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Prevalence and Antibiotic Susceptibility Profile of Uropathogenic ESBL-producing *Klebsiella pneumoniae* in Keffi Metropolis, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Authors MO and RA designed the study, collected samples and performed laboratory analyses and wrote the first draft of the manuscript. Author II designed the study, carried out statistical analysis and managed literature searches. Author ACA wrote the protocols and managed the analyses of the study. All authors read and approved the final manuscript.

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ABSTRACT

Urinary tract infection (UTI) remains the most common bacterial infection in humans despite the widespread availability of antibiotics. Exteded spectrum beta-lactamase production is an important mechanism of antibiotic resistance in the Enterobacteriaceae. Antibiotic resistance is a rising dilemma of significant implications on global public health. Few data exist for the prevalence and trends of *Klebsiella pneumoniae* antibiotic resistance in Keffi metropolis Nigeria. This study was done to determine the prevalence of ESBL-producing *K. pneumoniae* as well as its antibiotic susceptibility pattern regarding some predisposing factors.

Aim: This study was carried out to determine the prevalence and antibiotic susceptibility pattern of uropathogenic *K. pneumoniae* in Keffi metropolis, Nigeria.

Methodology: The current study was a carried out in Keffi, Nasarawa state, Nigeria from July to October 2024. It was a cross-sectional study comprising of 160 early morning urine samples randomly collected from consenting participants in the six selected hospitals. Isolation and identification of *K. pneumoniae* was done using standard microbiological methods. The antibiotic susceptibility profile of isolates was carried out using the Kirby-Bauer disc diffusion method and interpretation was done following the Clinical and Laboratory Standards Institute protocol. Results obtained in this study were analysed using Smith's Statistical Package (version 2.8, California, USA) and *P* value of ≤ 0.05 was considered statistically significant.

Results: The result of this study revealed an overall prevalence of 20/160 (12.5%). The highest prevalence of the isolate was seen in females 14(8.75) compared to males 6 (3.75%), while the highest prevance regarding age was recorded among the 15-34 age group 12 (7.5%) while the least was recorded among those greater than 65 years 0 (0%). Furthermore, the highest number of isolate was recorded at FMCK 7 (4.4%) followed jointly by GHK and PHC TK 4 (2.5%) with PHC, KP and PHC AJ 1 (0.63%) beign the least respectively. There was a high level of resistance to ceftazidime 20 (100%), followed jointly by ceftriaxone, cefurexime and treptomycin 19 (95%) and augmentin 18 (90%) but low to amoxicillin 6 (30%) and ofloxacin 6 (30%) respectively. Most of the isolates tested were multidrug resistant and all were extended spectrum beta lactamase (ESBL) producing.

Conclusion: The relatively high detection rate of multidrug resistant uropathogenic *K. pneumoniae* in this study calls for concern. More concerning is the isolation from primary health care centers (PHCs) signifying the importance of universal health coverage and the place of PHCs in antimicrobial stewardship (AMS) programs as one of the strategies to control the spread of antimocrobial resistance.

Keywords: Urinary tract infection; K. pneumoniae; antibiotic susceptibility; ESBL; primary health care; Keffi.

1. INTRODUCTION

The human gastrointestinal tract harbours Enterobacteriaceae which are a group of bacteria also referred to as commensals. Their presence renders few benefits to the host as long as they do not acquire virulent traits from invading pathogens in the environment **(**Moreira de Gouveia et al., 2024**)**. When they are found at different anatomical sites however, they can become virulent causing varying serious infections which include urinary tract infections (UTIs), sepsis, meningitis, and soft tissue infections depending on their loads and host´s immune system (Abbas et al., 2024). *Klebsiella pneumoniae* is one of such opportunistic bacterial pathogens that is mostly implicated in nosocomial and community-acquired infections such as meningitis, septicaemia, wound infection, pneumonia, and urinary tract infections (UTIs). Millions of people of all ages and gender across the world are affected by urinary tract infections and constitute one of the most common encountered conditions in the emergency unit in hospitals (Rønning et al., 2019, Alrashid et al., 2022). Urinary tract infection especially hospital acquired, are common and contribute to severe morbidity and high fatality rate in patients if not properly diagnosed and treated promptly. Patients who undergo instrumentation of the urinary tract including passing of catheter are more at risk (Gorrie et al., 2022, Narimisa and Bavari, 2022). The proximity and physiology of the female urethra to the opening of the intestinal tract contributes to the fact that UTIs are more

