Prevalence of Multidrug Resistant *Escherichia Coli* in Fish, Fish Handlers and Water in Sokoto State Nigeria

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ABSTRACT

Fish and sea-food constitute an important and cheap food source of protein for many groups of the world population. Fish contains good quality protein and other necessary nutrients that make it a valuable food. This study investigates the occurrence and antimicrobial resistance profiles of E. coli isolated from fish, fish handlers, and water sources in Sokoto State, Nigeria. Aquatic animals, especially fish, constitute a significant source of animal protein globally, with growing aquaculture practices implicated in environmental dissemination of antibiotic resistance due to extensive antimicrobial use. E. coli, a known opportunistic pathogen and vector for antibiotic resistance genes through horizontal gene transfer, poses public health risks, particularly when multidrug-resistant (MDR) strains prevail. The study was a cross-sectional descriptive survey conducted over six months, involving sample collection from institutional fish farms, rivers, lakes, and fish handlers. Isolation and identification of E. coli employed standard microbiological and biochemical methods, followed by antimicrobial susceptibility testing using the Kirby-Bauer disc diffusion method on 15 antibiotics, interpreted per CLSI guidelines. Out of 360 samples, E. coli was isolated in 5.83% overall prevalence, with higher detection in human samples (8%) compared to fish (3.33%) and water (5.71%). All isolates exhibited multidrug resistance, showing 100% resistance to Gentamycin, Quinupristin, Mupirocin, Amoxicillin-Cloxacillin, Ceftazidime, Cefpodoxime, Ertapenem, and Imipenem. Resistance levels varied for other antibiotics, with highest resistance against Tetracycline (95.2%) and moderate resistance for Sulphamethoxazole (38.1%) and Azithromycin (33.3%). Multiple antibiotic resistance index (MARI) values ranged from 0.6 to 0.8, indicating high-risk contamination sources. These findings highlight the presence of MDR E. coli in the aquatic environment and associated human contacts, underscoring the public health risk and the necessity for surveillance, rational antibiotic use, and improved sanitation in aquaculture and fish handling practices in Nigeria. This study fills a critical research gap in northwest Nigeria where limited data exist on antibiotic resistance in aquatic settings, providing essential baseline data to inform policy and control measures against antimicrobial resistance in aquatic food chains and human populations.

Keywords: *Fish, Fish Handlers, Multidrug Resistant E. coli, Prevalence, Sokoto State, Water*

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INTRODUCTION

Aquatic animals contribute to 17% of global animal protein consumption, with fish providing nearly 20% of per capita animal protein for over 40% of the world's population. Global food fish consumption growth has outpaced the consumption of meat from terrestrial animal production sectors, except for poultry (Schar *et al*., 2020). Aquaculture is a fast-growing food-production industry, supplying 30.1 million metric tons of aquatic plants, 80 million tons of total food fish and 37,900 tons of non-food products to the growing world population (FAO, 2018). The occurrence of antibiotics in the aquatic environment, especially in aquaculture farms and rivers, has been viewed as one of the major threatening issues causing environmental pollution worldwide. The usage of antimicrobial agents in aquaculture has increased exponentially, accounting for 63,151 tons in 2010, and is expected to increase to 67% by 2030 (Okocha *et al.,* 2018).

The occurrence of antibiotic resistance (ABR) in aquatic environments poses a significant threat not only to human health but also to a wide range of ecological and environmental aspects, including ecosystems and food webs, disrupting their delicate balance and resilience. When the delicate balance of microbial communities is thrown off, both nutrient cycling and ecosystem stability suffer. This disruption, often fuelled by the rise of antibiotic-resistant bacteria, directly impacts the organisms within these systems, posing a major threat to their well-being (Monahan *et al.,* 2021). This disruption can extend to soil ecosystems, affecting the intricate relationships between microorganisms and plants, thus influencing agricultural productivity and soil fertility. In agricultural settings, for instance, the use of antibiotics in livestock can foster the development of resistant strains that affect animal health, potentially impacting humans through the food chain (Iwu *et al.,* 2020). Similarly, in aquatic environments, the presence of antibiotic-resistant bacteria can disrupt the health of aquatic organisms, leading to imbalances in the ecosystem. The impact on fisheries and aquaculture due to antibiotic-resistant bacteria can affect food production and access to protein sources for humans (Pepi and Focardi, 2021).

