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Knowledge, Attitude, and Practices Regarding Carbapenem-Resistant *Escherichia coli* among Hospitalized Patients at Federal Teaching Hospital Gombe, Gombe State, Nigeria.

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Abstract

Public awareness and behavioural practices play important roles in influencing trends in antimicrobial resistance (AMR). Carbapenem-resistant *Enterobacteriaceae* (CRE) are among the most important antimicrobial-resistant pathogens and constitute a major global public health concern. This study assessed the knowledge, attitudes, and practices (KAP) regarding carbapenem-resistant *Escherichia coli* among hospitalized patients at Federal Teaching Hospital Gombe, Gombe State, Nigeria. A cross-sectional, hospital-based study was conducted among 384 hospitalized patients diagnosed with *E. coli*. Data were collected following standard procedures using a carefully tailored, structured, self-administered KAP questionnaire designed to evaluate participants' knowledge, attitudes, and practices regarding carbapenem-resistant *E. coli*. The collected data were analyzed using the Statistical Package for the Social Sciences (SPSS), version 23 (Chicago, IL, USA). The overall average scores for knowledge, attitude, and practice were 19.2%, 76.2%, and 47.9%, respectively. These findings indicate markedly low levels of knowledge regarding carbapenem-resistant *E. coli* among the hospitalized patients, despite a comparatively favourable attitude score. The practice score, however, remained inadequate, indicating an important gap between positive attitudes and the adoption of appropriate practices for limiting the emergence and transmission of antimicrobial-resistant organisms. The study therefore demonstrates substantial deficiencies in patient awareness and preventive practices related to carbapenem-resistant *E. coli*. These findings underscore the need for targeted patient education and sustained public awareness interventions, strengthened infection prevention and control measures, effective antimicrobial stewardship programmes, and continuous molecular surveillance to monitor resistance patterns and help prevent the emergence and further spread of carbapenem-resistant *E. coli* within healthcare settings.

Keywords

Carbapenem-resistant,
Escherichia coli,
Antibiotics,
Knowledge,
Attitude,
Practice,
FTH Gombe



INTRODUCTION

Antimicrobial resistance (AMR) is one of the major public health, food security, and sustainable development challenges of the 21st century. It occurs when microorganisms, including bacteria, viruses, fungi, and parasites, develop the ability to survive or resist the effects of antimicrobial drugs that would normally be effective against them. As a result, infections may persist, become more difficult to treat, and spread more easily (World Health Organization [WHO], 2023). The emergence and rapid spread of resistant pathogens over the past few decades have threatened many of the gains made in the control of infectious diseases and have contributed to increased morbidity and mortality, prolonged hospital stays, and rising healthcare costs worldwide (Murray et al., 2022). The WHO has also identified AMR as a growing threat to the prevention and treatment of an increasing number of infections, while increasing the risks associated with routine medical and surgical procedures (WHO, 2023).

AMR continues to increase at an alarming rate in both developed and developing countries. A landmark global study estimated that 4.95 million deaths were associated with bacterial AMR in 2019, of which approximately 1.27 million were directly attributable to resistant bacterial infections (Murray et al., 2022). The problem is particularly challenging in low- and middle-income countries (LMICs), where inadequate healthcare infrastructure, weak antimicrobial stewardship programmes, poor infection prevention practices, unrestricted access to antibiotics, and limited diagnostic capacity can contribute to the emergence and spread of resistant microorganisms (Laxminarayan et al., 2020). AMR is therefore not only a microbiological problem but also a major public health and socioeconomic challenge that requires coordinated efforts at local, national, and global levels.

Among the important groups of resistant pathogens identified by the WHO are carbapenem-resistant *Enterobacteriaceae* (CRE), which have been classified among the priority pathogens of major public health

concern (Tacconelli et al., 2018). *Enterobacteriaceae* are responsible for a wide range of healthcare-associated and community-acquired infections and include important pathogens such as *Escherichia coli*, *Klebsiella pneumoniae*, *Enterobacter* species, and *Citrobacter* species. The emergence of carbapenem resistance in these organisms is of particular clinical concern because carbapenems are often considered important last-line antibiotics for treating infections caused by multidrug-resistant Gram-negative bacteria (Nordmann et al., 2011). The increasing occurrence of carbapenem-resistant *Enterobacteriaceae* therefore threatens effective treatment and leaves clinicians with fewer therapeutic options, particularly when infections are caused by organisms resistant to multiple classes of antibiotics.

