Evaluation of Quality Indicators in an Indian Intensive Care Unit Using "CHITRA" Database

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Abstract

Background: Quality indicators (QIs) are essential for maintaining quality of care in the critically ill. The Indian Society of Critical Care Medicine proposed benchmarks and enabled Indian Intensive Care Units (ICUs) to capture data in an electronic database: Customized Health in Intensive Care Trainable Research and Analysis (CHITRA) tool. The purpose of this study is to report QIs in an Indian ICU using this database. **Materials and Methods:** Data from patients admitted to ICU between October 2015 and January 2017 were entered into CHITRA. The following QIs were analyzed: standardized mortality ratio (SMR), length of ICU stay (LOS-ICU), pressure ulcer (PU) rate, patient fall rate (FR), ICU readmission rate, reintubation rate, ventilator-associated condition (VAC), central line-associated bloodstream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), and iatrogenic pneumothorax rate. **Results:** A total of 2642 patient's information was suitable for analysis. Median age of ICU admission was 53 years (interquartile range [IQR]: 36–65), with a mean APACHE score of 18 (SD 7.7). Median LOS-ICU was 3 days (IQR 2–6) and SMR was 1.1 (95% confidence interval 1.05–1.38). Pneumothorax rate, PU rate, and FR were 2.6, 4.1, and 0.3 per 1000 respectively, whereas readmission rate was 0.7% and reintubation rate was 3.5%. VAC, CLABSI, and CAUTI were 8.5, 23, 3.1 per 1000 ventilator and catheter days, respectively. **Conclusion:** This study has successfully evaluated a range of QIs in a mixed ICU of a tertiary hospital utilizing CHITRA database.

Keywords: Benchmark, critically ill, intensive care, quality indicators

INTRODUCTION

Quality indicators (QIs) have gained importance in care of the critically ill due to the vulnerable nature of patients, complexity of care delivery processes, and significant economic and workforce burden to caregivers. The concept "quality" had evolved in the eighteenth century in the backdrop of the Crimean war,[1] where the importance of hand hygiene and sanitation were identified. The release of American College of Surgeon's "Minimum Hospital Standard" statement in 1919[2] was seminal to the development of modern hospital standards. Other significant milestones in the path to better quality have been the establishment of Joint Commission on the Accreditation of Hospitals,[3] Williamson's concept of "achievable benefit not achieved,"[4] and the Donabedian model[5] on quality of care.

Quality of care in the Intensive Care Units (ICUs) in developed countries has been well described.[3,6,7] In the year 2008, a task force was constituted by the Indian Society of Critical Care Medicine (ISCCM) to formulate quality control in Indian ICUs,

and benchmarks and standards were proposed.[8] However, data on the use and applicability of these indicators have not been well described in India.

Currently, there is scanty literature available on quality of care in ICUs across India. The use of electronic health records (EHRs) could help circumvent this issue. However, projections indicate that by the year 2020, only 1.5% of Indian hospitals will have EHRs of the highest level (Stage 7), which can provide automated data analytics.[9]

To address this issue, the ISCCM in 2014 took the initiative to enable all Indian ICUs to capture and store relevant data in a systematic manner in an electronic database: Customized Health in Intensive Care Trainable Research and Analysis

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tool ("CHITRA").[10] This database did not require a sophisticated EHR and aimed to be an independent system. The aim of the current study was to report QIs in a single ICU using the CHITRA database and also assess feasibility of collecting data as part of routine work.

MATERIALS AND METHODS

The approval for this study was obtained from the Institutional Ethics Committee. Patients admitted to the ICU between October 2015 and January 2017 were included in the study, and data were captured at bedside computers in which CHITRA database had been installed. Informed consent was obtained from the legally authorized representative at admission. Material for this study was abstracted from the CHITRA database.

At admission, patient-specific diagnostic data were entered by medical staff. Ventilation and procedural and safety data were entered daily by nursing staff. Data necessary for calculating severity of illness were captured by ICU secretarial staff, who had been trained for data entry. At discharge, outcomes were captured by secretarial and senior nursing staff. Microbiological data were independently extracted from the Hospital Laboratory Information System. Formal training was given to medical and nursing staff to ensure that data entry into CHITRA was part of their daily work pattern. Random checks were done to ensure completeness and accuracy of data capture.

