Chapter 11
Cost-Benefit Analysis of Implementing Telemedicine in the ICU

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What Is the Cost of Implementing a New Tele-ICU Program?

Implementing any technology solution entails added cost for the healthcare system. Hospitals looking to implement such solutions should carefully review the features and functionalities of all hardware, software, and associated costs and factor that into the use cases prior to purchasing decisions. Although the models of tele-ICU vary, fundamentally, costs can be broken down into the major components outlined below.

Costs related to technology equipment include the hardware and software installation associated with the operation. The hardware costs can vary widely depending on the choice of equipment and the operational structure of the tele-ICU. In one of the most commonly used tele-ICU systems (Philips eICU®), the hardware costs include fixed mounted high-definition cameras in patient rooms, cabling costs for the cameras, desktop computers for the remote physician/nursing workstations, multiple monitors for each workstation, and T1 lines for assured connectivity. The core audio-video technology component in the Philips system is a non-negotiable cost since it is tightly integrated with their proprietary software on the back end. Upgrades for the audio-video service may be required periodically and will result in additional costs.

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Additionally, some tele-ICU programs may use robots (e.g., InTouch Systems®) or other commercial mobile carts to facilitate care deliver in non-ICU locations. These carts consist of audio-video interfaces, interfaces for diagnostic equipment like stethoscopes, and software interface to integrate into the parent tele-ICU software (such as Philips eCARE® software). Programs which utilize devices such as tablets/iPad (Apple Corp®, Samsung Corp®) in lieu of fixed cameras and desktop workstations will likely incur lower costs than the above fixed camera "eICU" model. Software costs depend on the type of system used. The commonly used Philips eCARE® software is a bundled product which includes licensing fees for a fixed number of beds, software integration costs associated with data extraction from the EMR, bedside patient monitoring devices, costs for utilizing proprietary risk adjustment software (APACHE® Cerner Corp), and server costs.

In addition, technology costs may also include commercial software solutions to facilitate communication (video/text/audio) between care professionals for ongoing workflow and operational issues. Examples of such solutions include Cisco Jabber®, Vidyo®, etc. An illustrative cost example for some of the IT/IS components of setting up a Philips eICU is given below:

- Virtual servers for eCare: $250,000
- Charter Internet: $26,000 per year (as of 2016)
- In room audio-video equipment: $7500 per room, installation at additional cost
- Mobile carts: $12,000 each
- Sit/stand desk, electronic: $5000 each
- Computer workstations: $1300 each
- Monitors: $ 280 each
- UPS for workstations: $300 per desk

Staffing costs typically depend on the structure of the tele-ICU care delivery model. The predominant model in the marketplace currently consists of a "hub" or a "core" which consists of nurses and physicians assisted by support staff who are involved in remote care delivery. The number of nursing staff varies based on the number of patients within that tele-ICU system. Typically, ratios are one nurse for every 30–50 patients. The number of physicians employed at the core again is based on the number of beds covered by the system. On average, the physician to patient ratio is 1:100, with the physician being a highly leveraged resource. This staffing ratio will of course depend on the acuity of the ICUs being covered, and high acuity patients can be expected to have lower provider-to-patient ratios. Nursing wages are determined locally and subject to organizational wage standards and incentives. Additionally, nursing supervisors or charge nurses may be needed to assist with administrative tasks, nursing schedules, and assignments. In specific cases, additional nurses may be employed to assist with specialized tasks such sepsis surveillance, best practice audits, or APACHE scoring.

Support staff may consist of staff to assist with answering calls for the remote location and helping triage incoming calls from various locations and information technology staff to assist with software/hardware maintenance, support, and troubleshooting. The wages for the support staff vary and are determined by local wage standards. Additionally, database analysts and administrators may be employed by tele-ICUs to assist with data collection, analysis, creation of a database, database server setup, and maintenance. Administrative personnel may be hired by tele-ICU systems to assist with staff management, physician licensure, finance and accounting, contract negotiations, strategy, and business development.

