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Telehealth in Critical Care: Quality and Cost Outcomes

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ABSTRACT
As the population of the United States has continued to age, there has been an increase in usage and Hospital Length of Stay (LOS) costs of Intensive Care Unit (ICU) beds. In the early 2000s, it was determined there would be a shortage of all ICU providers within the next decade due to the increased need for critical care for the aging generation. Around this time, the Leapfrog Group was formed to demand that hospitals improve quality and decrease cost. Utilization of telehealth in the ICU was a possible alternative, which had a positive impact on both clinical and financial areas in the hospitals that utilized these programs in their ICUs. Although mortality rates and LOS were decreased and savings realized by the hospitals and Medicare, one barrier to increased implementation was the significant initial outlay. Further study could lessen this apprehension by revealing considerable Return on Investment (ROI).

Keywords
Telehealth, Telemedicine, Tele-ICU, Critical care, Clinical quality, Mortality rates, Financial impact, Cost, Cost savings

1 INTRODUCTION

As the population of the United States has continued to age, there has been a noticeable increase in the usage of intensive care unit beds. A total of 4 million patients have been admitted to ICUs throughout the U.S. each year. These ICU-related admissions have accounted for almost $80 billion annually and for 20% of deaths that occurred in hospitals (Kahn & Rubenfeld, 2015). A 2011 review of hospital admission data from 29 states showed that 26.9% of hospital stays involved time in an Intensive Care Unit (ICU). The highest rate of ICU use was at 93.3% for respiratory disease with ventilator support. Additionally, hospital length of stay that involved ICU care was 2.5 times costlier than other hospital stays (Barrett, Smith, Elixhauser, Honigman, & Pines, 2014).

In the early 2000s, red flags were raised regarding the imminent shortage of all ICU providers that was to occur within the next decade due to the increased need for critical care for the retiring baby boomer generation (Lois, 2014). Around the same time, the Leapfrog Group was formed by several Fortune 500 companies to demand hospitals improve quality and decrease cost (AHRQ, 2011). The group joined forces with member organizations such as the Business Roundtable and The Robert Wood Johnson Foundation to develop a plan of ICU physician staffing that would improve quality and reduce overall costs (AHRQ, 2011). To fully implement the ICU Physician Staffing standard, a hospital would operate their ICU with intensivists who were present during daytime hours and provide clinical care exclusively in the ICU (Leapfrog Group, 2018). When not present on-site or via telemedicine, the intensivists would return notification alerts at least 95% of the time, within 5 minutes, and arrange for a provider to reach the ICU patients within 5 minutes (Leapfrog Group, 2018). Nguyen, Kahn, and Angus (2010) noted the heterogeneous delivery of critical care in the U.S. and the lack of standardization because of the variations in physician coverage. This heterogeneity was possibly responsible for 100,000 preventable deaths in the U.S. per year (Nguyen et al., 2010).

Proper physician coverage was possible in high academic centers, but it was more difficult in rural and understaffed communities. In the early 2000s, it was estimated that only 37% of all ICU patients in the U.S. were cared for by intensivists in general (Lois, 2014). More recent data from 2011 estimated that only 14% of ICUs practice a bedside intensivist-led ICU model (Lilly *et al*., 2014).

According to the Center for Medicare and Medicaid (CMS) (2018), one possible solution to this problem was the use of telehealth, or telemedicine, to fill the gaps. CMS has defined telehealth as the use of an interactive audio and video telecommunication system to provide real-time communication between the provider and the patient (CMS, 2018). Telehealth was first used in 1906 to transmit electrocardiography over telephone lines and evolved with advances in technology such as the transmission of telemetry data by the National Aeronautics and Space Administration of astronauts in space to command centers on earth (Lilly et al., 2014). As of 2016, there were only 17% of hospitals that had initiated a telehealth service in their ICUs (Kohn et al., 2017). The cost of installing a tele-ICU ranged from $2-$5 million for set up costs and upwards of $1.5 million to operate annually (Franzini, Sail, Thomas, & Wueste, 2011).

Multiple factors such as state policies regarding reimbursement and regulation have slowed the adoption of telehealth (Adler-Milstein, Kvedar, & Bates, 2014). As of late 2012, 42% of hospitals had adopted some form of telehealth in their healthcare systems. Of these healthcare systems, it was found that rural hospitals were more likely to initiate a telehealth program with the desire to improve access (Adler-Milstein et al., 2014).

