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Prevalence of *Klebsiella pneumoniae* among patients attending Africa Inland Church Hospital Kijabe, Kenya

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Keywords

Klebsiella pneumoniae, Prevalence.

Abstract

Hospital acquired infections are a public health concern, particularly when the causative agents are multidrug resistant. Bacteria of genus Klebsiella frequently cause nosocomial infections in human. The most important medically involved is *Klebsiella pneumoniae* which accounts for a significant portion of hospital acquired urinary tract infections, pneumonia, septicemias and soft tissue infections. The modes of transmission of Klebsiella in hospitals are the fecal-oral route and the hands of healthcare workers. Nosocomial infections caused by multidrug resistant Klebsiella species, especially those in neonatal wards are often caused by strains of Klebsiella, for example extended- spectrum Beta-lactamase producers. The aim of this study is todetermine the prevalence of *Klebsiella pneumoniae* among patients in Paediatrics, NBU and Intensive Care Units..The clinical specimens which were used included; urine, aspirates, blood, cerebral spinal fluid (CSF), swabs of wound, device swabbing. The design was a prospective observational. Ethical approval was sought from the Kenyatta University ethical review committee and the Ethical committee in AIC Kijabe hospital as attached. The findings found that the total producing *Klebsiella pneumoniae* isolates were 21% (325/1553) of all collected over that period of one year. Out of the 384 study patients, 18 met these criteria giving the prevalence of *Klebsiella pneumoniae* at the AIC Kijabe hospital during the period of study to be 8.6% (95% CI: 9.4 %, 24.7 %).Proportion of nosocomial infections caused by *Klebsiella pneumoniae* in hospital acquired infections was 8.6% (28/325). There is sufficient evidence to suggest that *Klebsiella pneumoniae* isolated in patients is associated with nosocomial infections in AIC Kijabe hospital.

Introduction

Health-care-associated infection (HAI) is a major global safety concern for both patients and health-care professionals (Bates et al., 2009). HAI is defined as an infection occurring in a patient during the process of care in a hospital or other health-care facility that was not manifest or incubating at the time of admission. This includes infections acquired in the hospital and any other setting where patients receive health care and may appear even after discharge. HAI also includes occupational infections among facility staff WHO, (2017). These infections, often caused by multiresistant pathogens, take a heavy toll on patients and their families by causing illness, prolonged hospital stay, potential disability, excess costs and sometimes death. Various studies have been conducted in the world on *klebsiella* species. In USA, victims aged between 15 years and 45 years were found to be affected more than rest of the age groups (WHO, 2016). Nosocomial infection is the most frequently occurring infections in critical care patients. In the European Prevalence of Infections in Intensive Care study, shows that Nosocomial infection was the most frequent infection; accounting for 52 % of all infections in ICUs in Europe (Vincent et al., 2012). This study noted that *Klebsiella pneumoniae* continues to be a common cause of morbidity and mortality in critically ill patients. The incidence of Nosocomial infection ranged from 6 % to 52 %, with a crude case-fatality rate of 20 %-60 % in Spain, Russia, Sweden, Croatia, Cyprus, Monaco and Montenegro (Cook, 2011).

In a study done at the John Hopkins School of Public Health (Jaimes et al., 2006), the incidence of *Klebsiella pneumoniae* was 22.2 %. In another study carried out at ZonguldakKaraelmas University, a 350-bed referral and tertiary care university hospital, in Turkey by Akkoyunlu et al. (2013) on risk factors for nosocomial pneumonia, it was found that the overall prevalence rate of VAP was 11.5 %. However, the findings of this study are higher than the 8.1 % reported by the National Healthcare Safety Network (NHSN) which is used as a benchmark for hospitals in the United Kingdom (Michetti et al., 2012). In this study a combination of clinical criteria and positive microbiological cultures were used to define *Klebsiella pneumoniae* : and may explain the findings that the rate of *Klebsiella pneumoniae* is lower than reported from many centers and it can therefore be concluded that the *Klebsiella pneumoniae* rates at AKUHN is higher than 16 % considering that positive microbial cultures were used to define *Klebsiella pneumoniae* in this study. Klompas et al. (2008) further noted that the addition of microbiological criteria to standard clinical criteria decreased the range of apparent *Klebsiella pneumoniae* from 3.5 % to 15.5 %. The notable observation in this study is that all patients were on prophylactic antibiotics which may have reduced the possibility of growing positive cultures.