Physicians who provide tele-ICU care are most commonly paid an hourly salary rate between $180 and $225 per hour. If a physician is solely employed to provide tele-ICU services, additional costs would include usual benefits such as healthcare plan funding, retirement plan funding, disability and life insurance premiums, etc. It may be noted that current market forces favor at least a 25% additional incentive for tele-ICU services compared to bedside ICU services for physicians. In addition, nighttime coverage is paid out at a premium rate compared to daytime services. Over the last few years, given the concerns over sustainability of nighttime coverage models, tele-ICU nighttime coverage is sometimes outsourced to overseas physician staffing agencies located in Israel, India, Eastern Europe, or Africa where the time difference allows those physicians to work during daylight hours. The staffing costs for these outsourced models are dependent on prevailing wages for the country.

Other costs include contractual costs for vendors and licensing for applications and broadband coverage. Contractual relationships with technology vendors represent a common ongoing cost for tele-ICUs. The ongoing costs related to technology consist of support and maintenance costs for hardware and software platforms associated with the tele-ICU system. Contractual relationships with provider networks may be another source of ongoing cost, depending on the staffing model. Some tele-ICU systems may occasionally need to outsource providers such as physicians. Broadband, licensing, and IT-related costs represent yet another cost for tele-ICU systems. In the commonly used eICU model, dedicated T1 lines and broadband Internet access are required to keep all computer systems operational, and the yearly cost for this is roughly $26,000.

What Are the Financial Benefits of Implementing a New Tele-ICU Program?

In the absence of a defined insurer reimbursement model for care delivery, revenue sources for a tele-ICU system depend entirely on the organizational structure of the system/network and variable contractual relationships between entities. A few different revenue models appear to currently exist.

Fee-for-service remains the most common type of revenue model where recipients of the tele-ICU care delivery enter into a fee-for-service contract which is either based on the number of ICU beds being serviced or the number of ICU admissions. In the former, the tele-ICU provider charges an annual fee per bed to which the service is provided. The fee is essentially a pass-through cost incurred by the tele-ICU service provider for the expense of setting up the technology infrastructure to enable care delivery and other operational expenses, with an added markup to maintain profitability. These costs are reportedly between $20 and $30,000 per ICU bed for services provided using the Philips platform.

Shared savings models represent an alternative payment model. Conceptually, a shared savings model can be implemented wherein the tele-ICU provider would be paid a percentage of any demonstrated cost savings due to reduction in complications and reduction in ICU length of stay. It is unclear how prevalent this model currently is among tele-ICU providers, however.

In pay-for-value arrangements, tele-ICU providers may also enter into at-risk contracts, where payment is tied to achieving defined operational targets. While this model is theoretically attractive, there are many variables that may determine the outcome of interest, not all of which directly fall under the purview of the tele-ICU provider. Such a model is likely to be most successful when the tele-ICU functions as the sole provider for comprehensive ICU services with full control of upstream and downstream ICU care processes.

Payment can also be tied to increased ICU bed occupancy. As reported in various studies below, a reduction in ICU length of stay following implementation of tele-ICU creates added capacity for ICU patients, thus reducing the number of patients who may be getting transferred to outside facilities due to lack of ICU beds. The added ICU occupancy can elevate the case mix index for the hospital which in turn has a positive effect on reimbursement. Reducing ICU length of stay through tight management of care processes and efficient throughput driven by the tele-ICU system can lead to a reduction in ICU length of stay [1]. Given that ICU charges are not reimbursed fully (e.g., Medicare reimburses about 83% of ICU charges), a reduction in length of stay can reduce the losses incurred from ICU stays for hospitals.

