Does Telemonitoring Of Patients—The eICU—Improve Intensive Care?

A lack of hard data to answer the question argues for doing comparative effectiveness research on care delivery.

by Robert A. Berenson, Joy M. Grossman, and Elizabeth A. November

ABSTRACT: Intensive care units are an essential and costly component in most U.S. hospitals. However, little is actually known about what staffing and work-process interventions produce the best balance of quality and costs. We explore the reasons hospitals chose to either adopt or reject an innovative telemedicine approach to supporting delivery of intensive care. Hospital clinical leaders hold strong views but have little objective information on which to judge the worthiness of this innovation. We argue that comparative effectiveness initiatives should emphasize delivery-system and work-process innovations, which are relatively understudied compared to specific drugs, devices, and services. [Health Aff (Millwood). 2009;28(5):w937-47 (published online 20 August 2009; 10.1377/hlthaff.28.5.w937)]

Despite the central importance of intensive care services in most hospitals, relatively little is known about technological and work-process interventions to improve the quality and efficiency of care in the intensive care unit (ICU), including recent telemedicine innovations. Even an increased national focus on comparative effectiveness studies might not fill the evidence gap, because some current approaches emphasize comparisons of drugs, devices, and specific procedures and other services, while generally ignoring the comparative effectiveness of care delivery and work processes.

This study, which explores why hospitals have made different judgments on adopting telemedicine for the ICU, emphasizes the need for altered clinical and health services research priorities and a broader approach to comparative effectiveness activities. The ICU telemedicine approach, trademarked as eICU by the dominant vendor, offers the promise of a fundamental reengineering of how intensive care is provided, yet it remains largely unstudied.

Bob Berenson (rberenson@urban.org) is an institute fellow at the Urban Institute’s Health Policy Center in Washington, D.C., and a senior consulting researcher at the Center for Studying Health System Change (HSC), also in Washington. Joy Grossman is a senior health researcher at HSC. Elizabeth November is a health research analyst there.
**ICU population.** ICU beds account for about 10 percent of total inpatient beds and 30 percent of total hospital costs in U.S. hospitals, and more than half of the nation's ICU beds are in small hospitals. An estimated six million Americans are admitted to ICUs each year. Research indicates that care managed by intensivists (physicians who specialize in treating critically ill patients, often in an ICU) reduces patient mortality. Earlier in this decade, interest in moving toward round-the-clock intensivist-managed ICU care was stimulated by estimates that this staffing approach could save more than 50,000 U.S. lives each year. The Leapfrog Group has formalized standards for intensivist staffing.

However, a recent study across 100 hospitals now casts doubt on this premise; it finds that the odds of hospital mortality were higher for patients managed by intensivists than for those who were not, creating uncertainty about even this key workforce deployment issue. Relying partly on the earlier studies, many hospitals have sought to expand intensivist coverage in the ICU, although hampered by an inadequate and declining supply of trained intensivists; only 10–15 percent of U.S. hospitals now have full-time intensivists.

**Use of eICU.** A recent approach to addressing the complexity of intensive care and intensivist shortages involves combining the use of telemedicine with software applications to support advanced management of ICU patients from a central monitoring station, usually located off campus and staffed with intensivists, critical care nurses, and administrative personnel. The most widely sold ICU telemedicine product is eICU, developed by a commercial firm (VISICU Inc., in Baltimore, Maryland). An estimated 9 percent of ICU beds in the United States are monitored using eICU, first pilot-tested in 1997. Yet there are only a few limited studies assessing the impact of this innovative practice approach on quality and costs.

In the most recent round of the Community Tracking Study (CTS) site visits conducted in 2007 by researchers from the Center for Studying Health System Change, we learned that five hospital systems in the twelve CTS markets had adopted VISICU's eICU for some or most of their systems' ICUs. Most hospitals and systems in the twelve markets had not adopted this technology. We explored hospitals' strategic decisions about whether to adopt ICU telemedicine technology within the broader context of their efforts to improve the quality of ICU care, including increased intensivist staffing and quality improvement initiatives.