In a study carried out in Canadian ICU's on the prevalence, incidence, risk factors, and outcomes of ventilator-associated pneumonia caused by multidrug-resistant organisms such as *Klebsiella pneumoniae* (Parker et al., 2010), it was found that the incidence of high-risk organisms newly acquired during an ICU stay was low, however, the presence of high risk pathogens was associated with worse clinical outcomes.

Following the initial sporadic outbreaks in New York City, bacteria-producing KPC enzymes became endemic in many hospitals in the New York and New Jersey area (Landmann *et al*, 2011). In the ensuing decade, KPC-producing bacteria have spread throughout the US and worldwide. Data regarding nosocomial infections reported to the CDC showed the overall prevalence of carbapenem resistance among *Klebsiella pneumoniae* isolates rose from less than one percent in 2000 to eight percent in 2007 (CDC, 2009). At one academic medical center in New York City, the p-ercentage of carbapenem-resistant *Klebsiella pneumoniae* rose from 9% in 2002 to 18% in 2004, then further to 38% in 2008 (Phillips, 2009). To date, KPC-producing bacteria have been isolated in at least 33 states. In 2005, the first report of a clinical isolate producing a KPC outside of the US occurred in France from a patient who had recently been hospitalized in New York City (Naas, 2014). The first outbreak outside the US was in Israel and *Klebsiella pneumoniae* are now endemic in both Israel and Greece (Paterson, 2010). *Enterobacteriaceae*-producing KPCs have also been reported in Brazil, China, Colombia, Norway, United Kingdom, India, Sweden and more recently, Italy and Finland (Osterblad, 2009).

Despite the strides that have been made in the area of preventive interventions, nosocomial infections due to *Klebsiella pneumoniae* continues to complicate the course of 12 to 30 % of patients admitted in hospitals. In a prospective surveillance study carried out at Ibn Sina Hospital Medical ICU, Rabat, Morocco from

November 2004 to April 2008, of all hospital acquired infections (HAI), nosocomial infections rate was found to be 50 %. In contrast to infections of more frequently involved organs such as urinary tract and skin, for which mortality is low, ranging from 1 % to 4 %, the mortality rate for nosocomial infections ranged from 24 to 50 % and can reach 76 % in some specific settings or when lung infection is caused by high-risk pathogens (Madani et al., 2009).

The study investigated the Prevalence of Klebsiella species among patients suspected of UTI in Murtala Muhammad Specialist Hospital, Kano, Nigeria. Two hundred urine specimens of patients comparing of 135(67.5%) outpatients and 65(32.5%) inpatients and classified into 125(62.5%) females and 75(37.5%) males were bacteriologically evaluated. A total of 61(30.5%) yielded significant growth on culture of which 50(25%) were from females and 11(5.5%) from males. The age distribution of the patients with significant bacterial growth showed that patients within the age group of 21-30 years had the highest (UTI) cases of 33(16.5%) but those within the age group of less or equal to 10 years and those within the 51 to 60 years age bracket had 3(1.5%) UTI cases each. Of the uropathogens isolated. Klebsiella species with a prevalence of 16(8.0%) was isolated. The speciation of Klebsiella species isolated `showed that 14(7.0%) were Klebsiella pneumoniae and 2(1.0%) were Klebsiella oxytoca (Hamza &Abdulhadi , 2016).
Several studies have been done in Africa. For example the prevalence of urinary tract infection was 0.7% and 4.5% in two studies from Algeria and Senegal, respectively (Atif et al., 2011) while, a retrospective study from Nigeria reported a frequency of 12.3%.18 The study from Algeria reported that the prevalence of Klebsiella species decreased from 3% to 0.7% in 2001 and 2005, respectively, following an infection control intervention.

The hospital-wide prevalence of hospital-acquired pneumonia was 1.7% and 2.9% in studies conducted in Algeria and in Senegal, respectively (Dia et al., 2013). In another study from Algeria, the cumulative incidence of hospital-acquired pneumonia in the neonatal ICU was 2.4%.21 No microbiology data were reported in these studies. In one Senegalese study conducted in an ICU, the proportion of ventilated patients affected by ventilator-associated pneumonia was 50% (Diouf et al., 2016).

