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Phenotypic Detection and Prevalence of Plasmid-Mediated and Inducible AmpC β-Lactamases in Gram-Negative Uropathogens from Kano State, Nigeria

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ABSTRACT

AmpC βlactamases inactivate cephamycin, cephalosporins, aminopenicillins, and monobactams; but are less inhibited by clavulanic acids. This study aimed to determine prevalence of Plasmid mediated AmpC and inducible AmpC producing Gram-negative bacteria in urinary tract infected patients from Kano State, Nigeria. A cross-sectional study was conducted from Febuary to July 2026 at three hospitals in Kano (Aminu Kano Teaching Hospital, Imamu Wali urology centre and Murtala Muhammad Specialist Hospital, Kano) Nigeria.Urine samples were collected from 422 urinary tract infection (UTI) patients. Bacteria were isolated and identified using cultural and biochemical techniques. Plasmid mediated AmpC and Inducible AmpC β-lactamases production were detected using AmpC disc test and disc antagonism test respectively. A total of 164 (38.9%) Gram-negative uropathogens were isolated from the study participants. The age groups of the study participants ranged from 4 to 80 years and comprised of 68 male and 98 female. The most frequently isolated Gram-negative uropathogen was Escherichia coli with total occurrence of 50 (30.5%) while the least occurring was Acinetobacter baumanni with 1(0.6%). Plasmid mediated AmpC and inducible AmpC β-lactamases were seen in 29 (18.0%) and 7 (4.3%) of the total isolates respectively. This research highlights the high prevalence of Plasmid mediated AmpC and inducible AmpC producing bacteria in urinary tract infection in Kano, Nigeria. The findings underscore the need for effective infection control measures.

Keywords: AmpC, Urinary Tract Infection, Gram-Negative Bacteria, Uropathogens

INTRODUCTION

As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become increasingly difficult or impossible to treat (WHO, 2026).Urinary tract infections (UTIs) are infections that can occur in the urethra (urethritis), bladder (cystitis), or kidneys (pyelonephritis) and are one of the world's most common infectious diseases, affecting 150 million people each year, with significant morbidity and high medical costs (McCann *et al.,* 2020).Gram-negative bacilli particularly among family Enterobacteriaceae produce AmpC β-Lactamases which are often responsible for multidrug resistance. The detection of AmpC is important as they are concerned with treatment failure & their prevalence is increasing worldwide (Ashok *et al.*, 2016). The detection of AmpC production can be done by phenotypic and molecular methods. Different phenotypic AmpC detection tests have been described in the literature. Enzyme extraction methods have traditionally been cited as the optimum phenotypic detection method for AmpC activity. However, these are labour-intensive and not suitable for routine clinical use. Inhibitors of the AmpC enzyme are well described and include boronic acid compounds, cloxacillin, and novel inhibitors such as Syn2190. The use of disk approximation tests by Kirby-Bauer testing to detect inducible AmpC activity has also been described, using one antibiotic as an inducing substrate and a second antibiotic as a reporter substrate (Gupta *et al.*, 2014). A standard test for the detection of the plasmid-mediated AmpC enzyme is necessary. The phenotypic tests done namely Disk antagonism test (DAT) and AmpC Disk test are comparatively easier, cheaper and could readily be done in even small set up. Molecular techniques like Polymerase chain reaction (PCR) are costly and not available in every set up (Ashok *et al.*, 2016).

Escherichia coli, Pseudomonas aeruginosa, and *Klebsiella pneumoniae* are the most common Gram-negative bacillus (GNB) isolates from clinical samples. These bacteria produce enzymes such as ESBL, AmpC β-lactamase, and carbapenemase as a resistance mechanism. Enzymes are responsible for resistance development across all cephalosporin and carbapenem antibiotic generations. Microorganisms adapted multiple mechanisms to develop drug resistance. Gram-negative bacteria such as *E. coli, P. aeruginosa,* and *K. pneumoniae* are frequently isolated from clinical specimens and are associated with nosocomial infections. Most Gram-negative organisms produce enzymes such as ESBL, AmpC β-lactamase, and carbapenemase. All three enzymes are responsible for developing resistance to most cephalosporin generations and carbapenem antibiotics. The European Centre for Disease Control and Centre of Disease Control established a standard terminology for PDR, MDR, and XDR organisms (Rajal and Abhijeet, 2025).

