Telemedicine for the Intensive Care Unit

50

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Overview

The healthcare sector in the United States is undergoing a transformation. It has become apparent that hospital organizations face challenges in achieving sustainability. Challenges relate to ensuring quality and cost of care while transitioning patients safely across the continuum of care [1]. Organizations are collaborating to leverage resources and implement strategies to meet the needs of a growing, medically complex, aging population [2]. The challenges compound by a forecasted shortage of intensivist physicians [3], which is coinciding with a forecasted shortage of registered nurses [4]. State, federal, and commercial payer policies have been enacted to reward organizations to provide better health, better care, and lower costs [5, 6]. TeleICU services have been shown to reduce ICU mortality, reduce hospital length of stay, and lower rates of preventable complications [7, 8]. These remote services reinforced timely response to physiological alarms and adherence to critical care best practice protocols [7, 8]. TeleICU has emerged as a technological strategy to improve clinical outcomes in critical care populations across the nation.

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Historical Information

The teleICU concept is not new. In 1977, researchers hypothesized that remote patient monitoring would solve the problems of scarcity and misdistribution of critical care specialists. Using a two-way audiovisual platform to connect a small private hospital to a large university medical center, researchers demonstrated that telemedicine favorably influenced the quality of critical care service provided [9]. In 2001, the Society of Critical Care Medicine published guidelines focusing on the delivery of critical care, and recommended intensivist physicians lead the interprofessional teams to provide interventions necessary in urgent and emergent situations 24 h a day, 7 days a week [10, 11]. Shortly after that in 2002, the Institute of Medicine convened on health inequities in the United States and identified access to care resources as a significant contributor [12]. By 2013, approximately 11 % of adult critical care beds in the United States reported a teleICU program as an associated care paradigm [13]. The Society of Critical Care Medicine reconvened in 2015 to review models of critical care associated with improved outcomes and recommended institutional support for quality improvement programs, as well as institutional support for teleICU programs [14]. With innovative approaches to healthcare delivery, organizations are achieving scalable and sustainable teleICU programs.

Central Operations Room

TeleICU clinicians typically work together as a team in a remote centralized operations room (COR). The clinicians in the COR are considered the distant site practitioners who provide services to the originating site hospital. The COR has an arrangement of workstations, each of which has one or two central processing units (CPUs) and six or eight computer monitors. The COR workstations are often ergonomic desks that raise or lower so that clinicians can alternatively stand or sit throughout their work day. Lighting, noise, and backdrop are important considerations. Indirect lighting is superior in preventing computer eye strain. Given the prox-

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imity of workstations and the necessity for patient privacy, clinicians are cognizant of noise when interacting with patients, families, or ICU clinicians via the telemedicine platform. TeleICU programs often utilize a standardized backdrop image for patient encounters. Regarding the number of workstations necessary, clinicians may function with an intensivist to patient ratio in the range of 60 to 1 typically not exceeding 150 to 1, whereas the RN to patient ratio may be in the range of 30 to 1 typically not exceeding 70 to 1 [15, 16]. However, patient ratios are contentious and fundamentally dependent upon the role the telemedicine program.

Information Systems

A teleICU program requires three technological elements [17]. First, remote clinicians require *full access* to the clinical information systems deployed at the bedside. At a minimum, physiological, laboratory, pharmaceutical, and radiological data are necessary for real-time identification of impending or worsening conditions. Second, with an aim to enhance efficiencies in ICU population management, clinicians use *teleICU software* applications to support widespread surveillance. The applications organize a multitude of incoming information so that logical processing can occur in sequence. Complex algorithms are embedded within the data visualization features available in these applications. Third, a *connection network* is essential for the remote clinicians to communicate. Older systems provide one-way camera functionality where remote clinicians can be heard but not seen by the patients or ICU clinicians. More robust video platforms have afforded two-way camera functionality, essentially a bidirectional audiovisual link, where colleagues can see each other when they are communicating. Two-way camera functionality is superior in building the interactive, collaborative relationships that are necessary for teleICU programs to succeed.