In this paper we briefly describe the ICU telemedicine technology; summarize efforts to enhance intensivist staffing and quality improvement activities in ICUs more broadly; discuss factors driving only some hospitals to adopt eICUs; and examine how eICU hospitals assess the effects of adopting the technology. The paper concludes with a discussion of the findings' relevance to comparative effectiveness initiatives.
Study Data And Methods

- Study details. This research was conducted as a follow-up to the CTS site visits conducted between February and June 2007. The CTS is a longitudinal study of twelve nationally representative communities: Boston; Cleveland; Greenville (SC); Indianapolis; Lansing; Little Rock; Miami; northern New Jersey; Orange County (CA); Phoenix; Seattle; and Syracuse. The 2007 site visits included interviews with 453 local health care leaders, including senior executives of the two or three largest hospitals or hospital systems in each of the twelve sites. During these interviews, we identified five hospital systems in different markets that had adopted eICU.

We also interviewed respondents at one additional hospital or system in the five markets and two hospitals or systems in the remaining seven CTS markets, for a total of twenty-four hospitals or systems. Because hospital systems using eICU were among those with the largest market shares and best financial standing in their markets, comparison hospitals were selected purposively from among the largest hospital systems or freestanding hospitals in each of the twelve markets, excluding safety-net hospitals.

For the follow-up study, between October 2007 and January 2008, we conducted twenty-nine interviews with hospital representatives across the twelve sites and another five with national experts on ICU staffing, quality, and ICU telemedicine. In each of the five hospital systems using eICU, we talked with one physician respondent with an administrative perspective, such as the chief medical officer (CMO), and one respondent with direct eICU operational experience, either the eICU medical director (physician) or administrative director (nurse). In each of the nineteen non-eICU hospitals, we typically interviewed an intensivist manager of one or more ICUs or, less frequently, physicians with system-level administrative positions, such as the CMO.

Each interview was conducted by a two-person research team; notes were transcribed and jointly reviewed for quality and validation purposes. All interview data were coded and analyzed using Atlas.ti qualitative software.

- How ICU telemedicine works. In the eICU model, intensivist physicians and nurses, located in a central monitoring station, use a combination of visual and electronic monitoring and software tools to track care for patients across multiple ICUs in many hospitals. The eICU staff can use remote-control communication devices to see and hear ICU activities and orally communicate with the ICU. On computer screens, eICU staff view patients’ vital signs fed from bedside monitors and laboratory results and, ideally, other data from the hospital’s health information technology (IT) systems.

Using these data, the eICU software alerts eICU staff when early indicators of possible complications appear in patients’ data, such as alteration of blood pressure readings. Staff also use the software to conduct triage by electronically sorting ICU patients according to characteristics such as acuity, diagnosis, and treat-
ment, allowing them to identify gaps in care. Software also supports outcomes analysis, relying on sophisticated risk-adjustment software developed specifically for ICU patients (Acute Physiology and Chronic Health Evaluation, or APACHE), to assess the impact of eICU on patients’ acuity as well as on the provision of recommended care.

**Study Findings**

Among hospitals and systems adopting eICU, the costs of implementation, operation, and staffing were a major consideration overcome by motivation to improve clinical quality and patient safety as well as to increase the reach of ICU staff. Expectations of cost savings from reduced complications and lengths-of-stay were not major motivating factors for this group. There was broad perception among eICU users that the systems improved quality and safety in many ways, including providing additional sets of eyes and improved emergency response. But there were no objective data to support those beliefs. This group also found major problems in interoperability with hospitals’ existing health IT systems.

Among hospitals and systems that did not adopt eICU, there was widespread agreement that the limited potential benefits did not justify the substantial up-front and ongoing operating costs. The lack of third-party reimbursement was also seen as a disincentive. Virtually all of the non-eICU hospitals or systems expressed the belief that their current ICU staffing was adequate and that on-site staff was preferable to off-site staff.