Prevalence information available on HAI shows that Klebsiella species causes high mortality. In the study from the United Republic of Tanzania, the prevalence was estimated to be 27% compared with 32% for Zimbabwe those with surgical site infection (Eriksen et al., 2013). In the study from Burkina Faso, the HAI was estimated to be 41% (Sanou et al., 2010). A study from Ethiopia reported that Klebsiella prevalence was 33% and was attributable to surgical site infection (Kotisso & Aseffa, 2012).

A study was conducted to describe the epidemiology and antibiotic resistance pattern of K. pneumonia over a 10 year period in Moi Teaching and Referral Hospital, Eldoret, Kenya. The findings showed that *K. pneumoniae* accounted for 23% of the hospital isolates (231/1356) during the study period; of these, 82.6% were from the New Born Unit (Ogalo et al., 2016). The study concluded that there was a high prevalence of multidrug resistant *K. pneumoniae* isolates in the hospital, the majority originated from the New Born Unit.

A study was conducted on prevalence of *Klebsiella pneumoniae* circulating in Kenya which were isolated from stool the researcher assessed a collection of 90 Klebsiella spp. intestinal isolates as a model for the accumulation and evolution of resistance assemblages within the gut of Kenyan individuals. A total of 90 Klebsiella spp. strains were isolated from participants ranging in age from 4 months to 54 years (median age 57 months). Half (50%) of the subjects presented with acute diarrheal illness and half were healthy controls hence the prevalence was assumed to be 50%%. Kisii County was leading with a prevalence of 41.1% followed by Kisumu county 17.8% (Chris et al., 2017).

Statement of the problem

Hospital-acquired infections (HAI) are a significant hindrance in the delivery of healthcare services. Nosocomial infection prolongs patient's stay in the hospital by 5 - 10 days (Deep , 2014). This is an important preventable cause of increased cost, morbidity and mortality among hospitalized patients. The incidence of HAI increases with the use of invasive devices and with increased duration of hospitalization (Moodley, 2015).

Currently in Kenya there is inadequate information published indicating the prevalence of HAI so that can be of help to know the magnitude of HAIs. The *Klebsiella pneumoniae* have different strains which are widely distributed. There are those which are extended –spectrum Beta –lactamase (ESBL) producer and resistance to most of the antibiotics. The *Klebsiella pneumoniae* can be resistance to one antibiotic for example Amikacin and same species is sensitive to the same antibiotic. This poses a risk of getting a broad spectrum in treatment of *Klebsiella pneumoniae*. Antibiotic susceptibility pattern is an important study so that to determine and understand the antibiotics of choice in case of outbreak in healthcare services. The dealing with microorganism is often cumbersome process which could be as a result of dealing with different strains.

The incidence of HAI varies across intensive care units (ICUs) and with different patient profiles (Tullu , 2010). Patients in hospital facilities offering a higher level of care are at greater risk of developing HAI compared with those facilities offering a lower level of care.