Models of TeleICU Care

To minimize conflict among the interprofessional team, the roles and responsibilities of the remote team should be well defined and clearly evident to the clinician team at the bedside. Models of teleICU care have been developed and refined over the years and categorically will likely continue to broaden in scope. Clinicians will undoubtedly continue to collaborate and discover innovations in care paradigms as new technologies emerge.

The American Telemedicine Association [18] offers three models of care to illustrate alternatives for continuity of services. The first is a *continuous care* model where physiological (and other) monitoring of data occurs without interruption for a predetermined number of hours (i.e., 8, 12, or 24) every day. The second is a *scheduled care* model where periodic consultation occurs on predetermined schedule (i.e., morning ventilator rounds) every day. The third is a *responsive or reactive care* model where the teleICU encounter is prompted by an alert received and therefore unscheduled by context. Separate from the ATA's three models for continuity of care, Sapirstein et al. [17] offer four models of care to illustrate the operational interactions that may ensue staffing, supervision, compliance, and early warning.

Staffing Model

The staffing model builds on the premise that the teleICU intensivist can enhance the ICU staffing by providing virtual support. Remote surveillance occurs in real time through audio, visual, and electronic means. Population management software helps identify patients at risk. TeleICU nurses review patient cases with the intensivist who then acts as: (a) provider-to-provider support, (b) sole provider to the patient, or (c) a blended support model. First, *provider-to-provider* support is typical when intern physicians, resident physicians, fellow physicians, physician assistants, or advanced-practice registered nurses are available in the ICU. The intensivist offers support that may or may not document as a formal consultation. The ICU provider may retain the duty to enter the physician order into the medical record. Second, when there are no providers in the ICU, the intensivist acts as a *sole provider* and directs patient care entirely including entering all physician orders into the medical record. When this occurs, there is a consensus that the care provided by telemedicine should meet the standard of care provided in person. With that stated, at a minimum, the tele-intensivist should establish a patient-physician relationship [19]. However, the American Medical Association cites exceptions to when a patient-physician relationship is not required, in situations such as on-call, cross-coverage circumstances, emergency medical treatment, or other conditions [19]. Third, the intensivist may provide a *blended support* model where he or she may consult on one patient (or one ICU) and direct care entirely on another patient (or another ICU). While the staffing model may fill the void for an intensivist should none be available in the ICU, the staffing model was never intended to reduce the number of nurses at the bedside [15].

Supervision Model

The enhanced supervision model builds on the premise that teleICU clinicians provide an extra set of eyes for the ICU clinicians [15]. Supervision occurs when an intensivist consults with ICU providers or when a teleICU nurse collaborates with ICU nurses. For example, when subtle patient changes are occurring and observed interventions lie outside the realm of best practice protocols, experienced teleICU clinicians may collaborate to educate, encourage and support, and thereby foster action that drives evidence-based practice. At other times, when ICU clinicians are engaged and actively managing an emergency or other issue, teleICU clinicians may provide supervision to proximate patients on the unit. This type of *tag team supervision* approach, that is, ensuring all eyes are on all patients, is intuitive to teleICU clinicians who have successfully integrated themselves into the culture of the ICU unit. This multilayered integrated support model fundamentally builds on mutually trusting relationships, which are at times difficult to achieve.

The supervision model may involve continuous observation of patients deemed at risk. For example, patients who are at risk for fall may be monitored continuously by audiovisual means. There are inherent limitations to this type of intervention: (a) patients must be responsive to verbal cues from the remote team, (b) ICU team must be close enough to assist the patient if necessary, and (c) remote team must have the technology and resources available to conduct continuous monitoring. Resources to conduct continuous monitoring are often not licensed personal but rather telemedicine support associates who have had specialty training to manage the population at risk. In many ways, the virtual supervision model has the potential to shape resourcefully the future of critical care services.

