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Expanding Technology in the ICU: The Case for the Utilization of Telemedicine

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ABSTRACT

Introduction: Telemedicine has been utilized in various healthcare areas to achieve better patient outcomes, lower costs of providing services and increase patient access to care. Tele-Intensive Care Unit (ICU) technology has been introduced as a way to provide effective ICU services to patients with reduced access, as well as to decrease costs and improve patient care.

Materials and Methods: The methodology for this qualitative study was a literature research and review of case studies. The search was limited to sources published in the last ten years (2003-2013) in the English language. A total of 58 references were used for this research exploration, inquiry.

Results: Tele-ICU was found to be an effective way to use technology to decrease costs of providing intensive care, while improving patient outcomes such as mortality and length of stay. Several case studies supported the use of telemedicine in ICU's to provide intensive care to patients who lived in rural areas, and lacked access to traditional ICU's. Further, it was noted that, although the initial costs for tele-ICU start up were significant, as much as $100,000 per bed, the benefits of the utilization of this technology can offset those costs by reducing costs by 24% via decreased length of stay for patients.

Discussion/Conclusion: The finding of this study has suggested that the implementation of tele-ICU may has been more beneficial than costly, and it may have provided healthcare organizations the opportunity to increase quality of care, decrease mortality while might have decreased costs of delivering ICU services in both rural and urban areas.

Key Words: Tele-ICU, telemedicine, cost, benefits barriers, implementation

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INTRODUCTION

With advances in technology, physicians have been able to use state of the art medical technology to treat patients more efficiently and effectively. Telemedicine has been an example of the positive impact of technology on health care and it has been defined as the use of technology to provide medical services to patients across distances via telecommunications devices.[1] Telemedicine has been applied in several areas, including radiology, psychiatry, diabetes management, as well as in Intensive Care Units (ICU).[1,2]

Goran[3] (2011) has defined tele-ICU as the provision of critical care by a team via computer and audio visual, or telecommunication systems. Approximately 7.6% to 10% of hospitals in the United States (U.S.) currently use tele-ICU technology to provide intensive care.[4,5] Tele-ICU providers have not been utilized to replace traditional intensive care providers, but to work together to supplement effective intensive care.[3]

Each year, approximately six million individuals living in the U.S. are admitted to an ICU, which has accounted for 30% of total hospital costs in the U.S., as of 2010.[6] ICUs in the U.S. have experienced a mortality rate of 10%, or 540,000 patients annually.[7] A significant number of ICU patients have experienced a life-threatening medical error during their hospital stay. Medication errors account for 78% of serious medical errors in the ICU nearly all suffer a potentially life-threatening error at some point during their stay.[8] This evidence has supported the substantial need for improvement in ICUs across the U.S.[9]

As the U.S. population has continued to age, the need for intensive care providers has risen significantly. Unfortunately, providers such as intensivists have been decreasing in numbers, causing a shortage of care practitioners.[10]According to a 2006 HRSA study the US will need as many as 4,300 critical care physicians by 2020 and its predict a 1,500 intensivist shortfall[11,12] Physicians trained as intensivists who provide care via tele-ICU have been able to help fill this gap in order to deliver more effective health care.[13] It has been suggested that tele-ICU implementation and utilization has the potential to be as effective as having dedicated intensivists in the ICU 24 hours a day, relieving taxed staff, and providing quality care to the ever increasing ICU patient population.[10]

The purpose of this study was to determine the potential impact and direction of the implementation of the tele-ICU in the hospitals to assess current benefits and barriers of adoption of this technology.

METHODOLOGY

The methodology for this qualitative study was a literature research and review of case studies. The approach for this research study followed the systematic search steps and a modified research framework utilized by Yao, Chao-Hsien and Li.[14] The use of the framework in the current study is appropriate as the focus is on the sub-area of telemedicine application to the ICU.

Insert figure 1 about here

Figure 1 depicts the process of tele-ICU adoption in healthcare. To research how tele-ICU can help to improve healthcare practices in the ICU, it is first necessary to recognize the existing

problems in the ICU and issues that drive and impede adoption of tele-ICU by this industry. Then different applications can be identified to solve or partially unravel these challenges. As a final result of analyzing the literature, the benefits and barriers of tele-ICU utilization in healthcare can be identified (Figure 1).

