Review

Quality indicators in ICU

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The Copenhagen Poliomyelitis outbreak in 1952 witnessed the birth of the intensive care specialty which has grown at a remarkable pace since then. Target-oriented therapies and bundles are gaining favor as modalities to improve patient outcomes in intensive care units (ICU). A three-pronged strategy comprising standardisation, improvement and innovation is the preferred modality in formulating key performance indicators for quality care in ICU. Monitoring, auditing and improving these parameters is a dynamic process. Standardization involves removing the outliers, to minimize the standard deviation. Improvement denotes gradual and irreversibly consistent betterment of a parameter quality indicator from the previous level. Innovation is sporadic and often requires problem solving by reflection and concentration. In Total Quality Management (*TQM*) parlance, standardization and improvement come with all-round participation in the unit and are a product of daily management while innovation comes from a particular individual, or a section of the people connected with the unit and is a product of policy management. TQM is essential to judge the appropriateness and effectiveness of medical care.[1,2]

Importance of quality:

The quality indicators (QI) are measures of health care quality that use hospital inpatient administrative data for assessment by healthcare decision makers to identify quality concerns and areas of improvement over time. They are surrogate, but objective measurements of medical quality and patient outcomes. The majority of ICUs, especially in the developing world are being run as open or semi-closed units, with unaccountable custodians, impeding development of standardized QIs. They must be compliant with the "RUMBA" rule (Relevant, Understandable, Measurable, Behaviourable and Achievable). Regular evaluation using the "PDCA (Plan-Do-Check-Act) cycle", designed by Deming and Shewarts, facilitates quick and sustained implementation of quality improvement measures.[2,3]

Indicators of quality [4,5]

As per NICE's (National Institute for Health and Care Excellence, UK) definition, "a quality standard is a statement to help improve quality, and an indicator is a measure of outcomes that reflect the quality of care, or process linked, by evidence, to improved outcome". Indicators must comprise the three characteristics of validity, specificity and sensitivity.

Indicators of quality can be categorized as follows:

- Mortality indicators
  - Standardized Mortality Rate
- Morbidity indicators
  - Iatrogenic Pneumothorax
  - Incidence of Acute Renal Failure in Non-coronary ICU
  - Decubitus (Pressure) Ulcer
- Operational or Process Parameters
  - Length of Stay
  - Compliance to Protocol
  - ICU Readmission Rate
- Error and Patient Safety
  - Patients' Fall Rate
  - Medication Error
  - Needle-stick injury
  - Reintubation Rate
- Infection Control
  - Ventilator Associated Pneumonia (VAP)
  - Blood Stream Infection Due to Central Line
  - Urinary Catheter Related Infection
- Human Resource
  - Overall Staff Satisfaction

- Customer Focus
    - Patient Satisfaction (Customer Satisfaction)

Standard quality indicators in ICU[6,7]

Active use of QI in various countries follows the Donabedian's method (Avedis Donabedian 2003), to assess clinical performance using 3 different classes: Structure, Process and Outcome. The Dutch Intensive Care Medicine Society working group also divided the quality ICU indicators according to character into 3 types:

1. Outcome Indicators: Standardized Mortality Rate as per APACHE II or IV (Acute Physiology and Chronic Health Evaluation) score (as the denominator in SMR) ; Pressure sore rate; Accidental extubation rates.
2. Process Indicators: Duration of ICU stay; Duration of Mechanical Ventilation; Full-bed occupancy; Normoglycemia.
3. Structural Indicators: Availability of round-the-clock intensivist; Nurse-to-patient ratio; Risk management; Patient-relative satisfaction.

A detailed description of the various quality indicators in ICU[8,9] and how to calculate and interpret them is tabulated below:

