Quality Indicators in a Mixed Adult ICU in Nepal: An Observational Study

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ABSTRACT

Background:

Quality indicators (QIs) are vital for assessment of the performance of intensive care units (ICU) and guiding further improvement. In Nepal, systematic evaluation of these indicators remains scarce. This study aimed to evaluate structural, process, and outcome-based QIs in a Level III mixed adult ICU in Kathmandu, Nepal.

Method:

A retrospective observational study was conducted at Grande International Hospital's ICU, including all admissions during 2024. Data were extracted from routinely maintained hospital records and analyzed using Microsoft Excel 2024.

Result:

The ICU had 11 beds and admitted 768 patients in 2024. The occupancy rate was 63.7%, with a median length of stay of 3 days. The nurse-to-patient ratio of 1:1 was maintained. Hand hygiene compliance was 58%, while 82.2% of eligible mobilization days were fulfilled. A total of 118 patients received invasive mechanical ventilation during the study period. Among mechanically ventilated patients, venous thromboembolism (VTE) prophylaxis was provided on 93.6% of days and spontaneous awakening trial (SAT) was performed on 54.4% of days. The reintubation rate within 48 hours was 23.9%. The mortality rate was 10.3%, and the standardized mortality ratio (SMR) was 0.79. Culture-proven ICU-acquired infection rate was 2.8%, with central line associated blood stream infection (CLABSI), catheter associated urinary tract infection (CAUTI), and ventilator associated pneumonia (VAP) rates of 1.98, 1.97, and 13.04 per 1,000 device-days, respectively.

Conclusion:

The ICU demonstrated strong structural capacity and favorable outcomes, especially in SMR. However, improvement is needed in hand hygiene compliance and sedation practices. Regular QI audits may help strengthen ICU care quality.

Keywords: Quality indicators, ICU, standardized mortality rate, mechanical ventilation, hand hygiene, re-intubation.

Introduction

Quality indicators (QIs) are essential tools for measuring, monitoring, and improving the quality of care in Intensive Care Units (ICU). While several institutions in the developed world had implemented various forms of quality assessment and control, it was Dr. Avedis Donabedian who, in 1966, standardized the concept of healthcare quality evaluation. The Donabedian Model objectively measures key ICU quality indicators based on three fundamental dimensions: structure, process, and outcome.[1]

Structural indicators assess the physical infrastructure, organizational setup, and human

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resources present in the ICU. Structural elements are the foundation for delivering high quality critical care. Examples of structural indicators include parameters like bed occupancy, availability of trained intensivists, nurse-to-patient ratios, as well as access to essential equipments such as mechanical ventilators and hemodialysis machines.[2]

Process-related indicators provide insight into how effectively the services are delivered. Availability of infrastructures may not always lead to good patient outcomes unless the process of service delivery is efficient. Process indicators focus on adherence to standard clinical guidelines, organization-specific protocols and the effectiveness of interventions. Examples of these parameters include days of venous thromboembolism (VTE) prophylaxis, mobilization, spontaneous awakening trial (SAT) and spontaneous breathing trial (SBT).[3]

Outcome indicators measure the overall end results of care delivered. They reflect the sum total of the structural resources, healthcare delivery processes as well as the patient specific clinical factors. Examples of ICU-specific outcome indicators include standardized mortality rates, length of ICU stay, readmission rates, hospital acquired infection rates, incidence of pressure ulcers and medication errors.[4]

QIs are highly relevant for the public, as consumers of healthcare services, as well as for the hospital administrators and the policy makers to assess whether an institution is providing good healthcare services to the people and to identify gaps where they exist. However, the paucity of local data on the internet suggests that their evaluation and implementation remain limited in Nepal. It is presumable that ICUs in Nepal face challenges with limited infrastructure, staffing shortages, and inconsistent adherence to protocols.

There is a need to establish reference values for various quality metrics for ICU, especially in the context of Nepal, where systematic quality assessment remains under-evaluated despite growing critical care demands. The realization of this necessity was the rationale for the study.

