Chapter 5
Quality Indicators: The Use of Metrics in Critical Care Medicine

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Quality has been described as the degree to which the delivery of healthcare increases the likelihood of desired patient outcomes and is aligned with best-known medical practices. Safety has been described as the absence of clinical errors, which includes doing the wrong thing (errors of commission) and not doing the right thing (errors of omission). The last 20 years have seen a move in healthcare from a fee-for-service-based healthcare system toward a pay for performance or value-based purchasing-based healthcare system [1]. One of the proposed benefits of this system lies in the alignment of incentives for healthcare providers, hospitals, and what is best, for patients. With this movement toward recognizing and paying for value in healthcare, an increased interest in the development of quality indicators and metrics has taken place [2]. Furthermore, a landmark publication from the Institute of Medicine on medical errors has served as a catalysts for the pursuit of safety in healthcare delivery [3]. Critical care provided in intensive care units is usually lower volume, higher acuity, higher resource demanding, and higher cost than other service lines/areas within the healthcare system [4]. Critical care consumes a disproportionate amount of resources, has a high rate of adverse events, and is delivered inconsistently with unwanted variability in adherence to the best established evidence-based practices [5, 6]. These factors make critical care a prime target for improvements in value and safety. Critical care professionals must understand how to evaluate the care they provide with valid metrics and to utilize these metrics to continually improve the value of care provided to ICU patients.

The goal of this chapter is to expose critical care practitioners and leaders to the fundamentals of measuring ICU value and quality of care. We will briefly describe the basic conceptual framework of value in healthcare, discuss the types and attributes of metrics for measuring quality in healthcare, discuss important factors for success, summarize common metrics utilized in the ICU, and finally discuss

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J. Hidalgo et al. (eds.), *Critical Care Administration*,
https://doi.org/10.1007/978-3-030-33808-4_5

potential pitfalls in this process. We will not describe cost metrics in detail neither present a comprehensive all-inclusive list of currently utilized quality metrics in critical care. We believe that providing our readers with principles they can apply in their journey to improve quality is a better approach than a quick recipe of existing metrics.

Value in Healthcare

At a very high level, value in healthcare is defined by the formula V = Q/C, where V = value, Q = quality, and C = cost. Recognizing that the delivery of healthcare is complex, it is true that this single formula is unable to capture all the nuances involved in measuring quality and cost in healthcare. However, this basic formula is a useful conceptual framework to think about how quality and cost relate to the creation of high-value care in our ICUs. The highest value in healthcare is achieved by improving outcomes at a lower cost. Historically, clinicians have championed quality and ignored to some extent the cost portion of healthcare. Today we recognize that resources are finite and that high cost care is not always beneficial for patients. Critical care professionals need to own both parts of this equation if we want to drive high-value care in our ICUs.

Quality includes patient outcomes and patient experiences with the healthcare process. Patient outcomes are defined by the ultimate results of the interventions and care provided. Important patient outcomes include survival, preservation of limbs, and ultimately the ability to resume their lives with the same degree of functionality and independence they had prior to becoming critically ill. Additional patient outcomes include the development of hospital-associated infections and complications associated with the provision of critical illness. For years we have placed great emphasis on patients surviving critical illness. As important as this is, we are now recognizing that there are vast consequences of surviving critical illness with significant long-term issues related to cognitive capacity, functionality, and psychological well-being [7]. These are some of the patient outcomes that feed the quality component of the value equation. Patient experience measures the level of satisfaction patients and their families (very relevant for ICU care, since many of our patients have altered consciousness during their ICU stay) have with the experience of care they received in the ICU.

Cost includes both direct and indirect costs associated with the provision of care in the ICU. Direct costs also known as variable cost include drugs, diagnostics, and material costs. Direct costs are easily identified as the object cost and are attributable. Indirect costs in healthcare include both financial and nonfinancial costs related to an ICU stay. Financial costs also known as fixed cost (these costs would not change based on the number of patients in an ICU) are more difficult to measure upfront and are not always directly attributable. Indirect costs include the extensive hospital infrastructure required to provide critical care (includes hospital facilities, management, and personnel salaries). In addition, there are nonfinancial indirect costs of critical care associated with pain and suffering for patients and families,

burnout for ICU physicians and nurses, and lost productivity from patients and families dealing with critical illness (also known as the opportunity cost).

