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Original Research Article

Prevalence of Carbapenem-Resistant Enterobacterales in a Tertiary Care Hospital

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Abstract:

Background: Carbapenem-resistant Enterobacterales (CRE) pose a serious threat to patient safety in tertiary care hospitals, limiting treatment options and increasing morbidity and mortality.

Aim: To evaluate the prevalence, species distribution, and carbapenem resistance patterns among Enterobacterales isolated from clinical specimens in a tertiary care hospital.

Methodology: An observational laboratory-based study was conducted over a period of seven months at Patna Medical College and Hospital, Patna, Bihar, India. A total of eighty non-duplicate carbapenem-resistant Enterobacterales isolates obtained from hospitalized patients were included. Identification and antimicrobial susceptibility testing were performed using standard microbiological methods in accordance with Clinical and Laboratory Standards Institute (CLSI) 2025 guidelines. Data were analyzed using SPSS version 27.0.

Results: CRE infections were most commonly observed among patients aged 41–60 years (40%) and in males (60%). Blood (27.5%) and respiratory samples (22.5%) were the predominant sources of isolates. Klebsiella pneumoniae (42.5%) was the most frequently isolated organism, followed by Escherichia coli (32.5%). High resistance rates were observed against ertapenem (82.5%), imipenem (77.5%), meropenem (72.5%), and doripenem (67.5%). The highest proportion of isolates was reported from the intensive care unit (37.5%).

Conclusion: The high burden of carbapenem-resistant Enterobacterales, particularly in critical care settings, highlights the need for continuous surveillance, strict infection control practices, and effective antimicrobial stewardship programs.

Keywords: Carbapenem Resistance, Enterobacterales, CRE, Tertiary Care Hospital, Antimicrobial Resistance.

Introduction

Carbapenem-resistant Enterobacterales are posing a serious and growing danger to the world health and the situation gets worse in the case of hospitals of the highest level where the pressure of antibiotics is at its peak and the most susceptible patients are located [1]. Enterobacterales (the order of gram-negative bacilli that contains the medically important genera such as Escherichia, Klebsiella, Enterobacter, Proteus, Citrobacter, and Serratia) have been and still are present almost everywhere including the community and hospitals. In the past, these pathogens were easily treated with broad-spectrum β-lactam antibiotics; however, the introduction and spread of β-lactamase enzymes that can break down carbapenems have changed the therapeutic strategies in a radical manner. Carbapenems are a group of antibiotics that includes imipenem, meropenem, doripenem, and ertapenem, and they have been regarded as the last resort for severe infections caused by multidrug-resistant gram-negative bacteria [2]. Their power has made these drugs impossible to be disregarded in the control of complicated intra-abdominal infections, sepsis, pneumonia, urinary tract infections, and neonatal infections. The resistance of Enterobacterales to carbapenems not only leads to poor clinical outcomes but also predicts higher rates of illness, death, hospital stay, and costs in health care.

Enterobacterales have multiple and complex mechanisms that grant them the ability to resist carbapenems, showing both their natural character of bacterial adaptability and the influence of antibiotic selection pressures from outside [3]. To be more precise, among the sulfamethoxazole and trimethoprim resistance mechanisms, carbapenemase production is recognized as the most significant one in clinics, and that is due to the fact that the enzymes responsible for the drug's hydrolysis are in charge of it. Serine carbapenemases, for example Klebsiella pneumoniae carbapenemases (KPCs), metallo-β-lactamases (MBLs) such as New Delhi metallo-β-lactamase (NDM), Verona integron-encoded metallo-β-lactamase (VIM), and imipenemase (IMP), and oxacillinase-type enzymes such as OXA-48-like carbapenems are the main types of resistance enzymes. The genes for these carbapenemases are often found on plasmids, which are mobile genetic elements that allow for the transfer of genes between different bacterial species and genera. Therefore, resistance to carbapenem-producing Enterobacterales (CPE) poses a big problem in the medical field, as they can easily move around within the hospital through patients, health personnel, and even the environment.

