Epidemiological study of prevalence, determinants, and outcomes of infections in medical ICU at a tertiary care hospital in India

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ABSTRACT

Objectives: To determine the prevalence of infections, risk factors, and outcomes in a medical intensive care unit (ICU), we performed a hospital-based study. Materials and Methods: Consecutive patients were enrolled and details of risk factors and bacteriological data were obtained. Outcomes were death/transfer to palliative care or recovery. Statistical analyses were performed. Results: Four hundred and eighty-seven patients were admitted during the study period (age 55.6 ± 19 yr, men 68%). Diseases responsible were respiratory (37%), gastrointestinal/liver (22%), neurological (20%), renal (8%), and trauma (6%) related. Majority of admissions were direct (45%) or transfers from other hospitals (41%). Most important comorbidities were hypertension (41%), diabetes (31%), and chronic obstructive pulmonary disease (15%). Median APACHE-2 score was 13.0 (IQR 1–25). Antibiotics were administered in 98%. Bacteriological cultures were positive in 28% (n = 623). Respiratory infections were the most common (45.5%) followed by blood (23.3%) and urinary (16.1%). Gram-negative bacteria were common—Acinetobacter baumannii (20.9%), Klebsiella pneumoniae (19.7%), Escherichia coli (18.3%), and Pseudomonas aeruginosa (14.0%). There a high prevalence of resistance to common antibiotics. Patients with positive cultures were older, transferees (46 vs 37%, P = 0.07), with respiratory disease (48 vs. 33%, P = 0.003), with more than two comorbidities (33 vs 21%, P = 0.009), and higher APACHE-2 score (17.7 ± 8 vs. 13.3 ± 8, P = 0.07). Three hundred and fifty-two (72.3%) recovered, 68 (13.9%) died, and 67 (13.8%) were transferred to palliative care. Survival was associated with younger age, lower APACHE-2 score, negative cultures, and shorter duration in ICU (P < 0.05). Mortality was greater in patients with Acinetobacter (OR 2.36, 1.17–4.73), Klebsiella (OR 2.81, 1.33–5.92), Pseudomonas (OR 8.03, 2.83–22.76), or Enterobacter (OR 6.73, 1.29–35.12) infection. Conclusions: There is high prevalence of infections in patients in a medical ICU in India. Gram-negative bacteria are the most prevalent and resistance to antibiotics is high. Risk factors are age, hospital transfers, APACHE-2 score, and multiple comorbidities.

KEY WORDS: Acinetobacter baumannii, drug resistance, epidemiology, gram-negative infections, intensive care units, Klebsiella pneumoniae

INTRODUCTION

Infections are one of the most important causes of mortality in the world, more so in low and lower-middle income countries. The Global Burden of Diseases Study reported that although the mortality due to infections has decreased in the last 30 years, they still remain an important cause of death and persist as the most important cause of disability. Multiple factors are responsible. Rapid urbanization, aging of the population, and emerging viral and bacterial infections combined with the age-old upstream predisposing factors such as poverty, inequality, and illiteracy. In India, too, infections remain an important cause of morbidity and mortality. In the last century, the infectious diseases in India were mainly parasitic (malaria, leishmaniasis), viral (measles, poliomyelitis, and others) or bacterial and were mostly confined to children and young age groups. Bacterial infections were mild and easily treatable. Control
of viral and parasitic diseases has led to serious bacterial infections at all age groups, especially in middle-aged and the elderly patients.\textsuperscript{8,9}

Intensive care units (ICUs) are an important source of infections, especially bacterial.\textsuperscript{10-15} Studies in Europe and North America have reported that primary (at the time of admission) as well as secondary (nosocomial, ventilator-associated, device-related, and others) infections are common in ICUs. The European Studies on Prevalence of Infections in ICU (EPIC-1 and EPIC-2) reported a high prevalence of infections in a number of European countries.\textsuperscript{11,14} High prevalence of infections, especially nosocomial, has also been reported from medical ICUs in the United States.\textsuperscript{12} This is associated with higher age and APACHE-2 scores and high prevalence of comorbid conditions.\textsuperscript{14}

Infections are common in medical ICUs in India. Recent studies from different regions of the country have reported that both primary and secondary infections with gram-positive and gram-negative bacteria are widespread.\textsuperscript{15-28} Studies have also reported high prevalence of gram-negative bacterial infections such as with Acinetobacter baumannii, extended spectrum beta-lactamase, and metallo-beta-lactamase producing organisms (e.g., Escherichia coli, Klebsiella pneumoniae) and drug-resistant gram-negative organisms (methicillin-resistant Staphylococcus aureus, vancomycin-resistant Enterococci, and others).\textsuperscript{25-30} Recent reports of multidrug resistant gram-negative organisms in India have generated considerable scientific interest and public health response.\textsuperscript{28,33} To determine prevalence of infections, demographic and clinical risk factors, bacteriological profile, drug sensitivity patterns, outcomes, and determinants, we performed an epidemiological study in a large tertiary care hospital in Rajasthan. This is one of the larger studies of ICU infections in India with a focus on current patterns of bacteriological isolates at a tertiary care hospital in Rajasthan. There are no previous data available from this part of the country.