Outcomes measured

The following metrics from the QIs as suggested by the ISCCM quality guidelines[8] were collated: (1) standardized mortality ratio (SMR) (2) length of ICU stay (LOS-ICU), (3) pressure ulcer (PU) rate, (4) patient fall rate (FR), (5) ICU readmission rate, (6) reintubation rate, (7) ventilator-associated condition (VAC), (8) central line-associated bloodstream infection (CLABSI) rate, (9) catheter-associated urinary tract infection (CAUTI) rate, and (10) iatrogenic pneumothorax rate.

Statistical analysis

Data from CHITRA database were analyzed using STATA™ v14 (StataCorp. 2015. Stata Statistical Software: Release 14., StataCorp LP, College Station, TX, USA). QIs were calculated using standard formulae, which have been detailed in the electronic supplementary materials (ESM). The SMR was calculated using an internally generated predictive model based on prior data specific to the ICU. The coefficients and constants of the predictive model and methods to generate SMR have been detailed in the ESM. Iatrogenic pneumothorax rates, patient FRs, and decubitus ulcer rates were extracted from the database using the appropriate Systematized Nomenclature of Medicine-Clinical Terms codes which have been described in the ESM. LOS, VAC, CLABSI, CAUTI, and reintubation rates were calculated using scripts and standard formulae, which have been described in the ESM.

RESULTS

There were 2689 admissions to the ICU in the study period, of which 2642 patients (98%) had data which were captured in the CHITRA database and suitable for analysis. Demographic details are shown in Table 1.

Table 2 summarizes QIs over 3 monthly periods. LOS-ICU ranged from 1 to 93 days, with quarterly medians ranging from 3 to 4 days, and overall median ICU stay was 3 days (interquartile range [IQR] 2–6). The SMR was 1.1 (95% confidence interval 1.05–1.38), with one quarter having an SMR of 1.4. The total iatrogenic pneumothoraces were seven and rate of pneumothorax per 1000 ICU admissions ranged from 0 to 5.4 with a mean of 2.6 per 1000 ICU admissions. Before ICU admission, there were 44 PUs, and 11 patients acquired PU in ICU with quarterly incidence ranging from 0 to 7 and with overall incidence of 4.1 per 1000 admissions. Of 11 patients, eight had a single PU, two patients had two PUs, and one had four PUs. In our ICU, total readmissions within 24 h of discharge were 18 (0.7%). We noted only one fall in our study period, with FR of 0.3 per 1000 patient days (pd).

Of the 2642 patients, a total of 1075 (41%) received mechanical ventilation [Table 3]. Of these 37 (3.4%) patients were reintubated within 48 h of extubation. VACs were calculated per 1000 ventilator days (vd) and there were 37 VACs for 4347 vd, accounting to 8.5 per 1000 vd. There were no VACs recorded in first 3 months of the study period due to logistical issues in standardization of data collection. Table 3 also displays data of CLABSI and CAUTI over the study period. There were 23 and 3.1, CLABSI and CAUTI per 1000 catheter days (cd), respectively. However, the total cd for CLABSI and CAUTI were 10,210 and 11,203, respectively.

Table 1: Details of patients admitted to Intensive Care Unit

Variables	Values
Age, years (IQR)	53 (36-65)
Gender (female/male)	976/1666
APACHE II score (SD, range)	18 (7.7, 2-53)
LOD score (SD, range)	6.4 (3.5, 0-18)
Nursing ratio (nurses/patients)	1:2
Doctor:patient ratio	1:10
Outcome (%)	
Survived	70
Died ICU	19.6
DAMA	10.4
Source of admission (%)	
Emergency	47
Inpatient	34
Operation theater	5
Others	14

APACHE: Acute Physiology and Chronic Health Evaluation; SD: Standard deviation; ICU: Intensive Care Unit; IQR: Interquartile range; DAMA: Discharge against medical advice; LOD: Logistic Organ Dysfunction Score

Table 2: Quarterly data of quality indicators

Month	*N*	LOS, median (IQR)	SMR, mean (95% CI)	Pneumothorax, *n* (per 1000)	Pressure ulcer, *n* (per 1000)	Readmission, *n* (%)	Falls, *n* (per 1000 pd)
October-December 2015	332	4 (3-6)	1.0 (0.8-1.2)	0	-	1 (0.3)	1 (3)
January-March	492	4 (2-7)	1.4 (1.2-1.6)	2 (4)	7 (14)	4 (0.8)	-
April-June	548	3·5 (2-6)	1.2 (1.1-1.4)	3 (5.4)	2 (3.6)	2 (0.4)	-
July-September	640	3 (2-6)	1.1 (0.9-1.2)	2 (3.1)	1 (1.5)	4 (0.6)	-
October-December 2016	630	3 (2-6)	1.0 (0.8-1.2)	0	1 (1.6)	7 (1.1)	-
Total	2642	3 (2-6) Range (1-93)	1.1 (1.05-1.38) (*n*=1463)	7 (2.6)	11 (4.1)	18 (0.7)	1 (0.3)

