Journal of Bioscience and Biotechnology Discovery
Volume 3(1), pages 14-24, February 2018
https://doi.org/10.31248/JBBD2017.060
ISSN: 2536-7064. Copyright © 2018
Article Number: 75E08EE63
http://integrityresjournals.org/journal/JBBD

Full Length Research

Antibiotic susceptibility patterns of Uropathogenic *Escherichia coli* among patients with urinary tract infections in a tertiary care hospital in Maiduguri, North Eastern, Nigeria

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Received 20th December, 2017; Accepted 22nd January, 2018

ABSTRACT: *Escherichia coli* (*E. coli*) has been identified as the most common uropathogenic bacterial pathogen with increasing resistance to antibiotics. Aetiology of urinary tract infections (UTI) and their antibiotic sensitivity patterns vary from time to time and across different areas. In Nigeria, studies on the prevalence and antimicrobial susceptibility patterns of clinical isolates from urinary tract infections are inadequate. Employing standardised microbiological methods, this study assessed the prevalence and antimicrobial susceptibility patterns of *E. coli* isolates from UTI in University of Maiduguri Teaching Hospital (a tertiary health care institution) in North Eastern, Nigeria. Uropathogenic *E. coli* (UPEC) accounted for 150 (62.50%) of 240 urine isolates. Lowest susceptibility was for Ampicillin 54 (36.0%), Ciprofloxacin 69 (46.0%) and Norfloxacin 72 (48.0%). More than 50% were susceptible to Levofloxacin and Streptomycin 71 (54.0%) each, Cefuroxime and Co-trimoxazole 78 (52.0%) each, while highest susceptibility was for Nitrofurantoin 117 (78.0%), Chloramphenicol 105 (70.0%) and Gentamicin 96 (64.0%). The isolates were commonly resistant to 9 (24.24%) of the ten (MARI of 0.9) classes of antimicrobial agents used in this study and all the isolates were multidrug-resistant. There is a need for proper surveillance and development of hospital specific antibiograms to inform appropriate empiric therapy of urinary tract infections.

Key words: *Escherichia coli,* uropathogenic, antimicrobial susceptibility, urinary tract infection, multi-drug resistance.

INTRODUCTION

Urinary tract infections (UTIs) are the most common reason for patients to seek health assistance and Uropathogenic *Escherichia coli* (UPEC) are among the most common bacterial infections diagnosed in community and hospital practice with a high rate of morbidity and financial cost globally (Bano et al., 2012; Foxman, 2010; Annabelle et al., 1999; Gonzalez and Schaeffer, 1999). UTI encompasses both asymptomatic microbial colonization of the urine and symptomatic infection with microbial invasion and inflammation of urinary tract structures (Ochada et al., 2014). The term cystitis has been used to define the lower UTI infection and is characterized by symptoms such as dysuria, frequency, urgency, and suprapubic tenderness (Ochada et al., 2014). The presence of the lower UTI symptoms does not exclude the upper UTI which is often present in most UTI cases (Sobel and Kaye, 2010; Zelikovic et al., 1999). Though, it can affect lower and sometimes both lower and upper urinary tracts, microbiologically, growth of more than 10^5 colony forming unit (cfu)/mL from a properly collected midstream urine specimen indicates infection. However, a smaller number of bacteria (10^2-10^4/mL) may signify infection in specimen from suprapubic aspiration, catheter specimens and immunocompromised patients (Sabra and Abdel-Fattah, 2012).

The treatment of UTI can be classified into uncomplicated and complicated on the basis of their choice of treatment (Smelov et al., 2016; Sabra and Abdel-Fattah, 2012). Several studies (Gupta, 2003; Akoachere et al., 2012) haven shown geographic variations in aetiologic agents of UTIs and their resistance patterns to antibiotics. Laboratory results of antimicrobial susceptibility testing with urinary tract infections are usually obtained two to three days after sampling; therefore, in the majority of cases, in particular those that are community-acquired (CAUTI), the treatment choice is empirically based on the predictable spectrum of aetiological microorganisms and available data reflecting antibiotic resistance of previous infections (Akoachere et al., 2012). Considering that, as with many community-acquired infections, resistance rates to antimicrobials commonly used in treatment of UTI are increasing and susceptibility of microorganisms shows significant geographical variation (Gupta et al., 1999). Studies aimed at increasing knowledge of local aetiologic agents of UTIs and their resistance patterns to antibiotics are necessary to guide clinicians in empiric treatment. Available studies in Nigeria show a growing problem of antibiotic resistance, thereby establishing a need for continuous surveillance of antibiotic susceptibility of Uropathogenic *E. coli*. The present study sought to highlight the prevalence of Uropathogenic *E. coli* and determine their susceptibility patterns in order to generate data that will improve the efficacy of the empiric treatment of this infection.