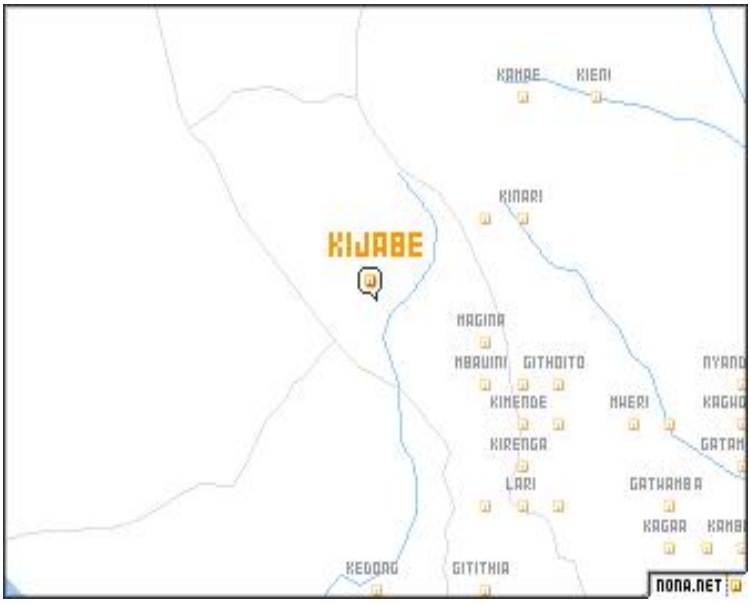
Justification

This study is important considering the increase in morbidity and mortality due to hospital acquired infections. The lack of effective infection control programmes in some hospitals especially in developing countries may be due to poor adherence to safe practices by health workers and also lack of personnel trained in infection control practices. There is need for renewed efforts geared towards education through training and re-training coupled with research to keep nosocomial infections especially with *Klebsiella pneumoniae* in check. The importance of this study is to present an overview of nosocomial infections, identify the major challenges of control in developing countries and make appropriate recommendations aimed at effective control.

Materials and Methods

3.1 Study site

The study was carried out at Kijabe Hospital which is sponsored by the African Inland Church (AIC). Kijabe Hospital is situated along Nairobi-Naivasha Highway in Kiambu West District, Kiambu County. Kijabe is a Maasai word which means a place of cold wind. The temperature ranges form 18-22 degree Celsius with a lot of wind mostly at night. It serves all people from different economic status and background.



3.2 Research design

The design was a prospective observational whereby, different specimens were collected and analyzed for *Klebsiellapneumoniae*.

3.3 Study population

The study population included those in patients who were admitted in the AIC Kijabe hospital.

3.4 Variables to be used in the study

They will be mainly: - (i) **Independent:-**
The *Klebsiella pneumoniae* microorganism
(ii) **Dependent:-**
Antibiotics used
Ward/ location in the hospital

3.5 Sampling procedure and sample size

Sampling Procedure: was done using the systemic random sampling method. The target sample size was determined using Fischer *et al* (2008) method. This is according to (Fisher *et al*, 2000). The prevalence of 50% (0.5) was considered for there is no documented figure at AIC Kijabe hospital to show the current prevalence.

Sample Size: The formula is as follows;

$N = \frac{Z^2_{\alpha/2pq}}{e^2}$ *$Z^2\alpha/2=Z0.025= 1.96$, $p= 0.5$, $q=1- 0.5$, e= error of estimating= 0.05*

$$n= \frac{1.96^2(0.5)(1-0.5)}{0.05^2} = \frac{0.9604}{0.0025} = 384$$

N is portion of population that will be considered for the study.

Z is the Z- Score which has a constant of 1.96.
E is the margin error which is also referred to as confidence interval that will be 95%.
P is the current prevalence of the main study variable.
Q is the 100% of the total population representative which can also be equivalent with one as the whole number.

3.6. Inclusive criteria

In patients who had bacterial infection symptoms after 48 hours after admission.

The age group from 3 days to 70 years.

3.7 Exclusive criteria

The age above 70 years.

3.5 Data Management and Analysis

After obtaining ethical approval and permission from the hospital director data were obtained from the Kijabe Hospital microbiology laboratory records. A coded questionnaire was used to abstract the information. Patient's names were left out for the sake of confidentiality. Data were extracted for the time period January 2015- December 2015. All the questionnaires were reviewed by the principle investigator to ensure they are completed appropriately. The filled questionnaires were in the safe custody of the principal investigator who filed and stored them in a locked cabinet for verification during analysis.

Data collected were entered into an Excel spreadsheet in a password protected computer. Back-up copies were stored in an external hard drive and compact disc which will be in sole custody of principal investigator.

Further cleaning was carried out after entry using frequency distributions and cross-tabulations until no more errors can be detected. The final step in the preparation for analysis was coding of the data and the creation of any composite variables from the cleaned data set. In order to achieve the objectives of the study, descriptive analysis was carried out. This involved frequency distributions for study variables. Variables were presented using bar charts and frequency distribution tables. Descriptive analysis was also used to give an understanding of the characteristics of the findings.

Data analysis was done using Statistical Package for Social Sciences Programme (SPSS) version 20.0.