Class C β-lactamases (AmpC) are generally considered plasmid-mediated in *K. pneumoniae*, *E. coli*, *Citrobacter freundii*, *Salmonella* spp., and *Proteus mirabilis*, but they have also been observed to be chromosomal-mediated. The existence of these enzymes comprises ESBLs, and the treatment of these infection types is critical. Chromosomal-mediated AmpC ESBLs are mainly observed in *Citrobacter*, *Serratia*, *Acinetobacter*, *Enterobacter*, and *Pseudomonas.* Therefore, identifying proper treatments is particularly important. ESBL and AmpC-ESBL detection can be

performed by conventional methods as well as by automated systems. ESBL- and AmpC-ESBL-associated infection treatment is particularly challenging and is associated both with mortality and morbidity (Rao *et al*., 2018).

The prevalence of antimicrobial-resistant bacteria has attained an incongruous level worldwide and threatens global public health as a silent pandemic, necessitating urgent intervention (Abdus *etal.,* 2023). Although some studies have confirmed the presence of ESBL, AmpC and Carbapenemase producers in the environment, where they can act as a reservoir of such resistance, their presence is nonetheless disturbing, as these genes can be transferred into human pathogens (Serwecinska *et al.,* 2021).The rates of resistant microorganisms which complicate the management of healthcare associated infections (HAIs) are increasing worldwide and getting more serious in developing countries (Mulatu *et al.,* 2022).There is need for continuous research works to the previous works on UTI due to the epidemiological spreads of the disease and the disease can be found in both symptomatic and asymptomatic individuals (Wagenlehner *et al.,* 2020).The high antibacterial resistance or emergence of new resistant genes, or virulence factors among the uropathogens (WHO,2023), necessitates research like this on antibacterial susceptibility pattern testing, phenotypic and molecular detection for the occurrence of resistant genes. The need for this research now in this region is also to report current antibiotic resistance pattern among common bacterial uropathogens due to constant mutations of the pathogens and resistant genes transfer (McCallum *et al.,* 2020).

MATERIALS AND METHODS

Study Area

The research work covered the urine samples of patients attending the three reference hospitals (Aminu Kano teaching hospital, Murtala Muhammad specialist hospital and Abubakar Imamu Wali urology hospitals). Kano is located at latitude 12°00' N and longitude 8°31' E in northern Nigeria. It sits in the Sudan savanna zone, roughly 473 meters above sea level, and features a hot, semi-arid climate with an average annual temperature of 26.4°C (79.5°F) and distinct wet and dry seasons.

Study Design

A crossectional study was conducted at three hospitals in Kano (Aminu Kano Teaching Hospital, Imamu Wali urology centre and Murtala Muhammad Specialist Hospital, Kano) for a period of six months.

Ethical Approval

Ethical approvals were obtained from the ethical committee of Kano State ministry of Health (NHREC/17/03/2018) and that of Aminu Kano Teaching Hospital (AKTH/MAC/SUB/12A/P-3/VI/1974).

Sample Size

The sample size for the study was determined using the formula of (Daniel, & Cross, 2013). at 95% confidence level, and a prevalence of 50%

$$n = \frac{Z^2pq}{d^2}$$

$$= \frac{(1.96)^2 x 0.5\ (1- 0.5)}{(0.05)^2}$$

= 384 as the minimum sample size for the study. Therefore, the sample size was rounded to 422 for attrition/non response/contingency adjustment.

Sampling Techneque

A total number of 422 midstream urine samples were collected from patients at the three referral hospitals in Kano. Aminu Kano Teaching Hospital (158 samples), Murtala Muhammed specialist Hospital (121 samples) and Abubakar Imam Wali urology centre (143). This was based on proportionate sampling technique: That is more samples were collected from the hospitals that receives large number of the target patients.

Culture of the Urine Samples

Urine samples were cultured aseptically by streaking method on sterile Cysteine Lactose Electrolyte Deficient Agar (CLED) agar (LabM, UK), according to standard methods (Cheesbrough, 2010). All inoculated plates were incubated at 37°C for 24hours aerobically and identified using Gram staining and biochemical tests (Cheesbrough, 2010).

Identification of the Isolates

The identification was based on the following.

Colonial Morphology

Colonies produced after 24 hours were physically examined for observable characters like size, shape, consistency, colour, opacity and Motility. These characteristics were used in identification of the isolates from the purity plates (Cheesbrouhg, 2010).