MATERIALS AND METHODS

Study area

The study was conducted at University of Maiduguri Teaching Hospital (UMTH), Maiduguri, Nigeria. The study subjects were from out-patient clinics. The sample collection site was chosen as it mostly covered the urban area of the city.

Ethics

The study was conducted after due ethical approval (IECO/UMTH/013/04/2017) which was subjected to the hospital administrations.

Study population

The urine specimens of 300 patients, who attended the Outpatient Departments (OPDs) of hospital and had clinical evidence of urinary tract infection, determined by attending physicians, were included in this study. The age of patients included in the study ranged from 15 to ≥50 years. Patients with history of hospital admission a week before their presentation in OPDs were excluded from the study to rule out hospital-acquired infections. However, the patients on antibiotic therapy were not excluded from the study, because most are on self-medications.

Sample collection

Urine specimens were collected in accordance to the standardised protocols as described by Cheesbrough (2006) and modified by Prakash and Saxena (2013) and Ochada et al. (2014). Clean catch midstream urine (MSU) was collected from each patient into a 20 mL calibrated sterile screw-capped universal container which was distributed to the patients. The specimens were labeled, transported to the laboratory, and analyzed within 6 hours. In each container boric acid (0.2 mg) was added to prevent the growth of bacteria in urine specimens. All patients were well instructed on how to collect sample aseptically prior to sample collection to avoid contaminations from urethra. Verbal informed consent was obtained from all patients prior to specimen collection.

Sample processing

A calibrated loop method was used for the isolation of bacterial pathogens from urinary specimens. A sterile 4.0 mm platinum wired calibrated loop was used which delivered 0.001 mL of urine. Simultaneously, a loopful urine sample was plated on Cystine-Lactose-Electrolyte Deficient (CLED) agar, Mac Conkey agar, and blood agar medium (Oxoid, England). The inoculated plates were incubated aerobically at 37°C for 24 h and for 48 h in negative cases. The number of isolated bacterial colonies was multiplied by 1000 for the estimation of bacterial load/mL of the urine sample. A specimen was considered positive for UTI if an organism was cultured at a concentration of $\geq 10^5$ cfu/mL or when an organism was cultured at a concentration of 10^4 cfu/mL and >5 pus cells per high-power field were observed on microscopic examination of the urine (Collee et al., 1996). Each urine sample with significant bacteria growth was sub-cultured to obtain pure isolates and the isolates were subjected to biochemical tests for identification.

Identification and maintenance of pure bacterial Isolates

Identification of bacterial isolates was done on the basis of their cultural characteristics as illustrated by Foxman and Brown (2003) and Foxman et al. (2000). Biochemical characterization was conducted on API 20E (Biomerieux, France). Identified and pure isolates were maintained by cryopreservation at -84°C.

Antibiotic susceptibility testing

In the Microbiology Laboratory of Faculty of Pharmacy, University of Maiduguri, the antimicrobial susceptibility pattern of all the isolates were determined using modified single disc diffusion technique in accordance to the guidelines of Clinical and Laboratory Standards Institute (CLSI, 2017). In brief, standardised overnight culture of each isolate (containing approximately 10^6 cfu/ml) which was equivalent to 0.5 McFarland Standard was used to flood the surface of Mueller Hinton agar plates and excess drained off and dried while the Petri dish lid was in place. The following standard antimicrobial discs namely: Ampicillin (AMP, 10µg), Cefuroxime (CEF, 30µg), Chloramphenicol (CHL, 30µg), Ciprofloxacin (CIP, 5µg), Co-trimoxazole (COT, 25µg), Gentamicin (GEN, 30µg), Levofloxacin (LEV, 5µg), Nitrofurantoin (NIT, 50µg), Norfloxacin (NOR, 5µg) and Streptomycin (STR, 10µg) obtained from Oxoid (England), were aseptically placed at reasonable equidistance on the inoculated plates and allowed to stand for 1 h. The plates (prepared in duplicates and the mean was considered) were then incubated at 37^0C for 18 to 24 h. The diameter of the zone of inhibition produced by each antimicrobial disc was measured with a ruler in millimeters. Breakpoints and interpretative for susceptibility/resistance was based on the CSLI (2017) criteria. Standard strains of *E. coli* (ATCC 25922), and *S. aureus* (ATCC 25923) were used routinely in this study as control.