Among these pathogens, *Escherichia coli* holds particular clinical importance because of its high prevalence in both community and healthcare settings. It is a Gram-negative, facultatively anaerobic bacterium that commonly inhabits the gastrointestinal tract of humans and animals as part of the normal intestinal microbiota. Although most strains are harmless commensals, certain pathogenic strains possess virulence factors that enable them to cause a broad spectrum of infections. These include urinary tract infections, bloodstream infections, neonatal meningitis, surgical site infections, pneumonia, and intra-abdominal infections (Kaper et al., 2004). Globally, **Escherichia coli** remains the leading cause of urinary tract infections and is among the most frequently isolated bacterial pathogens in clinical microbiology laboratories (Pitout, 2012).

Its considerable genetic adaptability allows it to acquire and disseminate antimicrobial resistance determinants through horizontal gene transfer. This process can occur through mobile genetic elements such as plasmids, transposons, and integrons, enabling *E. coli* to accumulate multiple resistance genes and making it an important reservoir and contributor to the spread of antimicrobial resistance (Poirel et al., 2018).

The emergence of carbapenem-resistant *Escherichia coli* (CREC) has become a growing concern among clinicians and public health professionals because these organisms may produce carbapenemase enzymes that can hydrolyze a broad range of β -lactam antibiotics. Among the most clinically important carbapenemases are *Klebsiella pneumoniae* carbapenemase (KPC), New Delhi metallo- β -lactamase (NDM), Verona integron-encoded metallo- β -lactamase (VIM), oxacillinase-48 (OXA-48), and imipenemase (IMP). These enzymes have been increasingly reported in different parts of the world, contributing to the growing challenge of antimicrobial resistance (Nordmann et al., 2011; Logan & Weinstein, 2017).

The genes encoding these resistance mechanisms are often carried on highly transmissible plasmids and other mobile genetic elements, which facilitate their movement between bacterial species. This promotes the rapid dissemination of carbapenem resistance and contributes to the spread of multidrug-resistant organisms within healthcare facilities and the wider community (Poirel et al., 2018). As a result, infections caused by carbapenem-resistant *E. coli* can be difficult to treat and are associated with delays in initiating effective therapy, prolonged hospital stays, increased healthcare costs, treatment failure, and higher mortality rates (CDC, 2019).

Hospitals provide a favourable environment for the acquisition and transmission of carbapenem-resistant organisms due to the high concentration of vulnerable patients, extensive use of antibiotics, invasive medical procedures, prolonged hospital stays, and frequent contact among patients, healthcare workers, and medical equipment (WHO, 2017). Hospitalized patients are particularly at risk because many have underlying health conditions or weakened immune systems, while others may be of advanced age or require admission to intensive care units. The frequent use of invasive devices, including urinary and central venous catheters and mechanical ventilators, further increases the risk of acquiring resistant organisms. Together, these factors promote both colonization and infection and

create opportunities for the transmission of resistant bacteria within healthcare settings (Magiorakos et al., 2012).

Although the development of antimicrobial resistance is closely linked to the ability of bacteria to adapt and evolve, human behaviour remains a major factor driving its emergence and spread. Inappropriate antibiotic use, including self-medication, treatment without laboratory confirmation, unnecessary antibiotic prescriptions, poor adherence to prescribed treatment, sharing of antibiotics, and premature discontinuation of therapy, can create selective pressure that allows resistant bacteria to survive and multiply (WHO, 2023). Inadequate infection prevention and control practices, such as poor hand hygiene, overcrowding, improper environmental sanitation, and limited adherence to standard infection control measures, can further facilitate the transmission of resistant organisms in both healthcare facilities and the wider community (WHO, 2017).

Addressing antimicrobial resistance therefore requires more than improvements in laboratory diagnosis and the development of new antimicrobial agents. It also requires greater public awareness, responsible antibiotic use, and sustained improvements in health-seeking and infection prevention behaviours. Knowledge, attitude, and practice (KAP) studies are widely used as epidemiological tools for assessing how people understand and respond to different health challenges. The knowledge component examines an individual's awareness and understanding of relevant health information, while attitude focuses on their beliefs, perceptions, and willingness to adopt recommended preventive measures. Practice, on the other hand, assesses the actual behaviours and routine actions individuals undertake in relation to disease prevention and health promotion (Launiala, 2009).

Taken together, these three components provide a broader understanding of how knowledge and perceptions may influence health-related behaviours. This information can help policymakers and healthcare

providers identify important behavioural gaps and design interventions that address specific needs and improve health outcomes. In the context of antimicrobial resistance, KAP studies are particularly useful because individual and community behaviours can influence antibiotic use, infection prevention practices, and adherence to antimicrobial stewardship measures.