Reduction in ICU harm and medical errors that incur financial penalties can also be a source of shared savings arrangements. Cost avoidance due to reduction in ICU complications, reduction in length of stay due to appropriate bed utilization, and improved decision support could justify the investment in tele-ICU [2, 3]. As reviewed below, these benefits are contingent upon a very deliberate integration of tele-ICU services with bedside services, allowing both to function cohesively to achieve strategic goals. An example is the "logistics center" approach by Lilly et al. which allowed for greater ICU bed utilization, driving up revenues and contribution margin [4]. The cost avoidance reported in the literature has varied and to a large extent will depend on the baseline performance of the units across which tele-ICU is implemented. High-performance institutions which already operate on the far end of the performance spectrum may see less benefits. Furthermore, once the processes that help drive down complications and improve compliance with best practices are hardwired, the incremental benefit will be expected to decrease over time.

Review of Published Studies on Cost-Benefit Analysis in Tele-ICU Programs

Cost-benefit analysis of ICU telemedicine implementation is not straightforward, as will be highlighted in the studies to follow. A few recurring issues in methodology should be considered whenever analyzing published results, whether they are pro/

con tele-ICU cost-effectiveness. The first revolves around the heterogeneity of case definitions of ICU telemedicine in the literature. Currently there is no standard definition for ICU telemedicine. There are many different models (centralized vs. decentralized being the most common), and within those models, there are a plethora of remote monitoring capabilities that will impact the effectiveness of tele-ICU care. This is an important consideration to keep in mind when evaluating the literature and applying the results to your institution. The second involves transparent, accurate, and comprehensive cost reporting. Many published studies lack all three of these elements, making it challenging to draw strong conclusions. Additional points to consider are tele-ICU monitoring of academic versus community hospitals or a mixture of both. Variability in acuity and volume of ICU patients monitored can bias results related to mortality and length of stay. Cost projections based off these models will then need to be accounted for across different health systems if their patient population is not similar.

One of the first published studies to analyze ICU telemedicine implementation reported on cost analysis in addition to patient care outcomes. The study was conducted by Rosenfeld et al. and published in *Critical Care Medicine* in 2000 [5]. The design of the study was an observational time series triple cohort study. The purpose of this study was to compare the prospective 16-week intervention period with two retrospective baseline periods of equal duration. One baseline was used to account for seasonal variations in critical care, and the other was used to account for any time-related, unit-based process improvement changes. The study site was a ten-bed surgical ICU in a large academic hospital. General medical patients, cardiac surgery, and transplant surgery patients were not included. Exclusion criteria were as follows: age <16, ICU stay <4 hours, transfer from ICU to another hospital, and missing APACHE data. The study ICU was an open unit without onsite ICU intensivist coverage. Daily ICU care was provided by house staff in addition to a surgical attending.

The intervention involved four intensivists providing patient care exclusively from their homes 24/7 for a 16-week period. Necessary equipment including cameras for remote care were installed in each ICU room and in the homes of the four intensivists. The intensivists rounded on “select patients,” either as a consultant or a physician providing management services. Daily virtual rounds and frequent patient reviews were performed by the ICU physicians. Urgent and emergent communication with the bedside team was carried out as needed. The results of the study showed lower ICU mortality and ICU length of stay during the intervention period compared to the two baseline periods. In addition, the APACHE III observed/predicted ICU mortality and length of stay ratios were lower for the intervention period. Cost data are outlined in Table 11.1. Compared to both baselines, ICU-based costs were reduced by roughly 25–30%. Total hospital costs were also less, but this was not found to reach statistical significance. A large portion of the cost reduction was related to the decrease in complications noted in the intervention period.

