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Original Research Article

Prevalence of *E. coli* as a causative agent of urinary tract infections and its drug susceptibility patterns among pregnant mothers seeking medicare at Kisii teaching and referral hospital, Kenya

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ABSTRACT

Background: *E-coli,* a gram-negative entero-bacteria has been associated with urinary tract infections (UTIs) and antimicrobial resistances in human and animals. This study aimed at establishing the prevalence of *E. coli* among other bacteria causing UTIs in pregnant women seeking Medicare at Kisii teaching and referral hospital (KTRH), Kenya and to establish the drug susceptibility patterns of the isolated *E. coli*. Setting-The project was done at Kisii teaching and referral hospital, Kenya.
Methods: This hospital based experimental and cross-sectional study conducted in 3 months between March and June 2020 involved 119 pregnant women whose urine samples were cultured on Cysteine Leucine Electrolyte deficiency media (CLED) at 37^0C overnight and sub-cultured on Mueller Hinton media. Bacterial identification was done by Gram stain and biochemical characterization using indole, methyl-red, Voges-Proskaur and citrate tests while susceptibility tests were conducted by Kirby Bauer disc diffusion technique.
Results: Out of the 119 urine samples, *E. coli* 28 (23.5%) was the second most prevalent after *S. aureus* 40 (33.6%). Others included *S. epidermidis* 27 (22.7%), and *Proteus* spp. 9 (7.6%). All *E. coli* isolates, 28 (100%) demonstrated resistance to sulfamethoxazole followed by amoxyclave 24 (85.75%), and ceftriaxone 20 (71.42%). They were least resistant to gentamycin 4 (14. 28%) and ofloxacin 6 (21.42%).
Conclusions: *E. coli* which largely exists as a commensal can cause UTIs and could be possessing antimicrobial resistant genes responsible for treatment failure. This demands for new effective therapeutic alternatives and more research on bacterial drug resistant.

Keywords: *E. coli*, Drug susceptibility, Resistance, Pregnant women, Kisii Kenya

INTRODUCTION

Urinary tract infections (UTIs) are diseases that affect the urinary tract from the bowel to the kidney, urethra and bladder.[1] These infections affect both sexes although occur 50 times more in women than men due to their short urethra and moist peri-urethral environment.[2] In pregnant women UTIs occurrence has been attributed to decreased abdominal strength in urine voiding and lack of oestrogen that causes introital colonization with *E. coli* and UTI recurrence.[3] Because of reduced immunity, HIV-infected pregnant women and those with diabetes tend to suffer from UTIs more often than non-infected ones.[4]

These UTIs are caused majorly by members of the *Enterobacterioceae* family which includes *E coli*, *Proteus mirabilis*, *Klebsiella* species and *Pseudomonas aeruginosa.*[5] According to many studies, *E. coli* is the leading amongst the major UTI causing bacteria and can be found at the community level and in hospital environments.[6] Some of its strains can survive for a long time in the outside environment and has several pathogenic strains including *Enterotoxigenic E. coli*, *Enteropathogenic E. coli* and *Uropathogenic E. coli*.[7] Despite this bacterium existing as a commensal, it's the main reservoir for spreading antibiotic resistance to other enteric pathogenic bacteria via mobile genetic elements.[8] Antibiotic resistance, according to world health organization (WHO) is a global public health problem resulting from antibiotic misuse due to poor medical knowledge, inappropriate prescription and lack of proper laboratory diagnosis.[9] Millions of people in the United States and Europe for instance, acquire antibiotic-resistant infection every year causing deaths.[10] In Latin America, a study done in Colombia on pregnant women indicated that Uropathogenic *E. coli* was the most common isolate (25%) followed by *E. faecalis* 20.8%.[11] In Argentina, it was again the most common isolate with 74% prevalence.[12] This was also the case in Pakistan where *E. coli* 33% lead in prevalence followed by *K. pneumonia* (18%) and *Proteus* spp. (10%). *E. coli* strains have not only indicated high prevalence rates, but also the highest overall resistance to various antibiotics amongst them imipenem 80%, ciproxacin 72% and amoxyclave 68%.[13] High prevalence rates have also been noted in Africa, for instance in Harare Zimbabwe, a study shows that *E. coli* (43.2%) was the most common pathogen isolated followed by *S. aureus* (15.8%) and was very resistant (100%) to ampicillin and penicillin (70%).[14] Similarly, at Mulago hospital in Uganda, *E. coli* isolates were reported to be highly resistant to cefuroxime (100%), ceftazidime (100%), nalidixic acid (90%), and ciprofloxacin (90%).[15] In another study conducted on 99 households in Nairobi Kenya, *E. coli* isolates showed high levels of prevalence and resistance of over 80% to sulphonamides, trimethoprim, aminoglycosides and penicillin.[16] All these studies clearly demonstrate that *E. coli* is one of leading UTI causing pathogens that has also become resistant to most of the commonly used antibiotics across the world.