Studies conducted across Europe, Asia, Africa, and the Middle East have consistently reported gaps in public knowledge about antibiotics and antimicrobial resistance, even though attitudes toward infection prevention are generally positive (McCullough et al., 2016; Castro-Sánchez et al., 2016). A considerable number of people still believe that antibiotics can be used to treat viral infections, stop taking them when they begin to feel better, keep leftover antibiotics for future use, or obtain them without a prescription. Such practices promote the inappropriate use of antibiotics and create conditions that favour the emergence and spread of resistant bacterial strains. They also present a major challenge to ongoing efforts to control antimicrobial resistance at both national and global levels (WHO, 2023).

The problem is particularly pronounced in low- and middle-income countries such as Nigeria, where the burden of antimicrobial resistance continues to grow in the presence of weak regulatory systems, easy access to antibiotics without prescriptions, inadequate laboratory capacity, limited antimicrobial stewardship programmes, weak surveillance systems, and insufficient public health education (O'Neill, 2016). Economic hardship may also encourage self-medication and incomplete antibiotic treatment, while overcrowded healthcare facilities and inadequate infection prevention and control practices create additional opportunities for the transmission of resistant organisms. The combined effect of these challenges has contributed to the increasing occurrence and spread of multidrug-resistant Gram-negative bacteria in healthcare facilities across Nigeria.

Recent microbiological studies in Nigeria have reported an increasing occurrence of carbapenem-resistant *Enterobacteriaceae*, including carbapenem-resistant *Escherichia coli*, particularly in tertiary healthcare facilities. Molecular investigations have also identified clinically important carbapenemase genes, including **NDM**, **VIM**, **OXA-48**, and **KPC**, suggesting the continued spread of highly resistant bacterial strains within the country (Manenzhe et al., 2015; Nordmann et al., 2011).

Despite these important findings, relatively little attention has been given to patients' knowledge, attitudes, and practices regarding carbapenem-resistant *E. coli*. Most studies conducted in Nigeria have largely concentrated on antimicrobial susceptibility patterns, molecular characterization, and prevalence, with limited emphasis on the behavioural factors that may contribute to the acquisition, transmission, and persistence of these resistant organisms. This represents an important gap in understanding the human factors associated with the spread of carbapenem-resistant *E. coli* in healthcare settings.

Hospitalized patients are an important population for assessing knowledge, attitudes, and practices because they are often exposed to antibiotic treatment, healthcare-associated infections, invasive procedures, and frequent contact with healthcare personnel. Their understanding of antimicrobial resistance, perceptions of infection prevention measures, and adherence to recommended healthcare practices may influence both treatment outcomes and the effectiveness of infection prevention and control programmes.

Assessing these factors among hospitalized patients can therefore provide useful insight into behavioural practices that may contribute to the spread of resistant organisms. Improving patients' understanding of antimicrobial resistance may also promote more responsible antibiotic use, encourage adherence to infection prevention measures, and support the implementation of effective antimicrobial

stewardship programmes within healthcare institutions.

Furthermore, evidence from behavioural research indicates that educational interventions directed at hospitalized patients can improve adherence to hand hygiene, appropriate antibiotic use, and other recommended infection prevention measures (Castro-Sánchez et al., 2016). Assessing patients' knowledge, attitudes, and practices can therefore provide valuable baseline information for identifying behavioural gaps and developing targeted awareness campaigns and patient-centred educational programmes. Such information can also guide the development of hospital policies and infection control strategies aimed at reducing the transmission of carbapenem-resistant organisms and strengthening efforts to combat antimicrobial resistance.

Given the growing threat posed by carbapenem-resistant *Escherichia coli* and the limited information available on patients' awareness and preventive behaviours in Nigeria, assessing the knowledge, attitudes, and practices of hospitalized patients is increasingly important. Such assessments can provide useful evidence for developing targeted health education strategies, strengthening antimicrobial stewardship programmes, improving infection prevention and control practices, and supporting national efforts to address antimicrobial resistance. Ultimately, improving patients' understanding of antimicrobial resistance while encouraging positive attitudes and appropriate preventive practices may

help reduce the transmission of carbapenem-resistant *E. coli*, preserve the effectiveness of carbapenem antibiotics, and improve treatment outcomes in Nigerian healthcare settings.

MATERIALS AND METHODS

Study Area

This study was conducted at the Department of Medical Microbiology/Immunology, Federal Teaching Hospital (FTH), Gombe, and the Microbiology Teaching Laboratory, College of Medical Sciences, Gombe State University, both located in Gombe State, Nigeria.

Federal Teaching Hospital (FTH), Gombe, is located in Gombe metropolis, the capital of Gombe State, Nigeria. The city lies approximately between latitudes 10°N and 11°N of the Equator and falls within the Sudan Savannah ecological zone. According to the 2006 population census, Gombe State had a population of approximately 2.5 million people and covers an area of about 18,000 km² (Figure 1).