Compliance Model

The compliance model builds on the premise that remote teleICU clinicians are well positioned to provide clinical surveillance to a large number of ICU patients to ensure compliance with *evidence-based protocols*. TeleICU clinicians monitor clinical activities in real time to facilitate interventions and ensure compliance with critical care best practice protocols across a health system. Table 50.1 displays bundled care protocols that teleICU services have supported.

In addition to supporting compliance with bundled care protocols, teleICU clinicians collect data for process improvement (PI). Data is typically collected to illustrate (a) observed versus expected severity-adjusted ICU mortality, (b) observed versus expected ICU length of stay, (c) ICU ventilator days, (d) DVT prophylaxis, (e) glycemic control metrics, (f) stress ulcer prophylaxis, (g) incidence of ICU complication, and (h) organized and efficient utilization of ICU beds in connection with the health system admission, discharge, and transfer (ADT) center.

Process improvement is the backbone of achieving high-quality ICU outcomes [14]. In a systematic data-driven manner, teleICU services provide many elements of a successful PI program [34]. Telemedicine does not guarantee quality improvement. Because PI initiatives often fail without specific goals, a successful teleICU program will perform a detailed needs assessment, including a review of the barriers to change, and then prioritize the ICU deficiencies with outlined interventions aimed to assist in managing the problems identified [35].

Early Warning Model

The early warning model builds on the premise that teleICU clinicians continually monitor trends in data to identify impending or worsening situations that may benefit from early clinical intervention. Strategies for *real-time data management* provide the foundation for the early warning model [36, 37]. TeleICU services provide accurate sepsis identification that correlates with both improved sepsis bundle compliance and reduced patient mortality [26, 28]. When clinicians leverage the data with automated prediction tools to identify at-risk patients, organizations have reported more timely sepsis care, improved sepsis documentation, and reduced mortality [38]. As teleICU nurses conduct active data surveillance overnight, the intensivists are awake, alert, and readily available should concerns be identified or should the ICU team request support. In this improved climate, where clinicians collaborate with a focus on safety, ICU providers have reported heightened levels of confidence about patient coverage and physician accessibility [39].

Architectural IT Framework

There are options for the architectural IT framework to provide teleICU services. The telemedicine architecture can be closed or open, and the operations can be centralized, decentralized, or hybrid [40]. *Closed architecture* is a less adaptable infrastructure that has point-to-point dedicated communication from a centralized teleICU operations room. Within a closed architecture, physicians outside the hospital network are prohibited from accessing the audio, video, clinical, or trended data analysis. Medical consultants who are technologically external to the closed architecture will be unable to perform a video assessment and thereby unable to provide a full scope of telemedicine consultative services. The closed architecture system typically installs with dedicated high-speed lines within a hospital network but not utilizing the Internet [40].

Alternatively, *open architecture* is an adaptable communication infrastructure that supports connectivity by one or more clinicians, from one or more sites, typically implying connectivity to the Internet [40]. The open architecture can

Table 50.1 Bundled care protocols that teleICU services have supported

Ventilator care bundles [20]
Bundle care aimed at reducing healthcare-associated infection (HCAI) [21]
Catheter-associated urinary tract infection bundle (CAUTI) [22]
Ventilator-associated pneumonia bundle (VAP) [23]
Central venous catheter insertion bundle (CLC) [24, 25]
Central line-associated blood stream infection bundle (CLABI) [23]
The surviving sepsis campaign sepsis bundle [26–28]
Rounds to ensure adherence to lung protective ventilation (LPV) [29]
Pressure ulcer prevention bundle [30]
Palliative care bundle [31]
Organ procurement care bundle [32]
Daily sedative interruption compliance [33]

take the form of single or multiple clinicians connecting from the hospital, office, or mobile device, providing virtual care to single or multiple patients, at one or more hospital sites. The open-architecture framework is a robust telemedicine platform that more easily enables consultative services from inside or outside the constraints of a hospital network.