**General staffing and quality improvement activities.** Despite the absence of specific payment or other incentives, most hospitals—including the eICU hospital systems interviewed—were working to improve ICU performance, primarily by adding more intensivists and adopting ICU-specific quality improvement tools. More than 80 percent of hospitals, including all eICU hospitals, reported having intensivists in house during weekdays and either in-house or on-call intensivists during nights and weekends. More than two-thirds of these hospitals reported meeting Leapfrog intensivist coverage standards.6

Many hospitals were interested in having ICU care managed predominantly by intensivists, although the national shortage of intensivists and labor costs were sometimes cited as barriers. Opinions about the need for 24/7 coverage were more mixed. Some respondents, including some at teaching hospitals with in-house physician staff, thought that intensivists should be accessible at all times but did not have to be physically present in the ICU at all hours. Others, particularly those who had adopted eICU, felt strongly that intensivists, whether in the ICU or through telemedicine, make an important difference in patient outcomes.

Hospitals with and without eICU were implementing, on average, six or more quality improvement initiatives to avoid complications. Almost all were engaged in preventing ventilator-associated pneumonia and central-line infections. Nearly three-fourths were working to achieve tight blood sugar control. Hospitals were
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variably implementing other quality initiatives, such as early sepsis detection and treatment and hand washing.

- **Adoption of eICU.** The five hospital systems that had adopted eICU were Clarian Health, Indianapolis; Baptist Health, Little Rock; Baptist Health South Florida, Miami; Banner Health, Phoenix; and Swedish Medical Center, Seattle. Each of these five hospital systems began installing the dedicated off-site central monitoring station, also referred to as the “command control center” and “bunker,” between October 2004 and February 2006, with phased-in schedules for bringing different ICUs online. The eICU programs serve a range of ICU sizes, from 75 beds in three Swedish hospitals to 200 beds in eight Banner Health hospitals. On average, eICU programs in our sample monitored 138 ICU beds in 4.6 system hospitals. The ICUs ranged from large medical ICUs in major hospitals in Little Rock and Indianapolis to a single ICU bed in a critical-access hospital in rural Arkansas.

On average, eICUs were staffed with one nurse per 30–35 ICU beds and one intensivist per 100–130 beds. In all five eICU programs, respondents indicated that there was no change in ICU bedside nursing, maintaining the standard 1:2 ICU nurse-to-bed ratio, despite having off-site nurses telemonitor units usually around the clock. Generally, the eICU’s central monitoring station expanded the number of clinicians involved in ICU care instead of substituting for critical care nurses and physicians at the bedside.

- **Factors driving eICU adoption.** The five systems cited several common reasons for adopting eICU. The primary motivation was to improve clinical quality and patient safety. Several respondents cited eICU’s potential to enhance the hospital’s reputation for quality and innovation as also important. Decisionmakers at most hospitals became aware of positive reports of apparent decreased mortality and declining ICU lengths-of-stay from an early adopter, Sentara Healthcare, in Norfolk, Virginia, and senior staff observed eICU in operation there or in other locations.

Another important strategic objective was to use eICU to leverage intensivist staffing to cover more patients. In addition, some hospitals saw eICU as a way to build relationships with smaller, more remote hospitals, to support the potential development of regional delivery systems.

It is important to note what hospitals did not identify as important facilitators of eICU adoption. When they made their decision, hospitals did not assume substantial cost savings from reduced complications and lengths-of-stay. Neither did they consider payers’ and purchasers’ expectations, outside of Leapfrog in three cases, or accreditation requirements as important. Finally, none of them adopted the ICU telemedicine approach explicitly to support an overall IT strategy.

Cost was the major consideration affecting adoption. For eICU implementa-
tion, according to VISICU, discounted costs range from about $30,000 to $50,000 per ICU bed. Therefore, the cost of equipping 100 ICU beds is approximately $3–$5 million. VISICU’s estimates of annual operating costs were approximately 20 percent of the software costs, 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–$2 million per year per 100 beds covered. Adding to the cost considerations, virtually no third-party payers pay for the professional services of the physicians and nurses staffing the eICU control center.

