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Prevalence of Hospital and Community acquired *Klebsiella pneumoniae* infections among Patients attending a Tertiary Hospital in Calabar, Nigeria

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Abstract

Klebsiella (k.) pneumoniae is listed by the World Health Organization among the priority-one critical pathogens, and reported to be a major opportunistic hospital-associated pathogen accounting for about one third of all Gram-negative infections, globally. This study investigated the prevalence of hospital-acquired K. pneumoniae (HA-Kp) and community-acquired K. pneumoniae (CA-Kp) infections among patients attending University of Calabar Teaching Hospital, Calabar, Nigeria. Clinical specimens, collected from 120 patients, were processed by conventional bacteriological methods for isolation and identification of pathogens. Presumed isolates of K. pneumoniae were confirmed by Vitek 2 Compact system® (bioMérieux, Marcy L'Étoile, France) and subjected to antibiotic susceptibility testing using Kirby-Bauer disc diffusion method. The prevalence of K. pneumoniae infections was 26.7%, with HA-

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Kp and CA-Kp strains accounting for 15.0% and 11.7%, respectively. The peak prevalence of infection was found among subjects aged above 60 years, while those aged 1-10 years had the least infection. Whereas the infection was more prevalent in females than the male subjects, a greater proportion of the K. pneumoniae strains were found to be urinary isolates (46.9%), ahead of sputum (37.5%) and wound specimens (15.6%). The high prevalence of infection among the elderly subjects in this study may reflect their increased vulnerability to infectious diseases, particularly K. pneumoniae infections, and underscore the vital need for strict infection-control protocols in hospitals as well as community settings to minimize the raging escalation of hospital and community acquired infections.

Keywords: Klebsiella pneumoniae isolates, prevalence, hospital-acquired and community-acquired strains, infection control and prevention.

INTRODUCTION

Klebsiella (K.) pneumoniae is a nosocomial and environmental bacterial pathogen that frequently causes difficult-to-treat infections, worldwide, due to its remarkable antibiotic resistance traits (WHO, 2017). The organism is a non-motile, encapsulated, lactose-fermenting, facultative anaerobic and rod-shaped gram-negative bacterium, best known as a pathogen of the human respiratory system (Dorman *et al*., 2017). However, *K. pneumoniae* is associated with a couple of common human diseases, including pneumonia, urinary tract infections, septicemia, wound infections and others that are acquired in both community and hospital settings (Schroll *et al*., 2010; Dorman *et al*., 2017).

The ability of this bacterium to evade and actively suppress many components of the immune system and grow in different sites in the host makes it a serious threat to human health, particularly in patients with underlying medical problems such as alcoholism or chronic pulmonary diseases. *K. pneumoniae* is characteristically an opportunistic pathogen, which affects mostly those with weakened immune systems and cause infections. Most often, *K. pneumoniae* infections occur in association with invasive treatment or long-term care in hospitals and community settings (Dao *et al*., 2014). However, a subset of hypervirulent *K. pneumoniae* serotypes with elevated production of capsule polysaccharide can affect previously healthy persons and cause life-threatening community-acquired infections, such as pyogenic liver abscess, meningitis, necrotizing fasciitis, endophthalmitis and severe pneumonia (Shon et al., 2013; Chen et al., 2022). The organism utilizes a variety of virulence factors, including capsule polysaccharide, lipopolysaccharide, fimbriae, outer membrane proteins and determinants for iron acquisition and nitrogen source utilization, for survival and immune evasion during infection (Cortes *et al.,* 2002; Schroll *et al*., 2010; Pan *et al.,* 2011). Although found as a normal flora of the mouth, skin, and intestines, *K. pneumoniae* can cause destructive changes to human and animal lungs if aspirated, specifically to the alveoli, resulting in production of bloody, brownish or yellow colored jelly- like sputum (Dorman *et al*., 2017). In healthcare settings, *K. pneumoniae* can be spread from person-to-person by contact or less commonly by contamination of the environment, since the bacteria are not spread through the air (Asuquo *et al*., 2022). The risk factors of the infection include long course of antibiotics treatment, weaken immune system, alcoholism and individuals who suffer from severe underlying disease such as cancer, diabetes mellitus, chronic pulmonary obstruction, chronic liver disease, solid-organ transplantation, and dialysis (Tsay *et al*., 2002).