The *centralized* teleICU is a hub and spoke model. Within this model, distant site clinicians work in the centralized hub and provide services outward to the spoke hospital sites [41]. The connection between the hub and one or more spoke hospital sites allows the intensivist to support the ICU services provided locally. Commonly, the hub and spoke is a closed architecture where teleICU clinicians work in the centralized location and cannot conduct video assessments from sites outside the centralized location.

Alternatively, in a *decentralized* teleICU model, clinicians are not devoted to being onsite at any centralized location. In this model, one or more clinicians can utilize the telemedicine platform to provide care, concurrently or not, from any device (desktop, laptop, or mobile) equipped with camera, speaker, and microphone [41]. In the decentralized model, the teleICU clinicians can conduct video assessments from the convenience of the hospital, office, or home. In a decentralized open-architecture model, the extent of virtual support available to ICU clinicians is wide ranging, regulated predominately by organizational policies and procedures, as well as the quality of Internet connection available to the remote clinicians.

Finally, *hybrid* models combine some of the best elements of centralized and decentralized models. In a hybrid model, a large hospital organization may partner with independent physician service lines to support teleICU services across multiple hospitals or multiple patients. The hybrid difference is that intensivists are not all located at a centralized hub, but rather in multiple remote facilities, potentially decreasing the cost of the centralized hub operations and effectively leveraging the resource to a wider span of ICUs under the umbrella of teleICU services [41].

Performance Metrics

The historic drive behind teleICU has been the promise to improve outcomes by providing an efficient means to connect critical care specialists to a large number of patients in need [17]. Implementation of teleICU services has been associated with reduced severity-adjusted ICU mortality [7, 8, 42–44], reduced hospital length of stay [7, 8, 42, 43], reduced ICU length of stay [44], improved rates of best practice adherence [7], and lower rates of preventable complications [7]. Remote services confirm that high-quality care can be provided to patients managed in less costly community settings [45]. Still others have reported no significant association between the implementation of teleICU services and severity-adjusted ICU mortality, ICU length of stay, or hospital length of stay [46, 47]. In 2011, Young et al. conducted a meta-analysis of 13 published studies including 35 ICUs to affirm that teleICU services significantly reduced ICU mortality and ICU length of stay, but they found no significant improvements in hospital mortality or hospital length of stay [48]. Kahn et al. have proposed that the primary difference between teleICU programs that demonstrate improved outcomes and those that do not are differences in the models of care, specifically that full discretion for all patients may be necessary to maximize the potential of a teleICU program [35]. Lilly and Thomas have proposed that the degree of benefit directly relates to the extent in which teleICU acceptance leads to a persistent change in the processes of care delivered in the ICU [49].

While researchers have evaluated the clinical and economic impact of teleICU, and their work provides foundation for understanding operations, their studies present with a number of conceptual and methodological limitations [35]. In 2011, the Critical Care Societies Collaborative convened an interprofessional work group to develop a research agenda for teleICU to address the gaps in literature and to best inform clinical decision-making and health policy. Previously developed framework for evaluating telemedicine was considered as a starting point. Acknowledging the limitations of the existing teleICU research, the group identified two major components of a framework: (a) standardized approach to assessing the pre-implementation ICU environment and (b) standardized lexicon for defining the telemedicine intervention. The group then organized gaps in evidence around the Donabedian framework for healthcare quality. Thereafter, they developed several high-priority topic areas to advise the framework for evaluating teleICU services: (a) structure to include teleICU, ICU, organizational climate, and readiness to change; (b) process to include optimal delivery, innovations, evidence-based care, and education; and (c) outcomes to include the effects on the patient, provider, and system [35].

Quite often stakeholders in ICU have strong opinions regarding the value of teleICU services. Opinions are often good as they are bad, especially true to those who have a monetary interest in the implementation or non-implementation of services [35]. Indeed, telemedicine services will continue to expand in coming years. The controversy surrounding teleICU is not whether it will prosper but rather how well can ICU clinicians leverage it to positively affect workflows, advance efficiencies, reduce costs associated with care, and ultimately improve patient-centered care experiences [50].