Determination of multiple antibiotic resistance index

The standard method as recommended by Krumpermann (1983), described by Ehinmidu (2003) and modified by Tambekar et al. (2006) were employed in the determination of Multiple Antibiotic Resistance Index (MARI). The isolated *E. coli* that were resistant to three or more antibiotics groups were considered multiple antibiotic resistant and the Multiple Antibiotic Resistance Index was determined using the formula;

MAR = x/y

Where: x is number of antibiotics to which the isolate was resistant and y is the total number of antibiotics to which the test isolates has been evaluated for sensitivity.

Statistical analysis

Statistical analysis was done using SPSS (version 20) to determine frequency distribution, mean, harmonic mean, standard deviation, analysis of variance (ANOVA), Duncan Multiple Range and Pearson correlation coefficient.

RESULTS

300 patients who fulfilled our inclusion criteria were sampled. Of these, 240 (80.0%) patients had significant bacteriuria. The age of the patients ranged from 10 to 55 years, with a mean of 39.2 ± 17.6 years and a median of 35 years. Of the 240 significant specimens, 193 (80.42%) were from females while 47(19.58%) were from males. UTI prevalence was significantly related to gender (*p* value = 0.002). As depicted in Table 1, the most common isolated uropathogens were *E. coli* with the prevalence rate of 150 (62.50%). Of these 150, 111 (74.0%) were isolated from females and 39 (26.0%) were from male patients. The prevalence rate for the occurrence of Uropathogenic *E. coli* (UPEC) within the age groups were as follows: 10 to19 years 12 (8.00%); 20 to 29 years 62 (41.33%); 30 to 39 years 37 (24.67%); 40 to 49 years 24 (16.00%) and ≥50 years 15 (10.00%).

Table 1. Age and sex distribution of patients with Uropathogenic *E. coli* infection in University of Maiduguri Teaching Hospital, Maiduguri, Nigeria.

Age (Yrs)	Male	Female	Total (%)
15 -19	3	9	12(8.00)
20 - 29	12	50	62(41.33)
30 - 39	9	28	37(24.67)
40 - 49	9	15	24(16.00)
50 and above	6	9	15(10.00)
Total	39	111	150(100.00)

Antibiotic susceptibility

Antibiotic susceptibility results showed the resistant and susceptible antibiotics for the tested UPEC. As presented in Figure 1, generally, Ampicillin was found to be the most resistant antibiotic as 96 (64.00%) of the UPEC isolates were found resistant against it. The second most resistant antibiotic was Ciprofloxacin 81 (54.00%), followed by Norfloxacin 78 (52.00%); however, the most sensitive antibiotic against the isolates was Nitrofurantoin 117 (78.00%) followed by Chloramphenicol 105 (70.00%), Gentamicin 96 (64.00%), Levofloxacin, Streptomycin 81 (54.00%) each, and Cefuroxime, Co-trimoxazole each showing 78 (52.00%) sensitivity. The χ^2 test for trend results showed a statistically significant variation ($P < 0.05$) between the resistant and sensitive variables ($\chi^2 = 9.152$; degree of freedom = 1; $P = 0.0025$).

Table 2, shows the Multiple Antibiotic Resistance Index of UPEC isolates to the antibiotics used during the study. Ninety-nine (66.00%) of the isolates were multiply resistant. Twenty-four (24.24%) of the isolates had MARI of 0.9 which is the most prominent. Eighteen (18.18%) had MARI of 0.8 and 0.3 each; 15 (15.15%) had 0.6, 9 (9.09%) had 0.5 and 0.4 each; 3 (3.03%) had 1.0 and 0.7 each. Multi-drug resistance in this study was defined as resistance of an isolate to at least three classes of antimicrobial agents tested. Three (3.03%) of the isolates were resistant to all the ten classes of agents used.