Gram Staining Reaction

Isolates were subjected to gram staining technique for identification according to Cheesbrough (2010).

Biochemical Tests

Indole Test, Oxidases test, Urease Test, Triple sugar iron Test, motility test, Methyl red test, Voges Proskauer test and Citrate test were carried out for identification of the isolates and by the use of API kit.

Indole

Using sterilized test tubes containing 4 ml of tryptophan broth. The tube was inoculated aseptically by taking the growth from 18 to 24 hrs culture. The tube was then be incubated at 37°C for 24-28 hours. 0.5 ml of Kovac's reagent was added to the broth culture. Presence or absence of ring red colour was observed (Cheesbrough, 2010).

Oxidase Test

A good-sized amount of inoculum (already incubated and grown) from a plate culture or slant culture was picked and was placed on a piece of filter paper. One drop of the oxidases reagent was dropped. A dark blue colour within 20 seconds was appeared on the paper showing positive, no colour negative (Cheesbrough, 2010).

Urease Test

The surface of a urea agar slant was streaked with a portion of a well-isolated colony. The cap was left on loosely and the tube was incubated at 35°-37°C in ambient air for 48 hours to 7 days. Development of a pink colour was observed for as long as 7 days (Leber, 2016).

TSI Test

A well-isolated colony was touched from a fresh culture of the test bacterium that was 18 to 24 hours old using a sterile inoculating wires. The butt was stabbed up to 3 to 5 mm above the base of the test tube using the inoculating wire and while withdrawing, the slant was streaked. The tube was incubated

aerobically (with a loose cap) at 35±22°C for about 24 hours. Color change of the slant and butt were examined and the color was reported within 24 hours of incubation (Leber, 2016).

Motility Test

A straight needle was used to touch a colony of a young (18- to 24-hour) culture growing on agar medium. The needle was stabbed once to a depth of only $^{1/3}$ to ½ inch in the middle of the tube. The tube was incubated at 35°-37°C and examine daily for up to 7 days. The tube was observed for a diffuse zone of growth flaring out from the line of inoculation. Positive: Diffuse, hazy growths that spread throughout the medium rendering it slightly opaque. Negative: Growth that was confined to the stab-line, with sharply defined margins and leaving the surrounding medium clearly transparent (Cheesbrough, 2010).

Methyl Red and Voges-proskauer Test

Prior to inoculation, the medium was allowed to equilibrate to room temperature.

Using organisms taken from an 18-24 hour pure culture, the medium was slightly inoculated

and incubated aerobically at 35ºC for 24 hours. Following 24 hours of incubation, aliquot 1ml of the broth was put to a clean test tube. The remaining broth was re -incubated in for an additional 24 hours (Cheesbrough, 2010).

For Voges-Proskauer (VP) Test

To the aliquot (step 4 above), 0.6ml of 5% alpha-naphthol was added. Next 0.2ml of 40% KOH was also added. The tube was gently shaken to expose the medium to atmospheric oxygen. The tube was allowed to remain undisturbed for 10-15 minutes. The medium was observed for a pink-red colour development. The test may be read for up to, but not beyond, one hour.

For Methyl Red (MR) Test

Following 48 hours of incubation (step 5 above), aliquot 2.5ml of the broth was put to a clean test tube. Five drops of Methyl Red reagent were added. The medium was observed for the immediate development of a red colour (Cheesbrough, 2010).

Citrate Test

A test tube with Simmons' citrate agar slants was inoculated with small amount of bacteria and was streaked in the entire slant of the citrate agar. The inoculated tube was incubated at 37°C for 24 hrs .The colour of the Simmons's citrate slant was observed. Bright blue positive, no colour change negative (Cheesbrough, 2010).

Screening Test for AmpC β-lactamases Production

Muller-Hinton agar (MHA) plates were inoculated with test organism (the bacteria to be screened) by swabbing. A 30-µg cefoxitin disk was placed on inoculated MHA and the plates were inverted and incubated overnight at 37°C. The zone diameter around 30-µg cefoxitin disk was measured; the isolates with zone diameters ≤18 mm were selected for confirmation of AmpC production (CLSI, 2024).