Framework for Assessing Quality

Two decades ago, Donabedian proposed a conceptual framework for assessing the quality of care that has been widely adopted and today is considered a standard [8]. This framework links three key domains: structure, process, and outcome (also known as the S-P-O model). The vast majority of quality indicators and metrics utilized in critical care will fall under one of these three domains. Structure refers to the conditions (organizational, infrastructure, materials, and personnel) that enable the delivery of healthcare. Process refers to the activities that take place during the delivery of care. In other words, what healthcare providers do while treating patients in the ICU. Process includes activities related to diagnosis, treatment, prevention of complications, and progression of care through different sites of care. Outcomes are the end results of the care patients receive in the ICU. Specific outcome measures that may be utilized in the ICU include mortality, morbidity, development of hospital-associated infections, and quality-of-life-related measures in survivors of critical illness.

There are unique aspects of each one of these domains (S-P-O) that make them useful for the basis of potential quality metrics in the ICU. Structures include aspects such as physical layout of an ICU or hospital which may be difficult to change for critical care leaders. On the other hand, structure also includes materials and how they are organized such as the development of an airway or central line cart. These aspects are usually within the control of an ICU leadership team. Staffing models and the organization of the ICU team fall within the structure domain. Intensivist-led teams, percent of ICU nurses with special critical care certifications, presence of dedicated clinical pharmacists and clinical nutritionist, and decision-making structure for admission or discharge are all examples of metrics that fall within this domain. Metrics that fall within the structure domain often are dichotomous and are either present or not. Furthermore, structure measures are important in creating value mostly through their influence in modifying processes of care. Therefore, they are not sufficient on their own to provide a balanced assessment of quality in an ICU.

Process measures evaluate the activities the ICU team is performing in the act of caring for patients. Every activity that occurs in an ICU during the care of critically ill patients is a process whether it is recognized as such or not and regardless if it occurs by design or by default. Multidisciplinary rounds, weaning patients from mechanical ventilation, placement of a central line, treating a patient in cardiac arrest, preventing deep vein thrombosis, initiating ECMO, and having goals of care discussions are all processes and can be measured. Process measures are important as they reflect the actions that ultimately impact the drivers of value in healthcare, patient outcomes, and cost. In addition, process measures can help focus individual critical care practitioners and ICU teams on the behaviors they need to implement to create value for patients.

Outcome measures represent the end result of the care we provide in the ICU. Because of this, they are usually the most relevant to patients, payers, and society. Outcome measures do pose unique challenges for ICU directors; they may be more difficult to measure, capture, or benchmark, and they may not always be modifiable by the actions of the ICU practitioner or team [9]. Mortality is a prime example of an important patient-related outcome that presents these challenges. What is the proper mortality for an ICU? We know that mortality is universal, so trying to quantify mortality for an ICU without qualifying severity of illness, patient values, and appropriate goals of care among other factors can provide a limited measure of quality. An avoidable death from a process error clearly represents low-value care. However, a peaceful and comfortable death in a terminal patient with care aligned with the patient's values represents high-value care. Outcome measures are most relevant and useful when paired with process and structure measures that provide broader context about the overall quality of care.