■ Perceived impact on quality and other benefits. All ten respondents from eICU hospitals were enthusiastic about the technology’s impact on ICU performance, particularly on quality and safety. They all emphasized the benefits of redundant processes in the care of critically ill patients, whose clinical conditions can worsen rapidly. As one respondent said, eICU “provides a second set of eyes to help support the bedside nurse.” An intensivist adopter summarized the benefits as “oversight, redundancy, and feedback” to the bedside care team.

A key advantage, these respondents thought, was the immediate ability to respond to emergencies. The eICU program provides “someone who is awake and has at his fingertips all the information needed to make decisions.” It becomes part of a rapid-response team, for example, if a patient experiences cardiac arrest—the eICU physician often takes charge of directing the resuscitation efforts, with nurses and later-arriving physicians physically in the ICUs performing hands-on care.

Respondents lauded the software that can provide earlier detection of complications by continuously analyzing patients’ physiological data. Respondents pointed to examples of patients who maintained vital signs “within normal limits” but for whom the eICU software showed a worsening trend, such as an early sign of sepsis calling for prompt intervention.

Respondents also noted using eICU to promote more systematic and consistent application of quality and safety activities, which bedside staff were sometimes too busy to do. Commonly cited was the ability of nurses in the control center to assure that as part of a set of best practices for ventilator-associated pneumonia (known as a “bundle”), beds were set at the prescribed thirty-degree angle.14 Moreover, respondents thought that ICU staff were more vigilant because of the direct oversight by a separate team, having overcome initial concerns about “big brother” watching, for example, to see if they were following dress codes.

■ Impact on staffing. The eICU program permits latitude in the allocation of staff responsibilities. In some cases, bedside staff are able to spend more time with families, track down patient information, or accomplish activities related to bundles or other activities while counting on the eICU staff to continuously monitor patients. Sometimes, eICU staff themselves communicate with patients and families or perform prevention surveillance.

Because eICU usually added staff, instead of substituting for existing staff, initial fears that eICU staffing would reduce bedside jobs were allayed. In fact, eICU
provided welcome job progression for ICU nurses and intensivists, who, because of physical limitations or “burnout,” no longer wanted to be at the bedside but could apply their accumulated ICU expertise in the command center.

Lack of interoperability. Poor interoperability between the eICU software and the hospitals’ enterprisewide IT systems, in all but one of the five eICU hospitals, created barriers to using the full extent of eICU advanced monitoring and outcome analysis features. Although vital signs from bedside monitors and electronic laboratory data could be imported into the eICU system, other data, such as volume of intravenous fluids administered, ventilator settings, and medications, could not. Similarly, the hospitals’ bedside and eICU documentation systems were not interoperable.

Among other limitations, the lack of interoperability meant that some “Smart Alerts” were not functional—for example, for drug interactions or mechanical ventilator regulation problems. In addition, poor interoperability prevented necessary clinical data from being put into the eICU software to produce reports for assessing outcomes and pointing to areas for quality improvement.

Hospitals adopted varying approaches to address these shortcomings. As one respondent noted, “Because of problems with interoperability, it is a challenge to make VISICU useful... Half the nurses’ time is spent moving data from point A to point B to make it available.” For the longer run, one hospital was investing substantially in improving interfaces to increase functionality, while another decided not to build interfaces with its new hospitalwide electronic medical record, noting, “We use the VISICU tools for what they are good at without labor-intensive data entry, and we don’t sweat the other stuff that we can get through other means.”

