Chapter 1
Patient Safety Standards in the Neuro-ICU

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Historical Perspective

The origins of the current healthcare quality and safety movement can be traced back centuries [1]. Early pioneers include Florence Nightingale, Ernest Codman, and Avedis Donabedian. Nightingale, a nurse, utilized statistical principles to correlate illness to poor sanitary conditions. She then utilized the findings to create interventions aimed at improving sanitation [1]. Codman, a US surgeon, introduced the concept of an *end results card*, meant to measure outcomes following surgery [1]. Donabedian, a physician, founded the model of care where healthcare quality focused on structure, process, and outcome of service [2].

Despite these early efforts, global changes to healthcare quality and safety are still evolving. The *Report to the Carnegie Foundation* published in 1910, first detailed the lack of standards to guide physician training and hospital care [2]. As a result of this work, five minimum standards were recommended to improve hospital care which include: hospital medical staff organization; medical staff membership limited to those with quality education, competency demonstration, and appropriate licensure and certification; regular staff meeting and clinical review establishment; medical record development and maintenance; and supervised diagnostic and treatment facility creation [2]. This publication led to the initial establishment of a compliance review process where representatives from a number of professional societies, such as the Canadian Medical Association, the American College of Physicians, the American Medical Association, and the American College of Surgeons, visited hospitals to

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Table 1.1 Performance standards for healthcare clinicians and organizations

Care is based on continuous healing relationships
Care is customized according to patient needs and values
The patient is the source of control
Knowledge is shared and information flows freely
Decision making is evidence based
Safety is a system property
Transparency is necessary
Needs are anticipated
Waste is continuously decreased
Cooperation among clinicians is a priority

ensure compliance with minimum standards [2]. In 1952, members from each of the organizations formally united to form the Joint Commission on Accreditation of Hospitals [2].

The most recent pivotal developments to guide healthcare quality and safety movements are the seminal publications from the Institute of Medicine, *To Err is Human: Building a Safer Health System* [3], and *Crossing the Quality Chasm: a New Health System for the 21st Century* [4], published in 1999 and 2001 respectively. These reports synthesized several decades of research, outlining the staggering number of deaths attributed to health care-related error. *To Err is Human* demonstrated that US healthcare errors are responsible for anywhere from 44,000 to 98,000 deaths annually translating to 1.7 medical errors daily [5]. In response to these findings, the IOM created a document, *"Crossing the Quality Chasm"* which outlined ten key initiatives to fundamentally change the quality and safety breakdown in healthcare [4] (See Table 1.1).

Further articles from other countries confirmed that deficiencies and reduced quality of care are not confined to the United States [6–9]. While the veracity of numbers and applicability in other countries may be debated, the fact that a large number of human errors occur in healthcare cannot be denied [5]. As a result of both foundational and recent work, a call to action to urgently redesign global care systems to enhance quality and improve patient safety has become a priority.

Measures of Quality and Safety Measures

While quality programs are both defined and measured by certifying agencies and professional associations, no clear definition of quality specific to Neurocritical care currently exists. Therefore, a culmination of quality recommendations and research findings from both general and Neurocritical care arenas will be presented. Utilizing Donabedian's healthcare quality model, quality measures may be classified as structure measures, process measures, or outcome measures. A structure measure may include the presence or absence of key infrastructure components. Examples may include physician or nurse caregivers with specific competency and education, or physiologic monitoring equipment that provides care to a specific patient

population. Process measures are care elements known to be associated with improved outcomes. For example, the early administration of antithrombotics in the setting of acute ischemic stroke is associated with a reduction in subsequent stroke events. Therefore, a measure of healthcare process might include patients who with ischemic stroke appropriately received an antithrombotic as indicated by the medical research. Outcome measures that are patient focused may include morbidity or mortality measures, readmission or reoccurrence rates, or other measures of patient or population health or illness. The following will be an overview of these measures as they relate to the Neurocritical care unit.

