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Antibiotic Susceptibility Patterns of Bacteria Isolated from Hospital Surfaces and Environment in Kenya

Maina Susan Muthoni[1*]

[1]Deparment of Medical Microbiology, Jomo Kenyatta University of Agriculture and Technology (Jkuat)-Nairobi Kenya.

Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

Objective: Control of hospital environment is key to success of healthcare quality. Increasing emergence and spread of pathogenic bacteria is of great concern and continues to challenge infection prevention and epidemiology practice. This study aimed at providing information about the management of hospital environment and wastes in selected hospitals in Kenya, determine prevalence of pathogenic bacteria and their antibiotic susceptibility.
Methods: A cross sectional study was conducted at Kenyatta National Hospital (KNH) (public) and Kikuyu Mission Hospital (KMH) (private) in Kenya from May 2015 to April 2017. In microbiological analysis, a total of 246 samples from each of the two hospitals was obtained using sterile cotton swabs from random sampling of hospital different surfaces, drainages, hands of healthcare givers and hospital waste dump site among others.
Results: A total of 471 bacterial isolates were recovered, and were distributed as follows; *Providentia spp, Staphylococcus aureus spp*, *Escherichia coli spp (E. coli*), other Gram negative bacteria were, *Pseudomonas spp*, coagulase negative *Staphylococcus* (CONS), *Serratia spp*, *Klebsiella spp, Proteus spp* and *Enterobacter spp*. Susceptibility test revealed that *Escherichia coli* isolates were the most sensitive isolate to antibiotics. Imipenem drug showed 100% sensitivity for Gram negative, while Gram-positive isolates, linezolid antibiotic was the most sensitive drug.

**Corresponding author: E-mail: muthonisusanmukiri@yahoo.com;*

Discussion: There is need for stringent review of hospital waste management system in Kenya. The frequency of ESBL producing strains among clinical isolates has been steadily increasing. **Conclusion:** Continued drug resistance surveillance of ESBL isolates is necessary to guide the appropriate and judicious antibiotic use.

Keywords: Hospital surfaces; antibiotics; susceptibility; public health concern.

1. INTRODUCTION

Hospital acquired infections also called nosocomial infection; is an infection acquired in hospital by a patient who was admitted for a reason other than that infection [1]. An infection occurring in a patient in a hospital or other healthcare facility in whom the infection was not present or incubating at the time of admission [2]. This includes infections acquired in the hospital but appearing after discharge, and also occupational infections among staff of the facility. Nosocomial pathogens are organisms causing diseases that are acquired from the hospital and healthcare environment within few days of admission and are responsible for nosocomial infections [1]. The frequency of overall infections in low income countries is three times higher than in high income countries whereas this incidence is three times higher in neonates [3]. With increasing infections, there is an increase in prolonged hospital stay, long-term disability, increased antimicrobial resistance, increase in socio-economic disturbance, and increased mortality rate [4].

Environmental surfaces in healthcare centers act as reservoir for bacteria and can as well serve as vectors of the bacterial pathogens [5]. Depending on the environmental conditions, these pathogens may remain infectious on the surfaces for weeks after the contamination event. The transmission of microorganisms from the environmental surfaces to patients is largely via hand contact with the surfaces [6]. Otter et al., [7] reported that surfaces can play important role in the epidemic and endemic transmission of the major pathogens linked to healthcare associated infections.

Micro-organisms universally attach to surfaces and produce extracellular polysaccharides, resulting in the formation of a biofilm. Biofilms pose a serious problem for public health because of the increased resistance of biofilm associated organisms to antimicrobial agents and the potential for these organisms to cause infections in patients with indwelling medical devices [8].

Nosocomial infections have impacted a great burden in the healthcare system where they have led to deteriorating health condition, prolonged hospitalization days, increased cost of healthcare, disabilities and high morbidity and mortality. This problem of multidrug- resistant pathogens usually carries antimicrobial resistance plasmids, which can spread within the same and to other species and are the major causes of diseases [9] boosts the adverse impact of these infections. This in turn has created a large burden economically due to loss of productivity and increased financial input in treatment of these diseases.

Potential health risk includes spreading of diseases by these pathogens and wide dissemination of antimicrobial resistance genes. The incidence of infections caused by Beta lactam resistant organisms due to the production of various enzymes has increased in recent years [10]. Detection of ESBL production is of paramount importance both in hospital and community isolates.

