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# Intensive Care Unit Telemedicine: Review and Consensus Recommendations

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On behalf of the University HealthSystem Consortium ICU Telemedicine Task Force

**Intensive care unit telemedicine involves nurses and physicians located at a remote command center providing care to patients in multiple, scattered intensive care units via computer and telecommunication technology. The command center is equipped with a workstation that has multiple monitors displaying real-time patient vital signs, a complete electronic medical record, a clinical decision support tool, a high-resolution radiographic image viewer, and teleconferencing for every patient and intensive care unit room. In addition to communication functions, the video system can be used to view parameters on ventilator screens, infusion pumps, and other bedside equipment, as well as to visually assess patient conditions. The intensivist can conduct virtual rounds, communicate with on-site caregivers, and be alerted to important patient conditions automatically via software-monitored parameters. This article reviews the technology's background, status, significance, clinical literature, financial effect, implementation issues, and future developments.**

**AUTHORS' NOTE:** The authors are with the University HealthSystem Consortium Intensive Care Unit Telemedicine Task Force. A list of the University HealthSystem Consortium Intensive Care Unit Telemedicine Task Force members follows this article.

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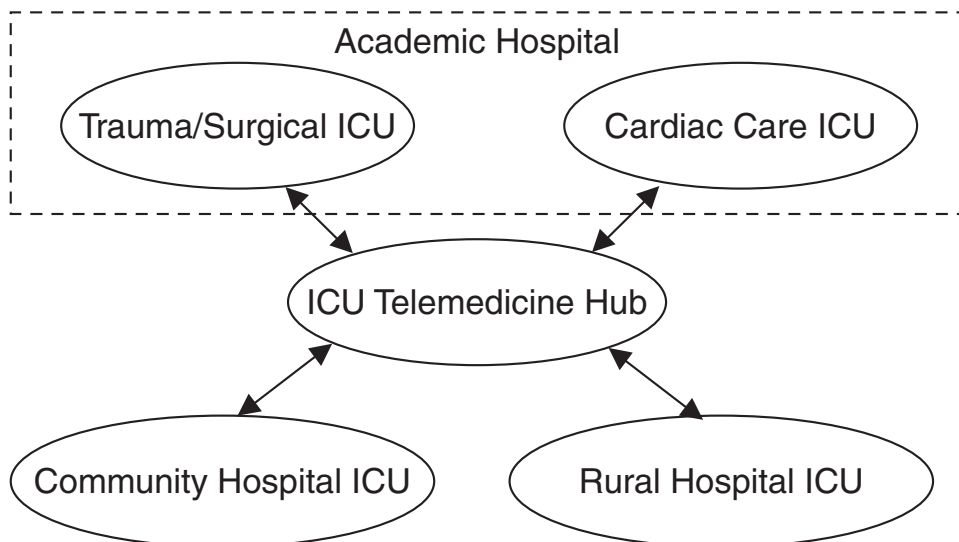
**Recommendations from a University HealthSystem Consortium task force are also presented. (Am J Med Qual 2007;22:239-250)**

**Keywords:** eICU; ICU telemedicine; consensus recommendations; ICU IT; telemedicine

Telemedicine can be broadly defined as the use of electronic information and communications technology to provide and support health care when distance separates the patient and the caregiver.<sup>1</sup> Telephone consultation is a form of telemedicine that has been in use for decades. More complex telemedicine is also widespread, including hundreds of thousands of teleradiology consultations annually and comprehensive, telemedically provided care to Native American populations, prisoners, astronauts, armed forces personnel, and increasingly to rural populations.<sup>2</sup> Telemedicine's broad goal is to improve the availability, timeliness, and quality of medical care.

The rapid advance in technology is a trend driving telemedicine dissemination. For example, wide availability of high-speed broadband Internet, inexpensive audio and video equipment, and cheap multimedia-capable computers readily allows videoconferencing in many different settings, including the home, office, and hospital areas. Other key trends in information technology (IT) affecting telemedicine include better computer-human interfaces, advances in software infrastructure, improved compatibility among off-the-shelf products (eg, plug-and-play capabilities), development of software-based clinical decision support tools, and digitization of clinical reference materials.<sup>3</sup>

Trends in health care are also driving telemedicine dissemination. For example, shortages of specialists often lead to innovative strategies to access expertise on an as-needed basis. Furthermore, in situations of limited caregiver supply, employee satisfaction becomes an important issue. Flexibility in