Although the cost data certainly was significant in favor of ICU telemedicine, several factors should be considered in this study. First, given this study was published nearly 20 years ago, it was mostly a proof of concept design for ICU

Table 11.1 ICU cost data

	Baseline 1 ($)	Baseline 2 ($)	Intervention ($)	Intervention vs. baseline	Intervention vs. baseline 2
ICU-based					
Inpatient costs	7965 ± 8669	8922 ± 19,936	6273 ± 6330	0.79 (0.0255)	0.70 (0.0777)
Professional fees	3192 ± 2228	3317 ± 4349	2133 ± 1746	0.67 (0.0001)	0.64 (0.0005)
Total costs	11,157 ± 10,168	12,239 ± 23,448	8417 ± 7554	0.75 (0.0022)	0.69 (0.0308)
Hospital-based					
Inpatient costs	13,692 ± 13,688	15,211 ± 25,294	12,690 ± 13,023	0.93 (0.4438)	0.83 (0.2147)
Professional fees	4457 ± 3265	4577 ± 5129	3244 ± 2536	0.73 (0.0001)	0.71 (0.0012)
Total costs	18,149 ± 16,102	19,788 ± 29,809	15,935 ± 15,033	0.88 (0.1513)	0.81 (0.1077)

ICU = intensive care unit
Values are mean dollars (entire ICU and hospital stay) ± SD. Comparisons between intervention and baseline periods show ratio of costs, with *p* values in parentheses

telemedicine. Commercial technology and electronic medical records that are widely used today were not available at that time. The design of the study was not to prove cost-effectiveness given the limited scale of developed ICU telemedicine technology. Second, although the authors mentioned in the methods section that technology costs were accounted for, it is not readily apparent in the cost data tables or supplement sections, making conclusions on cost savings challenging. Results would also have to be taken into context given this was a single center study in a small, surgical ICU, in an academic environment where select patients were monitored by the tele-intensivists without specific mention of selection criteria.

A follow-up by Breslow et al. was published in *Critical Care Medicine* in 2004 [6]. The authors instituted an ICU telemedicine program with commercial technology in part to address some of the flaws in the initial study and build on the proof of concept established previously. The study design was a before-and-after trial comparing a 6-month intervention period to randomly selected patients from the year prior. Risk adjustment using APACHE scoring was used to compare the groups across the different time periods. An off-site, centralized model for patient monitoring was established (referred to as the eICU), and monitored patients were located in two ICUs (one medical ICU and one surgical ICU) at a large tertiary care teaching hospital. The bedside coverage model was slightly different between the two units. Nearly all medical ICU patients were staffed by an intensivist, while roughly 35% of surgical ICU patients had an intensivist consulting. The ICU telemedicine service monitored all patients admitted to these units during the intervention period, and the eICU was staffed 19 hours/day (noon–7 AM) when the bedside intensivist was often not present. The level of intervention of the eICU was determined a priori (categories 1–4 of involvement), but bedside teams could not completely "opt out."

This centralized eICU was similar to many tele-ICU models currently in use, with advanced audio-video equipment, access to real-time patient data, and computerized decision support tools. Like the previous study, overall ICU mortality and ICU length of stay decreased during the intervention period. ICU mortality was down approximately 25%, and ICU length of stay decreased by nearly 16%. More robust financial data were captured and are illustrated in Table 11.2. This financial analysis was performed by an independent firm using financial data provided by the hospital. ICU variable costs per case decreased by $2500 or roughly 25%. A significant increase in monthly contribution margin was seen, totaling nearly $525,000. Over a 6-month time period, this equated to $3.14 million of financial benefit. ICU telemedicine hardware/software costs and eICU physician staffing cost roughly $600,000 over the same 6-month period.

Although it was not completely clear from the data presented if this amount was factored into the variable costs, a sizeable financial gain is still apparent even if it was not. How exactly this ICU telemedicine program generated a large financial impact is likely multifactorial. One theory is that variable costs were reduced secondary to a decrease in length of stay, and lower daily ICU ancillary costs were also achieved. Factored into this equation would also be a reduction in complications observed which would decrease costs and length of stay. Furthermore, with increased bed availability, there was an increase in case volume, increasing the total contribution margin. This study was a significant step toward a better understanding of