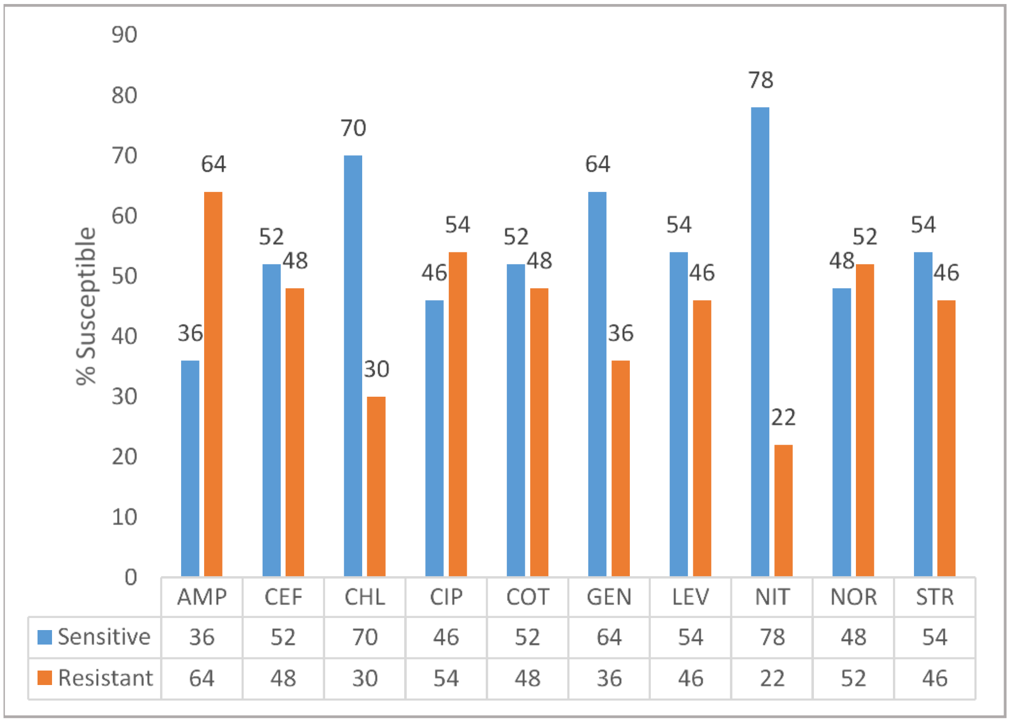

Figure 1. Antibiotic sensitivity and resistance pattern of patients with Uropathogenic *E. coli* infection in University of Maiduguri Teaching Hospital, Maiduguri, Nigeria.
KEY: AMP, Ampicillin, CEF-Ceftriaxone; CHL, Chloramphenicol, CIP, Ciprofloxacin; COT, Co-trimoxazole; GEN-Gentamycin; LEV, Levofloxacin; NIT, Nitrofurantoin, NOR, Norfloxacin, and STR, Streptomycin.

Table 2. Multiple Antibiotic Resistance Index Multi-resistant *E. coli* isolates form UTI in University of Maiduguri Teaching Hospital, Maiduguri.

MARI	Number	Percentage
0.00	24	16.00
0.10	12	8.00
0.20	15	10.00
0.30*	18	12.00
0.40	9	6.00
0.50	9	6.00
0.60	15	10.00
0.70	3	2.00
0.80	18	12.00
0.90	24	16.00
1.00	3	2.00
Total	150	100.00

***Multi-drug resistance in this study was defined as resistance of an isolate to at least three classes of antimicrobial agents tested.

DISCUSSION

This study shows the prevalence and antibiotic susceptibility pattern of Uropathogenic E. coli isolated from patients attending University of Maiduguri Teaching Hospital in Maiduguri, Northeastern Nigeria. The findings of the study reveal that the UTI prevalence is 80.0% and this rate of prevalence is higher than in previous studies which accounts for [4.2% (Bigwan and Elijah, 2013), 11% (Ibeneme et al., 2011), 17.19% (Akram et al., 2007), 22% (Ekweozor and Onyemenen, 1996), 29.3% (Ochada et al., 2014), 35.5% (Ebie et al., 2001), 38.6% (Akinyemi et al., 1997), 47% (Ojo et al., 2004), 48% (Agbagwa et al., 2015)] in Nigeria; [34.5% (Dash et al., 2013), 36.68% (Mehta et al., 2013), 10.86% (Kothari and Sagar, 2008), 40.4% (Yengkokpam et al., 2007)] in India; [49% in Trinidad and Tobago (Orrett, 2001)]; and [14.6% (Uddin et al., 2016)] in Bangladesh. However, higher prevalence rate of UTI as seen in this study has been reported by various authors in Nigeria 62.67% (Ajide et al., 2016), Cameroon 59.8% (Nzalie et al., 2016), India (Prakash and Saxena, 2013) and Mexico (Garc´ıa-Mor´ua et al., 2009) which showed such more highly significant uropathogens of 53.82% and 97.3% respectively. The regional disparities in prevalence rate supports earlier report made by Amin et al. (2009), that the relationships and variances in the type and distribution of uropathogens may result from different environmental (geographical) conditions and host factors, practices such as health care and education programmes, socioeconomic standards and hygiene practices in each country. It is worthwhile to remark that our patients were from an insurgence raveled region (Northeastern, Nigeria), and most of them are displaced from their localities, thus warranting them conceding their hygiene practices such as hand washing and bathing habits, because access to water becomes very challenging, subsequently exposing them to this worrisome prevalence rate.

