the present study, although, the same concentration of antibiotic was used for amoxicillin and streptomycin. Moreover, there were discrepancies in the resistance of the isolates to ciprofloxacin, amoxicillin, and tetracycline. Resistance of *L. monocytogenes* to the respective antibiotics was 50%, 100% and

50% [43] which is not in agreement with the observation from the present study. Furthermore, while resistance of *L. innocua* to tetracycline and ceftriaxone was high in both studies; varying resistance rate was observed in this study which is not in agreement with full susceptibility reported in the other study [43]. The resistance of all the *Listeria* isolates to ceftriaxone in this study and that of Akano et al. [43] is similar with 86.6% and 85.2% respectively. However, resistance of the isolates in this study was lower to amoxicillin, chloramphenicol, ciprofloxacin and ofloxacin. But the resistance of all the listeria isolates in this study which was 100% (ampicillin), 41.5% (chloramphenicol), 36.6% (streptomycin) and 65.5% (tetracycline) was much higher than the 12% (ampicillin), 15% (chloramphenicol), 15.8% (streptomycin) and 23.3% (tetracycline) obtained from the study of listeria isolates from open-air fish market [44]. More so, the observation was similar to the resistance of *L. monocytogenes* isolates in which all the strains in this study is higher than those of the later study. The reason for these discrepancies may be due to the studied samples. The observation of the resistance patterns of *L. monocytogenes* to ampicillin, chloramphenicol, tetracycline and streptomycin in this study is not in agreement with another study from Gaborone, Botswana where resistance to the respective drugs was reported to be 0%, 28.3%, 67.8% and 80.7% [45] as against the 100%, 36.4%, 59.1% and 40.9% respectively. These discrepancies could be as a result of the samples studied which may impact on their adaptation and response to different chemicals and antimicrobial agents. While the samples for this study were from abattoir wastewater, the Botswana samples were from various foods. The high resistance of the isolates to some of the tested antibiotics shows the probability of natural resistance to third/fourth-generation cephalosporin. This is an indication that the isolates showed resistance to antibiotics that are currently being used in the treatment of listeriosis infection such as ampicillin and trimethoprim-sulfamethoxazole [34]. Consequently, these isolates potentially constitute high risk when these traditional treatments are used. Multiple drug resistance in these organisms might be attributed to antimicrobial selective pressure and gene transfer mechanisms between and among the *Listeria* species and close relatives of the bacteria such as *Enterococcus*, *Streptococcus* and *Staphylococcus* species [46,47].

Table 1. Number and percentage occurrence of isolated organisms from the abattoir wastewater sample in Akinyele, Ibadan

| Isolates | Source | | Total (%) |
|-------------------------------|--------------------|--------------|-----------|
| | Slaughter slab (%) | Drainage (%) | |
| <i>Listeria monocytogenes</i> | 14 (17.1) | 8 (9.6) | 22 (26.8) |
| <i>Listeria ivanovii</i> | 12 (14.6) | 3 (3.7) | 15 (18.3) |
| <i>Listeria innocua</i> | 9 (11) | 8 (9.8) | 17 (20.7) |
| <i>Listeria spp.</i> | 13 (15.9) | 15 (18.3) | 28 (34.2) |
| Total | 48 (58.5%) | 34 (41.5%) | 82 (100%) |

Table 2. Antibiotic susceptibility pattern of *Listeria* species isolated from the abattoir wastewater. Number (%)