N: Number of patients; LOS: Length of stay ICU; SMR: Standardized mortality ratio; IQR: Interquartile range; CI: Confidence interval; *n*: Indicate exact number of events; ICU: Intensive Care Unit

Table 3: Quarterly data of quality indicators (cont'd Table 2)

Month	*N*	Reintubation <48 h	VAC		CLABSI		CAUTI	
		Reintubated/ intubated (%)	*n*/ventilator days	Per 1000 ventilator days	*n*/catheter days	Per 1000 catheter days	*n*/catheter days	Per 1000 catheter days
October-December 2015	332	4/118 (3.4)	-	-	36/1233	29	1/1385	0.7
January-March	492	6/196 (3)	3/733	4	57/2234	25	6/2376	2.5
April-June	548	9/253 (3.5)	12/1314	9	73/2284	31	7/2481	2.8
July-September	640	8/261 (3)	15/1174	12.7	41/2452	16	11/2698	4
October-December 2016	630	10/247 (4)	7/1126	6.2	33/2007	16	10/2263	4.4
Total	2642	37/1075 (3.5)	37/4347	8.5	240/10,210	23	35/11,203	3.1

N: Number of patients; *n*: Indicate exact number of events; VAC: Ventilator-associated condition; CLABSI: Central line-associated bloodstream infection; CAUTI: Catheter-associated urinary tract infection

Discussion

This is the first single-center report on QIs, derived from the CHITRA database. CHITRA project had been initiated in the year 2014, as an endeavor to capture and scrutinize QIs and thereby attempting to standardize delivery of care in Indian ICUs and provide national benchmarks. Our results provide a range of QIs analyzed from a single center in contrast to earlier publications, which have focused on particular subsets of performance indicators.[11]

The median LOS in our ICU was 3 days (IQR 2–6), which was close to benchmark of 3.3 days. SMR is an objective way to evaluate the performance of an ICU and provides an appropriate estimate to compare outcomes between different units by adjusting disease severity and type.[12] SMR is influenced by geographical location and spectrum of cases in a particular region; hence while benchmarking, these factors should be considered.[13] SMRs published from Indian ICUs should be interpreted cautiously, as a well-validated scoring system has not been published for Indian ICUs and it is known that scoring systems perform poorly when applied in environments different from where they were derived.

Iatrogenic pneumothorax is one of the morbidity indicators that indicate patient safety. In a retrospective cohort study by John and Seifi,[14] they described a higher incidence of pneumothoraces in teaching, compared to nonteaching hospitals (1.3 vs. 1.0). Similar to this, our results from a tertiary teaching hospital showed an incidence of 2.6, which

was double the incidence noted in western teaching hospitals. Multiple factors such as level of training of person performing the procedure, degree of supervision, patient-related factors such as comorbidities, severity of illness, type of patients admitted to tertiary hospitals, and also availability of equipment (ultrasound machines) could have influenced the outcome.

Shea[15] classified PU into five grades. By including redness or erythema as grade 1, this classification has the potential to identify evolving ulcer at early stages. We used the same classification in our unit, and the incidence of PU was 4.1 per 1000 cases, which was better than western literature (22/1000).[16] These results are not surprising as preexisting PUs have been excluded and more than 34% of the admissions are from inpatient wards or other hospitals and preexisting PUs can thus be attributed to the original healthcare facility.