**Figure 1.** Centralized model of intensive care unit telemedicine.

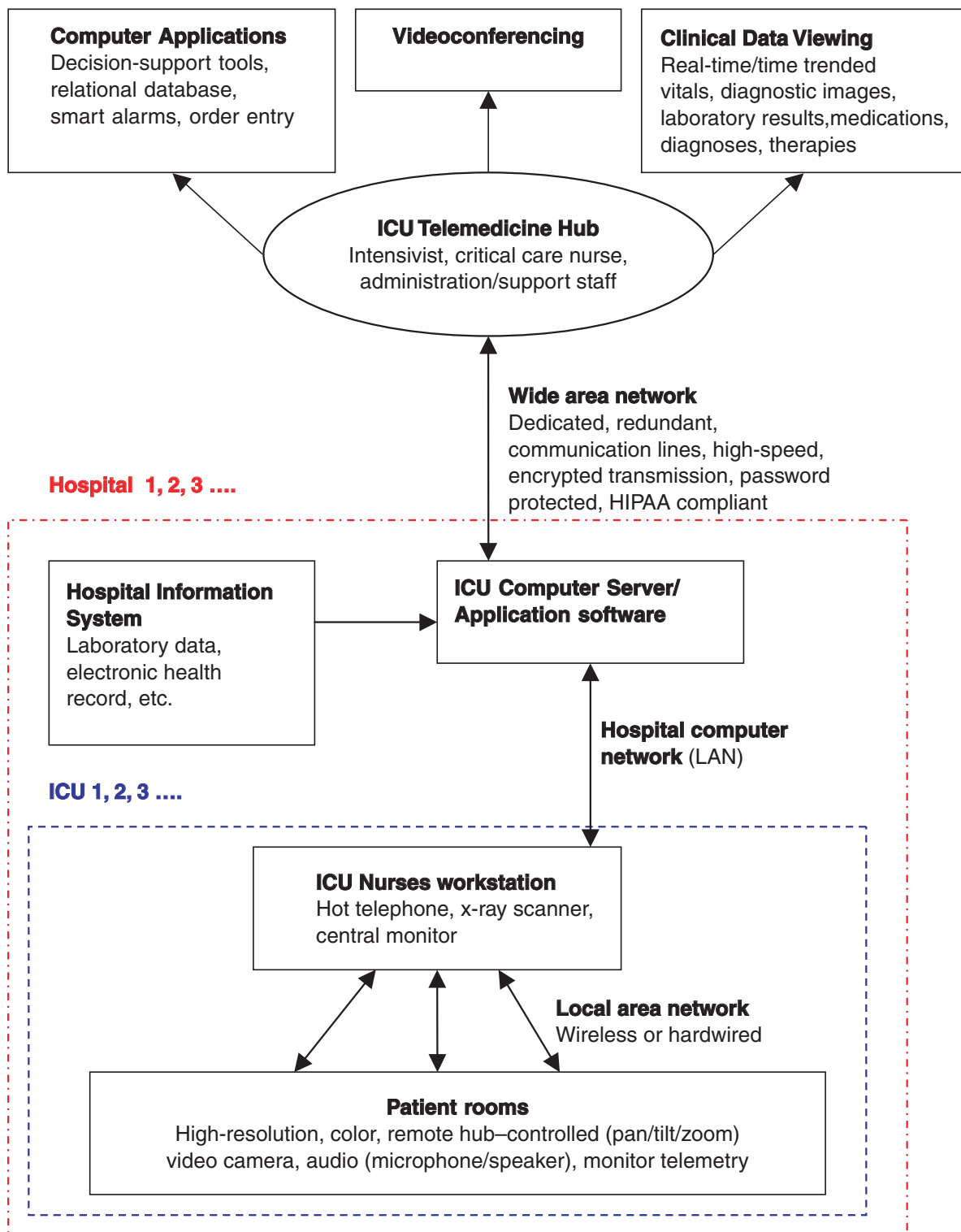
work schedule derived from the use of telemedicine may favorably affect employee retention. Another trend in the health care arena involves consolidation of multiple, geographically separated institutions under a single corporation or business plan. Telemedicine may benefit these arrangements by allowing efficient distribution of an employee's time and expertise over as many of the involved institutions and caregiver settings as possible. In large academic hospitals, this model may apply within a single institution.

Telemedicine in critical care areas is a specialty subset of the overall field of telemedicine. Intensive care unit (ICU) telemedicine typically involves specialists located at a dedicated central hub providing care to patients in multiple, remotely located ICUs (Figure 1).<sup>4</sup> Staff located at the hub may include a physician intensivist, critical care nurses, nurse practitioners, hospitalists, or other members of the multidisciplinary team such as pharmacists or respiratory therapists, as well as associated administrative staff. Staffing and coverage models may vary with individual circumstances. For example, the hub may be staffed only during times when on-site physicians are not present (eg, at night and on weekends). Furthermore, responsibilities of the hub intensivist can vary from treating emergent situations, with all other care managed by the admitting physician (open ICU model), to complete intensivist management, with only notification of treatments given to

the patient's physician (closed ICU model). The frequency of virtual rounds is determined by patient severity (typically ranging from once an hour to once per day). A well-supported intensivist may staff approximately 50 to 100 remote ICU beds.

Because of the technology-intensive nature of ICUs, the telemedicine process is also technology centric (Figure 2). Technology may be used to facilitate remote communications (eg, teleconferencing and hotlines), to view patient clinical status (eg, from in-room monitors), and to access patient clinical data (eg, records from the hospital information system, order entry system, laboratory and radiology results, and electronic health records).<sup>4</sup> Intensive care unit devices may be connected via a wireless or hard-wired local area network to a hospital-based server. This is then connected via dedicated, high-speed communication lines to the ICU hub.