Escherichia coli are opportunistic pathogens that can endure well in aquatic systems and are exceptionally proficient at horizontal gene transfer, which is believed to be the vector for antibiotic resistance dissemination (Maeusli *et al*., 2020). Multidrug resistant *Entero-bacteriaceae* are of public concern, especially disease-causing *E. coli* (Nordman *et al*., 2011), mainly because *E. coli* has been reported to show resistance to all regularly prescribed antibiotics (Yu *et al*., 2016). The World Health Organization (WHO) has placed *E. coli* in the list of 12 families of bacteria that present the biggest dangers to human health (Tagliabue and Rappuoli 2018; Serwecinska *et al.,*2021). Ever since the first reported cases, *E. coli*'s resistance to antibiotic treatment has been continuously growing (Hong *et al*., 2016; Spagnolo *et al.,* 2016; van den Bergh *et al*., 2016; Mutairi *et al*., 2018). The water used in aquaculture often comes from waste water effluents, which contain antibiotic resistance genes (ARGs) from humans and from agricultural practices and may lead to the dissemination of these ARGs (Singer *et al.,* 2016). Aquaculture environments may act as reservoirs of ARGs and can accelerate the spread of antibiotic resistance to humans and animals through the ingestion of contaminated food and water and to other parts of the environment, leading to a public health problem (Silver *et al.,* 2019).

In Nigeria, AMR is a major public health threat to humans, animals and the environment. A recent situation analysis of antimicrobial use (AMU) and resistance in Nigeria documented high levels of AMR among microbes causing urinary, gastrointestinal and respiratory tract infections, as well as blood and skin infections (NCDC, 2017). Furthermore, antimicrobial-resistant pathogens and antimicrobial-resistance genes have been isolated from different environments (air, water and soil) that serve as reservoirs for human and animal infections (Bengtsson-Palme and Larsson, 2015; Bengtsson *et al.,* 2018). These developments result from the irrational and indiscriminate use of antimicrobials, including over dosage, incomplete treatment regimens, non-observance of withdrawal periods, lack of expert supervision of antibiotic usage and the availability and easy accessibility to counterfeit antimicrobials. Other contributing factors include environmental pollution, poor sanitation and infrastructure and the indiscriminate disposal of waste from abattoirs, hospitals and effluents from industry into the environment (FAO, 2018).

Despite the untenable rate of antibiotic resistant bacterial infections reported in most Nigerian cities, there is substantial gap in the surveillance of these infections in several Nigerian cities especially in northwest Nigeria where limited research has been done on the prevalence of difficult to treat infections (Yusuf *et al.,* 2014; Olowo-Okere *et al*., 2019). In the few studies conducted, a limited number of antimicrobial classes have been tested (Olowo-Okere *et al*., 2020). Also, the few researches conducted on antimicrobial resistant *E. coli* were limited to humans, the few available researches in animals and food products in the study area were limited to livestock meat, milk and poultry, to the best of our knowledge there is no any publish research on the aquatic environment, and in contact humans, hence the need to carry out this research. The overall aim of this study is to isolate, identify, and determine the antibiotic susceptibilities of *E. coli* from fish, water and fish handlers in Sokoto state.

MATERIALS AND METHODS

Study area

The study was carried out in Sokoto State. The State is located within the Sudan savannah agroecological zone of Nigeria. The State is located on latitude 13^0N and between longitudes $4^0 8^/$ E and $6^0 54^/$ E in North-western Nigeria. The State covers an area of approximately 32,000 square

kilometres (Blench, 1999). It shares boundaries with Republic of Niger to the north, Kebbi State to the South-west and Zamfara State to the East (Figure 1). Sokoto State's primary water bodies are the Sokoto River and Rima River, which are tributaries of the larger Niger River. Other bodies include the Goronyo, and Shagari Dams, which impounds water for the state, and numerous seasonal flood ponds like the Mashe, Baja, and Fakka/Uwamange lakes (FAO, 1990).

