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THE BUSINESS CASE FOR THE EFFICIENCY AND EFFECTIVENESS OF TELE-INTENSIVE CARE UNITS

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ABSTRACT

A tele-Intensive Care Unit (tele-ICU) is the use of telemedicine in an Intensive Care Unit (ICU) setting, using technology to provide care to critically ill patients by off-site clinical resources. This literature review examined a large number of studies of the implementation of tele-ICU systems in hospitals. Generally, implementation of a tele-ICU system was associated with cost savings, shorter lengths of stay, and decreased mortality. Implementation of tele-ICUs is initially relatively expensive but result in cost savings and better clinical outcomes. Intensivists working these systems are used more effective providing better clinical outcomes for patients at lower costs for hospitals.

INTRODUCTION

Telemedicine is the use of medical information exchanged from one site to another via electronic communications to improve a patient's clinical health status. Telemedicine includes a growing variety of applications and services using two-way video, smart phones, wireless tools, and other forms of telecommunications technology (American Telemedicine Association, 2013-ok). A tele-ICU involves the use of telemedicine in an Intensive Care Unit (ICU), using technology to assist in providing care for critically ill patients by off-site clinical resources (Aust, 2012).

More than four million patients are admitted to ICUs each year (ICU Outcomes, 2012); treatment for these critically ill patients accounts for 30% of acute care hospital costs (Wenham and Pittard, 2009). Patient safety concerns persist in the ICU and serious medication errors in this environment alone account for 78% of serious medical errors in the ICU (Rothschild et al., 2005). Costs are high; hospital costs for critically ill patients have being estimated in 2003 to be in excess of $67 billion annually - mortality rates averaged from 10% to 28% or approximately 540,000 deaths each year (Angus et al., 2004; Kersten et al., 2003; Mayr et al., 2006.)

ICU costs are expected to escalate because of the continuous growth of the aging American population and increasing complexity of care both available and required (Angus et al. 2000). A patient 65 to 74 years of age is more than three times likely to use critical care units compared to a middle-aged patient, and a patient over 85 is 6 times more likely to use the critical care unit (Fifer et al., 2010).

Tele-ICUs can be effective when established in hospitals. Three distinct types of tele-ICU have been identified. In a decentralized tele-ICU, a medical facility or multiple medical facilities are located at remote sites such as office, home, or mobile. There is no distinct tele-ICU, rather there is a process of care having multiple sites of access to the patient, with physicians monitoring the patients. A centralized tele-ICU program has been often implemented as the tele-ICU system of choice. In the centralized system, one central ICU provides intensive care via telemedicine and remote monitoring to several satellite ICUs. Finally, a hybrid of centralized and decentralized tele-ICU models has been explored, to include continuity of care, data collection and reliable multiple specialists and local physicians with higher levels of patient knowledge, however, only one hospital has implemented such a tele-ICU In the tele ICU model the tele-ICU is a definable entity providing continuous monitoring to sites with high level of needs via private, dedicated telecommunications lines (Reynolds, Bander and McCarthy, 2012). Networks of audiovisual communication and computer systems link hospitals ICUs to intensivists and other critical care professionals, which can be used to store and forward data (e.g., medical records), to conduct remote real-time monitoring of vital signs or chronic conditions, or to facilitate staff interactions via video, phone or online computer. Video cameras located on the ceiling of an ICU patient room can zoom to see equipment and monitors and cameras typically have an electronic doorbell to announce that the tele-ICU staff are in visual contact to share observations and care recommendations with bedside caregivers (Myers and Reed, 2008).

Studies have demonstrated both clinical and economic benefits associated with adoption of tele-ICUs, including decreased mortality rate, decreased incidence of ICU complications, decreased ICU length of stay and decreased ICU costs following a 16 week implementation of technology-enabled remote care (Breslow et al. 2004; Groves, Holcomb Smith, 2008; Rosenfeld et al., 2000). A recent meta-analysis of non-severity-adjusted data from 11 studies (Wilcox and Adhikari, 2012) confirmed these results and found each of them to be statistically significant. These results are particularly important, as studies which reported results based upon both severity-adjusted data and non-severity-adjusted data have found that level of statistical significance of these outcome variables when using non-severity-adjusted data was higher than when using severity-adjusted data (e.g., Kohl et al., 2012; Lilly et al., 2011).