As much as this has been documented in most parts of the world less scientific validation and documentation have been done locally. Therefore, it's against this background that this study aimed at isolation, characterization and deducing susceptibility patterns of *E. coli* among other organisms associated with UTIs among women attending antenatal care at Kisii teaching and referral hospital.

METHODS

Study design and site

This hospital based experimental-cross sectional study was conducted between March and June 2020 at Kisii teaching and referral hospital, Kenya.

Study population

The study involved pregnant women who sought for ANC services from KTRH whose urine samples contained 10 pus cells (leucocytes)/mm^3 who had consented to participate.

Sample size calculation

The sample size was calculated using a formula for cross sectional studies [17] with the following assumptions: 95% level of confidence (p=0.05), p=Expected proportion in population based on the previous studies' prevalence of *E. coli* producing extended spectrum of beta lactamases.

$$N= Z_1\text{-}\alpha_{/2}^2 \, p\,(1\text{-}p)/d^2$$

A sample size of 119 pregnant women was achieved.

Recruitment and sample collection

The study applied consecutive sampling technique (total enumerative sampling) where every subject of interest who met the criteria of inclusion was selected until the required sample size was achieved.

Inclusion criteria

The study involved all pregnant women attending antenatal clinic at KTRH who had consented to participate and whose early morning mid-stream urine contained 10 pus cells (leucocytes) /mm^3 of urine.

Exclusion criteria

Pregnant women not willing to participate in this study or had not consented.

Bacterial identification and isolation

The process commenced by the collection of early morning midstream urine specimen. In the laboratory, the urine was centrifuged at 1500 R.P.M for 3 minutes using DSC-200T electrical centrifuge and the deposit was observed microscopically under power 10x objective of Olympus CX22LEDRFS1 electrical microscope for pus cells. The samples with 10 pus cells (leucocytes)/mm^3 were processed for culture overnight on cysteine leucine electrolyte deficiency (CLED) media at 37^0C aerobically. The grown pure colonies were identified by gram staining and further by IMViC (Indole, methyl red, Voges Proskaur and citrate) biochemical tests.

Antimicrobial susceptibility testing

All the 28 identified *E. coli* isolates were tested for susceptibility against eight antibiotics (combi-44 Oxoid company REMEI Inc, USA) using Kirby Bauer disc diffusion technique on Mueller-Hinton agar. The negative control used was *E. coli* American type culture collection (ATCC) 25922) a non-ESBL producer and the positive control was *K. pneumonia* K6 ATCC 700603.

Data analysis

Data entry and cleaning were routinely performed using Microsoft excel and analysis was done at 95% confidence level using SPSS version 25.0 (IBM SPSS statistics Inc., Chicago, IL, USA). The data on isolated pathogens were subjected to descriptive statistics using frequency tables and graphs. One sample chi-square test was used to determine statistical significance ($p \leq 0.05$).

Ethical consideration

Confidentiality and privacy were strictly observed and participants were prior informed on their personal rights and benefits. They were required to sign a written consent form before participating. Permission was granted by the board of postgraduate studies (BPS) of Kisii university and Kisii county health research committee. The ethical approval was offered by the institutional research ethics committee (IREC) of university of Eastern Africa Baraton (Ref. No. UEAB/REC/23/01/2020) and the National Commission of Science, Technology and Innovations (NACOSTI)-Ref. no. 382068.