Table 11.2 Cost and revenue data

	All patients		MICU		SICU	
	Base	Intervention	Base	Intervention	Base	Intervention
Average ICU daily cost	$1648	$1411	$1303	$1041	$1933	$1756
Average floor daily cost	$389	$366	$387	$394	$390	$340
Average case cost[a]	$10,444	$7871	$10,926	$8494	$9698	$6528
Average case revenue	$17,276	$18,510	$17,281	$16,950	$17,272	$19,964
Average case contribution margin	$6832	$10,639	$6355	$8456	$7574	$13,436
Cases per month	116.4[b]	124	52.6	59.8	63.8[b]	64.2
Contribution margin per month	$795,245	$1,319,236	$334,273	$505,669	$483,221	$862,591

MICU medical intensive care unit, *SICU* surgical intensive care unit, *ICU* intensive care unit
[a]Calculated from average daily ICU and floor costs and average ICU and floor lengths of stay
[b]SICU during the baseline period had ten beds

modern-day ICU telemedicine program capabilities and cost-effectiveness. Although there were considerable strengths to this study, weaknesses related to vendor funding, as well as author affiliation with the vendor as a conflict of interest, should be noted. Similarly, as is problematic with all ICU telemedicine studies, a causal relationship is challenging to prove given before-and-after study designs. However, conducting a randomized controlled trial of tele-ICU implementation would be challenging given the culture change in each ICU required and the variability that exists between different hospitals and ICUs.

Given the limited quantity of ICU telemedicine cost-effectiveness studies to date, Yoo et al. published an intriguing article in *Critical Care Medicine* in 2016 using a simulation model to perform a cost-effectiveness analysis [7]. Recognizing that capital startup costs for ICU telemedicine can be exorbitant (up to $75–100,000 per ICU bed), it is understandable that hospital administrators may be reluctant to institute such a program without predictive financial tools. The purpose of this study was to provide an economic evaluation using a hypothetical model of patients monitored with ICU telemedicine and those without. Their primary objectives were to determine incremental cost-effectiveness in dollars and incremental cost-benefit (in quality-adjusted life-years [QALYs]). Using QALYs supports the theory that an ICU telemedicine program can impact more than just patient survival but also enhance their quality of life post ICU discharge [8]. These hypothetical results could potentially impact both policy decision-makers (federal and state payers) and hospital systems exploring the financial impact of starting an ICU telemedicine program.

In order to perform a simulation analysis, data based on prior published literature was used to construct parameters to run the simulation model. Two separate analyses were run: a cost-effectiveness analysis and a break-even analysis. The cost-effectiveness analysis examined whether the incremental cost-effectiveness ratio (ICER) of ICU telemedicine exceeded a $100,000 threshold (not cost-effective) or was less than zero (indicating cost savings). This threshold is often cited in the medical literature as a reasonable target for determining the cost-effectiveness of an intervention, albeit it is a subjective determination [7]. The break-even analysis then analyzed the threshold values for key predetermined parameters. Their simulation model results estimated that tele-ICU had an approximate ICER of $45–50,000 per QALY compared to an ICU without telemedicine. In simplified terms, the hypothetical model estimated that tele-ICU extends life with a perfect health status by 1 year to a single ICU patient at a cost of $45–50,000 [7]. Running nearly 1000 simulations resulted in wide confidence intervals, but nearly 67% of all iterations resulted in an ICER below $100,000, indicating cost-effectiveness.

The break-even analysis reported several parameters where ICU telemedicine would be considered cost-effective. Examples included per-patient per-hospital stay tele-ICU operation cost <$1560 and baseline ICU mortality without telemedicine that was greater than 6.3%. This hypothetical simulation model adds value to the existing literature regarding tangible figures and endpoints to which interested parties in ICU telemedicine can consider during the decision-making process. Limitations of this study include the assumptions that are made from secondary data. The model utilized the few existing ICU telemedicine cost reporting studies to create cost estimations, some of which are of questionable quality and applicability. This in turn makes interpreting and applying the simulated cost-effectiveness analysis more challenging. Furthermore, the model was based on a centralized system of ICU telemedicine using data extracted from telemedicine programs using Philips eICU technology. Any hospital system with plans to operate under a different model or use non-Philips software technology would not be able to apply these projections, albeit costs would likely be lower and favor tele-ICU implementation. Finally, this simulation model cannot account for all variables that a tele-ICU program may experience, such as changes in case volume or patient transfers. These are critical elements that any healthcare leader would need to consider during the evaluation process.