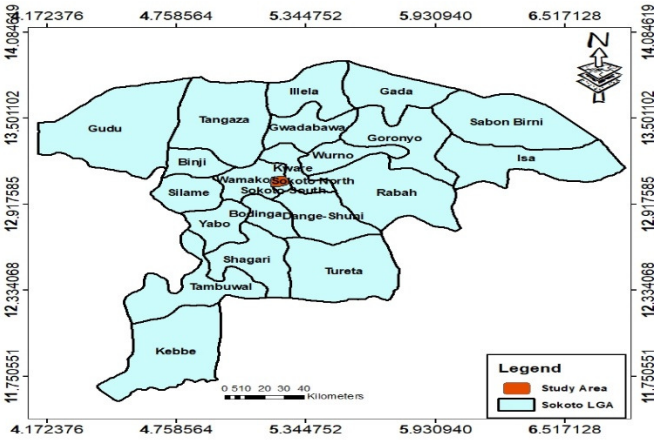

Figure 1: Map of Sokoto State Showing the Study Area (Garba *et al*., 2022)

Study design

A cross-sectional descriptive study that last for a period of 6 months involving important rivers, lakes, institutional fish farms, fishermen, and fish farmers was conducted to determine the occurrence of antibiotic resistant *E. coli* in Sokoto state.

Sample collection

A total of 32 samples was collected weekly for a period of 3 months, fish samples (whole fish) from each source was collected in separate plastic bag (Rocha *et al.,* 2014). All samples were collected during farm/river visit, as for the fish handlers, samples were collected by rolling the swab stick over the dorsal and palmar surfaces of the hands (Grema *et al.,* 2015, Shokr *et al*., 2018). A sample of 100ml of water was collected at two different locations in case of river and lakes, while 100ml was collected each from the water source and the ponds or tank. The samples (whole fish, water and, human swabs) were then transported on ice container, immediately to the Veterinary Microbiology Fleming Laboratory Usmanu Danfodiyo University Sokoto for processing.

Isolation and identification of *E. coli*

Fish swab samples were collected from the intestine by cutting open a part of large intestine after disinfecting the surface with 70% alcohol, and sterilizing with red-hot scalpel blade. All swab samples were inoculated into lactose broth for enrichment and incubated at 37ºC for 24h. thereafter, a loop-full culture from enrichment broth were streaked onto MacConkey agar and incubated at 37℃ for 24 hr. Suspected *E. coli* colonies, usually pink to red will be picked and further streaked on Eosin Methylene Blue (EMB) agar, on which the bacterial colonies appear green metallic sheen (Shakya *et al.,* 2016). For the isolation of *E. coli* from water samples; the membrane filtration technique was used. Single sterile 0.45µm pores filter disks were placed in a filtration unit to filter each 100 ml of the water sample. The filter membranes were then placed on TBX agar plates and incubated at 37 °C for 24 hr.

A single pure colony from each isolate was identified using a battery of screening biochemical tests which include Indole, Methyl Red, Voges Proskauer, Citrate, Urease, motility and, triple sugar iron reactions (TSI). For further confirmation the presumptive *E. coli*, isolates were further identified using Microgen A (MB 1073A, Oxoid UK).

