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Review Article

Quality Indicators in Adult Critical Care Medicine

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ABSTRACT

Quality indicators are increasingly used in the intensive care unit (ICU) to compare and improve the quality of delivered healthcare. Numerous indicators have been developed and are related to multiple domains, most importantly patient safety, care timeliness and effectiveness, staff well-being, and patient/family-centered outcomes and satisfaction. In this review, we describe pertinent ICU quality indicators that are related to organizational structure (such as the availability of an intensivist 24/7 and the nurse-to-patient ratio), processes of care (such as ventilator care bundle), and outcomes (such as ICU-acquired infections and standardized mortality rate). We also present an example of a quality improvement project in an ICU indicating the steps taken to attain the desired changes in quality measures.

Keywords: intensive care, patient safety, quality improvement, quality measures, quality indicators

INTRODUCTION

Attaining the desired outcomes of patients in any healthcare system is the direct result of the quality of provided care.[1] The Institute of Medicine describes quality care in healthcare as a care that is safe, timely, effective, efficient, equitable, and patient-centered.[1] Intensive care medicine is a core component of modern healthcare systems. Because of the complexity of patients, invasiveness of interventions, the interdependence of several providers, and reliance on teamwork, medical errors and adverse outcomes are common in intensive care units (ICUs).[2] In addition, variations in available resources and training backgrounds lead to variations in the provided health services and practice patterns among different healthcare providers, institutions, and countries.[3,4] As the demand for intensive care services and the associated costs have increased in the past few decades, several healthcare authorities and institutions have focused on improving the quality of care in the ICU and mandated the monitoring of quality indicators to compare their performance with national standards or international benchmarks.

CHARACTERISTICS AND SELECTION OF QUALITY INDICATORS FOR THE ICU

Quality improvement in healthcare depends on the measurement of relevant quality measures and indicators. Quality indicators are tools that are used to identify potential areas for improvement in the quality of care. In the ICU as well as in other settings, a quality measure can be a measure of structure, process, or outcome and can be selected based on the best available evidence or expert consensus if the evidence is lacking. A good quality measure should meet the following criteria.

1. *Important*, thus addressing an essential structure (such as ICU staff qualifications and staffing patterns), a common process with a large effect on outcome (such as the care processes related to mechanical ventilation) or a clinically meaningful outcome (such as mortality or development of a complication that is related to a common ICU process, i.e., ventilator-associated pneumonia [VAP]).[5]
2. *Relevant* to the patients and/or their families, thus being a patient-centered measure (such as pain control).[5]
3. *Feasible*, such that data collection is not too burdensome.[5]
4. *Valid*, thus the measure is supported by robust evidence linking it to improved outcomes.[5–7] In addition, data collection tools are standardized so that the results reflect the true problem, able to capture what providers do rather than patients' characteristics and are comparable across all ICUs.[5–7]

5. *Interpretable*, such that there are estimates, expressed in common metrics with sufficient variability to differentiate poor performers from good ones, and there are care processes associated with the indicator that are measurable.[8] This will make the quality measure more actionable.[5]

The selection process of a quality indicator usually goes through multiple steps.[7] It usually starts with a thorough literature review of the interventions/processes that improve one or more outcomes in the ICU.[7] This is followed by the selection of a pilot indicator in order to investigate the feasibility of data collection and to determine the required changes that would positively influence the indicator.[7] The data collection process should be defined (who, what, when, how) and the validity and reliability of data should be based on field studies.[7] Finally, the pilot indictor should be tested to evaluate how it performs in the ICU.[7] An indicator that does not provide opportunities for improvement can be dropped and other indicators that may potentially improve care can be adopted. If an indicator does not show any more variability, the indicator can be exchanged for a new one. As there are numerous quality measures, each ICU should select the indicators that are more likely to impact the outcomes of its patients.

QUALITY INDICATORS AS A DRIVER FOR QUALITY IMPROVEMENT IN THE ICU

More than 20 years ago, Berenholtz and coworkers[9] performed a systematic review of all studies that were published between 1965 and 2000 and provided a potential measure of the quality of intensive care and identified six outcome measures (ICU mortality rate; ICU length of stay >7 days; average ICU length of stay; average days on mechanical ventilation; optimal pain management; and patient/family satisfaction). They tested 18 items that were considered to be core quality indicators for the ICU and demonstrated the feasibility of implementing them in 13 adult medical and surgical ICUs in urban community teaching and community hospitals.[10] National institutions in several countries followed and developed quality indicators based on the best evidence and with the goal of improving the outcome of ICU patients.[11–14] In 2005, the Joint Commission on Accreditation of Healthcare Organizations instituted a reporting requirement for a set of four ICU core measures (patient positioning, stress ulcer prophylaxis, thromboprophylaxis, and central line–associated bloodstream infection [CLABSI]) that were based on the National Quality Forum report, with an additional two test measures (risk-adjusted ICU length of stay and hospital mortality). A task force of the European Society of Intensive Care Medicine published a list of quality indicators in 2012.[15] The structure indicators included compliance with national standards and an “adverse event” reporting system.[15] The process indicators included routine multidisciplinary ICU visits and a standardized transfer protocol.[15] The outcome indicators included standardized mortality rate, 48-hour readmission rate, rate of CLABSI, and rate of unplanned extubation.[15] Quality improvement programs in the ICU setting frequently use the following concepts.