The purpose of this study was to gauge the potential for the implementation of telehealth in the Intensive Care Unit to determine its impact on the quality of care and overall healthcare costs. Also, the study also reviewed possible barriers to its implementation.

2 RESULTS

Financial Impact of Telehealth Use in Critical Care

In a series of studies, UMass Memorial Medical Center found that tele-ICU can save millions of dollars and recoup hospital's capital cost within months of implementation (Wicklund, 2017). The University of Minnesota Medical Center's Fairview Health System in 2011, began employing the use of telehealth within its ICU facilities. This study of the 106-bed ICU Fairview Program was conducted to review, among other aspects, the initial cost of implementation and the annual operating costs of a tele-ICU program. It was stated that the average initial capital cost of tele-ICU control centers ranged between $2,000,000 and $6,000,000. Fairview's capital cost was $1,186,220. Furthermore, the average combined implementation and first-year operation cost, per tele-ICU bed, ranged between $50,000 and $100,000. Fairview's combined implementation and first-year operational cost, per tele-ICU bed, was $45,117. Its annual operational cost for one tele-ICU bed was $23,150 (Fortis, Weinart, Bushinksi, Greiner Kohler, & Beilman, 2014).

The Fairview researchers also reviewed and compared data from the Veterans Health Administration (VHA) hospitals. In their study, these facilities had a combined capital and first-year operational cost, per tele-ICU bed, that ranged from $70,000 to $87,000 (Fortis et al., 2014). Additional VHA data showed a tele-ICU program that was initiated in 7 separate VHA hospitals, containing 74 ICU beds. The total cost of implementation for the program, plus first-year operating costs of the off-site monitoring hub, was $9,097,410 (Kumar et al., 2013). More specifically, the total cost for technology, including hardware, software, operating equipment, networking, and licensure requirement fees was $5,196,661 (see Table 1).

Table 1. 2011 VHA Network – Tele-ICU First Year Implementation Costs

Cost Category	Monitoring Facility (74 beds)	Hospital 1,2 ICU (23 beds)	Hospital 2 (10 beds)	Hospital 3 (6 beds)	Hospital 4 (16 beds)	Hospital 5 (5 beds)	Hospital 6 (5 beds)	Hospital 7 (9 beds)	System Total (8 ICUs, 74 beds)	% of Grand Total
Hardware/Upgrades	331,593.79	185,493.62	80,649.40	48,389.64	129,039.04	40,324.70	40,324.70	72,584.46	928,399.35	11
CIS Software	N/A	444,175.24	115,263.67	66,736.05	228,495.50	77,519.97	69,712.65	115,263.08	1,117,166.16	12
Telemedicine Software	414,000.00	167,533.60	73,982.00	47,889.20	113,121.20	41,336.00	31,366.00	67,458.80	956,686.80	10
Installation Fees	780,867.00	276,775.20	72,864.00	72,864.00	72,864.00	72,864.00	72,864.00	72,864.00	1,494,826.20	16
Equipment and Network	43,323.59	261,624.29	53,676.84	30,087.57	107,063.44	50,561.57	58,236.79	84,978.85	689,552.94	8
Technology Total	1,569,784.38	1,335,601.95	396,435.91	265,996.46	650,583.18	282,636.24	282,504.14	413,149.19	5,196,691.45	57
Physician Fees (p/year)	1,576,800.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,576,800.00	18
Nursing Fees (p/year)	1,295,987.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1,295,987.00	15
Technical Fees (p/year)	136,664.00	…	…	…	…	…	…	…	136,664.00	1
Managerial Fees (p/year)	384,744.00	…	…	…	…	…	…	…	384,744.00	5
Industry Training	…	14,256.00	8,298.00	8,298.00	14,256.00	8,298.00	8,298.00	8,298.00	70,002.00	…
Nonindustry Training	5,000.00	…	…	…	…	…	…	…	5,000.00	…
Travel Expenditures	35,000.00	…	…	…	…	…	…	…	35,000.00	…
Staffing Total	3,434,195.00	14,256.00	8,298.00	8,298.00	14,256.00	8,298.00	8,298.00	8,298.00	3,504,197.00	39
CIS Site Design Prep	120,858.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	120,858.00	…
Tele-ICU Site Design Prep	26,635.00	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26,635.00	…

(Kumar, et al., 2013)