3.7 Dissemination of results

This was carried out by information presentation and thesis write up. The defense of the research expected to done in presence of panel.

3.8 Material, methods of sample collection and procedure

3.8.1 Sample collection and preparation:-

The clinical specimens which were used included; urine, aspirates, blood, cerebral spinal fluid (CSF), swabs of wound, device swabbing. Sterile containers and swabs were used in the specimen collection. An autoclave was used to sterilize these containers and where applicable new sterile containers were procured. The morning midstream urine was collected in a sterile container. Blood was collected and aseptically drained in the sterile Bactec bottles which were then entered in the Bactec machine where it gave signal if there was microorganism growth. Aspirates and CSF were collected by clinicians as appropriate and put in sterile bottles. In case of orthopeadic patients sterile swabs were used to swab their wound and placed in staurt transport media.

3.8.2 Procedure

3.8.2.1. Culture of *Klebsiella pneumoniae*

All the specimens were inoculated on MacConkey and Blood agar Culture media. Inoculated plates were incubated at 37^{o} C for 18- 24 hours. Lactose fermenters that were non-motile with mucoid colonies, citrate positive and methyl red negative was identified as Klebsiella (Crichton, 2012).

Procedures:

DNA Extraction

Deoxyribonucleic acid (DNA) was extracted using the QIAGen DNA extraction kit (Qiagen, Germany) according to the kit manufacturer's instructions. Briefly, 200µl bacterial suspension in 'broth' was mixed with 20µl proteinase K on a 1.5ml Eppendorf tube. Later, the addition of 200µl lysis buffer (AL buffer) was done. This was incubated at 560C for 10 minutes. After incubation, 200µl of molecular grade ethanol was added to the mixture and mixed using a vortex. After the mixing, the Eppendorf tube was briefly centrifuged to remove drops from inside the Eppendorf tube lid. Carefully, 600µl was transfer to a spin column and centrifuged at 8000 rpm for 1 minute. The remaining mixture was added to the spin column and spun at the same conditions as previously described. Later, 500µl of wash 1 buffer (AW1) was added to the spin column and spun at 8000 rpm for 1 minute. The filtrate discarded and add 500µl of wash buffer 2 (AW2) to the spin column. Thereafter spin at 14,000 rpm for 3 minutes. Discard the filtrate and spin again at 14,000 rpm for 1 minute. Later add, 50µl of elution buffer (buffer AE), incubate at room temperature for 15 minutes before spinning at 8000 rpm for 1 min.

PCR Protocols

Two polymerase chain reactions (PCRs) were carried out to determine the presence of resistance genes for extended spectrum beta (β) lactamases (EBSLs) from the bacterial isolates collected. These are the most common plasmid mediated enzymes that confer resistance to these group of antibiotics. One uniplex PCR targeted the TEM while the other was a multiplex PCR targeting the CTX and SHV resistance genes.

TEM PCR Protocol

A uniplex PCR was carried out in order to determine the presence of TEM resistance genes from the bacterial isolates obtained. The primer sequences were obtained from Doosti, et al., 2015. The master mix consisted of 10x buffer (2.5µl), MgCl2 (3µl), dNTPs (1µl), primers forward and reverse (0.5µl each), nuclease free water to make the total master mix volume to 25µl.

The PCR was carried out on an Applied Biosystems 9700 PCR machine with an initial denaturation step at 94oC for 5 min, and then 32 cycles with denaturation at 94oC for 45 sec, primer annealing at 50oC for 40 sec and extension at 72oC for 60 sec. A final extension step at 72oC for 10 min was performed and the products were stored at 4oC. After gel electrophoresis was carried out on a 2% gel stained with ethidium bromide for PCR products visualization.

SHV plus CTX PCR Protocol

A multiplex PCR was carried out in order to determine CTX and SHV resistance genes. The primers were obtained from Ahmed, et al., 2018 targeting a 544bp SHV and 1018bp CTX gene fragments. The master

mix consisted of 10x buffer (2.5µl), MgCl2 (3µl), dNTPs (1µl), primers for both CTX and SHV forward and reverse (0.5µl each), nuclease free water to make the total master mix volume to 25µl.

