Section: Microbiology

Original Research Article

# PREVALENCE OF ESBL, AMPC AND CARBAPENEMASE PRODUCERS IN GRAM NEGATIVE ISOLATES IN MEDICAL ICUS

*Preeti Badhan[1], Deepinder Chhina[2], Rama Gupta[3], Rajesh Mahajan[4]*

[1]*Assistant Professor, Department of Microbiology, Institute Army College of Medical Sciences, New Delhi, India*
[2]*Professor, Department of Microbiology, Institute DMCH Ludhiana, Punjab, India*
[3]*Associate Professor, Department of Microbiology, DMCH, Ludhiana, Punjab, India*
[4]*Professor, Department of Medicine, DMCH, Ludhiana, Punjab, Punjab, India*

***Received*** *: 13/07/2026*
***Received in revised form*** *: 12/08/2026*
***Accepted*** *: 24/08/2026*

**Corresponding Author:**
**Dr. Preeti Badhan,**
Assistant Professor, Department of Microbiology, Institute Army College of Medical Sciences, New Delhi, India.
Email: preetibadhan@gmail.com

**DOI:** 10.70034/ijmedph.2026.4.342

**Source of Support:** Nil,
**Conflict of Interest:** None declared

**Int J Med Pub Health**
2026; 16 (4); 2271-2277

ABSTRACT

**Background:** The aim is to study the antimicrobial susceptibility pattern of the Gram negative isolates, to categorize them into MDR, XDR, PDR and to study the prevalence of ESBL, AmpC and Carbapenemase producers among the isolates.

**Materials and Methods:** All the samples from patients admitted in the ICUs (medical) of Dayanand Medical College and Hospital over a period of one year (April 2015- March 2016) were processed as per standard protocol. The Gram negative isolates obtained were subjected to AST. Isolates were further characterized as MDR, XDR and PDR and prevalence of ESBL/AmpC/Carbapenemase production among the isolates was observed.

**Results:** Out of 1968 samples received, 502 Gram negative isolates were obtained which were further characterized. The most common Gram negative isolate was Acinetobacter spp. followed by Klebsiella spp. Maximum resistance was seen against beta-lactams including penicillin, cephalosporin followed by beta lactam-lactamase inhibitors. 74.5% of the isolates were MDR and 57.1% were XDR. Majority of the Gram negative isolates were ESBL producers (37%), followed by Carbapenemase producers (16.9%) and AmpC producers (10.9%).

**Conclusion:** Antibiotic resistance is increasing so in order to prevent it beta-lactamases should be detected routinely as the failure to do so contribute to their uncontrolled spread and therapeutic failures. Hence, these should be reported to clinicians in time, so that inappropriate use of antibiotics can be stopped.

**Keywords:** Gram negative bacteria, beta-lactams, antibiotic resistance.

## INTRODUCTION

Gram negative bacterial infections have been responsible for a large number of mortality and morbidity and there has been a constant state of conflict with Gram negative bacteria since time immemorial for the diseases they produce. The rapid emergence of antibiotic resistance among these pathogens is becoming a serious threat to the management of infectious diseases.[1] These pathogens possess a wide range of mechanisms for drug resistance which is a matter of great concern. Further, reduction in development of new antibiotics poses a threat to the mankind. In order to deal with this menace antimicrobial susceptibility pattern need to be studied along with various drug resistance mechanisms so that proper control measures can be taken in order to prevent this spread. Gram negative bacteria which cause infections are widely categorized on the basis of growth on MacConkey and oxidase test, they include Enterobacteriaceae, Acinetobacter, Pseudomonas, Burkholderia and other organisms.[2]

Gram negative bacteria causes a wide range of infections like pneumonia, blood stream infections, wound or surgical site infections, meningitis etc. These infections can turn out to be life threatening if appropriate use of antibiotics is not done. But major concern is the fact that with the increase in cases of infections there has been marked increase in antibiotic drug resistance. All available drugs are becoming resistant and options available are less,

starting with the antibiotics like penicillin and cephalosporins which belong to beta-lactam antibiotics. increased mortality.