Structure Measures

Specialized Neurocritical Care Units

The polio outbreak first highlighted the need for neurologic specialty care. Despite this early notion, modern development and implementation of specialized Neurocritical care units (NCCU) remains a relatively new phenomenon [10]. The recent NCCU development has occurred due to private hospital growth, economic increases, and expansion of medical subspecialty caregivers into Neurocritical care [11]. Further driving support for NCCUs are research findings which highlight the types of patients and care providers that can be utilized to improve patient care. Creating the research foundation for which patients should receive care in a NCCU, Zacharia noted that typical diagnoses who may benefit from specialty care were post-cardiac arrest, ischemic and hemorrhagic strokes, postoperative spine and brain diseases, traumatic injuries, seizures, and neuromuscular diseases [12–14].

Literature evaluating where and by whom neurologic critically ill patients should receive care is evolving. Multiple research studies have attempted to answer questions to determine if a physical unit, the presence of a specialized team, or combination of both is responsible for improved patient outcomes. Supporting the creation of a dedicated NCCU are studies that have noted improved outcomes in the form of reduced mortality, reduced ICU and hospital length of stay, improved resource utilization, decreased sedation usage, increased nutritional support, and increased fiscal benefits [15–23]. The majority of studies to date suggest experienced and specialized Neurocritical care units likely provide better outcomes due to focused and consistent attention to neurologic details [15]. If a dedicated NCCU is not possible, several creative solutions have been presented and evaluated. One creative approach to location of care was described in a Canadian based study. In this work, the creation of a virtual Neurocritical care unit within a mixed ICU was evaluated by looking at the implementation of this care without a dedicated NCCU. Changes in patient allocation, physician staffing, and care protocols were developed to support this effort. The program created multiple tools to overcome barriers of inconsistent care inherent in a virtual unit including team education, rounding protocols,

and patient triage algorithms that were then implemented by a collaborative team of clinicians [24]. The study demonstrated the model is feasible. Another creative solution was presented by Burns. This study evaluated the impact of a Neurocritical care service line without a dedicated NCCU. Improvement was noted in hypertensive control and dysphagia screening but results also indicated an associated trend toward a longer length of stay in intracranial hemorrhage (ICH) patients [25]. Despite some positive finding in the latter studies, both authors emphasized that the ideal care model goal should still be a specialized, dedicated NCCU [24].

System Support

While support for dedicated Neurocritical care units is growing, research regarding the impact of systemic integration is largely lacking. Although healthcare providers exert influence at the point of care, very often system failures are the proximal cause of error [25]. According to Tourgeman-Baskin, 95 % of near healthcare misses were attributable to work environment and system factors [25]. Therefore, system factors and work environments need to be optimized to prevent error or mitigate consequences should an error occur [26].

The ideal institutional design supports interdepartmental integration. In a study conducted in the United Kingdom, researchers noted increased survival of critically ill neurologic patients when system integration occurred between critical care unit, emergency department, and step down unit [27]. National certifying bodies also acknowledge the importance of system integration. For example, integrated team-based care from admission to discharge is required for any organization seeking Comprehensive Stroke Certification by The Joint Commission.

Team

Role modeling of positive unit culture is frequently set by institutional and unit leadership but ultimately supported by a team. Specific team interactions and behaviors identified as having a positive impact on care include: humor, personal sharing, and inclusion of all levels of staff in key decision making. These behaviors were found to improve information flow and team relations which translated to enhanced patient safety. Flat hierarchies and clear role expectation policies were also noted as potential ways to improve care. In a study by Suarez, care delivered by a specialized neurologic critical care team was noted to be associated with reduced in-hospital mortality and LOS without changes in readmission rates or long-term mortality [28]. The Brain Attack Coalition consensus statement also reiterates the positive impact of a dedicated neurologic team. These recommendations include the mandatory presence of dedicated, neurologic expert staff and licensed independent care providers 24 h a day, 7 days a week.

Unit Leaders

According to the American Association of Critical Care Nurses, a healthy work environment consists of several key factors including authentic leaders [29]. In 2000, France utilized a multidisciplinary safety attitudes survey and found that a positive safety climate was impacted by the staff's perception of management [30, 31]. In a study of 32 Australian general ICUs, collaboration with competent and respectful medical staff and nursing unit management were cited as key to a safe care environment [32, 33]. Therefore, unit leadership is necessary to role model and impact behavior that supports a positive unit culture. Formally and informally identified team leaders can be found among a variety of NCCU healthcare professionals. Included among this group are intensivists, advanced practice providers, managers, bedside nurses, pharmacists, and specialized therapy professionals.