The review was conducted in distinct stages including: 1) determining the search strategy and establishing inclusion and exclusion criteria, 2) literature categorization and 3) extracting and analyzing the findings.

Step 1: Determining the Search Strategy and Establishing Inclusion and Exclusion Criteria

Telemedicine and its applications in healthcare, can be applied to radiology, psychiatry, emergency medicine, and intensive care medicine, each potentially with its own set of benefits and barriers to implementation and rates of adoption, so it was decided early that the scope of the study should be narrowed just to the tele-ICU. When executing the search, the following terms were used: 'tele-ICU' OR 'eICU' AND 'cost' OR 'outcomes' OR 'implementation' OR barrier OR benefit. A mix of databases and online sources were used to compile a set of references covering both academic peer reviewed research and practitioner literature (grey literature). It was believed that this approach would help create the most comprehensive and up-to-date review. The following electronic databases and sources were used: Pub Med, Medline, ESBCOhost, Academic Search Premier, and Google scholar.

Step 2: Literature Categorization

The literature review yielded 58 sources which were assessed for information pertaining to this research project. Given the technology- and enterprise-oriented nature of the current study, literature was selected for review based on, but not limited to, the following key areas:

technological issues, organizational issues, and organizational impacts. References were reviewed and determined to have satisfied the inclusion criteria if the material provided accurate information about tele-ICU with a particular focus on benefits and barriers to its implementation. Only articles that were written in English were included for review. Attempting to stay current in research, all articles that were older than 12 years (starting from 2000) were eliminated from the search. The results presented were extracted from journal articles, case studies and different online sources.

Step 3: Literature Analysis

In the third step, academic articles and practitioner health IT sources were analyzed and relevant categories were identified. The findings are presented in the subsequent sections using the categories of utilization of telemedicine technology in the ICU, tele-ICU providers, benefits of utilization of telemedicine in the ICU, and barriers to implementation of telemedicine in the ICU.

RESULTS

Utilization of Telemedicine Technology in the ICU

The primary provider for tele-ICU services in the U.S. has been Phillips, in Baltimore, Maryland.[15] This organization has provided necessary components for tele-ICU, such as bedside monitors that send information about the patient's status to both the ICU and the tele-ICU, and visual or audio alert systems to notify the tele-ICU team of significant changes in the patient's conditions.[16] Phillips has also provided computers and audio visual communication devices, such as cameras and microphones, an interface to allow the tele-ICU team access to lab reports, test results, X-rays, and a means of adding to the patient's medical record while ensuring data security.[16] Telemedicine implementation and utilization in the ICU has served two purposes.

First, it has allowed remote intensivists to assist in monitoring several ICU patients and to provide support to limited ICU staff, particularly in rural settings, via the use of data and decision support systems.[17] Tele-ICU use also has been used to assist intensivists in treating patients as though the practitioners were present in the physical facility. This has allowed more than simple data transmission, it has enabled physicians to see and hear everything he or she may see and hear in the ICU itself.[17] The tele-ICU has been implemented as a central station or hub, in a remote, or outside of the treating hospital, facility, where intensivist physicians and nurses can monitor it. The ICU staff has also communicated throughout the ICU via remote control to hear and see one another and the patients. The tele-ICU screen is used to show the providers patient information such as vital signs and laboratory results. The physicians and nurses have had notification of any problems with the patients' data such as vital signs and test results, as well as having a bedside or overhead view of the patient via video camera.[31]