Antibiotic susceptibility testing

Isolates were selected for antimicrobial susceptibility testing according to Kirby-Bauer disc diffusion techniques on Mueller Hinton agar using the following antibiotic discs, Sulphamethoxazole (SXT25µg), Mupirocin (MUP200µg), Azithromycin (AZM15µg), Gentamicin (GN10µg),Tetracycline (TC30µg), Imipenem (IM10µg), Ertapenem(ETP10µg), Meropenem (MEM10µg), Amoxicillin-Cloxacillin (AX10µg), Quinupristin (QD15µg), Ciprofloxacin (CP5µg), Ofloxacin (OFX5µg), Cefpodoxime (CPD10µg), Ceftriaxone (CRO30µg), and Ceftazidime (CAZ30µg), (Bio-Rad). The zone of inhibition was interpreted according to Clinical Laboratory Standard Institute (CLSI, 2025). Multiple antibiotic resistance index (MARI) was calculated isolates with MARI ≥ 0.2 originate from a high-risk source of contamination where several antibiotics are used. Multidrug resistance (MDR) is defined as resistance to more than 3 classes of antibiotics among all tested antibiotics (Magiorakos *et al*., 2012; Khan *et al*., 2015).

RESULTS

A total of 150 fishes were tested for the presence of *E. coli*, 84 from institutional farms, 66 from rivers and lakes, 3(3.6%) were positive from institutional farm, 2(3.03%) from rivers and lakes, the overall positive sample from fish is 5(3.33%). A total of 175 humans were tested for the presence of *E. coli*, 50 from fish market, 84 from rivers and 41 from institutional farms, 11(22%) were positive from fish market, 2(2.4%) from rivers 1(2.44%) from institutional farms respectively, the overall positive samples from humans is 14(8.0%). A total of 35 water samples were tested for the presence of *E. coli,* of which 27 were from farms, and 8 from rivers, 2(7.41%) were positive from institutional farms, and 0(0%) from rivers, the overall positive samples from water is (5.71%). The overall positive sample is 21(5.83%). Table 1 shows the overall sample distribution.

Table 1: Overall total number of *E. coli* samples isolated

Sample Source	Total Number of Samples	Positive Samples (%)
Fish from Farms	84	3 (3.60)
Fish from Rivers	66	2 (3.03)
Human from Fish Market	50	11 (22.0)
Human from Rivers	84	2 (2.40)
Human from Farms	41	1 (2.44)
Water from Farms	27	2 (7.41)
Water from Rivers	8	0 (0.0)
Total	360	21 (5.83)

Table 2: The Frequency Rate of Resistance to each Antibiotic against Total Number of Positive Samples

Antibiotics (n=15)	Resistance (%)	Intermediate (%)	Susceptible (%)
Sulphamethoxazole	8 (38.1)	8 (38.1)	5 (23.8)
Quinupristin	21 (100)	0 (0)	0 (0)
Tetracycline	20 (95.2)	0 (0)	1 (4.8)
Amoxycillin-Cloxacillin	21 (100)	0 (0)	0 (0)
Gentamycin	21 (100)	0 (0)	0 (0)
Mupirocin	21 (100)	0 (0)	0 (0)
Azithromycin	7 (33.3)	0 (0)	14 (66.7)
Ofloxacin	5 (23.8)	3 (14.3)	13 (61.9)
Ciprofloxacin	3 (14.3)	8 (38.1)	10 (47.6)
Ceftazidime	21 (100)	0 (0)	0 (0)
Ceftriaxone	3 (14.3)	3 (14.3)	15 (71.4)
Cefpodoxime	21 (100)	0 (0)	0 (0)
Ertapenem	21 (100)	0 (0)	0 (0)
Meropenem	2 (9.5)	9 (42.9)	10 (47.6)
Imipenem	21 (100)	0 (0)	0 (0)

Table 3: Antibiotics Resistant Pattern and Multiple Antibiotic Resistance Index of *E. Coli* Isolates.