Antibiotic resistant bacteria are becoming an increasingly difficult problem in intensive care units (ICUs).[3] Between 3% and 12% of hospitalized patients in developed countries acquire a health care-associated infection (HAI).[4] This increase in the incidence of multidrug resistance has led to the study of various resistance mechanisms adopted by Gram negative bacteria which will help in dealing with this increasing menace. Beta-lactamases are a family of enzymes involved in bacterial resistance to beta-lactam antibiotics. Extended-spectrum β-lactamases (ESBLs) are a group of plasmid-mediated, diverse, complex and rapidly evolving enzymes. Derived from the name Temoniera, a patient from whom the strain was first isolated in Greece. β- lactamases, these enzymes share the ability to hydrolyze third-generation cephalosporins and aztreonam and yet are inhibited by clavulanic acid. Extended spectrum beta-lactamase are classified according to two schemes; the Ambler molecular classification and Bush Jacoby-Medierros functional classification. Ambler classification divides beta-lactamases into four major classes (A to D) on the basis of protein homology whereas Busch and Jacoby groups beta-lactamases according to their functional similarities. ESBLs are mostly class A enzymes, even though there are ESBLs belonging to other classes as well. AmpC beta-lactamases belong to class C or group I cephalosorinases which shows resistance to a variety of beta-lactam antibiotics including alphamethoxy beta-lactams such as cefoxitin, cephalosporins and aztreonam etc.For treatment of infections caused by AmpC beta-lactamases, cefepime and carbapenems can be used.[5]

Carbapenemases are the most versatile members of the beta-lactamases family with a breadth of spectrum unrivaled by other beta-lactam hydrolyzing enzymes.[6] Carbapenemases are divided into two groups according to their active sites: (i) serine carbapenemases belonging to the class A penicillinases and class D oxacillinases, which contain a serine in the active site and can be inactivated by β-lactamase inhibitors, including clavulanic acid and tazobactam; and (ii) metallo-β-lactamases belonging to the class B carbapenemases, which contain one or more zinc atoms at the active site, allowing them to hydrolyse the bicyclic β-lactam ring. These enzymes are inhibited by EDTA.

**Aims and Objectives:** To study the antimicrobial susceptibility pattern of the Gram negative isolates, to categorize them into MDR, XDR, PDR and to study the prevalence of ESBL, AmpC and Carbapenemase producers among the isolates.

## MATERIALS AND METHODS

This was a prospective study conducted from 1st April 2015 to 31st March 2016 in the Department of Microbiology, Dayanand Medical College and Hospital, Ludhiana.

**Source of data:** All the samples from patients admitted in Pulmonary ICU, Medical ICU, Stroke ICU were included in the study.

**Inclusion Criteria**

Samples like sputum, endotracheal secretions, bronchoalveolar lavage, urine, pus, blood and body fluids etc. received from adult patients admitted in various ICUs were included in the study.

**Transportation:** Samples were collected and transported immediately to microbiology laboratory.

**Processing:** All samples received were processed as per standard protocol.

**Direct Microscopy:** For respiratory samples and pus, smear was prepared directly from the sample and Gram's staining was done. For cerebrospinal fluid, ascitic fluid, pleural fluid etc. samples were first centrifuged in a sterile tube and then smear was made from the deposit.

**Culture:**[7]

Blood and body fluids were inoculated into blood culture bottles and loaded into the BacT/Alert or BACTEC blood culture system till they were flagged positive or maximum for a period of 7 days.

All other samples were inoculated onto Blood agar and MacConkey's agar plates and incubated at 37°C for 24 hours.

**Processing of positive bottles:** Smears were prepared from the positive culture bottles and Gram's staining of the smears was done. Simultaneously subcultures from positive bottles were done on blood agar and MacConkey's agar plates. The plates were incubated at 37°C for 18-24 hours. Growth was identified and further characterization was done.

**Identification:**[7]

Organisms were identified on the basis of colony characteristics, Gram's staining, motility and various biochemical reactions like catalase, oxidase, triple sugar iron, nitrate reduction test, urease test, phenylalanine deaminase test, indole test, methyl red, Voges Proskauer test, citrate utilization test, sugar fermentation test etc.

**Antimicrobial Susceptibility Testing:** Antimicrobial susceptibility testing was done by Kirby Bauer's disc diffusion method on Mueller Hinton Agar.