Utilizing the S-P-O model as a foundational basis for quality assessment in healthcare has been ultimately proposed by the Institute of Medicine summarizing major goals and key elements of high-quality healthcare [10]. High-quality healthcare should aim to be patient-centered, timely, effective, efficient, safe, and equitable [10]. Patient-centered care requires that all care be provided in a respectful and compassionate way with the patient's preferences and values directing the goals of care and clinical decisions. Timely refers to the delivery of appropriate care without delays and in the proper time window as to allow the best outcomes for patients. Effective care provides evidence-based care to all patients who will benefit from this type of care and avoids providing futile or harmful care to patients who do not benefit from a specific type of care. Effective care is meant to avoid both under and over utilization of medical interventions. Efficient care seeks to drive value by addressing both outcomes and cost of care. If two drugs provide the same outcome for a specific patient; efficient care would guide the use of the drug with a lower cost. Efficient care is critical in eliminating waste in healthcare. Waste is a significant area of opportunity in the ICU. Safe care refers to the avoidance of avoidable harm to patients receiving care intended to help. Medical errors are a large cause of mortality and morbidity in healthcare. Quality metrics measuring safety are prevalent in critical care. Finally, equitable care relates to the moral imperative that every patient receive the right care at the right time irrespective of factors such as socioeconomic status, race, gender, or location. With the use of the S-P-O model as a foundation and the goals proposed by the Institute of Medicine, critical care leaders can start building quality programs with metrics that will help move their ICUs toward providing high-value care.

Essential Attributes of Quality Metrics

The S-P-O model provides the basis for broad categories from which to create quality metrics. When moving to the creation of individual quality metrics for critical care, one must also consider specific attributes required for a robust and useful

Table 5.1 Essential attributes of a good ICU quality metric

Importance
Validity
Reliability
Responsiveness
Interpretability
Feasibility

metric. A good quality metric in critical care should be important, valid, reliable, responsive, interpretable, and feasible (Table 5.1) [11]. We will further discuss each characteristic and how they relate to the ICU.

An important quality measure should be associated with high prevalence outcomes or outcomes that lead to significant morbidity and mortality. For structure measures to be important, they must have a proven connection to clinically important outcomes. For example, studies have shown that ICU teams led by critical care specialists and that ICU teams with dedicated clinical pharmacists are associated with improved patient outcomes [12, 13]. Measuring the presence of these structural factors in an ICU would meet this requirement. Furthermore, to meet this requirement, a quality measure should be important from the perspective of different stakeholders (i.e., patients, clinicians, hospital administrators, and payers). For some quality measures, the importance might vary depending on a specific group of stakeholders. In these cases, the critical team should consider the different perspectives from all stakeholders and seek balance when selecting quality measures. However, the ultimate guiding principle should always be to pursue what is best for our patients.

A valid measure is one that ultimately quantifies what it is intended to measure. Validation might require comparisons of a new quality metric to a previously established standard (criterion validity) or to other measures or constructs that are expected to give similar results (construct validity) [11]. It is common for ICU teams to adopt quality measures that have already been shown to be valid. If developing new measures, following their performance for validity is recommended.

A reliable measure will yield the same result when assessed by a different rater and should yield the same result when the factor being measured remains unchanged. These are known as interrater and intra-rater reliability. Similarly to the case of validity, ICU teams generally will use measures that have been found to be reliable. In the case of newly developed measures, following their performance for reliability is recommended.

A responsive measure is defined by its sensitivity to capture the result of changes introduced by a quality improvement program [11]. A measure such as this can determine that the changes produce meaningful impact on a particular element of the care. Fundamental requirements for a responsive measure include the presence of room for improvement in the measure and that the measure be capable of identifying that improvement. It is recommended that a gap between current performance and desired performance be present. Implementing quality measures where there is no room for improvement (a topped-out measure) or measures that are unable to detect improvement are not useful in driving value.

Lastly, good quality measures must be interpretable and feasible. A quality measure that is interpretable is easily understood by the critical care team involved, by the hospital administration, by payers, and ideally by patients. Success for a given quality measure must be clearly defined and understood by all stakeholders. Feasibility is a key ingredient for practical reasons. The best quality measure is unlikely to be of any utility in creating and/or assessing value if it is not feasible to obtain. Many critical care teams propose quality measures that unfortunately they are unable to measure or obtain consistently. Feasibility ultimately is determined by local resources. A measure may be feasible in one ICU but may not be transferable to another ICU at a different institution due to a lack of resources needed to obtain the measure reliably. Critical care teams need to assess feasibility for each quality measure they are considering for their quality program.