This study had several objectives. The first objective was to review the quantitative parameters which are validated as tools for assessment of quality in the ICU, based on the Donabedian model. The second was to retrospectively evaluate the quality indicators in a Level III mixed adult ICU in Nepal. The third was to determine the adherence of the ICU to standard critical care protocols, such as hand hygiene compliance, VTE prophylaxis and spontaneous awakening and breathing trial, in order to identify areas for improvement in care delivery. Similarly, another objective of the study was to compare the ICU's performance against international benchmarks for metrics like mortality rates, infection rates, and reintubation rates.

The study is expected to add to the limited literature on ICU quality in the region. The study will also offer a benchmark for comparison in the future. Ultimately, assessing the quality indicators will help in implementing patient safety protocols, reduce preventable complications, identify problems and help formulate appropriate policies to improve ICU performance.

Methods

A retrospective observational study was performed in the Level III, mixed adult ICU of Grande International Hospital, Kathmandu, Nepal. All the patients admitted in the unit in the year 2024 were documented. Standard observational checklists and documentation templates were used for recording ICU occupancy each day, hand hygiene compliance, VTE prophylaxis, sedation interruption and breathing trials, mobilization, and infection surveillance. Data were also extracted from routinely maintained institutional registers and electronic records. These data included the number of unplanned ICU re-admission within 48 hours of transfer-out, re-intubation with 48 hours of extubation, return of spontaneous circulation after cardiopulmonary resuscitation and mortality.

Definitions and Protocols

In this study, a bed was considered occupied if it had a patient present at 6 AM on a given day. ICU occupancy rate was calculated by dividing the total number of occupied bed-days (the number of days each ICU bed had a patient present at 6 AM) by the total number of available bed-days (the number of ICU beds multiplied by the number of days) during the study period, expressed as a percentage.

Hand hygiene compliance was assessed by trained infection control nurses using the WHO's "Five Moments for Hand Hygiene" observation framework.5 Compliance was calculated as the number of correct hand hygiene actions divided by the total number of observed opportunities, expressed as a percentage. A minimum of two hundred opportunities were observed per month.

Eligible days for mobilization were defined as the total number of ICU days for patients who were not on neuromuscular blockade, moderate to deep sedation (Richmond agitation-sedation scale ≤ -3), or receiving multiple vasopressor and inotropic support. Mobilization was considered "appropriate" if the patient was mobilized as per the ICU mobility scale.[6]

Spontaneous awakening trial was considered performed if sedation was interrupted daily for at least half an hour in patients with mechanical ventilation. All mechanically ventilated patients were eligible for this procedure. The days when SAT were performed were recorded and expressed as a percentage of total mechanically ventilated days. Subsequently, all the patients who completed the spontaneous awakening trial safely were considered eligible for a spontaneous breathing trial (SBT). The procedure was considered performed if the eligible patients were assessed for spontaneous breathing using either a pressure support mode on the mechanical ventilator or a T-piece. The days when SBT were performed were recorded and expressed as a percentage of total patients in whom SAT was performed successfully. Similarly, reintubation rate was calculated as the proportion of patients who required reintubation within 48 hours of planned extubation.

Venous thromboembolism (VTE) prophylaxis included either pharmacological or mechanical method using a sequential compression device. Their application was recorded on a daily basis for each patient on invasive mechanical ventilation.

ICU-acquired infections (CLABSI, CAUTI, and VAP) were defined using CDC surveillance criteria, the elaboration of which is not in the scope of this article.[7] Infection rates were calculated per 1,000 device-days. Similarly, new pressure sores were defined as areas of localized injury to the skin and underlying tissue that developed after ICU admission.

Standardized Mortality Ratio (SMR) was calculated by dividing the observed ICU mortality by the expected mortality as predicted by the APACHE-II scoring system. APACHE-II scores were calculated within the first 24 hours of ICU admission.

In this study, return of spontaneous circulation (ROSC) was considered achieved if the patient had a palpable pulse and measurable blood pressure for at least 20 minutes following cardiopulmonary resuscitation (CPR), without the need for ongoing chest compressions.

All data remained anonymous and were entered into Microsoft Excel 2024. Proportions, means, medians, and interquartile ranges were calculated as appropriate. Quality indicator rates were benchmarked against international standards where available.