Savings appear to have been achieved because higher quality care was delivered to critically ill patients (Venditti et al., 2012). It has been estimated that full implementation of the tele-ICU standard in community hospitals could prevent between 5,400 and 13,400 deaths and could potentially save $5.4 billion annually (Pronovost, Waters and Dorman, 2001).

One of the main barriers to adoption of tele-ICUs has been installation costs: the cost of construction, installation and training the "command center" for a tele-ICU system has been estimated to be between $2 and $5 million, with each additional tele-ICU added to the system costing $250,000 ("NEHI, MTC and HTC", 2007). Such substantial financial outlays can be a challenge for hospitals and health systems that lack significant financial savings or borrowing capacity, especially with annual operating costs of about $2 million including maintenance costs, licenses, staffing expenses, and additional upgrades (Nielsen and Sarcino, 2012). If the tele-ICU system is not fully compatible with the hardware or software systems of the physical ICU, additional upgrades maybe required, which would have additional financial consequences.

Regardless of the need for upgrades, staff will have to deal with computer issues including difficulty logging on, short battery life, frequent rebooting, and other technical issues with computer or software. Some of the possible solutions include ensuring computers remain plugged in, passwords are able to be used in multiple programs, and IT assistance to be available by phone and on site as required (Lynden, 2008).

Although tele-ICUs are expensive, they should not be overlooked as a possible solution for ICUs. Since ICU patients frequently have such complex medical and/or surgical conditions there can be more complications (Zapatochny Rufo, 2008).

The purpose of this study was to examine the implementation and utilization of tele-ICU systems to determine their efficiency and efficacy.

METHODOLOGY

The methodology for this qualitative study was a literature research and review of case studies complemented with a semi structured interview of Dr. Craig Lilly, a clinician well versed in the utilization of telemedicine in ICU's (Appendix A). This interview was tape recorded, and only relevant and pertinent answers were used to support the information found in the literature review to provide a comprehensive overview of this technology and its utilization

in ICUs. The approach for this research study followed the systematic search steps and a modified research framework utilized by Yao, Chao-Hsien and Li.[11] The use of the framework in the current study is appropriate as the focus is on the sub-area of telemedicine application to the intensive care unit.