RESULTS

Gram stain and colonial morphology

A total of 119 pregnant women were investigated representing 100% of the total cases observed in the study. After an overnight culture and gram staining, 67 (56.3%) gram positive cocci, 0 (0%), gram positive bacilli, 6 (5.04%), gram negative cocci and 46 (38.65%) gram negative bacilli were isolated as shown in Table 1. The gram-negative bacilli appeared as red rods and gram-negative cocci appeared round and red. Gram positive cocci appeared singly or in clusters, were round and bluish purple in colour. There weren't any gram-positive bacilli isolated in this study. Again, as illustrated in Table 1, 28 (23.52%) of the isolates had large yellow opaque colonies with deep centres to a yellowish medium while 9 (7.56%) had large translucent blue colonies to blue medium. Six (5.04%) had extremely mucoid colonies varying in color from yellow to whitish to a yellowish medium. Majority of the isolates 40 (33.61%) had small deep yellow and white colonies uniform in colour, 27 (22.68%) were Small pale yellow white opaque colonies, 3 (2.52%) had large yellow dry colonies and 6 (5.04%) of the isolates were small greyish and white colonies.

Biochemical characterization

After gram staining, the cultured colonies were biochemically tested for further identification and results are shown in table 3.2. From the findings, 28 (23.5%) of the isolates that tested as gram negative bacilli were found to be lactose fermenters, indole, methyl red, catalase and coagulase tests positive but negative for citrate and voges-Proskauer highly suggestive of the presence of *E. coli.* Also, 9 (7.56%) of the isolates exhibited the same characteristics except for lactose fermenting suggestive for *Proteus* species. Another gram-negative bacillus that had 6 (5.04%), fermented lactose, was coagulase, catalase, Voges Proskauer, Citrate tests positive but tested negative for Indole and Methyl red, suggestive of the presence of *Klebsiella* species. The last gram-negative bacilli isolate fermented lactose, was catalase, coagulase, Methyl red and Citrate positive but tested negative for indole and Voges-proskaur suggesting the presence of *Citrobacter* species. Again, from same table, 40 (33.61%) of the gram-positive cocci isolates fermented lactose, were positive for catalase and coagulase tests suggesting the possibility of the presence of *S. aureus* while 27 (22.68%) of them had the same characteristics except were coagulase negative suggesting the presence of *S. epidermidis.* The only Gram-negative cocci present was a non-lactose fermenter, catalase positive and coagulase negative diplococci highly suggestive *of N. gonorrhoea*.

Table 1: Gram stain and culture results.

Variables	N	Percent (%)
Colonial morphology on CLED		
Large yellow with slightly deep centres colonies	28	23.52
Large translucent blue colonies	9	7.56
Large yellow to white mucoid colonies	6	5.04
Small deep yellow colonies uniform in colour	40	33.61
Small pale yellow white opaque colonies	27	22.68
Large yellow dry colonies	3	2.52
Small greyish and white colonies	6	5.04
Gram staining		
Gram positive		
Cocci	67	56.3
Bacilli	0	0
Gram negative		
Cocci	6	5.04
Bacilli	46	38.65

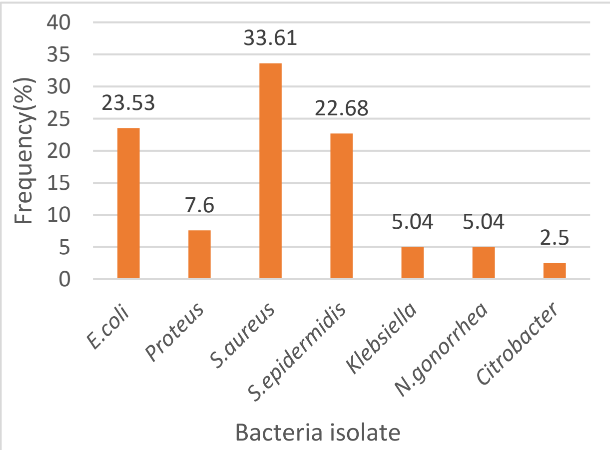

Figure 1: Bacterial frequency bar graph.

