

# Outcomes of Healthcare-Associated Infections in Respiratory Intensive Care Unit

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## ABSTRACT

**Background:** Healthcare-associated infections (HAIs) are the major cause of morbidity and mortality. This study aimed to investigate the prevalence, microbiological profile, resistance patterns, risk factors, and outcomes of HAIs in a respiratory ICU (RICU) of a tertiary care hospital in Nepal.

**Methods:** A prospective observational study was conducted in RICU. HAIs were diagnosed according to the CDC criteria. Descriptive statistics were reported as mean (SD) and frequencies. Unpaired t-tests, chi-square tests were used for comparisons, and multivariable logistic regression was used to assess the risk factors.

**Results:** Among 121 ICU admissions, 42 patients developed 50 episodes of HAI, yielding a prevalence of 34.7%. Ventilator-associated pneumonia was the most common HAIs. The most frequently isolated organisms were *Acinetobacter baumannii* in 42.0% and *Klebsiella pneumoniae* in 18.0%. Both were resistance to Ceftriaxone. Resistance to Piperacillin–tazobactam were 85.8% and 77.8% and to carbapenems were 92% and 90% respectively. Tigecycline resistance was seen in 20% of *Acinetobacter* isolates and none of the *Klebsiella* isolates. Sensitivity to Polymyxin B was 100%. Mechanical ventilation, urinary catheters and history of prior hospitalization were the strongest predictors of HAI. Patients who developed HAI had a longer ICU stay (9.5 vs. 5.2 days,  $p=0.001$ ) and higher mortality (28.6% vs. 13.9%,  $p=0.04$ ).

**Conclusions:** HAIs, particularly VAP caused by MDR organisms, were common in our ICU and there was a high resistance to beta lactams and carbapenem antibiotics. Low resistance to tigecycline and polymyxin B warrants careful stewardship.

**Keywords:** Healthcare-associated infections; multidrug resistance; respiratory ICU.

## INTRODUCTION

Healthcare-associated infections (HAIs) are infections acquired during healthcare delivery, not present or incubating at admission.<sup>1</sup> HAIs in ICU patients account for over 20% of hospital infections increasing morbidity, mortality and health care cost particularly in resource limited settings.<sup>2-4</sup> Common infections include catheter-related bloodstream infections (CRBSIs), ventilator-associated pneumonia (VAP), catheter-associated urinary tract infections (CAUTIs), ventilator-associated tracheobronchitis (VAT), and *Clostridium difficile*-associated diarrhoea (CDAD).<sup>5</sup> The risk factors are invasive procedures, immunosuppression, prolonged hospital stays, and prior antibiotic exposure.<sup>4,6</sup>

Globally, HAI prevalence is higher in developing countries compared to high-income settings (3.2-5.9%).<sup>4,7</sup> Prior studies from Nepal have reported a prevalence of

5-11.25%, with a higher incidence of multidrug-resistant (MDR) Gram-negative pathogens like *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Pseudomonas aeruginosa* predominant.<sup>7,8</sup> ICUs in developing countries are limited by available resources, inconsistent infection control practices, and lack of local data.<sup>9</sup> In Nepal, data on the precise microbiological profile and antibiotic resistance patterns of HAIs in respiratory ICUs remain scarce, hindering the use of evidence-based empiric antibiotics. This study was conducted to generate local epidemiological evidence on HAI prevalence, identify modifiable risk factors, and document resistance patterns to guide antimicrobial stewardship and improve patient outcomes in this high-risk setting.

## METHODS

This was a prospective, observational, cross-sectional study conducted in the Respiratory ICU of X Hospital