Figure 1: Conceptual Framework

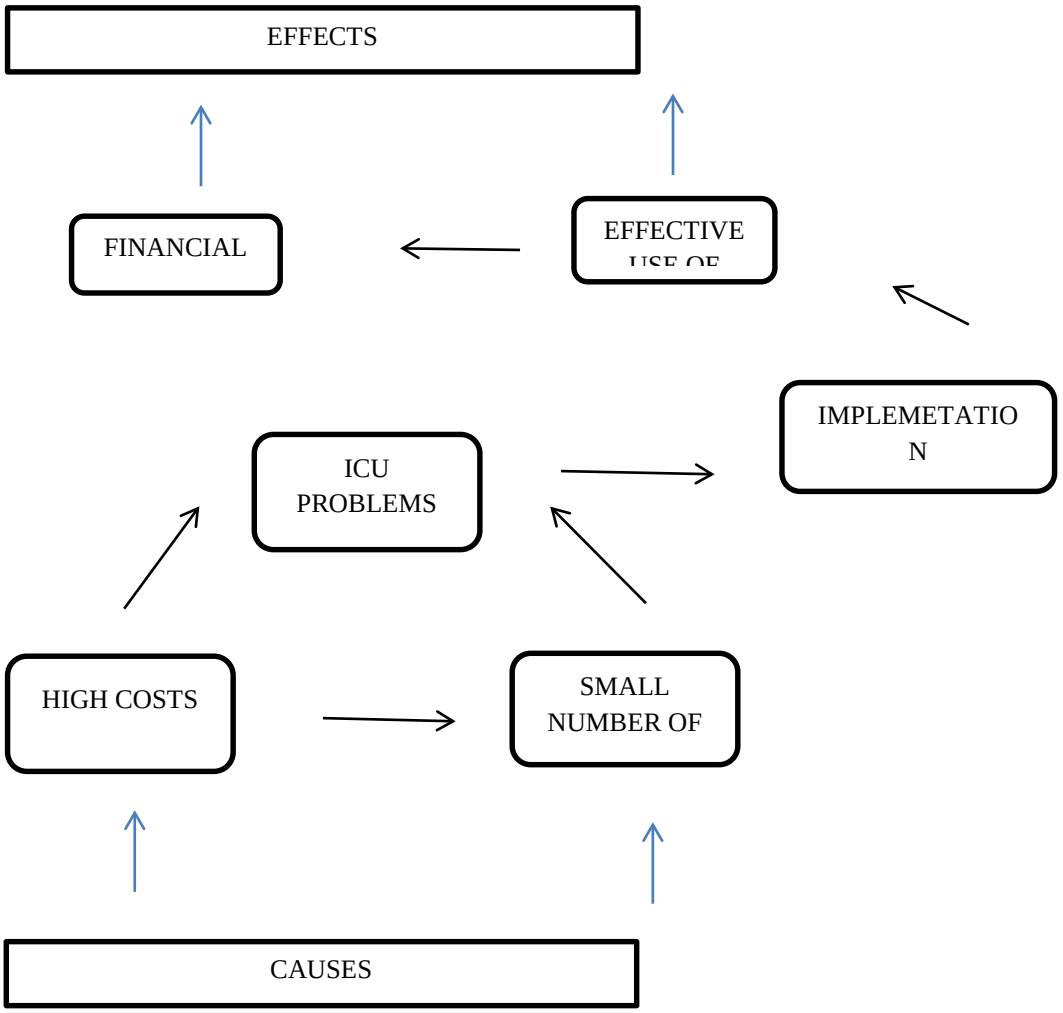

Figure 1 depicts the process of tele-ICU adoption in healthcare. To research how tele-ICU can help to improve healthcare practices in the intensive care unit, it is first necessary to recognize the existing problems in the ICU and issues that drive and impede adoption of tele-ICU by this industry. Then 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.

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 'tele-ICU' OR 'telemedicine ICU' OR 'virtual ICU' AND 'cost' OR 'benefits.' 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: PubMed, Academic Search Premier, Science Direct, ProQuest, and Google Scholar. Websites of the Society of Critical Care Medicine and American Telemedicine Association were also searched.

Literature categorization

The literature review yielded XX 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.

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 cost of telemedicine technology in the ICU and several case studies.

RESULTS

How tele-ICUs can be cost effective

According to the leading tele-ICU systems vendor, Philips-VISICU (Goran, 2010), tele-ICU implementation costs ranged from about $30,000 to $50,000 per bed (Becker, 2002), therefore the cost of equipping 100 beds was approximately $3 to $5 million. Annual operating costs (e.g., overhead, maintenance, staffing) have being estimated by Philips-VISICU to be approximately 20% of the software costs (Cummings et al., 2008), or about $300,000 for 100 beds. Staffing costs depend on hours in use and level of additional staff in the off-site center; typical staffing scenarios add approximately $1 to $2 million per year per 100 beds covered (Berenson, Grossman and November, 2009).

Brief case study 1: Sentara Healthcare

Sentara HealthCare was the first hospital to establish a tele-ICU program in 2000 through the vendor VISICU (Sentara HealthCare, 2000). Implementation of the tele-ICU took five months and cost more than $1 million. In 2002, Sentara reported a reduction in hospital mortality of 25% with a 17% decrease in ICU LOS (Sentara HealthCare, 2002). (See Table 1).