The technology used in the tele-ICU has evolved to include three different models. As identified by Reynolds, Rogove, et al, [18] these models are the centralized, decentralized, and hybrid models. The centralized model has been the most used, hub and spoke model wherein tele-ICU intensivists are situation in a central location in an urban hospital (the hub) that provides tele-ICU interventions to several outlying units or rural hospitals (the spokes). This model, while effective, has had implementation costs of $50,000 to $100,000 per bed, thus the decentralized model was created as a way to prevent significant startup costs.[19] The decentralized model has allowed intensivists in several office locations to access the tele-ICU via desktop or laptop without relying on a central hub from which to practice. This has saved organizations from investing considerable capital to start a traditional tele-ICU.[20] Finally, a third, hybrid model of tele-ICU combines parts of both the centralized and decentralized models. In this model, a

large hospital organization partners with an independent physicians organization to provide tele-ICU care to multiple hospitals. This is different from the centralized model in that the physicians are not located in one central area, but are in multiple facilities, thus it has decreased costs for the central hub, while allowing multiple facilities to utilize the tele-ICU care available.[18]

One hospital system in West Virginia, Charleston Area Medical Center (CAMC), has used tele-ICU implementation to improve patient care in the organization's Women and Children's Hospital.[21] The hospital has an Intermediate Care Unit located in the Gynecology/Gynecological Oncology Unit, and has utilized tele-ICU care in this unit. Two cameras have been installed in each of the two rooms in the Intermediate Care Unit, one on the ceiling directly above the patient bed, and one near the foot of the bed. CAMC intensivists in other CAMC facilities use these cameras to monitor patients in these two beds, along with data from a cardiac monitor. Furthermore, an interactive monitor has been mounted in each room, which is used to allow verbal and visual interactions between the intensivist and any care providers or patients in the room (Linda Cobb, personal communication, 2012). The tele-ICU in this facility has been utilized to promote effective, efficient care for gynecological or oncological patients who have had a history of significant cardiac complications, or who have exhibited arrhythmias during surgery. As these patients are monitored by an intensivist, if problems such as chest pain or changes in EKG develop, the patients can be transferred to the CAMC's cardiac center, at CAMC Memorial Hospital (Linda Cobb, personal communication, 2012).

Tele-ICU Providers

Goran[22] identified two distinct groups of providers on the tele-ICU team: physicians and nurses. It has been recommended that physician providers be trained intensivists, or at least have significant experience in an intensive care environment. These physicians must have been credentialed and have privileges in all hospitals where they provide tele-ICU interventions. Similarly, nurses on a tele-ICU team should have several years of experience in a traditional ICU setting.[23] Effective communication skills have been identified as the most important skill a tele-ICU team member must possess, as clear and effective communication is necessary to establishing rapport between ICU and tele-ICU, building a productive team, and providing appropriate and effective care to ICU patients.[24] The tele-ICU team has not replaced the traditional ICU team, rather, it has been used to support, supplement, and augment the traditional team.[25] This support has allowed for more positive patient outcomes such as decreased length of stay and decreased mortality. Other healthcare providers that can join the tele-ICU team have been identified such as pharmacists, nurse practitioners, and administrative support staff in order to provide more comprehensive care .[23]

Benefits of Utilization of Telemedicine in the ICU

Studies have examined the benefits of tele-ICU implementation Lilly and Thomas[26] found evidence to support tele-ICU utilization.[27] The researchers identified adherence to best practices, early intervention, and increased education opportunities as well as additional provider resources for patient care and decreased medication errors as identifiable benefits to tele-ICU implementation (Table 1). Positive outcomes linked to tele-ICU utilization have included decreased mortality rate and Length of Stay (LOS). Sapirstein et al.[28] found that tele-ICU technology increased staffing, which was related to decreased LOS. Further, other studies performed from 2004 to 2012, have found LOS decreased between 0.5 and 1 day (Table 1).

Several test/retest, or pre/posttest studies after Tele ICU implementation, as well as qualitative research have identified the most significant benefits of its implementation and utilization as decreased LOS of one to two days, decreased mortality rates of between 7% and 27%, improved patient outcomes, and cost control and savings of between $5000 per bed to $8 million over 8 years. (Table 1).

TABLE 1 ABOUT HERE

A 2005 test-retest study examined the implementation of tele-ICU for a six month period. The results showed a decrease in mortality rate of 3.5% during the time the tele-ICU was implemented.[29] Another study by the University of Massachusetts Memorial Hospital in 2010 indicated the use of tele-ICU decreased the mortality rate by 19.6%, and the LOS by 29.7%.[30] This study also showed that the cost per case was reduced by more than $5,000 per bed (Table 2).