Phenotypic Confirmatory Detection of AmpC Beta-lactamase Production

AmpC Disk Test Method

Briefly, 0.5 McFarland suspensions of ATCC *E. coli* 25922 were inoculated on the surface of Mueller-Hinton agar plate. A 30 µg cefoxitin disc was placed on the inoculated surface of the agar. A sterile plain disc inoculated with several colonies of the test organism (the bacteria to be screened and confirm the presence of enzyme production) was placed beside the cefoxitin disc almost touching it, with the inoculated disk face in contact with the agar surface. After overnight incubation at 37°C, the plates were examined for either an indentation or a flattening of the zone of inhibition, indicating enzymatic inactivation of cefoxitin (positive result), or the absence of a distortion, indicating no significant inactivation of cefoxitin (negative result) (Black *et al.*, 2005).

Phenotypic Detection of Inducible AmpC β-lactamase Production (Disc Antagonism Test)

The test isolates were exposed to disks of ceftazidime (30µg) and imipenem (10µg) which were placed 20mm apart (edge to edge). It was incubated at 37° C for 18-24 hours. After overnight incubation flattening of the radius of the zone of inhibition around ceftazidime disk when produced indicated inducible AmpC production by the isolate (Gupta *et al.*, 2014; Ashok *et al.*, (2016).

RESULTS AND DISCUSSION

Results

Table 1 shows the number of urine samples collected from each of the hospitals selected and the growth observed from the three hospitals. Aminu Kano with highest number of samples collected (162), Imamu Wali with highest positive culture (67) and Murtala hospital with least number of sample collected (112) and least number of positive cultures obtained (44).

Table 1: Samples Collection and Total Growth Observed from the Three Hospitals

Site of sample collection	No. of urine samples collected from each Hospital	Culture positive samples	Percentages of samples with growth	P-Value
Aminu Kano Teaching Hospital	162	53	32.3	0.3220.
Imamu Wali Urology Centre	148	67	40.9	
Murtala Muhammad Specialist Hospital	112	44	26.8	
Total	422	164	100	

Table 2 reveals the results of Gram reaction and biochemical tests used for identification of the isolates. The table was explained more in the key.

Table 3 revealed the biochemical reaction for further confirmation of the isolates using API 20E. Test involves the reactions of the isolates to 20 different sugars.

Table 2: Samples Showing Gram-Negative Reaction and Biochemical Characteristics of Uropathogenic Uropathogenic Aerobic Gram-Negative Bacterial Isolates

		Biochemical Tests												
Sample codes	Gram Reaction	Oxi	Ind	Ure	Cit	Mot	Cat	Mr	Vp	TSI (gas	H_2S	butt	slant)	Bacteria Identified
UA11	Gram-ve Bacilli	-	+	-	-	+	+	+	-	+	-	y	y	*Escherichia coli*
UI163	Gram-ve Bacilli	-	-	+	+	-	+	-	+	+	-	y	y	*Klebsiella pneumoniae*
UI173	Gram-ve Bacilli	-	+	+	+	-	+	+	+	+	-	y	y	*Klebsiella oxytoca*
UA12	Gram-ve Bacilli	-	-	+	+	+	+	-	+	+	-	y	y	*Enterobacter cloacae*
UI283	Gram-ve Bacilli	-	-	-	+	-	+	-	-	-	-	r	r	*Acinetobacter baumanni*
UM319	Gram-ve Bacilli	-	-	+	+	+	+	+	-	+	+	y	y	*Citrobacter freundii*
UM359	Gram-ve Bacilli	+	-	-	+	+	+	-	-	+	-	r	r	*Pseudomonas aeruginosa*
UM417	Gram-ve Bacilli	-	-	+	+	+	+	+	-	+	+	y	r	*Proteus mirabilis*

Key: Oxi=oxidase, Ind=indole, Ure=urease, Cit=citrate, Mot= motility, Cat=catalase, Mr=methyl red, Vp=voges proskauer, TSI=triple sugar iron, Butt=lower part of tube, y=yellow, r=red, UA11= Urine sample of Aminu Kano Hospital, UI163= Urine sample of Imamu Wali Hospital, UM319= Urine sample of Murtala Muhammad Hospital.