**MATERIALS AND METHODS**

The study was performed at a tertiary care hospital in Rajasthan, India. Protocol was approved by institutional ethics committee. Consent was obtained from the hospital administration and academic and research committee of the hospital for use of anonymized data of the patients. Individual patient consent was not obtained. Consecutive patients admitted to the medical ICU over 12 months from June 2011 to May 2012 were enrolled.

A case-report form was developed. We obtained the details of demographic characteristics (age, gender, education, residence), clinical history, primary diagnosis, comorbidities, bacteriological profile, outcomes, and risk factors. Infection was defined according to International Sepsis Forum. Patients who had undergone surgery in the 4 weeks preceding admission were considered surgical admissions. Trauma admissions were defined as ICU admissions directly related to, or occurring as a complication of, a traumatic event in the 30 days preceding admission. All other admissions were considered medical. The presence of the following comorbid conditions were noted: diabetes mellitus, hypertension, chronic obstructive pulmonary disease (COPD), chronic renal failure (need for chronic renal support or history of chronic renal insufficiency, with a serum creatinine level greater than 3.6 g/dL [300 μmol/L]), coronary heart disease, heart failure (New York Heart Association class III-IV), human immunodeficiency virus (HIV) infection (HIV-positive patients with clinical complications such as *Pneumocystis jirovecii pneumonia*, Kaposi sarcoma, lymphoma, tuberculosis, or toxoplasmosis), liver cirrhosis, cancers, and anemia.

In each patient admitted to the ICU, we obtained cultures of blood, urine, wound swab, sputum or endotracheal secretions, and other relevant specimens were collected using standard procedures at admission and when indicated. Identification of the causative organisms was performed by standard microbiological methods. Organism identification and susceptibility testing was performed on Microscan Autoscan-4 (Siemens Healthcare, Germany). The interpretation was based on the recommendations of Clinical Laboratory Standards Institute (CLSI).\textsuperscript{33} APACHE-2 score was calculated at admission for every patient.\textsuperscript{34} This score is a composite of multiple components and clinical variables. The four components are: age, major disease category (reason for ICU admission), acute (current) physiology, and prior site of health care (e.g., hospital floor, emergency room). The physiologic variables are the following vital sign and laboratory abnormalities: Pulse rate, mean blood pressure, temperature, respiratory rate, PaO\textsubscript{2}/P (A-a) O\textsubscript{2} hemocrit, white blood cell count, creatinine, urine output, blood urea nitrogen, serum sodium, albumin, bilirubin, glucose, acid-base status, and neurologic status.\textsuperscript{34} Outcomes included death, transfer to palliative care/other hospitals, and recovery.

**Statistical analysis**

All the case-report forms were computerized and entered into a database (Microsoft Excel) and analyses performed within this program. Descriptive statistics are reported. Numerical data are reported as mean ± 1 SD when variables were normally distributed and median and interquartile intervals (IQR) when skewed. Categorical variables are reported as percent. Intergroup comparisons were performed with χ\textsuperscript{2} test for categorical variables and unpaired t-test for numerical variables. Univariate odds ratios were calculated using χ\textsuperscript{2} test with death or transfer to palliative care as dependent variable and others as independent variables. P values less than 0.05 were considered significant.

**RESULTS**

Four hundred and eighty-seven patients were admitted during the study period from June 2011 to May 2012. Mean age of the subjects was 55.6 ± 19 years and there
were 331 men (68%) and 156 women (32%). Other demographic details are reported in Table 1. Majority of admissions were direct (n = 221, 47.0%) or transfers from other hospitals (n = 198, 40.6%), whereas 14.0% were from within hospital. Diseases responsible for admission were respiratory 37.2%, digestive/liver 22.4%, neurological 20.1%, renal 8.2%, trauma 5.9%, and others. Most important comorbidities were hypertension (41.5%), diabetes (31.0%), COPD (14.8%), and more than two comorbidities were seen in 32.0%. Mean APACHE-2 score at admission was 14.5 ± 8 (median 13, IQR 1–25).

Antibiotics were administered for suspected infections in 478 (98%). Bacteriological cultures were positive in 134 (28%). There were 623 bacteriological isolates from 134 patients [Table 2]. Gram-negative bacteria were the most common and included A. baumannii (20.9%), K. pneumoniae (19.7%), E. coli (18.3%), and Pseudomonas aeruginosa (14.0%). Gram-positive infections were S. aureus (8.2%) and Enterococcus species (5.0%). Respiratory tract isolates were the most common (44.5%) followed by blood stream (23.3%), urinary tract (16.1%), skin/soft tissue (9.1%), and intra-abdominal (4.3%).