Parameter	Definition	Calculation	Interpretation
Standardized Mortality Rate or Risk-adjusted Mortality.	Allows comparison of actual performance of the institution with predicted performance, based on the average mortality as expressed by national/international data.	SMR = (Observed Rate/Risk-adjusted expected Rate) X100 Observed rate = Actual death in ICU Risk adjusted expected rate = Predicted death rate by predictive Model	Equal to 100: Hospital's mortality rate and the expected average rate are the same. >100: Hospital's mortality rate is > expected average mortality rate <100: Hospital's mortality rate is < the expected average. Provides opportunity to individual ICUs for improving the processes and techniques.
Iatrogenic Pneumothorax	Procedure related pneumothorax	(No. of pneumothorax / No. of cases) X 1000	Associated mortality and morbidity, prolonged stay, cost implications
Incidence of Acute Renal Failure in Noncoronary ICU	Denovo acute renal failure requiring renal replacement therapy or when urine output is < 200 mL in 12 h and/or marked azotemia defined as a BUN level > 84 mg/dL) during patient's ICU stay.	Number developed severe renal failure/Number managed in ICU X 100	Renal failure increases possibility of death, (60.3%). Modest increase in the serum creatinine level (0.3 to 0.4 mg per decilitre) increases risk of death by 70% when compared to normal creatinine levels.
Decubitus (Pressure) Ulcer	Prolonged continuous pressure over bony prominences causes ulcerative necrosis. Decubitus ulcers undergo stages: Stage-1: Superficial color change; Stage-2: Partial-thickness skin loss; Stage-3: Full-thickness skin loss; Stage-4: Extensive deep tissue damage (muscle, tendon, bone). 67% of pressure sores involve hip and buttocks.	Number of pressure ulcers / Number of cases X 1000	Annual cost of treatment in the US exceeds $1 billion.
Length of ICU Stay (LOS)	Total hours+days patients managed with midnight bed occupancy are more accurate	Total occupied bed days / number of patients in a	No. of ICU beds being limited, rational utilization for needy patients is desirable. Hence,

	than the number of calendar days spent in the ICU. Median is better than Arithmetic Mean as it circumvents outliers.	given time interval (week/month/year)	LOS is a quality of care and resource utilization indicator.
Compliance to Protocol	90% compliance to selected guidelines, protocols, treatment bundles in the ICU (to optimize patient care, resource utilization, and iatrogenic complications) is the benchmark.	Number of times followed/ number of times expected to follow × 100	Compliance to protocols, guidelines and treatment bundles are expected to improve patient care. Compliance to protocol could be absolute or partial.
ICU Readmission Rate	ICU readmission within 24h of transfer during a single hospital stay.	(Number of readmitted patients/ Total patients managed in ICU) × 100	Zero readmission rate: Defensive approach by the ICU team (increases LOS in ICU with risk of nosocomial infection, iatrogenic complications, and nonavailability of beds for deserving patients).
Patients' Fall Rate	An untoward event, resulting in the patient coming to rest unintentionally on the ground/lower surface.	Fall rate = (no. of falls/no. of bed days) × 1000	Fall could be accidental, anticipated physiological or unanticipated physiological. This is a safety issue for a patient in ICU. Accidental fall could lead to morbidity, prolonged stay and customer dissatisfaction.
Medication error	Medication error could be due to wrong prescription, dosing or communication gap (verbal or written)	Medication error rate = (no. of error /no. of bed days) × 1000	The need for assessing ICU medication error frequency is highlighted by the finding that 78% of the serious medical errors that occurred in the ICU were attributed to medications.
Adverse Events /Error Rate	Common ICU errors are related to treatment, procedure, ordering or carrying out medication orders, reporting or communication, and failures to take precautions or follow protocols.	Adverse events/ error rate = (no. of error /no. of bed days) × 1000	Critically ill patients are at high risk for complications due to the severity of medical conditions, complexity of treatment, poly pharmacy and technology-based interventions. 45% of the adverse events are preventable.
Needle Stick Injury Rate	Penetrating stab wound with/without exposure to blood/other body fluids	Incidence per 10,000 venipunctures	Although a minor injury, disease transmission is a concern. Blood filled hollow bore needles account for 63% of the needle stick injuries.
Reintubation Rate	Reintubation within 48 hours of extubation	(Number reintubated/ Number extubated) × 100	Accidental extubation and reintubation can prolong LOS: Longer ventilation, higher nosocomial pneumonia and mortality.