Table 3: Sugar Fermentation Profile of the Isolates (API 20E)

S/N	Sugars	*E. coli*	*K. neum*	*P. mirabili*	*C. Freundii*	*A. bauman*	*K. oxy*	*P. aeru*	*E. cloa*
1	B-galactosidase	+	+	+	-	-	+	-	-
2	Arginie hydrolysis	-	-	-	-	-	+	+	+
3	Lysine decarboxylase	+	+	-	-	-	+	-	-
4	Ornithine decarboxylase	+	-	+	-	-	-	-	-
5	Citrate utilisation	-	+	+	+	+	+	+	+
6	Hydrogen sulphide	-	-	-	-	-	-	-	-
7	Urease production	-	+	+	-	-	+	-	-
8	Tryptophan deaminase	-	-	+	+	-	-	-	-
9	Indole production	+	-	-	-	-	+	-	-
10	Acetone production	-	+	-	-	-	+	-	-
11	Gel hydrolysis	-	-	+	-	+	+	+	-
12	Glucose	+	+	+	+	+	+	+	+
13	Manitol	+	+	-	+	-	+	-	+
13	Inositol	-	+	-	+	-	+	-	-
14	Sorbitol	+	+	-	+	-	+	-	+
15	Rhaminose	+	+	-	+	-	-	-	+
16	Sucrose	-	+	-	+	-	+	+	+
17	Melibiose	+	+	-	+	+	+	-	+
18	Amayloid	-	+	-	+	+	+	-	+
19	Arabinose	+	+	-	+	+	+	-	+
20	Oxidase	-	-	-	-	-	-	+	-

Key: *E. coli= Escherichia coli, K. neu – Klebsiella pneumoniae, P. mirab= Proteus mirabilis, C. freud =Citrobacter freundii, A. baum= Acinetobacter baumanni, K. oxy=Klebsiella oxytoca, P. aeru=Pseudomonas aeruginosa, E cloa=Enterobacter cloacae,*

Table 4: Gram-Negative Isolates Obtained from Each of the Hospitals

Site of samples Collection	*E.col*	*K.pne*	*P.mir*	*P.aer*	*C.freu*	*K.ox*	*E.clo*	*A.bau*	*Total*
Aminu Kano Teaching Hospital	18	11	5	8	4	2	2	3	53
Imamu Wali Urology Centre	23	17	7	3	3	7	3	4	67
Murtala Muhd Specialist Hospital	9	6	8	10	6	2	3	0	44

Site of samples Collection	***E.col***	***K.pne***	***P.mir***	***P.aer***	***C.freu***	***K.ox***	***E.clo***	***A.bau***	***Total***
Total	50	34	20	23	11	11	8	7	164

Key: Key: *E col=Escherichia coli, K pneu=Klebsiella pneumonia, P. mir=Proteus mirabilis, K. ox=Klebsiella oxytoca, E. clo=Enterobacter cloacae, C. freu=Citrobacter freundii, A. bau=Acinetobacter baumanni, P. aer=Pseudomonas aeruginosa, P. put=Pseudomonas putida, P. P2=Pantoea spp2, P.P416=Pantoea spp4.*
(P- Value= 0.16.02)

In this study, *E. coli* was identified as the most common causative agent of UTIs (30.5%) of the total isolates in both sexes followed by *K. Pneumonia* (20.7%).Frequency of *Proteus mirabilis, Pseudomonas aeruginosa, Citrobacter freundii, Klebsiella oxytoca, , Enterobacter cloacae, Acinetobacter baumanni,* were 12.2%, 14.0%, 6.7%, 6.7%, 4.9%, 4.3%, respectively. Frequency of UTIs isolated from urine samples in the three referral hospitals is as shown in Table 5 below.

Table 5: Frequency of Occurrence of Gram-Negative Uropathogens Isolated from UTI Patients

Isolates	**Frequency**	**Percentage (%)**
Escherichia coli	50	30.5
Klebsiella pneumonia	34	20.7
Proteus mirabilis	20	12.2
Pseudomonas aeruginosa	23	14.0
Citrobacter freundii	11	6.7
Klebsiella oxytoca	11	6.7
Enterobacter cloacae	8	4.9
Acinetobacter baumanni	7	4.3
Total	164	100

Among all the 164 (39.9%) bacterial isolates obtained, the majority of isolates 76 (46.3) were found from participants within the age group 21- 40 years followed by 39 (23.8) in age group 0-20, 32 (19.5) in age group 41- 60 years. Patients within the age brackets of 61- 80 years recorded the least number 17 (10.4) of bacterial isolates (Table 6). On the basis of gender, females had the highest isolates obtained 96 (58.5%) compared to males with 68 (41.5%).