Bacteriological profile in infections of respiratory tract, blood stream, urinary tract, and skin and soft tissue infections are shown in Figure 1. Gram-negative bacteria (Acinetobacter, Pseudomonas, and Klebsiella) were the most prevalent in respiratory tract, urinary tract, and blood stream infections and less common in skin and soft tissue. Bacteriological drug sensitivity patterns revealed high prevalence of resistance to commonly used as well as third- and fourth-generation antibiotics [Figure 2]. Less than 50% K. pneumoniae isolates were susceptible to carbapenems, whereas these drugs were effective in about 80% of E. coli isolates. Prevalence of extended spectrum beta-lactamase producing K. pneumoniae was in 18.9% and E. coli in 36.4%. However, the absolute number of enterococci grown was low (n = 31) resistance to vancomycin was observed in 30.9%.

Risk factors in subjects with or without bacteriological isolation are shown in Table 3. Significant proportions of patients with positive cultures were older (58.8 ± 18 vs 54.7 ± 20 yr), transferred from other hospitals (48% vs 39%, P = 0.07), had respiratory disease (48% vs 33%, P = 0.003) and higher APACHE-2 score (17.7 ± 8 vs 13.3 ± 8, P = 0.07) [Table 3].

Of the 487 study subjects, 353 (72.3%) recovered, 68 (13.9%) died, and 67 (13.8%) were transferred to palliative care or other hospitals. Thus, 27.7% patients died or were transferred to palliative care. Details of patient outcomes and the associated risk factors are shown in Table 4. Recovery was associated with direct admissions (48% vs 39%, OR 0.71, CI 0.47–1.06), lower APACHE-2 score (19.8 + 8.2), negative cultures (24% vs 36%, OR 0.58, CI 0.38–0.90) and shorter duration of ICU care (P < 0.01). There was a significant linear relationship of APACHE-2 score with adverse outcomes [Figure 3]. Greater mortality was observed in patients with A. baumannii [OR 2.36, CI 1.17–4.73], K. pneumoniae [OR 2.81, CI 1.33–5.92], P aeruginosa (OR 8.03, CI 2.83–22.76), and Enterobacter [OR 6.73, CI 1.29–35.12] infections [Table 5].

Table 1: Demographic and clinical characteristics of the patients

| Parameters                        | Patients N=487 |
|----------------------------------|---------------|
| Age (years)                      |               |
| <30                              | 79 (16.2)     |
| 31-59                            | 169 (34.7)    |
| ≥60                              | 239 (49.1)    |
| Gender                           |               |
| Male                             | 331 (67.9)    |
| Female                           | 156 (32.0)    |
| Residence status                 |               |
| Rural                            | 141 (28.9)    |
| Urban                            | 346 (71.7)    |
| Source of admission              |               |
| Direct admissions                | 221 (45.4)    |
| Transfer from other hospitals    | 198 (40.6)    |
| Transfer from hospital floor     | 68 (14.0)     |
| Socioeconomic status             |               |
| Professional/executive           | 85 (17.4)     |
| Business/administration           | 88 (18.1)     |
| Office clerk                     | 43 (8.8)      |
| Skilled labor, manual, nonmanual | 26 (5.3)      |
| Unemployed or retired or housewife| 243 (49.7)   |
| Smoking/alcohol abuse            |               |
| Smoking                          | 82 (16.8)     |
| Alcohol abuse                    | 45 (9.2)      |
| Both smoking and alcohol         | 26 (5.3)      |
| Reason for ICU admission         |               |
| Respiratory                      | 181 (37.2)    |
| Digestive/liver                  | 109 (22.4)    |
| Neurological                     | 98 (20.1)     |
| Renal                            | 40 (8.2)      |
| Trauma                           | 29 (5.9)      |
| Cardiovascular                   | 6 (1.2)       |
| Others                           | 24 (4.9)      |
| Comorbidities                    |               |
| Hypertension                     | 202 (41.5)    |
| Diabetes                         | 151 (31.0)    |
| COPD                             | 72 (14.8)     |
| Coronary heart disease           | 42 (8.6)      |
| Chronic renal failure            | 16 (3.3)      |
| Others                           | 10 (1.8)      |
| Number of comorbidities          |               |
| None                             | 207 (42.5)    |
| 1                                | 119 (24.5)    |
| 2                                | 113 (22.4)    |
| 3+                               | 48 (9.8)      |
| APACHE-2 score                   |               |
| <10                              | 160 (32.9)    |
| 10-19                            | 195 (40.0)    |
| ≥20                              | 132 (27.1)    |
| Mean±SD                          | 14.5±8.0      |
| Median (IQR)                     | 13.0 (11-25)  |