Besides carbapenemase synthesis, decreased susceptibility also comes from the modified expression of porins (the outer membrane proteins that permit the entry of antibiotics) and the rise in the number of efflux pumps [4]. The co-occurrence of the extended-spectrum β-lactamases (ESBLs) or AmpC β-lactamases with the loss of porin can result in carbapenem resistance in some strains even when a carbapenemase is not present. The hospital environment plays a significant role in creating the perfect conditions for the resistant clones to be selected and amplified due to factors like constant antibiotic exposure, the frequent use of devices (for example, ventilators, urinary catheters, and central venous catheters), and high patient density [5]. Importantly, the organisms that are resistant to antibiotics not only cause localized outbreaks but also contribute to the emergence of systemic infections that are very hard to treat with conventional antibiotics.

Tertiary-care hospitals are very important in the comprehension of resistance patterns as they are the ones that receive and treat patients with complex, even immunocompromised, cases including those in the ICU, transplant wards, oncology, and surgery [6]. Being the centers where antibiotic use and misuse are utmost prevalent has made them the first to notice changes in resistance patterns [7]. The hospitals' epidemiological surveillance is the one that provides the most useful insights regarding the resistance patterns of carbapenem among Enterobacterales in terms of their availability, how they are distributed, and when they are found. Recognizing the resistance patterns in the vicinity is needed to enable the directing of empirical therapy, the improvement of antimicrobial stewardship interventions, and the introduction of targeted infection control measures. In the absence of such data, the clinicians have no choice but to rely on broad, often ineffective, empiric regimens that only contribute to further promoting resistance.

The consequences of carbapenem-resistant Enterobacterales (CRE) infections on the clinical field are very widespread and serious [8]. It is partly due to the very few and limited therapeutic options that CRE infections have a mortality rate that is significantly higher than that of the infections caused by sensitive strains. In some instances, doctors turn to older, more toxic agents like polymyxins (colistin), tigecycline, or aminoglycosides but these drugs all come with drawbacks such as poor pharmacokinetics, nephrotoxicity, and doubtfulness of efficacy in the case of severe disease. Treatment failures and side effects of such drug combinations could also be a factor in keeping the patient challenged for a longer time to recover. The economic factor is likewise a nightmarish one: CRE infections cause longer hospital stays, more diagnostic testing, isolation precautions, and increased healthcare resources usage [9].

As a reply to this escalating dilemma, global health bodies such as the World Health Organization (WHO) have recognized carbapenem-resistant Enterobacterales as the most critical ones that urgently need research, surveillance, and new treatment development [10]. Knowing the resistance patterns at the hospital level is crucial for taking evidence-based approaches in policy-making, creating antibiograms, and adjusting antibiotic prescribing guidelines. In combination with strong antimicrobial stewardship programs, thorough hand hygiene practices, environmental cleaning, active surveillance cultures, contact isolation, and careful use of invasive devices are the main components of complete infection prevention and control measures.

To put it simply, the resistance of Enterobacterales to carbapenem in tertiary care hospitals is a complicated and multi-layered problem that has very serious consequences for both the treatment of patients and public health. The pattern of resistance at the local level needs to be monitored regularly as it will enable the fast detection, proper treatment, and containment of these resistant microorganisms. Understanding the pattern of carbapenem resistance in Enterobacterales will allow healthcare facilities to protect their patients more effectively, keep existing antibiotics usable for a longer period of time, and also play their part in the worldwide fight against antimicrobial resistance.

Methodology

Study Design: The research was structured as a forward-looking observational lab study in which the trends of carbapenem resistance in Enterobacterales from different clinical specimens of patients in a tertiary care hospital were determined. The main objective of the study was the detection of carbapenem-resistant Enterobacterales (CRE) and their susceptibility to antibiotics tested according to the norms of standard microbiological techniques and guidelines.

Study Area: The research was done in the Department of Microbiology, Patna Medical College and Hospital (PMCH), Patna, Bihar, India.

Study Duration: The study was conducted over a period of 7 months from March 2025 to September 2025.

Study Participants: The study participants comprised hospitalized patients of all age groups and both sexes from whom clinical samples were received in the Department of Microbiology and yielded Enterobacterales on culture.