The present study revealed *E. coli* as uropathogens with a prevalence rate of 62.5% which is similar to the prevalence rate of 66.3% reported by Adeyemi et al. (2014) in Bida, North central, Nigeria. Studies on UTI in other places of the world also presented that UPEC are the commonest uropathogens in UTI (Akram et al., 2006; Kothari and Sagar, 2008; Selvakumar and Jasmine, 2007; Bahadin et al., 2011; Bano et al. 2012; Oreh and Attama, 2013; Prakash and Saxena, 2013; Cullen et al., 2013; Sabir et al., 2014; Nzalie et al., 2016). Higher incidence of *Enterobacteriaceae*, in causing UTI has many virulence factors which are responsible for their attachment to the uroepithelium. In addition, Das et al. (2006), reported that *Enterobacteriaceae* are able to colonize the urogenital mucosa with virulence factors such as: adhesins, pili, fimbriae, and P-1 blood group phenotype receptor.

There was higher number of females 111 (74.00%) attending the hospitals on UTI cases with UPEC than males 39 (26.00%). The age group, 20 to 29, recorded the highest prevalence with 62 (41.33%) while 10 to 19 age group had the lowest prevalence rate 12(8.00%). This is in accordance with the patterns that UTIs follow universally and various reasons had been adduced for this. For example, Warren et al. (1999) in their studies revealed that UTI is more common in females than in males because structurally the female urethra are less effective in preventing the bacterial entry for colonisation. This may be due to the proximity of the genital tract and urethra (Schaeffer et al., 2001) and adherence of urothelial mucosa to the mucopolysaccharide lining (Akortha and Ibadin, 2008). According to Arul et al. (2012), other main factors which make females more prone to UTI are pregnancy and their sexual activities. In pregnancy, the physiological increase in plasma volume and decrease in urine concentration develop glycosuria in up to 70% women which ultimately leads to bacterial growth in urine (Lucas and Cunningham, 1993). Also in the non-pregnant state, the uterus is situated over the bladder whereas in the pregnant state the enlarged uterus affects the urinary tract (Warren et al., 1982). Sexual activity in females also increases the risk of urethra contamination as the bacteria could be pushed into the urethra during sexual intercourse as well as bacteria being massaged up the urethra into the bladder during child birth (Ebie et al., 2001; Kolawole et al., 2009). Using a diaphragm also causes UTI as it pushes against the urethra and makes the urethra unable to empty the bladder completely and the small concentration of urine left in the bladder leads to the growth of bacteria which ultimately causes UTI (Okonko et al., 2009b).

Being aware of the local antimicrobial susceptibility of uropathogens makes it more possible for clinicians to prescribe an appropriate empirical antibiotic treatment. Therefore, patients would experience fewer treatment failures and health care costs would decrease. Studies from Europe and North America showed that the antimicrobial susceptibility patterns of *E. coli*, *Klebsiella* species, and *Proteus* species isolates collected from outpatients (Daza et al., 2001; Goldstein et al., 2000) and inpatients (Hoban et al., 2012) with UTIs were similar to those presented in studies from Africa including Nigeria.