Intensivists

Evidence to guide the necessary personnel included in the Neurocritical Care team is mixed. Several studies reflect that there may be no benefit to subspecialty ICUs [34, 35] and question the benefit of the intensivist-led team model [36]. However, other studies have found positive outcomes attributed to the introduction of an intensivist. These include the decreased number of complications, reduced LOS, higher home or rehab discharges, and improved documentation [20, 36–41]. In a study by Pronovost, 17 studies evaluated intensivist staffing levels and hospital mortality. Sixteen of those reflected lower in-hospital mortality with the mandatory presence of an intensivist [42]. Given these results, both the Society of Critical Care Medicine and the Leapfrog Group implemented guidelines supporting the need for a dedicated "intensivist" to staff all ICUs [42–47]. While this recommendation does not specifically outline the presence of a specialty trained neurointensivist, a study by Markandaya indicates that 70 % of practitioners believe neurointensivists are important for quality care of the neurologically critically ill [34].

Adequate staffing levels have also been identified as a factor affecting patient safety. A statement from the Society of Critical Care Medicine Taskforce was created to address Intensivist/patient ratios in a general closed ICU. Literature is present to support that in academic medical ICUs; ratios greater than 1:14 had negative impacts on education, staff well-being, and patient care [48]. While specific intensivist number recommendations could not be established for all institutional types, realistic markers were suggested. High staff turnover or decreases in quality indicators may be overload markers. While 24 h a day, 7 days per week physician staffing is recommended by a Society of Critical Care Medicine guideline, a Canadian study of general adult and pediatric ICUs reflected compliance variability due to financial or resource unavailability [49]. Solutions listed as useful solutions to suboptimal intensivist staffing includes the utilization of non-intensivist medical staff, such as advanced practice professionals (Nurse Practitioners and Physician Assistants), and telemedicine [48].

Advanced Practice Providers

As Neurocritical Care (NCC) is a relatively new and evolving subspecialty, the evidence to specify practitioner skill mix is also being formed [34]. Despite this gap in research regarding types of providers, that a division of labor for these complex patients would enable practitioners to subspecialize their focus with concomitant outcome improvement [34]. In a variety of critical care units are an emerging group of clinicians. Non-physician providers, midlevel practitioner, and advanced practice providers (APP) are all terms utilized to refer to advanced level practitioners including nurse practitioners (NPs), physician assistants (PAs), and clinical nurse specialists (CNSs).

NPs and PAs are the most commonly used advanced practice direct care providers in the ICU. The utilization of NP and PA practice providers has been catalyzed by the National Health Service Management Executive group secondary to the decrease in available resident/junior medical staff [50]. Physician manpower issues have occurred due to resident work hour restrictions and intensivist caregiver shortfalls. According to the Society of Critical Care Medicine, these shortfalls are projected to continue due to the anticipated lack of trainees [51, 52]. NPs and PAs have been identified as a growing group of healthcare providers of critical care providers to meet the gap in ICU coverage. The Leapfrog staffing group recognizes that NPs and PAs that reach ICU patients in less than 5 min, along with an intensivist response by pager, can help to promote quality ICU staffing coverage [51, 53]. General ICU studies that have examined care outcomes from NP and PA providers have included positive results in ventilator weaning [51], length of stay, readmission rates, mortality, costs, discharge instructions, radiograph interpretation, and physician time savings [51]. While actualization and education of NP and PA roles vary, general roles and responsibilities include patient assessment, history and physical examinations, rounding with multidisciplinary teams, admissions, discharges, routine care, medication administration, ordering/reviewing/interpreting diagnostic and laboratory tests, updating families, coordinating care, and insertion of invasive procedures such as arterial lines, central lines, lumbar punctures, suturing, first assist, and cranial monitoring devices [51, 54–56]. In a study by Van Rhee, PA care for acute stroke among other diagnosis found that fewer laboratory resources for stroke patients were noted with the implementation of PA providers [51, 57]. Shorter lengths of stay, lower rates of UTI and skin breakdown, shorter time to Foley discontinuation, and time to mobility were noted in a study that specifically evaluated NP care for neuroscience ICU patients [51, 54]. In this study, the shorter length of stay totaled 2,306 fewer days which translated to $2,467,328 worth of savings [54]. Finally, in a study by Robinson, NP's and PA's care was associated with higher scores in safety, improved ability to promote a team environment, ability to address patient or staff concerns, enhanced communication, and most importantly, the ability to anticipate or prevent a neurological deterioration [58].