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Nepal. Consecutive patients admitted to the ICU, who developed an episode of HAI, from February 2024 to July 2025 were included into the study. Demographic and clinical profile, comorbidities and risk factors like prior hospitalization or antibiotic use in the last 90 days were recorded in a proforma designed for the study. Hospital acquired infections were diagnosed according to the CDC/NHSN criteria.<sup>10-14</sup> (a) VAP: Worsening oxygenation ( $\text{FiO}_2 \geq 20\%$  or  $\text{PEEP} \geq 3$  cm H<sub>2</sub>O) after  $\geq 2$  days of stability, plus infection signs (fever  $>38^\circ\text{C}$  or  $<36^\circ\text{C}$ , leucocytosis /leukopenia) and positive cultures, (b)VAT: Purulent secretions, no new infiltrates, positive endotracheal aspirate (ETA) cultures, (c) CAUTI:  $\geq 10^5$  CFU/mL uropathogens with symptoms. (d) CRBSI: Same pathogen in catheter and peripheral blood, no other source, (e) CDAD:  $\geq 3$  loose stools in 24 hours, positive *C. difficile* toxin assay. Blood cultures and cultures from appropriate sites (e.g. sputum for VAP or VAT, urine for CAUTI) were obtained in all suspected HAI episodes. Conventional culture methods were used. Samples were inoculated in 5% sheep blood agar, MacConkey agar and Gram's stain and biochemical tests were performed in culture isolates. Antibiotic Sensitivity testing (AST) was performed using the modified Kirby Bauer disk diffusion method and broth dilution of Colistin and polymyxin B. Data pertaining to ICU length of stay, total hospital stay, duration of HAI, discharge status (survived, expired, left against medical advice) were collected in patients who developed HAIs during their ICU stay.

This study was approved by the Institution Review Board of National Academy of Medical Sciences, Bir Hospital. An informed written consent was obtained from all participants or their relatives and confidentiality regarding the diagnosis and treatment was maintained throughout the study. No additional tests apart from those routinely used in the management of these patients in the ICU were ordered. Data were entered in Microsoft Excel and analysed using IBM SPSS Statistics software (Version 29.0). Descriptive statistics included means (SD) and frequencies. Unpaired t-tests and chi-square tests were used for comparisons of continuous and categorical variables respectively among those who developed HAI versus those who did not. Multivariable logistic regression was used to assess the risk factors of HAI and p value of less than 0.05 was considered significant.

## RESULTS

During the study period a total of 121 patients with a mean age of  $61.3 \pm 17.2$  years were admitted in the ICU. Majority of the patients were between 60 to 80

years of age. The commonest primary diagnoses were COPD (30.6%) and pneumonia (21.5%). Hypertension (42.1%) and diabetes (30.6%) were the commonest comorbidities. Prior antibiotic use and hospitalization within 90 days of admission was present in 33(27.3%) and 32 (26.4%) patients respectively. The baseline characteristics of the patients is shown in Table 1.

Fifty episodes of HAIs occurred in 42 of the 121 (34.71%, 95% CI: 26.4-43.7%) patients. The most common HAIs were VAP in 24 (48%), HAP in 7 (14%), CAUTI in 6 (12%), blood stream infections in 4 (8%) patients. Other infections like UTI, infected bed sore, empyema and central lines associated blood stream infections were present in 9 (18%) patients.

Causative pathogens were isolated in cultures in 43 of the 50 HAI episodes. *Acinetobacter baumannii* was the pathogen, accounting for 42% (21/50) of all infections. *Acinetobacter* was the causative organism in 14 of the 24 (58%) cases of VAP. Hospital-acquired pneumonia (HAP) demonstrated a more heterogeneous microbiological profile, with *Acinetobacter baumannii*, *Klebsiella pneumoniae*, and *Citrobacter freundii* each contributing approximately 29% of isolates. Bloodstream infections and other device-related HAIs were likewise predominantly caused by *Acinetobacter baumannii*. In contrast, catheter-associated urinary tract infections (CAUTI) were mainly caused by *Klebsiella pneumonia* and *Citrobacter koseri*, while uncomplicated urinary tract infections by *Escherichia coli*. Resistance to  $\beta$ -lactam antibiotics was extremely high, with ceftriaxone resistance of 100% in *Acinetobacter baumannii* and *Klebsiella pneumoniae*, while piperacillin-tazobactam resistance was 85.8% and 77.8% respectively. Carbapenem resistance was observed in 92% of *Acinetobacter* isolates and 90% of *Klebsiella* isolates. Tigecycline and polymyxin B sensitivity was seen in 80% and 100% of *Acinetobacter* isolates. The organisms isolated in different HAIs and their antibiogram i.e. sensitivity and resistance patterns are depicted in table 2 and 3.