frequently reported in women than in men (Sakamoto et al., 2019). Antibiotic resistance in health care facilities and indeed the general population is an increasingly worrying public health trend. One of the mechanisms by which Gram-negative bacteria acquire resistance to beta-lactam antibiotics is the production of beta-lactamase enzymes (Butt and Butt, 2017). Plasmid-mediated enzymes known as the extended-spectrum β-lactamases (ESBLs) are able to hydrolyze and inactivate broad spectrum β-lactam antimicrobials namely: third-generation cephalosporins, penicillins and aztreonam but are inhibited by clavulanic acid.

Extended spectrum beta-lactamases are commonly found in *Klebsiella* species and *E. coli*, but have been described in other members of the Enterobacteriaceae such as Enterobacter, Serratia, Citrobacter, Proteus and Salmonella. Urinary tract infection is one of the commonest infections globally and is responsible for frequent hospital visits especially among females with an incidence of 50 to 60%. This is especially common among young sexually active females (Medina and Castillo-Pino, 2019). Patients who are admitted in the hospital are predisposed to UTI caused by Gram-negative bacteria such as *Klebsiella*, *E. coli*, *Proteus* and *Pseudomonas* (Muhammad et al., 2020). In Nasarawa State, a prevalence ranging from 10% to 12.78% have been reported (Ashefo et al., 2023a, Ngwai et al., 2023, Ashefo et al., 2023b), while a prevalence of 8.0% to 37.0% have been reported in other parts of the country (Hamza et al., 2016, Mike-Ogburia et al., 2023, Chinyere et al., 2020, Onanuga and Selekere, 2016, Mofolorunsho et al., 2021, Akinyemi et al., 2021). Antibiotic resistance is on the rise globally due to inappropriate use and the emergence of resistant bacteria, this among other factors complicates the treatment of UTIs (Antimicrobial Resistance Collaborators, 2022). The access to health or universal health coverage as defined by the World Health Organization is the access by all people to the health services they need, when and where they need them of sufficient quality to be effective, without financial hardship. This covers essential health services, from health promotion to prevention, treatment, rehabilitation, and palliative care across the life course (WHO, 2023). Primary health care (PHC) refers to a broad range of health services provided by medical professionals in the community. This means universal health care is accessible to all individuals and families in a community (Behera et al., 2022).The primary health care (PHC) facilities are domicilled in all the LGAs as the point of entry into the health care system for the community, rendering preventive, curative, promotive, and pre-referral care services. Laboratory services are however restricted to certain test which does not include culture and sesitivity (Obasanya et al., 2022). Overprescribing by health care professionals, rising incomes, high background rates of infectious diseases and easy, over-the-counter access to antibiotics, driven in part by lack of access to good-quality primary care, are exacerbating the problem of resistance in low- and middle-income countries. Low-income countries including Nigeria are particularly vulnerable because the second-line antibiotics needed to combat the most resistant infections are often unaffordable (World Bank, 2017). The importance of primary healthcare in the war against antimicrobial resistance can not be overemphasized, given the growing threat of antimicrobial resistance (WHO, 2018). Literatures have shown that optimising antimicrobial use through functional hospital antimicrobial stewardship (AMS) programs is one of the strategies to control the spread of AMR (Garau and Bassetti, 2018, Majumder et al., 2020). This study seeks to contribute to the understanding of the the prevalence of antibiotic resistance associated with *K. pneumoniae* isolated from patients with UTIs in the study area. Furthermore, data obtained in this study will inform the development of effective diagnostic and therapeutic strategies for managing *K. pneumoniae* infections in Keffi, ultimately improving patient outcomes and reducing the global burden of antibiotic resistance. By carrying out this study, we intend to provide data on the prevalence of ESBL-producing K. Pneumoniae associated with UTI in the study area.