Federal Teaching Hospital Gombe was established in 1996 to serve as a referral tertiary healthcare institution for Gombe State and its surrounding communities. The hospital has a bed capacity of approximately 500 and typically records a bed occupancy rate of between 90% and 95%. As a major referral centre, the hospital provides a wide range of specialized healthcare services and receives patients from different parts of Gombe State and neighbouring areas.

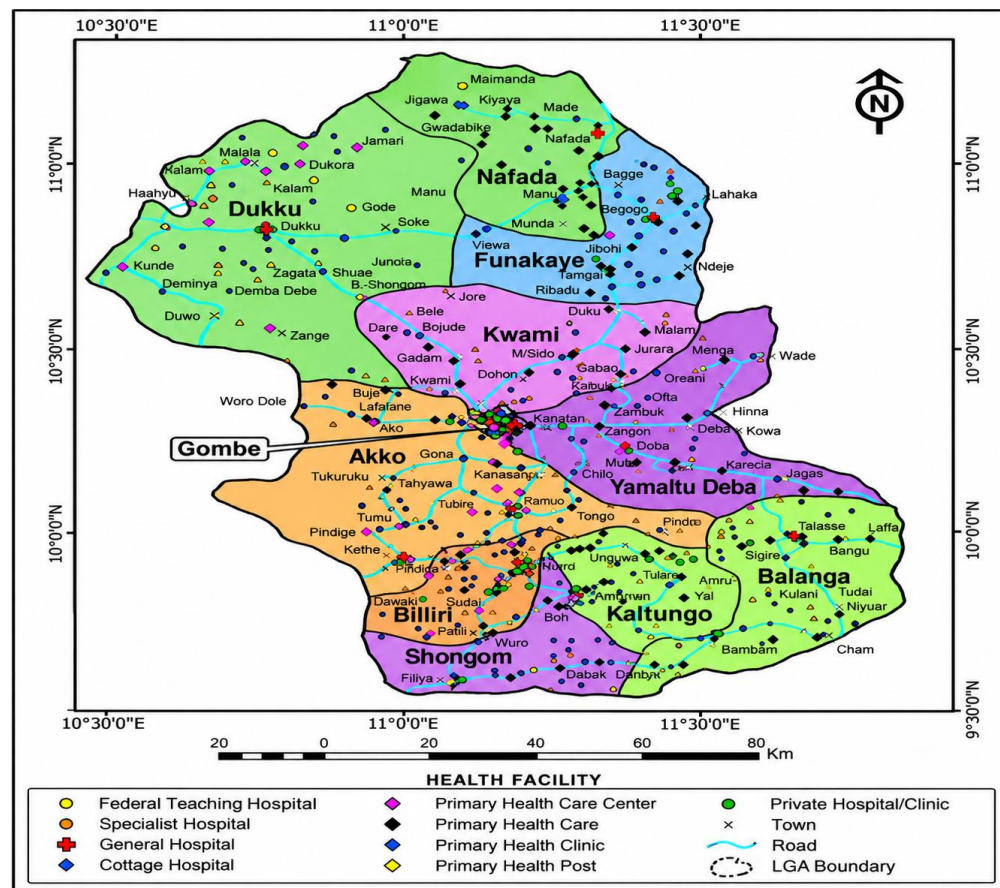


Figure 1: Map of Gombe state, showing the location of Federal Teaching Hospital Gombe (Oghenebrume, 2021).

Study Design

A hospital-based descriptive cross-sectional study design was employed to assess the knowledge, attitudes, and practices of hospitalized patients regarding carbapenem-resistant *Escherichia coli*.

Study Period

The study was conducted over a period of 11 months, from August 2024 to June 2025.

Ethical Approval

Ethical clearance and approval were obtained from the Ethics and Research Committee of the Federal Teaching Hospital, Gombe.

Data Collection

Data were collected using a structured, self-administered questionnaire developed for the study. The questions were carefully formulated to reflect the study objectives and to assess respondents' knowledge, attitudes, and practices regarding carbapenem-resistant *Escherichia coli*. The questionnaire consisted mainly of closed-ended questions, allowing respondents to provide their answers independently and making the responses easier to organize and analyse. The questionnaires were administered to eligible respondents, who completed them on their own.

A total of 384 patients participated in the study. The sample size was determined using Fisher's formula for estimating sample size, based on an assumed prevalence of 50%.