Antimicrobial susceptibility testing for Gram negative organisms was done for the following drugs: penicillin (ampicillin, piperacillin), cephalosporins (cefotaxime, ceftriaxone, ceftazidime, cefepime), beta-lactam+lactamase inhibitors (piperacillin-tazobactam, cefoperazone- sulbactam), aminoglycosides (amikacin, gentamicin), flouroquinolones (ciprofloxacin), folate pathway inhibitors (trimethoprim-sulfamethoxazole), carbapenems (ertapenem, meropenem, imipenem), polymixin B and tigecycline.

For Gram negative isolates obtained from urine samples, antimicrobial susceptibility testing was done for drugs like penicillin (ampicillin), cephalosporins (cefuroxime, cephalothin, cefixime,

cefotaxime, ceftriaxone, ceftazidime, cefepime) ,beta-lactam +lactamase inhibitors (piperacillin-tazobactam, amoxicillin-clavulinic acid, cefoperazone-salbactam), flouroquinolones (ofloxacin, norfloxacin), aminoglycosides (amikacin, gentamicin), folate pathway inhibitors (trimethoprim-sulfamethoxazole), carbapenems (imipenem, ertapenem), nitrofurantoin and polymixin B.[85]

For quality control E.coli ATCC 25922 and Pseudomonas aeruginosa ATCC 27853 were used as per CLSI guidelines.

**Interpretation:** After overnight incubation, sizes of zone of inhibition were measured and compared with Performance Standards of Antimicrobial Disc Susceptibility Test provided by CLSI.[84]

**Categorization into MDR, XDR, PDR [8]**

On the basis of antimicrobial susceptibility testing, Gram negative isolates were characterized into: Multi Drug Resistance (MDR): non susceptible to ≥1 agent in ≥3 antimicrobial categories.

Extensively Drug Resistance (XDR): non susceptible to ≥1 agent in all but ≤2 categories.

Pan Drug Resistance (PDR): non susceptible to all antimicrobial agents.

Screening Test for ESBL/ AMPC B-Lactamases/ Carbapenemase Production:[84]

Screening was done on Mueller Hinton agar (MHA) plate. The antimicrobial discs used for screening were ceftazidime/cefotaxime (for ESBL), cefoxitin (for AmpC) and ertapenem/imipenem/meropenem (for Carbapenemase).

| Enzyme | Antimicrobial disc | Zone Size Indicating Resistance (zone in mm) | | |
|---|---|---|---|---|
| ESBLs | Ceftazidime (30µg) | ≤22 | | |
| | Cefotaxime (30µg) | ≤27 | | |
| AmpC β-lactamases | Cefoxitin (30µg) | <18 | | |
| Carbapenemases | | S | I | R |
| For Enterobacteriaceae | Ertapenem (10µg) | ≥22 | 19-21 | ≤18 |
| | Imipenem (10µg) | ≥23 | 20-22 | ≤19 |
| | Meropenem (10µg) | ≥23 | 20-22 | ≤19 |
| Pseudomonas aeruginosa | Imipenem (10µg) | ≥19 | 16-18 | ≤15 |
| | Meropenem (10µg) | ≥19 | 16-18 | ≤15 |
| Acinetobacter spp | Imipenem (10µg) | ≥22 | 19-21 | ≤18 |
| | Meropenem (10µg) | ≥18 | 15-17 | ≤14 |

S=Sensitive; I=Intermediate; R=Resistant

Interpretation: If zone sizes were as mentioned above, the isolates were labelled as probable ESBL producer / probable AmpC and probable Carbapenemase producer and were subjected to confirmatory tests.

**Confirmatory test for ESBL production:**

**Double disc diffusion test [84]**

It was done using Mueller Hinton agar plates. The discs applied were of ceftazidime alone (30µg) and ceftazidime in combination with clavulanic acid (10µg). The discs were placed in such a way that the centre to centre distance between the discs was minimum 30mm.The MHA plates were incubated at 35°C for 24 hours as per CLSI guidelines.

Interpretation: An expansion of zone ≥5mm around the combination disc was considered as positive result.

**Confirmatory test for AMPC β-lactamase production:**

**AmpC disc test [85]**

A lawn culture of E. coli ATCC 25922 was prepared on a MHA plate and a cefoxitin disc (30µg) was placed on the plate. AmpC disc was moistened with sterile saline and inoculated with colonies of test organism. This disc was then placed beside the cefoxitin disc (almost touching) with inoculated side facing downwards. The MHA plate was incubated at 35°C for 24 hours.