2. MATERIALS AND METHODS

2.1 Study Design and Population

The investigation was a cross-sectional study which utilized random sampling of patients from four hospitals in Keffi, Nigeria from July to October 2024.

2.2 Study Area

Keffi is located approximately 50 km from Abuja, the Federal Capital Territory of Nigeria and 128 km from Lafia, the capital of Nasarawa State. It is located geographically between latitude $8^{0}3$'N of the equator and longitude $7^{0}50$'E and situated at

an altitude of 850m above sea level (Akwa, 2007).

2.3 Sample Size Determination

A total of 160 samples was estimated using the formula described by (Sapra, 2022)

$$N = \frac{Z^2 pq}{D^2}$$

Where; N=sample size,

Z= standard normal distribution at 95% confidence interval=1.96,
P = prevalence rate of *K. pneumoniae* infection from previous studies = 10.13% (Ashefo et al., 2023a).
d = level of significance (allowable error) = 5% or 0.05
q = 1-p

Thus, N = $(1.96)^2 \times 0.1013 \times (1-0.1013)/ (0.05)^2$ = 3.8416 × 0.1013 × 0.8987 /0.0025 = 139.893109 ≈ 140

N = 140

However, actual sample size = Calculated sample size + 10% Attrition rate. But 10% Attrition rate = 14

Therefore, actual sample size = 140 + 14= 154

However, to increase chances of isolation, it was rounded up to 160 samples.

2.4 Inclusion and Exclusion Criteria

Patients of all age group and gender with suspected UTI assessing healthcare in the selected health facilities were included in this study. While those with suspected UTIs but on antibiotics attending the selected health facilities were excluded from this study.

2.5 Sample Collection

A total of 160 early morning mid-stream urine samples of patients with suspected cases of UTI were collected from six hospitals in the study area designated: Federal Medical Centre Keffi (FMCK), General Hospital Keffi (GHK), Primary Health Centre Angwan Waje (PHC AW), Primary Health Centre Kofar Pada (PHC KP), Primary Health Centre Tsohon Kasuwa (PHC TK), Primary Health Centre Angwan Jaba (PHC AJ) using sterile sample containers and transported to the Microbiology Laboratory of Federal Medical Centre Keffi for analysis. The socio-demographic and clinical data for each patient were obtained through a structured questionnaire.

2.5.1 Isolation of *Klebsiella pneumoniae*

Urine samples were mixed gently by inverting the containers several times. Using a sterile wire loop, the samples were streaked on Cysteine Lactose electrolyte-deficient agar (CLED) agar (Oxoid Ltd., UK) and incubated at 37˚C for 24 hours. Yellowish colonies from the 24 hours plates were selected as presumptive *K. pneumoniae* (Public Health England. UK Standards for Microbiology Investigations, Karah et al., 2020).

2.5.2 Identification of *Klebsiella pneumoniae*

Identification of *K. pneumoniae* isolates was done by cultural, morphological, biochemical and motility testing following standard procedures (Osman et al., 2020, Sagar, 2022).

2.6 Antibiotic Susceptibility Testing

The susceptibility profile of antibiotics commonly prescribed for *K. pneumoniae* infections was determined using Kirby-Bauer disc diffusion method in accordance with CLSI guidelines (CLSI, 2021). The antimicrobial agents tested included: Ofloxacin (10 µg), Augmentin (30 µg), Ceftazidime (30 µg), Gentamycin (10 µg), Ciprofloxacin (10 µg), Chloramphenicol (30 µg), Ceftriaxone (30 µg), Streptomycin (30 µg), Cefurexime (30 µg), and Amoxicillin (30 µg) (Oxoid Ltd., UK).