The present study was carried out to investigate the resistance among the bacterial strains that were isolated and identified from the hospital waste environment and surfaces of Kenyatta National Hospital (KNH) & Presbyterian Church of East Africa (PCEA) Kikuyu Mission Hospital. The ongoing emergence of resistance in the community and hospital is considered a major threat for public health.

Extended-spectrum beta-lactamases (ESBLs) are the rapidly evolving group of β-lactamase enzymes which have the ability to hydrolyze all cephalosporins and monobactams, but are inhibited by β-lactamase inhibitors, such as clavulanic acid [11]. ESBLs are undergoing continuous mutation causing the development of new enzymes showing expanded substrate profiles [12]. At present, there are more than 300 different ESBL variants. Antibiotic sensitivity or susceptibility is the susceptibility of bacteria to antibiotics. It varies within a species as some strains are more resistant than others. It is usually carried out to determine which antibiotic will be most successful in treating bacterial infection in vivo. Testing for antibiotic

sensitivity is often done by the Kirby-Bauer method [13] Small wafers containing antibiotics are placed onto a plate upon which bacteria are sensitive to the antibiotics are placed onto a plate upon which bacteria are growing. Antimicrobial resistance is driving up health care costs, increasingly the severity of disease, and increasing the death rates from certain infections.

2. MATERIALS AND METHODS

The research study site included Kenyatta National Hospital (KNH) situated in Nairobi County and PCEA Mission Hospital, Kiambu County. A cross-sectional study design utilizing a systematic random sampling technique was adopted. Sampling was done in repeated visiting days until the desired numbers of respondents was achieved. Simple random sampling method was used to collect samples from ten sections in each hospital. A total of 246 samples from solid and liquid wastes of the two hospitals were swabbed from the selected public and private hospital in Kenya. Solid waste samples were swabbed from surfaces such as door handles, toilet and bathroom knobs, bed rails, cabinet locks and handles, water dispensers' taps, tables including operating tables, scrubber surfaces, sink surfaces, theatre equipment surfaces, different types of hospital waste bin surfaces door handles and knobs, and floor surfaces and dump sites etc. They were then put into sterile tubes, tightly capped and labeled appropriately as above. The collected samples were transported in ice cooler box to the medical microbiology laboratory (JKUAT) for processing. They were refrigerated as soon as they were transported until when they were needed for processing, isolation and identification of bacteria. Each sample was analyzed in triplicate.

2.1 Antimicrobial Susceptibility Testing

All the bacteria isolates obtained were standardized using 0.5 Mcfarland turbidity standards. This was prepared by picking about three colonies from each sample of the freshly grown bacteria in 5 ml sterile nutrient broth and the turbidity was adjusted to a 0.5 Mcfarland standard. Bacterial susceptibility testing was done by the disk diffusion method according to Jan Hudzieki method [13] following the NCCLS assessment criteria [14]. Impregnated antibiotic discs were carefully and aseptically placed on the inoculated agar plates. The antibiotic susceptibility testing for each isolate was carried out in triplicate plates. All the plates were then incubated at 37^0 C and the results were observed after 24 hours as per the protocol of [14]. The diameter of the zone of inhibitions was measured in millimeters using a transparent meter ruler. The test organisms were classified as sensitive, intermediate or resistant according to the interpretive standard of the clinical and laboratory standards institute [14].

The antimicrobial agents were chosen on the basis of treatment of Gram negative and Gram positive bacteria and were based on routine antimicrobials used for bacteria and beta lactamase detection antibiotics. The following antibiotics were used; Beta lactams, quinolone, carbapenems, aminoglycosides, cephalosporins, tetracycline, sulfonamide trimethoprim etc. [15] were tested at the concentrations. These antibiotics were chosen because they are either used in both human medicine and animal veterinary practice [15].