Interpretation: If there was flattening or indentation of cefoxitin inhibition zone, it was considered as an AmpC producer.

**Confirmatory test for carbapenemases production:**

**Modified HODGE test: [84]**

**Procedure:** A 0.5 McFarland standard suspension of E.coli ATCC 25922 was prepared in saline, and was diluted 1:10 in saline. Lawn culture was done on a MHA plate as for the routine disc diffusion method. The plates were allowed to dry for 3-10 minutes. One meropenem (10µg) disc was placed at the centre of the plate. Then using a loop, colonies of the test organism were picked and inoculated in a straight line out from the edge of the disc. The streak was 20-25 mm in length. The plates were incubated at 35-37°C for 24 hours.

**Interpretation:** Enhanced growth around the test organism at the intersection of the streak and the zone of inhibition was considered positive for carbapenemases.

**Statistical Analysis:** Data obtained from the study was analyzed by using descriptive statistical methods. p value <0.05 was considered significant.

## RESULTS

A total of 1968 samples were received during the study period. Out of the total samples 619 (31.4%) were respiratory, 586 (29.8%) blood and 475 (24.1%) urine samples. Rest of the samples were body fluids 206 (10.5%) and pus 82 (4.2%). Out of all the 1968 samples, growth was obtained in 661 (33.6%) samples, whereas 1307 (66.4%) samples did not show

growth. Out of 661 positive samples, monomicrobial growth was obtained in 595 (90%) samples whereas 66 (10%) samples had polymicrobial growth. A total of 727 isolates were obtained including 502 Gram negative isolates, 122 Gram positive isolates and 103 Candida isolates The Gram negative isolates thus obtained were further studied.

Among the Gram negative isolates, Acinetobacter spp. (30.6%) was the most common followed by Klebsiella spp. (27.5%), E. coli (19.1%) and Pseudomonas aeruginosa (17.1%). In overall antimicrobial resistance profile of Gram negative isolates, higher resistance was seen towards nitrofurantoin (74%), cotrimoxazole (59%) and cephalosporins. Among aminoglycosides higher resistance was seen to gentamicin (52%) as compared to amikacin (47%). Least resistance was reported to carbapenems. Among carbapenems less antimicrobial resistance was seen to meropenem (32%) as compared to ertapenem (48%) and imipenem (41.6%).

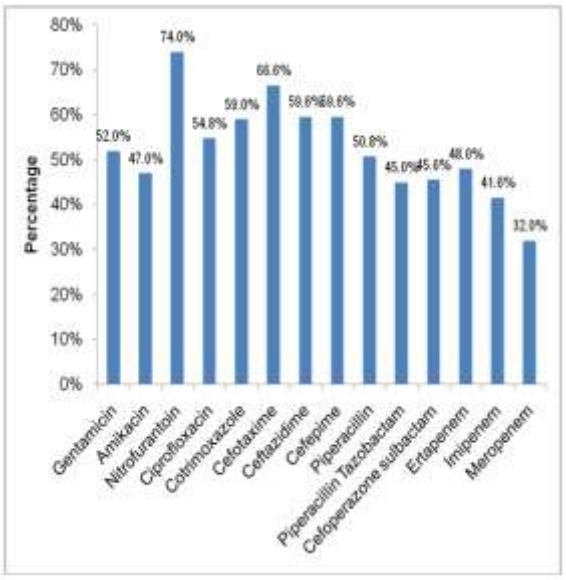


**Figure 1: Antimicrobial resistance profile of Gram negative isolates (n=502).**

**Table 1: Categorization of Gram negative isolates into MDR/ XDR/PDR**

| MDR/XDR/PDR | Number (%) |
|---|---|
| MDR | 374 (74.5) |
| XDR | 287 (57.1) |
| PDR | 0 (0) |

**Table 2: β-Lactamase production among Gram negative isolates**

| Resistance pattern | Probable No. (%) | Confirmed No. (%) |
|---|---|---|
| ESBL | 462 (92) | 186 (37) |
| AmpC | 459 (91.4) | 55 (10.9) |
| Carbapenemase | 415 (82.6) | 85 (16.9) |

Out of 502 Gram negative isolates 92%, 91.4% and 82.6% were labelled as probable ESBL, probable AmpC and probable Carbapenemases producers respectively which were further subjected to confirmatory tests and after which 37%, 10.9% and 16.9% were labeled as confirmed ESBL, confirmed AmpC and confirmed Carbapenemases producers respectively.