Unknown impact on quality and costs. Although eICU adopters perceived an improvement in ICU quality and lower costs, they could not point to convincing objective data. Respondents using the eICU thought that improved quality might reduce costs—through reduced complication rates and lengths-of-stay. However, they agreed that it was difficult to isolate the impact of the eICU from the effects of other quality improvement initiatives implemented concurrently. Adopters, some with the help of VISICU, were attempting to assess the impact on cost and quality using the ICU-specific case-mix adjustment software. But none were confident that they had verifiable data on eICU’s unique impact on quality and safety, and none had yet been able to calculate case-mix-adjusted changes in lengths-of-stay or costs.

Nonadopters’ Views Of eICU

VISICU’s eICU product was known to almost all respondents in nonadopting hospitals. Indeed, more than half of these hospitals had considered adopting the VISICU eICU or rival products, and five were still considering adoption.

Preference for on-site staff. Virtually all non-eICU hospitals thought that their current ICU clinical staffing was adequate or nearly so. Skeptics among the
“Several respondents saw the value of eICU for supporting bedside nurses, especially during hours when intensivists are not in house.”

nonadopters emphasized their preference for on-site staff, perceiving that bedside staff could provide better quality of care than remote staff; they pointed to the need for hospitals to maintain on-site physicians 24/7 to perform procedures, interact with families, and supervise trainees—even with eICU.

As summarized by one nonadopting intensivist, “We get a lot of bang for our buck with face-to-face interaction.… eICUs are good in crisis-type situations, where patients are going bad. But eICU would fall short on the bread-and-butter stuff: day-to-day rounding and communication with families.” Another respondent challenged the premise that increased surveillance of ICU patients was a benefit, suggesting that additional information would not often alter actual clinical decisions or sometimes might lead to detrimental overreaction to minor deviations in patients’ clinical status.

Further, eICU was viewed as restricting staff mobility: “One of the problems is that you need a large number of pulmonologists [intensivists] to cover it. This might work in some hospitals, but we have pulmonologists doing more than one thing.… To trap the pulmonologist in a monitoring room where they can’t take care of patients directly is a problem.”

Questions about return on investment. Making a bottom-line assessment, most nonadopters thought that the limited potential benefits of eICU did not justify its substantial up-front and ongoing operating costs and the lack of third-party reimbursement for professional services. A few respondents asserted that the eICU value proposition had not yet been established, in contrast to the case for dedicated intensivist coverage.15 In the words of one respondent, “The issue is whether you get a return on investment; a lot depends on the structure of your unit before you begin. I don't think we would gain much because our complication rate is low. If a hospital’s outcomes are poorer and they don't have adequate resources, then eICU makes sense.”

Several respondents saw the potential value of eICU for supporting bedside nurses, especially during hours when intensivists are not in house. And some nonadopting hospital respondents were enthusiastic about eICU’s advanced monitoring and other clinical decision-support functions for their hospital, particularly since many perceived their own IT systems as inadequate. As explained by one nonadopting respondent, “[VISICU] does a good job of presenting data in a way that makes the data easy to interpret and evaluate. Our current system is not that easy or nice. I think it would be a real improvement to have this extra data analysis; that would be the biggest reason I would want to do the eICU.” However, as noted above, interoperability problems in eICU hospitals limited the potential of sophisticated data analysis.
Policy Implications

Hospital CMOs and ICU directors had strong opinions about the pros and cons of eICU. Although the telemedicine concept encompassed by eICU has often been proposed as a possible approach to addressing the national shortage of intensivist physicians and, to a lesser extent, critical care nurses, particularly for less-populated areas, the five hospital systems that had adopted the approach in CTS sites as of 2007 thought that its primary benefit was in the largest urban and suburban hospitals with the sickest ICU populations.

In these locations, eICU staff were add-ons to the already large complement of ICU nursing and physician staff. Respondents from these systems emphasized the virtues of redundancy—“backing up the front lines”—to improve care, particularly during “off-hours,” when there are fewer in-hospital personnel. Respondents from nonadopting hospitals, in contrast, were not convinced that the added purported benefits justified the substantial costs.