Table 1: Tele ICU Cases Studies, Implementation Costs and Major Outcomes

Institution	Setting	Implementation Costs	Major Results/Outcome
Sentara Healthcare	Sentara HealthCare, academic tertiary care medical center	$1 million	Decreased hospital and ICU LOS; decreased hospital mortality (see Breslow et al., 2004)
Massachusetts Technology Collaborative and New England Healthcare Institute	The University of Massachusetts Memorial Medical Center, academic hospital	$7.12 million	Decreased length of stay, costs of implementation recovered, lower rates of complications
Resurrection HealthCare	Community hospital	$7 million	38% decrease in ICU LOS in 6 months = approximately $3,000,000 in savings (see Goran, 2010)
Franzini et. al, 2011	Five community hospitals/ Six ICUs	Not stated	Hospital daily cost rose 24%, hospital cost/case rose 43%, cost/patient rose 28%

Findings from an independent evaluation by Cap Gemini, Ernst and Young suggested a $2 million tele-ICU cost that was offset by $3 million in net savings annually (Sentara HealthCare, 2002). It was also reported extra revenue, approximately $460,000 per month, due to increased patient throughput resulting from decreased length of stay (Sentara HealthCare, 2010). Table 2 displays the findings of the reduced per patient costs of $2,150 based on reduced patient expenses and increased ICU capacity, as well. (See Table 2).

Table 2: Sentara HealthCare and Resurrection Health Center tele-ICU implementation savings

Hospital	Cost of Implementation	Outcomes	Return on Investment
Sentara HealthCare savings from 2002-2010 SentaraHealth (2002-ok; 2010-ok) Breslow et al. (2004-ok)	$1 million	Reduced patient cost ($2,150) Reduction in mortality (27%) Decreased length of stay (17%)	Average case contribution margin increased 55.6%
Resurrection Health Center savings from 2007-2011	$7 million	Decrease in length of stay, 38% $3 million in savings 7% reduction in blood transfusions ($11,200 in savings)	estimated cost savings of $11.5 million

The centralized model has allowed optimization of time and services of intensivists without the requirement of staffing intensivists at multiple locations. Intensivists in a single location also have given patients the opportunity to stay in location, instead of traveling and being transferred to a different hospital (Goran, 2010). As of 2010, more than one million ICU patients had been cared for using the strategy of frequent re-assessment, alert-prompted evaluation, and rapid response to clinical needs (Sentara HealthCare, 2010).

Brief case study 2: University of Massachusetts Memorial Medical Center

The University of Massachusetts Memorial Medical Center (UMMMC) installed a tele-ICU command center in 2005 and extended the tele-ICU coverage to two Massachusetts community hospitals in 2007 and 2008. Over a period of three years, one tele-ICU command center extended coverage to nine adult ICUs covering 116 ICU beds in central Massachusetts (New England Healthcare Institute and Massachusetts Technology Collaborative, 2010).

Table 3 shows the initial expenses with the installation of a tele-ICU at UMMC. The operating costs of $7.12 million also required an increment of annual operating cost of $3.15 million (see Table 3).

Table 3: University of Massachusetts Memorial Medical Center Capital and One-Time Costs for tele-ICU, 2010

Expense Type	% of Total	$ Amount
tele-ICU Support Center Build out and Servers	17	1,190,000
tele-ICU Licensing and Implementation Fees	34	2,400,000
tele-ICU Equipment Costs	15	1,100,000
Network and Infrastructure Costs	4	260,000
Software Costs	1	80,000
ICU Facility Costs (Cabling, Electrical)	7	470,000
Patient Monitoring System Upgrade Costs	5	370,000
Project Management and Consultant Costs	17	1,230,000
Miscellaneous (Marketing, Travel Expenses, Supplies)	.3	20,000
Total Capital Costs	100%	$7,120,000

Source: The Massachusetts Technology Collaborative and New England Healthcare Institute, 2010

Table 4 shows the operating costs and the continuous ongoing costs for UMMMC. The net effect produced a rapid payback such that total costs of implementation were recovered within one year.