The ESBL + AmpC and AmpC + Carbapenemase co-production was detected in 4.5 % and 1.2% respectively, while ESBL + Carbapenemases co-production was seen in 2.2%. None of the isolates showed simultaneous production of ESBL +AmpC + Carbapenemase. Most common resistance pattern amongst co-producers was seen to be ESBL+AmpC (4.5%)

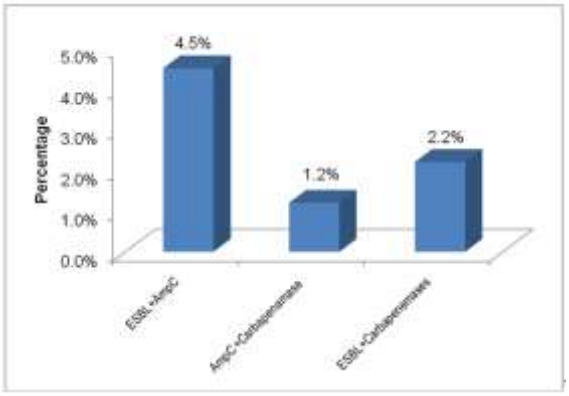


**Figure 2: β-Lactamase co-production among Gram negative isolates.**

**Table 3: Distribution of ESBL, AmpC, carbapenemase and their simultaneous production in Gram negative isolates.**

| Organism | ESBL alone | AmpC alone | Carbapenemase alone | ESBL+ AmpC | ESBL+ Carbapenemase | AmpC + Carbapenemase |
|---|---|---|---|---|---|---|
| Acinetobacter spp. (n=154) | 73 (47.4) | 22 (14.3) | 32 (20.8) | 6 (3.8) | 7 (4.5) | 3 (1.9) |
| Klebsiella spp. (n=138) | 50 (36.2) | 0 | 24 (17.4) | 9 (6.5) | 3 (2.2) | 2 (1.4) |
| E. coli (n=96) | 28 (29.2) | 4 (4.2) | 12 (12.6) | 7 (7.2) | 1 (1) | 1 (1) |
| P. aeruginosa (n=86) | 0 (0) | 0 (0) | 0 | 1 (1.2) | 0 (0) | 0 (0) |

The ESBL + AmpC co-production was detected maximum in E. coli (7.2%) followed by Klebsiella spp. (6.5%) whereas ESBL + Carbapenemase (4.5%) as well as AmpC + Carbapenemase (1.9%) co-production was seen maximum in Acinetobacter spp.

## DISCUSSION

An alarming rise in the antimicrobial drug resistance has become a common and a serious public health concern, with severe implications, especially in the intensive care units. Patients admitted to the intensive care units are susceptible to various infections because of certain factors like underlying disease, severity of illness, length of ICU stay, use of invasive devices and procedures, prolonged use of antibiotics and frequent contact with healthcare workers. In such patients infections caused by Gram negative organisms are responsible for the increased morbidity and mortality. A variety of β-lactamases which include ESBLs, AmpC β-lactamases and Carbapenemases have emerged as the most worrisome mechanism of antimicrobial drug resistance among the Gram negative bacteria, which pose a therapeutic challenge to the health care settings. The detection of drug resistance mechanism is of paramount importance as these strains are more prevalent than recognized and constitute a serious threat to currently available antibiotic.

In our study 502 Gram negative isolates were obtained from various samples received from patients admitted in medical intensive care units. Majority of Gram negative isolates were obtained from PCCU (27.1%) followed by Stroke ICU (26.1%) and MICU (22.4%). Maximum number of Gram negative isolates were obtained from respiratory (362) samples followed by urine (50), pus (36), blood (32) and body fluids (22). Acinetobacter spp.(154) was the most common isolate followed by Klebsiella spp.(138) Similar observations had also been reported in previous studies.[8-10] However in a study done by Madhumati et al. E. coli was the most common organism to be isolated.[11] Whereas Klebsiella pneumoniae was reported as the most common organism by Subhedar.[12] In another study from Iran similar findings were reported.[13]