Ventilator Associated Pneumonia (VAP)	Ventilated patient developing new opacity and also fulfilling criteria of VAP.	No. of patients with VAP / No. of days of mechanical ventilatory support with endotracheal tube x 1000	It increases days of ventilation. Reported crude mortality rates in VAP exceed 50%, and the attributable cost of VAP approaches $20,000
Blood Stream Infection Due to Central Line (BSI)	Blood stream infection rates = number of central line related BSI per 1000 central line-days	No. of central line associated BSI / No of central line days x 1000	BSI is ranked as the eighth leading cause of death in the United States
Urinary Catheter Related Infection (UTI)	Incidence of UTI per 1000 catheterized days in patients catheterized in ICU but not infected on the day of catheterization.	No. of UTI cases / No. of catheter days x 1000	UTI has the highest prevalence rate and increases morbidity, mortality, cost and stay.
Overall Employee Satisfaction	Satisfaction level of the ICU staff	On a 1-to-5-point scale where 1 represents lowest satisfaction and 5 indicates highest possible satisfaction	Satisfied work force gives better output and higher retention rate.
Patient Satisfaction	A perceived parameter by the patient.	Survey can be conducted by external agency to eliminate bias or feedback forms can be collected regularly and should analyze admission/registration process, facilities, food, interactions with nurses and physicians, discharge process, personal issues, overall assessment of the care and other services. (10-point scale;10 stands for the best possible service). Patients give a rating for all the questions. Average score for each service is calculated from the rating given by each patient.	Reflects performance of the hospital as perceived by patients (customer) Satisfaction of the customer is directly related to financial return to the hospital and also reveals institutions credibility in the population it functions. It also gives opportunity for improvement.

Quality Indicators of Cardiac Critical Care[10]

There are several QIs of cardiovascular intensive care which can be divided into process, structure and outcome measures on the basis of general parameters such as overall CCU mortality, length of stay, re-admission rate; and disease-specific indicators such as myocardial infarction, heart failure, atrial fibrillation and cardiac rehabilitation.

	General	Myocardial Infraction (MI)	Heart Failure (HF)
Process	*Adherence to protocols for common acute cardiac conditions	*Aspirin prescription for all acute MI patients within 24 hours and at hospital discharge *Statin and dual anti-platelet therapy at discharge	
Structure	#Electronic prescription and Medication safety #CCU volume #Interventional cardiology lab availability (24x7)		
Outcome	^CCU length of stay ^CCU mortality	^Acute MI mortality ^Post-MI Re-admission	^CCU length of stay for HF patients ^Mortality rate due to HF ^post-HF re-admission rates

Quality Indicators of Respiratory Critical Care[11]

The quality indicators pertaining to respiratory critical care can be either general parameter like overall standardised mortality rate, length of ICU stay, unplanned re-intubation and re-admission rate; and/or disease-specific measures encompassing asthma, COPD (chronic obstructive pulmonary disease), pneumonia and tuberculosis.

Quality Indicators of Nephro-Critical Care[12]

Critical care nephrology is a rapidly growing and challenging field covering the spectrum of acute to chronic kidney injury to renal failure, requiring intermittent to continuous renal replacement therapy. CRRT is a complex, costly and highly specialized form of life-sustaining therapy, whose optimal delivery demands a quality assurance system based on multi-disciplinary team assembly, CRRT protocol standardisation, electronic CRRT flow sheets, and monitoring of quality metrics of CRRT deliverables. The following are the quality indicators pertaining to CRRT in ICUs -

a) Dose (25-30 ml/Kg/hour): prescription, delivery, downtime, fluids
b) Anticoagulation: Selection, Monitoring and Complications.
c) Treatment interruptions: number, duration, prescription to therapy time
d) Catheter-and Circuit-related issues: Infections, Bleeding, Clotting, Alarm

Quality Indicators of Neuro-Critical Care (NCC)[13]

In addition to general ICU quality indicators, neuro-critical care units can be assessed using disease-specific measures relating to stroke, seizures, brain haemorrhage and traumatic brain injury (TBI). Studies have found that organisational factors like NCC team expertise, and the centres' volume and experience in managing NCC conditions have a great impact on quality of patient care imparted. The "bouncing back" rate is a QI, as NCC patients have a high rate of returning back to the ICU after transfer-out.

Quality indicators in Onco-critical care[14]

QIs in oncology ICUs can be developed for the specific type, location and stage of cancer as well in relation to the modality of treatment or its complications: diagnostic, therapeutic, palliative, surgical and end-of-life care. RIOT (Return to Intended Oncologic Treatment) is an important quality indicator in onco-critical care units, besides infection of indwelling bloodstream catheters like central venous and chemoport lines.