Data Analysis

The data collected were entered into a computer and analysed using the Statistical Package for the Social Sciences (SPSS), version 25 (IBM SPSS Statistics, Chicago, IL, USA). Descriptive statistics, including frequencies and percentages, were used to summarize the data. The chi-square test was used to assess the association between knowledge, attitudes, and practices (KAP) and the occurrence of carbapenem-resistant *E. coli*. Statistical significance was set at a p-value of less than 0.05. The results were presented using tables and charts.

Results and Discussions

The findings of this study showed that respondents generally had limited knowledge of microorganisms, microbial infections, antibiotic resistance, and infection prevention. Overall, only 19.2% of the respondents had correct knowledge of basic microbiological concepts. Specifically, 19.3% reported that they knew what microorganisms were, while 59.4% reported that they did not. Similarly, only 14.8% reported having knowledge of microbial infections, compared with 69.3% who reported that they had no knowledge of them. Knowledge of the ways in which microbial infections are spread was also low, as only 12.0% of respondents gave a positive response, while 72.1% gave a negative response (**Table 1**).

Table 1: Response of participant to CREC risk factors based on Knowledge Questions on Questionnaire

QUESTIONS (Appendix 1)	RESPONSE FREQUENCIES				Pearson chi-square	Significance (p-value)
	Yes	Not Sure	No	Total		
Q1. Do you know what Microorganisms are?	74(19.3%)	82(21.4%)	228(59.4%)	384(100%)	1.697	.428
Q2. Have you ever heard of Microbial infections?	57(14.8%)	61(15.9%)	266(69.3%)	384(100%)	1.297	.523
Q3. Do you know that Microbial infections are transmissible?	46(12.0%)	61(15.9%)	277(72.1%)	384(100%)	.563	.755
Q4. Have you heard about antibiotic resistance in Microorganisms?	44(11.5%)	68(17.7%)	272(70.8%)	384(100%)	2.455	.293
Q5. Do you know that washing your hands with soap and detergents helps in preventing the spread of microorganisms?	148(38.5%)	88(22.9%)	148(38.5%)	384(100%)	1.364	.506

KEY: p ≤0.05 = Statistically significant, p ≥0.05 = No statistical significance

The low level of knowledge observed in this study suggests that many hospital visitors may not have received adequate information about infectious diseases and how they are transmitted. This is a concern because adequate knowledge is an important starting point for adopting appropriate infection prevention practices. Individuals who have limited knowledge of microorganisms and antimicrobial resistance may be less likely to follow recommended infection prevention measures or understand the importance of responsible antibiotic use and antimicrobial stewardship (World Health Organization [WHO], 2023).

A similar gap was observed in respondents' awareness of the consequences of antibiotic resistance. Only 11.5% of the respondents reported having knowledge of antibiotic resistance in microorganisms, while more than 70% indicated that they were not aware of it. This finding is particularly relevant in many low- and middle-income countries, where health education programmes may be limited and access to reliable health information remains inadequate. These challenges can contribute to low public awareness and understanding of antimicrobial resistance (AMR) (WHO, 2023; Centers for Disease Control and Prevention [CDC], 2024). This finding is consistent with Ocan et al. (2015), who reported that patients in sub-Saharan Africa had limited knowledge of antibiotic resistance despite frequent use of antibiotics.

Although respondents demonstrated poor knowledge in most of the areas assessed, their awareness of handwashing was relatively better. About 38.5% agreed that washing hands with soap and detergent helps prevent the spread of microorganisms, while an equal proportion (38.5%) disagreed and 22.9% were uncertain. This suggests that, despite some level of awareness, there were still considerable gaps in understanding the role of hand hygiene in preventing healthcare-associated infections (HAIs). The finding may also indicate that previous hand hygiene messages

have reached some members of the population but have not resulted in a consistent understanding of their importance. Proper hand hygiene remains one of the most effective measures for reducing the transmission of multidrug-resistant organisms, including carbapenem-resistant *Escherichia coli* (CREC) (Allegranzi & Pittet, 2009; WHO, 2009).

The Pearson chi-square analysis showed that none of the knowledge variables was statistically significant ($p > 0.05$). This indicates that there was no statistically significant association between the respondents' knowledge responses and the variables assessed. The lack of statistical significance also suggests that the observed gaps in knowledge were generally widespread among the respondents rather than being concentrated in a particular subgroup.

These findings are consistent with the overall knowledge score reported in this study, in which only 19.2% of respondents demonstrated good knowledge of CREC risk factors. Limited public knowledge of antimicrobial resistance remains a major challenge to efforts to control its spread. Individuals who have little understanding of antimicrobial resistance may be more likely to use antibiotics inappropriately or engage in practices that encourage the development and spread of resistant organisms (WHO, 2023).