2.1.1 ESBL screening and confirmation by phenotypic methods

This test was done according to procedure by Helene et al., in 2011, where two antimicrobial disks were placed 30mm apart (center to center). One of the disks contained amoxicillin/clavulanic acid and the other contained an expanded-spectrum cephalosporin (for example, ceftriaxone, cefotaxime or ceftazidime) in this case ceftazidime was used. The test was positive if, after 24-hour incubation, the zone of inhibition in between the disks was enhanced. The enhancement was due to the inhibition of the ESBL by clavulanic acid (provided by the amoxicillin/clavulanic acid disk) and the subsequent action of the expanded-spectrum cephalosporin. A 5 millimeter increase in zone diameter for either antimicrobial agent tested in combination with clavulanic acid versus its zone when tested alone was designated as ESBL positive. A previously identified *Klebsiella pneumoniae* an ESBL positive isolate was used as a positive control and a negative control nuclease free water was included in each run [13].

3. RESULTS

3.1 Antibiotic Susceptibility Test Patterns of Isolated Bacteria Strains

Results from API 20E test confirmed presence of the following Gram negative bacteria, *Klebsiella pneumoniae*, *Klebsiella oxytoca*, *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*,

Pseudomonas oryzihabitans, *Escherichia coli*, *Providentia rettgerri*, *Providentia alcalifaceans*, *Serratia marscens*, *Serratia liquafaceans*, *Enterobacter cloaca*, *Proteus vulgaris*, *Proteus milabilis*, and other Gram negatives included *Roultella ornithylitica*, *Ochrobactrum anthropic*, *Pantoea sp*. In total among the isolates, Gram negative bacteria were most abundant (72.3%) as compared to Gram positive bacteria (27.7%).

On average the most sensitive bacteria were *E. coli* species among the Gram negatives (66%) and Gram positives were *S. aureus* with 56% isolates while, the most resistant among the Gram negatives included *Proteus species* (68%) and the least resistant was *S. aureus* with 37%. (Table 1). Overall results indicate that KNH had more sensitive bacteria (52.12%) as compared to KMH (47.61. *E. coli* was the most sensitive bacteria with the antibiotics that was recorded according to the data (Table 1). KNH had more resistant isolates than KMH hospital.