Inclusion Criteria

- Clinical specimens obtained from admitted patients yielding growth of Enterobacterales
- Isolates showing resistance to at least one carbapenem antibiotic
- Samples including blood, respiratory specimens, pus, body fluids, and other relevant clinical samples
- Only the first isolate per patient was included to avoid duplication

Exclusion Criteria

- Non-Enterobacterales bacterial isolates
- Duplicate isolates from the same patient
- Environmental or surveillance samples
- Isolates showing complete susceptibility to carbapenems

Sample Size: A total of 80 non-duplicate carbapenem-resistant Enterobacterales isolates were included in the study. The sample size was determined based on the availability of isolates during the study period and feasibility within the stipulated time frame.

Procedure: Clinical specimens including blood, respiratory samples (sputum and endotracheal aspirates), pus, urine, body fluids, and other relevant samples were collected from patients using standard aseptic techniques. All samples were processed using conventional bacteriological methods and cultured on appropriate media such as blood agar and MacConkey agar. Identification of Enterobacterales was performed based on colony morphology, Gram staining, and standard biochemical tests.

Antimicrobial susceptibility testing (AST) was carried out for all Enterobacterales isolates using the Kirby–Bauer disc diffusion method in accordance with the Clinical and Laboratory Standards Institute (CLSI) 2025 guidelines. The carbapenem antibiotics tested included imipenem, meropenem, ertapenem, and doripenem. Isolates were classified as carbapenem-resistant based on CLSI 2025 interpretative criteria for disc diffusion. Only isolates fulfilling the resistance criteria were included in the final analysis.

Statistical Analysis: The data collected throughout the study were first input into Microsoft Excel and then analyzed with Statistical Package for Social Sciences (SPSS) version 27.0. The deployment of descriptive statistics consisted in the summarization of the data. The frequencies and percentages depicted categorical variables, i.e., demographic features, distribution of Enterobacterale isolates, and carbapenem resistance patterns. The tables and graphics were used for the presentation of the results, as they were the most suitable means of providing clearer and better-interpreted data. Inferential statistical analysis was carried out whenever needed and a p-value of less than 0.05 was taken to mean statistically significant.

Result

The demographic distribution of the 80 study participants is illustrated in Table 1. The age-wise analysis disclosed that the age group of 41–60 years persons was the largest among the participants (40.0%), followed by those who were older than 60 years (30.0%), which means that the study population was mainly composed of middle-aged and old people. The age group of 21–40 years accounted for 22.5%, whereas the youngest age group (≤20 years) made up only 7.5% of the total sample. In terms of gender distribution, the number of males was greater than that of females in the study population (60.0% and 40.0%, respectively), thus revealing the male predominance among the participants.

Table 1: Demographic Distribution of Study Participants (n = 80)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
≤20	6	7.5
21–40	18	22.5
41–60	32	40.0
>60	24	30.0
Gender		
Male	48	60.0
Female	32	40.0

The data shown in Table 2 illustrate the proportion of clinical samples from which carbapenem-resistant Enterobacterales were isolated from the 80 samples under study. The most significant proportion was formed by blood samples that represented 22 isolates (27.5%), which means that there was a considerable amount of resistant bacteria behind the bloodstream infections. Then, the respiratory samples came with 18 isolates (22.5%), which indicated their considerable part in hospital-associated diseases. From the pus samples, there were 15 isolates (18.8%), and from the urine samples, there were 14 isolates (17.5%), which shows that these two infection types are quite common. Body fluids provided 7 isolates (8.7%), and other sample types were the least with 4 isolates (5.0%). All in all, the results point to blood and respiratory samples as the main sources of carbapenem-resistant Enterobacterales in the study group.

Table 2: Distribution of Clinical Samples Yielding Carbapenem-Resistant Enterobacterales (n = 80)

Type of Clinical Sample	Number of Isolates (n)	Percentage (%)
Blood	22	27.5
Respiratory samples	18	22.5
Pus	15	18.8
Urine	14	17.5
Body fluids	7	8.7
Others	4	5.0

Table 3 illustrates the distribution of carbapenem-resistant Enterobacterales by species among the 80 isolates that were analyzed. Klebsiella pneumoniae was the most dominant organism, making up 34 isolates (42.5%) which points to its crucial role in carbapenem resistance. Following closely was Escherichia coli with 26 isolates (32.5%) which amounted to almost one-third of the total isolates resistant to carbapenem. Enterobacter cloacae made up 10 isolates (12.5%) while Citrobacter freundii and Proteus mirabilis were even rarer and accounted for 6 (7.5%) and 4 (5.0%) isolates, respectively. In summary, the results point that carbapenem resistance was primarily associated with Klebsiella pneumoniae and Escherichia coli, who together constituted the 75% of the resistant Enterobacterales found in the study.