Recently, clinical research has reexamined broadly accepted ICU clinical interventions that were believed to be standard critical care, including the routine use of pulmonary artery catheters to monitor hemodynamics; the use of sedatives and antibiotics; and the clinical management of nutrition, fluids, and electrolytes. These studies challenged what had been consensus-based, relatively aggressive ICU interventions. Given this record, it is possible that the eICU approach, which detects even minor clinical deviations from baseline, might similarly produce overtreatment, to the detriment of patients’ well-being.

Even senior clinicians from eICU-adopting hospitals, who are strong advocates, acknowledged that because so many different ICU changes and initiatives are occurring concurrently, it is hard to isolate eICU’s impact; clinical and health services research of ICU care is difficult for a range of technical, ethical, and practical reasons.

Policymakers have had a long-standing interest in knowing under what circumstances improved quality and safety also result in reduced health care costs. ICU quality initiatives in general and the eICU approach in particular seem ripe areas for expanding knowledge of the quality/cost trade-off, not only because the ICU is a core clinical service in virtually all hospitals, but also because ICU care is a large and growing contributor to rising health care spending.

Sorting out what works to improve care for critically ill patients, although challenging, requires an increased commitment to health services research, in addition to clinical research. Almost 10 percent of ICU beds now are part of eICUs, yet there is an inadequate evidence base to assess whether the technology has benefit and in what situations, and whether it is worth the substantial investment. Indeed, there has not been a critical evaluation of the broad-based efforts to implement bundles and other quality-enhancing ICU organizational and management improvements that have been taking place as well.
The Medicare Payment Advisory Commission (MedPAC), Congressional Budget Office (CBO), and others have recently endorsed the need to make a national commitment to “comparative effectiveness” analysis, which has been defined as an approach that “compares the relative value of drugs, devices, diagnostic and surgical procedures, diagnostic tests and medical services.”\(^{17}\) Substantial comparative effectiveness funding was included in the American Recovery and Reinvestment Act (ARRA) of 2009 (the so-called stimulus bill). ARRA expanded the breadth of comparative effectiveness research to include “health care treatments and strategies” (emphasis added). The Institute of Medicine (IOM), which was asked in ARRA to recommend national priorities for questions to be addressed by comparative effectiveness research and supported by ARRA funds, expanded and reinforced this new emphasis on delivery and work process improvements in their definition of comparative effectiveness research: “CER is the generation and synthesis of evidence that compares the benefits and harms of alternative methods to prevent, diagnose, treat and monitor a clinical condition or to improve the delivery of care” (emphasis added).\(^{18}\) By this expanded definition, eICUs could be considered a topic for comparative effectiveness research. However, the IOM did not include any intensive care topics in their top hundred recommended priorities.

More than a decade after the development of and, now, widespread reliance on hospitalists to care for inpatients, there is little agreement on what the meager evidence shows about their impact.\(^{19,20}\) Similarly, more than a decade after disease management was widely adopted by commercial health plans, the CBO’s recent evidence review concluded that there was “insufficient evidence” to conclude whether or not disease management programs can reduce health spending.\(^{21}\) Although telemonitoring has certainly not garnered as much attention as hospitalists and disease management have, its growing presence in ICU care, and its potential for other care settings deserves formal, comprehensive evaluation, possibly in clinical trials. Further, the impact of these process changes deserves as much attention in the National Institutes of Health’s research agenda as more traditional clinical research focused on discrete drug or device interventions. A national comparative effectiveness initiative should identify potentially important innovations in care delivery that deserve priority for the research agencies.

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NOTES


12. A summary of the literature is available in an appendix, online at http://content.healthaffairs.org/cgi/content/full/healthaff.28.5.w937/DC2.

13. A graphical representation of ICU telemedicine workflow is in an appendix, online as in Note 12.

14. Institute of Healthcare Improvement bundles are sets of simple best practices performed routinely and in sequence.

15. These interviews were conducted before the recent study (see Note 7) challenging the prevailing understanding of the value of intensivists.