Therefore, based on the biochemical tests carried out on these isolates, it can be concluded that *E. coli* 28 (23.5%) was second prevalent after *S. aureus* 40 (33.6%) followed by *S. epidermidis* 27 (22.7), *Proteus spp.* Nine (7.56%), *Klebsiella* 6 (5.04%), *N. gonorrhoea* 6 (5.04%) and lastly *Citrobacter* species 3 (2.5%) as shown in the Figure 1.

Antimicrobial susceptibility pattern of E. coli

All the 28 *E. coli* isolates were resistant to sulfamethoxazole 28 (100%). Amoxyclave 26 (85%) was second, followed by ceftriaxone 20 (71.42%), nalidixic acid 20 (71.42%), nitrofurantoin 16 (57.14%), norfloxacin 10 (35.71%), ofloxacin 6 (21.42%) and lastly gentamycin 4 (14.28%). This is shown in Table 3.

One sample chi square was applied to determine the statistical significance in the drug susceptibility testing. Gentamycin, ofloxacin and norfloxacin were the most sensitive drugs while sulfamethoxazole, amoxyclav and ceftriaxone proved to be the most resistant.

Table 2: Biochemical results.

L.F (%)	INDL (%)	M-R (%)	V-P (%)	CIT (%)	CAT (%)	COAG (%)	Possible isolate
28 (23.5)	28 (23.5)	28 (23.5)	0 (0)	0 (0)	28 (23.5)	28 (23.5)	*E coli*
0 (0)	9 (7.56)	9 (7.56)	0 (0)	0 (0)	9 (7.56)	9 (7.56)	*Proteus spp.*
40 (33.61)	-	-	-	-	40 (33.61)	40 (33.61)	*S. aureus*
27 (22.68)	-	-	-	-	27 (22.68)	0 (0)	*S. epidermidis*
6 (5.04)	0 (0)	0 (0)	6 (5.04)	6 (5.04)	6 (5.04)	6 (5.04)	*Klebsiella spp.*
0 (0)	-	-	-	-	6 (5.04)	0 (0)	*N. gonorrhoea*
3(2.5)	0 (0)	3 (2.5)	0 (0)	3 (2.5)	3 (2.5)	3 (2.5)	*Citrobacter spp.*

L.F-Lactose fermenter; INDL- Indole; M-R-Methyl Red; V-P -Voges Proskauer; CIT- Citrate; CAT- Catalase; COAG - Coagulase. The dashes in the Table 2 above indicate that, the biochemical tests did not apply to those particular organisms, 0 (0%) indicated test negative results while the numbers and percentages showed the positivity rate.

Table 3: Drug susceptibility results.

Drugs	Zones of inhibition for *E. coli*					
	S		I		R	
	Zone (mm)	N (%)	Zone (mm)	N (%)	Zone (mm)	N (%)
AMC (20/10 µg)	≥15	2 (2.29)	12-14	2 (33.3)	≤11	24 (85.12)
GEN (30 µg)	≥20	24 (27.58)	17-19	0 (0.00)	≤16	4 (14.28)
NITRO (200 µg)	≥25	10 (11.49)	24-18	2 (33.3)	<17	16 (57.14)
NA (30 µg)	≥28	7 (8.04)	27-23	1 (16.66)	<22	20 (71.42)
OFLX (5 µg)	≥29	21 (24.13)	26-28	1 (16.66)	≤25	6 (21.42)
NRX (10 µg)	≥16	17 (19.54)	0	0 (0.00)	≤15	10 (35.71)
SMX (100 µg)	≥14	0 (0.00)	0	1	≤13	28 (100)
CTR (30 µg)	≥28	6 (6.74)	24-27	2 (33.33)	≤23	20 (71.42)

PC-Positive control, AMC-Amoxyclav, GEN-Gentamycin, NITR-Nitrofurantoin, NA-Nalidixic Acid, OFLOX-Ofloxacin, NRX-Norfloxacin, SMX-Sulfamethoxazole, CTR- Ceftriaxone, AMC-Amoxyclav, R-resistant, I-oIntermediate, S-sensitive.