Of the 121 patients, 89 (73.6%) were discharged from the ICU while 23 (19%) died. In nine (7.4%) patients de-escalation of care was done according to relative's wishes. The mean ICU stay was  $6.9 \pm 5.9$  days. The duration of ICU stay was longer in patients who developed HAI compared to those who did not (9.5 vs. 5.2 days,  $p=0.001$ ). Mortality was also higher in patients who developed an HAI episode compared to those who did not (28.6% vs. 13.9%,  $p=0.04$ ). The comparison of the two groups is depicted in table 4. Mechanical ventilation was the strongest risk factor for HAI in our

study with and Odds ratio of 3.5 (95% CI 1.8-6.7) and a p value of <0.001. Urinary Catheters (OR 1.8, p=0.04), and prior hospitalization (OR 2.5, p=0.01) were other significant risk factors. Prior diabetes and antibiotics use although increased the Odds of developing HAI, were not statistically significant. The risk factors are depicted in table 5.

**Table 1. Baseline Characteristics of patients included in the study.**

| Patient Characteristics (N=121) | Frequency | Percentage |
|---------------------------------|-----------|------------|
| <b>Age Group</b>                |           |            |
| <20 years                       | 1         | 0.8%       |
| 20-40 years                     | 13        | 10.7%      |
| 41-60 years                     | 36        | 29.8%      |
| 61-80 years                     | 55        | 45.5%      |
| >80 years                       | 16        | 13.2%      |
| <b>Sex</b>                      |           |            |
| Male                            | 54        | 44.6%      |
| Female                          | 67        | 55.4%      |
| <b>Primary Diagnosis</b>        |           |            |
| COPD                            | 37        | 30.6%      |
| Pneumonia                       | 26        | 21.5%      |
| Interstitial Lung Disease       | 11        | 9.1%       |
| Others                          | 47        | 38.8%      |
| <b>Comorbidities</b>            |           |            |
| Hypertension                    | 51        | 42.1%      |
| Diabetes                        | 37        | 30.6%      |
| Chronic Kidney Disease          | 12        | 9.9%       |
| <b>Risk Factors</b>             |           |            |
| Prior Hospitalization (90 days) | 32        | 26.4%      |
| Antibiotics (90 days)           | 33        | 27.3%      |

**Table 2. Frequency of organisms isolated in different HAIs in the study.**

| Type of HAI | <i>S. aureus</i> | <i>E. coli</i> | <i>C. freundii</i> | <i>A. baumannii</i> | <i>K. pneumoniae</i> | <i>E. faecalis</i> | <i>P. aeruginosa</i> | <i>C. koseri</i> | Not isolated | Total |
|-------------|------------------|----------------|--------------------|---------------------|----------------------|--------------------|----------------------|------------------|--------------|-------|
| HAP         | 1                | 0              | 2                  | 2                   | 2                    | 0                  | 0                    | 0                | 0            | 7     |
| VAP         | 0                | 0              | 1                  | 14                  | 4                    | 0                  | 3                    | 1                | 1            | 24    |
| BSI         | 0                | 0              | 0                  | 2                   | 1                    | 0                  | 0                    | 0                | 1            | 4     |
| UTI         | 0                | 1              | 0                  | 0                   | 0                    | 0                  | 0                    | 0                | 1            | 2     |
| CAUTI       | 0                | 0              | 0                  | 0                   | 1                    | 1                  | 0                    | 2                | 2            | 6     |
| Others      | 0                | 0              | 0                  | 3                   | 1                    | 1                  | 0                    | 0                | 2            | 7     |
| Total       | 1                | 1              | 3                  | 21                  | 9                    | 2                  | 3                    | 3                | 7            | 50    |

Table 3. Antibigram of MDR and XDR pathogens isolated in culture specimen expressed in sensitive % / resistant %