The PCR was carried out on an Applied Biosystems 9700 PCR machine with an initial denaturation step at 94oC for 5 min, and then 30 cycles with denaturation at 94oC for 30 sec, primer annealing at 52oC for 30 sec and extension at 72oC for 50 sec. A final extension step at 72oC for 10 min was performed and the products were stored at 4oC. After gel electrophoresis was carried out on a 2% gel stained with ethidium bromide for PCR products visualization.

3.8.2.2 Identification

Identification was confirmed by using the API method which identifies the species level. The antibiotic susceptibility pattern of these isolates was determined by disc diffusion on Muller Hinton Agar using Kirby-Bauer disc diffusion method (Heathley, 2011).

Picture for API identifying *Klebsiella pneumoniae*

Ethical Consideration

The study complied with International Conference on Harmonization and Good Clinical Practice (ICH GCP) standards on biological research. Ethical approval was sought from the Kenyatta University ethical review committee. Approval was also sought from the Ethical committee in AIC Kijabe hospital as attached. The subjects were informed that information gained was for academic purposes only. No names or any of the identification of subjects was used for example hospital numbers and therefore confidentiality was maintained. The results from the findings were availed to the healthcare providers for the management of the participants. In cases where patients have mixed infections, it was not fully diagnostic to attribute the nosocomial infections to just *Klebsiella pneumoniae* yet this study was only look at *Klebsiella pneumoniae.* Only the consented participants were entered in the study.

Results

4.1 Demographic characteristics of study participants

A total of 384 intubated and mechanically ventilated patients were sampled during the study period. Males were 100 and females were 284, representing 26.04% and 73.95 % respectively. The mean age was 55.86 years (95 % CI: 52.15, 59.67). The youngest patient was aged 3 days with the oldest being 70 years. Patients aged between 51-60 years were the majority at 125(32.55 %) while patients aged 10-19 years comprised of the smallest proportion at 7(1.82%)Minimum age was 3 days and maximum age was 70 years. There was no significant difference in ages between those patients had *Klebsiella pneumoniae* with the ones who did not have, t = 1.256, p-value = 0.212 (Figure 4.1).