Sample I. D.	Sample Source	Resistant Pattern	MAR Index
MA 1	Human	QD, TC, AX, GN, MUP, AZM, CAZ, CPD, ETP, IM	0.67
MA 2	Human	QD, TC, AX, GN, MUP, OFX, AZM, CAZ, CRO, CPD, ETP, IM	0.80
MA 4	Human	SXT, QD, TC, AX, GN, MUP, OFX, AZM, CAZ, CPD, ETP, IM	0.80
MA 5	Human	QD, TC, AX, GN, MUP, AZM, CAZ, CPD, ETP, IM	0.67
MA 6	Human	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
MA15	Human	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
MA 17	Human	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
MA 19	Human	QD, TC, AX, GN, MUP, OFX, AZM, CAZ, CPD, ETP, MEM, IM	0.80
MY 6	Human	QD, TC, AX, GN, MUP, AZM, OFX, CP, CAZ, CPD, ETP, IM	0.80
MY 8	Human	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
MY 18	Human	SXT, QD, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
BH 1	Human	SXT, QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.67
GHA 6	Human	SXT, QD, TC, AX, GN, MUP, AZM, CAZ, CPD, ETP, IM	0.73
RH 1	Human	SXT, QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.67
BBF2	Fish	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
SSF 6	Fish	QD, TC, AX, GN, MUP, OFX, AZM, CAZ, CPD, ETP, IM	0.73
ZF 2	Fish	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, MEM, IM	0.67
RFF 8	Fish	QD, TC, AX, GN, MUP, CAZ, CPD, ETP, IM	0.60
RFF 12	Fish	SXT, QD, TC, AX, GN, MUP, AZM, CAZ, CRO, CPD, ETP, IM	0.80
HWWP	Water	SXT, QD, TC, AX, GN, MUP, AZM, CAZ, CPD, ETP, IM	0.73
Naal WP	Water	QD, TC, AX, GN, MUP, OFX, CAZ, CPD, ETP, IM	0.67

(Abbreviations: SXT, Sulphamethoxazole; QD, Quinupristin; TC, Tetracycline; AX, Ampicillin-Cloxacillin; GN, Gentamycin; MUP, Mupirocin; AZM, Azithromycin; OFX, Ofloxacin, CP, Ciprofloxacin; CAZ, Ceftazidime; CRO, Ceftriaxone; CPD, Cefpodoxime; ETP, Ertapenem; MEM, Meropenem; IM,

Antibiotics Resistance

Percentage resistance to 15 antimicrobial is presented in table 4.2 and figure 4.0, all the isolates were resistant to Gentamycin, Quinupristin, Mupirocin, Amoxicillin-Cloxacillin, Cefpodoxime, Ceftazidime, Ertapenem and Imipenem. Out of all the isolates 20(95.2%) shows resistance to Tetracycline, 8(38.1%) shows resistance to Sulphamethoxazole, 7(33.3%) shows resistance to Azithromycin, 5(23.8%) shows resistance to Ofloxacin, 3(14.3%) shows resistance to Ciprofloxacin and Ceftriaxone and 2(9.5%) shows resistance to Meropenem. Five resistance patterns were observed with the resistance pattern of 0.8 being the highest and 0.6 being the lowest recorded (Tables 2 and 3). All the isolates exhibited multi-drugs resistance, with the highest showing resistance to 12 antimicrobial agents and the lowest to 9 antimicrobial agents (Tables 2 and 3; Figures 2 and 3).