In the present study, the high patterns of multidrug resistance among the isolates is alarming and should be of great concern, and still corroborates other global trends (Schmiemann et al., 2012; Shaifali et al., 2012; Butcu et al., 2011; Gundogdu et al., 2011; Maraki et al., 2009; Zhao et al., 2009; Lobel et al., 2008; Ho et al., 2007; Grude et al., 2001; Kahlmeter et al., 2000). Hryniewcz et al. (2001) in a study conducted in Poland reported that multidrug resistance was usually related to production of *Extended Spectrum Beta Lactamases* (*ESBL*) among the *Enterobacteriaceae* in both community and hospital isolates. Multi-drug resistant *Enterobacteriaceae* have been widely reported in some studies (Aboderin et al., 2009; Abubakar, 2009; Gales et al., 2000). High prevalence of multiple antibiotic resistance strains is a possible indication that very large population of bacterial isolates has been exposed to several antibiotics.

The prevalence of antimicrobial resistance among UTI agents is increasing and its treatment has become more complicated due to increasing resistance and empirical therapy leading to treatment failures mostly. In this study, the isolated UPEC were found to be most sensitive to Nitrofurantoin, Chloramphenicol and Gentamicin by exhibiting 78.0%, 70.0% and 64.0% susceptibility rate respectively. Thus, meaning that Nitrofurantoin is the most active drug in this study showing the highest activity against the UPEC isolates. This outcome, thus supports earlier report ascribed to Gupta et al. (2011) that nitrofurantoin would be a better choice for UTI empiric (treatment) therapy and it could be administered while awaiting the culture result. Similar to this Nitrofurantoin susceptibility report are those documented by Al-Jebouri and Mdish (2013) with *Escherichia coli* (60%) susceptible to Nitrofurantoin in Iraq; Adeyemi et al. (2014) reported 61.4% susceptibility among UPEC in Bida, North Central Nigeria; Sevki et al. (2011) reported *Escherichia coli* (95.4%) susceptible to Nitrofurantoin in Turkey, Rangari et al. (2015) reported *Escherichia coli* (97.22%) in India; David et al. (2008) reported 94% susceptibility to UPEC in London, while Igwegbe et al. (2012) and Okonko et al. (2009a) reported 100% susceptibility of uropathogenic *Escherichia coli* (100%) to Nitrofurantoin in Nnewi, southeastern, and Ibadan, Southwestern Nigeria, respectively. Contrary to the efficacious outcome of Nitrofurantoin in this study, a significant increase in resistance of UPEC to Nitrofurantoin have been reported in various part of the world. For example, Nzalie et al. (2016) in Cameroon reported 32.7% susceptibility rate, Kalantar et al. (2008) reported *Escherichia coli* (29.1%) susceptible to Nitrofurantoin in Iran, while in Nigeria, Ochada et al. (2014) reported 36.8% susceptibility rate in Southwestern and Onoh et al, (2013) in Abakaliki, Southeastern Nigeria reported *Escherichia coli* (21.1%) susceptible to Nitrofurantoin. Aside to its multiple mechanisms of action that have enabled it to retain potent activity against pathogens (Al-Jebouri, 2006), other reasons that might have allowed nitrofurantoin to still show a moderate efficacy against UPEC in this study might be attributed to its horrible side effects such as, gastrointestinal discomfort, pulmonary, liver, and nerve toxicity (Rego et al., 2016; Huttner et al., 2015) that scare people away from its abuse and self-medication.

In this study, the susceptibility of Chloramphenicol was 70.0%, making it the second most efficacious drug. This outcome corroborates the findings of Tansarli et al. (2013) and Al-Jebouri and Mdish (2013) that reported the susceptibility of Chloramphenicol to vary from 57 to 72% among Africa and Asia countries. The encouraging susceptibility of these isolates to Chloramphenicol cannot be farfetched from the fact that it is strictly regulated and it is not preferred to be commonly used for medication as it might cause aplastic anaemia.

The overall assessment of the antibiotics used for UTI treatment revealed that most of the UPEC isolated were moderately sensitive among the aminoglycosides, the susceptibility varied from 54.00 to 64.00% among Streptomycin and Gentamicin respectively. These antibiotics susceptibility results correlate with other studies (Uwaezuoke and Ogbulie, 2006; Salas, 2011; Akoachere et al., 2012; Tansarli et al., 2013; Nzalie et al., 2016). Contrary to these findings were reports made by Rangari et al. (2015) and Jeevan and Zarrin (2017) documenting low susceptibility to these drugs. The reason for the moderate susceptibility recorded to these agents supports earlier documentation by Abdu and Lamikanra (2016); that the aminoglycosides (Gentamycin and Streptomycin) appears to be infrequently used as they are administered parenterally, a dosage form which is far less amenable to self- medication than orally administered antibiotics in this locality, while, the reason given by Swartz (1997) that the activity of Gentamicin against all the isolates may be due to its widespread use in the hospital environment as a broadspectrum antibiotic and the use especially when only one type is employed, may lead to an increased level of resistance.