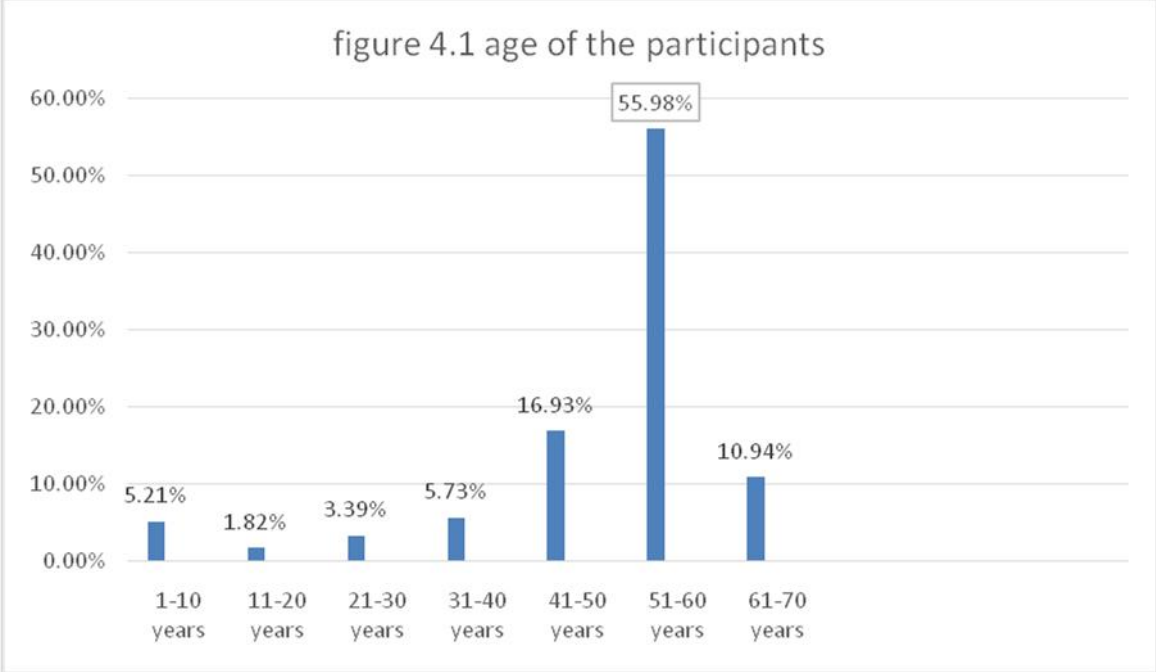


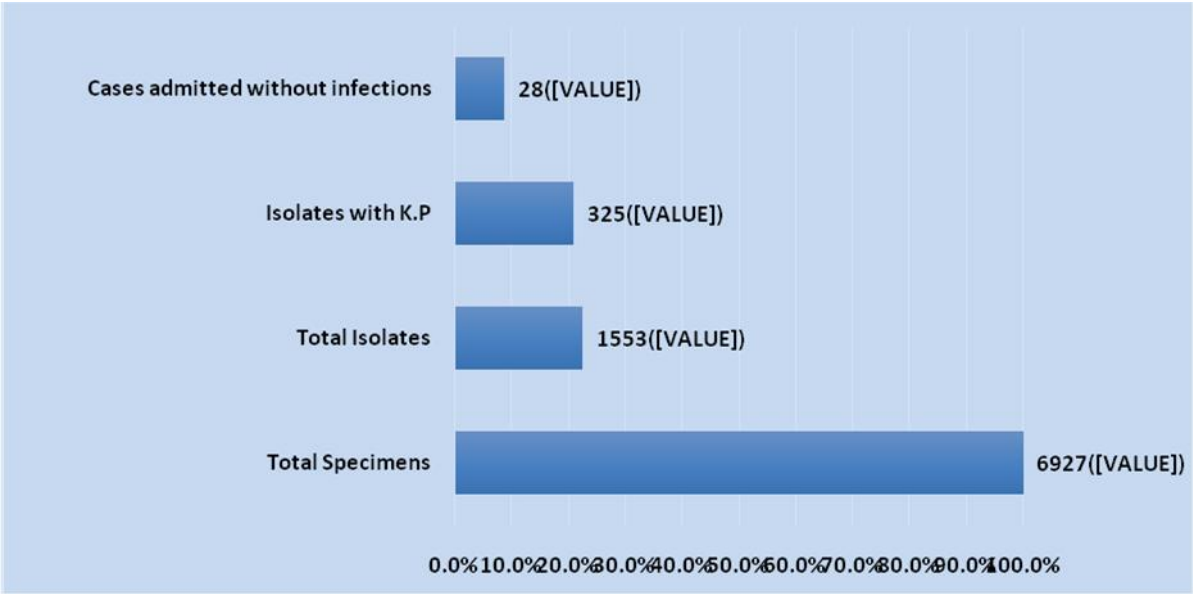
Table 4.1 Cross tabulation of patient characteristics and independent variables of patients with *Klebsiella pneumoniae at* AIC Kijabe hospital.

Gender	Yes	No	Total	Chi-square value	p-value
Male	10 (62.5 %)	47 (56.0 %)	57 (57.0 %)	0.05	0.809
Female	6 (37.5 %)	37 (44.0 %)	43 (43.0 %)		

Key: Yes = Characteristic associated with *Klebsiella pneumoniae*
No = Characteristic was not associated with *Klebsiella pneumoniae*

4.2 Prevalence of *Klebsiella pneumoniae.*

The patients classified as having *Klebsiella pneumoniae* are those who met the criteria of having grown a pathogen, had cultures grown positive for *Klebsiella pneumoniae*, had elevated WBC or low WBC count. About 28(8.6%) patients were rated as having *Klebsiella pneumoniae*, after meeting two of the above criteria, that is, a high WBC count, culture growth, gram stain and biochemical test. Between January 2015 and December 2015, 6927 specimens were collected in AIC Kijabe Hospital. The total producing *Klebsiella pneumoniae* isolates were 21% (325/1553) of all *collected* over that period of one year. Out of the 384 study patients, 18 met these criteria giving the prevalence of *Klebsiella pneumoniae* at the AIC Kijabe hospital during the period of study to be 8.6% (95% CI: 9.4 %, 24.7 %).