2.7 Data Analysis

The data obtained were analyzed using Smith's Statistical Package (version 2.8, California, USA). Chi-square test was conducted at 95% confidence interval and P values ≤ 0.05 were considered statistically significant.

3. RESULTS

3.1 Distribution of *K. pneumoniae* Isolates Regarding Some Sociodemographic Variables

In the current study, 20 (12.5%) out of the 160 urine samples collected were positive for *K.*

Pneumoniae. The distribution of infection on the basis of gender revealed that females had higher 14(8.75%) compared to males 6(3.75%) P=0.789. On the basis of age group, the highest prevalence was recorded among those within 15-34 age group 12 (7.5%), followed by 35-64 age group 5(3.13%) and those aged less than 14 years 3 (1.87%) with the least seen among those greater than 60 years 0 (%) P=0.100. The prevalence regarding marital status was found to be higher among the singles 12 (7.5%), followed by married 5 (3.12%) while the least was among those divorced 2 (1.25%) and widowed 1 (1.25%) P= 0.035. Furthermore, the prevalence regarding occupation was found to be higher among the unemployed 7 (4.37%) followed by students 5 (3.13%), and the self employed 4 (2.5%) while it was lower among the civil servants and privately employed 2 (1.25%) respectively P= 0.021 as shown in Table 1.

3.2 Prevalence of *K. pneumoniae* Isolates Regarding Some Clinical Signs and Symptoms

Of the 160 participants, 25(15.6%) experienced painful urination, 12(7.5%) experienced frequent urination, 31(19.37%) experienced burning sensation, 16(10.0%) experienced itching, 23(14.4%) had lower abdominal pain, 13(8.13%) had dicharge, 18(11.3%) urine had fishy smell, and 22(13.7%) had fever. Those thatexperienced painfull urination and those that had discharge jointly had a prevalence of 4(2.5%) respectively, followed by those who experienced burning sensation while urinating, lower abdominal pain and those who had fever 3(1.87%) respectively, 2(1.25%) for those who urinated frequently, while the least was recorded among those whose urine had a fishy smell 1(0.63%). *K. pneumoniae* was not isolated in the urine of those that experienced itching 0(0.0%) *P*= 0.353 as shown in Table 2.

3.3 Antimicrobial Resistance Profile of the Urinary *Klebsiella pneumoniae* Isolated in Selected Hospitals of Keffi

The antibiotic resistance profile of the *K. pneumoniae* isolates is represented in Table 3, where a significantly high 20(100%) resistance to ceftazidime was recorded, closely followed by ceftriaxone 19(95%), streptomycin 19(95%), cefurexime 19(95%) and augmentin 18(90%), chloramphenicol 17(85%). While the least resistance was recorded for ciprofloxacin 8(20%), amoxicillin 6(30%) and ofloxacin 6(30%) P=0.000.

Table 1. Distribution of *K. pneumoniae* isolates regarding some sociodemographic variables

Age	Number examined (%)	Number of isolates (%)	*P* value
< 14	26(16.25)	3(1.87)	
15-34	113(70.62)	12(7.5)	0.100
35-64	16(10.00)	5(3.13)	
≥ 65	5 (3.13)	0(0)	
Total	160(100)	20(12.5)	
Gender			
Male	44(27.5)	6(3.75)	
Female	116(72.5)	14(8.75)	0.789
Total	160(100)	20(12.5)	
Marital staus			
Married	48(30)	5(3.12)	
Divorced	37(23.1)	2(1.25)	0.035
Widowed	23(14.4)	1(0.63)	
Single	52(32.5)	12(7.5)	
Total	160(100)	20(12.5)	
Ocupation			
Student	54(33.75)	5(3.13)	
Self employed	41(25.63)	4(2.5)	0.021
Civil servant	33(20.62)	2(1.25)	
Unemployed	20(12.5)	7(4.37)	
Private employed	12(7.5)	2(1.25)	
	160(100)	20(12.5)	