Fluoroquinolones are widely used for empirical treatment of UTI, including the cases of upper urinary tract infections (Rocha et al., 2012). From this study, high resistance rates of the main isolated species to the tested antimicrobials (> 25% for *E. coli*) was observed. Similar data were described by Andrade et al. (2006) in samples of five Latin American countries (Argentina, Chile, Brazil, Mexico, and Venezuela). The previous use of quinolones is an independent risk factor for resistance to ciprofloxacin (Killgore et al., 2004). The indiscriminate use of this class of antimicrobials in community-acquired infections may have contributed to the high percentage of resistance observed, considering that the Nigerian population had free over-the-counter access to antimicrobials. Therefore, quinolones as empirical therapy must be considered carefully. In this respect, if susceptibility is confirmed by pathogen isolation, quinolones are alternatives for de-escalation therapy, given the possibility of their oral administration (Gupta et al., 2011). Quinolones, especially ciprofloxacin have been used for *E. coli* associated with urinary tract infections in recent past. In the present study however, the isolated UPEC were moderately resistant to Ciprofloxacin (54.00%) and Norfloxacin (52.00%), which is consistent with the previous reports (Mavroidi et al., 2012; Sabir et al., 2014). This reduction in susceptibility might be due to using antibiotics without restriction. In several studies, it has been shown that the highly prescribing habits of the physicians are the driving factor for the antibiotic resistance for this group of antibiotic (Goettsch et al., 2000; Kahlmeter, 2003; Goossens et al., 2005). In addition to selective pressure and self-medication, McEwen et al. (2003) established that 37% of physicians actually prescribe trimethoprim-sulphamethoxazole closely followed by fluoroquinolones (32%) and the average duration of antibiotic therapy is 8.6 days in the United States which is the best example of this problem; empiric use of fluoroquinolones should be restricted and founding the strategies against increasing resistance of pathogens to these antibiotics should be done. Nevertheless, despite the moderate resistance observed in this study, other fluoroquinolones such as Levofloaxacin (54.00% susceptible) employed were found efficient for the *E. coli*. Other studies from the different parts of the world also showed that some quinolones are still active against UTI infections (Mavroidi et al., 2012; Nzalie et al., 2016).

This study points out a considerable difference in the prevalence of resistance between ciprofloxacin and the other quinolones tested. This is particularly striking, since the quinolones have the same mechanism of action. When the activities of levofloxacin and ciprofloxacin were compared against bacterial uropathogens, Drago et al. (2001) found that resistance to the latter was generally more frequent. Other studies (Coyle et al., 2001; Jones et al., 1999) have also noted that ciprofloxacin-resistant bacteria retain susceptibility to newer quinolones. This difference still remains controversial. Nonetheless, there are many reasons for this discrepancy, including the situation of drug use, where people take antimicrobial drugs without a prescription, differences in animal husbandry, and over–the-counter use of quinolones in veterinary medicine, as well as environmental conditions.

The wide use of quinolones and fluoroquinolones has triggered increased bacterial resistance worldwide. Mutations in *gyrA* and *parC* genes are the most common mechanism involved in high-level quinolone resistance, yet the spread of plasmid- mediated quinolone resistance genes and efflux-pump mutants have also been described by Mavroidi et al. (2012).

The susceptibility of Co-trimoxazole (trimethoprim-sulfamethoxazole) in this study is exciting, in that reasonably, 52.00% of the UPEC isolated were susceptible to it. This underscores the fact that many studies have reported highly resistant and have recommended the disbandment of its use as the drug of choice for empirical treatment of UTI management globally. For instance, high rate of resistance against Co-trimoxazole was reported by studies done in India, Brazil, and Iran (Prakash and Saxena, 2013; Jeevan and Zarrin, 2017; Peixoto De Miranda et al., 2014; Rocha et al., 2012; Aghazadeh et al., 2015) and also by other studies done in Ethiopia (Derbie et al., 2017). Nonetheless, reduced susceptibility of *E. coli* isolates from patients with UTI to Co-trimoxazole varying from (0.00% susceptibility) to (13.90% susceptibility) have been reported by other studies done in different part of Nigeria (Ochada et al., 2014; Oreh and Attama, 2013; Dada-Adegbola and Muili, 2010; Uwaezuoke and Ogbulie, 2006). The reason for isolates reasonable susceptibility to Co-trimoxazole could not identified, however, reasons for low susceptibility has been attributed to indiscriminate use of these agents for infections outside the urinary tract, in which our subjects are culprit of such action. So based on this outcome, the recommendation made by Rangari et al. (2015) should be supported, that sensitivity of a uropathogen to a particular antibiotic should be conducted because they vary from time to time and across different areas. To reduce the incidence of resistance, empirical antibiotic selection in treatment of UTI must be based on the knowledge of local prevalence of causative uropathogens and their respective antimicrobial sensitivities rather than on universal guidelines.