In September of 2004, an ICU in central Florida launched Florida's first tele-ICU program. The central tele-ICU monitored patients from four different hospitals miles away from the central location. It was found that after the implementation, the tele-ICU promoted prompt action, with fewer complications, and improved patient outcomes generating a 27% decrease in mortality and a 17% decrease in LOS.[31] (Table 1).

A 2009 study examined the financial benefits of tele-ICU implementation in a rural health system that stretched across several mid-western states.[32] The tele-ICU system revealed a

cost savings of $8 million to the rural system (Table 2). These savings demonstrated the ability to obtain a return on investment based on savings from length of stay reductions, decrease in transportation costs, and more accurate billing.[32]

INSERT TABLE 2 HERE

Also in September of 2004, a large hospital system in the northwest U.S. implemented a tele-ICU program. This program utilized telemonitoring in several types of ICU's, including medical, cardiovascular, surgical, and neurological ICU's in different hospitals within this organization.[33] A test/retest study found several positive outcomes of Tele ICU implementation and utilization of this program in these ICU's. The mortality rate of all admitted ICU patients was reduced by 13%, and a savings of $920,000 was identified over the course of one year (Table 3).

The economic impact of tele-ICU in an academic surgical ICU allowing ongoing intensivist supervision has been measured, to study the overall cost benefits of the transition.[34] The researchers found that based on an average surgical tele-ICU cost per 24 hours of $1,500-$2,000 and a daily cost in a regular room of $500-$600, a nearly 10% reduction in ICU stay and 20% decrease in regular room stay resulted after implementation of the tele-ICU. The savings amounted to over $800,000 for the ICU and over $2,500,000 for the regular rooms (Table 1and Table 3).

TABLE 3 ABOUT HERE

While cost containment and improved patient outcomes have been identified as the primary benefits of tele-ICU utilization, these are not the only benefits. Improved staff

communication, teamwork, and improved supervision have also been recognized as advantages (Table 1). In a 2005 pre/post tele-ICU implementation study, Chu-Weininger, et al.,[35] measured the effects of tele-ICU utilization on teamwork and patient safety in the ICU via the Teamwork Climate Scales and the Safety Climate Score. The authors found tele-ICU utilization improved teamwork among staff members and improved patient safety in two out of three ICUs studied, with teamwork scores increasing by 12% (Table 1).

Other benefits of tele-ICU utilization have been found, as well. Yeo, Grass-Ahrens, and Wright[19] found that tele-ICU prevented unnecessary transfers from rural hospitals, allowing patients to remain close to home and family support during the ICU stay (Table 1). Operation of tele-ICU technology has been shown to improve patient and provider satisfaction by increasing access to appropriate care, increasing the ability of providers to meet the needs of patients, and improving patient outcomes.[36]

Additionally, a qualitative study in which Khunlertkit & Carayon[37] used semi-structured interviews of ICU practitioners to explore the benefits of tele-ICU yielded the well substantiated results of decreased mortality rate and decreased LOS. These researchers also found that in the views of the practitioners, tele-ICU utilization was connected with an increase in evidence based medicine compliance and improved medication management, as well as increased patient safety via decreased patient falls and extubation (Table 1).

Barriers to Utilization of Telemedicine in the ICU

While tele-ICU implementation and utilization has been shown to be beneficial in several areas, barriers to this technology have also been identified. Tele-ICU's are expensive to implement and maintain, costing up to $100,000 per bed for implementation alone. Also lack of staff and practitioner acceptance and organizational challenges such as absence of corporate and practitioner education about tele-ICU and nonexistence of provider buy-in hinder the utilization of the technology (Table 3).

A cost analysis of pre and post tele-ICU implementation from 2003 to 2006 in six ICU's in Texas found that costs per day, per case, and per patient rose significantly, between 24% and 43%, after the technology was implemented. These authors did note that tele-ICU use was cost effective with the most acutely ill patients in the ICU, thus costs for those patients did not significantly increase (Table 2).