| Antibiotics | <i>L. m.</i> | <i>L. iv</i> | <i>L. in</i> | <i>L. spp</i> | <i>L. m.</i> | <i>L. iv</i> | <i>L. in</i> | <i>L. spp</i> | TR |
|---------------------------------------|--------------|--------------|--------------|---------------|--------------|--------------|--------------|---------------|-----------|
| | n=(22) | (n=15) | (n=17) | (n=28) | n=(22) | (n=15) | (n=17) | (n=28) | N=82 |
| | Sensitive | | | | Resistance | | | | |
| Ampicillin (10 µg) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 22 (100) | 15 (100) | 17 (100) | 28 (100) | 82 (100) |
| Amoxicillin/Clavulanate (30 µg) | 8 (36.4) | 9 (60) | 5 (29.4) | 4 (14.3) | 14 (63.6) | 6 (40) | 12 (70.6) | 24 (85.7) | 56 (68.3) |
| Ceftriaxone (30 µg) | 2 (9.1) | 4 (26.7) | 3 (17.6) | 2 (7.1) | 20 (90.9) | 11 (73.3) | 14 (82.4) | 26 (92.9) | 71 (86.6) |
| Ciprofloxacin (5 µg) | 22 (100) | 15 (100) | 17 (100) | 28 (100) | 0 (0) | 0 (0) | 0 (0) | 0 (0) | 0 |
| Ofloxacin (5 µg) | 22 (100) | 15 (100) | 16 (94.1) | 24 (85.7) | 0 (0) | 0 (0) | 1 (5.9) | 4 (14.3) | 5 (6.1) |
| Cloxacillin (5 µg) | 21 (95.5) | 13 (86.7) | 15 (88.2) | 24 (85.7) | 1 (4.5) | 2 (13.3) | 2 (11.8) | 4 (14.3) | 9 (11.0) |
| Chloramphenicol (30 µg) | 14 (63.6) | 8 (53.3) | 12 (70.6) | 14 (50) | 8 (36.4) | 7 (46.7) | 5 (29.4) | 14 (50) | 34 (41.5) |
| Tetracycline (30 µg) | 9 (40.9) | 6 (40) | 5 (29.4) | 8 (28.6) | 13 (59.1) | 9 (60) | 12 (70.6) | 20 (71.4) | 54 (65.5) |
| Trimethoprim/sulfamethoxazole (25 µg) | 14 (63.6) | 8 (53.3) | 8 (47.1) | 13 (46.4) | 8 (36.4) | 7 (46.7) | 9 (52.9) | 15 (53.6) | 39 (47.6) |
| Streptomycin (10 µg) | 13 (59.1) | 9 (60) | 11 (64.7) | 19 (67.9) | 9 (40.9) | 6 (40) | 6 (35.3) | 9 (32.1) | 30 (36.6) |

L. m., *Listeria monocytogenes*; *L. iva*, *L. ivanovii*; *L. inn*, *L. innocua*; *L. spp*, other *Listeria* species; TR Total Resistance

Table 3. Antibiotypes of all *Listeria* species isolated from abattoir wastewater