FR in our study was 0.3 per 1000 pd, which is markedly lower than the standard 8.46 as quoted by Barnett and House.[17] There have been wide variations in the incidence of FRs in various studies, ranging from 3.3 to 11 per 1000 pd. This is probably due to heterogeneity in study population.[18] FR is a significant safety concern and can lead to patient and family dissatisfaction, morbidity, and rarely mortality. Implementing protocolized care by multidisciplinary healthcare teams may reduce risk of falls in ICUs.[17]

ICU readmission may be related to quality of care in step-down units or errors in assessment for suitability of transfer out

of patients from ICU.[19] Readmission rates of 4%–6% have been published,[20,21] and lower rates could indicate long LOS in ICU and increased risk of nosocomial infections. Higher readmission rates may signify premature ICU discharges and such patients when readmitted have an increased LOS with 1.5–10 times greater mortality.[19,21,22] Our lower readmission rates (0.7 vs. 4%–6%) could be explained by financial constraints and perceived poor prognosis that could have influenced caregivers to opt for continuing care in the ward.

Reintubation rates in this study were also lower than that described by McMillan and Delgado (3.5 vs. 12%).[6,23] A near-zero reintubation rate may not be desirable as this may result in prolonged weaning or excessive tracheostomy rates. The optimal reintubation rate to be considered remains still an enigma. A balance should be maintained between the negative consequences of early extubation, resulting in reintubation, and the sequelae of delayed liberation from mechanical ventilation, resulting in higher incidence of nosocomial pneumonia and increased LOS-ICU.[24] In a large prospective observational study, 12.2% patients were reintubated within 48 h of extubation.[25] Lower reintubations in this study could be due to the following reasons: We routinely use ultrasonography to determine the fitness for extubation, especially in patients who are at high risk of extubation failure.[26] Second, we use prophylactic noninvasive ventilation in extubated patients with type 2 respiratory failure, congestive heart failure and patients who had weaning difficulties before extubation.[27] Third, we consider early tracheostomy in patients who are likely to fail extubation (e.g., chronic neurological/neurosurgical patients) although this approach is still debatable.

Nosocomial infections impose both financial and resource burdens. Commonly monitored nosocomial indicators are VAE, CLABSI, and CAUTI. In 2002, Centers for Disease Control and Prevention (CDC) defined ventilator-associated pneumonia (VAP) depending on specified clinical and radiological criteria.[28] Due to lack of consistency in the diagnosis;[29-31] in 2011, CDC modified the definition and grouped all conditions that lead to impaired oxygenation and termed it as VAE.[32] It was designed to capture the entire spectrum of infectious and noninfectious events that lead to impaired oxygenation and was implemented in the National Healthcare Safety Network (NHSN) in January 2013 for clinical practice. VAE also represents one of the patient safety indicators and is an important cause of morbidity and mortality.[33] We have calculated VAC in the hierarchical definition of VAE as we have limited data available on daily white blood cell count, culture reports, and other clinical parameters to define IVAC, possible and probable VAP. VAC incidence in this study was comparatively better than the International Nosocomial Infection Control Consortium (INICC) surveillance data (8.5 vs. 19.5) from ICUs of Latin America, Asia, Africa, and Europe.[34] Whereas, it is comparable with NHSN 2014 reported VAE incidence of 2–11 per 1000 vd.[35] We adopted routine practice of VAP prevention bundles as proposed by Institute for Healthcare Improvement

to minimize the risk.[36] We postulated that universal use of closed suction systems might have contributed to lower incidence of VAE.

CLABSI and CAUTI are two other commonly adopted nosocomial QIs. The rate of CLABSI in our ICU was 23 per 1000 cd, which was 3–5 folds higher than INICC and NHSN reported rates, 9.2 and 2–5 per 1000 cd, respectively.[34,37] CAUTI incidence in this study was 3.1 per 1000 cd, which was comparable to INICC (4 per 1000 cd) and NHSN (6 per 1000 cd) surveillance studies.[34,37] As compared to VAE and CAUTI rates, our CLABSI rates were higher than the published benchmarks. The probable explanations could be that there were relatively more manipulations of the central venous catheters by our health care providers, in contrast to urinary drainage and endotracheal suction systems which were closed systems. Femoral location of central lines may contribute to increased CLABSI rates; however, despite more than half of the central line days being femoral (55%), the proportion of CLABSI attributable to femoral central lines were not significantly different (22.5 femoral vs. 24.6 nonfemoral per 1000 cd, $P = 0.5$ Fisher's exact test).