Table 4: Results for one sample Chi square.

Chi-square	AMC	GEN	NITRO	NA	OFLO	NRX	CTR
	34.571[a]	14.286[b]	2.286[b]	7.000[b]	23.214[a]	1.286[b]	19.143[a]
Df	2	1	1	1	2	1	2
Asymp. Sig.	0.000	0.000	0.131	0.008	0.000	0.257	0.000

a. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is 9.3.
b. 0 cells (0.0%) have expected frequencies less than 5. The minimum expected cell frequency is

DISCUSSION

This study was designed to find out the prevalence of *E. coli* among other bacteria causing UTI in pregnant women attending ANC clinic of Kisii teaching and referral hospital (KTRH) and to establish the drug susceptibility patterns of the isolated *E. coli*. The findings indicate that out of the 119 isolates, *E. coli* 28 (23.5%) was second most prevalent bacteria isolated from pregnant women with UTIs after *S. aureus* 40(33.6%) which led as a causative agent of UTIs.

Then followed *S. epidermidis* 27(22.7%), *Proteus spp.* 9(7.56%), *Klebsiella spp.* 6(5.04%), *N. gonorrhoea* 6 (5.04%) and lastly *Citrobacter spp*. Three (2.5%). This is a finding that can easily be attributed to the fact that *E. coli* and *S. aureus* are normal floras in our systems, and they could easily take advantage of the hormonal changes such as the progesterone effect on smooth muscles which decreases bladder capacity on pregnant women hence becoming pathogenic, inducing UTI in them.[3,18] Such findings have been reported in various parts of the world for instance in a study at Mbarara regional referral hospital, South-Western Uganda, *E. coli* 28.78% was second most prevalent causative agent after *Klebsiella pneumoniae* 37.41% in urine samples cultured from pregnant women. In this study other causative agents of UTI included *S. aureus* 23.57% and *P. mirabilis 5.04%*.[19] This study also agrees with another one done at Sri Vijay hospital, India on UTIs causing pathogens amongst the pregnant women where *S. aureus* had a leading frequency of 43.53%, followed by *E. coli* 35.89 %, *K. pneumoniae,* 10.25*%, Pseudomonas aeruginosa* 7.69% and *Proteus spp.* 2% [20]. The same applies to clinical findings from referral hospitals in Tanzania which saw *S. aureus* 28.4% lead in prevalence followed by *E. coli* 15.2% (59), *P. aeruginosa* 10.6% (41) and *P. mirabilis* 7%.[21]

The gram-negative bacteria dominated in the isolates just like in the previous studies and this can easily be associated with the fact that many of these bacilli live in the gut and the urinary tract system as commensals but can turn pathogenic when there are physiological body changes especially in cases of reduced immunity.[3,22] In many cases *E. coli* is the major UTI causing agent and this was observed at Puskesmn Kenangan, Indonesia where pregnant women had *Escherichia coli* prevalence of 35.7%, followed by *Staphylococcus aureus* 28.6%, *Staphylococcus epidermidis* 28.6%, and *Klebsiella pneumonia* 7.1%.[23] In Ethiopia, a study on asymptomatic bacteriuria isolated *Escherichia coli* (43%) and *Staphylococcus aureus* (20%) as the most predominant bacteria while in Uganda at Bushenyi, *E. coli* 41.9% lead in Uropathogenic infections followed by *Staphylococcus aureus* 31.4% and *Klebsiella pneumoniae* 11.6%.[15,24] Similar findings were also documented in Nairobi Kenya, where a study on UTI in pregnant women from some selected county council clinics had 38.8% prevalence for *E. coli* followed by *S. aureus* at 29.7%, *Klebsiella spp. 7.8%, Pseudomonas* 2.7% *Proteus spp. 2.7*%, *Citrobacter spp.* 2.3% and *Enterococcus* 0.9%.[25] Epidemiologically this indicates a change in trend whereby *E. coli* and other bacterial are equally gaining virulence to dominate in UTIs aetiology in different regions.