325 clinical samples that were infected with *Klebsiella pneumoniae*, were isolated from patients admitted in 3 wards; 294(90.5%) from pediatric ward, 22(6.7%) from NBU ward, and 9(2.8%) from ICU ward. Of the 325 samples, 55(16.9%) were blood samples, 78(24.0%) were urine samples and 192(59.1%) were other samples.

Testing of hypothesis

The null hypothesis stated that Klebsiella pneumoniae is not isolated in patients with nosocomial infections in AIC Kijabe hospital. To test this hypothesis, Chi-Square was used to analyze whether pneumoniae is isolated in patients with nosocomial infections. The data was presented in table 5

Table 4.5 Contingency of *Klebsiella pneumoniae*

		Diagnosed	Not diagnosed	Total
Nature of morbidity	Positives	21	2	23
	Negatives	3	15	18
	Total	24	17	21

Table 4.6 Chi-square

Cell	***Oi*** λ_i	λi	***Oi*** - λ_i	$(O_i - \lambda_i)^2$	$\frac{(Oi-\lambda_I)^2}{\lambda_i}$
1, 1	21	13.5	7.5	56.25	4.17
1, 2	02	9.5	- 7.5	56.25	5.92
2, 1	03	10.5	- 7.5	56.25	5.35
2, 2	15	7.5	7.5	56.25	7.5

Chi-square computed

The sum of the last column gives (χ2c) = 22.94 at the 95% confidence level and a degree of freedom of = (2-1) (2-1) = 1, χ 2a=3.841. Since χ 2c is more than χ 2a, we reject the null hypothesis H_0 `and accept the alternate hypothesis and conclude that there is sufficient evidence to suggest that *Klebsiella pneumoniae* isolated in patients is associated with nosocomial infections in AIC Kijabe hospital table 4.6.

Discussion

Prevalence of *Klebsiella pneumoniae*

This study found an overall prevalence rate of *Klebsiella pneumoniae* isolates from AIC Kijabe hospital, Nairobi to be 18 %. The findings of this study are in the range of findings from other University hospitals around the world where a *Klebsiella pneumoniae* prevalence rate between 8.1 % and 22.2 % has been reported. In a study done at the John Hopkins School of Public Health (Jaimes et al., 2006), the incidence of *Klebsiella pneumoniae* was 22.2 %. In another study carried out at Zonguldak Karaelmas University, a 350-bed referral and tertiary care university hospital, in Turkey by Akkoyunlu et al. (2013) on risk factors for nosocomial pneumonia, it was found that the overall prevalence rate of VAP was 11.5 %. However, the findings of this study are higher than the 8.1 % reported by the National Healthcare Safety Network (NHSN) which is used as a benchmark for hospitals in the United Kingdom (Michetti et al., 2012). In this study a combination of clinical criteria and positive microbiological cultures were used to define *Klebsiella pneumoniae*: and may explain the findings that the rate of *Klebsiella pneumoniae* is lower than reported from many centers and it can therefore be concluded that the *Klebsiella pneumoniae* rates at AKUHN is higher than 16 % considering that positive microbial cultures were used to define *Klebsiella pneumoniae* in this study. Klompas et al. (2008) further noted that the addition of microbiological criteria to standard clinical criteria decreased the range of apparent *Klebsiella pneumoniae* from3.5 % to 15.5 %. The notable observation in this study is that all patients were on prophylactic antibiotics which may have reduced the possibility of growing positive cultures.

Conclusion

This study established that *Klebsiella pneumoniae* rates in this hospital match those from other studies carried out in most parts of the world. However, this rate is higher than the NHSN (8.1%) benchmarking used by hospitals in the United Kingdom. The pathogens causing nosocomial infection are mainly acquired from the ICU environment while the patient is under care since no particular patient characteristics increased the risk of *Klebsiella pneumoniae*. The pathogens isolated demonstrate a high resistance and MDR patterns to the antibiotics commonly prescribed in the hospital setup.

Recommendations for further study

The study recommends further research on molecular characteristics of *K. pneumoniae* to establish whether it is the same strain.

The study focused on AIC Kijabe Hospital Kiambu County only, therefore, the same study can be extended in other hospitals and other counties for comparison purposes.

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