Table 6: Distribution of Bacterial Isolates in Relation to Sex and Ages

Demographic Factors	**No. Examined & %**	**Isolated Organisms**								**P-value**
		E. coli	**K. pneu**	**P. mir**	**C. fre**	**A. bau**	**K. ox**	**P. aer**	**E. clo**	
Age Groups										
0 – 20	39 (23.8)	13	10	4	2	1	2	4	3	0.0324
21- 40	76 (46.3)	26	17	11	4	3	5	8	4	
41 – 60	32 (19.5)	7	5	3	1	3	1	8	1	
61 – 80	17 (10.4)	4	2	2	4	0	3	3	0	
Gender										
Male	68 (41.5)	24	16	9	0	3	5	11	0	0.0163
Female	96 (58.5)	26	18	11	11	4	6	12	8	
Total	164 (100)	50	34	20	11	7	11	23	8	

Key: *E. coli=Escherichia coli, K. pneu=Klebsiella pneumonia, P. mir=Proteus mirabilis, K. ox=Klebsiella oxytoca, E. clo=Enterobacter cloacae, C. fre=Citrobacter freundii, A. bau=Acinetobacter baumanni, P.aer=Pseudomonas aeruginosa.*

Phenotypic screening of resistant enzymes was carried out and the following enzymes were detected

Table 7: Prevalence of AmpC Producers Among the Bacterial Isolates Screened

Bacterial isolates	**No. of isolates screened**	**No. of suspected AmpC producers (%)**	**No. of confirmed AmpC producers (%)**
E. coli	50	21 (42)	18 (36)
K .pneumoniae	34	6 (17.6)	4 (11.8)
A. baumanni	7	3 (42.9)	3 (42.9)
C. freundii	11	3 (27.3)	2 (18.2)
P. mirabilis	20	2 (10)	2 (10)
K. oxytoca	11	0 (0.0)	0 (0.0)
P. aeruginosa	23	0 (0.0)	0 (0.0)
Enterobacter cloacae	8	0 (0.0)	0 (0.0)
Total	164	35 (21.3)	29 (18.0)

Table 8: Prevalence of Inducible AmpC Producers Among Bacteria Isolated from the Three Hospitals

Bacterial isolates	No. of isolates screened	No. of suspected Inducible AmpC producers (%)	No. of confirmed Inducible AmpC producers (%)
E. coli	50	7 (14)	0 (0.0)
K. pneumoniae	34	3 (8.8)	0 (0.0)
C. freundii	11	3 (27.3)	3 (100)
A. baumanni	7	3 (42.9)	3 (100)
P. aeruginosa	23	1 (4.3)	1(100)
E. cloacae	8	0 (0.0)	0 (0.0)
K. oxytoca	11	0 (0.0)	0 (0.0)
P. mirabilis	20	0 (0.0)	0 (0.0)
Total	164	17 (10.4)	7 (4.3)

Table 8 shows the result of an inducible AmpC production; *K. pneumoniae* and *A. baumanni* and *P. aeruginosa were* found to be the inducible AmpC producers in this study. *K. pneumoniae* and *A. baumanni* have the highest production rate.