Studies carried out in most parts of Nigeria have reported increasing prevalence of hospital-acquired *K. pneumoniae* infections, with remarkable resistance to routinely used antibiotics and high morbidity among patient populations (Ayorinde *et al*., 2021; Asuquo *et al*., 2022; Ezeh *et al*., 2024). In order to fill the gaps in knowledge on the population characteristics and

strategies for prevention/control of *K. pneumoniae* infections in this geographical axis, this study investigated the prevalence of *K. pneumoniae* strains acquired from both hospital and community settings in Calabar, South-south Nigeria. Data obtained from this study would likely provide a useful guide for developing new strategies aimed at reducing the prevalence of *K. pneumoniae* infections in this epidemiological setting.

Materials and methods

Study area

This study was carried out between April 2022 and March 2023 in the University of Calabar Teaching Hospital (UCTH), a tertiary healthcare facility located in Calabar Municipal area of Cross River State, Nigeria. Calabar is a coastal city with a total area of 406-kilometer square, and estimated population of 631,000 (United Nations, 2022). The city has a typical tropical humid climate comprising of wet and dry seasons that spans annually between the months of April to November and December to March, respectively. Calabar has both metropolitan and urban-slum settings with remarkable socioeconomic potentials, rich cultural and beautiful historical sites that make the city a tourist delight. However, in recent years, the serene and once environmental-friendly city has been challenged with indiscriminate and poor waste disposal and management system that pose serious environmental hazards and threat to public health.

Study population and sample size

This cross sectional study was carried out, using simple random sampling, on patients attending UCTH, Calabar, specifically those whose clinical specimens were requested for microscopy, culture and sensitivity tests. A total of 120 participants, comprising of 50 in-patients and 70 out-patients, were enrolled in the study following collection of signed or thumb-printed written informed consents from the patients or parents/guardians for minors.

Collection and processing of clinical specimens

A total of 120 clinical specimens, comprising of urine, sputum and wound swabs, was collected from both out-patients and in-patients of all ages, whose specimens were specifically requested for microscopy, culture and sensitivity tests. Patients' information including age, gender, date of hospital-visit, admission or discharge, clinical diagnosis, and presence of underlying disease were carefully noted before collection of the samples.

Freshly collected clinical specimens were inoculated onto appropriate culture media, including blood agar, cysteine lactose electrolyte-deficient (CLED) agar, or Mac conkey agar. The inoculated plates were incubated at 37 degrees Celcius for 24 hours, and examined for moist, raised, large, lactose-fermenting colonies of *K. pneumoniae*.

Identification of *Klebsiella pneumoniae* isolates

Isolates of *K. pneumoniae* were presumptively identified based on colonial morphology, gram's reaction, catalase and urease positivity (Mofolorunsho *et al*., 2021). The identity of the presumed *K. pneumoniae* isolates were confirmed using Vitek 2 Compact system® (bioMérieux, Marcy L'Étoile, France), according to the manufacturer's instructions. The isolates were classified as hospital-acquired *K. pneumoniae* (HA-Kp) and community-acquired *K. pneumoniae* (CA-Kp), based on infections acquired after 48 hours of hospital admission or within 48 hours of hospital discharge and infections acquired before hospital visit or after 48 hours of hospital discharge, respectively (Vysakh & Jeya, 2013).

Data analysis

Data obtained from this study was analyzed using IBM SPSS Statistics 25.0 computer software (SPSS for Windows 20.0; SPSS Inc, Chicago, Illinois). Proportions were presented in frequencies and percentages. Pearson's chi-square analysis was used to test the statistical significance of the prevalence of infection in association clinical sources the isolates, age and gender of the participants, and hospital/community-acquired strains of *K.pneumoniae.* P-value less than or equal to 0.05 (P≤0.05) were considered statistically significant.

Ethical considerations

Ethical approval (*UCTH NHREC NO: NHREC/07/10/2022*) for the study was obtained from the Health Research Ethics Committee (HREC) of University of Calabar Teaching Hospital, Calabar.

Results

Yield of *Klebsiella* isolates from the clinical specimens

Out of 120 non-repetitive clinical specimens used in this study, only 39 (32.5%) yielded growth of *Klebsiella* isolates, from which 32 (26.6%) were confirmed as *K. pneumoniae* isolates, while 5 (4.2%) and 2 (1.7%) were found to be isolates of *K. oxytoca* and *K. quasi-pneumoniae*, respectively, using Vitek 2 identification system (Table 1).