1. Setting stretch goals

A stretch goal is a goal that may be difficult to attain. It usually involves setting a target for a change/improvement in a certain period. An example is the reduction of the rate of VAP by more than 50% within a 6-month period in an ICU with a high baseline rate. This usually inspires growth, counters complacency in teams, and communicates immediately and clearly that maintaining the current status is not an option.[16]

2. Zero-event target

Targeting zero events for certain quality indicators in the ICU reflects zero tolerance policy for adverse events and may be a realistic goal.[17,18]

3. Care bundles and the all-or-none approach

In a care bundle, related care processes, which are usually performed separately, are bundled to ensure that they are given together and to reduce the chance of important aspects of care being missed. This concept has been used to reduce VAP, CLABSI, and catheter-associated urinary tract infection (CAUTI). The all-or-none approach to measuring performance, in which all elements of a bundle must be done to be considered compliant, offers several important advantages over either individual or composite item measurement.[19]

4. The Comprehensive unit-based safety program (CUSP) model

This is a multifaceted approach to patient safety that has been proven to improve and sustain quality of care.[20] Its framework is composed of five steps: (1) train staff in the science of safety; (2) engage staff to identify defects; (3) senior executive partnership and patient safety rounds; (4) continue to learn from defects; and (5) implement tools to improve teamwork and communication.[20,21] The CUSP model provides a strategy for healthcare organizations to improve culture and learn from mistakes through the integration of safety practices into daily work.[21]

PERTINENT QUALITY INDICATORS IN THE ICU

There are many measures that are candidates to be quality indicators for the ICU.[8,13] These indicators usually address the most relevant core processes of intensive care such as mechanical ventilation, analgesia, sedation and delirium treatment, anti-infective therapy, nutrition, hygiene, and communication with patients and their relatives. An important factor is the number of indicators in the ICU at any given time and 10 indicators are thought to be a manageable number. It is also believed that some ICU quality indicators in one setting might not be transferred unchanged to another setting. In addition, quality indicators need to be reviewed periodically, as new evidence may refute the implementation of certain interventions. Table 1 describes important ICU quality indicators. The core indicators are the ones that should be implemented in all or most ICUs. We also present additional details on pertinent indicators and selected quality improvement projects that were related to them.

ICU Occupancy

Occupancy is a measure of capacity strain such that ICUs with high occupancy rates may be less capable of providing the same high-quality care on a given day as an ICU with more available beds.[22] There is no commonly accepted method for calculating ICU occupancy, but dividing the number of patient bed hours by the total number of available bed hours is probably the most accurate method.[23] This will allow the calculation of daily occupancy, which is a better benchmark of care quality than mean annual occupancy.[24] There is a clear association between higher daily ICU occupancy and early discharge/nonclinical transfer,[24] but whether this may lead to worse outcomes is unknown. It should be noted that some ICUs may be able to function as high-reliability organizations, where outcomes are maintained during low and higher occupancy rates.[25] In general, the optimal ICU occupancy rate is approximately 70–75%.[23]

Mortality

Mortality is an outcome measure that is important to healthcare providers as well as patients. The actual mortality rate can be misleading if it does not consider changes in patient mix (demographics, comorbidities, and diagnoses), and severity of illness. The standardized mortality ratio is the observed mortality divided by the mortality rate that is predicted by a prognostic score such as the various versions of Acute Physiology and Chronic Health Evaluation, Simplified Acute Physiology Score, and the Mortality Probability Model score.[26,27] The reliability of these scores depends on the completeness and accuracy of the abstracted data. In addition, they have been shown to overestimate the risk of death in the studied populations, as older scoring systems are used in newer data sets.[28] Standardized mortality ratios are useful in examining overall performance among general and specific ICU populations on a retrospective basis and in benchmarking across ICUs and institutions. They, however, cannot be used to prognosticate individual cases or to determine medical futility.

ICU Readmission Rate Within 48 Hours

Readmission rate is frequently used as a quality indicator because it is related to both patient outcome (increased mortality, cost, and length of stay) and organizational efficiency.[29] Currently, available studies are not clear about modifiable factors as tools to reduce readmission rate. In a retrospective study of 19,750 ICU admissions, the readmission rate was 7% and the independent variables associated with readmission were age, severity of disease, type of admission, infection, immunodeficiency, and last-day noradrenaline use.[30] In this study, the latter factor was the only one that could be modified.[30] Another study found that ICU readmission was associated with greater severity and complexity of illness.[29] Hence, readmission rates require case-mix adjustment before they can be a useful quality indicator.[29,30] Another study found that post-ICU admission hospital mortality and ICU readmission were poorly correlated and that ICU readmission performed poorly as a performance metric.[31]

Length of Stay

ICU length of stay is highly associated with the costs of care in the ICU. It is an easily quantifiable outcome indicator for the efficiency of ICU care. ICU discharge is often based on subjective criteria and could be influenced by the availability of bed and staff resources.[32] It is greatly influenced by the post-ICU setting and bed availability in the wards.