| Antibiotic              | <i>E. coli</i><br>(S/R) | <i>Citrobacter</i><br><i>freundii</i> | <i>Acinetobacter</i><br><i>baumannii</i> | <i>Klebsiella</i><br><i>pneumoniae</i> | <i>Pseudomonas</i><br><i>aeruginosa</i> | <i>Citrobacter</i><br><i>koseri</i> | <i>Enterococcus</i><br><i>faecalis</i> | <i>Staphylococcus</i><br><i>aureus</i> |
|-------------------------|-------------------------|---------------------------------------|------------------------------------------|----------------------------------------|-----------------------------------------|-------------------------------------|----------------------------------------|----------------------------------------|
| Piperacillin-tazobactam | 0/100                   | 0/ 100                                | 14.2/ 85.8                               | 22.2 / 77.8                            | 0 / 100                                 | 0 / 100                             | 50 / 50                                | NT                                     |
| Meropenem               | 100/0                   | NT                                    | 6/94                                     | 17/ 83                                 | 0/100                                   | NT                                  | NT                                     | NT                                     |
| Imipenem                | NT                      | 100 / 0                               | 13/87                                    | NT                                     | 0/100                                   | NT                                  | NT                                     | NT                                     |
| Polymyxin B             | NT                      | 100 / 0                               | 100 / 0                                  | 100/ 0                                 | 100/ 0                                  | NT                                  | NT                                     | NT                                     |
| Ceftazidime-avibactam   | NT                      | 0 / 100                               | 5/ 95                                    | 0 / 100                                | 0/ 100                                  | 0 / 100                             | NT                                     | NT                                     |
| Tigecycline             | 100/0                   | 100 / 0                               | 80 / 20                                  | 100 / 0                                | 100 / 0                                 | 100 / 0                             | NT                                     | NT                                     |
| Doxycycline             | NT                      | 50 / 50                               | 100 / 0                                  | 75/ 25                                 | NT                                      | NT                                  | 100 / 0                                | 100 / 0                                |
| Ceftriaxone             | 0/100                   | 33 / 67                               | 0/ 100                                   | 0/ 100                                 | 0 / 100                                 | NT                                  | 0/ 100                                 | 0/ 100                                 |
| Ampicillin              | NT                      | NT                                    | NT                                       | NT                                     | NT                                      | NT                                  | NT                                     | NT                                     |
| Levofloxacin            | NT                      | NT                                    | 0 / 100                                  | NT                                     | 13/87                                   | NT                                  | 0/ 100                                 | NT                                     |
| Vancomycin              | NT                      | NT                                    | NT                                       | NT                                     | NT                                      | NT                                  | 100/ 0                                 | NT                                     |
| Teicoplanin             | NT                      | NT                                    | NT                                       | NT                                     | NT                                      | NT                                  | 100/ 0                                 | 100/ 0                                 |
| Linezolid               | NT                      | NT                                    | NT                                       | NT                                     | NT                                      | NT                                  | 100/ 0                                 | 100 / 0                                |
| Clindamycin             | NT                      | NT                                    | NT                                       | NT                                     | NT                                      | NT                                  | NT                                     | 0/ 100                                 |
| Cefepime                | 0/100                   | 33 / 67                               | 0 / 100                                  | 0 / 100                                | 0 / 100                                 | 0 / 100                             | NT                                     | NT                                     |
| Cotrimoxazole (SXT)     | 50/50                   | 0/ 100                                | 5 / 95                                   | 14/ 86                                 | 50/ 50                                  | 0/ 100                              | NT                                     | 100 / 0                                |
| Ciprofloxacin           | 0/100                   | 50/ 50                                | 10 / 90                                  | 11 / 89                                | 25/ 75                                  | 0/ 100                              | NT                                     | 0/ 100                                 |
| Amikacin                | NR                      | 0 / 100                               | 0/ 100                                   | 0/ 100                                 | 0/ 100                                  | 0/ 100                              | NT                                     | NT                                     |
| Tobramycin              | NR                      | NT                                    | 0/ 100                                   | NT                                     | NT                                      | NT                                  | NT                                     | NT                                     |
| Nitrofurantoin          | 100/0                   | NT                                    | NT                                       | 0 / 100                                | NT                                      | NT                                  | NT                                     | NT                                     |
| Gentamicin              | 100/0                   | NT                                    | 100 / 0                                  | 5/ 95                                  | 0 / 100                                 | 0 / 100                             | NT                                     | 100/ 0                                 |

Footnote: NT: not tested

Table 4. Comparison of outcomes between the HAI vs non-HAI group.

| Outcome                        | HAI           | Non-HAI       | P value* |
|--------------------------------|---------------|---------------|----------|
| ICU stay (days, mean $\pm$ SD) | 9.5 $\pm$ 6.2 | 5.2 $\pm$ 4.8 | 0.001    |
| Mortality (%)                  | 28.6          | 13.9          | 0.04     |

\*Unpaired t-test and Chi-square test.