Table 2: Response of participant to CREC risk factors based on Attitude Questions on Questionnaire.

KEY: $p \leq 0.05$ = Statistically significant, $p \geq 0.05$ = No statistical significance.

QUESTIONS (Appendix 1)	RESPONSE FREQUENCIES				Pearson chi-square	Significance (p-value)
	Yes	Not Sure	No	Total		
Q1. Do you believe it is necessary to have a Doctor's prescription before taking Antibiotics??	283(73.7%)	60(15.6%)	41(10.7%)	384(100%)	3.350	.187
Q2. Do you think it is necessary to finish taking all the antibiotics as instructed by the doctor?	305(79.4%)	45(11.7%)	34(8.9%)	384(100%)	1.624	.444
Q3. Do you believe that raising public awareness on antibiotic resistance in microorganisms can help reduce the spread of Hospital-acquired infections?	310(80.7%)	39(10.2%)	35(9.1%)	384(100%)	3.397	.183
Q4. 9. Do you believe that washing your hands with soap/detergent will help in preventing Carbapenem-Resistant <i>E. coli</i> (CREC) spread?	313(81.5%)	53(13.8%)	18(4.7%)	384(100%)	1.079	.583
Q5. Do you think it is necessary to sanitize your hands during your stay at the hospital?	252(65.6%)	93(24.2%)	39(10.2%)	384(100%)	1.819	.403

The findings presented in **Table 2** showed that respondents generally had positive attitudes toward infection prevention and appropriate antibiotic use, despite their limited knowledge of antimicrobial resistance. A substantial proportion of the respondents (73.7%) believed that antibiotics should only be used following a doctor's prescription, while nearly 80% agreed that patients should complete the full course of prescribed antibiotics. These findings suggest that although respondents may have had limited understanding of the scientific aspects of antibiotics and antimicrobial resistance, many were aware of the importance of using antibiotics responsibly.

The positive attitudes observed in this study may partly reflect respondents' exposure to health education and counselling provided by healthcare workers during hospital visits. Previous studies have reported that patients may develop favourable attitudes toward appropriate antibiotic use through direct advice from physicians and pharmacists, even when their overall knowledge of antimicrobial resistance is limited (McCullough et al., 2016).

More than 80% of the respondents also believed that increasing public awareness about antibiotic resistance could help reduce hospital-acquired infections. This finding is encouraging, as public education and awareness are important components of efforts to promote appropriate antibiotic use and strengthen infection prevention practices (WHO, 2023). Similarly, 81.5% of the respondents believed that regular handwashing with soap or detergent could help reduce the spread of CREC. This positive perception is consistent with international infection prevention guidelines, which recognize hand hygiene as one of the most effective measures for reducing the transmission of multidrug-resistant organisms in healthcare settings (WHO, 2009; CDC, 2024).

In addition, approximately two-thirds of the respondents (65.6%) believed that hand sanitization

during hospital admission was necessary. Although this proportion was lower than that reported for regular handwashing, it still indicates a generally favourable attitude toward hand hygiene and infection prevention measures among the respondents.

Despite these encouraging findings, the chi-square analysis showed that none of the attitude variables was statistically significant ($p > 0.05$). This indicates that the observed differences in responses were not statistically significant and that the positive attitudes were generally consistent across the study population. Similar findings have been reported in previous studies, where positive attitudes toward responsible antibiotic use were observed even among individuals with limited knowledge of antimicrobial resistance. For example, Gebeyehu et al. (2015) reported that although patients had poor knowledge of antimicrobial resistance, most expressed positive attitudes toward physician-guided antibiotic use. Ocan et al. (2015) also reported similar findings among patients in sub-Saharan Africa.

Overall, the attitude score of 76.2% indicates that respondents had a generally favourable attitude toward infection prevention and responsible antibiotic use. This suggests that positive attitudes may exist even in the presence of limited factual knowledge about antimicrobial resistance and CREC.

Table 3: Response of participant to CREC risk factors based on Practice Questions on Questionnaire.

QUESTIONS (Appendix 1)	RESPONSE FREQUENCIES				Pearson chi-square	Significance (p-value)
	Yes	Not Sure	No	Total		
Q1. Do you routinely wash your hands with soap/detergents during your stay at the hospital?	267(69.5%)	94(24.5%)	23(6.0%)	384(100%)	7.291	.026
Q2. Do you take medications without a prescription from a medical doctor?	114(29.7%)	93(24.2%)	177(46.1%)	384(100%)	19.247	.000
Q3. Have you consistently completed the entire course of antibiotics as prescribed by your doctor?	257(67.0%)	72(18.8%)	55(14.3%)	384(100%)	33.391	.000
Q4. During your time in the hospital, do you utilize hand sanitizer?	125(32.6%)	84(21.9%)	175(45.6%)	384(100%)	2.013	.365
Q5. Before leaving the hospital environment, do you sanitize your hands?	95(24.7%)	94(24.5%)	195(50.8%)	384(100%)	6.338	.042

KEY: $p \leq 0.05$ = Statistically significant, $p \geq 0.05$ = No statistical significance.