Table 2. Prevalence of *K. pneumoniae* isolates regarding some clinical signs and symptoms

Variable	Number examined (%)	Number positive (%)	*P* value
Painful urination	25(15.6)	4(2.5)	
Frequent urination	12(7.5)	2(1.25)	0.353
Burning sensation	31(19.37)	3(1.87)	
Itching	16(10.0)	0(0)	
Lower abdominal pain	23(14.4)	3(1.87)	
Discharge	13(8.13)	4(2.5)	
Fishy smell	18(11.3)	1(0.63)	
Fever	22(13.7)	3(1.87)	
Total	160(100)	20(12.5)	

Table 3. Antimicrobial resistance profile of the urinary *Klebsiella pneumoniae* isolated in selected hospitals of Keffi, Nasarawa State, Nigeria

Antimicrobial agent	Disc content (µg)	Number of tested isolates	Sensitive number (%)	Resistance number (%)	*P*. value
Ofloxacin (OFX)	10	20	14(70)	6(30)	
Augmentin (AU)	30	20	2(10)	18(90)	0.000
Ceftazidime (CTZ)	30	20	0()	20(100)	
Gentamycin (CN)	10	20	9(45)	11(55)	
Ciprofloxacin (CPX)	10	20	12(60)	8(20)	
Chloramphenicol (CH)	30	20	3(15)	17(85)	
Ceftriaxone (TRX)	30	20	1(5)	19(95)	
Streptomycin (S)	30	20	1(5)	19(95)	
Cefuroxime (CEF)	30	20	1(5)	19(95)	
Amoxicillin (AM)	30	20	14(70)	6(30)	

Table 4. Multidrug resistance pattern of the urinary *Klebsiella pnuemoniae* isolated from selected hospitals of Keffi, Nasarawa State, Nigeria

Antibiotic resistance types	*K. pnuemoniae* isolates number (%)	*P value*
CTZ	1(5)	$X^2 = 10.967$
AU, CEF ,CTZ, S, TRX	2(10)	P = 0.89
AU, CEF, CH, CTZ, S, TRX	4(20)	
AU, CEF, CH, CN, CTZ, S, TRX	5(25)	
AU, CEF, CH,CTZ, OFX, S, TRX	1(5)	
AU, CEF, CH, CN, CPX, CTZ, S, TRX	1(5)	
AM, AU, CEF, CH, CN, CPX, CTZ, OFX, S, TRX	6(30)	
Total	20(100)	

Key: AM= Aoxycillin, AU= Augmentin, CEF= Cefurexime, CH= Chloramphenicol, CN= Gentamycin, CPX= Ciprofloxacin, CTZ= Ceftazidime, OFX= Ofloxacin, S= Streptomycin, TRX= Cefriaxone

3.4 Multidrug Resistance Pattern of the Urinary *Klebsiella pnuemoniae* Isolated from Selected Hospitals of Keffi

Different antimicrobial resistance combinations (Multidrug) by the isolate were recorded as represented in Table 4. The highest multidrug profile was AM, AU, CEF, CH, CN, CPX, CTZ, OFX, S, TRX 6(30%), followed by AU, CEF, CH, CTZ, S, TRX 5(25%), AU, CEF, CH, CTZ, S, TRX 4(20%) and AU, CEF ,CTZ, S, TRX 2(10%), while the least was CTZ 1(5%) AU, CEF, CH,CTZ, OFX, S, TRX 1(5%) and AU, CEF, CH, CN, CPX, CTZ, S, TRX 1(5%) respectively (P=0.89).