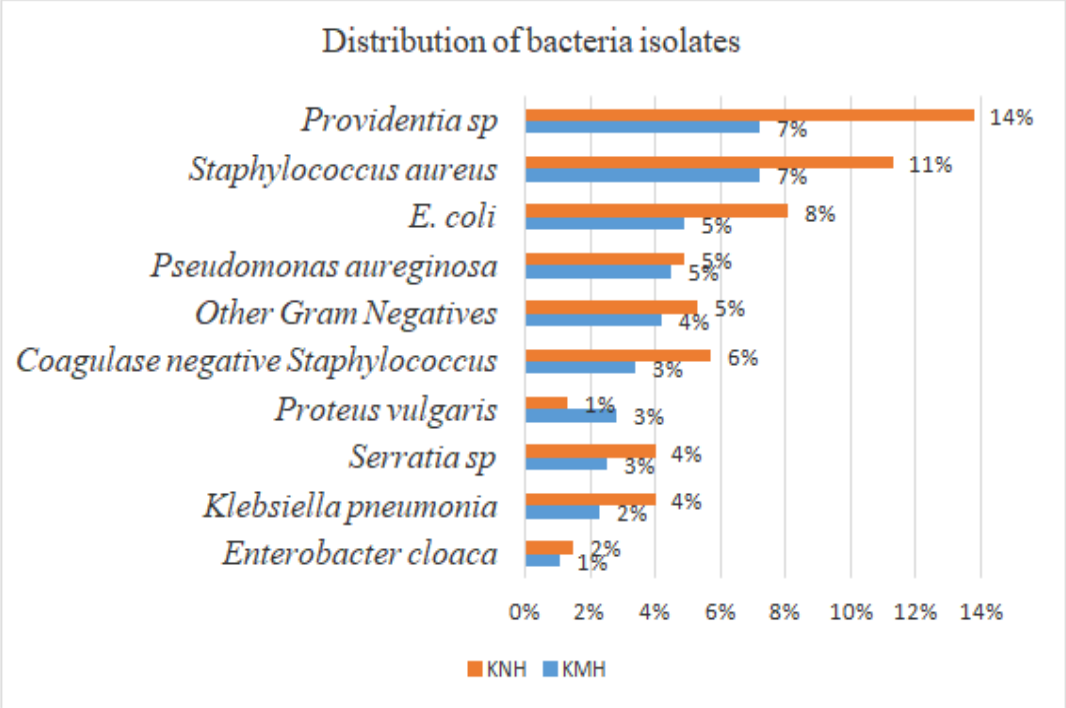

Fig. 1. Frequency of bacterial isolates from the sampled sites

Table 1. Overall percentage level of susceptibility among the isolated bacteria

	Percentage level of susceptibility among antibiotics in percentages		
Bacterial isolates	**Sensitive**	**Intermediate**	**Resistant**
E.coli	66	21	13
Providentia species	51	15	34
Enterobacter cloaca	42	33	25
Pseudomonas species	36	16	48
Proteus species	21	11	68
Serratia species	45	7	48
Klebsiella species	47	20	33
Other Gram negatives	47	9	44
S. aureus	56	7	37
Coagulase negative *Staphylococcus* (CONS)	56	8	36

3.2 Percentages of Susceptibility Patterns among the Isolates

E. coli had 100% sensitivity to imipenem, cefuroxime, levofloxacin, and chloramphenicol antibiotics, and it showed high level of resistance to ampicillin (80%), cotrimaxazole (60%) and erythromycin (40%) (Fig 2). In *Providentia* species erythromycin was the most effective drug (94%) while tetracycline was the least effective drug (100%). In most sensitivity test imipenem had (100%) sensitivity and resistance of 88% in cefotaxime, erythromycin while ampicillin had 100% resistance (Fig 2). In *Serratia* the highest sensitivity was at 100% in imipenem, cefotaxime, levofloxacin, chloramphenicol and nalidixic acid while tetracycline, ampicillin and erythromycin had 100% resistance (Table 4) (Fig. 2).

Among the Gram negatives were sensitive to imipenem with 96% followed by cefepime (68%) and levofloxacin 65%, with tetracycline 71% followed by cefotaxime 70% (Table 4).

In Gram negatives imipenem antibiotic was the most effective with 96% sensitivity and 0% resistance while tetracycline was the least effective with 4% sensitivity.

The following are patterns of antimicrobial susceptibility in Gram negative isolates from both hospitals environment and waste in Kenya (Fig. 2).

Other Gram negatives for example *Roultella ornithylitica, Ochrobactrum anthropi, and Pantoea species.*

Imipenem is the most active antimicrobial agents among the Gram negatives. Results from Gram negative bacteria activity against classes of antibiotics reveals that there was no significance difference among the organisms in the susceptibility. x^2= 1.1674, df= 2, p=0.5578 not significant (Fig. 2).

Among Gram positive bacteria, *S. aureus* and coagulase negative *Staphylococcus* were most sensitive to linezolid (99%) followed by gentamicin 90%, while the most resistant drug to ampicillin with 96% (Fig. 3). In Gram positives linezolid had 99% sensitive drug while least effective drug was ampicillin at 96% (Fig. 3).

Among the Gram positives were most sensitive to linezolid antibiotic with 100% then gentamicin and chloramphenicol with 90% each respectively. Gram positives were most resistant to ampicillin with 100%. The drug of choice for Gram positives was linezolid with 100%, and the least effective was ampicillin with 0% sensitivity (Fig. 3).

Linezolid was the most potent drug among the Gram positives, followed by gentamicin.

It was reported in this study that some bacterial isolates recorded resistant to more than three classes of antibiotics and this indicated multidrug resistance (Table 2).