Challenges and Limitations

TeleICU programs can encounter a number of operational challenges [51]. Optimal performance is contingent upon the integration of the teleICU operations into the operations of the healthcare system. Stakeholders from all levels of the organization including executive, finance, information technology, management, and regulatory should be transparent about their support for the teleICU program and that transparency should be unambiguous to clinicians [17]. It is essential for clinicians to establish collegial relationships across the telemedicine platform. The practice of teleICU nursing is directed by guidelines established by the American Association of Critical Care Nurses (AACN) with a focus on bold, authentic leadership to optimize patient outcomes [52]. The teams on both sides of the camera must have shared knowledge, shared goals, and mutual respect. With optimized technology, expert clinical practice, skilled communication, and collaborative relationships, the patient remains the center of focus. The AACN's standards for a healthy work environment provide the clinician teams with shared principles to uphold: (a) skilled communication, (b) true collaboration, (c) effective decision-making, (d) authentic leadership, (e) appropriate staffing, and (f) meaningful recognition [52]. The CCRN-E certification validates the expertise and competency of nurses practicing in the teleICU [53]. Schleifer-Kwan et al. conveyed criterion-based competencies to assist in clarifying the role of the teleICU nurse in contrast to the role of the critical care nurse at the bedside [54]. Healthcare organizations should define and evaluate accountability for telemedicine communications and establish how a lack of collaboration will be addressed [52].

Strategies to enhance the integration of teleICU operations into the ICU operations should be established early. Integration is influenced by the degree of acceptance formulated by the leaders of the critical care teams. Resistance to integration degrades performance [42, 55, 56]. In a true collaborative care model, clinical outcomes are shared outcomes. Strategies for integration may include blended unit champions or unit liaisons, overlying membership in unit-based clinical leadership teams, integrated critical care orientation, ongoing education to ensure continued competence, shared PI or research initiatives, joint governance over nursing positions (full time, part time, or per diem), or simulated clinical emergencies to promote standardized team interactions and cohesive team processes. The value of teleICU is not in the technology but rather how well the technology is interwoven with the daily practice of the interprofessional team at the bedside [57]. Continuous evaluation of a teleICU services is essential in identifying opportunities to advance telemedicine paradigms as the technology and degree of cultural acceptance rapidly evolves in society.

There are obvious limitations associated with teleICU services. Foremost, remote clinicians cannot perform bedside procedures that are a necessary component of care prescribed. For example, central line placement may aid in the completion of elements necessary for the severe sepsis bundle [26]. While the remote clinician can direct and supervise the placement of a central line, the real advantage emerges when the central line access is established and clinicians have confirmed time zero relative to all future elements of the severe sepsis bundle [26]. By leveraging technology and promoting remote clinicians to calculate and track compliance with all elements of the bundle, clinicians work together to ensure performance. While limitations of teleICU services are apparent, a collaborative clinician effort that is supported by technology provides a most efficient model of care [26].

Complex Valuations for Return on Investment

TeleICU programs may encounter barriers to entry such as high-priced technology [58, 59], fragmented clinician support [58], regulatory and licensure obstacles [60], and reimbursement challenges [61, 62], which have inhibited widespread adoption of services [63]. Despite the lack of a direct reimbursement model, there are significant indirect financial benefits to deploying teleICU services. TeleICU programs must outline robust, sustainable business plans.

Working with the financial officers, teleICU programs can show cost avoidance and cost savings to support return on investment. Focus should be on the reductions in ICU mortality and ICU length of stay, increased compliance to best practice protocols, decreased ventilator time, decreased rate of ICU complications, and active management of ICU beds including triaging patients in and out 24/7/365, thereby enhancing throughput and tendering an increased capacity for admissions, ultimately driving revenue [63, 64].