As shown in **Table 3**, the respondents demonstrated mixed infection prevention practices. Although some of the reported practices were encouraging, others were less satisfactory and could increase the risk of transmission of carbapenem-resistant *Escherichia coli* (CREC).

Approximately 69.5% of the respondents reported routinely washing their hands with soap and detergent after using the toilet, suggesting that handwashing was a relatively common practice among the respondents. This finding is consistent with WHO recommendations, which emphasize regular hand hygiene as an important measure for preventing healthcare-associated infections and reducing the transmission of antimicrobial-resistant organisms (WHO, 2009). However, about one-quarter of the respondents were uncertain about their handwashing practice, while 6% reported that they did not routinely wash their hands, indicating that further improvement is still needed.

Self-medication with antibiotics was another important finding. About 29.7% of the respondents reported taking medication without a medical prescription, while 46.1% reported that they did not engage in self-medication. The Pearson chi-square analysis showed a statistically significant association between the variables assessed ($\chi^2 = 6.692$, $p = 0.035$). This finding suggests that self-medication was not uniformly reported among the respondents and remains an important concern in relation to inappropriate antibiotic use. The use of antibiotics without appropriate medical guidance can contribute to antibiotic misuse and create selective pressure that favours the emergence and spread of resistant organisms (WHO, 2023; CDC, 2024).

Similarly, completion of prescribed antibiotic treatment showed a statistically significant association ($\chi^2 = 9.051$, $p = 0.011$). Approximately 67% of the respondents reported completing their antibiotics as prescribed, while 14.3% reported that they did not. Completing antibiotic treatment as

prescribed is an important aspect of responsible antibiotic use, as poor adherence can result in inadequate treatment and may contribute to the persistence of resistant organisms. Inappropriate antibiotic use and poor adherence to treatment have been identified as important factors associated with antimicrobial resistance (Ventola, 2015).

In contrast, the use of hand sanitizers within the hospital was relatively low. Only 32.6% of respondents reported using hand sanitizer while in the hospital, whereas 45.6% reported that they did not. Similarly, only 24.7% reported sanitizing their hands before leaving the hospital environment, while 50.8% reported that they did not. Although neither of these variables was statistically significant ($p > 0.05$), the findings point to gaps in compliance with recommended hand hygiene practices. Factors such as limited access to hand sanitizer dispensers, inadequate patient education, and poor adherence to infection prevention measures may contribute to these practices.

The overall practice score of 47.9% further indicates that adherence to recommended infection prevention practices was moderate. The difference between the generally positive attitudes observed among respondents and their relatively weaker practices is noteworthy. Similar patterns have been reported in KAP studies, where having a positive attitude does not always translate into appropriate health-related behaviour. Actual practices may be influenced by access to resources, environmental conditions, healthcare infrastructure, socioeconomic factors, and the level of institutional support available (Ajzen, 1991; WHO, 2023).

Overall, the findings suggest that although respondents recognized the importance of infection prevention, important gaps remained in their day-to-day practices, particularly in relation to responsible antibiotic use and hand hygiene within the hospital environment. Strengthening patient education, promoting responsible antibiotic use, improving

antimicrobial stewardship programmes, and ensuring adequate infection prevention resources could help address these gaps and reduce the risk of

transmission of carbapenem-resistant *E. coli* in healthcare settings.