Results

Altogether, 768 patients were admitted to the mixed adult Level-III ICU in the year 2024, with a median length of ICU stay of 3 days [Interquartile range (IQR) 2-4]. The population had a median age of 60 years (IQR 46-72), with a range from 13 to 101 years. 424 patients (55.2%) were male and 334 patients (44.8%) were female. The largest proportion of patients were admitted for primary pulmonary pathologies (21.1%), followed by neurosurgical (12.5%) and neurological (12.1%) pathologies respectively. A table (Table 1) showing the characteristics of the admitted patients is provided below.

Table 1: Characteristics of the admitted population

Characteristics	Values
Total patients admitted	768
Median age [years]	60 (IQR 46-72)
Range of age [years]	13-101
Primary medical pathologies	67.4%
Primary surgical pathologies	32.6%
Median ICU length of stay (Level-III) [days]	3 (IQR 2-4)
Male	55.2%
Female	44.8%

Survey of Structural Indicators

A total of 11 beds were present in the ICU where the retrospective study was done. The ICU occupancy rate, determined by dividing the total number of bed-days used by the total bed-days available was 63.7%. During the study period, 23 patients required ICU readmission within 48 hours of being transferred out (2.99% readmission rate). The unit maintained continuous intensivist coverage, with specialists holding a Master's degree in Anesthesiology and Critical Care conducting daily rounds. Furthermore, intensivists were available within 2 minutes of notice at all times. The ICU maintained 1:1 nurse-to-patient ratio for 99.6% of cases, ensuring that high-quality individualized care was provided.

The unit was equipped with seventeen mechanical ventilators (supporting both controlled and spontaneous ventilation modes). No patient requiring mechanical ventilation was denied access during the study year. Other available equipments included four bilevel positive airway pressure (BiPAP) machines, three sequential compression devices, and twenty-one syringe pumps. Continuous renal replacement therapy and extracorporeal membrane oxygenation was not available in the unit. Hemodialysis machines were shared with the hospital's dialysis ward and no delays in hemodialysis due to logistic issues were reported during the study period.

Survey of process related indicators

Hand hygiene compliance in the ICU was assessed through a minimum of two hundred randomly observed hand hygiene opportunities each month. Based on these observations, the overall compliance rate was determined to be 58%. Likewise, the proportion of eligible days on which appropriate mobilization was provided was calculated to be 82.2%.

Invasive mechanical ventilation remains one of the most important organ support measures provided in the ICU. As such, evaluating quality indicators related to its use is essential. In this study, a total of 118 patients received invasive mechanical ventilation, for a median duration of 2.5 days (IQR: 1–5 days). A key quality indicator among patients who receive mechanical ventilation is the rate of re-intubation within 48 hours of extubation.[3] A total of 92 patients were extubated in the ICU, out of which 22 patients were re-intubated within 48 hrs. This resulted in a reintubation rate of 23.9%. There was a single event of unplanned extubation during the study period.

The rate of venous thromboembolism (VTE) prophylaxis among mechanically ventilated patients was determined by dividing the total number of days on which mechanically ventilated patients received VTE prophylaxis—either chemical or mechanical—by the total number of eligible days during the same period. This resulted in a VTE prophylaxis rate of 93.6% among mechanically ventilated patients. Similarly, it was found that spontaneous awakening trial (SAT) was performed on 54.4% of the mechanical ventilation days. Although all the patients on mechanical ventilator were considered eligible for SAT, patients with certain conditions such as elevated intracranial pressure, excessive agitation leading to autonomic instability and respiratory distress with unacceptable patient-ventilator asynchrony were exempted from this procedure based on the clinicians' discretion. Subsequent to a successful SAT, spontaneous breathing trial (SBT) was performed in 91.7% of eligible patient-days.

Survey of outcome related indicators

Among the 768 patients admitted, a total of 79 mortalities were documented. This corresponded to a mortality rate of 10.28%. Standardized Mortality Rate (SMR) based on APACHE-II compares observed ICU deaths to those predicted by the APACHE-II score. It is calculated as observed deaths divided by expected deaths. An SMR greater than one indicates higher-than-expected mortality, while an SMR less than one suggests better outcomes. The ICU under study had an annual SMR of 0.79 during the year. Additionally, the SMR remained below one in every month of the year.