The role of the Clinical Nurse Specialist varies by country. Regardless of the exact actualization of this role, common attributes include the need for: advanced

assessment skills, experience in the field of practice, postgraduate qualifications, role autonomy, and contributions to both education and research within their specialty. In a 15-hospital study, improved stroke evidence-based practice application occurred when driven by a CNS. Improved outcomes of smoking cessation, dysphagia screening, national institutes of health stroke scale use, and documentation of reasons for the lack of tissue plasminogen activator (t-PA) utilization were noted [59]. Jahnke also noted improved emergency room door to exam by physicians; order and completion of head CAT scans; t-Pa utilization; and pathway use and compliance when driven by a CNS-created process improvement effort [60].

While limited positive research regarding NCCU specific CNSs, NPs, and PAs exists, the complete impact of these providers in the NCCU setting is yet to be determined. Despite these research gaps, the utilization of these providers appears to enhance patient outcomes and should be considered when creating NCCU core staff.

Nursing Management

Literature is scarce to address whether outcomes are improved through the support of a NCCU specific manager. In a 2004 Suarez study, the hiring of a neurologic specific nurse manager along with specialty trained 24 h/day bedside nursing staff was associated with reduced Neurocritical care and hospital length of stay and in-hospital mortality [28]. In another study, essential skills for an effective nurse manager included trust, motivation, excellent communication, and problem-solving skills [61]. Having someone with these skills present, to specifically advocate for this subspecialty and oversee the staff and care given, intuitively translates to adherence of patient quality and safety initiatives.

Direct Care Nursing Staff

As the largest proportion of healthcare workers, nurses remain integral to the provision of quality care. In an international study, the presence of specialty-trained nurses with the ability to perform skilled neurologic exams was noted to be paramount to optimal neurologic critical care [34]. Despite the limited evidence, it is intuitive that having a 24 hours per day, 7 days per week staff with specialty training to assist with the early identification of subtle changes in neurologic critical care patients is imperative to patient safety. Therefore, obtainment of neurologic specific training should occur to enable preemptive, rather than reactive, care.

In addition to proper education, adequate nurse staffing is necessary to support optimal patient care. In a multinational study, errors on medication administration

were attributed to excessive workload, extended working hours, fatigue, and sleep deprivation [25]. Workload also impacted the risk of iatrogenic infection rates [25]. In a study evaluating the effect of workload on infection risk, higher nurse staffing equated to a 30 % reduction in infection [25]. In a study by Beckmann, drug administration/documentation problems, lack of patient supervision, ventilator or equipment set up errors, accidental extubations, patient/family dissatisfaction, and physical injury had an inverse relationship with staffing [62]. Therefore, ICU managers and administrators need to optimize schedule design to ensure appropriate staffing levels [25]. That said, what equates to adequate bedside nurse staffing remains allusive. A consensus driven method was created in Australia in an attempt to define formulas to determine the required number of nurses to staff critical care units [63]. The American Association of Critical Care Nurses states that adequate staffing matches the skillset of the provider with the needs of the patients [64, 65]. A more literal translation adopted by most American and Canadian critical care units as the unofficial staffing guideline is one to two patients per nurse with some states mandating this ratio [64, 66, 67]. Australia, New Zealand, Europe, and the United Kingdom all recommend at least one RN to one patient however with the RN workforce shortage; practical application of these ratios may at times be unachievable [64].

Multidisciplinary Providers

In addition to specialty trained physician, APP, management, and nursing staff, optimal NCC should be further supplemented with the incorporation of a variety of specialty staff. Specialty focused pharmacists have been identified as providing safe and effective use of medications in a NCCU [6]. Physical therapists, occupational therapists, dieticians, and speech therapists with neurologic expertise also enhance care and should be considered when establishing a critical care team.