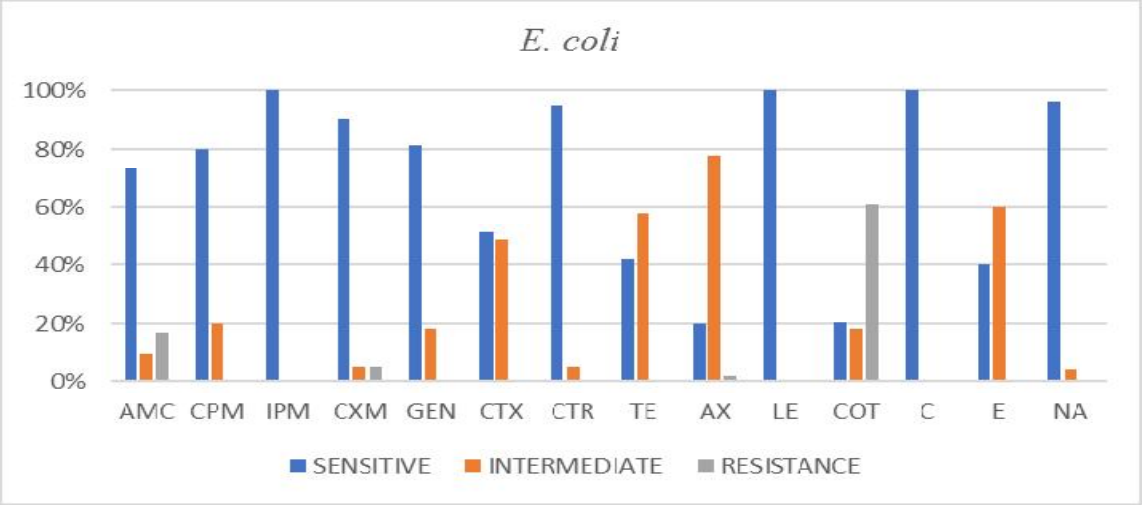

Fig. 2. Patterns of antimicrobial susceptibility in Gram negative isolates

Key: AMC-amoxicillin/clavulanic acid, CPM-cefepime, IPM-imipenem, CXM-cefuroxime, GEN-gentamicin, CTX-cefotaxime, CTR-ceftriaxone, TE-tetracycline, AX- ampicillin, LE- levofloxacin, COT-cotrimoxazole, C-chloramphenicol, E- erythromycin, NA- nalidixic acid

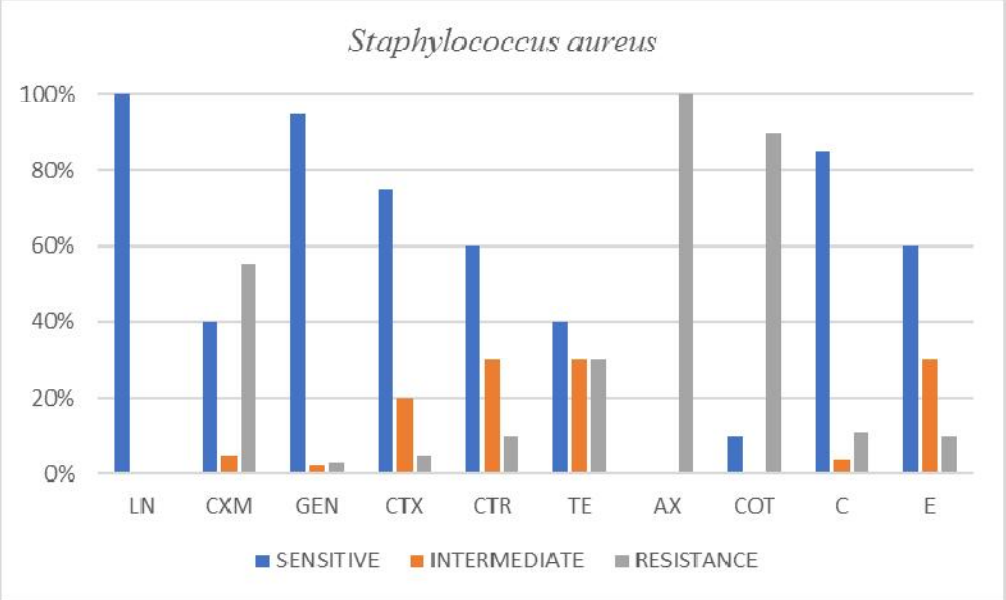

Fig. 3. Susceptibility patterns of gram positive bacteria

Table 2. Summary of resistant bacteria to different antibiotics

Bacterial isolates	Resistant antimicrobial agent with over 30%
Providentia spp	CXM, CTX, TE, AX, COT, NA
Enterobacter cloaca	CTX, CTR, AX
Pseudomonas spp	CXM, CTX, CTR, TE, AX, COT, C, E, NA
Proteus spp	CPM, GEN, CTX, CTR, TE, AX, LE, COT, C, E, NA
Serratia spp	AMC, CTX, TE, AX, E
Klebsiella spp	AMC, CTX, CTR, TE, LE, COT, C
Other Gram negatives	AMC, CXM, CTX, CTR, TE, AX, COT, E
Staphylococcus aureus	CXM, TE, AX, COT
coagulase negative *Staphylococcus* (CONS)	CXM, TE, AX, COT

Key: AMC-amoxicillin/clavulanic acid, CPM-cefepime, IPM-iminepem, CXM-cefuroxime, GEN-gentamicin, CTX-cefotaxime, CTR-ceftriaxone, TE-tetracycline, AX- ampicillin, LE- levofloxacin, COT-cotrimoxazole, C-chloramphenicol, E- erythromycin, NA- nalidixic acid

Multi drug resistant isolates were considered to be resistant to more than three antimicrobial agents. In this case all the isolates isolated in this study were multidrug resistant.