Table 5. Comparisons of risk factors of HAI.

| Risk Factors           | Odds Ratio (95%CI) | P value* |
|------------------------|--------------------|----------|
| Mechanical Ventilation | 3.5 (1.8-6.7)      | <0.001   |
| Urinary Catheter       | 1.8 (1.0-3.3)      | 0.04     |
| Prior Hospitalization  | 2.5 (1.2-5.1)      | 0.01     |
| Diabetes               | 1.4 (0.8-2.5)      | 0.12     |
| Prior Antibiotics      | 1.6 (0.9-2.8)      | 0.08     |

\*Multivariable logistic regression

## DISCUSSION

This study provides an insight into the epidemiology of healthcare-associated infections (HAIs) of a respiratory ICU in a tertiary care hospital of a developing country. The prevalence of HAIs was 34.7%, which is significantly higher than previously reported rates of 5% to 11.25% in mixed medical-surgical ICUs in Nepal.<sup>7,8</sup> The higher prevalence can be attributed to several factors including the higher use of mechanical ventilation and assisted breathing in patients with underlying disorders like COPD, asthma, ILD and pneumonia, which are more prevalent in the respiratory ICU. Over 50% of our patients had COPD and pneumonia. VAP was the most common HAI in our study and mechanical ventilation was the strongest risk factor for development of HAIs. Intubation and mechanical ventilation increase the risk of VAP as intubation disrupts normal respiratory defences, predisposing to colonization by opportunistic pathogens.<sup>10</sup> Prior studies report VAP to be the most common infection in ventilated patients accounting for 10-20% of infections.<sup>10,15</sup> The incidence of VAP in our ICU was higher at 48% of all HAIs. The higher occurrence can be attributed to resource constraints like limited access and practice of advanced ventilation bundles (head-end elevation, sedation vacation, subglottic suction etc.) and suboptimal oral care protocols. Amatya et al. in their study reported that only 10% ICU nurses had training in infection prevention and control and the practice of HAI bundles were only average among the participants.<sup>16</sup> Interventions targeted at incorporating these infection control measures may reduce the VAP rates in our ICUs.

HAP at 14.0%, CAUTI at 12.0% and BSI at 8% were other common HAIs in our ICU. These infections are predominantly spread through cross contamination driven by either contact or respiratory droplets.<sup>17,18</sup> Karkee et al in their study demonstrated incidence of CAUTI to be 12.5%.<sup>19</sup> Khanal et al. in their study showed slightly higher incidence of BSI (12.1%).<sup>20</sup> VAT and CDAD, despite inclusion in the diagnostic criteria, were not diagnosed in any of our patients. VAT may be underdiagnosed owing to limited microbiological resources and clinical overlap with VAP. Advanced diagnostics (e.g., toxin assays for CDAD) are not routinely available in our settings, causing such infections to be misclassified or overlooked, leading to underreporting.<sup>11,14</sup>

Overall, gram negative pathogens contribute to over 60% of HAIs globally.<sup>4</sup> This study revealed a predominance of MDR Gram-negative bacteria, with *Acinetobacter baumannii* accounting for 42% of isolates. Prior studies

from settings like ours report a similar prevalence of this pathogen.<sup>7,8</sup> *Klebsiella pneumoniae* (18.0%) and *Citrobacter* spp. (12.0%) were other gram-negative organisms prevalent in our study. The prevalence of *Pseudomonas* and *E. coli* was low in this study compared to other studies from Nepal where their incidence was in range of 20%.<sup>21</sup> Gram-positive pathogens like *Enterococcus faecalis* (4%) and *Staphylococcus aureus* (2.0%) were isolated less frequently in our study. Gram positive pathogens are reported less frequently from medical ICUs due to differences in underlying disease, antibiotic usage patterns or patient demographics.<sup>22</sup> In 14% of HAI episodes in our study, incriminating organism was not isolated. This finding may indicate challenges in sample collection or empirical antibiotic use prior to collection of culture samples.

Our study shows a high resistance of pathogens to antibiotics such as Ceftriaxone (95.2%), Ciprofloxacin (92.3%), Piperacillin-tazobactam (87.5%) and Carbapenem (89.1%). This finding is alarming and reflects the escalating MDR crisis in our ICUs. This pattern is fuelled by over-the-counter antibiotic availability, empirical broad-spectrum use, and lack of stewardship programs.<sup>3</sup> Our isolates were 89.2% sensitive to Tigecycline and 100% sensitive to Polymyxin B. These antibiotics offers a viable option for treatment of MDR Gram-negatives in our ICUs. The major limitation of Tigecycline is that it is bacteriostatic and not suitable to be used alone in severe sepsis. Polymyxin B is the antibiotic of choice for carbapenem-resistant isolates like *A. baumannii*. However, it is nephrotoxic and necessitates careful monitoring in critically ill patients, which may be constrained in resource-poor settings.<sup>23</sup> The EPIC II study on point prevalence of infections in ICU, reported an increasing resistance of MDR pathogens to Tigecycline and Polymyxin.<sup>4</sup> The dual burden of HAIs and MDR pathogens in our ICUs can be prevented by strengthening IPC protocols alongside the establishment of a formal antimicrobial stewardship program including education, prescribing guidelines, and regular resistance surveillance. Such integrated approaches break the cycle of empirical broad-spectrum use, reduce selective pressure, and safeguard the efficacy of these antibiotics.