The current study shows that, although the *E. coli* isolates were fairly susceptible to common antimicrobial agents used against it, there was a clear indication of multidrug resistance limiting and narrowing the choice of antimicrobials which can be attributed to several reasons. The emergence of resistant bacteria such as *E. coli* represent a substantial global public health crisis and the majority are in WHO's list of priority bacterial pathogens for research and development of new antibiotics.[26]

All the *E. coli* isolates were resistant to sulfamethoxazole 28 (100%) disqualifying it as a choice for UTI treatment in the area of study. This drug being a sulphonamide, competes with p-aminobenzoic acid causing sequential blockage of folic acid synthesis required for bacterial DNA and protein synthesis. Its resistance has been attributed to the formation of the *sul1* and *dfrA* genes located in integrons and the *sul2* genes linked to transposase in bacteria.[27] It has been the first-line treatment for UTIs in Kenya, and it is commonly prescribed for gastrointestinal tract infections, respiratory tract infections and skin infections. The wide usage, uncontrolled and over the counter access and also with the fact that it is relatively cheap may have contributed towards the emergence of its resistance. Similar findings were observed in Germany where *E. coli* resistance to trimethoprim and sulfamethoxazole at 15.2% and 13.0% respectively and were the most resistant.[28] This was also the case in Mexico 54% and USA 74.5%.[29,30] Locally, resistance for sulfamethoxazole was noted at Kenyatta National hospital (83%) and 75% in a study at Thika referral hospital, Kenya.[31,32] The world health organization (WHO) guidelines recommends sulfamethoxazole-trimethoprim and ampicillin as the first choice for the UTI treatment and empiric treatment is recommended for treatment of uncomplicated UTI, however from this revelation it does not make a suitable choice.[33] There is a possibility that lack of improved access to reference laboratories, efficiency and quality control assay schemes would again be some the contributing factors towards the resistance by specific priority pathogens such as *E. coli.*[34]

Ceftriaxone resistance to *E. coli* exhibited a big percentage rate 20 (71.42%) in this study. This drug is commonly used to treat UTIs, upper respiratory infections and gastrointestinal diseases. This drug is among the most stocked drugs in chemists and drug stores in Kenya and is easily acquired over the counter without a doctor's prescription. Because of this, the current study links its resistance to misuse and over subscription by clinicians like in the cases of suspected meningitis, sepsis, and febrile illnesses.[35] For this reason, again, it cannot be utilized as an option for treatment of UTIs in Kenya. It's a third-generation cephalosporin which works by binding to penicillin binding proteins on the membrane protoplasm blocking bacterial cell wall synthesis. It gains resistance by bacteria altering the penicillin-binding protein sites on the cell wall and drug efflux from bacterial cells.[36] The current findings agree with several studies globally where for instance in India *E. coli* was reported to be having a resistance of 71.4%, in Victoria and Australia 89%.[37,38] It is however very susceptible in other parts of the world and is recommended for use in places like Ankara, Turkey where resistance to *E. coli* is only 2.7%.[39]

Nitrofurantoin is another drug commonly used against UTIs and was bio assayed against *E. coli* isolates. This drug acts by attacking bacterial ribosomal proteins non-specifically, causing complete inhibition of protein synthesis.[40] It had a resistance of 57.14% in the present study, a result that is contrary to what was found in Tunisia where it was found to be the most sensitive antimicrobial agent with susceptibility rate of 91.8% on community acquired *E. coli* in urinary tract infection.[37] This drug is fairly susceptible making it still usable for UTI treatment despite being in use for a long time and much attention and care is necessary to protect it from misuse.