3.3 Frequency of ESBL Positive Strains

Susceptibility testing against ceftazidime and ceftazidime/clavulanate with ESBL strains showed distinct zone clearance areas with increased diameters of more than or equal to 5mm indicating presence of an ESBL. Most of the resistant strains are found in drainages from waste water, internal medicine and the operation table areas. The areas with less resistant isolates included sterilization room and pediatrics areas. An increase in zone diameter of 5 mm for antimicrobial agent tested in combination with Clavulanate versus its zone when tested alone indicated a positive result or presence of an ESBL (Table 3).

Drainage from waste water (site A) had the most ESBL positive strains, while general ward and sterilization room had the lowest number of ESBLs. Non ESBLs were mostly found in internal medicine department. 35 out of 80 (44 %) ESBL strains were from KMH, while 45 out of 80 (56%) ESBL strains were from KNH. Non- ESBL strains from KNH were 41 out of 91(45%), while in KMH 50 out of 91(55%) were isolated. The distribution of ESBLS and non-ESBLs was 46.8% and 53.2% respectively. There was no significance difference among the isolates.

Table 3. Distribution of ESBL and non-ESBL strains as tested from the resistant bacterial isolates

Departments	Total number resistant strains (N= 171)	ESBL strains (N= 80)	Non ESBL strains (N= 91)
A drainage from waste water	43	25	18
B ICU	17	5	12
C operation table	28	12	16
D sterilization room	5	2	3
E pediatrics ward	6	4	2
F Gynecology ward	7	5	2
G internal medicine	30	8	22
H General ward	7	2	5
I Orthopedic surgery	19	11	8
J Hospital dump site	9	6	3
Total	171	80	91
%	100%	46.80%	53.20%

Table 4. Summary of resistant bacteria to different antibiotics

Bacterial isolates	Resistant antimicrobial agent with over 30%
Providentia sp	CXM, CTX, TE, AX, COT, NA
Enterobacter cloaca	CTX, CTR, AX
Pseudomonas sp	CXM, CTX, CTR, TE, AX, COT, C, E, NA
Proteus sp	CPM, GEN, CTX, CTR, TE, AX, LE, COT, C, E, NA
Serratia sp	AMC, CTX, TE, AX, E
Klebsiella sp	AMC, CTX, CTR, TE, LE, COT, C
Other Gram negatives	AMC, CXM, CTX, CTR, TE, AX, COT, E
Staphylococcus aureus	CXM, TE, AX, COT
coagulase negative *Staphylococcus* (CONS)	CXM, TE, AX, COT

Key: AMC-amoxicillin/clavulanic acid, CPM-cefepime, IPM-iminepem, CXM-cefuroxime, GEN-gentamicin, CTX-cefotaxime, CTR-ceftriaxone, TE-tetracycline, AX- ampicillin, LE- levofloxacin, COT-cotrimoxazole, C-chloramphenicol, E- erythromycin, NA- nalidixic acid

4. DISCUSSION

4.1 Antibiotic Resistance on Gram Negative Bacteria

Antibiotic resistance has become a major clinical and public health problem within the lifetime of most people living today p16]. Determining their antibiotic resistance profiles is fundamental to understand the risks these organisms represent to public health [17]. In this study, percentage of Gram negative isolates resistant to tetracycline, cefotaxime was 1%, and 52% respectively. Highest rate of sensitivity pattern was found to be in imipenem antimicrobial agent.

A total of 61%, 60% and 50 % of the *E. coli* isolates exhibited resistance to cotrimoxazole erythromycin and tetracycline [15] respectively; this is in contrast to [18] who also reported resistance of *E. coli* to gentamicin (47%), ciprofloxacin (43%) and ceftriaxone (26%). According to [16], these antibiotics have been subjected to widespread abuse a possible reason as to why high rates of resistance are being reported. Co-trimoxazole and erythromycin are largely misused in the country and hence it is not surprising that many of the *E. coli* strains isolated in the study were resistant to it. The resistance of *E. coli* to ampicillin (10%) could be because of production of β-lactamase enzyme which has the ability to deactivate the efficacy of this β-lactam drug as reported [19].