Setting Your Quality Program Up for Success

There are a host of important factors that should be considered prior to initiating a quality program. These factors can contribute in a significant way to the success of the program. We will discuss the importance of understanding purpose when measuring quality metrics, the benefit of engaging all disciplines within the ICU team, and finally the value of setting priorities and focusing on less rather than more. We have chosen these specific factors as the representative ones understanding that there are many others that could be considered.

Carol Dweck has championed the concept of developing a growth mindset. This school of thought is based on the basic understanding that becoming is better than being. The primary purpose of measuring quality metrics in the ICU is to improve the care we provide. Quality scorecards are not about getting great marks but about producing change. A great quality program will move care forward by allowing us to identify areas of opportunity and measure the impact of our team-based solutions. Making sure the purpose is clear to all team members and that this purpose is always present is critical. Too often, ICU leaders favor quality metrics where they think they will "look good." If we only measure what is done well, we are failing our patients.

The ICU by its very nature is an environment that thrives and flourishes when the input and expertise from the multiple disciplines involved in critical care have the opportunity to work as one team [14]. Likewise, solid quality metrics should be chosen with the input from all disciplines involved in the ICU team. Having alignment and buy-in from the entire multidisciplinary ICU team is a fundamental factor for success. Engagement is significantly more likely when all disciplines are involved early in the process. Furthermore, the expertise of the different disciplines is likely to shed important insights. The multiple disciplines in the ICU need to be aligned on the quality metrics and develop a shred consciousness on those measures that are important to their particular ICU.

Finally, it is important to discuss the value of focus and being deliberate in choosing priorities. If everything is important, nothing is important. Many ICUs measure

a vast number of quality metrics. Unfortunately, in many cases this approach leads to a loss of focus within the ICU team reacting to the latest metric out of target. Less is often better. Fewer meaningful quality metrics are more likely to result in significant progress and change in the way care is delivered. It is upon ICU leaders to make sure the ICU team is working on the right number of metrics. Making choices is often hard but ultimately assures we are placing our efforts on the right quality metrics.

Examples of Quality Metrics in Critical Care

A comprehensive list of available and possible quality metrics for ICU leaders to use is beyond the scope of this chapter. We have deliberately focused on the foundational principles that guide the selection and use of robust quality metrics in the ICU. A solid understanding of these principles will arm critical care leaders with the tools to select and create useful metrics for their ICUs. There are many possible intensive care unit quality metrics to consider (Table 5.2). In this section, we will

Table 5.2 Possible quality metrics for intensive care units

Structure measures
Pre-established ICU minimum requirements
Intensivist staffing model
Critical care certified nurses
System to report adverse events
Process measures
Multidisciplinary intensivist daily clinical rounds
Patient handover and discharge
Deep vein thrombosis (DVT) prophylaxis
Stress ulcer prophylaxis
Ventilator-associated events prevention strategies
Central venous catheter bloodstream infection prevention strategies
Protocol-guided mechanical ventilation weaning
Severe sepsis and septic shock bundle implementation
Lung protective mechanical ventilation protocols
Palliative care
Timely family conferences
Advance directive and goals of care discussions
Early enteral nutrition
Appropriate blood transfusion thresholds
Outcome measures
Risk-adjusted mortality
Unplanned extubation rate
Hospital-acquired infection rate
Catheter-related bloodstream infections (CLABSI)
Catheter-associated urinary tract infections (CAUTI)
Ventilator-associated pneumonia
Intensive care unit readmission

review a sample of quality metrics that represent robust metrics with potential applicability in diverse types of ICUs. These are based on prospectively developed metrics by an international task force through consensus, as metrics that could be used to improve quality in a wide range of intensive care units [15].