Table 5. Phenotypic detection of ESBL-producing *K. pneumoniae*

Facility	No. Resistant	PCDDT			DDST		
		ESBL Pos. (%)	ESBL Neg.	*P* value	ESBL Pos (%)	ESBL Neg	*P* value
FMCK	7	7(43.75)	0		7(46.6)	0	
GHK	3	3(18.75)	0	0.000	3(20.0)	0	0.464
PHC AW	3	3(18.75)	0		2(13.3)	1	
PHC KP	1	1(6.25)	0		1(6.7)	0	
PHC AJ	1	1(6.25)	0		1(6.7)	0	
PHC TK	1	1(6.25)	0		1(6.7)	0	
Total	16	16(100)	0		15(100)	1	

Key: FMCK= Federal Medical Centre Keffi, GHK= General Hospital Keffi, PHC AW= Primary Healthcare Clinic Angwan Waje, PHC KP= Primary Healthcare Clinic Kofar Pada, PHC AJ= Primary Healthcare Clinic Angwan Jamaa, PHC TK= Primary Healthcare Clinic Tsohon Kasuwa, ESBL= Extended spectrum betaLactamase, PCDDT= Phenotypic Confirmatory disc difusion test, DDST= Double disc synergy test

3.5 Phenotypic Detection of ESBL-Producing *K. pneumoniae*

Out of the 20 positive isolates, 16 were found to be ESBL producing after screening using the phenotypic confirmatory disc difusion test, P=0.000, while 15 turned out to be ESBL producing *K. pneumoniae* after the double disc synergy test as seen in Table 5. FMCK recorded the highest ESBL producers 7(46.6%) followed by GHK 3(20.0%), PHC AW 2(13.3%) while the least was recorded from PHC KP, PHC AJ and PHC TK 1(6.7%) respectively P= 0.464.

4. DISCUSSION

Urinary tract infections (UTIs) are among the most encountered bacterial in fection of humans that affect both gender of all age groups. If not managed properly, it can result in high mortality of infected patients (Mancuso, et al., 2023). *K pneumoniae* has been reported to be an important pathogen commonly associated with UTI (Maldonado-Barragán et al., 2024). Historically, *K. pneumoniae* have been associated with infections in patients that have compromised immuninity. With the recent appearance and dissemination of hypervirulent strains however, healthy individuals have also become susceptible to infection (Abass et al., 2024, WHO, 2024). In this study, out of 160 urine samples collected from patients with UTI in the selected hospitals in Keffi metropolis for the detection and phenotypic characterization of *K. pneumoniae*, an overall prevalence of 12.5% was recorded. FMCK recorded the highest 7(4.4%) followed jointly by GHK and PHC TK 4(2.5%) and PHC AW 3(1.9%), whereas the least was detected in PHC KP and PHC TK 1(0.63%) respectively though there was no statistical significance (P = 0.509).

Plate 1. Showing positive disc difusion synergy test

The prevalence of 12.5% obtained in this study is higher than 10.13% reported by (Ashefo et al., 2023a) in Nasarawa South senatorial district. Similarly, it was higher than 8.0% reported by (Tessema et al., 2020) among HIV clients in Ethiopia, 8.5% reported in the Gambia by (Kebbeh et al., 2023), 8.7% reported by (Ali et al., 2022) in Somaliland, 11.6% reported in Uganda by (Odoki et al., 2019). In Gabon, a low prevalence of 11.6% was reported by (Prastiyanto et al., 2024) while 10.3% was reported by (Shaaban et al., 2021) in Bahrain. Interestingly, similar prevalence of 12.78% was previously reported in Lafia the capital city of Nasarawa state (Ashefo et al., 2023a) and (Mokennen et al., 2023) in Ethiopia even though this study focused on children. Conversely, higher prevalence have been reported in various parts of Nigeria such as 60% by (Innocent et al., 2023), 16% by (Mike-Ogburia et al., 2023) and 15.8% by (Haruna et al., 2024), 16.4% by (Ugwu et al., 2020), 14.0% by (Mofolorunsho et al., 2021), 34% by (Akinyemi et al., 2021), 20.0% by(Abhadionmhen and Imarenezor, 2024), 14.78% by (Abdulfatai et al., 2023), 18.1 % by (Ndako et al., 2019), 23.1% by (Bassey et al., 2024) and 23.53 % by (Echendu et al., 2024). Simillary, higher prevalence have been recorded in other parts of Africa and accross other continents (Mouanga et al., 2021, Haque et al., 2023, Lin et al., 2022, Kaye et al., 2024).