The resistance pattern for each bacterium varied according to the site which the bacteria was isolated. For example *Proteus sp* the highest resistance rate to cefotaxime, ceftriaxone, tetracycline, ampicillin, levofloxacin, and nalidixic acid from the water waste of drainages (in this study 21% is among the most prevalent collection site for *Proteus* species), the same result was reported in previous study and

indicated that the highest resistance rates to tetracycline and chloramphenicol were found in strains of a domestic sewage treatment plant from El- Goela oasis in Algerian Sahara [20]. *E. coli* resistance to various antimicrobial agents, renders amoxicillin clavulanate could be used as an alternative to the above antibiotics for treatment of *E. coli* infections, particularly nosocomial infections [21]. Regarding *Pseudomonas spp* the resistance rate was shown to be high for most antibiotics particularly for ampicillin, cefotaxime and chloramphenicol (Mukhtar & Saeed, 2011). High resistant rate for *Pseudomonas species* isolated from clinical sources against the same antibiotics was also demonstrated in another study conducted in Gaza Strip hospitals [22]. The high resistance rate of *Klebsiella* species was against amoxicillin (100%). The high resistance rate found in samples collected from waste drainages is likely due to heavy metals biocides, antibiotics and various chemicals that are discharged in drainages of these hospitals and these substances have the potential to select for antibiotic resistance as researched by [15].

The resistance rate for tetracycline was high for most of the isolated bacteria with an average of 74% among the gram negatives and 40% in Gram positives unlike in other studies reported as 23% and quinolone resistance was less than 25% among environmental isolates [21]. The low resistance rate for nalidixic acid may be due to the fact that quinolones antibiotics are excreted mostly as unchanged substances, and they are among the most persistent antibiotics in the environment thus losing its potency [17]. Low resistance rate for chloramphenicol was recorded and is rare in most studies [23] possibly as the result of the restricted use of this drug.

This high resistant rate (89.18%) for bacteria isolated from drainages could be due to the fact that only few compounds were partially biodegraded in under test conditions in aquatic systems [17] and most were persistent. This can be attributed to the fact that, drainages contain a high content of both organic and inorganic matter, as well as high densities of living organisms, including pathogenic, commensal and environmental bacteria. Generally, waste water and drainages are rich in nutrients, which enhance the multiplication of microorganisms facilitating gene exchange due to cell to cell contact making waste disposal sites important reservoirs of antibiotics resistance genes that can be exchanged by bacteria from different environmental compartments [24]. Furthermore, unknown amount of antibiotics enters the sewers by waste derived from disposal of a surplus of drugs. This result is quite similar to that reported that, indeed, various antibiotics have been found in municipal sewage, including fluoroquinolones, sulfonamides and erythromycin metabolites [25].

The carpabenem (imipenem) drug (100%) used in the study was found to be most sensitive drug against the Gram negative and Gram positive bacteria respectively. These antibiotic susceptibility results correlate with other studies. [26] reported imipenem and meropenem with 100% and 98% respectively. Imipenem antibiotic had a low resistance rate in Kenyan hospitals probably because it is very restricted for life threatening infections therefore no resistance at all [27].

The study showed that Gram negative bacteria were more resistant to the tested antibiotics than the Gram positive organisms. It is the remarkable difference in structure and composition of the cell wall's murein layer between the Gram negative and the Gram positive bacteria that is responsible for this trend [27].

This study indicated presence of multiple drug resistance for majority of the isolated strains, this result is consistent with that reported in another study done in Gaza strip but the isolated bacteria were from patient samples and indicated a high percentage of multiple drug resistance [22]. The emergence, selection and dissemination of resistant organisms have been reported to occur in areas where antibiotics have been heavily used such as human, veterinary and agriculture (Wool house *et al*., 2013). Bacteria have shown the capability of attaching themselves onto surfaces in the waste water thereby forming biofilms, which enables the bacteria to withstand environmental stresses [28].