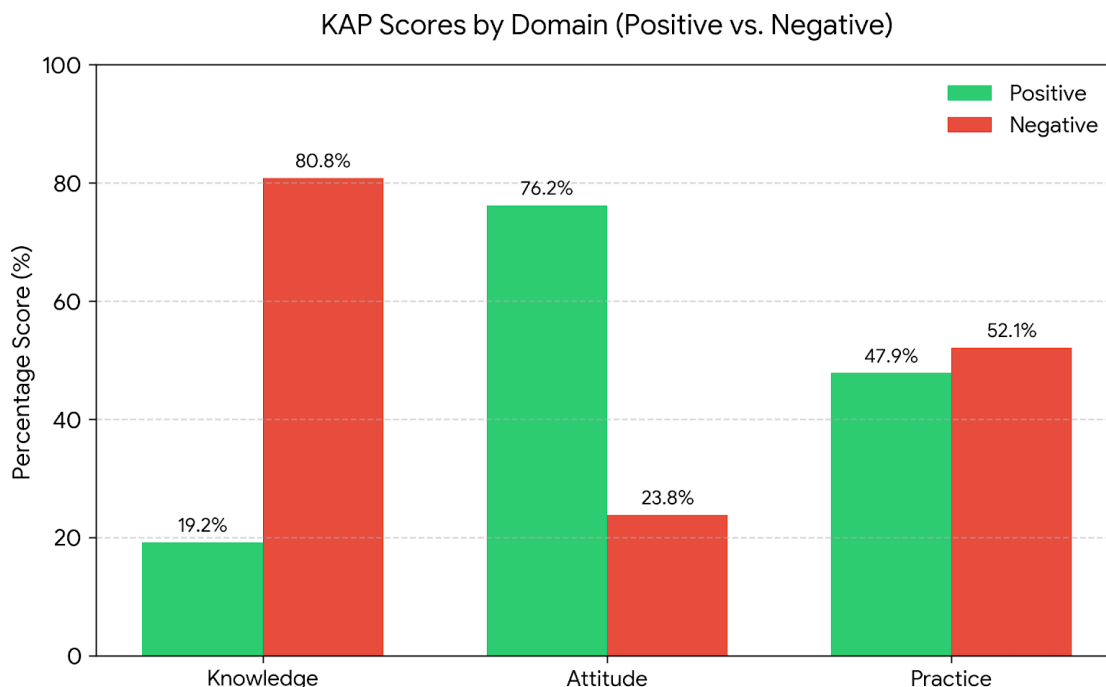


Figure 2: Percentage score based on Knowledge, Attitude and Practice of the respondent to CREC risk factors.

Figure 2 illustrates the percentage distribution of respondents' knowledge, attitudes, and practices regarding risk factors for carbapenem-resistant *Escherichia coli* (CREC), as presented in **Tables 1, 2, and 3**. The findings showed that only 19.2% of the respondents had satisfactory knowledge, while 80.8% had inadequate knowledge. In contrast, the attitude score was relatively high, with 76.2% of respondents demonstrating a positive attitude and 23.8% demonstrating a negative attitude. The practice score was lower, with 47.9% of respondents reporting satisfactory practices, while 52.1% reported inadequate practices.

Overall, the findings indicate a clear gap between knowledge, attitude, and practice among the respondents. The low knowledge score is consistent

with the findings presented in **Table 1**, where a large proportion of respondents reported limited knowledge of microorganisms, microbial infections, and antibiotic resistance. In contrast, the relatively high attitude score in **Table 2** suggests that many respondents had positive perceptions regarding responsible antibiotic use and infection prevention despite their limited factual knowledge. However, the practice score in **Table 3** indicates that these positive attitudes did not always translate into appropriate day-to-day practices, particularly with regard to hand hygiene and responsible antibiotic use.

A similar pattern was reported by Omololu-Aso et al. (2020), who found that although many patients had limited knowledge of antimicrobial resistance, they generally expressed positive attitudes toward

infection prevention and control measures. This difference between knowledge and attitude highlights the importance of providing appropriate health education that not only improves awareness but also encourages individuals to apply what they have learned in their daily practices. Improving patients' understanding of CREC and antimicrobial resistance, together with continued reinforcement of appropriate infection prevention measures, may help promote safer practices and reduce behaviours that contribute to the spread of resistant organisms.

CONCLUSION

This study showed that hospitalized patients at Federal Teaching Hospital Gombe had limited knowledge of carbapenem-resistant *Escherichia coli* (CREC), antimicrobial resistance, and infection prevention. Despite this, respondents generally had positive attitudes toward appropriate antibiotic use and infection prevention measures. The overall knowledge score was low (19.2%), while the attitude score was relatively high (76.2%) and the practice score was moderate (47.9%). These findings show a clear gap between what respondents knew, how they perceived infection prevention, and how they applied these measures in practice. The presence of practices such as self-medication and inadequate adherence to some infection prevention measures further highlights the need to improve patients' understanding of antimicrobial resistance and promote safer health practices.

The findings emphasize the importance of strengthening patient-focused health education, antimicrobial stewardship, and infection prevention and control measures in healthcare facilities. Patients should be provided with clear and consistent information on antimicrobial resistance, appropriate antibiotic use, hand hygiene, and adherence to prescribed treatment. Continuous health education during hospital admission, supported by regular public awareness activities and adequate infection prevention

resources, could help improve patients' knowledge and practices. These measures may contribute to reducing behaviours that encourage the spread of CREC and other multidrug-resistant organisms and support broader efforts to control antimicrobial resistance in Nigeria.

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