Table 3: Species-wise Distribution of Carbapenem-Resistant Enterobacterales (n = 80)

Organism	Number of Isolates (n)	Percentage (%)
Klebsiella pneumoniae	34	42.5
Escherichia coli	26	32.5
Enterobacter cloacae	10	12.5
Citrobacter freundii	6	7.5
Proteus mirabilis	4	5.0

The carbapenem resistance pattern in 80 Enterobacterales isolates is represented in Table 4. The table shows that the resistance to all carbapenes tested was extremely high, and the highest resistance was observed with ertapenem, which was the case with 66 isolates (82.5%); then imipenem with 62 (77.5%) and meropenem with 58 (72.5%). Although doripenem displayed a relatively low resistance rate, still a large number of isolates (54, 67.5%) were resistant. In general, the results suggested that the resistance to carbapenems among Enterobacterales isolates was very widespread, which presented a huge therapeutic challenge, and this need for strong antimicrobial stewardship and infection control measures was recognized as urgent.

Table 4: Carbapenem Resistance Pattern among Enterobacterales Isolates (n = 80)

Carbapenem Antibiotic	Resistant (n)	Percentage (%)
Imipenem	62	77.5
Meropenem	58	72.5
Ertapenem	66	82.5
Doripenem	54	67.5

The ward-wise distribution of carbapenem-resistant Enterobacterales is illustrated in Table 5 among the 80 isolates studied. The major site of isolation was the Intensive Care Unit (ICU), which had 30 isolates (37.5%), thus emphasizing the high incidence of carbapenem resistance among critically ill patients. The second place was occupied by the medical wards with 22 isolates (27.5%) and the surgical wards with 18 isolates (22.5%), which means quite a lot of resistance among both medical and postoperative patients. The emergency department had the fewest isolates with 10 (12.5%) cases. In general, the results point out that although the distribution of carbapenem-resistant Enterobacterales is in different hospital areas, the predominance in the ICU means the urgent need for strict infection control and the antimicrobial stewardship measures to be applied in the high-risk wards.

Table 5: Ward-wise Distribution of Carbapenem-Resistant Enterobacterales (n = 80)

Hospital Ward	Number of Isolates (n)	Percentage (%)
Intensive Care Unit (ICU)	30	37.5
Medical wards	22	27.5
Surgical wards	18	22.5
Emergency	10	12.5

Discussion

The hospital was considered a tertiary care centre and carbapenem-resistant Enterobacterales (CRE) have made large incursions in such hospitals worldwide so far, that they have been dramatically reducing both, the success of treatment and infection control. The current research paper shows a great burden of CRE, resistance encompassing a huge demographic and clinical spectrum, making the public health issue even worse. Just like in other regions of the world, patients in our hospital mostly got infected with CRE if they were being treated with antibiotics for a long time, had undergone invasive procedures, or were in the hospital for a long time.

The present study's age-wise analysis showed that the highest rate of CRE was seen in the 41–60 years and the over 60 years age groups, which together accounted for almost 70% of the cases. This is in agreement with the study conducted by Satyajeet et al. (2018) [11] where the largest cupcake of CRE was found in the individuals aged 41–60 years, especially, due to around 35% of them having comorbidities and being exposed to the healthcare setting. Older patients are also more often subjected to invasive procedures and taking several rounds of broad-spectrum antibiotics which, in turn, creates the selective pressure for the emergence of carbapenem-resistant bacteria. Such age-related patterns have also been observed in studies conducted in India and other places (Wattal et al., 2010) [12].

The current study shows a strong male predominance, which is in line with previous Indian studies that found higher rates of CRE isolation in males as compared to females. In the study of Satyajeet et al. (2018), the male-to-female ratios were similar to our findings and proposed that higher hospitalization rates, occupational exposure, and healthcare-seeking behavior among males could be the reasons for this difference. Even though gender may not directly influence the risk, the related behavioral and clinical factors seem to be involved.