ICU: Intensive care unit, COPD: Chronic obstructive pulmonary disease, IQR: Interquartile range. Numbers in parentheses are percent unless specified.
DISCUSSION

This study shows that infections are common in a medical ICU at a tertiary care hospital in India. Infection was suspected at admission in 98% and in 28% patients, bacterial isolation with multiple organisms was observed. Risk factors for infections are transfer from other hospitals, greater age, multiple comorbidities and high APACHE-2 score. Gram-negative bacteria (Acinetobacter, Klebsiella, Escherichia, and Pseudomonas) are the most prevalent and resistance to common antibiotics is high. Mortality (and transfer to palliative care) is high and risk factors are greater APACHE-2 score and gram-negative infections.

Critical care illnesses are a major problem in health care worldwide. The Global Burden of Critical Care Diseases study reported a high prevalence and mortality from such diseases, especially in low and middle income countries. ICU mortality in unselected patients in high income countries varies from 8% to 18%. However, in patients with acute lung injury the mortality rates vary from 35% to 45% and in patients with septic shock it is as high as 50%-60%. Rates could be higher in low income countries and studies have reported mortality rates from 15% to 60% in various studies. Results of a surveillance study of International Nosocomial Infection Control Consortium (INICC) in 422 ICUs of 36 countries in Latin America, Asia, Africa, and Europe reported on prospective data from 313,008 patients were obtained and reported a high rate of mortality. MOSAICS Study in Asia prospectively studied 1285 patients admitted to medical ICUs in 16 Asian countries with severe sepsis and reported a mortality of 44.5%. The INDICAP Study reported a high mortality in medical ICUs in India with a greater mortality in patients with infections among 4000 patients admitted to medical ICUs in different parts of the country. The present study shows that in-hospital mortality was 14% and another 13% patients were transferred to palliative care or other hospitals, most of these patients were very sick and qualitative evaluation indicated that they were unlikely to survive. Transfer to palliative care of terminally ill patients has been reported from a study in Mumbai and elsewhere and is a common practice in medical ICUs, especially in low income countries. We do not have outcomes data on these subjects and this is a study limitation. High mortality in the present series of patients could be related to high prevalence of infections, especially drug-resistant gram-negative bacterial infections as well as an older population with high prevalence of comorbidities. A median APACHE-2 score of 14 indicates a high proportion of seriously ill patients.

Bacteriological profile in Indian ICUs differs from that in the west. West Gram-negative organisms are the most common. Our study is consistent with these observations.

Table 2: Bacteriological isolates in culture positive patients (623 isolates)

| Organisms              | Numbers (n=623) |
|------------------------|-----------------|
| Gram-negative bacteria |                 |
| Acinetobacter          | 130 (20.9)      |
| Klebsiella pneumoniae  | 123 (19.7)      |
| Escherichia coli       | 114 (18.3)      |
| Pseudomonas aeruginosa | 87 (14.0)       |
| Entero bacter spp.     | 21 (3.4)        |
| Gram-positive bacteria |                 |
| Staphylococcus aureus  | 51 (8.2)        |
| Enterococcus spp.      | 31 (5.0)        |
| Streptococcus spp.     | 17 (2.7)        |
| Fungi                  |                 |
| Candida albicans       | 26 (4.2)        |
| Non-Candida albicans   | 23 (3.7)        |

Numbers in parentheses are per cent

Figure 1: Bacteriological isolates at different sites in percent
In a study conducted at Chennai (South India), 25% patients had a positive bacteriological culture, which is similar to our results. A study on Acinetobacter infections in a tertiary level ICU in northern India showed that such infections are highly prevalent in the ICU, with patients being more susceptible to lung infection. Similarly, in a study on nosocomial pathogens in ICU in Pune (West India), major infections found in ICU were due to A. baumannii, E. coli, K. pneumoniae, P. aeruginosa, S. aureus, and Streptococcus spp. Acinetobacter isolates in multiple medical ICUs in India and elsewhere have displayed high level of antibiotic resistance similar to that observed in the present study. The pharmacological sensitivity profile for common bacteria such as Escherichia and Klebsiella reveal a disturbing trend. There is a high prevalence of resistance to common antibiotics and carbapenem resistance is observed in more than 50% of Klebsiella isolates and in about 20% of E. coli isolates. We have not performed detailed gene identification but such high incidence suggests the presence of NDM-1 gene, this is similar to reports from other Indian ICUs.