The mean duration of ICU stays in patients who developed HAIs was significantly longer than those who did not, in our study. Studies have reported an average of 7-10 additional days of ICU and hospital stay per HAI episode.<sup>4</sup> These findings are important as prevention of HAI in ICUs may help to reduce the existing strain in an already overburdened ICU. The mortality was also significantly higher in those with HAIs. Our study results

are consistent with a high attributable mortality rates of 15-40% of HAIs reported from developing countries.<sup>24</sup> Delayed diagnosis and limited availability of antibiotics exacerbate these outcomes. The true mortality may have been underestimated as 7.4% patients discontinued treatment in our study possibly owing to Catastrophic Health Expenditure and futility of treatment.

The risk factors for HAI include age, immunocompromise, chronic kidney disease, heart failure and underlying chronic respiratory diseases. Prolonged hospital stays, invasive devices, prior history of hospitalization and antibiotic use within the past 90 days are significantly associated with increased risks in prior studies.<sup>25,26</sup> Our study showed mechanical ventilation as the strongest risk factor for HAI with an odds ratio of 3.5. Artificial airways bypass the upper respiratory defences, promoting aspiration and biofilm formation and subsequent VAP.<sup>10</sup> Similarly presence of urinary catheters and a history of prior hospitalization were also significant risks. Platt et al.<sup>27</sup> and Pittet et al.<sup>28</sup> in their studies also showed similar findings. However, our study failed to demonstrate a significant association of diabetes and prior antibiotics with risks of developing HAI in contrary to previous reports.<sup>29</sup>

The strengths of this study are use of standardized CDC-based case definitions and comprehensive microbiological profiling, which provides critical baseline data for our setting. However, several limitations must be acknowledged. The single-center design limits generalizability, and the small sample size may have reduced statistical power for subgroup analyses. We did not perform molecular study of resistance genes, nor did we differentiate colonization from infection using quantitative cultures which may have led to overestimation of VAP prevalence. Additionally, we did not adjust for severity of illness scores potentially overlooking severity impact on HAI susceptibility. Long-term outcomes were not assessed. Despite these limitations, our findings offer valuable insights into the MDR crisis in Nepalese ICUs and underscore the urgent need for stewardship interventions.

## CONCLUSIONS

We hereby report a high incidence of HAIs in respiratory ICU at a tertiary level hospital in Nepal. VAP was the commonest HAI and multidrug-resistant (MDR) *Acinetobacter* and *Klebsiella* were the commonest isolates. These isolates were frequently resistance to beta lactam and carbapenem antibiotics but sensitive to Tigecycline and Polymixin B. These antibiotics must be

used judiciously in ICUs in developing countries like ours to prevent further resistance emergence. Mechanical ventilation, urinary catheters and prior hospitalisations were the strongest predictors of HAI and patients with HAIs had prolonged ICU stay and higher mortality. We recommend urgent adoption of device-associated infection prevention bundles, continued surveillance, antibiotic stewardship protocols and evidence-based, locally adapted empiric antibiotic guidelines to prevent HAIs by MDR pathogens in our ICUs.

## CONFLICT OF INTEREST

The authors declare no competing interest.