One particular study that focused exclusively on ICU telemedicine cost-effectiveness was published in 2017 by Lilly et al. [4]. This publication was a detailed financial analysis of a tele-ICU program over time. In addition, a description of a logistics center operated by the tele-ICU and the impact on financial outcomes were detailed along with a series of care-standardization projects. The logistics center was phased in over many years, functioning essentially as a bed 'czar' to coordinate effective patient placement due to limited ICU availability year-round. The financial analysis was a before-and-after study examining a consecutive case cohort of roughly 50,000 ICU patients over a period of 9 years. It was conducted in a large academic medical center covering seven adult ICUs. The primary outcome was change in the annual direct contribution margin. Secondary outcomes were changes in case volume, annual per-case revenue, and hospital length of stay, among others. Finances from three separate time periods were compared: pre-ICU telemedicine group, ICU telemedicine group, and logistic center group.

The total annual direct contribution margin, total annual revenue, revenue per case, and annual case volume increased significantly from the pre-ICU telemedicine implementation period to the ICU telemedicine period. The contribution margin increase was roughly $30 million. When the logistic center time period was compared to the ICU telemedicine group, a further increase in total annual direct contribution margin of nearly $25 million was observed after adjustment for inflation. The capital costs of implementing a tele-ICU program (~$7 million) were recuperated in roughly 3 months based on the improved net contribution margin of $30 million seen with the tele-ICU program. In addition to improved clinical outcomes, this study showed improved financial outcomes with an ICU telemedicine program. The cause of this is likely multifactorial and includes increased case volume and increased per-case net revenue with a tele-ICU program and further enhancements with the addition of a logistics center (Fig. 11.1).

Creating a centralized command center for bed allocation helped decrease ICU length of stay, which in turn allowed for increased case volume. This concept may not pertain to all hospital systems that do not run at maximum ICU bed capacity but is a potential key benefit of ICU telemedicine implementation. Potential limitations to the impressive financial outcomes documented in this study may relate to the single center, before-and-after design. Similar outcomes may not be seen in hospi-