Fifer et al. demonstrated that the capital investment and first-year operating cost of a teleICU can be recovered in approximately 1 year [65]. Franzini et al. confirmed that teleICU services were cost-effective in caring for the sickest of patients [66]. Deslich and Coustasse verified the implementation of teleICU to be more beneficial than costly, denoting the strategic advantage to providing telemedicine services [67]. Kahn and Rubenfeld advised using teleICU to sustain best practice compliance [68]. Fortis et al. described significantly reduced capital costs associated with a teleICU program that integrated the audiovisual technology within the electronic medical record; the capital cost was $1,186,220 with an annual operating cost of $23,150 per monitored bed [69].

There are other ways to measure the investment return of a teleICU program. With a mounting petition for patient-centered care, large university hospitals can enhance and support the ICU services provided by small community hospitals, thereby decreasing unnecessary tendencies for disruptions in care. In this win-win model, the large university hospital attains an increased referral source from patients who are clinically deteriorating and thus require transfer; while conversely, the small community hospital attains increased revenue from actively managing patients who are stabilizing clinically and thus benefit from staying in their community setting. Moreover, ICU physicians have reported increased satisfaction, reduced burden, and improved recruitment and retention metrics when remote intensivists are available to assist in the management of clinical issues that arise 24 h a day, 7 days a week [70]. With a focus on human capital, teleICU provides an equally challenging alternative setting for experienced critical care nurses who are physically unable to provide care at the bedside [71].

Governance

Medical Licensure

Many citizens of the world look to the United States as a leader in healthcare innovation and technology, yet the field of telemedicine has stifled in the absence of one medical license recognized throughout the nation [72]. In 2014, the Federation of State Medical Boards passed the interstate medical license compact allowing for expedited licensure by eradicating the primary source verification process if states agree. Even though a physician must still apply to each and every state he or she wishes to practice medicine, this is an advancement in the right direction. Physicians have the legal ability to practice in any of the European Union member states, and similarly, Australia has moved away from a state-based system to a single national agency that licenses all physicians [60]. While the medical license portability debate continues in the United States and stakeholders remain elusive to a collective solution that would safeguard medical care to underserved populations, if there was ever an urgency to resolve this barrier to broad adoption of telemedicine, now is the time [72].

Credentialing

Any physician, who prescribes, renders a diagnosis, offers a radiological interpretation, or provides clinical treatment via telemedicine, must be credentialed and privileged through the hospital's office of medical affairs. Credentialing is to evaluate and verify the physician's qualifications, while privileging is to verify the competency in his or her specialty [60]. The process can be complicated at times by inconsistencies that may occur within hospitals of the same healthcare system, ultimately adding time and expense to the process. Hospitals that provide care via telemedicine must revise the medical staff bylaws and the credentialing and privileging policies to include criteria for granting privileges to the remote intensivists. The bylaw revisions should address what category of the medical staff the remote intensivist will join, what level of involvement he or she will have in the medical staff committees, and what procedural rights he or she will be granted. To mitigate malpractice and negligent credentialing claims, written agreements should be established to ascertain who will be providing the care to patients and when will the care be provided to patients, including the specified representations, warranties, and indemnifications [73]. Hospitals should establish means to evaluate the quality of care delivered, while teleICU programs should establish means to evaluate the quality of service rendered by telemedicine.

Professional Fee Billing

There are challenges associated with the reimbursement of telemedicine services [61, 62]. There are several recent regulatory and legislative changes that can assist in understanding how substantial the reimbursement barrier will remain in coming years [60]. There are three major patient insurance classes: Medicare, Medicaid, and private insurers. While the federally organized program Medicare has guidelines for telemedicine that are consistent across the nation regardless of state, the reimbursement policies for Medicaid and private insurers can vary significantly by state [60]. Most teleICU services rendered meet the eligibility requirements for *Medicare* reimbursement although policy restricts any form of payment unless the patient is within an established rural area. Forty-six states provide *Medicaid* reimbursement for telemedicine although the fiscal impact on teleICU programs varies by the definition of common services [60]. There are a series of state Medicaid programs that have legislatively mandated reimbursement for services that would otherwise be reimbursed in person, suggesting a greater likelihood of Medicaid reimbursement for teleICU services in the future. *Private insurers* are regulated at the state level and therefore reimbursement varies by the state and even insurers within a state. With the growing trend to legislatively mandate reimbursement for services that would otherwise be reimbursed in person, teleICU programs might soon submit claims for reimbursement across all insurances. Even in states where no such mandate exists, there is growing evidence to imply that private insurers have voluntarily adopted reimbursement policies for telemedicine services [61]. In summary, reimbursement for teleICU services depends on geographic location, type of service, and the clinical model. Organizations should proactively review fee schedules of the payers they bill and, when negotiating payer contracts, seek to reference the inclusion of reimbursement for teleICU services [60].