Hand Hygiene

Hand hygiene is an important indicator of safety and quality of care in any ICU. There is substantial evidence demonstrating that effective hand hygiene reduces ICU-acquired infection. Several quality measures, related to structure, process, and outcome, may be used in relation to hand hygiene.[33] In general, hand hygiene compliance is lower than the target for most ICUs worldwide. A systematic review that included 61 studies found a mean hand hygiene compliance of 59.6% (high-income countries 64.5%, adult ICU 58.2%, nursing staff 43.4%, physicians 32.6%).[34] To emphasize the importance of hand hygiene in preventing hospital-acquired infections, the World Health Organization started the "Clean Care is Safer Care" campaign in 2005, and then adopted the "SAVE LIVES: Clean Your Hands" initiative in 2009. It also provided tools and protocols on how to measure and monitor hand hygiene compliance. Optimal monitoring requires manual and continuous observation of hand hygiene practices, which is time-consuming and not feasible. Periodic audits are frequently performed but might be inadequate to measure the real compliance rate. A less complicated alternative is a monthly measurement of the volume of alcohol used for handrub. Published studies reported an average use of 68–73 mL of alcohol per patient per day[35]; however, this measurement does not provide information about the quality of hand hygiene or the compliance rates by specific healthcare providers.[35]

Strategies to improve hand hygiene compliance consist of the following: increasing the availability of alcohol-based hand hygiene products, staff education, reminders

Table 1. Description of important ICU quality indicators

Quality Indicator	Operational Definition	Measure Type	Applicability in the ICU
Quality Domain: Safety			
Availability of intensivists	The average number of hours per day that an intensivist is available within 5 minutes at the ICU, including weekends.	Structure	All ICUs
Intensive care specialist present 24/7	On-site presence of an intensive care specialist 24 hours per day, 7 days per week.	Structure	All/most ICUs
Patient-to-nurse ratio	Number of ICU patients present compared with the number of qualified ICU nurses that are available in day shift, evening shift, and night shift.	Structure	All ICUs
Hand hygiene compliance	Numerator: Number of healthcare providers performing appropriate handwashing using soap and water or an alcohol-based hand rub during any of the five moments of hand hygiene. Denominator: number of healthcare providers observed.	Process	All ICUs
Unplanned extubation	Number of patients who had unplanned extubation per 1000 invasive mechanical ventilation days.	Outcome	All ICUs
Readmission to ICU	Numerator: Number of patients with an unplanned readmission to ICU within 48 hours of ICU discharge. Denominator: Number of live discharges.	Outcome	All ICUs
Incidence of ventilator-associated pneumonia	Number of pneumonias occurring in patients requiring invasive ventilation through a tracheostomy or endotracheal tube (in place for at least 2 consecutive days before the onset of infection) divided by the number of ventilator days in the ICU in the same period. The measure is reported per 1000 ventilator days.	Outcome	All ICUs
Incidence of central line–related bloodstream infections	Number of cases with a laboratory-confirmed bloodstream infection associated with a central venous catheter. The measure is expressed per 1000 line days.	Outcome	All ICUs
Stress ulcer prophylaxis in ventilated patients	Numerator: Number of ventilator days on which patients received stress ulcer prophylaxis. Denominator: Total ventilator days.	Process	All ICUs
Thromboprophylaxis in ventilated patients	Numerator: Number of ventilator days on which patients received thromboprophylaxis. Denominator: Total ventilator days.	Process	All ICUs
Incidence of pressure injury of the skin	Number of ICU patients with incidence of decubitus, level 3 or 4 compared with the total number of treated patients in the same period.	Outcome	All ICUs
Rate of resistant infections	Numerator: Number of patients who developed resistant infections in the ICU (such as methicillin-resistant *Staphylococcus aureus*). Denominator: Total ICU patient days.	Outcome	Selected ICUs
The percent of ventilator days on which the head of bed is elevated ≥ 30°	Numerator: Number of ventilator days on which the head of the bed is elevated ≥30°. Denominator: Total ventilator days.	Process	All ICUs
Appropriate sedation	Numerator: Number of ventilator days on which (1) sedation was held for ≥12 hours or until patient followed commands or (2) patient followed commands without sedation held. Denominator: Total ventilator days.	Process	All ICUs
Appropriate blood transfusion	Numerator: Number of packed red blood cell transfusions for which the hemoglobin level immediately before transfusion was < 7–8 g/dL (include transfusions during massive bleeding and assume that these transfusions all had hemoglobin levels < 7–8 g/dL). Denominator: Total number of transfusions.	Process	All ICUs
Glucose (%) measurements > 8 mmol/L or < 2.2 mmol/L	Number of measurements greater than 8.0 mmol/L or lower than 2.2 mmol/L compared to the total number of glucose measurements.	Process	All ICUs
Use of daily goal sheets	Numerator: Number of patients in the ICU with completed daily goal sheet. Denominator: Number of patients in the ICU.	Process	All/most ICUs
Use of structured handover at transition of care	Numerator: Number of patients who had a structured handover at transition of care (i.e., shift change). Denominator: Total number of patients.	Process	All/most ICUs