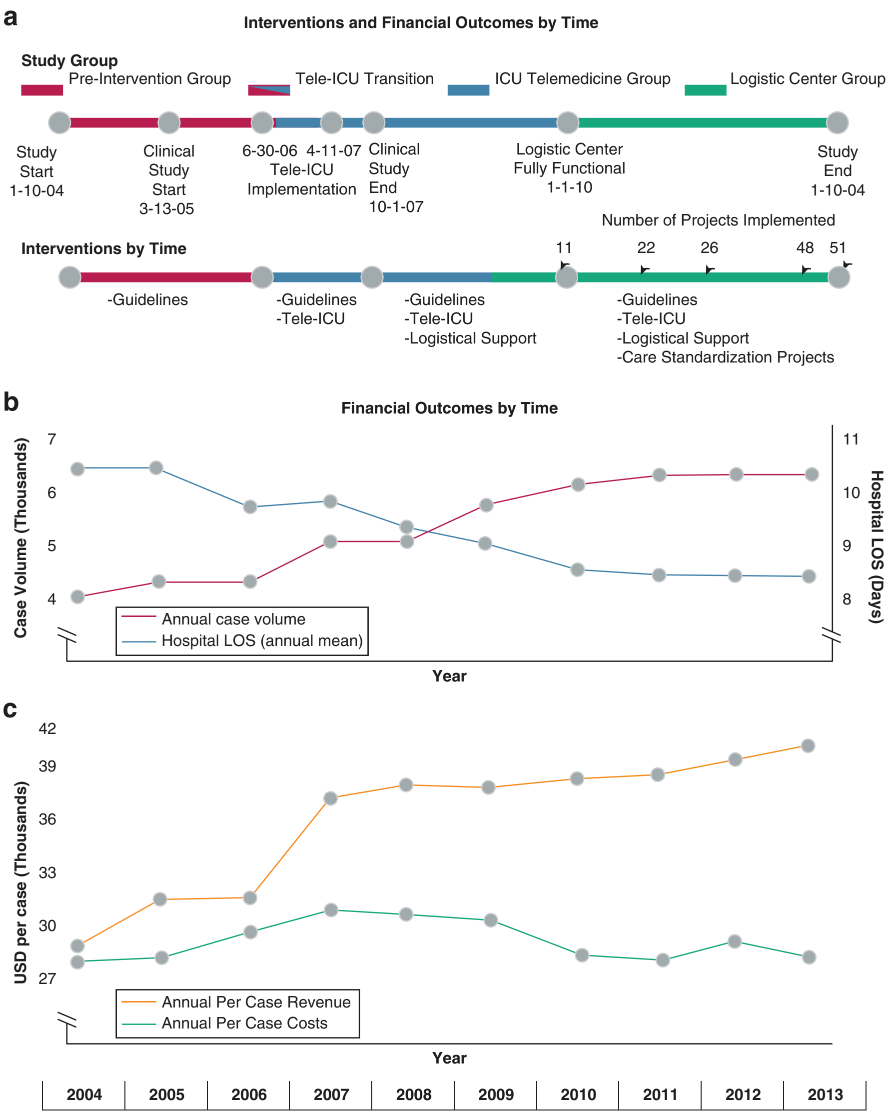

Fig. 11.1 Relation of study interventions to financial outcomes. (**a**) The study groups are indicated by color on the top bar. The pre-ICU telemedicine group is indicated by the red bar, the ICU telemedicine group by the blue bar, and the logistic center group by the green bar. The time in which some ICUs had telemedicine support, whereas others did not, is represented by the blue-red bar. The bar below presents the times of the interventions. The pre-ICU telemedicine group task forces are represented by the red bar, and the period in logistic center function that was added in a graded manner is represented by the blue bar. The green bar defines the times in which care-standardization projects were implemented. The cumulative numbers of implemented care-standardization projects are presented at the time designated by the arrows. (**b**) Case volume is plotted in red, and mean annual hospital LOS is plotted in red as a function of time and in relation to intervention bundle elements. (**c**) Inflation-adjusted annual case revenue is plotted in orange as a function of time, and annual direct costs are plotted in green as a function of time. The difference between annual per-care direct costs and revenue is per-case direct margin. Direct cost and revenue plots are presented in relation to intervention bundle elements. LOS = length of stay

tals with different ICU bed availability or patient acuity. Regarding the temporal changes related to the before-and-after trial design, the tele-ICU and logistic center time period utilized a more efficient and effective documentation system for coding compared to the pre-tele-ICU timeframe. This may have led to increases in case revenue separate from any ICU telemedicine influence.

Future studies and unanswered questions for cost-benefit of tele-ICU programs are needed. As the pressure for cost containment and more efficient care delivery grows, reimbursement models are expected to shift more toward value-based payments and shared risk contracts and away from traditional fee-for-service models. The ability of tele-ICU and telemedicine in general to facilitate efficient care delivery and manage population health will likely lead to more reimbursement for telemedicine-based services, but how this component of reimbursement will evolve remains unknown.

Answering the Question for Yourself: How to Measure Costs and Benefits of Your Hospital's Tele-ICU Program?