DISCUSSION

The rise of antibiotic resistant bacteria (ARB), particularly

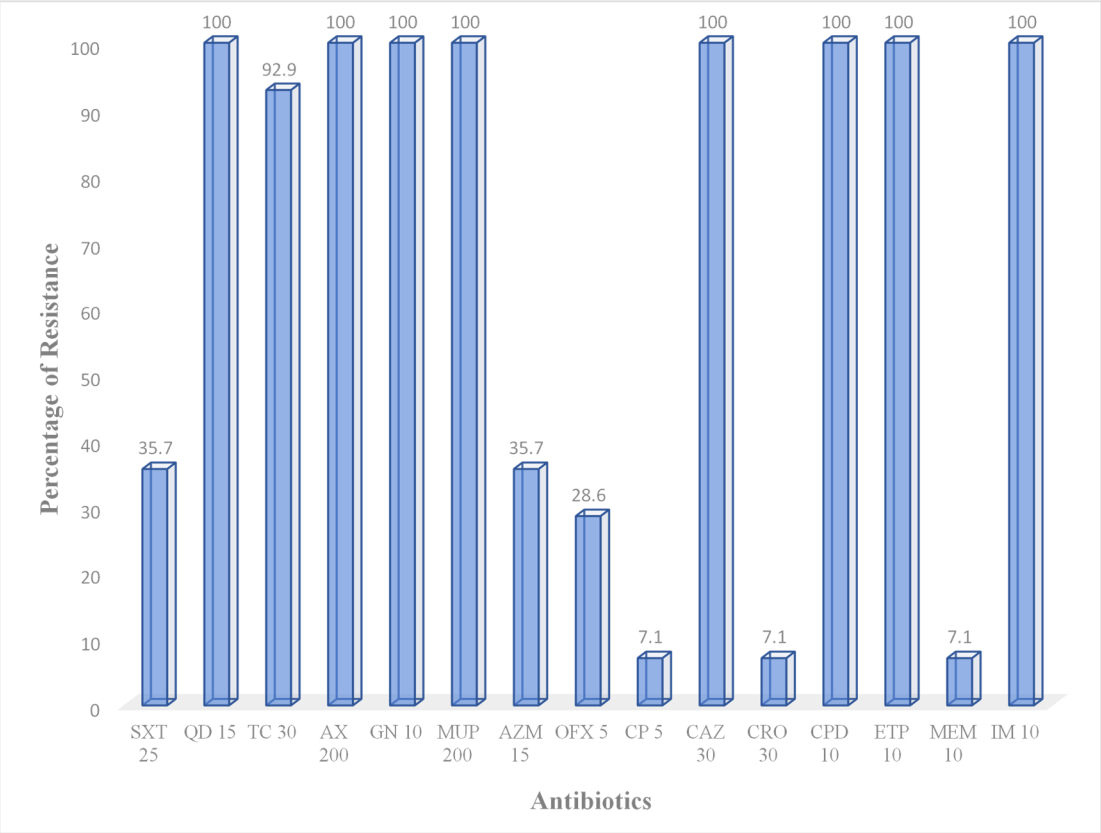

Figure 2: Overall percentage of resistance to 15 selected antibiotics by the Escherichia coli isolates (Abbreviations: SXT, Sulphamethoxazole; QD, Quinupristin; TC, Tetracycline; AX, Ampicillin-Cloxacillin; GN, Gentamycin; MUP, Mupirocin; AZM, Azithromycin; OFX, Ofloxacin, CP, Ciprofloxacin; CAZ, Ceftazidime; CRO, Ceftriaxone; CPD, Cefpodoxime; ETP, Ertapenem; MEM, Meropenem; IM, Imipenem)