Beyond not being cost effective in some instances, tele-ICU has been found to have sizeable start- up costs. A 2013 meta- analysis of the costs to implement tele-ICU found those costs ranged from $50,000 to $100,000 per tele-ICU bed. According to a 2009 study, the cost of tele-ICU implementation has been estimated between $30,000 to $50,000 per bed (Table 3).

In contrast, one U.S. based study suggested that 50-60 ICU beds have to be utilized in order to make the tele-ICU program effective, requiring the participation of 8-12 satellite ICUs in the network (Table 2). The authors suggested that tele-ICU on its own was not what lead to a reduction in ICU, hospital mortality, and length of stay, but it was the means for intensivists to treat not only more ICU patients, but also to offer more continuous care.[38] Other studies, from 2010 and 2011 also have identified no significant cost savings or decreased length of stay between tele-ICU and traditional ICU care (Table 2).

Resistance to change and to implementation of the technology has also been a major barrier to the utilization of the tele-ICU. According to Wood[39], tele-ICU have become a perceived threat to some physicians because the care is shared. This sharing of care and responsibility requires physicians to relinquish some control. A few physicians may have difficulty doing so (Table 1).

Part of the resistance to the implementation of the tele-ICU may be due to lack of provider understanding of the technology. Shahpori, et al. [40], conducted an online survey study with intensivists in a Canadian health care organization to assess practitioner knowledge, education, and acceptance of tele-ICU technology. The authors found the practitioners rated their knowledge of, and education about the technology low, and expressed little acceptance and significant doubt of the efficacy of tele-ICU technology (Table 1).

DISCUSSION

The purpose of this study was to determine the potential impact of tele-ICU technology, as well as to determine the direction of the implementation of the electronic ICU in the hospitals to assess current benefits of and barriers to the adoption of this technology. In our study, Tele-ICU implementation and utilization was identified as having several benefits, such as allowing ICU care to be delivered to far reaching rural areas, and has been shown to decrease costs of providing intensive care, as well as improved quality of care by reducing errors and increasing patient safety. Further, findings of this technology suggest that it has been able to improve patient outcomes such as mortality rate and decreased LOS.

The total cost of tele-ICU, as much as $100,000 per bed, has been identified as a potential barrier to implementation[41] .The potential for long-term benefits of the system, however, have been demonstrated to significantly outweigh the substantial financial costs[39] .The biggest disadvantages found for implementing the tele-ICU were the financial burden of implementing this system and the costs of maintaining it. Nevertheless, it has become evident that the implementation of tele-monitoring has had financial benefits and has produced positive patient outcomes. After operating the tele-ICU system for more than a year, there has been reported a significant decrease in total ICU costs, patient mortality rate, from 1.0 to 0.65, and length of stay, from 1.18 additional days to 0.96 days.

Study Limitations

This study was limited due to the restrictions in the search strategy used, such as the number of databases searched, researcher and publication bias may have limited the availability and quality of the research identified for review. Additionally, the search was limited to hospital organizations in the United States alone, thus excluding many international providers of tele-ICU care.

Implications

The implementation of tele-ICU has had long-term financial benefits and an increase of patient safety and patient satisfaction. Significant decreases in total ICU costs have occurred after the tele-ICU system has been operating for more than a year. Financial benefits have been identified, as well as benefits in patient safety and patient satisfaction, however, the mixed results of this literature review have indicated further research is necessary. Tele-ICU has the potential to be the wave of the future in intensive care medicine due to the costs savings and

improvement of provided quality of care however in the U.S., implementation cost for hospitals have been the main barrier of the use of telemedicine in the ICU.

CONCLUSION

The present study findings suggest that the implementation of tele-ICU has been to some extent more beneficial than costly. Hospitals may spend a significant amount of money implementing and maintaining the Tele-ICU system, and long-term benefits may outweigh the costs through a decrease in LOS as well as a decrease in mortality rates. This technology could be identified as a technological and strategic advantage in critical care for the future.

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