Review of Literature and Clinical Implications[15,16,17]

The following table summarizes some of the reported studies regarding different measures of quality indicators in the ICU:

Manuscript; Author; Year	Findings	Clinical Implications
Wenzel et al. The impact of hospital-acquired bloodstream infections. Emerg Infect Dis. 2001;7:174-7.	Population-based surveillance studies of nosocomial infections in U.S. hospitals indicate a 5% attack rate or incidence of 5 infections per 1,000 patient-days. Bloodstream infections represent the eighth leading cause of death in the United States	Because most risk factors for dying after bacteremia or fungemia may not be changeable, efforts at prevention must focus on new infection-control technology and techniques.
Raad I, Intravascular catheter-related infections: advances in diagnosis, prevention, and management. The Lancet infectious diseases. 2007; 7:645-57.	Indwelling vascular catheters are a leading source of bloodstream infections in critically ill patients and cancer patients. Because clinical diagnostic criteria are either insensitive or non-specific, such infections are often over-diagnosed, resulting in unnecessary and wasteful removal of the catheter.	Catheter-sparing diagnostic methods, such as differential quantitative blood cultures and time to positivity have emerged as reliable diagnostic techniques. Novel preventive strategies include cutaneous antisepsis, maximum sterile barrier, use of antimicrobial catheters, and antimicrobial catheter lock solution. Management of catheter-related bloodstream infections involves deciding on catheter removal, antimicrobial catheter lock solution, and the type and duration of systemic antimicrobial therapy. Such decisions depend on the identity of the organism causing the bloodstream infection, the clinical and radiographical manifestations suggesting a complicated course, the underlying condition of the host (neutropenia, thrombocytopenia), and the availability of other vascular access sites.
The quality indicator study group. An approach to the evaluation of quality indicators of the outcome of care in hospitalized patients; with a focus on nosocomial infection indicators. Infect Control hosp Epidemiol. 1995;16:308–16.	Premature transfer can reduce ICU stay and expenditure.	LOS therefore should also be correlated to ICU readmission within 24 hours of transfer during a single hospital stay. Reported ICU readmission rates are around 5–6%. which can be used as benchmark data to compare readmission rate of a given ICU setup. Reduction in ICU readmission rate can be taken as improvement initiative to reduce crude mortality.
Nyamogoba H, Obala AA. Nosocomial	Premature transfer comes at the cost of worse outcome.	Higher risk of nosocomial infection and iatrogenic complications and creating a strain on hospital resources will be the end result of

infections in developing countries: cost effective control and prevention. East Afr Med J. 2002;79:435–41		prolonged and unnecessary ICU stay but premature transfer increases the ICU readmission rate.
McMillan TR, Hyzy RC. Bringing quality improvement into the intensive care unit. Crit Care Med 2007;35:S59–65.	They reviewed the breadth of approaches to quality improvement in the intensive care unit, including mortality and length of stay, and the use of protocols, bundles, and the role of large, multiple-hospital collaboratives.	Although "zero defects" may not be possible in all measurable variables of quality in the intensive care unit, several measures, such as catheter-related bloodstream infections, can be significantly reduced through the implementation of improved processes of care, such as care bundles. Large, multiple-centre, quality improvement collaboratives, such as the Michigan Keystone Intensive Care Unit Project, may be particularly effective in improving the quality of care by creating a "bandwagon effect" within a geographic region. Quality revolution maybe facilitated by the transition to the electronic medical record.

Future Prospects [18,19]

National level quality indicators have to be developed separately for pediatric, adult, geriatric and obstetric ICUs in the future, along with inclusion of Patient Reported Outcome Measures (PROM). The individual parameters need to be checked for feasibility and reliability at all levels of ICUs, especially in resource-limited settings. The global impact from the implementation of the validated QIs must be studied using large cohort and randomized controlled trials. Specific QIs dealing with various organ systems must be developed for different sub-speciality ICUs for assessing overall outcomes. The various international intensive care societies must formulate consensus guidelines regarding the various parameters used for defining QIs.

Healthcare is becoming transparent, and more customer focused. Patients and their relatives have the right to know the standard of care and its cost. Performance indicators are the basis for quality improvement in any ICU and should be utilized with scientific rigor. The adoption of JACHO (Joint Commission on Accreditation of Healthcare Organizations) and NABH (National Accreditation Board for Hospitals) protocols in institutions is a positive development towards standard quality improvement. Quality indicators are the key to comprehensive assessment and advancement of all critical care units.

Conflict of Interest: None

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