Resistance to ofloxacin 21.42% and Norfloxacin 35.71% for the *E. coli* isolates was relatively low. These drugs' mode of action is by blocking the bacterial nucleic acid synthesis and their resistance is associated with bacteria chromosomal mutations that alter the target enzymes and increase in drug efflux.[42] From the findings of this study, it is clear that there is need for these group of drugs to be closely safeguarded as they are still effective against *E. coli* isolates. Because of the narrowing choice of antibiotics in UTIs treatment such drugs should strictly be under prescription.[25] This study concurs with previous studies globally like in Turkey where ofloxacin showed high sensitivity (86.9%)[39] and in Nairobi, Kenya 45.2%.[42] In Thika county hospital Kenya, up to 80% of the *E. coli* isolates were susceptible to Norfloxacin recommending it as a drug of choice UTI treatment in that area.[25]

Gentamycin an aminoglycoside proved to be the drug with least resistance (14.28%). It was the most susceptible among the drugs tested against *E. coli* and the drug of choice in this case for treating UTI infections despite the fact it should not be used alone. This class of drugs remains useful for treating serious infections due to multidrug resistant enteric and Uropathogenic bacteria.[25] This drug was found to be the most effective against *E. coli* and recommended for use in Kisii county. Its mechanism of action is by irreversibly binding to receptors on the 30S ribosomal subunit of bacteria, preventing attachment of aminoacyl-transferable ribonucleic acid (tRNA) to the transferable ribonucleic acid (RNA)-ribosome complex**.** This blocks the formation and initiation of bacterial protein synthesis and eventual bacterial cell death. Resistance although rare, results from plasmid mediated drug inactivation by transferase enzymes.[43] This observation was also noted in Turkey where gentamicin 97.6% was very sensitive to *E. coli*, at Kisii teaching and referral hospital in Kenya on diabetic patients 100% and in Nairobi 83.5% in a study by Adelaide Ogutu on UTI in pregnant women.[25,39,44]

Amoxyclave (Augmentin), another broad-spectrum antibiotic showed a considerable resistance of 85% to *E. coli* isolates on the *invitro* susceptibility tests. This drug is normally recommended for UTIs and upper respiratory tract infections according to WHO.[26] However, with this resistance, it fails as a drug of choice against *E. coli* in the study area which is Kisii county, Kenya. The component Clavulanic acid is a beta-lactamase inhibitor often used in conjunction with amoxicillin to broaden its spectrum further to combat drug resistance. This drug is readily available in drug stores and because of its frequent use, its resistance can closely be associated with inappropriate use and hyper production of the chromosomal class C β-lactamase of *E. coli* and that of plasmid-mediated TEM enzymes.[45]

Kisii county falls under the sub-Saharan Africa where majority of its population suffers from social economic burdens and low levels of hygiene hence most likely have its environment contaminated with bacteria such as *E. coli* existing as normal flora. Many of the pregnant women have a tendency of eating soil most often from this contaminated environment.[46] From these findings, this can be seen as one of the reasons for resistance noting that, when bacteria in environments with poor sanitation are enriched from antibiotic use, ideal conditions for a steady production of antibiotic-resistant bacteria are achieved.[50] This observation is agreeable to studies in India where 74.4% resistance is observed and in Uganda 72.9%.[15,47]

Nalidixic acid had a resistance of 71.42% in this study. Its continued use for a long time and oversubscription may be the reason for the observed treatment failure although its resistance is primarily associated with the presence and development of bacteria conjugative plasmids. Several factors determine the variance in drug resistance between different geographical locations and from many studies there is direct relationship between antibiotic consumption and the emergence and dissemination of resistant bacteria strains.[48] The inappropriate use of drugs clearly drives the creation of resistance and despite any cautions concerning this, they are still overprescribed worldwide.

CONCLUSION

E. coli is the second most prevalent causative agent of UTI after *S. aureus* at KTRH, showing high rates of resistance to the first-line antibiotics mainly the Amoxyclave, sulfamethoxazole and ceftriaxone. This study recommends strict rules when dispensing prescribed drugs. Routine culture and drug sensitivity should be practiced often and enough resources be put in place to do more research on antimicrobial resistance.

Limitations

There were a few challenges during sample collection where some of the participants could not produce the right sample. This also happened when looking out for a polymerase chain reaction (PCR) machine for gene sequencing since they were not readily available within the research area.

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