Education

A highly trained workforce with adequate resources for education is required to support optimal patient care [25]. Since the inception of critical care units, practice standards outlining nursing educational preparation have been developed along with fundamental critical care training [32, 64]. Results of several studies in general critical care environments suggest that support of knowledgeable and educated nurses is crucial and may translate to improved outcomes [64]. Increased education has been found in nursing research to promote more assertiveness in practice which leads to

greater confidence and job satisfaction. Additionally, hospitals with a greater proportion of Bachelor's prepared critical care nurses were noted to experience a lower odds of death [67]. The Australian College of Critical Care Nurses, European Federation of Critical Care Nursing associations, World Federation of Critical Care Nurses, and New Zealand Nurse's Organization Critical Care Nurses Section adopted the position statement that critical care nurses should have postgraduate qualification in critical care nursing [64]. Despite this consensus, debate continues on whether all nurses, or just a percentage of nurses within these critical care units, require all these qualifications and the content of critical care course curriculum remain [64].

In addition to formalized academic training, certification has been noted to increase critical care and neurologic nursing knowledge. Results show that in addition to having a larger percentage of baccalaureate trained nurses, units with a larger numbers of nurses with additional certification training had lower 30-day mortality and failure to rescue rates [68]. Neuroscience Registered Nurses, Stroke Certified Registered Nurses, and Critical Care Registered Nurses are three certification exams that focus on the enhancement of neurological, stroke, and critical care nursing expertise and should be considered to support improvement in care safety and quality.

Advanced practice provider education requirements for CNSs, NPs, and PAs either already require or are evolving to standardize masters level education as the minimum expected educational foundation. In 2013, an APP nursing consensus document was released and determined that advanced education must match the needs of the patient for whom care is being provided. Only acute care trained practitioners have been educated and trained to manage critically ill patients in an ICU setting [51]. Therefore, acute care, not primary or family care education and certification, should be the foundation for APP nursing providers working within the NCC environment.

In a study of 980 physicians, 57 % of those that responded indicated that neurology residency training should offer a separate training track for those that desire NCC as a career path [34]. Neurosurgeons also recommended neurologic intensive care training to be important to neurosurgical resident education [15]. The United Council of Neurological Subspecialties is a nonprofit organization that is committed to the development of neurological fellowship training programs. To that end, the UCNS formally granted Neurocritical care acceptance as a medical subspecialty opening the door for specialty training and certification exams [34]. In Germany, 6 months in a neurosurgical intensive care is required to sit for board certification. Post board certification requires an additional 2 years plus completion of a catalogue specifying interventions given [15]. Two years of NCC fellowship training is required in the United States. Neurosurgery, anesthesiology, internal medicine, and emergency medicine residency were also supported as background specialties into NCC entry [34]. This variation reflects the need for training standardization to support NCC specialty training.

Process Outcomes

Culture

Organizations with a culture of safety are more likely to have less adverse events, decreased mortality, and staff that are more likely to report errors or near misses than organizations without this culture [69]. The impact of organizational culture on safety has been studied widely throughout various inpatient settings. A recent systematic review identified 33 culture of safety studies that evaluated the impact of interventions. In an organization with a culture of safety, leadership plans programs that acknowledge that delivering healthcare is a high-risk endeavor. Organizations with a culture of safety prioritize team-based care, high-quality communication, family involvement in decision making, and utilization of evidence-based practice, including protocols and other means to standardize care to reduce variation [4, 70]. The presence and involvement of the patient and family in patient care rounds and ongoing decision making is a best practice established in several studies in pediatric and general medical ICUs [71]. No research to date has evaluated organizational patient safety initiatives or culture of safety characteristics related specifically to a NCC program but it stands to reason that the global concepts also apply to the NCC population [6].