Table 4: University of Massachusetts Memorial Medical Center Capital Ongoing Operating Costs, 2010

Expense Type	% of Total	$ Amount
tele-ICU MD, NP, and PA Salary and Benefits	72	2,270,000
Software License Fees	7	230,000
Non-Clinical tele-ICU Staff Salary and Benefits	20	630,000
tele-ICU Office Supplies, Telephone, Copier Lease	1	20,000
Total Operating Costs	100%	$3,150,000

Source: The Massachusetts Technology Collaborative and New England Healthcare Institute, 2010

Dr. L., the Medical Director of the tele-ICU program of UMMMC, stated in a semi structured interview that the centralized tele-ICU program has been one of the most beneficial programs to their hospital. The system itself is a continuous tool that is patient triggered, rather than a robot model that has to be plugged in when the doctor needs extra help, making the doctor do more work. Dr. L explained that a tele-ICU provides high quality care for a lower price due to the fact that more patients are being seen by a more effective workforce.

Brief case study 3: Resurrection Health Center

Covering seven acute hospitals and a long term-care facility, Resurrection Health Center in Des Plaines, Illinois introduced telemedicine into its 14 ICUs in 2007. The tele-ICU command center in Resurrection's Holy Family Medical Center promoted proactive intervention, including trended alerts that showed incremental changes in such factors such as blood pressure, oxygen levels, and drip rates (Society of Critical Care Medicine, 2010).

Within the first 6 months after installation in 2007, a cost savings of $3 million was reported including $11,200 from a 7% reduction in blood transfusions. The hospital found a 38% decrease in ICU length of stay in 6 months which totaled to approximately $3 million in savings (See Table 2).

Resurrection leadership wanted to know how the system was going to prove its return on the $7 million investment spent to set up all 14 ICU systems simultaneously. In 2011 it was reported that it had a $387,000 financial benefit; tele-ICU support for ICU patients across the health system resulted in 9,000 ICU days saved for an estimated cost savings of $11.5 million and also reported the reengineering of the existing tele-ICU infrastructure has target expanded support for tele-stroke, tele-psych, skilled nursing facilities, and sepsis management initiatives (Shaw, 2010).

Brief case study 4: six ICUs in five large hospitals

A study by Franzini et al. (2011) was conducted to determine the costs and cost effectiveness of 6 ICUs in 5 large hospitals in the Gulf Coast region after the installation of a tele-ICU program. Data was obtained from 4,142 ICU patients: 2,034 before tele-ICUs and 2,108 post tele-ICUs. Table 5 shows the ICU average daily cost before and after tele-ICUs were installed. The average daily costs and costs per case increased in all 6 ICUs after implementation (post period) from the period before implementation of the tele-ICU (pre-period). Overall the daily average ICU increased from $2,851 to $3,653, or a 28% increase after tele-ICUs were installed which was statically significant. Two hospitals experienced cost increases greater than 30% (See Table 5).

Table 5: 2010 Average Daily Costs Pre tele-ICU and Post tele-ICU Installation in six ICUs in U.S. Dollars

Costs	Overall	ICU 1	ICU 2	ICU 3	ICU 4	ICU 5	ICU 6
Pre tele-ICU Period	$2,851	2,586	3,647	4,248	3,155	2,355	2,370
Post tele-ICU Period	$3,653	3,272	4,307	4,252	4,131	3,275	2,746
Change	$802	686	660	4	976	920	376
Percentage Change	28%	27	18	0	31	39	16

Source: Franzini e. al, 2011

The floor daily average costs increased 16%, from $1,451 to $1,687, after tele-ICUs were installed. The overall ICU costs per case increased from $13,029 to $18,324 in the post period. The authors also found costs per patient for hospitals increased while the costs for patients remained the same. Average ICU hospital cost per patient was $20,231 in the pre-period and $25,846 in the post period which was statically significant (See Table 6). Overall, the installation of the tele-ICU programs in the 6 ICUs were associated with higher costs not attributable to medical inflation. Frazini et al. (2011) did note that sicker patients did exhibit lower mortality and also noted that about two-thirds of physicians in their study chose only minimal participation in the tele-ICU intervention (See Table 6).