The difference in the prevalence could be attributed to gender, age, duration of hospitalization, the methods employed, sample size, geographic location and level of personal and environmental hygiene (Miftode et al., 2021, Jelly et al., 2022, Mtenga et al., 2024).

In this study, the prevalence regarding some sociodemographis was highlighted. Out of the 160 urine samples collected in the selected hospitals, the prevalence of UTI was higher among females 14(8.75%) compared to males 6(3.75%) with no statistical significance P=0.789. Similar prevalence regarding gender have been reported within and outside Nigeria such as (Mike-Ogburia et al., 2023, Kebbeh et al., 2023, Odoki et al., 2019, Shaaban et al., 2021, Innocent et al., 2023, Yabwa et al., 2020, Metha et al., 2023). Also, (Polse et al., 2020) reported a higher prevalence among females compared to males. These diferrences could be as a result of the shorter distance from the urethral opening to the bladder, and the closer proximity of the urethral opening to the bacteria-rich vagina and rectum. For healthy premenopausal females, the risk of both acute cystitis and recurrent UTI is increased with recent or frequent sexual activity, the use of contraceptives and pregnancy (Lacerda Mariano and Ingersoll, 2020, Rosenthal et al., 2021, Vicar et al., 2023).

Regarding the age of the participants, a significant relatinship was observed (P=0.100). Those aged between 15-36 had the highest 113(70.62) prevalence followed by those less than 14 years 26(16.25%) and thse aged between 35-64 years 16(10.0%) while it was least prevalent among those greater than 65 years 5(3.13%). A similar high prevalence was reported by (Shaaban et al., 2021, Metha et al., 2023). Interestingly, urinary tract infection and asymptomatic bacteriuria are common in older adults. Distinguishing symptomatic urinary tract infection from asymptomatic bacteriuria is problematic unlike in younger adults (Cortes-Penfield et al., 2017, Akhtar et al., 2021).

There was no statistical relationship regarding marital staus even though those who are single had the highest 52(32.5%) followed by those that are married 48(30.0%), those that are divorced 37(23.1%) and the least from those that are widowed 23(14.4%) (P=0.035). Report by (Mike-Ogburia et al., 2023) is in agreement with our findings as singles presented higher prevalence followed by married, widowed although in their study the least was seen among the divorced. (Tessema et al., 2020) and (Ugwu et al., 2020) both reported a diverging prevalence from ours with a higher prevalence among married participants followed by those who were single while (Bassey et al., 2024) and (Odoki et al., 2019) in their respective studies reported higher prevalence among the married participants.

Regarding the participant's occupation, a significant relationship was established in this study where students recorded the highest 54(33.75%) closely followed by the self employed 41(25.63%), civil servants 33(20.62%), the unemployed 20(12.5%) while the least was recorded among those that are private employed 12(7.5%) P=0.021. In a similar study, (Mike-Ogburia et al., 2023) reported a prevalence of 98% among students, while (Bassey et al., 2024) and (Barwa and Bishop, 2022) reported higher prevalence among students. Overcrowding in hostels, lack of adequate hygiene in latrines necessitated by absence of water could predispose students to easily pick up infection (Barwa and Bishop, 2022).

There was no statistical relationship with regard to clinical symptoms (P= 0.353). Of the 160 participants, 31(19.37%) experienced burning sensation, 25(15.6%) experienced painful urination, 3(14.4%) had lower abdominal pain 12(7.5%) experienced frequent urination, 16(10.0%) experienced itching, 13(8.13%) had dicharge, 18(11.3%) urine had fishy smell, and 22(13.7%) had fever. Those that experienced painfull urination and those that had discharge jointly had a prevalence of 4(2.5%) respectively, followed by those who experienced burning sensation while urinating, lower abdominal pain and those who had fever 3(1.87%) respectively, 2(1.25%) for those who urinated frequently, while the least was recorded among those whose urine had a fishy smell 1(0.63%). *K. pneumoniae* was not isolated in the urine of those that experienced itching 0(0.0%). (Mike-Ogburia et al., 2023) reported frequent urination as the most prevalent symtom while the least was abdominal pain, while (Bassey et al., 2024) recorded the highest among clients that had increased frequency of urination. On the contrary, (Gosh et al., 2020) reported dysuria as the common symptom.