Table 1 continues on next page

Table 1. Continued

Quality Indicator	Operational Definition	Measure Type	Applicability in the ICU
Quality Domain: Effectiveness			
ICU length of stay	Numerator: Sum of ICU length of stay for all discharges. Denominator: Total number of ICU discharges (including deaths and transfers).	Outcome	All ICUs
% of ICU patients with ICU length of stay >7 days	Numerator: All ICU patients with ICU stay > 7 days. Denominator: Total number of ICU discharges (including deaths and transfers).	Outcome	All ICUs
Extubation failure rate	Numerator: Number of patients requiring reintubation within 48 hours of a planned extubation. Denominator: Total number of invasively ventilated patients.	Outcome	All ICUs
ICU mortality	Numerator: Number of ICU deaths. Denominator: Number of ICU discharges (including deaths and transfers).	Outcome	All ICUs
Hospital mortality	Numerator: Number of patients who died while under the care of the ICU team or following discharge from the ICU during the same hospitalization. Denominator: Total number of ICU discharges.	Outcome	All ICUs
Risk-adjusted hospital mortality, such as standardized mortality rate	Observed hospital mortality rate divided by expected mortality rate by a predictive model such as APACHE II score.	Outcome	All ICUs
Consent rate for solid organ donation	Numerator: Number of patients with a neurologic determination of death for who consent was obtained for solid organ donation. Denominator: Number of eligible patients with a neurologic determination of death.	Process	Selected ICUs
Quality Domain: Timeliness			
Occupancy	Days of 100% bed occupation compared with the total number of days in the same period.	Process	All ICUs
ICU discharges that occur at night	Numerator: Number of patients discharged alive to a ward, step-down, high-dependency, high-observation, or another non-ICU patient area in the same hospital, between the hours of 22:00 and 06:59. Denominator: All live ICU discharges.	Process	All/most ICUs
Surgery cancellation	Number of cancelled operating room cases owing to lack of ICU bed.	Process	Selected ICUs
Early enteral nutrition	Numerator: Number of patients receiving enteral nutrition within 48 hours of ICU admission. Denominator: All patients who received enteral nutrition.	Process	All ICUs
Quality Domain: Efficiency			
Ventilated patient flow	The number of patients receiving mechanical ventilation (invasive or noninvasive for an acute indication) per ICU bed per year.	Process	All ICUs
Avoidable days in ICU	The amount of time that patients occupy an ICU bed for more than 4 hours after a transfer order is written is considered avoidable. Numerator: Avoidable days (24 hours). Denominator: Total patient days.	Process	All/most ICUs
Quality Domain: Patient/Family-Centered Outcome			
Patient/family satisfaction	Total score and domain subscales from the Family Satisfaction-24 survey (as an example of a validated survey).	Process	All ICUs
End-of-life pathway in place	Presence of a pathway for the care of patients at the end of life.	Process	All ICUs
Effective assessment of pain	Numerator: Number of 4-hour intervals for which patients had a pain score measured with the visual analogue scale. Denominator: Total number of 4-hour intervals.	Process	All ICUs

Table 1 continues on next page

Table 1. Continued

Quality Indicator	Operational Definition	Measure Type	Applicability in the ICU
Open visitation policy for family members of patients on palliative care	The presence of a policy in the ICU that allows family members and friends to spend time in patient's room regardless of the time of the day.	Structure	All ICUs
Quality Domain: Staff Work Life			
Staff turnover	Numerator: Number of nurses leaving ICU. Denominator: Total number of nurses working in the ICU.	Process	All ICUs
Overtime	Numerator: Number of nursing overtime hours. Denominator: Total hours worked.	Process	Selected ICUs
Absenteeism	Numerator: Number of nurse sick hours. Denominator: total number of hours.	Process	All ICUs

APACHE II: Acute Physiologic Assessment and Chronic Health Evaluation II; ICU: intensive care unit.

(written, electronic, and verbal), performance feedback, administrative support, and staff involvement.[36] Studies have reported variable improvement results with the different strategies.[36] Strict compliance with hand hygiene is time-consuming (a nurse may spend 58–70 minutes on hand hygiene per ICU patient per 12-hour shift),[37] and should be considered in staff planning.

Ventilator Care

Historically, the outcome measure that is related to ventilator care is VAP (Table 1). The Centers for Disease Control and Prevention in the United States replaced their longstanding VAP definitions with ventilator-associated event definitions in 2013 to capture harm not only from pneumonia but also from pulmonary edema, atelectasis, and acute respiratory distress syndrome.[38] Whether ventilator-associated event definitions are suitable to serve as quality indicators for the ICU is a controversial issue.[39] Interventional data demonstrating the preventability of these events are limited and conflicting.[40–42]

Process measures related to ventilator care are also used as quality indicators in the ICU. In 2004, the Institute for Healthcare Improvement recommended a ventilator bundle as part of the 100,000 Lives Campaign.[43] This bundle had four components: (1) elevation of the head of bed to 30–45°, (2) daily "sedation vacation" and assessment of readiness to extubate, (3) stress ulcer prophylaxis, and (4) thromboprophylaxis.[43,44] In 2010, the Institute for Healthcare Improvement added a fifth intervention: (5) daily oral care with chlorhexidine. Other elements were added with time as the related evidence evolved and included the use of subglottic secretion drainage, avoidance of scheduled ventilator circuit changes, and oral hygiene without chlorhexidine as chlorhexidine oral care was associated with higher risk of ventilator-associated events.[45,46] Improving ventilator care was also part of the ICU Liberation Collaborative, which focused on implementing pain, agitation, and delirium guidelines in ventilated patients.[47] This collaborative adopted the ABCDEF (A, assess, prevent, and manage pain; B, both spontaneous awakening and spontaneous breathing trials; C, choice of analgesic and sedation; D, delirium: assess, prevent, and manage; E, early mobility and exercise; and F, family engagement and empowerment) bundle.