We have compared performance of QIs in various Indian studies with our results [Table 4]. There is no large single-center study, which has evaluated a range of QIs. To our knowledge, QIs such as iatrogenic pneumothorax and FR in Indian ICUs have not been widely published. A wide variation in the performance of QIs in Indian ICUs is shown in Table 4. This is possibly due to heterogeneity of study population. For instance pressure ulcer rates were studied in only one study by Babu *et al*.,[51] where the incidence was 31 per 1000 pd in a dedicated neuro-surgical ward, and the higher rate could be attributed to the specialized subset of patients in this study. Median LOS-ICU in a large multicenter trial was 6 days whereas median LOS-ICU in this study was 3 days.[38]

Our study which included mixed medical and surgical population ($n = 2642$) had a readmission rate of 0.7%, whereas readmission rate (<48 h) in the study by Amin *et al*.,[39] which included 1190 surgical patients was two folds higher (1.4 vs. 0.7%). This may be due to a lower cutoff chosen in our study for readmissions (<24 h of discharge from ICU). Karthikeyan *et al*.[40] reported a reintubation rate of 29%, where 41% of patients had poisoning and envenomation, explaining the higher reintubation rate as compared to our study (29 vs. 3.5%).

There are numerous studies published on incidence of VAP, CLABSI, and CAUTI with varying incidence.[41-45] Earlier studies on VAP incidence used the clinical pulmonary infection score,[42-44,46,47] which is known to have unpredictable sensitivity and specificity,[31,47] whereas a recent study by Mathai *et al*.[41] had not specified the exact criteria used to define VAP. We have calculated VAC using recent CDC guidelines.[32]

Dasgupta *et al*.[43] and Datta *et al*.[44] reported CLABSI and CAUTI rates using 2008 CDC/NHSN surveillance

Table 4: Comparison of performance of quality indicators

Quality indicator	Results from our study	Other Indian studies	Benchmarks (international)
LOS, median (IQR)	3 (2-6)	6, 4.5[38-50]	3.3[23]
Pneumothorax (per 1000)	2.6	-	0.9-1.4[14]
Pressure ulcer (per 1000)	4.1	31[51]	22[16]
Readmission (<24 h) (%)	0.7	1·4 (<48 h)[39]	4-6[6,23]
Falls (per 1000 pd)	0.3	-	3.3-11[18]
Reintubation (<48 h) (%)	3.5	29[40]	12[6,23]
VAC (per 1000 ventilator days)	8.5	40.1, 31.7, 26.6, 6.04[41-44]	2-11 and 19.5[34,35]
CLABSI (per 1000 catheter days)	23	2.46, 13.86[43,44]	2-5 and 9.2[34,37]
CAUTI (per 1000 catheter days)	3.1	7.44, 9.08, 4.9[43-45]	4 and 6.5[34,35]

LOS: Length of stay ICU; IQR: Interquartile range; VAC: Ventilator-associated condition; CLABSI: Central line-associated bloodstream infection; CAUTI: Catheter-associated urinary tract infection; ICU: Intensive Care Unit

guidelines.[47] The incidence of CLABSI in Dasgupta *et al.*[43] and Datta *et al.*[44] was 2.46 and 13.86 per 1000 cd, respectively, and CAUTI rates in these studies were 7.44 and 9.08 per 1000 cd, respectively. We followed recent criteria to define CLABSI[48] and CAUTI[49] to improve the diagnostic accuracy and found the incidence as 23 and 3.1 per 1000 cd, respectively. The number of patients included in prior studies from India was less than the present study.

During the study period, 98% of all admissions had data successfully captured and suitable for generation of quality metrics. This has demonstrated the feasibility of collection of quality data on a routine basis. This has been possible using the CHITRA system which has been developed at a modest cost of INR 3,500,000 (USD 55000). The EHR penetration in developing countries is likely to be low over the next few years; due to economic constraints, there is a role for systems such as CHITRA. Projects such as CHITRA if implemented in a significant number of Indian ICUs can lead to the development of national benchmarks, which will contribute to better quality and safety.

This study has limitations, and being a single-center study, the results cannot be easily generalized. All QIs as suggested by the ISCCM could not be captured in this study. Medication errors and adherence to protocols were metrics which required significant contributions in time from personnel, which was difficult to implement. Calculating the denominator for needle stick injuries was also difficult to execute successfully. The SMR has been calculated from an internally derived scoring system. In the absence of a validated general purpose Indian scoring system, the SMR can only be used as an internal quality metric.

Conclusion

This study has successfully evaluated a range of QIs in a mixed ICU of a tertiary hospital from India. This study has also demonstrated the utility of the CHITRA system and the feasibility of generating QIs as a part of routine care.

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Conflicts of interest

There are no conflicts of interest.

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