The antibiotic resistance was substantially linked with the rate of the *K. pneumoniae* infection (P=0.000). A 20(100%) resistance to ceftazidime was recorded, closely followed by ceftriaxone 19(95%), streptomycin 19(95%), cefurexime 19(95%) augmentin 18(90%) and chloramphenicol 17(85%). While the least resistance was recorded for ciprofloxacin 8(20%), amoxicillin 6(30%) and ofloxacin 6(30%). This is in agreement with the report by (Shaaban et al., 2021) where there was high resistance to ceftazidime (38.46%), ceftriaxone (22.73%) and cefurexime (28.57%).In contrast however, (Echendu et al., 2024) reported high susceptibility to ceftazidime 90.3 % and cefotaxime 95.1%. Intrestingly, in other related studies carbapenems exhibit the broadest spectrum of β-lactam antibiotics, and have been shown to present the highest potency against Gram-negative bacteria. Also, they are characterized by stability to hydrolysis by the majority of β-lactamases. Their use in treatment of severe ESBL-producing *K. pneumoniae* infections is associated with improved outcomes in patients and remains the 'gold standard' especially in critically ill patients (Pana and Zaoutis, 2018, Hammoudi and Ayoub, 2020, Armstrong et al., 2021).

The occurence of multidrug resistant ESBL-producing *K. pneumoniae* was determined using phenotypic and molecular methods. There was no statistical significance with respect to multidrug resistant *K. Pneumoniae* isolated in the study area P= 0.89. The occurence 6(30%) of multidrug resistant ESBL- producing *K. Pneumoniae* in the study area calls for concern. Several reports are available on the prevalence of multidrug resistant *K. Pneumoniae* within and outside Nigeria (Ashefo et al., 2023b, Mofoloronsho et al., 2021, Akinyemi et al., 2021, Odoki et al., 2019, Jalal et al., 2023, Kijineh et al., 2024, Sahoo et al., 2024, Santella et al., 2024).

5. CONCLUSION

The relatively high prevalence (12.5%) of multidrug resistant uropathogenic *K. pneumoniae* isolated in this study is a thing of concern. The isolation of *K. pneumoniae* from primary health care centers signifies the importance of universal health coverage and the place of PHCs in antimicrobial stewardship (AMS) programs as one of the strategies to control the spread of antimocrobial resistance. Amoxicillin–Clavulanic acid along side ceftriaxone and ceftazidime use in the double-disk synergy test for phenotypic confirmatory test for checking carbapenemases production was a potent and strong predictor for the reliability of phenotypic confirmatory results in Keffi.

6. RECOMMENDATIONS

1. Carrying out antibiotic susceptibility test before prescription of drugs is highly recommended
2. Continuous monitoring for mechanisms of resistance to a new generation of β-lactam using combined disk test is recommended.
3. Further studies on phenotypic and genotypic detection of of ESBL-producing *K. pneumoniae* and sequencing is recmmended.
4. In addition to testing for ESBL production by *K. pneumoniae*, testing for biofilm production is encouraged as it is a strong indicator for pathogenesis.
5. Including more antibiotics in the testing of suceptibility will improve patient outcomes.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image

generators have been used during the writing or editing of this manuscript.

CONSENT

Written informed consent was taken from each participant.

ETHICAL APPROVAL

Ethical clearance for this research was obtained from the Nasarawa State Ministry of Health (NHREC Protocol number: 18/06/2017) in line with the Declaration of Helsinki on the conduct of biomedical research involving human subjects.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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