The approximate cost for staffing and operating the monitoring site for the first year of implementation was $3,300,000, or $123,000, per ICU-bed (Kumar et al., 2013). According to Barnes (2018), ICUs that employed the use telemedicine were measured for cost savings via quality-adjusted life years, or a measure of disease burden (pain, self-care, and many more) and the ability for healthcare to sustain life. The findings were that the cost of the tele-ICU care was $45,320 per quality-adjusted life year. This fell well below the benchmark of $100,000 to be labeled cost-effective compared to, for example, the charge for dialysis at approximately $129,092, (Barnes, 2018). Variables such as staffing, and mortality rate were also considered. According to the findings, these tele-ICUs yielded cost savings in 37% of the 1,000 scenarios it assessed (Barnes, 2018). Also, Lilly et al. 2017 found significant cash flow of 21% and an increase in marginal revenue up to 376% when tele-ICU was implemented allowing the hospital to accommodate more patients and refocus on more critical cases (Lilly, Motzkus, Rinco, et al., 2017).

Emory Healthcare began using a telehealth program in its ICU and, during an independent audit of this program that spanned 15-months leading up to 2017, the cost savings were monitored. During this initiative, the institution saved Medicare $4.6 million (Leventhal, 2017). During the monitoring process, the program at Emory Healthcare, including 136 beds at 5 hospital locations, was compared to 9 other hospitals in the Atlanta area to determine the program implementation's success. Relative to the comparison group, the total savings included: a decrease of $1,486 in average Medicare spending, per 60-day episode, a 4.9% increase in discharges to home healthcare, a 6.9% decrease to skilled nursing facilities and long-term care hospitals, and a 2.1% decrease in the rate of 60-day inpatient readmissions (Leventhal, 2017).

In 2007, Resurrection Health Care in Des Plaines, IL implemented the use of telemedicine into its 14 ICUs. Cost savings of $3 million was reported in the first six months (Coustasse, Deslich, Bailey, Hairston, & Paul, 2014). This included $11,200 from a 7% decrease in blood transfusions and a 38 % decrease in ICU Length of Stay (LOS). By 2011, tele-ICU support for patients across the implemented system resulted in 9000 ICU days saved. This was an estimated cost savings of $11.5 million (Coustasse et al., 2014).

The implementation of telehealth, examined in a study by Kumar, Merchant, and Reynolds (2013), found a 10% reduction in ICU LOS. This allowed for the ability to care for one new patient per day and resulted in a Present Net Value of $2.5 million. ICU costs decreased by 25% to 31% during the intervention period, while total hospital costs decreased by 12% to 19%. Also, the cost of care per day of service was considered. This list included items such as equipment, staffing, and miscellaneous costs associated with managing a tele-ICU system. The results were a 24.6% decrease in variable costs per patient (Kumar et al., 2013). Furthermore, tele-ICU offers cost savings of up to $10,000 per case to payors by allowing community hospitals to take care of more complex cases, avoiding transfer to referral hospital (Pannu, Sanghavi, Sheley, et al., 2017)

Clinical Impact of Telehealth Use in Critical Care

One clinical measure used to assess the effectiveness of care in the ICU has been mortality. Sadaka et al. (2013) examined the implementation of a tele-ICU program at a large community-based hospital. The study was a retrospective study of 2,823 patients. It took 630 pre-intervention patients as well as 2,193 tele-ICU and controlled them for baseline characteristic – Acute Physiologic and Chronic Health Evaluation IV (APACHE IV) and Acute Physiologic Scores (APS). ICU mortality dropped from 7.9% in the pre-intervention group and 3.8% during the tele-ICU period. Overall hospital mortality dropped from 8.8% to 6.9% (Sadaka et al., 2013).

A retrospective study was conducted that investigated at pre- and post-deployment of a tele-ICU program. This research controlled the groups with APS and APACHE IV scores. In the pre-implementation period, a mortality of 21.4% was reported. After implementation, the crude mortality was 14.7% (McCambridge et al., 2010). Additional clinical markers were evaluated. Ventilator use, for example, was examined. It was found that, in the pre-implementation group, 36.1% of patients required a ventilator, compared to 31.5% in the tele-ICU group (McCambridge et al., 2010).

Length of stay (LOS) was also an indicator of clinical quality. Sadaka et al. (2013) found a decrease in ICU LOS from 2.7 days to 2.2 days in the tele-ICU group; however, an increase in the overall length of stay from 5.2 days to 6.2 days was noted (Sadaka et al., 2013). McCambridge et al. (2010) found similar findings with ICU LOS going from 4.06 days to 3.77 days. It was noted an increase in total hospital length of stay from 9.15 days to 9.21 days (McCambridge et al., 2010).