## REFERENCES

1. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. *Am J Infect Control*. 2008;36(5):309-332. doi: <https://doi.org/10.1016/j.ajic.2008.03.002>
2. Fridkin SK, Welbel SF, Weinstein RA. Magnitude and prevention of nosocomial infections in the intensive care unit. *Infect Dis Clin North Am*. 1997;11(2):479-496. doi: [https://doi.org/10.1016/S0891-5520\(05\)70366-4](https://doi.org/10.1016/S0891-5520(05)70366-4)
3. Haley RW, Culver DH, White JW, Morgan WM, Emori TG, Munn VP, et al. The efficacy of infection surveillance and control programs in preventing nosocomial infections in US hospitals. *American journal of epidemiology*. 1985 Feb;121(2):182-205. doi: <https://doi.org/10.1093/oxfordjournals.aje.a113990>
4. Vincent JL, Rello J, Marshall J, Silva E, Anzueto A, Martin CD, et al. International study of the prevalence and outcomes of infection in intensive care units. *Jama*. 2009 Dec 2;302(21):2323-9. doi: <https://doi.org/10.1001/jama.2009.1754>
5. Ferguson JK. Preventing healthcare-associated infection: risks, healthcare systems and behaviour. *Intern Med J*. 2009;39(9):574-581. doi: <https://doi.org/10.1111/j.1445-5994.2009.02004.x>
6. Pittet D, Tarara D, Wenzel RP. Nosocomial Bloodstream Infection in Critically Ill Patients: Excess Length of Stay, Extra Costs, and Attributable Mortality. *JAMA: The Journal of the American Medical Association*.

- Association. 1994;271(20):1598-1601. doi: <https://doi.org/10.1001/jama.1994.03510440058033>
7. Marasine NR, Shrestha S, Sankhi S, Paudel N, Gautam A, Poudel A. Antibiotic utilization, sensitivity, and cost in the medical intensive care unit of a tertiary care teaching hospital in Nepal. *SAGE Open Med.* 2021;9. doi: <https://doi.org/10.1177/20503121211043710>
8. Thapa S, Thapa N, Rokaya M. Knowledge, attitude, and practice regarding hospital-associated infections among health care professional of a tertiary-level hospital. *Europasian Journal of Medical Sciences.* 2025;7:1-8. doi: <https://doi.org/10.46405/ejms.v7i10.565>
9. View of Nosocomial Bacterial Infection and Antimicrobial Resistant Pattern in a Tertiary care Hospital in Nepal. Accessed April 5, 2026. [\[Article\]](#)
10. Kalil AC, Metersky ML, Klompas M, Muscedere J, Sweeney DA, Palmer LB, et al. Management of adults with hospital-acquired and ventilator-associated pneumonia: 2016 clinical practice guidelines by the Infectious Diseases Society of America and the American Thoracic Society. *Clinical infectious diseases.* 2016 Sep 1;63(5):e61-111. doi: <https://doi.org/10.1093/cid/ciw353>
11. Craven DE, Chroneou A, Zias N, Hjalmarson KI. Ventilator-associated tracheobronchitis; the impact of targeted antibiotic therapy on patient outcomes. *Chest.* 2009;135(2):521-528. doi: <https://doi.org/10.1378/chest.08-1617>
12. Gould C V, Umscheid CA, Agarwal RK, Kuntz G, Pegues DA. Guideline for Prevention of Catheter-Associated Urinary Tract Infections 2009. *Infect Control Hosp Epidemiol.* 2010;31(4):319-326. doi: <https://doi.org/10.1086/651091>
13. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, O'Grady NP, et al. Clinical practice guidelines for the diagnosis and management of intravascular catheter-related infection: 2009 Update by the Infectious Diseases Society of America. *Clinical infectious diseases.* 2009 Jul 1;49(1):1-45. doi: <https://doi.org/10.1086/599376>
14. McDonald LC, Gerding DN, Johnson S, Bakken JS, Carroll KC, Coffin SE, et al. Clinical practice guidelines for *Clostridium difficile* infection in adults and children: 2017 update by the Infectious Diseases Society of America (IDSA) and Society for Healthcare Epidemiology of America (SHEA). *Clinical infectious diseases.* 2018 Apr 1;66(7):e1-48. doi: <https://doi.org/10.1093/cid/cix1085>
15. Dongol S, Kayastha G, Maharjan N, Pyatha S, KC R, Thwaites L, et al. Epidemiology, etiology, and diagnosis of health care acquired pneumonia including ventilator-associated pneumonia in Nepal. *PloS one.* 2021 Nov 17;16(11):e0259634. doi: <https://doi.org/10.1371/journal.pone.0259634>
16. Amatya BR, Singh P, Pokharel S, Gurung S, Sharma B, Khatri S, et al. Awareness and practice of care bundles for prevention of healthcare-associated infections in critical care units of a tertiary care hospital. *Journal of Nepalese Society of Critical Care Medicine.* 2025 Jan;3(1):5-10. doi: <https://doi.org/10.3126/jnscm.v3i1.73500>
17. Hooton TM, Bradley SF, Cardenas DD, Colgan R, Geerlings SE, Rice JC, et al. Diagnosis, prevention, and treatment of catheter-associated urinary tract infection in adults: 2009 International Clinical Practice Guidelines from the Infectious Diseases Society of America. *Clinical infectious diseases.* 2010 Mar 1;50(5):625-63. doi: <https://doi.org/10.1086/650482>
18. Greene MT, Chang R, Kuhn L, Rogers MA, Chenoweth CE, Shuman E, et al. Predictors of hospital-acquired urinary tract-related bloodstream infection. *Infection Control & Hospital Epidemiology.* 2012 Oct;33(10):1001-7. doi: <https://doi.org/10.1086/667731>
19. Karkee P, Dhital D, Madhup SK, Sherchan JB. Catheter Associated Urinary Tract Infection: Prevalence, Microbiological Profile and Antibigram at a Tertiary Care Hospital. *Annals of Clinical Chemistry and Laboratory Medicine.* 2018;3(2):3-10. doi: <https://doi.org/10.3126/acclm.v3i2.19675>
20. Khanal B, Shrestha LB, Sharma A, Siwakoti S. Bloodstream infections: trends in etiology and antimicrobial resistance in 10 years in Eastern Nepal. *BMC Infect Dis.* 2025;25(1):1001-. doi: <https://doi.org/10.1186/s12879-025-11413-4>
21. Shrestha SK, Trotter A, Shrestha PK. Epidemiology and Risk Factors of Healthcare-Associated Infections in Critically Ill Patients in a Tertiary