In the present study, more than 95% patients were prescribed antibiotics at admission. This is despite a well-established antibiotic policy and significant control on third- and fourth-generation antibiotic use in our hospital. Global Antibiotic Resistance Partnership (GARP) guidelines recommend a multipronged strategy in low and middle income countries to optimize the use of antibiotics and to reduce antibiotic resistance. The priority actions recommended are (1) national surveillance of antibiotic use and antibiotic resistance, (2) increasing use of diagnostic tests, especially microbiological tests, (3) strengthening of infection control committees in hospitals, and (4) restricting the use of antibiotics for nontherapeutic use such as in agriculture. However, most of the hospitals in our region lack these practices and empirical use of antibiotics is high in critically ill patients. High use of antibiotics in the present study is a reflection of clinical certainty regarding the presence of infections with limited evidence. Positive bacterial cultures in only a third of patients could be due to empirical antibiotic prescribing.

**Figure 2:** Pharmacological antibiotic sensitivity patterns for various bacteriological species. Numbers in each figure legend are bacterial isolates and numbers in bars indicate sensitivity %. Cefoperazone-S = cefoperazone sulbactam.
Table 3: Risk factors in subjects with or without bacteriological isolation

| Characteristic                      | Culture negative | Culture positive | P value |
|------------------------------------|------------------|------------------|---------|
| Age (years), mean±2SD              | 54.7±20.0        | 58.8±18.0        | 0.985   |
| Median (IQR)                       | 58 (28-88)       | 60 (35-85)       | -       |
| Men, n (%)                         | 239 (68)         | 93 (69)          | 0.719   |
| Source of admission                | Direct           | Other hospitals  |         |
|                                    | 176 (50)         | 133 (38)         | 0.001   |
|                                    | Other hospitals  | 65 (48)          | 0.071   |
|                                    | Hospital floor   | 44 (12)          | 0.129   |
| Reasons for admission              | Respiratory      | Digestive/liver |         |
|                                    | 117 (33)         | 90 (25)          | 0.006   |
|                                    | Neurological     | 74 (21)          | 0.449   |
|                                    | Renal            | 29 (8)           | 1.000   |
|                                    | Trauma           | 17 (5)           | 0.097   |
|                                    | Others           | 26 (7)           | 0.055   |
| Comorbidities, n (%)               | Hypertension     | Diabetes mellitus|         |
|                                    | 142 (40)         | 100 (28)         | 0.363   |
|                                    | Chronic obstructive | 48 (14)      | 0.239   |
|                                    | Pulmonary disease | Coronary heart disease | 28 (8) | 0.386   |
|                                    | Chronic renal failure | 13 (4)       | 0.407   |
|                                    | Others           | 8 (2.2)          | 0.225   |
| Number of comorbidities, n (%)     | None             | 163 (46)         | 0.007   |
|                                    | 1                | 75 (21)          | 0.009   |
|                                    | 2                | 82 (23)          | 1.000   |
|                                    | 3+               | 33 (10)          | 0.546   |
| APACHE II score                    | Mean±SD          | 13.3±7.9         | 1.000   |
|                                    | Median (IQR)     | 12 (1-24)        | 0.070   |

Numbers in parentheses are percent. IQR: Interquartile range, SD: Standard deviation, APACHE: Acute Physiology And Chronic Health Evaluation

CONCLUSION

This study shows a high prevalence of infections in patients hospitalized in a medical ICU. Risk factors for infections include transfer from other hospitals, age, greater APACHE-2 score, and multiple comorbidities. Gram-negative bacteria (Acinetobacter, Klebsiella, Escherichia, and Pseudomonas) are the most common, and resistance to usual antibiotics is common. Mortality (and transfer to palliative care) is high and risk factors include infections with gram-negative bacteria and greater APACHE-2 score. These findings indicate that antibiotic guidelines for empirical management of infections in India should include antibiotics for gram-negative bacteria (in contrast to western guidelines where gram-positive infections are more common). This also suggests that appropriate and effective microbiological surveillance practices, at potential reservoir sites, and standard epidemiological approaches for prevention should be used for these organisms. Greater prevalence of infections in patients transferred from other health care facilities suggests rampant nonjudicious use of antibiotics in primary and secondary care. National, regional, and hospital-specific antibiotic policies should be formulated to promote rational use of third- and fourth-generation antibiotics.
Table 4: Association between outcomes and risk factors