In general, the evidence supports the use of the ventilator care bundle in the ICU. In a systematic review of studies that evaluated the implementation of the Institute for Healthcare Improvement ventilator bundle, 22 of 38 studies showed more than 36% decrease in VAP and 10 studies showed more than 65% decrease.[48] Another systematic review of 45 randomized controlled trials (5493 patients) showed that daily sedation interruption significantly reduced mechanical ventilation duration, ICU stay length, sedation duration, and tracheostomy and VAP.[49] In another improvement collaborative, the ABCDEF bundle was associated with a lower risk of hospital death within 7 days.[50] The multicenter prospective quasi-experimental National Approach to Standardize and Improve Mechanical Ventilation collaborative assessed the impact of evidence-based practices (subglottic suctioning, daily assessment for spontaneous awakening trial, spontaneous breathing trial, head-of-bed elevation, and avoidance of neuromuscular blockers) in 42 ICUs from 26 hospitals in Saudi Arabia, using the CUSP model and interventions that included online educational activities and real-time benchmarking of daily care process measures to drive improvement.[51] The collaborative was associated with improvements in daily care processes and with a reduction in mortality.[51]

Central Line–Associated Bloodstream Infection

CLABSI represents an important quality indicator as it is associated with significant morbidity, mortality, and cost and there is a good understanding of the related evidence-based prevention measures. Rates of CLABSI are tracked, reported, and tied to reimbursement by the Centers for Medicare and Medicaid Services. Studies show that the mean rate is 7.5 per 1000 catheter days, but vary widely between centers and countries (1.1 to 12.1 per 1000 catheter days in studies from the United States and 1.4 to 45.9 per 1000 catheter days in studies from other countries).[52] The CUSP model has been used for CLABSI prevention in the ICU and its effectiveness has been demonstrated in the implementation of the CLABSI bundle (hand hygiene, use of full barrier precautions, avoidance of femoral lines, skin antisepsis, and removal of unnecessary lines) in several institutions, which led to a sustained reduction in CLABSI rates by > 60%.[17,18]

Catheter-Associated Urinary Tract Infection

CAUTI is probably the most common infection in the ICU. The mean rate is 12.5 per 1000 catheter days (1.4 to 15.8 per 1000 catheter days in studies from the United States; 0.8 to 90.1 CAUTIs per 1000 catheter days in studies from other countries).[52] The principles of CLABSI prevention (aseptic insertion, maintenance care, and prompting removal) and the CUSP model have been applied to CAUTI prevention. There has been a slower adoption of CAUTI bundle than CLABSI likely due to less awareness about the clinical significance of CAUTI as well as lower success in reducing CAUTI rates.[53]

Hospital-Acquired Pressure-Induced Skin and Soft Tissue Injury

Pressure injury is a recognized metric of quality of care by the Centers for Medicare and Medicaid Services, which restricts reimbursement for hospital-acquired pressure injuries. Unavoidable pressure injuries do occur and may represent a form of acute organ failure.[54] Silicone foam dressing has been shown to reduce sacrum and heel pressure injuries in the ICU.[55] However, the evidence on other interventions, such as nutrition, skin-care regimen, positioning and repositioning schedule, support surfaces, and the role of education, is limited.[55] Pressure injury prevention and treatment in the ICU should be a multidisciplinary quality improvement initiative.

Patient Family Satisfaction

The perception of patients and their relatives about the care received is important. Their feedback on care provided in the ICU may provide information about a hospital's ability to provide good service and ultimately will support healthcare professionals in their continuing efforts to improve care.[56] Patient satisfaction is a complex measure that may not be consistent with patient outcomes,[57] nor with other markers of quality of care.[58] However, studies suggested that patient or family ratings correlated with other quality domains (organization and safety) in some settings.[59] In general, high ratings may reflect low expectations, and rising expectations might lower satisfaction. As the public increasingly adopts patient- and family-centered care, satisfaction ratings may drop further.

Tools to measure satisfaction include Critical Care Family Needs Inventory, the Society of Critical Care Medicine Family Needs Assessment, the Critical Care Family Satisfaction Survey, and the Family Satisfaction in the Intensive Care Unit.[60]

Staffing

It is intuitive that the ICU staffing level impacts the quality of care, patient outcomes, and staff well-being. A British study found no influence of registered nurse staffing on mortality rates, but a positive impact for doctor staffing and mortality.[61] By contrast, a Finnish study demonstrated that high nursing workload is associated with increased hospital mortality.[62] The optimal nurse-to-patient ratio in the ICU depends on the complexity of provided care but is usually 1:2 or fewer in high-level ICUs.[63] In academic medical ICUs, an intensivist-to-patient ratio less than 1:14 may negatively impact education, staff well-being, and patient care.[64] A taskforce of the Society of Critical Care Medicine suggested that high staff turnover or decreases in quality indicators in an ICU may be markers of overload.[64]

AN EXAMPLE OF A QUALITY IMPROVEMENT PROJECT IN THE ICU

The Scenario

The Infection Prevention and Control Department performed an audit in a busy 15-bed medical ICU of a tertiary-care hospital and reported to the medical director that 10 patients developed VAP in the preceding 3 months (12 cases per 1000 ventilator days). This was higher than the two cases of VAP diagnosed during a previous audit that was performed 9 months earlier. The ICU medical director embarked on a quality improvement project for VAP prevention.

Performing the Quality Improvement Project

In the following, we describe the quality improvement project as performed in the ICU focusing on the main steps and referring to the tools, concepts, and strategies (Six Sigma, Lean, and the Model for Improvement)[65–67] that were used during the process.

1. Establishment of a team

A team was formed and consisted of involved stakeholders and had a champion (a senior respiratory therapist who was responsible for the day-to-day management of the project), a leader (an intensivist who understood the implications of changes on other parts of the system), improvement advisor (a specialist with expertise in quality improvement methods), and three other team members (one ICU fellow and two ICU nurses). This team had the right balance of leadership, management, expertise, and power so that the project could succeed. The members received training in the Science of Improvement and a project charter was completed to document and outline the main aims.