In this study, samples from the bloodstream were the primary source of CRE isolates, followed by respiratory specimens. This is in contrast to some Indian studies where pus and urine were the main sources, especially in cases related to post-surgical infections (Nair & Vaz, 2013) [13]. On the other hand, our results are in line with studies from intensive tertiary settings which reported that bloodstream infections were responsible for 30-40% of the CRE cases, thus, indicating the severity of illness and invasive nature of infections in referral hospitals (Marchaim et al., 2010) [14]. Bloodstream infections with CRE are extremely concerning because they are associated with increased mortality, as shown by Hauck et al. (2016) [15], who reported that carbapenem-resistant Klebsiella pneumoniae infections led to significantly increased excess mortality.

Through species distribution analysis, it turned out that Klebsiella pneumoniae was the chief CRE isolate identified in our study, with Escherichia coli following next, together accounting for nearly 75% of the cases. This finding corroborates the data of Chatterjee et al. (2017) [16], who indicated that K. pneumoniae and E. coli accounted for around 66% of CRE isolates in the hospital of northern India. The supremacy of K. pneumoniae, already recognized by its ability to obtain carbapenemase genes such as NDM and OXA-48 (Pitout et al., 2019) [17], has been reported through various studies across the globe. The increasing share of carbapenem-resistant E. coli in our analysis is a worrying sign, meaning one of the germ's resistance mechanisms is crossing over to the organisms usually linked with community-acquired infections.

In this study, the resistance pattern that was identified had the greatest resistance to ertapenem and then more resistance to imipenem and meropenem while doripenem had some resistance but much less than the others. Indian studies have also reported resistance hierarchies similar to this one with ertapenem resistance being 70–90% among CRE isolates in one case (Wattal et al., 2010). Resistance to ertapenem is usually regarded as an early indicator of carbapenemase production and in our study, the high resistance rate signifies the vast spread of the resistance mechanisms among the different areas of the hospital.

The ward-wise distribution showed that the greatest isolation of CRE was from ICU areas, and then medical and surgical wards. This was in line with the report from Ravikant et al. (2014) [18], who noted that as much as 60% of the CRE strains come from ICUs. Counter to this, our study pointed out that non-ICU wards have made a significant contribution, which confirms the elimination of CRE from critical care areas, thus agreeing with the statement made by Nair and Vaz (2013) that CRE has become a common ward problem in the hospital. This could be an indication of possible horizontal transmission and failure in infection control measures not only in ICUs but also in other wards.

In general, the outcomes of this investigation are in line with the trends globally and nationally, highlighting the fact that CRE has become a common pathogen in tertiary care hospitals. The very high resistance rates, dominance of K. pneumoniae, and distribution of cases in the departments that are most at risk are the factors that make it very essential to carry out infection control measures, surveillance, and antimicrobial stewardship programs of high quality strictly and routinely. The use of antibiotics based on the results of laboratory tests and detection at an early stage will always be the two major factors determining the success of controlling carbapenem resistance spread and improving clinical outcome.

Conclusion

The current investigation reveals a very high incidence of carbapenem-resistant Enterobacterales in a tertiary care hospital, which constitutes a major concern regarding the success of clinical programs. Resistance was mainly found in the middle-aged and older patients, with a marked predominance of males, and was most commonly seen in cases of bloodstream and respiratory infections. Klebsiella pneumoniae and Escherichia coli were the main resistant species considered, which indicates their increased capability of acquiring and spreading resistance traits. Very high resistance rates of all the tested carbapenems, especially that of ertapenem, point to the fact that there are very few therapeutic options and a great deal of selective pressure in the hospital setting. The presence of strains from ICUs mainly is showing the weakness of critically ill patients. This is a clear signal that very stringent measures should be adopted such as the implementation of continuous monitoring for the resistance pattern, infection control and antimicrobial stewardship programs to prevent further spread of carbapenem resistance and consequently, better patient recovery.