Technology Regulations

While telemedicine intensivists are limited by the acquisition of state medical licensure and hospital credentialing, Reynolds et al. confer how the technology of telemedicine devices has counterpart regulations [74]. The Federal Food and Drug Administration (FDA) issued a ruling to differentiate medical device data systems (MDDS) from those designed to perform active patient monitoring (APM). In a teleICU setting, APM devices are the bidirectional audiovisual link used to conduct active, real-time, or online patient monitoring. Devices used for APM must be FDA class II approved, subject to more stringent manufacturer controls, whereas devices used for MDDS must be FDA class I approved, subject to less stringent manufacturer controls. Although other vendors will likely acquire FDA class II certification for APM devices in the future, as of 2012, approved devices for APM in teleICU setting were limited to Philips VISICU® technology and the InTouch Health Remote Presence technology, both having significant costs associated [74]. With good reason to consider, organizations may be tempted to develop their systems and thereby unwittingly subject themselves to stringent manufacturer controls defined by the FDA. In simpler terms, an organization would be in violation of FDA ruling requiring APM certification if a decision was made to deploy uncertified cameras, speakers, or monitoring equipment to be used in the immediate clinical decision-making process. In summary, teleICU programs have a very limited selection of FDA class II-approved APM technologies. Any consideration of an innovative solution should not be without consideration to the consequences associated with operating outside the FDA requirements for manufacturing of APM equipment [74].

Future Directions

With a predicted shortage of critical care clinicians on the horizon and rapidly expanding healthcare technologies, one might presume that ICUs across the nation would swiftly achieve broad implementation of teleICU services. However, the implementation equation is not so simple. There are barriers to be reckoned, in particular, the high cost of technology, fragmented clinician support for services, and regulatory, licensure, and reimbursement challenges. An additional strife is that existing teleICU software is often a free-standing application in a period of high demand for systems integration [17]. Although the data can certainly be delivered remotely with integration interfaces, the maintenance of interfaces is onerous yet essential to the accuracy of information reported outward [75].

There is consensus on the research necessary to discover strategies to optimize teleICU services in a way that is clear and understandable to clinicians yet practical and suitable to hospital administrators who guide implementation decisions [35]. Reynolds et al. have proposed the future of teleICU services as a catalyst for innovators to shape the imminent. In this future, the centralized and decentralized systems will foster alternative staffing models for an acute care telemedicine solution, promoting sustainability through vertical and horizontal scaling, supporting patients and caregivers across the continuum of care, on an open-architecture system with mobile connectivity, and an umbrella of administrative direction over the regional critical care units [74].

Summary

Healthcare organizations are contending with intensified scrutiny. There are clear directives to provide better health, better care, and lower costs. The stakes are high for critical care medicine as some of the largest costs incurred in healthcare are associated with ICU care delivery. Organizations have turned to technology to advance the delivery of care in ICUs across the nation. The collaborative team approach enables redundancies in care, with aims to improve the quality of care by reducing variation and complication. There are limitations to the research documenting the full advantages and potential consequences of teleICU services but what is apparent is that traditional egocentric approaches to critical care medicine are not sustainable. An ICU culture that leverages the technical and human capital available improves the quality of care. With innovative approaches to healthcare delivery, increasing market competition, strengthening relationships across telemedicine platforms, and emerging evidence for efficient resource utilization, organizations are strategically achieving scalable and sustainable teleICU programs.

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