| Characteristic                              | Death/transfer to palliative care (N=135, 28%) | Recovery (N=352, 72%) | Odds ratio (95% confidence interval) | P value |
|--------------------------------------------|-----------------------------------------------|-----------------------|-------------------------------------|---------|
| Age, years, mean±SD                        | 55.7±18.3                                     | 55.6±20.0             | -                                   | 0.52    |
| Men, n (%)                                 | 91 (67)                                       | 240 (68)              | -                                   | 0.87    |
| Reason for ICU admission                   |                                               |                       |                                     |         |
| Respiratory                                | 55 (41)                                       | 126 (36)              | 1.23 (0.82-1.85)                    | 0.31    |
| Digestive/liver                            | 26 (19)                                       | 83 (23.5)             | 0.77 (0.47-1.27)                    | 0.30    |
| Neurological                               | 26 (19)                                       | 72 (20)               | 0.93 (0.56-1.53)                    | 0.77    |
| Renal                                      | 13 (10)                                       | 27 (8)                | 1.28 (0.64-2.57)                    | 0.49    |
| Trauma                                     | 9 (7)                                         | 20 (6)                | 1.19 (0.53-2.67)                    | 0.68    |
| Others                                     | 6 (1)                                         | 24 (6)                | 0.63 (0.25-1.59)                    | 0.02    |
| Source of admission                        |                                               |                       |                                     |         |
| Direct                                     | 53 (39)                                       | 168 (48)              | 0.71 (0.47-1.06)                    | 0.006   |
| Other hospital                             | 55 (44)                                       | 139 (39)              | 1.10 (0.74-1.66)                    | 0.61    |
| Hospital floor                             | 23 (17)                                       | 45 (13)               | 1.42 (0.81-2.42)                    | 0.05    |
| APACHE II score, mean±2SD                  |                                               |                       | 2.66 (0.65-10.78)                   | 0.18    |
| Comorbidities, n (%)                       |                                               |                       |                                     |         |
| Hypertension                               | 58 (43)                                       | 144 (41)              | 1.09 (0.73-1.63)                    | 0.68    |
| Diabetes mellitus                          | 35 (26)                                       | 116 (33)              | 0.71 (0.46-1.11)                    | 0.13    |
| COPD                                       | 24 (18)                                       | 48 (14)               | 1.37 (0.80-2.34)                    | 0.26    |
| Coronary heart disease                     | 13 (10)                                       | 29 (8)                | 1.19 (0.60-2.36)                    | 0.63    |
| Chronic renal failure                      | 7 (5)                                         | 9 (3)                 | 2.08 (0.76-5.71)                    | 0.16    |
| Cirrhosis                                  | 2 (1)                                         | 3 (1)                 | 1.75 (0.29-10.59)                   | 0.55    |
| Number of comorbidities, n (%)             |                                               |                       |                                     |         |
| None                                       | 52 (39)                                       | 155 (44)              | 0.79 (0.53-1.19)                    | 0.27    |
| 1                                          | 36 (27)                                       | 83 (24)               | 1.18 (0.75-1.86)                    | 0.48    |
| 2                                          | 35 (26)                                       | 78 (22)               | 1.23 (0.78-1.95)                    | 0.38    |
| 3+                                         | 12 (8)                                        | 36 (10)               | 0.86 (0.43-1.70)                    | 1.00    |
| APACHE II score, mean±2SD                  | 19.8±8.2                                      | 12.5±7.3              | -                                   | 1.00    |
| Culture positive                           | 48 (36)                                       | 86 (24)               | 1.71 (1.11-2.62)                    | 0.01    |

ICU: Intensive care unit, COPD: Chronic obstructive pulmonary disease

Table 5: Association of microbiologic isolates and outcomes

| Organisms                          | Death/transfer to palliative care N=135 | Recovery N=352 | Odds ratio (95% confidence intervals) |
|------------------------------------|----------------------------------------|----------------|---------------------------------------|
| **Gram-negative organisms**        |                                        |                |                                       |
| Acinetobacter baumannii            | 16 (19)                                | 2.36 (1.17-4.73)* |                                       |
| Klebsiella pneumoniae              | 15 (15)                                | 2.81 (1.33-5.92)** |                                       |
| Escherichia coli                   | 9 (24)                                 | 0.98 (0.44-1.6) |                                       |
| Pseudomonas aeruginosa             | 14 (5)                                 | 8.03 (2.83-22.76)** |                                       |
| Enterobacter spp.                  | 5 (2)                                  | 6.73 (1.29-35.12)* |                                       |
| **Gram-positive organisms**        |                                        |                |                                       |
| Staphylococcus aureus              | 10 (21)                                | 1.26 (0.58-2.75) |                                       |
| Enterococcus spp.                  | 5 (8)                                  | 1.65 (0.53-5.15) |                                       |
| Streptococcus spp.                 | 1 (3)                                  | 0.87 (0.09-8.42) |                                       |
| Fungi                              |                                        |                |                                       |
| Candida albicans                   | 9 (20)                                 | 1.18 (0.53-2.67) |                                       |
| Non-Candida albicans               | 15 (18)                                | 2.32 (1.13-4.75)* |                                       |