Biofilms are characterized by high bacterial density and diversity, which provide suitable conditions for horizontal gene transfer and genetic exchange of resistant traits [8]. In this study isolates recovered from waste drainages and sites records the highest numbers of antibiograms, indicating that they present the best selection sites for antibiotic resistance [22] has shown that biofilm formation increases the rate of genetic exchange for antibiotic resistance traits in drainages. Microbes have also been shown to acquire antimicrobial resistance as one

of the mechanisms which help them survive in hostile environments [8]. Efflux pumps have been reported as one of the mechanisms responsible for the antimicrobial resistance in biofilm structures due to diffusion of antibiotics through the biofilm among others. Efflux pumps allow the microorganisms to regulate their internal intracellular antibiotic concentration, allowing bacteria to survive at higher antibiotic concentrations [29]. They are site- specific recombination systems capable of recruiting open reading frames in the form of mobile genes cassettes [29].

4.2 Antibiotic Resistance on Gram Positive Bacteria

The high percentage of ampicillin resistant *S. aureus* in this research (96 %) confirms the earlier report of Dudhagara et al. [30] that the resistance of the *S. aureus* to this ampicillin antibiotic, may be as result of the ability of β-lactamase enzyme to break the β-lactam ring in the antibiotic and rendered it ineffective. *S. aureus* produces β-lactamase in the presence of ampicillin [31]. The 100% susceptibility of *S. aureus* to linezolid in this finding agreed with the findings of [32]. Linezolid has an advantage over other antibiotics like vancomycin for treating MRSA because it has an intravenous preparation and an oral tablet that has excellent bioavailability [33]. The 10% resistance of *S. aureus* to gentamicin in this finding is not similar to the report of [34] that reported 39% of this pathogen was resistant to gentamicin. As indicated by [31], multidrug resistant *Staphylococci* (*S. aureus* and coagulase negative *Staphylococci* have been a common problem and recovered from diverse environmental sources (Tula *et al*., 2013), such as drinking water supplies, foodstuffs, the mucosa of humans and farm animals and hospital environments which can be important public health concern [31].

4.3 Frequency of ESBL Strains

Resistance to an extended spectrum beta-lactams among Gram negatives pathogens is increasingly associated with ESBLs [35]. In the current study 37, 47% ESBL positive strains were identified while 43, 53% non ESBL strains were identified. This is slightly higher than in Asia [36]. Where the prevalence of ESBL producing *K. pneumoniae* and *E. coli* vary from 5% in Japan to 20–50% in other countries [36]. In Europe, the prevalence of these organisms varies from country to country (3% in Sweden to 34% in Portugal) [37]. In this study *E. coli* strains were more frequently isolated than *K. pneumoniae* strains, the production of ESBLs was more often present in *K. pneumoniae*.

The prevalence of ESBL positive strains in the current study indicated that there was higher number of ESBL strains in orthopedic surgery unit than in internal medicine 8/80 (10%) and respectively. Points for intervention could be reduction of personnel during surgery, better treatment of wounds and reduction of the time between surgical site shaving and the intervention [38]. The increase of motor bike public service vehicles as a result of legalization could also contribute to the increase in accidents as noted during the study. This difference was not statistically significant ($p > 0.05$). This observation confirms findings in other studies that ESBL producing *Enterobactericeae* are detectable in different environments and hospitalized patients with varying preference levels as researched in Ghana 43% [38] and 26% in Kenya [20]. Routine use of an ultra-clean air system exhaust ventilated clothing is frequently recommended. However, other less costly measures, including the reduction of the number of persons in the operating room, probably may ensure similar preventive effect [38].

5. CONCLUSION

Multiple drug resistance has been exhibited by most of the isolates in this study. Measures such as observation of proper personal hygiene by health staff and patients, use of effective disinfectants in reducing the possible pathogenic organisms in these hospitals should be practiced. These findings have therefore showed the need for the hospital management to be concerned about the potential of hospitalized patients becoming infected with nosocomial infections, especially resistant strains of *E. coli.*

6. LIMITATIONS OF THE STUDY

More hospitals in the studied counties and the country at large must also be studied in order to generate enough data which will help in the development of a holistic control programme in dealing with the threat posed by resistant nosocomial pathogens. Antibiotics currently administered in our hospitals should be added more as the ones in the study are the

commonly used in the Kenyan hospitals are not enough to determine the level of resistance of microorganisms.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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