Quality and Safety

As the field of NCC grows and develops, defining quality and safety in NCC programs will likely incorporate existing measures from general critical care and other fields of neurology such as stroke. These global measures can then be used in combination or to focus developing measures unique to the NCC population. Within the field of general critical care, national organizations such as the Society of Critical Care Medicine, The Leapfrog Group, and the National Quality Form (NQF) and Centers for Medicare and Medicaid Services (CMS) contribute a number of quality and safety measures. Included in these measures are physician staffing models, infection rates including blood stream infection rates, ventilator associated pneumonia, and catheter associated urinary tract infections, sepsis rates and resuscitation, and overall ICU mortality. These measures are certainly relevant to a Neurocritical care program, and should be used as a means to benchmark the care in the NCC unit to other critical care units throughout the nation.

Additionally, stroke certification programs offered through The Joint Commission and Det Norske Veritas (DNV) publish standards and quality metrics that the stroke program must meet. Many of these standards and metrics relate specifically to NCC. For example, the standards for Comprehensive Stroke Certification with TJC require a model of NCC, and an organized approach to disease management within the NCC unit. Several of the TJC proposed quality metrics also relate to processes occurring in the NCCU unit. Examples of these metrics include: infection rates and

complication monitoring associated with external ventricular drains, craniectomy, and neurointerventional procedures; procoagulant reversal in the setting of intracerebral hemorrhage; and interdisciplinary peer review process creation to address any complications occurring in a patient with the diagnosis of ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. However, these standards are stroke specific and do not address the varied diagnoses routinely seen in a NCC program. Therefore, a high-quality NCC program could reasonably be expected to develop and utilize protocols or standard operating procedures to guide care of both routine and high-risk patient care situations including; placement and maintenance of an external ventricular drain, management of elevated ICP and herniation syndromes, and disease processes such as ischemic stroke, ICH, SAH, meningitis/encephalitis, status epilepticus, and other common diseases.

While protocols and standard operating procedures help standardize care, formal and informal communication mechanisms are required to assist with communication of the care given. The importance of team communication is highlighted in a number of publications dating back to the IOM safety series published in 2000 and 2001. Handoff between providers, hospital locations, and inpatient and outpatient organizations represents an area of recent interest and concern as it relates to patient safety and quality outcomes. Studies suggest that poor handoff between care team providers as well as between unit or hospital locations is associated with a number of safety risks, including errors and omissions in care [72]. Electronic health records (EHRs) are one potential solution. There is evidence that EHRs minimize errors in some regards while increasing the risk for error and miscommunication in other areas [73]. EHRs decrease errors related to transcription, incomplete and or incomprehensible medical records, but may place practitioners at risk for errors of omission related to unmet data display needs, insufficient interaction with software or hardware content, and lack of attention to matching EHR process to typical workflow processes in patient care [73]. However, EHRs may improve data capture, allowing for quality monitoring and intervention that was traditionally manually collected when paper documentation was prevalent. Best practice in provider-to-provider handoff is also being researched. Evaluation of verbal versus verbal accompanied by written shift-to-shift handoff as well as other initiatives is currently underway to define and measure best practice in this area but has yet to be established [74].

Outcome Measures

Managing Error and Quality Improvement

With the rapid expansion of technology and knowledge, there is a gap between what providers know should be done and what is actually done [75, 76]. To bridge this gap, practitioners should understand the basics of healthcare process improvement [75].

As critically ill patients require a higher intensity of care, they are at a greater risk of iatrogenic harm. Given the increase in illness severity and likely comorbid states, resiliency to combat the error is less likely [77]. Therefore, ways to eliminate or minimize the occurrence of these errors is imperative. Before errors can be addressed, they have to be recognized. Two studies noted enhanced error recognition and reporting when a paper-based reporting system was utilized [5]. Anonymous reporting has also been found to increase the likelihood of reporting errors or near misses. Cultures that embrace formal sharing through morbidity and mortality and review of outcome data were also found to create cultures where care could be enhanced through the evaluation of errors and identification of trends. The creation of a data repository in a study by O'Connor noted a threefold improvement in efficiency and accuracy of care when reports from this data were utilized [78]. Therefore, communication cultures should be established that support error reporting and trending of patient outcomes.