*P<0.05, **P<0.001

REFERENCES

1. Murray CJ, Lopez AD. Global mortality, disability and the contribution of risk factors: Global burden of disease study. Lancet 1997;349:1436-42.
2. Lozano R, Naghavi M, Foreman K, Lim S, Shibuya K, Aboyans V, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: A systematic analysis for the global burden of disease study 2010. Lancet 2012;380:2095-128.
3. Murray CJ, Vos T, Lozano R, Naghavi M, Flaxman A, Michaud C, et al. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: A systematic analysis for the Global Burden of Disease Study 2010. Lancet 2012;380:2197-223.
4. Leon D, Walt G. Poverty, inequality and health: An international perspective. Oxford: Oxford University Press; 2001. p. 217-56.
5. Marmot M. Health in an unequal world. Lancet 2006;368:2081-94.
6. Airoldi E, Getaz L, Stoll B, Chappuis F, Loutan L. Urbanization and infectious diseases in a globalised world. Lancet Infect Dis 2011;11:131-41.
7. Gupta R, Guin P. Communicable diseases in the South-East Asia Region of the World Health Organization: Towards a more effective response. Bull World Health Organ 2010;88:199-205.
8. John TJ, Dandona L, Sharma VP, Kakkar M. Continuing challenge of infectious diseases in India. Lancet 2011;377:252-69.
9. Ganguly NK, Arora NK, Chandy SJ, Fairozie MN, Gill JP, Gupta U, et al. Global Antibiotic Resistance Partnership (GARP-India Working Group. Rationalising antibiotic use to limit antibiotic resistance in India. Indian J Med Res 2011;134:281-94.
10. Spencer RC. Epidemiology of infection in ICUs. Intensive Care Med. 1994;20(Suppl 4):S2-6.
11. Vincent JL, Bihari DJ, Suter PM, Bruining HA, White J, Nicolas‑Chanoin MH, et al. The prevalence of nosocomial infection in intensive care units in Europe. Results of the European Prevalence of Infection in Intensive Care (EPIC) Study. EPIC International Advisory Committee. JAMA 1995;274:639-44.
12. Richards MJ, Edwards JR, Culver DH, Gaynes RP. Nosocomial infections in medical intensive care units in the United States. National nosocomial infections surveillance system. Crit Care Med 1999;27:887-92.
13. Hanberger H, Diekmann D, Fluit A, Jones R, Strelens M, Spencer R, et al. Surveillance of antibiotic resistance in European ICUs. J Hosp Infect 2001;48:161-76.
14. Vincent JL, Rello J, Marshall J, Silva E, Anzueto A, Martin CD, et al.; EPIC II Group of Investigators. International study of the prevalence and outcomes of infection in intensive care units. JAMA 2009;302:2323-9.
15. Merchant M, Karnad DR, Kanbur AA. Incidence of nosocomial pneumonia in a medical intensive care unit in general medical wards patients in a public hospital in Bombay, India. J Hosp Infect 1998;39:143-8.
16. Trivedi TH, Shejale SB, Yelekar ME. Nosocomial pneumonia in medical intensive care unit. J Assoc Physicians India 2000;48:1070-3.
18. Agarwal R, Gupta D, Ray P, Aggarwal AN, Jindal SK. Epidemiology, risk factors and outcome of nosocomial infections in a respiratory intensive care unit in north India. J Infect 2006;53:98-105.

19. Mehta AM, Rosenthal BD, Mehta Y, Chakravarthy M, Todi SK, Sen N, et al. Device-associated nosocomial infection rates in intensive care units of seven Indian cities. Findings of the International Nosocomial Infection Control Consortium (INICC). J Hosp Infect 2007;67:168-74.

20. Varaiya A, Kulkarni N, Kulkarni M, Bhalekar P, Dogra J. Incidence of metallo beta lactamase producing *Pseudomonas aeruginosa* in ICU patents. Indian J Med Res 2008;127:398-402.

21. Ghosh A, Karmakar PS, Pal J, Chakravorty N, Debnath NB, Mukherjee J. Bacterial incidence and antibiotic sensitivity pattern in moderate and severe infections in hospitalised patients. J Indian Med Assoc 2009;107:21-2, 24-5.

22. Azim A, Dwivedi M, Rao PB, Baronia AK, Singh RK, Prasad KN, et al. Epidemiology of bacterial colonisation at intensive care unit admission with emphasis on extended spectrum beta-lactamase- and metallo-beta-lactamase producing Gram-negative bacteria—an Indian experience. J Med Microbiol 2010;59:955-60.

23. 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(Suppl):32-6.

24. Patel AK, Patel KK, Patel KR, Shah S, Dileep P. Time trends in the epidemiology of multiresistant infections at a tertiary care center in West India over last 5 years. J Assoc Physicians India 2010;58(Suppl):37-40.