During their stay, 22 patients (2.8%) developed culture proven ICU-acquired infections. Among these infections, 22.7% were bloodstream infections, 27.3% were urinary tract infections, and 50% were hospital-acquired pneumonias. The CAUTI rate was calculated by dividing the number of culture-confirmed CAUTI cases by the total catheter-days and multiplying by 1,000. The CAUTI rate was found to be 1.97 infections per 1,000 catheter-days. Similarly, CLABSI rate was calculated by dividing the number of culture-confirmed CLABSI cases by the total central line-days and multiplying by 1,000. The CLABSI rate was 1.98 infections per 1,000 central line-days. Likewise, ventilator associated pneumonia (VAP) rate was calculated by dividing the number of culture-confirmed ventilator-associated pneumonia cases by the total number of ventilator-days expressed per 1000 ventilator days. It was found to be 13.04. Additionally, there were 12 cases of new pressure ulcers developed in the ICU (1.56% of total patients).

A total of 57 incidences of CPR were recorded within the ICU during the study period, out of which 24 (42%) had a return of spontaneous circulation. Medication errors were documented in 11 incidences during the study period.

A summary table (Table 2) of quality indicators and their corresponding values are tabulated below.

Table 2: Quality indicators and their corresponding values for the year 2024

Indicators	Values
ICU occupancy rate	63.7%
ICU readmission within 48 hours	2.99%
Hand hygiene compliance	58%
Eligible days with appropriate mobilization	82.2%
Reintubation rate within 48 hours of extubation	23.9%
VTE prophylaxis in eligible patients with invasive mechanical ventilator	93.6%
Days with spontaneous awakening trial	54.4%
Days with spontaneous breathing trial (subsequent to a successful SAT)	91.7%
Mortality rate	10.3%
SMR based on APACHE-II score	0.79
ICU acquired infection (Culture proven)	2.8%
CAUTI rate per 1000 urinary catheter days	1.97
CLABSI rate per 1000 days with central venous catheter	1.98
VAP rate per 1000 mechanical ventilator days	13.04
New pressure sores	1.56%
ROSC after CPR	42%

Discussion

The study findings indicate that the ICU is well-equipped and effectively structured. The ICU has adequate staffing, and continuous intensivist coverage, which contribute to its favorable outcomes. Compared to well-equipped, Level-III ICUs in developed countries, the ICU in this study lacked a few advanced facilities, which include cardiac output monitoring devices, extracorporeal membrane oxygenation (ECMO) and continuous renal replacement therapy machines (CRRT).

Similarly, this study found an ICU occupancy rate of 63.7%. Although there are no definitive guidelines specifying the ideal occupancy rate, expert opinion suggests that maintaining an occupancy of approximately 70% is best suited to achieve an optimal balance between accessibility and quality of care. This ensures that ICUs can accommodate additional critically ill patients without becoming overburdened and the ICU beds remain available for emergencies. Consequently, at this level, staffs are not routinely stretched beyond their capacity, which could compromise the level of care.[8]

The observed ICU readmission rate of 2.99% indicates a conservative approach to patient discharge, which may lead to pronged ICU stay in some patients. This figure falls below the benchmark range of 4-6%, mentioned by several international studies for ICU readmission rates.[9,10] On the positive side, a conservative approach potentially improves the patient safety as higher ICU readmission rates have been associated with higher mortality rates.[9]

Similarly, the survey reported a hand hygiene compliance rate of 58% in the ICU, which mirrors the average global rate of 59.6% found in a large systematic review from 2019. The review also highlighted regional differences, with compliance rates of 64.5% in high-income countries and just 9.1% in low-income countries.[11] Hand hygiene plays a key role in preventing the incidence of hospital acquired infections. Therefore, achieving a hand hygiene compliance rate of 90%, as recommended by the World Health Organization remains a goal worthy to strive for.[12]