Acinetobacter spp. (128) was the most common organism isolated from respiratory samples followed by Klebsiella spp. (100) In a similar study done in a tertiary care hospital in Punjab maximum number of Acinetobacter spp. were isolated from respiratory samples.[14] Pradhan et al. also reported that respiratory infections were most frequently associated with Acinetobacter, followed by Pseudomonas and Klebsiella.[15]

Klebsiella spp. and Acinetobacter spp. were the common isolate from blood samples. Similar finding were observed by Latif et al.[16] Some of the other studies also reported K. pneumoniae as the most common Gram negative bacteria isolated from septicemia patients.[17] However, Mehta et al has reported A.baumannii and Pseudomonas aeruginosa, as the commonest Gram negative isolates from blood samples.[18]

E. coli was observed as the most common isolate from pus and urine samples in the present study. Shinu et al in their study also observed E. coli as most common isolate, followed by K. pneumoniae, P. aeruginosa, P. mirabilis, M. morganii and C. freundii from pus and urine samples.[19]

In the present study Acinetobacter spp. was observed as the most common Gram negative isolate obtained from the samples received from patients admitted in PCCU and stroke ICU, However in MICU, most common organism isolated was Klebsiella spp. followed by Acinetobacter spp. The above findings were in concordance with other studies.[10,12]

The pattern of drug resistance keeps on changing frequently with use and withdrawl of drugs. So the resistance pattern of all organisms isolated from ICUs can serve as good guide for future empiric therapy.

In the present study, out of 502 Gram negative isolates 74.5% were multidrug resistant and 57.1% were extensively drug resistant. No pan-drug resistant isolate was found. Most of the multidrug resistant and extensively drug resistant Gram negative isolates were obtained from the samples received from patients admitted in PCCU followed by Stroke ICU and MICU. However a lower incidence of MDR and XDR has been reported by Basak et al, among the Gram negative isolates from intensive care units.[20]

The incidence of infections by resistant organisms due to production of various enzymes like extended-spectrum β- lactamases (ESBLs), AmpC β-lactamases and carbapenemases by Gram negative bacteria has increased in recent years. Prescription of antibiotics to control infection is the basic treatment offered, but drug resistance to multiple classes of drugs is becoming another huge problem associated with organisms isolated from the ICUs.

ESBL production was detected in 37% which was similar to a study conducted in intensive care units of Punjab.[21] Higher rates of ESBL production was reported in the some of the previous studies.[22-24] However, Laghawe et al, has reported 19.67% ESBL producers among the Gram negative isolates from ICU patients.[25]

In our study 55.8% of Acinetobacter baumannii and 44.9% of Klebsiella pneumoniae were ESBL producers. A higher prevalence of ESBL producers among Klebsiella spp. and Acinetobacter spp. has been reported by various studies from India.[26-27] It has been documented that the prevalence of the ESBLs among the clinical isolates varies from country to country and institution to institution within the same country.

AmpC production was seen in 10.9% of Gram negative isolates. However higher rates of AmpC production was observed in some of the studies done earlier.[24,28] A study done by Oberoi et al reported only 5.4% AmpC production in Gram negative isolates.[21] In our study AmpC production was high in Acinetobacter spp.20.1%) and E. coli (12.5%). In another studies conducted by Altun et al,[29] and Madhumati et al.[11] AmpC production was observed maximum in Acinetobacter baumanii in contrast to this Subha et al reported maximum AmpC production among Klebsiella (24.1%) and E.coli (37%).[30]

The only Beta-lactams which were active against ESBL and AmpC were Carbapenemase, however recently the resistance due to Carbapenemase production has been increasing. In our study, Carbapenemase production was seen in 16.9% of Gram negative isolates. Carbapenemase production was mostly observed among Acinetobacter spp.(29.2%) followed by Klebsiella spp.(17.4%) which was similar to the studies conducted by Kaur et al.[31] A study conducted in Turkey also reported high Carbapenemase production in Acinetobacter baumannii.[29]

The coexistence of different classes of β-lactamases in a single bacterial isolate may pose diagnostic and treatment challenges. In our study the ESBL/carbapenamase coproduction was observed in only 2.2 % of Gram negative isolates, whereas ESBL/ AmpC co production was detected in 4.5% isolates. AmpC/ carbapenemase, co production was seen in 1.2% isolate only. However, a study from North India has reported coproduction of ESBL/ MBL in 8.79% isolates, AmpC / MBL co production in 3.67% isolates and AmpC/ ESBL co production in 6.59% isolates.[21] Arora et al has reported the AmpC/MBL coproduction in 46.6% isolates and the ESBL/ AmpC co production in 3.3% isolates.[27]

The increase in the prevalence of the β-lactamase producing isolates are indicating the increasing trend of more and more isolates acquiring the resistance mechanisms and narrowing down the treatment options available for empiric therapy against infections. Therefore, early detection in routine laboratory, immediate infection control and antibiotic stewardship programs should be implemented in order to limit the spread of β-lactamase-producing organisms.