Potential quality metrics within the structure domain include ICUs meeting a pre-established minimum requirement to provide critical care, staffing of the ICU with intensivists, and the presence of a system to report and evaluate adverse events. As we discussed above, structure-based quality metrics are usually binary (present or not). Structure-based metrics in the ICU are valuable if their presence helps drive improved delivery of critical care resulting in improved patient outcomes. ICU fulfills pre-established requirements to provide critical care. These requirements could be established at the national or regional level. The designation of a unit as an ICU results in standard resource allocation and reporting mechanisms. Studies have shown that critical care patient outcomes can be improved when cared by professionals trained in critical care [12, 16, 17]. Furthermore, the immediate availability of critical care expertise 24 hours a day can enhance quality of care, decrease morbidity and mortality, and improve length of stay of critically ill patients. Adverse events are common in medicine, and they are related to poor patient outcomes and increased cost of care. The presence of an adverse event reporting system in an ICU can be measured as a quality indicator [18, 19]. In order to understand the nature of the adverse events occurring in an ICU, a system to report and evaluate them must be in place. A systematic approach is necessary to identify the best solutions and changes needed to prevent adverse events from repeating themselves [20].

Process quality indicators are commonly utilized in the ICU. Two potential metrics in this domain are the presence of routine multidisciplinary clinical rounds in the ICU and standardized procedures for handover of patients leaving the ICU. Routine multidisciplinary clinical rounds for all patients admitted to an ICU can constitute a critical driver of quality [21, 22]. The value created for patients from a team approach where all disciplines contribute their expertise in the ICU is significant. Transitions of care from one unit to another within the hospital or healthcare system are points of tremendous vulnerability for patients. A standardized process to assure safe handover of patients leaving the ICU is a marker of quality [23]. Documentation for patients leaving the ICU is also a prime opportunity for standardization and improvement [24]. Evaluating and measuring this process is an attractive metric than can move the needle in quality and patient safety.

Many outcome measures are utilized in ICU quality programs. As we discussed, outcome measures probably capture best the final product of care and are driven by many factors. Factors such as structure and process of care are influenced by critical care providers. However, patient- and disease-specific factors may be out of our control. Some of the outcome measures to consider include reporting of standardized mortality ratio (SMR), ICU readmission rate, rate of central venous catheter-related bloodstream infections, and the rate of unplanned extubations. Raw mortality is not considered a strong quality metric because it is not risk adjusted and is unable to capture severity of illness [15, 25]. The use of a SMR calculated from an appropriately calibrated severity of illness score allows for more meaningful audits and

comparisons [26]. With proper benchmarking, it can provide the ICU leaders with observed versus expected mortality and can facilitate the identification of expected versus unexpected deaths. The readmission rate to an ICU within 48 hours is an outcome that reflects many processes underlying care [27]. A high early readmission rate suggests poor ICU discharge decision and processes [28]. Readmission to the ICU is an important outcome as it is associated with increased length of stay, morbidity, mortality, and overall cost of care [29]. The use of central venous catheters is widespread in the ICU. Catheter-related bloodstream infections are associated with increased morbidity, mortality, and resource utilization [30]. Catheter-related bloodstream infections are often preventable, and there are evidence-based interventions that have proven effective in drastically decreasing their incidence [31]. Measuring the rate of catheter-related bloodstream infections is a valuable quality metric when paired with the implementation of proven evidence-based practices [32]. The last example we will describe is the rate of unplanned endotracheal extubations. Unplanned extubations are associated with a high rate of re-intubation, increased risk of ventilator-associated pneumonia, and increased mortality [33]. The rate of unplanned extubations is closely associated with various processes of care such as proper management of sedation, delirium recognition, and proper transport protocols [34].

Potential Pitfalls to Avoid

Most ICU programs travel down the quality journey with the best intentions and a true impetus to improve care for patients. However, we have seen repeated examples of quality initiatives going of their initial goals and creating tension and problems within the ICU team. Two important pitfalls to avoid this situation are the potential effect of surrogation and the impact of small numbers.