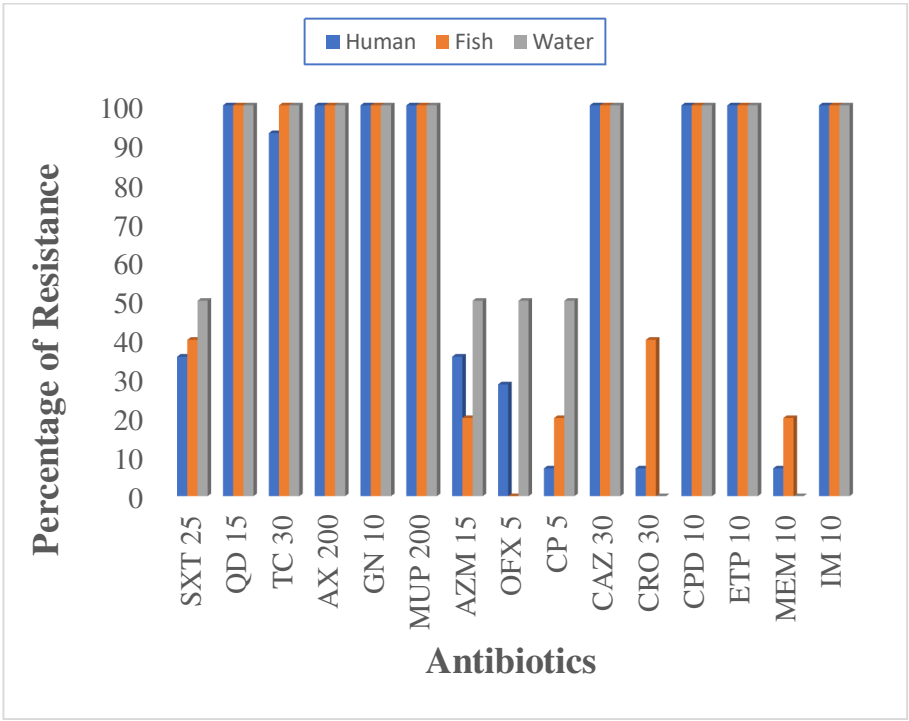

Figure 3: The frequency rate of resistance to each antibiotic per origin of sample (Abbreviations: SXT, Sulphamethoxazole; QD, Quinupristin; TC, Tetracycline; AX, Ampicillin-Cloxacillin; GN, Gentamycin; MUP, Mupirocin; AZM, Azithromycin; OFX, Ofloxacin, CP, Ciprofloxacin; CAZ, Ceftazidime; CRO, Ceftriaxone; CPD, Cefpodoxime; ETP, Ertapenem; MEM, Meropenem; IM, Imipenem)

multidrug-resistant (MDR) Enterobacterales, is a growing global health crisis (WHO, 2015, WHO, 2019, Salam *et al.,* 2023). These resistant organisms pose a significant threat to public health due to the diminishing effectiveness of standard antibiotic treatments (WHO, 2015; WHO, 2019; NASEM, 2022; Salam *et al.,* 2023; Zanichelli *et al*., 2023). This study was conducted to detect the presence of multidrug resistant *Escherichia Coli* in fish, fish handlers, and water, our overall detection rate for *Escherichia coli* is 5.83%, this is lower than previous reports by Aworh *et al.* (2021) who reported 26.8% in poultry faecal samples using the same method of isolation, also Kabir *et al*. (2025) reported a prevalence of 16.4% in dressed broiler chickens in Sokoto, the low number prevalence can be attributed to the fact that *E. coli* is more common in poultry than in fish, Coliforms such as *E. coli* are not normal bacteria in fish and are commonly present where there has been faecal contamination from warm blooded animals (Chao *et al*., 2003). Saif *et al*. (2017) and Shokr *et al*. (2018) reported a prevalence of 7.5% and 14.6% respectively in fish in Egypt, Adesoji *et al*. (2019) reported a prevalence of 24.4% in smoked fish in Dutsinma in Katsina State and Ogunleye *et al*. (2021) reported a prevalence of 63% in fish in Ibadan. *E. coli* is known to be a reliable indicator of faecal contamination in small numbers and large numbers, and it is an indicator of mishandling (Echezona and Uzodinma, 2011).

A significant finding from this study is that all the isolates are multidrug resistant, and this could be as a result of abuse of antibiotics in animal husbandry leading to the replacement of antibiotics sensitive organism with resistant organism and this is in agreement with the work of Ogunleye *et al*. (2021) who recorded a 100% MDR in combination of Cefuroxime, Ceftazidime and Meropenem, in Ibadan in Tilapia fish and Ahmed *et al.* (2023) who reported a 100% MDR in ducks and human isolates in Egypt. The presence of antibiotic-resistant bacteria, in aquatic environments can disrupt the health of aquatic organisms, leading to imbalances in the ecosystem. The impact on fisheries and aquaculture due to antibiotic-resistant bacteria can affect food production and access to protein sources for humans (Pepi and Focardi, 2021).