Table 1: Yield of Klebsiella spp. from the clinical specimens (n=120)

Klebsiella spp.	Number (%) of isolates [n=39]	Prevalence %
K. pneumonia	32 (82.1)	26.7
K. oxytoca	5 (12.8)	4.2
K. quasipneumoniae	2 (5.1)	1.7

Distribution of *K. pneumoniae* according to clinical sources

The distribution of *K. pneumoniae* isolates in this study showed that the highest proportion was obtained from urine 15(43.7%), followed by sputum 12(37.5%) and wound specimens 5(9.4%), while none was isolated from blood (Table 2). The yield of the isolates had no significant association with the clinical sources (P=0.895).

Table 2: Distribution of *K. pneumoniae* isolates according to clinical sources (n=32)

Sources	No. of isolates (%)	Hospital- acquired isolates* (%)	Community-acquired isolates** (%)	P-value
Urine	15 (46.9)	9 (28.1)	6 (18.7)	0.895
Sputum	12 (37.5)	6 (18.7)	6 (18.7)	
Wound	5 (15.6)	3 (9.4)	2 (6.2)	
Blood	0 (0.0)	0 (0.0)	0 (0.0)	
Total	**32 (100)**	**18 (56.2)**	**14 (43.8)**	

Prevalence of *K. pneumonaie* infection by age and gender of patients

The prevalence of *K. pneumoniae* infection by age and gender of patients is shown in Table 3. The highest prevalence of infection by age was found among those above 60 years of age (40.0%), followed by those aged 51-60 (23.3%), while those aged 1-10 years had the least (11.1%). Although the prevalence of infection increased marginally with increasing age of the participants, there was no significant association between age and the prevalence of infection (P=0.288)

Table 3: Prevalence of Kp infection by age and gender of the participants (N=120)

Variables	Number of patients	Number (%) of isolates [n=32]	Prevalence (%)	P-value
Age (years)				
1-10	9	1 (3.1)	11.1	0.288
11-20	14	3 (9.4)	21.4	
21-30	17	4 (12.5)	23.5	
31-40	32	8 (25.0)	25.0	
41-50	23	7 (21.9)	30.4	
51-60	15	5 (15.6)	33.3	
>60	10	4 (12.5)	40.0	
Gender				
Male	54	12 (37.5)	22.2	0.157
Female	66	20 (62.5)	30.3	

Distribution of the isolates according to gender showed a higher prevalence of infection among the females (20.6%) than the male subjects (13.9%). However, the prevalence of infection did not have any significant association with the gender of the participants (P=0.157).

Stratification of *K. pneumoniae* isolates into hospital-acquired and community-acquired strains

Stratification of the study isolates into hospital-acquired *K. pneumoniae* (HA-Kp) and community-acquired *K. pneumoniae* (CA-Kp) strains is presented in Table 4.

The distribution showed that 14 (43.7%) of the total 32 *K. pneumoniae* isolates in this study were CA-Kp strains, with a 10% prevalence of infection among the study subjects, while the HA-Kp strains accounted for 18 (56.3%) of the isolates and infection prevalence of 15% among the participants. However, in spite of the higher proportion and prevalence rate of the HA-Kp compared to CA-Kp strains, there was no significant association between the former and the prevalence of infection among the participants (P=0.317).

Table 4: Prevalence of hospital-acquired and community-acquired *K. pneumoniae* infections among the participants (n=120)

Infection	Number (%) of isolates [n=32]	Prevalence (%)	P-value
HA-Kp*	18 (56.2)	15.0	0.317
CA-Kp**	14 (43.8)	11.7	

*Infection acquired after 48 hours of hospital admission or within 48 hours of hospital discharge
**Infection acquired before hospital visit or after 48 hours of hospital discharge