25. Gopalakrishnan R, Sureshkumar D. Changing trends in antimicrobial susceptibility and hospital acquired infections over an 8 year period in a tertiary care hospital in relation to introduction of an infection control programme. J Assoc Physicians India 2010;58(Suppl):25-31.

26. Nasa P, Juneja D, Singh O, Dang R, Singh A. An observational study on bloodstream extended-spectrum beta-lactamase infection in critical care unit: Incidence, risk factors and its impact on outcome. J Intern Med 2012;23:192-5.

27. Mathai AS, Oberoi A, Madhavan S, Kaur P. Acinetobacter infections in a tertiary level intensive care unit in northern India: Epidemiology, clinical profiles and outcomes. J Infect Public Health 2012;5:145-52.

28. Indian Network for Surveillance of Antimicrobial Resistance (INSAR) Group, India. Methicillin resistant *Staphylococcus aureus* (MRSA) in India: Prevalence and susceptibility pattern. Indian J Med Res 2013;137:363-9.

29. Kumarasamy KK, Toleman MA, Walsh TR, Bagaria J, Butt F, Balakrishnan R, et al. Emergence of a new antibiotic resistance mechanism in India, Pakistan and in the UK: A molecular, biological and epidemiological study. Lancet Infect Dis 2010;10:597-602.

30. Deshpande P, Rodrigues C, Shetty A, Kapadia F, Hegde A, Soman R. New Delhi metallo-beta lactamase (NDM-1) in Enterobacteriaceae: Treatment options with carbapenem compromised. J Assoc Physicians India 2010;58:147-9.

31. Ghafur A. Can India be the wing commander in the global fight against antimicrobial resistance? J Assoc Physicians India 2012;60:42-3.

32. Ghafur A, Mathai D, Murugananthan A, Juyalal JA, Kant R, Chaudhary D, et al. The Chennai declaration: A roadmap to tackle the challenge of antimicrobial resistance. Indian J Cancer 2013;50:71-3.

33. Clinical and Laboratory Standards Institute. Performance Standards for Antimicrobial Susceptibility Testing. Twenty First Informational Supplement: M100-S21. Wayne, PA, USA: Clinical and Laboratory Standards Institute; 2011. p. 34-124.

34. Beck DH, Taylor BL, Millar B, Smith GB. Prediction of outcome from intensive care: A prospective cohort study comparing Acute Physiology and Chronic Health Evaluation II and III prognostic systems in a United Kingdom intensive care unit. Crit Care Med 1997;25:9-15.

35. Adhikari NK, Fowler RA, Bhagwanjee S, Rubenfeld GD. Critical care and the global burden of critical illness in adults. Lancet 2010;376:1339-46.

36. Vincent JL, Singer M. Critical care: Advances and perspectives. Lancet 2010;376:1354-61.

37. Rosenthal BD, Bijie H, Maki DG, Mehta Y, Apisarnthanarak A, Medeiros EA, et al. INICC Members. International Nosocomial Infection Control Coalition (INICC) report, data summary of 36 countries for 2004-2009. Am J Infect Control 2012;40:396-407.

38. Phua J, Koh Y, Du B, Tang YQ, Divatia JV, Tan CC, et al.; MOSAICS Study Group. Management of severe sepsis in patients admitted to Asian intensive care units: Prospective cohort study. BMJ 2011;342:d3245.

39. Debroy S. 1 in 4 ICU patient gets sepsis, 1 in 2 dies. INDICAP study. Available from: http://articles.timesofindia.indiatimes.com/2012-09-12/india/33788306_1_sepsis ICU-patients-hand-hygiene. [Last accessed on 2013 Aug 01].

40. Kapadia F, Singh M, Divatia J, Vaidyanathan P, Udwadia FE, Raisinghani SJ, et al. Limitation and withdrawal of intensive therapy at the end of life: Practices in intensive care units in Mumbai, India. Crit Care Med 2005;33:1272-5.

41. Curtis R, Vincent JL. Ethics and end-of-life care for adults in the intensive care unit. Lancet 2010;376:1346-53.

42. Ravi KP, Suresh D, Sankalp P, Ramesh V, Ramasubraman V, Ramakrishna N. Epidemiology of intensive care unit infections and impact of infectious disease consultants in managing resistant infections. Am J Infect Control Dis 2013;9:30-3.

43. Patwardhan RB, Dhakephalkar PK, Nhaphidkar KB, Chopade BA. A study on nosocomial pathogens in ICU with special reference to multiresistant *Acinetobacter baumannii* harbouring multiple plasmids. Indian J Med Res 2008;128:178-87.

44. Okeke IN, Laxminarayan R, Bhutta ZA, Duse AG, Jenkins P, O'Brien TF, et al. Antimicrobial resistance in developing countries. Part I: Recent trends and current status. Lancet Infect Dis 2005;5:481-93.

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