Depending on choice of vendor, the adoption of tele-ICU may require a substantial up-front capital investment with ongoing costs of operation and maintenance. The dominant product in this domain is provided by Philips Corporation (eICU), and in general, $2–$5 million is the estimated cost to set up a command center and install a centralized tele-ICU system, with operating costs ranging from $600,000 to $1.5 million per year, according to costs reported by various adopters. These costs may impede the adoption of this technology, especially with the lack of fee-for-service reimbursement for many tele-ICU services and uncertainties about return-on-investment calculations. Moreover, the return on investment is merely calculated using indirect clinical effects and the expected length of stay reduction. We recommend that hospitals perform an exhaustive cost-benefit analysis customized to their unique situation rather than extrapolating data from other institutions for the reasons mentioned earlier. Payback period or net present value (NPV) is a commonly used indicator to calculate return on investment. More specifically, the financial equation related to tele-ICU is desired to be the following [5]:

$$\left[\text{Capital cost} + \text{Operating cost}\right] \leq \begin{bmatrix}\text{Revenue from reimbursement} \\ + \text{ Cost savings attained}\end{bmatrix}$$

As discussed above, the cost of tele-ICU varies depending on the setting, hardware, software, training, and compatibility with other systems. Institutions should, therefore, create a detailed itemized list with associated costs. One study reported a cost of more than $2 million to set up a command center and its components [8]. In general, $2–$5 million is the estimated cost to set up a command center and install a tele-ICU system, with operating costs ranging from $600,000 to $1.5 million per year, according to costs reported by various adopters (unpublished communications). On the revenue side, one study found a 10% reduction in ICU length of stay, creating the ability to care for one new ICU patient per day, which could result in a positive $2.5 million NPV.

Most studies reviewed above used length of stay and mortality to determine cost savings. For example, according to Rosenfeld et al., ICU costs decreased between 25% and 31% during the intervention period, and hospital costs decreased by 12–19% [5]. Breslow et al. hired an independent consulting firm to determine the financial outcome of a tele-ICU program [6]. They determined the cost of care per day of service and also included equipment costs, staff costs, and other costs associated with having a tele-ICU system. The report showed a 24.6% decrease in variable costs per patient. This decrease is probably due to a shorter length of stay in the ICU and improved clinical outcomes [5, 9].

The impact of an ICU telemedicine program has the potential to be far reaching, both clinically and financially, if it is well planned and operated with calculated intentions. Healthcare leaders must have a vision for their organization's strategic goals and decide if telemedicine technology can affect those goals and if the additional cost is warranted [8]. The up-front capital investment in a tele-ICU program may be substantial, but through cost-effective care, the return on investment can be significant and realized quickly. It has been repeatedly shown that when ICU telemedicine can assist in driving down ICU mortality and shortening length of stay, there is a tremendous opportunity for financial gain. While the question of technology versus human factors being responsible for these gains is debatable, the creation of a coordinated ICU care delivery system has the clear potential for significant financial gains [10]. Furthermore, not only can an ICU telemedicine program potentially improve ICU patient outcomes, but it can facilitate outreach and growth of a hospital system into the community, if desired. This can be a cost-effective means for community hospitals to provide high-level care closer to the patient's home while simultaneously off-loading the receiving hospital of lower acuity patients that can be safely managed elsewhere.

A detailed and careful analysis of the current ICU must be considered when doing a cost-effectiveness analysis pre-implementation. Not only must administrators evaluate ICU mortality, length of stay, acuity scores, best practice compliance, and opportunities for intervening on common ICU medical errors, but they also should consider factors such as nursing competency, staff burnout, and the current culture of the ICU. Each of these entities can have indirect effects on cost-effectiveness and is variable between different hospitals and ICUs.

Further cost-effectiveness research is needed to continue to evaluate the complex and rapidly growing ICU telemedicine venture. Studies with decentralized models, comprehensive financial data, community hospital focus, and a more current timeframe would be helpful. It is likely that, as technology evolves and patient care moves from the bedside to the digital world, ICU telemedicine will grow with it. Efficient, cost-effective, and improved patient care is the goal for healthcare systems, and ICU telemedicine may prove to be a pivotal and transformative link if instituted wisely.

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