Discussion

In this study, *E. coli* was identified as the most common causative agent of UTIs (30.5%) of the total isolates in both sexes followed by *K. Pneumoniae* (20.7%). This is similar to the research of Amina *et al.,* (2026) conducted in AKTH and Soma *et al.,* (2023) conducted in Eastern India. The age group 21- 40 years accounted for the highest proportion of cases 76 (46.3%), may be attributed to increased exposure to risk factors such as occupational hazards. This agrees with work of Hassan *et al.* (2018) conducted among UTI patients at college health science, Osun State University. More than half of the positive cases of isolated bacteria were from the female participants 96 (58.5). Amina *et al.,* (2026) showed similar pattern. This confirmed that UTI is more common in the females than males (Bergamin and Kiosoglous, 2017), mainly due to the female lower urinary tract anatomy and its proximity to the reproductive organs. The female urethra is relatively short, reducing the distance for bacterial ingress (Krzysztof *et al.,* 2021). This finding is also similar to the research of Hassan *et al.,* (2018).There was a significant relationship between the demographic parameters of the participants and the presence of the isolates (P-value 0.0324). In this study 18.0% of the isolates produced AmpC beta lactamase with high production seen in *E. coli, K. pneumoniae, A. baumanni* and the least production were observed in *C. freundii* and *P. mirabilis* with 2 numbers of producers each. This is in agreement with work of Yakubu *et al.,* (2022) in Bauchi, Nigeria with 72.9% AmpC production and where *E. coli and K. pneumoniae* were the predominant producers, the finding is also similar to the research of Satish *et al.* 2025 conducted among diabetic patients with 17.34% AmpC prevalence where *E. coli, K. pneumoniae, A baumanni and P. mirabilis* where among the AmpC producers.. The result of an inducible AmpC production reveals that, A. *baumanni, C. freundii* and *P. aeruginosa* were found to be the inducible AmpC producers in this study. *C. freundii* and *A. baumanni* had the highest production rate. The prevalence of inducible AmpC production was 4.3% obtained in this study which was lower compared to the prevalence of 28.3% obtained by Japhet *et al.,* (2025) in Darussalam Tanzania. *C. freundii* and *A. baumanni* have the highest production rate. The AmpC production in this research indicates the antibiotic resistance as well as the occurrence of resistance genes in the study area. The danger of AmpC production is that Enterobacterales with chromosomal (inducible) AmpC β-lactamases are prone to acquiring additional resistance traits such as ESBL or carbapenemases (Castanheira *et al.,* 2021).

CONCLUSION

This research highlights the occurrence of AmpC enzyme production and prevalence of antibiotic resistant AmpC enzymes producing bacteria in urinary tract infection in Kano, Nigeria. The findings underscore the need for effective infection control measures, antibacterial stewardship programs and regular surveillance of antibiotic resistant enzymes producing bacteria to combat the spread of antibiotic resistant bacteria.

REFERENCE

Abdus, S., Yusuf, A., Moushumi, T. S., Jogendra, S. P., Naseem, A., Ali, A. R., Mohammed, A . A. (2023). Antimicrobial Resistance: A Growing Serious Threat for Global Public Health. *JournalsHealthcareVolume 11Issue 13 DOI:* https://doi.org/10.3390/healthcare11131946

Amina, A. R., Adamu, R. T., Abdulwahid, I. A., Yakubu, A. B., Yasir, A.M., Ibrahim, A. K and Tasiu, M (2026). Detection of Antibiotic Resistance in Gram-Negative Uropathogens Isolated from Urinary Tract Infected Patients in Kano State, Nigeria. *Dutse Journal of Pure and Applied Sciences Vo*l. 12 (1a): 44-53.

Ashok, A. K., Jaryal, S. C. , Thakur, K. , Sood, A. , Gupta, P. K., Thakur, S. (2016). Detection of Inducible and Non-inducible (constitutive) AmpC β-lactamaseproducing Gram-Negative Bacteria among Family Enterobacteriaceae by Two Phenotypic Methods-Disk Antagonism Test (DAT) and AmpC disk Test at a Tertiary Care Hospital, Himachal Pradesh, India. *International Journal of Current Microbiology and Applied Sciences* 5 (4): 133-139

Bergamin, P.A., Kiosoglous, A.J. (2017). Non-surgical management of recurrent urinary tract infections in women. *Translational Andrology and Urology;* 6(2): S142-S152.

Black, J. A., Moland, E.S., Thomson, K.S. (2005). AmpC Disk Test for Detection of Plasmid-Mediated AmpC β -Lactamases in Enterobacteriaceae Lacking Chromosomal AmpC β -Lactamases. *Journal of Clinical Microbiology*. 43(7). 3110–3113.

Castanheira, M., Simner, P.J., Bradford, P.A. (2021). Extended-spectrum β-lactamases: An update on their characteristics, epidemiology and detection. *JAC Antimicrobial Resistance*.3 (3):dlab092. doi: https://doi.org/10.1093/jacamr/dlab092

Cheesbrough, M. (2010). *District Laboratory Practice in Tropical Countries.* 2nd Edition, Cambridge University Press, Cambridge, United Kingdom: PP 96-115

Clinical laboratory standard institute (CLSI). (2024). Performance Standards for Antimicrobial Susceptibility Testing; Twenty-six Informational Supplement. CLSI document M100-S26. Clinical and Laboratory Standards Institute, 940 West Valley Road, Suite 1400, Wayne, Pennsylvania 19087 USA.