With regard to *beta lactams*, the antimicrobial susceptibility of the isolated UPEC varied among the studies at the following rates: Ampicillin, 36.00%; and Cefuroxime, 52.00%. Interestingly, Cefuroxime were found to be more sensitive than the Ampicillin. This pattern of antibiotic susceptibility is similar to that seen among *beta lactams* (Ampicillin, 25%; Augmentin, 35.7% and Cefuroxime, 92.9%) in an earlier reports among UPEC in Cameroon (Nzalie et al., 2016); Ampicillin, 5%, Ceftazidime-clavulanic, 30% and Cephalotin, 81% in India (Rangari et al., 2015); Ampicillin, 33.5%; Amoxycillin, 9.2%; and Cefoxitin, 57.8% in Iraq (Al-Jebouri and Mdish, 2013). Despite these drugs having similar mode of actions, the reason for these differences might be that the Cephalosporins (For instance Cefuroxime) are least prescribed drugs and have higher cost. Indeed, cost may explain the higher prescription frequency of the less potent drugs, while the high level of resistance seen among the Ampicillin could probably be because they have been in the market for a long time. In addition to its easiness to obtain and misuse, usage of antibiotics from unknown origin (uncontrolled source of production), utilizing of inactivated antimicrobials, selective pressure of antibiotics and lacking of quality control on some sources of antibiotics entering Nigeria, thus, allowing microorganisms' time to develop resistance towards them.

One of the limitation of this study is lacking *extended spectrum beta lactamase* production status of the isolates due to limited resources. Thus, the study was exclusively based on bacteriological viewpoint. However, this study is one of the reports that provide current information on the type of UPEC isolates and their antimicrobial resistance profile.

This present study also investigated the MARI. This is described as resistant to at least one member from three different antibiotic classes being used for the treatment of *E. coli*. The findings highlights that higher level of antibiotic resistance, MARI is present in the isolates. This correlates with findings from other studies (Aghazadeh et al., 2015; Okonko et al., 2009c; Ebrahimzadeh et al., 2005). Highest MAR index was observed in 24 (24.24%) of the isolates where MAR index of 0.9 was recorded. This indicated that the isolates involved do not respond to the effect of nine of ten antibiotics tested. However, 3 8(3.02%) of the isolates had MARI of 1.00, indicating resistance to all the antibiotics tested. This is quite worrying, even though, many factors contribute to the emergence of MAR in *E. coli* among which over prescribing of antibiotics by clinicians, over usage and incomplete course of antibiotics by patients, availability of the antibiotics could not be ignored in Northeast and Nigeria at large. Environmental and personal hygiene can also contribute to the spread of resistant species among people especially in clinical settings. Mass campaign, regular training, and reformation of drug policies would to greater extent alleviate the increased spread of MARI isolates among the populace.

Conclusion

In conclusion, the results of this study showed high rates of antimicrobial susceptibility to Nitrofurantoin, Chloramphenicol, Gentamicin, Levofloxacin, Streptomycin, Cefuroxime and Co-trimoxazole. This should be considered appropriate for empirical treatment of UPEC in the study area, and clinicians should be aware of this existing data and treat patients according to this susceptibility patterns. Nevertheless, periodic monitoring of antimicrobial susceptibility both in the community and hospital settings is recommended. Further studies from Maiduguri metropolis are warranted.

ACKNOWLEDGEMENT

The authors would like to acknowledge the staff of Department of Medical Microbiology and Parasitology, University of Maiduguri Teaching Hospital for their technical support during the collection, processing and analysis of samples.

CONFLICTS OF INTEREST

No potential conflict of interest is declared for this paper.

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