## CONCLUSION

Antimicrobial drug resistance is emerging worldwide as a major public health problem. The selective pressure of misuse and overuse of antibiotics in hospitals has resulted in the emergence and dissemination of resistant bacteria. In view of this emerging drug resistance the practice of routine testing along with conventional antibiogram would be useful which will help in the proper treatment of the patient and also prevent further development of drug resistance. The study emphasises the need for continuous surveillance in the ICUs to detect the resistant strains, strict guidelines for the antibiotic therapy and the implementation of infection control measures to reduce the increasing burden of antibiotic resistance.

## REFERENCES


1. Singh N, Pattanaik D, Neogi DK, Jena J, Mallick B. Prevalence of ESBL in Escherichia coli isolates among icu patients in a tertiary care hospital. J Clin Diagn Res. 2016;10(9):19–22.
2. Winn WC, Allen SD, Janda WM, Koneman EW, Procop Gary, Schreckenber PC, et al. Mycology. In: Konmann's atlas and Textbook of Diagnostic Microbiology 6th edition. Lippincott Wilkins. 2006.
3. Kaul S, Brahmadathan KN, Jagannati M, Sudarsanam TD, Pitchamuthu K, Abraham OC, et al. One year trends in the gram-negative bacterial antibiotic susceptibility patterns in a medical intensive care unit in South India. Indian J Med Microbiol. 2007;25(3):230.
4. World Health Organization. [Internet] Report on the burden of endemic health care-associated infection worldwide. 2011 [cited 2016 Nov.28]. Available from: http;//www.who.int/gpsc/country_work/burden_hcai/en/.
5. Thomson KS. Extended-spectrum-β-lactamase, AmpC, and carbapenemase issues. J Clin Microbiol. 2010;48(4): 1019-25.
6. Queenan AM, Bush K. Carbapenemases: the versatile β-lactamases. Clin Microbiol Rev. 2007;20(3):440-58.
7. Collee JG, Miles RS, Watt B. Tests for identification of bacteria. In: Collee JG, Fraser AG, Marmion BP, Simmons A. editors. Mackie and MacCarteny Practical Medical Microbiology. 14th edition. Churchill Livingstone, Edinburg 2006.
8. Ghanshani R, Gupta R, Gupta BS, Kalra S, Khedar RS, Sood S. Epidemiological study of prevalence, determinants, and outcomes of infections in medical ICU at a tertiary care hospital in India. Lung India. 2015;32(5):441-8.
9. Pradhan NP, Bhat SM, Ghadage DP. Nosocomial infections in the medical ICU: a retrospective study highlighting their prevalence, microbiological profile and impact on ICU stay and mortality. J Assoc Physicians India. 2014;62(10):18-21.
10. Luna CM, Rodriguez-Noriega E, Bavestrello L, Guzmán-Blanco M. Gram-Negative Infections in Adult Intensive Care Units of Latin America and the Caribbean. Crit Care Res Pract. 2014;2014:1-12.
11. Madhumati B, Rani L, Ranjini CY, Rajendran R. Prevalence of AmpC beta lactamases among gram negative bacterial isolates in a tertiary care hospital. Int J Curr Microbiol App Sci. 2015;4(9):219-27.
12. Subhedar V, Jain SK. Gram negative super bugs: a new generation of ICU infections, an emerging challenge for health care settings. Am J Microbiol Res. 2016;4(1):47-50.
13. Mohammadi-mehr M, Feizabadi MM Antimicrobial resistance pattern of Gram-negative bacilli isolated from patients at ICUs of Army hospitals in Iran. Iran J Microbiol. 2011;3(1):26-30.
14. Kaur A, Singh S, Singh A, Kuar N, Mahajan A. Isolation of acinetobacter baumannii and it's antimicrobial resistance pattern in an intensive care unit (ICU) of a tertiary care hospital. Int J Contemp Med Res.2016; 3(6):1794-6.
15. Pradhan NP, Bhat SM, Ghadage DP. Nosocomial infections in the medical ICU: a retrospective study highlighting their prevalence, microbiological profile and impact on ICU stay and mortality. J Assoc Physicians India. 2014;62(10):18-21.
16. Latif SH, Anwar MS, Ahmad IS. Bacterial pathogens responsible for blood stream infection (BSI) and pattern of drug resistance in a tertiary care hospital of Lahore. Biomedica. 2009;25(2):101-5.
17. Wisplinghoff H, Bischoff T, Tallent SM, Seifert H, Wenzel RP, Edmond MB. Nosocomial bloodstream infections in US hospitals: analysis of 24,179 cases from a prospective nationwide surveillance study. Clin Infect Dis. 2004;39(3):309-17.
18. Mehta M, Dutta P, Gupta V. Antimicrobial susceptibility pattern of blood isolates from a teaching hospital in North India. Japanese J Infect Dis. 2005;58(3):174.
19. Shinu P, Bareja R, Goyal M, Singh VA, Mehrishi P, Bansal M, et al. Extended-spectrum β-lactamase and AmpC β-lactamase production among gram-negative bacilli isolates obtained from urinary tract infections and wound infections. Indian J Clin Pract. 2014;24(11):1019-26.
20. Basak S, Singh P, Rajurkar M. Multidrug resistant and extensively drug resistant bacteria: A study. J Path. 2016;2016:1-5.
21. Oberoi L, Singh N, Sharma P, Aggarwal A. ESBL, MBL and Ampc β lactamases producing superbugs–Havoc in the