2. Definition of the key metrics to measure success

The team decided that the target was a reduction in the VAP rate by 50% in the next 6 months. The team reviewed evidence-based practices to reduce VAP and decided that ventilator care bundle was the best process measure that would lead to VAP prevention.

3. Measurement (data collection)

The team performed audits daily at unannounced and variable times using a standardized and tested data collection form (a paper checklist). The average compliance rates for the elements of the ventilator care bundle were 91% for head-of-bed elevation, 95% for stress ulcer prophylaxis, 91% for thromboprophylaxis, 65% for sedation vacation, 70% for oral care, and 50% for subglottic suctioning. The total bundle compliance was 70%.

4. Analysis of data and determination of the causes and setting of goals

The team performed root cause analysis[68] to evaluate the causes of the increasing rate of VAP taking into consideration the measured data. A fishbone diagram was used to identify causes categorized into physical (equipment/environment), human (patient/provider), and system factors. The team decided that the low ventilator care bundle compliance was the root cause with a need to focus on elements with compliance less than 90%.

5. Improvement plan

The team produced an action plan that consisted of staff education on ventilator care bundle through posters and PowerPoint presentations, revision of the oral care protocol, and having only endotracheal tubes with subglottic suction lines in the ICU. The team used the PDSA (Plan, Do, Study, and Act) framework to test changes. One of the PDSA cycles was testing the validity of an electronic ventilator bundle checklist that was built in the electronic health record. Another PDSA cycle was related to improving daily sedation vacation. The team tested implementing a protocol to lighten sedation daily at 8 AM for eligible patients. The team also evaluated the precautions to prevent self-extubation (a balancing measure), such as increased monitoring and vigilance during the trial. Multiple cycles were performed to achieve the desired goals. Common tools used during the PDSA cycles were brainstorming, cause-and-effect diagram, prioritization of "vital few" causes (Pareto principle), corrective action, and monitoring of impact.

6. Control

This involved standardizing the changes so that they became part of daily routine work to facilitate sustainability.

Project Outcome

Compliance with the ventilator care bundle improved to 85%. The rate of VAP went down to 4.5 per 1000 ventilator days in 6 months. A control chart that depicted VAP rates at 3-month intervals was periodically reviewed by the team.

SUSTAINING QUALITY IMPROVEMENT IN THE ICU

Sustaining quality of care requires continuous or periodic auditing of quality indicators, and so significant resources, which may not be available for many ICUs. Electronic health records may have the feature of automated extraction of data including quality indicators,[51,69] as well as the real-/near-real-time display and share of data in different formats including control charts and dashboards.[12,51] This may also allow for detecting variation in process or outcome measures and identifying data points (i.e., a significant decline in a certain measure) that should be investigated,[12] thus possibly contributing to the performance and sustainability of quality projects. In practice, automated data extraction is currently limited by the variable capabilities of the different electronic health records and by the validity of entered data. These and other limitations should be addressed in the design and implementation of electronic health records in the future.

CONCLUSIONS

Quality indicators are crucial for the measurement of the quality of care in the ICU and are essential to inform quality improvement efforts. Each ICU should determine which indicators to measure and monitor taking into consideration national regulations and their specific needs. ICU staff knowledge of the essentials of quality improvement methods will help quality improvement efforts. Such efforts depend on the monitoring of quality indicators, which requires significant resources to perform. Automated data extraction from electronic health records may contribute to the sustainability of quality improvement efforts but is currently limited by multiple factors.