All the isolates were 100% resistant to gentamycin, amoxicillin-cloxacillin, quinupristin, mupirocin, cefpodoxime, ceftazidime, ertapenem, and imipenem, this somewhere close to the work of Ahmed *et al* 2023 who reported 100% resistance to penicillin, amoxicillin, ceftazidime, ampicillin, cefotaxime, and ceftriaxone, Ogunleye *et al*., 2021 also reported 100% resistance to cefuroxime, meropenem, and ceftazidime, Jonas *et al.* (2020) reported 100% resistance to ticarcillin, ceftazidime, piperacillin, kanamycin, aztreonam, Fosfomycin, ciprofloxacin, and norfloxacin in fish isolate in Congo, this shows that the organism. *Escherichia coli* is not only an agent of disease, but also a driving force behind antimicrobial resistance (AMR). In fact, *E. coli* is one of the most significant global concerns in human and animal health sectors, the food industry and in the environment (Paitan, 2018). AMR surveillance programs have indicated that resistance to all the major classes of antibiotics now circulate among *E. coli* strains (Pitout, 2012), including extended-spectrum β-lactams (ESBL), carbapenems, and more recently, plasmid-mediated colistin resistance (*mcr-1*), particularly in food animals (Liu *et al*., 2016; Huang *et al*., 2017; Caruso, 2018).

Only two isolates show resistance to meropenem, while there is 100% resistance to imipenem and ertapenem, which is an indication that most of our isolate have carbapenems resistance genes, this is in agreement with the work of Kiros *et al.* (2023) in Ethiopia that reported susceptibility of 93.1% to meropenem by the *E. coli* isolates, however Varandas *et al.* (2023) reported a resistance of 70%, and 60% in meropenem and ertapenem respectively in fresh water Mussels.

Most of the isolates from this research show some degree of susceptibility to sulphamethoxazole 38.1% which is still worrisome as sulphonamide are one of the important drugs in treatment of *E. coli* infections, our work is in agreement with the work of Eltai *et al*. (2018) that reported a resistance of 33.3% in food handlers in Qatar, but does not agree with the work of Kiros *et al.* (2023) that reported 100% resistance to sulphonamide.

There was low degree of resistance to the flouroquinolones ciprofloxacin 14.3%, and ofloxacin 23.8%, this is similar to the work of Eltai *et al.* (2018) that reported a resistance of 14.2% in Qatar. Also Saeed *et al*. (2023) reported a susceptibility of 97.2% to norfloxacin. There was a high resistance to tetracycline (95.2%) in this study which is higher compare to the work of Sharma *et al.* (2021) that reported a resistance of 8.1% in Shrimp. Hwang *et al*. reported survival of antibiotic-resistant strains of *E. coli* with the *tet*(A) gene in the human gastrointestinal tract after consumption of retail ready-to-eat food contaminated ARB *E. coli* strains (Hwang *et al*., 2017). They further reported the transfer of the resistance gene from the ARB strain associated with food to antibiotic sensitive cells in the human gastrointestinal tract (Hwang *et al*., 2017).

Conclusion

This study shows that multi drugs resistant *E. coli* is present in fish, fish handlers and water in Sokoto state, which is a serious public health concern to the public especially the fish handlers that always in contact with fish and other foods stuff without proper hand washing. This study also shows that multi-drug resistant characteristics of *E. coli* isolates from fish, fish handlers and water, could lead to transfer of resistant bacteria and genes to humans from handling and/or consumption of contaminated fish and from the environment.

Recommendations

1. Poor hygiene in fish farms and markets and unregulated antibiotic use by farmers, often due to lack of awareness, contribute to the spread of antimicrobial resistance. Immediate, coordinated actions such as

stricter regulations, hygiene improvement, antibiotic stewardship, and public education are essential to mitigate the growing threat of resistant infections.

2. There is a need to strengthen collaboration and cooperation among stakeholders/professionals in the food chain which include public health, veterinary, and environmental sectors as well as farmers and consumer groups through a 'One Health' approach to promote the detection, reporting and control of zoonotic foodborne pathogens.

3. There is need for continuous surveillance for multi drug resistant bacteria from food animals by public health authorities, because of the growing threat to available antibiotics used for therapy in human and veterinary medicine.

4. There is need for proper education and awareness campaign, especially in the fish market on the need for personal hygiene, and dangers of antimicrobial resistance organism.

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