Discussion

K. pneumoniae is listed by the World Health Organization among the priority-one critical pathogens (WHO, 2017), and reported to be a major opportunistic hospital-associated pathogen accounting for about one third of all Gram-negative infections, globally (CDC, 2015). This study investigated the prevalence of hospital and community acquired *K. pneumoniae* infections among patients attending a tertiary healthcare facility in Calabar, Nigeria. The prevalence of *K. pneumoniae* infection was 26.7%, besides that of other Klebsiella species-including *K. oxytoca* (4.2%) and *K. quasipneumoniae* (1.7%), found among the participants of this study. The prevalence rate of *K. pneumoniae* infections in this study was high compared to 12.8% and 17.9% reported in studies carried out in northern Nigerian States of Kaduna

and Kogi, respectively (Olowo-Okere *et al.,* 2020; Mofolorunsho *et al*., 2021), Nevertheless, higher prevalence rates of 34% and 46.3% for *K. pneumoniae* infections have been reported in Lagos, South-west Nigeria, and elsewhere in Uganda, respectively (Akinyemi *et al*., 2021; Ssekatawa *et al*., 2021; Odewale *et al*., 2023). The remarkable variations in the prevalence rates of infectious diseases in various parts of the country or globe may be attributed in part to disparities in population composition and socio-demographic structure of each epidemiological setting.

In relation to population composition, the female gender outnumbered the males in this study, with a corresponding higher prevalence of infection among the females (30.3%) compared to the male subjects (22.2%). Although the difference was not statistically significant, this finding is consistent with the report of a similar study in southwest Nigeria which found a higher prevalence of *K. pneumoniae* infections among females than males (Odewale *et al*., 2023).

The distribution of *K. pneumoniae* isolates by age of the subjects in this study showed that the highest prevalence of infection occurred among those who were over 60 years of age, ahead of those aged 50-60 years, while those aged 1-10 years had the least infection. Whereas the prevalence of infection increased sequentially with increasing age of the participants, there was no significant association between age and the prevalence of infection. However, this finding corroborates the report of a study that found 53.6% prevalence among the elderly compared to 4.8% among minors in the study population (Wang *et al*., 2021). The incremental prevalence of infection observed with increasing age of the participants in this study may be a pointer to the heightened vulnerability of elderly persons to *K. pneumoniae* infections, likely due to gradual depreciation of immunity and presence of underlying chronic ailments. Available clinical history of the participants in this study showed that a significant proportion of those aged 50 years and above had some underlying ailments including chronic respiratory diseases, diabetes, and high blood pressure, among others.

Categorization of *K. pneumoniae* isolates according to clinical sources in this study showed that urine specimens accounted for the highest proportion of the isolates, followed by sputum and wounds specimens, while no isolate was obtained from blood specimens. This finding contrasted with that of a study in New York which found majority of *K. pneumoniae* isolates from blood culture (Parrott *et al.,* 2021), but aligned with that of a study report in Uganda where most *K. pneumoniae* isolates were obtained from urine and pus specimens (Ssekatawa *et al*. 2021). Considering that majority of the *K. pneumoniae* infections were linked to the females in this study, it was not surprising that the highest proportion of the isolates were urinary pathogens, generally known to be more prevalent among females than males. On the other hand, the finding of more isolates of *K. pneumoniae* from urinary sources in this study may support the known attribute of the organism as a major etiologic agent of urinary tract infections, also known to be a common nosocomial infection.

In this study, majority of the *K. pneumoniae* isolates [18(56.2%)] were linked to infections acquired during hospitalization (nosocomial infections), while a lesser number [14(43.8%)] was acquired outside hospital setting (community-acquired infections) among the out-patients, who actually constituted a larger proportion of the study population. This finding is consistent with the reported attribute of the organism as a leading hospital-associated pathogen that accounts for a third of all gram-negative infections worldwide (CDC, 2015). In contrast, however, a higher prevalence of community-acquired *K. pneumoniae,* compared to hospital-acquired strains, was reported in a study conducted in Portugal (Caneiras *et al*., 2019).

However, in spite of the higher prevalence of HA-Kp infections in the present study, the difference in the prevalence of HA-Kp and CA-Kp infections was not statistically significant.

CONCLUSION

The prevalence of *K.pneumoniae* infections among the study participants was 26.7%, with HA-Kp and CA-Kp strains constituting 15.0% and 11.7%, respectively. The prevalence of infection was found to increase with increasing age of the subjects, with peak prevalence found among those aged above 60 years. Whereas the infection was more prevalent in females than the male subjects, more of the *K. pneumoniae* strains were found to be urinary isolates, ahead of other clinical sources. The high prevalence of infection among the elderly subjects in this study may expound their increased vulnerability to infectious diseases, particularly *K. pneumoniae* infections, and underscore the need for strict infection-control protocols in hospitals as well as community settings to minimize the raging escalation of hospital and community acquired infections.

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