- Care Teaching Hospital in Nepal: A Prospective Cohort Study. *Infectious Diseases: Research and Treatment*. 2022;15. doi: <https://doi.org/10.1177/11786337211071120>
22. Wolff M, Brun-Buisson C, Lode H, Mathai D, Lewi D, Pittet D. The changing epidemiology of severe infections in the ICU. *Clinical Microbiology and Infection*. 1997;3(SUPPL. 1):s36-s47. doi: <https://doi.org/10.1111/j.1469-0691.1997.tb00645.x>
23. Dolma K, Malaysia MWMJ, 2022 U. *Acinetobacter baumannii*: An overview of emerging multidrug-resistant pathogen. e-mjm.org. Published online 2022. Accessed April 6, 2026.[\[Download PDF\]](#)
24. Alberti C, Brun-Buisson C, Burchardi H, Martin C, Goodman S, Artigas A, et al. Epidemiology of sepsis and infection in ICU patients from an international multicentre cohort study. *Intensive care medicine*. 2002 Feb;28(2):108-21. doi: <https://doi.org/10.1007/s00134-001-1143-z>
25. Appelgren P, Hellström I, Weitzberg E, Söderlund V, Bindslev L, Ransjö U. Risk factors for nosocomial intensive care infection: A long-term prospective analysis. *Acta Anaesthesiol Scand*. 2001;45(6):710-719. doi: <https://doi.org/10.1034/j.1399-6576.2001.045006710.x>
26. Freeman J, McGowan JE, Freeman J, McGowan JE. Risk factors for nosocomial infection. *Journal of Infectious Diseases*. 1978;138(6):811-819. doi: <https://doi.org/10.1093/infdis/138.6.811>
27. Platt R, Polk BF, Murdock B, Rosner B. Risk factors for nosocomial urinary tract infection. *Am J Epidemiol*. 1986;124(6):977-985. doi: <https://doi.org/10.1093/oxfordjournals.aje.a114487>
28. Pittet D, Harbarth S, Ruef C, et al. Prevalence and Risk Factors for Nosocomial Infections in Four University Hospitals in Switzerland. *Infect Control Hosp Epidemiol*. 1999;20(01):37-42. doi: <https://doi.org/10.1086/501554>
29. Safdar N, Maki DG. The commonality of risk factors for nosocomial colonization and infection with antimicrobial-resistant *Staphylococcus aureus*, *enterococcus*, gram-negative bacilli, *Clostridium difficile*, and *Candida*. *Ann Intern Med*. 2002;136(11):834-844. doi: <https://doi.org/10.7326/0003-4819-136-11-200206040-00013>