References

1. Baker A. Crossing the quality chasm: a new health system for the 21st century. *BMJ*. 2001;323:1192.
2. Rothschild JM, Landrigan CP, Cronin JW, et al. The Critical Care Safety Study: the incidence and nature of adverse events and serious medical errors in intensive care. *Crit Care Med*. 2005;33:1694–1700.
3. Vincent J-L, Marshall JC, Ñamendys-Silva SA, et al. Assessment of the worldwide burden of critical illness: the intensive care over nations (ICON) audit. *Lancet Respir Med*. 2014; 2(5):380–386.
4. Wunsch H, Angus DC, Harrison DA, et al. Variation in critical care services across North America and Western Europe. *Crit Care Med*. 2008;36:e2787–e2788.
5. Curtis JR, Cook DJ, Wall RJ, et al. Intensive care unit quality improvement: a "how-to" guide for the interdisciplinary team. *Crit Care Med*. 2006;34:211–218.
6. Silber JH, Rosenbaum PR, Ross RN. Comparing the contributions of groups of predictors: which outcomes vary with hospital rather than patient characteristics? *J Am Stat Assoc*. 1995;90:7–18.
7. Pronovost PJ, Berenholtz SM, Ngo K, et al. Developing and pilot testing quality indicators in the intensive care unit. *J Crit Care*. 2003;18:145–155.
8. Jawad I, Rashan S, Sigera C, et al. A scoping review of registry captured indicators for evaluating quality of critical care in ICU. *J Intens Care*. 2021;9:1–12.
9. Berenholtz SM, Dorman T, Ngo K, Pronovost PJ. Qualitative review of intensive care unit quality indicators. *J Crit Care*. 2002;17:1–12.
10. Pronovost PJ, Miller MR, Dorman T, et al. Developing and implementing measures of quality of care in the intensive care unit. *Curr Opin Crit Care*. 2001;7:297–303.
11. Braun J-P, Mende H, Bause H, et al. Quality indicators in intensive care medicine: why? Use or burden for the intensivist. *Ger Med Sci*. 2010;8:Doc22.
12. Chrusch CA, Martin CM. Quality improvement in critical care: selection and development of quality indicators. *Can Respir J*. 2016;2016:2516765.
13. De Vos M, Graafmans W, Keesman E, et al. Quality measurement at intensive care units: which indicators should we use? *J Crit Care*. 2007;22:267–274.
14. Ray B, Samaddar D, Todi S, et al. Quality indicators for ICU: ISCCM guidelines for ICUs in India. *Indian I Crit Care Med*. 2009;13:173.
15. Rhodes A, Moreno RP, Azoulay E, et al. Prospectively defined indicators to improve the safety and quality of care for critically ill patients: a report from the Task Force on Safety and Quality of the European Society of Intensive Care Medicine (ESICM). *Intens Care Med*. 2012;38:598–605.
16. Sitkin SB, See KE, Miller CC, et al. The paradox of stretch goals: organizations in pursuit of the seemingly impossible. *Acad Manage Rev*. 2011;36:544–566.
17. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med*. 2006;355:2725–2732.
18. Pronovost PJ, Watson SR, Goeschel CA, et al. Sustaining reductions in central line–associated bloodstream infections in Michigan intensive care units: a 10-year analysis. *Am J Med Qual*. 2016;31:197–202.
19. Nolan T, Berwick DM. All-or-none measurement raises the bar on performance. *JAMA*. 2006;295:1168–1170.
20. Berenholtz SM, Lubomski LH, Weeks K, et al. Eliminating central line–associated bloodstream infections: a national patient safety imperative. *Infect Control Hosp Epidemiol*. 2014;35:56–62.
21. Sawyer M, Weeks K, Goeschel CA, et al. Using evidence, rigorous measurement, and collaboration to eliminate central catheter-associated bloodstream infections. *Crit Care Med*. 2010;38:S292–S298.
22. Rodriguez-Carvajal M, Mora D, Doblas A, et al. Impact of the premature discharge on hospital mortality after a stay in an intensive care unit. *Med Intensiva*. 2011;35:143–149.
23. Tierney LT, Conroy KM. Optimal occupancy in the ICU: a literature review. *Aust Crit Care*. 2014;27:77–84.
24. Blayney M, Donaldson L, Smith P, et al. Intensive care unit occupancy and premature discharge rates: A cohort study assessing the reporting of quality indicators. *J Crit Care*. 2020;55:100–107.
25. Iwashyna TJ, Kramer AA, Kahn JM. Intensive care unit occupancy and patient outcomes. *Crit Care Med*. 2009;37:1545.
26. Garland A. Improving the ICU: part 2. *Chest*. 2005;127:2165–2179.
27. Herridge MS. Prognostication and intensive care unit outcome: the evolving role of scoring systems. *Clin Chest Med*. 2003;24:751–762.
28. Mann SL, Marshall MR, Holt A, et al. Illness severity scoring for Intensive Care at Middlemore Hospital, New Zealand: past and future. *N Z Med J*. 2010;123:47–65.
29. Kramer AA, Higgins TL, Zimmerman JE. Intensive care unit readmissions in US hospitals: patient characteristics, risk factors, and outcomes. *Crit Care Med*. 2012;40:3–10.
30. Woldhek AL, Rijkenberg S, Bosman RJ, Van Der Voort PH. Readmission of ICU patients: a quality indicator? *J Crit Care*. 2017;38:328–334.
31. Maharaj R, Terblanche M, Vlachos S. The utility of ICU readmission as a quality indicator and the effect of selection. *Crit Care Med*. 2018;46:749–756.
32. Verburg IW, Holman R, Dongelmans D, et al. Is patient length of stay associated with intensive care unit characteristics? *J Crit Care*. 2018;43:114–121.
33. Allegranzi B, Storr J, Dziekan G, et al. The first global patient safety challenge "clean care is safer care": from launch to current progress and achievements. *J Hosp Infect*. 2007;65:115–123.
34. Lambe KA, Lydon S, Madden C, et al. Hand hygiene compliance in the ICU: a systematic review. *Crit Care Med*. 2019;47:1251–1257.
35. Tschudin-Sutter S, Pargger H, Widmer AF. Hand hygiene in the intensive care unit. *Crit Care Med*. 2010;38:S299–S305.
36. Lydon S, Power M, McSharry J, et al. Interventions to improve hand hygiene compliance in the ICU: a systematic review. *Crit Care Med*. 2017;45:e1165–e1172.