Among the quality indicators applicable to mechanically ventilated patients, the rate of re-intubation within 48 hours of extubation was found to be 23.9%, which is close to the optimal benchmark of 10-20%.[13] Re-intubation rates lower than 10% is often indicative of an overly defensive extubation policy, which may inadvertently lead to a prolonged ICU length of stay and increased expenses to the patient. Similarly, this study found a high degree of compliance to VTE prophylaxis among mechanically ventilated patients (93.6%). Mechanical ventilation has been recognized as a high risk factor for developing VTE in ICU patients.[14] The high degree of VTE compliance indicates good adherence to the American College of Chest Physicians (ACCP) guideline, which recommends that all mechanically ventilated ICU patients receive VTE prophylaxis unless contraindicated.[15] The observed rate is also comparable to that reported in developed countries like Canada and France, where a cross-sectional study noted chemical prophylaxis in 92%.[16] Regarding daily interruption of sedation with spontaneous awakening trial in mechanically ventilated patients, the standard benchmark is set at a targeted compliance of at least 80%. This value allows for the exclusion of patients with intracranial hypertension, status asthmaticus, acute respiratory distress syndrome, or other conditions in which daily interruption of sedation might be considered

unsuitable by the treating physician.[17] In this context, the performance of the studied ICU was found to be less than optimal.

The outcome indicators in this study were generally favorable. The ICU mortality rate was 10.3%. It is important to note that ICU mortality is influenced not only by the quality of ICU care provided, but also by factors such as disease severity, patient age, and existing comorbidities. Hence, risk-adjusted mortality rates are calculated, which portray a relatively more accurate picture of the performance of the ICU rather than absolute mortality rate values. Several statistical methods exist to assess risk adjusted mortality in ICUs, including multivariate analysis. This study utilized the standardized mortality ratio (SMR), which uses Acute Physiology and Chronic Health Evaluation II (APACHE-II) scores. APACHE-II is a well-established, validated and very widely used tool for predicting ICU mortality that is inherently adjusted for age, chronic health conditions, and acute physiological parameters.[18] This study calculated an SMR of 0.79. An SMR value of less than one indicates an actual mortality rate which is lower than that predicted by the APACHE-II. This suggests that the ICU achieved good outcomes in terms of patient survival.

Likewise, the rates of ICU-acquired infections in this study compare fairly well with international standards. The unit's observed CLABSI and CAUTI rates were 1.98 per thousand central line days and 1.97 per thousand catheter days respectively. These values were significantly lower than the international data provided by the International Nosocomial Infection Control Consortium (INICC) which reported the data from 45 countries between 2015 and 2020. Similarly, the observed VAP rate in the studied ICU was 13.04 per thousand ventilator days, which was similar to the VAP rate internationally. For reference, the INICC report noted a CLABSI rate of 4.11, a CAUTI rate of 5.07 and a VAP rate of 13.10 per thousand device days.[19]

This study has several limitations. Notably, 14.2% of ICU patients either left against medical advice, were discharged on request, or had life support withdrawn. These cases, as expected, have an effect on the reported mortality rate. Similarly, significant differences exist in the sampling practices for cultures across ICUs. Likewise, culture positivity rates across laboratories also vary. This may have an effect on the observed rates of hospital acquired infections. Although the Donabedian model examines structures, processes, and outcomes, it does not account for the subjective satisfaction levels of patients, families, and healthcare providers. This may be considered another significant drawback in this assessment of ICU quality, which is based entirely on Donabedian model. Integrating their perspectives through questionnaires could make this study more comprehensive. Likewise, data on the incidence of carbapenem resistant organisms may serve as another process related quality indicator in the ICU.

Conclusion

In conclusion, the unit demonstrates strong structural and outcome-related indicators, like individualized nursing care and a favorable standardized mortality rate, reflecting good care delivery. However, there are opportunities for improvement, particularly in increasing hand hygiene compliance and optimizing spontaneous awakening trial adherence. These areas should be addressed in the future and current best practices should be maintained. Additionally, future quality assessments should incorporate subjective perception of satisfaction from both patients and healthcare providers to ensure a more holistic evaluation.