Table 6: 2010 ICU costs per case Pre tele-ICU and Post tele-ICU installation in six ICUs

Costs	Overall	ICU 1	ICU 2	ICU 3	ICU 4	ICU 5	ICU 6
Pre tele-ICU Period	$13,029	7,422	12,912	26,296	8,770	13,328	15,167
Post tele-ICU Period	$19,324	10,797	18,519	33,594	19,002	15,392	18,947
Change	$6,295	3,374	5,608	7,298	10,232	2,065	3,780
Percentage Change	48%	45	43	28	117	15	25

Source: Franzini et al., 2011

DISCUSSION

This research study has examined potential benefits of implementing a centralized tele-ICU system. The evidence supporting cost savings is mixed. The hospitals in the first 3 cases either saw some form of a full return on investment, actual cost savings, or a decreased length of stay. Dr. L stated that return on investment for hospitals implementing a tele-ICU system depend on how the system is utilized, as well as the number of patients the hospital ICU treats. If a hospital system wants to use a tele-ICU system for safety reasons or to make their workforce more efficient, the tele-ICU can be a tool that would help. Dr. L also mentioned another benefit of implementation is an expansion of markets; the tele-ICU takes care of more patients which decreases geographic barriers and potentially allows the provision of ICU services into previously inaccessible markets.

The hospital systems examined by Franzini et al. (2011-ok) and Morrison et al. (2010-ok) both found that costs, rather than falling after the implementation of a tele-ICU system, rose. Both studies noted that costs associated with physicians choosing a low or non-existent involvement with tele-intensivists rose more quickly that those costs associated with physicians choosing a higher level of tele-intensivist involvement, and Frazini (2011) noted that the tele-ICU system used in the study was not fully integrated with the hospitals' electronic health record system, which may also have contributed to increased cost.

The length of stay decreased due to intensivists having more time to spend with the patient and being able to do more for the patient such as running more appropriate tests.. Franzini et al. (2011) and Morrison et al. (2010) noticed a higher level involvement with patients as well, and patients were being served at a higher level of care than prior to the implementation of a tele ICU system.

Overall, hospitals have few research findings to help guide them when making a decision. The findings of the research does not confirm that the implementation of a centralized tele-ICU system is cost effective, but it does support the hospital uses ICU staff more efficiently.

Study limitations

This literature review was limited due to the restrictions in the search strategy used, such as the number of databases searched. Unfortunately, there appeared to be no follow-up articles – especially ones which provided additional data - to those examined in this study. There were articles about the benefits of tele-ICUs, but limited data on the actual financial savings or cost of implementing a tele-ICU, or other articles had numbers about the savings, but did not have numbers of how much ICUs were costing them before a tele-ICU implementation. Publication and researchers bias may have limited the availability and quality of the research identified for review. Additionally, the research was limited to hospital organizations in the United States alone, thus excluding many international providers of tele-ICU care.

Practical implications

The implication of this study is implementation of tele-ICU systems can be cost effective and improve patient outcomes. Future research should examine the results attributable to the implementation of a tele-ICU. Other potentially fruitful areas include how tele-ICUs affect different types of ICUs such as surgical versus non-surgical ICUs and whether or not similar findings might be achieved in rural hospitals.

CONCLUSION

Although mixed results were found in the literature, the vast preponderance of evidence indicates that the implementation of tele-ICUs system systems produce change with an ICU staff more efficient and effective, providing better clinical outcomes, decreased mortality and lower costs for hospitals.

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APPENDIX A

Questions Asked in Semi-Structured Interview of Expert in tele-ICU:

- Why do you think hospitals should install/invest a tele-ICU program?
- Why did you think a centralized model would be the best model?
- How has the tele-ICU been beneficial to your program?

What could be some improvements to improve the efficiency of the p