Intensive Care Units of Punjab India. J Clin Diagn Res. 2013;7(1):70-3.
22. Mathur P, Kapil A, Das B, Dhawan B. Prevalence of extended spectrum (beta) lactmase producing gram negative bacteria in a tertiary care hospital. Indian J Med Res. 2002;115:153-7.
23. Taneja J, Mishra B, Thakur A, Dogra V, Loomba P. Nosocomial blood-stream infections from extended-spectrum-beta-lactamase-producing Escherichia coli and Klebsiella pneumonia from GB Pant Hospital, New Delhi. J Infect Dev Ctries. 2010;4(08):517-20.
24. Bandekar N, Vinodkumar CS, Basavarajappa KG, Prabhakar PJ, Nagaraj P. Beta lactamases mediated resistance among gram negative bacilli in burn infections. Int J Biol Med J. 2011;2(3):766-70.
25. Laghawe A, Jaitly N, Thombare V. The simultaneous detection of the ESBL and the AmpC b-lactamases in gram negative bacilli. JCDR. 2012;6:660-3.
26. Goyal A, Prasad KN, Prasad A, Gupta S, Ghoshal U, Ayyagari A. Extended spectrum beta-lactamases in Escherichia coli & Klebsiella pneumoniae & associated risk factors. Indian J Med Res. 2009;129(6): 695-700.
27. Arora S, Sal M. AmpC [beta]-lactamase producing bacterial isolates from Kolkata hospital. Indian J Med Res. 2005;122(3):224-33.
28. Jain A, Roy I, Gupta MK, Kumar M, Agarwal SK. Prevalence of extended-spectrum -lactamase producing Gram-negative bacteria in septicaemic neonates in a tertiary care hospital. J Med Microbiol. 2003; 52:421-5.
29. Altun S, Tufan K, Yagci S, Onde U, Bulut C, Kinik S, et al. Extended spectrum beta-lactamases, AmpC and metallo beta-lactamases in emerging multi-drug resistant gram-negative bacteria in intensive care units. Open Access Scientific Reports. 2013;2(4):1-4.
30. Subha A, Devi VR, Ananthan S. AmpC [beta]-lactamase producing multidrug resistant strains of Klebsiella spp. & Escherichia coli isolated from children under five in Chennai. Indian J Med Res. 2003;117:13-8.
31. Kaur DC, Puri JS, Kulkarni SS, Jayawant A. Prevalence of AmpC β-lactamases in clinical isolates of E. Coli from a tertiary care rural hospital. Int J Pharm Pharmaceut Sci. 2015 19;7(6):165-8.