37. Stahmeyer J, Lutze B, Von Lengerke T, et al. Hand hygiene in intensive care units: a matter of time? *J Hosp Infect*. 2017;95:338–343.
38. Klompas M. Complications of mechanical ventilation—the CDC's new surveillance paradigm. *N Engl J Med*. 2013;368:1472–1475.
39. Klompas M, Berra L. Should ventilator-associated events become a quality indicator for ICUs? *Respir Care*. 2016;61:723–736.
40. Klompas M. Ventilator-associated events: what they are and what they are not. *Respir Care*. 2019;64:953–961.
41. Pena-Lopez Y, Ramirez-Estrada S, Eshwara VK, Rello J. Limiting ventilator-associated complications in ICU intubated subjects: strategies to prevent ventilator-associated events and improve outcomes. *Expert Rev Respir Med*. 2018;12:1037–1050.
42. Ervin JN, Rentes VC, Dibble ER, et al. Evidence-based practices for acute respiratory failure and acute respiratory distress syndrome: a systematic review of reviews. *Chest*. 2020;158:2381–2393.
43. Munro N, Ruggiero M. Ventilator-associated pneumonia bundle: reconstruction for best care. *AACN Adv Crit Care*. 2014;25:163–175.
44. Resar R, Pronovost P, Haraden C, et al. Using a bundle approach to improve ventilator care processes and reduce ventilator-associated pneumonia. *Jt Comm J Qual Patient Saf*. 2005;31:243–248.
45. Rello J, Lode H, Cornaglia G, et al. A European care bundle for prevention of ventilator-associated pneumonia. *Intens Care Med*. 2010;36:773–780.
46. Harris BD, Thomas GA, Greene MH, et al. Ventilator bundle compliance and risk of ventilator-associated events. *Infect Control Hosp Epidemiol*. 2018;39:637–643.
47. Ely EW: The ABCDEF bundle: science and philosophy of how ICU liberation serves patients and families. *Crit Care Med*. 2017;45:321.
48. Mastrogianni M, Katsoulas T, Galanis P, et al. The impact of care bundles on ventilator-associated pneumonia (VAP) prevention in adult ICUs: a systematic review. *Antibiotics*. 2023;12:227.
49. Chen TJ, Chung YW, Chen PY, et al. Effects of daily sedation interruption in intensive care unit patients undergoing mechanical ventilation: a meta-analysis of randomized controlled trials. *Int J Nurs Pract*. 2022;28:e12948.
50. Pun BT, Balas MC, Barnes-Daly MA, et al. Caring for critically ill patients with the ABCDEF bundle: results of the ICU liberation collaborative in over 15,000 adults. *Crit Care Med*. 2019;47:3–14.
51. Arabi YM, Al Aseri Z, Alsaawi A, et al. Impact of a national collaborative project to improve the care of mechanically ventilated patients. *PloS One*. 2023;18: e0280744.
52. Patel PK, Gupta A, Vaughn VM, et al. Review of strategies to reduce central line-associated bloodstream infection (CLABSI) and catheter-associated urinary tract infection (CAUTI) in adult ICUs. *J Hosp Med*. 2018;13:105–116.
53. Saint S, Greene MT, Krein SL, et al. A program to prevent catheter-associated urinary tract infection in acute care. *N Engl J Med*. 2016;374:2111–2119.
54. Edsberg LE, Langemo D, Baharestani MM, et al. Unavoidable pressure injury: state of the science and consensus outcomes. *J Wound Ostomy Continence Nurs*. 2014;41:313–334.
55. Tayyib N, Coyer F. Effectiveness of pressure ulcer prevention strategies for adult patients in intensive care units: a systematic review. *Worldviews Evid Based Nurs*. 2016;13:432–444.
56. Lyu H, Wick EC, Housman M, et al. Patient satisfaction as a possible indicator of quality surgical care. *JAMA Surg*. 2013;148:362–367.
57. Kennedy GD, Tevis SE, Kent KC. Is there a relationship between patient satisfaction and favorable outcomes? *Ann Surg*. 2014;260:592.
58. Chang JT, Hays RD, Shekelle PG, et al. Patients' global ratings of their health care are not associated with the technical quality of their care. *Ann Intern Med*. 2006;144:665–672.
59. Dodek PM, Wong H, Heyland DK, et al. The relationship between organizational culture and family satisfaction in critical care. *Crit Care Med*. 2012;40:1506–1512.
60. van den Broek JM, Brunsveld-Reinders AH, Zedlitz AM, et al. Questionnaires on family satisfaction in the adult ICU: a systematic review including psychometric properties. *Crit Care Med*. 2015;43:1731–1744.
61. Griffiths P, Ball J, Murrells T, et al. Registered nurse, healthcare support worker, medical staffing levels and mortality in English hospital trusts: a cross-sectional study. *BMJ Open*. 2016;6:e008751.
62. Junttila JK, Koivu A, Fagerström L, et al. Hospital mortality and optimality of nursing workload: a study on the predictive validity of the RAFAELA nursing intensity and staffing system. *Int J Nurs Stud*. 2016;60:46–53.
63. Marshall JC, Bosco L, Adhikari NK, et al. What is an intensive care unit? A report of the task force of the World Federation of Societies of Intensive and Critical Care Medicine. *J Crit Care*. 2017;37:270–276.
64. Ward NS, Afessa B, Kleinpell R, et al. Intensivist/patient ratios in closed ICUs: a statement from the Society of Critical Care Medicine Taskforce on ICU Staffing. *Crit Care Med*. 2013;41:638–645.
65. Raisinghani MS, Ette H, Pierce R, et al. Six Sigma: concepts, tools, and applications. *Industrial Management & Data Systems*. 2005;105:491–505.
66. Silver SA, Harel Z, McQuillan R, et al. How to begin a quality improvement project. *Clin J Am Soc Nephrol*. 2016;11:893.
67. Scoville R, Litter K. *Comparing Lean and Quality Improvement*. Institute for Healthcare Improvement; 2014.
68. Bagian JP, Gosbee J, Lee CZ, et al. The Veterans Affairs root cause analysis system in action. *Jt Comm J Qual Iimprov*. 2002;28:531–545.
69. Sirgo G, Esteban F, Gómez J, et al. Validation of the ICU-DaMa tool for automatically extracting variables for minimum dataset and quality indicators: the importance of data quality assessment. *Int J Med Inform*. 2018;112:166–172.