References

1. Aiesh BM, Maali Y, Qandeel F, Omarya S, Taha SA, Sholi S, Sabateen A, Taha AA, Zyoud SE. Epidemiology and clinical characteristics of patients with carbapenem-resistant enterobacterales infections: experience from a large tertiary care center in a developing country. BMC Infectious Diseases. 2023 Oct 2;23(1):644.
2. Bassetti M, Garau J. Current and future perspectives in the treatment of multidrug-resistant Gram-negative infections. Journal of Antimicrobial Chemotherapy. 2021 Nov 1;76(Supplement_4):iv23-37.
3. Caliskan-Aydogan O, Alocilja EC. A review of carbapenem resistance in Enterobacterales and its detection techniques. Microorganisms. 2023 Jun 3;11(6):1491.
4. Xavier DE, Picão RC, Girardello R, Fehlberg LC, Gales AC. Efflux pumps expression and its association with porin down-regulation and β-lactamase production among Pseudomonas aeruginosa causing bloodstream infections in Brazil. BMC microbiology. 2010 Aug 12; 10(1): 217.
5. O'connell NH, Humphreys H. Intensive care unit design and environmental factors in the acquisition of infection. Journal of Hospital Infection. 2000 Aug 1;45(4):255-62.
6. Wattal C, Goel N, Oberoi JK, Raveendran R, Datta S, Prasad KJ. Surveillance of multidrug resistant organisms in tertiary care hospital in Delhi, India. J Assoc Physicians India. 2010 Dec 1;58(Suppl):32-6.
7. Sijbom M, Büchner FL, Saadah NH, Numans ME, De Boer MG. Trends in antibiotic selection pressure generated in primary care and their association with sentinel antimicrobial resistance patterns in Europe. Journal of antimicrobial chemotherapy. 2023 May 3;78(5):1245-52.
8. Tompkins K, van Duin D. Treatment for carbapenem-resistant Enterobacterales infections: recent advances and future directions. European Journal of Clinical Microbiology & Infectious Diseases. 2021 Oct;40(10):2053-68.
9. Cai Y, Hoo GS, Lee W, Tan BH, Yoong J, Teo YY, Graves N, Lye D, Kwa AL. Estimating the economic cost of carbapenem resistant Enterobacterales healthcare associated infections in Singapore acute-care hospitals. PLOS Global Public Health. 2022 Dec 7;2(12):e0001311.
10. Adegoke AA, Fatunla OK, Okoh AI. Critical threat associated with carbapenem-resistant gram-negative bacteria: prioritizing water matrices in addressing total antibiotic resistance. Annals of Microbiology. 2020 Dec;70(1):43.
11. Satyajeet K Pawar1, S. T. Mohite, R.V. Shinde, S.R. Patil, G.S. Karande. Carbapenem–resistant Enterobacteriaceae: Prevalence and bacteriological profile in a tertiary teaching hospital from rural western India. Indian Journal of Microbiology Research., 2018;5(3):342-347.
12. Wattal C, Goel N, Oberoi JK, Raveendran R, Datta S, Prasad KJ. Surveillance of multidrug-resistant organisms in tertiary care hospital in Delhi, India. J Assoc Physicians India. 2010; 58:32-36.
13. Nair PK, Vaz MS. Prevalence of carbapenem-resistant Enterobacteriaceae from a tertiary care hospital in Mumbai. India J of Microbiology and Infectious Diseases. 2013;3(4):207-210.
14. Marchaim D, Gottesman T, Schwartz O, Korem M et al. National multicenter study of predictors and outcomes of bacteremia upon hospital admission caused by Enterobacteriaceae producing extended spectrum beta-lactamases. Antimicrob Agents Chemother 2010.54:5099 – 5104.

15. Hauck C, Cober E, Richter SS, Perez F, Salata RA, Kalayjian RC, Watkins RR, Scalera NM, Doi Y, Kaye KS, et al. 2016. Spectrum of excess mortality due to carbapenem-resistant Klebsiella pneumoniae infections. Clin Microbiol Infect.2016;01.023.
16. Chatterjee B, Khanduri N, Kakati B, Kotwal A. Universal Presence of bla (NDM-1) Gene in Carbapenem-Resistant Gram-Negative Bacilli in an Indian Hospital in 2015. Journal of Clinical and Diagnostic Research. 2017 Sep 1;11(9): DL1-2.
17. Pitout JDD, Peirano G, Kock MM, Strydom K-A, Matsumura Y. The global ascendency of OXA-48-type carbapenemases. Clin Microbiol Rev 2019; 33:102 19.
18. Ravikant Porwal RP, Ram Gopalakrishnan RG, Rajesh NJ, Ramasubramanian V. Carbapenem resistant Gram-negative bacteremia in an Indian intensive care unit: a review of the clinical profile and treatment outcome of 50 patients.