| Antibiotypes | <i>L. monocytogenes</i> 22 (26.8) | <i>L. ivanovii</i> 15 (18.3) | <i>L. innocua</i> 17 (20.7) | Other <i>Listeria</i> . spp. 28(34.1) | Total n/% (82/100) |
|------------------------------|--------------------------------------|---------------------------------|--------------------------------|--|-----------------------|
| AMP | 2 (9.1) | 3 (20.1) | 1 (5.9) | 2 (7.1) | 8 (9.6%) |
| AMP~OB | 0 (0) | 1 (6.7) | 1 (5.9) | 2 (7.1) | 4 (4.9%) |
| AMP~T | 0 (0) | 0 (0) | 1 (5.9) | 0 (0) | 1 (1.2%) |
| AMP~AMC~OB | 1 (4.5) | 1 (6.7) | 0 (0) | 1 (3.6) | 3 (3.7%) |
| AMP~T~OB | 1 (4.5) | 1 (6.7) | 0 (0) | 0 (0) | 2(2.4%) |
| AMP~S~SXT | 0 (0) | 0 (0) | 1 (5.9) | 0 (0) | 1 (1.2%) |
| AMP~OB~SXT | 1 (4.5) | 0 (0) | 0 (0) | 1 (3.6) | 2 (2.4%) |
| AMP~T~OB~C | 0 (0) | 1 (6.7) | 0 (0) | 1 (3.6) | 2(2.4%) |
| AMP~T~OB~S | 1 (4.5) | 1 (6.7) | 0 (0) | 0 (0) | 2(2.4%) |
| AMP~OB~S~SXT | 2 (9.1) | 1 (6.7) | 0 (0) | 0 (0) | 3 (3.7%) |
| AMP~AMC~OB~SXT | 2 (9.1) | 0 (0) | 1 (5.9) | 1 (3.6) | 4 (4.9%) |
| AMP~T~AMC~OB | 3 (13.6) | 0 (0) | 3 (17.6) | 2 (7.1) | 8 (9.6%) |
| AMP~T~OB~SXT | 0 (0) | 0 (0) | 1 (5.9) | 1 (3.6) | 2(2.4%) |
| AMP~T~AMC~OB~C | 3 (13.6) | 0 (0) | 0 (0) | 3 (10.8) | 6 (7.3%) |
| AMP~T~CRO~OB~SXT | 0 (0) | 0 (0) | 1 (5.9) | 0 (0) | 1(1.2%) |
| AMP~T~AMC~OB~SXT | 1 (4.5) | 0 (0) | 1 (5.9) | 1 (3.6) | 3(3.7%) |
| AMP~T~AMC~OB~C~SXT | 1 (4.5) | 1 (6.7) | 2 (11.8) | 0 (0) | 4 (4.9%) |
| AMP~T~AMC~OB~S~SXT | 1 (4.5) | 1 (6.7) | 1 (5.9) | 7 (25.0) | 10 (12.2%) |
| AMP~T~AMC~OB~OFX~SXT | 0 (0) | 0 (0) | 0 (0) | 1 (3.6) | 1(1.2%) |
| AMP~T~AMC~OB~C~S | 2 (9.1) | 0 (0) | 1 (5.9) | 0 (0) | 3(3.7%) |
| AMP~T~AMC~CRO~OB~C~SXT | 0 (0) | 1 (6.7) | 0 (0) | 0 (0) | 1(1.2%) |
| AMP~T~AMC~OB~C~S~SXT | 0 (0) | 2 (13.3) | 0 (0) | 1 (3.6) | 3(3.7%) |
| AMP~T~AMC~CRO~OB~C~S | 1 (4.5) | 0 (0) | 0 (0) | 0 (0) | 1(1.2%) |
| AMP~T~AMC~CRO~OB~S~SXT | 0 (0) | 0 (0) | 1 (5.9) | 0 (0) | 1(1.2%) |
| AMP~T~AMC~OB~OFX~C~S~SXT | 0 (0) | 0 (0) | 1 (5.9) | 1 (3.6) | 2(2.4%) |
| AMP~T~AMC~CRO~OB~C~S~SXT | 0 (0) | 1 (6.7) | 0 (0) | 1 (3.6) | 2(2.4%) |
| AMP~T~AMC~CRO~OB~OFX~C~SXT | 0 (0) | 0 (0) | 0 (0) | 1 (3.6) | 1(1.2%) |
| AMP~T~AMC~CRO~OB~OFX~C~S~SXT | 0 (0) | 0 (0) | 0 (0) | 1 (3.6) | 1(1.2%) |

CIP, Ciprofloxacin; AMP, Ampicillin; T, Tetracycline; OFX, Ofloxacin; CRO, Cloxacillin; OB, Ceftriaxone; C, Chloramphenicol; S, Streptomycin; SXT, Trimethoprim/sulfamethoxazole; AMC, Amoxicillin/clavullanate; A, Slaughter slab; B, drainage

The results indicated alarming multi-resistance frequencies to at least three or more of the tested antibiotics. This could constitute public health concern because the abattoir wastewater can act as reservoir of resistant strains which could be transmitted to humans. Similar patterns of resistance have been reported by Srinivasan et al. [24] who found that all *L. monocytogenes* strains isolated from a dairy farm environment were resistant to ampicillin, tetracycline and chloramphenicol. Therefore, the emergence of resistance to these antibiotics demands attention due to the risk of increasing multidrug resistance in *Listeria* and the possibility of its transference to other bacteria [24].

5. CONCLUSION

In conclusion, this study has further confirmed a high prevalence of *Listeria* species especially *L. monocytogenes* in wastewater samples. This is an indication that such wastewater could serve as a public health threat especially among the immune compromised individuals like the HIV/AIDS patients that are at greater risk as it may lead to the outbreak of listeriosis disease. It was also evident that *L. monocytogenes* exhibited high resistant to ampicillin, ceftriaxone, amoxicillin/clavulanate and tetracycline which is suggestive that the misuse of antimicrobial drugs for therapeutic purposes in both animals and humans may lead to antibiotic resistance development. It is therefore recommended that adequate measure should be put in place for the proper treatment of the abattoir wastewater before they are discharged into the environment and further study is needed to provide better understanding of the epidemiology of listeriosis in Nigeria.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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