References

1. Donabedian A. Evaluating the quality of medical care. The Milbank memorial fund quarterly. 1966 Jul 1;44(3):166-206. doi: 10.1111/j.1468-0009.2005.00397. x.
2. Ray B, Samaddar DP, Todi SK, Ramakrishnan N. Quality indicators for ICU: ISCCM guidelines for ICUs in India. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2009 Oct;13(4):173. PMID: 20436688.
3. Al-Dorzi HM, Arabi YM. Quality indicators in adult critical care medicine. Global Journal on Quality and Safety in Healthcare. 2024 May 1;7(2):75-84. doi: 10.36401/JQSH-23-30.
4. Duke G, Santamaria J, Shann F, Stow P. Outcome-based clinical indicators for intensive care medicine. Anaesthesia and intensive care. 2005 Jun;33(3):303-10. doi: 10.1177/0310057X0503300305.
5. Toney-Butler TJ, Gasner A, Carver N. Hand hygiene. InStatPearls [Internet] 2023 Jul 31. StatPearls Publishing.

6. Tipping CJ, Hodgson CL. Clinimetrics: the intensive care unit mobility scale. Journal of physiotherapy. 2020 Oct 1;66(4):271. doi: 10.1016/j.jphys.2020.06.001.

7. 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. American journal of infection control. 2008 Jun 1;36(5):309-32. doi: 10.1016/j.ajic.2008.03.002.

8. Tierney LT, Conroy KM. Optimal occupancy in the ICU: a literature review. Australian Critical Care. 2014 May 1;27(2):77-84. doi: 10.1016/j.aucc.2013.11.003.

9. McMillan TR, Hyzy RC. Bringing quality improvement into the intensive care unit. Critical care medicine. 2007 Feb 1;35(2):S59-65. doi: 10.1097/01.CCM.0000252914.22497.44.

10. Delgado M, Pericas L, Moreno J, Torra L, Varela J, Suero F, et al. Quality indicators in critically ill patients. Madrid: SEMICYUC. 2005 May.

11. Lambe KA, Lydon S, Madden C, et al. Hand hygiene compliance in the ICU: a systematic review. Critical care medicine. 2019 Sep 1;47(9):1251-7. doi: 10.1097/CCM.0000000000003868.

12. Chavali S, Menon V, Shukla U. Hand hygiene compliance among healthcare workers in an accredited tertiary care hospital. Indian journal of critical care medicine: peer-reviewed, official publication of Indian Society of Critical Care Medicine. 2014 Oct;18(10):689. doi: 10.4103/0972-5229.142179.

13. Whitmore D, Mahambray T. Reintubation following planned extubation: incidence, mortality and risk factors. Intensive care medicine experimental. 2015 Dec 1;3(Suppl 1):A684. doi: 10.1186/2197-425X-3-S1-A684.

14. Jagiasi BG, Chhallani AA, Dixit SB. Indian Society of Critical Care Medicine Consensus Statement for Prevention of Venous Thromboembolism in the Critical Care Unit. Indian Journal of Critical Care Medicine: Peer-reviewed, Official Publication of Indian Society of Critical Care Medicine. 2022 Oct;26(Suppl 2):S51. doi: 10.5005/jp-journals-10071-24195.

15. Kearon C, Akl EA, Comerota AJ. Antithrombotic therapy for VTE disease: antithrombotic therapy and prevention of thrombosis: American College of Chest Physicians evidence-based clinical practice guidelines. Chest. 2012 Feb 1;141(2):e419S-96S. doi: 10.1378/chest.11-2301.

16. Lacherade JC, Cook D, Heyland D et al. Prevention of venous thromboembolism in critically ill medical patients: a Franco-Canadian cross-sectional study. Journal of critical care. 2003 Dec 1;18(4):228-37. doi: 10.1016/j.jcrc.2003.10.006.

17. Sociedad Española de Medicina Intensiva, Crítica y Unidades Coronarias (SEMICYUC). Quality Indicators in Critically Ill Patients: Update 2011. Madrid: SEMICYUC; 2011. ISBN: 978-84-615-3670-2.

18. Knaus WA, Draper EA, Wagner DP, Zimmerman JE. APACHE II: a severity of disease classification system. Critical care medicine. 1985 Oct 1;13(10):818-29. PMID: 3928249.

19. Rosenthal VD, Yin R, Nercelles P, Rivera-Molina SE, Jyoti S, Dongol R, et al. International Nosocomial Infection Control Consortium (INICC) report of health care associated infections, data summary of 45 countries for 2015 to 2020, adult and pediatric units, device-associated module. American Journal of Infection Control. 2024 Sep 1;52(9):1002-11. doi: 10.1016/j.ajic.2023.12.019.