Surrogation is the behavioral tendency to confuse what is being measured with the metric being used. Surrogation is a common behavior and is deeply imbedded in the way people think about metrics. It is prevalent in a wide spectrum of businesses and disciplines including healthcare [35]. In the ICU, surrogation can be seen when a team is trying to decrease hospital-acquired infections (HAI). They intend to measure the quality of care as expressed by their ability to impact HAIs, and they decide to use the rate of catheter-associated urinary infections (CAUTI) as a quality metric. The team starts measuring and reporting the rate of CAUTI every month. Surrogation quickly leads team members to start fixating on the metric itself as the goal. They become more concerned with the outcome (rate of CAUTI) than with implementing processes that would improve care and lead to significant reductions in preventable HAIs. Soon they are focusing on definitions, questioning the validity of the data, and gaming the system in terms of when cultures are obtained among other strategies focused on changing the metric and not improving the care. We control the process not the outcome. Therefore, if we want to impact the outcome, we must focus on managing and implementing the processes we believe will make a difference. We

can see similar patterns with sepsis mortality, bundles, ventilator-associated pneumonias, and many other quality metrics. Critical care leaders must focus and refocus the team on the goals of quality programs (i.e., reduce severe sepsis mortality vs. bundle compliance). It is also important that the team spend their efforts on implementing processes that are designed to improve care and that they learn from the metrics measured what works and where there is opportunity for further imporvement. Finally, from the perspective of regulatory agencies and other stakeholders, setting the appropriate targets for specific quality measures is critical.

Another important pitfall to avoid relates to the law of small numbers and our lack of insight into what numbers and statistics really mean in the real world. Confirmation bias is the behavior that leads us to interpret data or results in a way that fits a preexisting belief regarding what we are measuring instead of objectively assessing the measured data itself. This is common in science. We frequently see this manifest itself in quality metrics and quality improvement initiatives in medicine. On the one hand, if the measured metric implies high quality in our performance, we accept it on face value and believe we are doing great. On the other hand, if the measured metric result (data) implies poor performance, we often question the data's validity as opposed to seeking the opportunities to improve our performance. This is a recurring theme in ICUs and medical teams working with quality metrics. However, even when we are able to overcome our confirmation bias, we are prone to mistakes in interpreting data in the ICU as a result of the law of small numbers. The law of small numbers, described by Kanheman and Tveresky, is a judgmental bias that leads us to believe that samples based on small amounts of data represent accurately what is occurring in a larger population [36]. If an ICU has three consecutive months with no hospital-associated infections, the interpretation will lead the team to believe they are doing "very well." If on the fourth month there are two cases of HAIs, suddenly this interpretation shifts and now the team believes there is something wrong. The idea that predictions should be far less extreme than the data there are based on is counterintuitive. However, it has been shown that we are systematically biased toward placing excessive credence in dramatic results, even when they are derived from small samples (in statistical terms, the vast majority of data we use in the ICU for quality assessment is derived from a small sample). Critical care leaders must be cognizant of this bias and mindful of how the data they obtain best describes the reality of their ICU. A drop in mortality from 1 month to the other is most likely due to chance. However, consistent trends over time with larger data points may be a true reflection of changes in practice.

Conclusions

The healthcare landscape is rapidly changing. With a movement toward value-based payment models, the role of quality and cost has become prominent in managing our ICUs. Critical care leaders must understand the basic principles of measuring value in the ICU. Our roles today are centered on the creation of value for the critical

care patients we serve. Quality and safety are key determinants of value in healthcare. We have reviewed the basic framework that informs all quality indicators. In addition, we have described unique characteristics of robust quality indicators for critical care, briefly reviewed examples of quality metrics in the ICU, and finally discussed some potential pitfalls to avoid when implementing quality metrics. Critical care leaders are responsible for choosing the right metrics within the domains of structure, process, and outcomes for their specific ICU. Establishing quality programs that accurately measure these and more importantly help the team improve their practice patterns is essential to running a successful ICU.

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