Cummings, Krsek, Vermoch, and Matuszewski (2007) reported a decrease in mortality by 27% and a decrease in ICU LOS by 16% for the group using the telemedicine technology (Cummings et al., 2007).

Kahn et al. (2016), examined took 521 hospitals using 2001-2010 Medicare claim data linked to a national survey identifying U.S. hospitals that had adopted ICU medicine. It was found that, overall, 3.8% of the 5,650 hospitals had adopted an ICU telemedicine program. After exclusion criteria were applied, 132 tele-ICU hospitals were compared to 389 control hospitals. The finds were that 12.1% of the tele-ICU hospitals had a statistically significant reduction in mortality, 81.1% had no reduction, and 6.1% had increased mortality. A 90-day mortality measure that compared pre-adoption with post-adoption found a slight difference from 24.3% to 24.00; however, this study showed there was heterogeneity in effect across those studied hospitals, finding a most significant difference in large volume urban hospitals (Kahn et al., 2016).

A meta-analysis was performed by Young, et al. (2011) that included 35 ICUs. All evaluations were done with a before and after comparison. A large patient population of 41,374 patients was found to have reduced ICU mortality (pooled odds ratio, 0.80; 95% p=.08), but not in-hospital mortality. This study also showed a reduction in ICU length of stay of mean -1.26 days. This was not so with hospital length of stay, with only a mean difference of -.16 days with a p=.16 (Young et al., 2011).

The use of tele-ICU has allowed for small community and rural hospitals to have care managed by an intensivist. This type of coverage has been called a closed ICU (Armaignac, Saxena, Rubens, et al., 2018). Several studies were done on closed ICU and the quality of care provided (Juneja, Nasa, & Singh, 2012). Gasperino (2011) examined the impact this type of unit had on acute lung injury (ALI) patients, a lung disorder typically caused by infection. After correcting the patients for variables, it was found that the closed units had a 26% less chance of ALI (Gasperino, 2011).

3 DISCUSSION

The purpose of this study was to gauge the potential for the implementation of telehealth in the Intensive Care Unit to determine its impact on the quality of care and overall healthcare costs. The results of the literature review suggested that hospitals that employed the use of telehealth in their ICUs generated substantial return-on-investment and improved clinical quality outcomes. The review results of the actual cost to implement and maintain a tele-ICU program was expected but remarkable. The cost to establish this type of program ranged from $2,000,000 to $6,000,000, regardless of facility type (Fortis et al., 2014). This enormous outlay was setup cost only and did not include annual operational costs such as administrative expenses, intensivist fees, or equipment maintenance. Also, the combined capital and first-year operational cost remained comparable across all facility types as well, ranging from $50,000 to $100,000 per tele-ICU bed (Fortis et al., 2014).

In further reviewing the financial material associated with tele-ICU implementation, the documented findings related to overall cost savings were promising. Regardless of the initial cost to implement the program, the results were indicative of positive outcomes about substantial savings for the hospitals involved. Tele-ICU allowed for significant decreases in ICU LOS. These reduced LOS allowed for a savings of $11.5 million (Coustasse et al., 2014). This further translated to savings in the cost of care per day of service per patient, with a significant decrease of 24.6% (Kumar et al., 2013).

Tele-ICU implementation showed a substantial decrease in mortality, both in the hospital and, more significantly, in the ICU (pre-intervention of 7.9% versus post intervention of 3.9%) (Sadaka et al., 2013). The closer monitoring and quicker interventions allowed by the tele-ICU also showed a significant decrease in ALI injury, one of the leading causes of mortality. This was found to show an adjusted odds ratio of 0.68 in the high-intensity group, compared to 0.98 in the control group (Gasperino, 2011). LOS in the ICU also had a significant impact on clinical outcomes and mortality. For example, decreased LOS would diminish the likelihood of developing any hospital-acquired infections or skin breakdown leading to mortality with a reduction of crude mortality from 21.4% to 14.7% (McCambridge et al., 2010). Given the study limitations, the benefits of telehealth are still encouraging in both the financial and clinical areas. In a specialty such as critical care with increasing demand, telehealth could be a viable option for struggling critical care programs.

4 CONCLUSION.

The literature review suggested consistent positive clinical and financial outcomes as a result of the introduction of telehealth in the ICU. Although the initial outlay was noteworthy, the increase in quality clinical outcomes and, in turn, ROI was significant.

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