Patient Outcomes

Reduction in hospital acquired infections is a priority for worldwide healthcare. Higher mortality, longer hospital stays, and additional cost are all associated with infected patients. Between 15 and 30 % of hospital-acquired infections are felt to be preventable [78–81]. Variability in care and outcomes, and a growing evidence base makes critical care a prime target for improvement efforts. Despite the growing evidence base, implementation of best practices has either been delayed or incomplete [79]. Routine procedures are therefore a starting point for systematic patient improvement efforts [25]. One routine practice that has major implications related to infection is better hand washing. Despite being an easy first step, healthcare provider compliance with hand washing remains poor with compliance largely overestimated by physicians. Quality outcomes were also found to be enhanced through education and protocol bundle implementation for line insertion and maintenance. Through these efforts, central line associated bloodstream infections were noted to decrease [25].

Adverse events related to medications have also been reported to be among the most prevalent types of error [6]. Electronic prescriptions or pharmacist involvement to guide clinical decision making support for correct dosing, drug/lab value check and drug/drug interaction, have been reported to decrease error [6]. Improving interdisciplinary communication during bedside rounds is also associated with medication error decrease [6]. Factors adversely effecting medication events include attention deficit, elevated workload, communication failure, time pressure, and insufficient staffing [6]. Therefore, efforts to reduce the incidence of these triggers should occur. Solution examples might include providing quiet areas that limit disruption, enhancing cultures of communication and safety, and providing adequate staffing.

QI Programs Based on Total Quality Management Principles Quality/Safety Reporting

Incorporating new guidelines or best practice is difficult to achieve due to the need to change clinical routine and the organization of care. Changing practice routines requires a systematic, well-planned approach that considers practitioner, system, and patient relevant factors. Engaging practitioners in both the development of the innovation as well as the implementation of the plan will not only aide in identifying issues but also with addressing potential system barriers. Attempts to change clinical practice should be accompanied by ongoing monitoring to follow progress or adjust plans. There are a variety of process improvement methodologies that can be utilized to support efforts. Examples of these methods include six-sigma, plan-do-study-act (PDSA) and lean. Each methodology has similar techniques [75]. Six-Sigma uses a rigorous statistical measurement methodology to decrease process variation. It is achieved through a series of steps: define, measure, analyze, improve, and control [75]. PDSA is the most common approach for rapid cycle improvement. This involves a trial and learning approach. In this method, a hypothesis or suggested change is tested on a smaller group before implementing within the whole system. Detailed improvement plans, assigned tasks, and expectations are created. Measures of improvement are then selected and trended during the implementation phase. If deviations from the plan occur, these are analyzed and adjustments are made and implemented in the next test cycle [75].

Lean methodology is driven by the identified needs of the customer and aims to improve processes by removing non-value-added activities (NVAA). NVAA do nothing to add to the business margin or the customer's experience. Value stream mapping is the tool that graphically displays the process using inputs, throughputs, and outputs. Using this process, areas of opportunity are highlighted allowing staff to generate ideas for improvement [75]. To identify waste lean experts will frequently use the 5 "S" strategy: *S*ort: sort items in the immediate work area and keep only those that are needed frequently, *S*hine: clean and inspect equipment for abnormal wear, *S*traighten: set work items in order of workflow efficiency, *S*ystemize: standardize workflow processes, and *S*ustain: sustaining gains made in the first four steps [75]. Focusing on processes that are either high frequency or at increased potential for harm is most effective [25]. No matter the process used, commitment by formal and informal unit leaders is necessary to support all levels of quality innovation and change.

Possible NCCU specific measures of quality may include the use and availability of EEG monitoring for seizure or status epilepticus, timeliness of recognition and care in acute meningitis or encephalitis, as well as procedure related processes for neurosurgery or neurointervention. Measures of outcome may include overall unit morbidity and mortality measures as well as specific disease processes and procedures. The morbidity and mortality measures should be compared to other programs using national databases such as Premier, University Hospital Consortium (UHC), or other national/international databases.

Conclusions

Despite historical evidence reflecting the need for specific neurologic care, NCCUs are in their infancy. Building upon general intensive care data, NCCU quality and safety practices can be extrapolated and then enhanced to focus on the unique needs of the neurological critically ill patient. To ensure the safe passage of these vulnerable patients, systems, units, providers, and processes need to be determined and established. The specifics of what constitutes quality within the NCCU continue to require further study.

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