Daniel, W.W., Cross, C.L. (2013). Biostatistics: A foundation for analysis in the health sciences. 10th ed. New York: John Wiley & Sons: pp 185-187

Drekonja, D. (2024). Approach to the patient with urinary tract infection. In: Goldman L, Cooney KA, eds. *Goldman-Cecil Medicine.* 27th ed. Philadelphia, PA: Elsevier; :chap 263

Gupta, G., Tak, V., Mathur, P .(2014) Detection of AmpC β lactamases in gram-negative bacteria. *Journal of Laboratory Physicians* 6 (Issue 1):7-11. DOI: https://doi.org/10.4103/0974-2727.12908

Hassan, A. O., Adebimpe, W.O., Fadeju,O. J., Ojo, T., Omisakin, A.O.(2018). Causative agents of Urinary Tract Infection and their antibiotic susceptibility pattern in a tertiary health institution. *International Journal of Medicine and Biomedical Research* 7(Issue 1): 40-51

Krzysztof , C., Magdalena, B., Justyna, T. (2021). Urinary tract infection in women. *Menopause Review* 20(1): 40-47. DOI: https://doi.org/10.5114/pm.2021.105382

Leber, A. L. (2016). Clinical microbiology procedures handbook (Fourth edition). Washington, DC: ASM Press 1752 N St., N.W.

McCann, E., Sung, A.H., Ye , G., Vankeepuram, L., Tabak, Y.P. (2020). Contributing Factors to the Clinical and Economic Burden of Patients with Laboratory-Confirmed Carbapenem-Nonsusceptible Gram-Negative Urinary Tract Infections. *Clinical Outcomes Research.* . 12:191–200.

Mulatu , G., Melkamu , B., Sisay . B,, Gebre , K., Lule , T., Yonas , Y., (2022). Emergence of high drug resistant bacterial isolates from patients with health care associated infections at Jimma University medical center: a cross sectional study. Antimicrobial Resistance & Infection Control volume 7, Article number: 138

Rajal, D. and Abhijeet, J. (2025). Occurrence of ESBL, AmpC-ESBL, and Carbapenemase Producer Organisms in Clinical Specimens: An Observational Prospective Study. *J Pure Appl Microbiol.* 2025;19(2):1541-1550. https://doi.org/10.22207/JPAM.19.2.59

Rao, M.J., Harle, S., Padmavathy, M. (2018). Prevalence of Extended Spectrum Beta-lactamases and AmpC beta-lactamases in clinical isolates of gram-negative bacilli at a tertiary care hospital. *J Evol Med Dent.* 2018;7 (39):2278-4748.

Satish, R. P., Karande, G.S., Ravindra, V. S., Satyajeet, K. P. (2025). Gram-negative uropathogens in diabetic patients: A study of ampicillinase cephalosporinase, extended-spectrum beta-lactamases, and metallo beta-lactamases producing phenotypes. *Journal of pharmaceutical Bioallied Science* 17(3):S2569–S2571. doi: https://doi.org/10.4103/jpbs.jpbs_914_25

Serwecińska, L., Kiedrzyńska, E.. Kiedrzyński, M. (2021). A catchment-scale assessment of the sanitary condition of treated wastewater and river water based on fecal indicators and carbapenem-resistant Acinetobacter spp. Sci. Total Environ. 2021, 750, 142266

Soma, M., Avijit , M., Abhijit, B. (2023) . Detection of extended spectrum beta-lactamase producing organisms and its antibiotic resistance pattern among Enterobacteriaceae isolates in a teaching hospital of Eastern India. *International Journal of Science and Technology*, 04(01), 065–072

Wagenlehner, F.M., Bjerklund, J. T., Cai, T, Koves. B., Kranz, J., Pilatz, A., Tandogdu, Z. (2020). Epidemiology, definition and treatment of complicated urinary tract infections. *Nat Rev Urol.* 17(10): 586-600

WHO. (2026). Antimicrobial resistance. Available on https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance Retrieved on (16 July, 2026)

Yakubu, H., Muhammed, B., Mukhtar, M. D. and Kalgo, Z. M. (2022). Prevalence of extended-spectrum beta lactamase and ampc producing enterobacteriaceae among diabetic patients in Bauchi State, Nigeria. *Bayero Journal of Pure and Applied Sciences,* 13(1): 546 - 553