In addition to the hardware components of telemedicine, associated software applications are emerging that support clinical decision making, standardize care processes, and guide quality improvement initiatives.<sup>5</sup> These applications may include the following: smart alarms that collect and analyze trends in clinical data (eg, heart rate, oxygen saturation, respiratory rate, and creatinine clearance) independent of caregiver attention and alert the caregiver to possible important changes in patient status, online clinical tools used for clinical decision making such as clinical pathways and



**Figure 2.** Overview of components involved in intensive care unit telemedicine.

guidelines, and data storage, retrieval, and analysis packages that facilitate outcomes tracking and monitor resource utilization. Software packages are also available that collect data from all monitors and therapeutic equipment for easy-access viewing by a remotely located caregiver.<sup>6</sup>

As with all emerging technologies, there are associated claims of advantages and disadvantages to ICU telemedicine. Advantages are mainly related to having an ICU physician rapidly available, having an intensivist available more hours of the day, and having rapid access to all forms of clinical data through improved ITs. Having an ICU physician available allows for more rapid interventions in case of problems, potentially decreasing complications and morbidity and minimizing length of stay (LOS) secondary to treating complications. Length of stay and resource utilization may also be affected by commencing care as soon it is warranted (eg, ventilator weaning begun during the nighttime).

Potential disadvantages relate mostly to putting a layer of technology between the patient and the physician. The technology comes with significant upfront and maintenance costs and is subject to malfunction and downtime. Physicians typically are cited as the greatest barrier to implementation of telemedicine options. They may be uncomfortable dealing with new technology, may perceive a threat to their clinical autonomy and fiscal concerns, and may believe that lack of direct interaction, eye contact, and other sensory input with the patient may cause them to miss critical diagnostic cues.

### TECHNOLOGY SIGNIFICANCE

Intensive care units treat approximately 4.5 million patients annually in the United States.<sup>7</sup> Intensive care units typically comprise about 10% of hospital beds. However, although the nationwide number of hospital beds significantly decreased from 1995 to 2000, the number of ICU beds increased by 26% during the same period.<sup>8</sup> Further growth in ICU care is expected as the population ages and as the acuity of hospitalized patients continues to increase. The increased acuity of hospitalized patients is largely a function of advancements in medicine that now provide treatment options and prolong life for patients with life-threatening diseases. The health care trend toward hospitals, particularly academic hospitals, becoming centers for critical care is a reason why many hospitals are focusing on the use of

technology to improve this important component of their business.

In 2000, ICU costs exceeded \$55 billion, accounting for 13.3% of hospitalization costs and 4.2% of national health care expenditures.<sup>8</sup> Intensive care unit bed costs per day typically exceed \$2500. As one of the most expensive areas in the hospital, cost-saving initiatives are often directed at the ICU. Implementing ICU telemedicine technology is often touted as a means to optimize labor costs. It also may affect costs secondary to improving patient outcomes and decreasing complications, lowering resource utilization. Decreased LOS in the ICU lowers treatment costs and may allow more efficient use of ICU areas with bed shortages via higher patient throughput. However, these potential advantages are institution specific, and institutions need to carefully weigh the high upfront and maintenance costs against these potential cost savings to determine their unique financial implications. For example, some of the labor costs to staff the electronic ICU (eICU) may be additive if institutions maintain the current system of staffing instead of replacing some staff.

Intensive care unit telemedicine is often implemented for patient safety reasons. The ICU mortality rate is approximately 10% to 20% and accounts for more than 500 000 deaths annually in the United States.<sup>9</sup> Some morbidity and mortality among ICU patients may be preventable. Organizational and human factors are a potential cause of ICU medical errors and preventable deaths. Findings from several studies<sup>10-12</sup> suggest that patient outcomes are better in ICUs managed predominantly by physicians with a specialty in critical care medicine. Estimates suggest that full implementation of intensivist-model ICUs across the United States would result in about 50 000 fewer ICU deaths annually (approximately a 10%-15% reduction times 500 000 deaths annually).<sup>13</sup> This has led patient safety groups such as The Leapfrog Group<sup>14</sup> to set standards on ICU physician staffing. However, nationwide implementation of this strategy is unlikely because of personnel shortages.<sup>15</sup> There are fewer than 6000 intensivists in practice today, and fewer than 15% of hospitals meet The Leapfrog Group intensivist staffing model. Certain telemedicine alternatives such as the eICU may be used to meet The Leapfrog Group standard and to provide more intensivist coverage to more places.

Intensive care unit telemedicine technologies also may reduce medical errors through increased

physician availability and improved communication between caregivers. An ICU observational study<sup>16</sup> reported a mean medical error incidence rate of 1.7 per patient per day and a severe error rate potentially causing patient harm of 2 per day per ICU. Physicians and nurses had almost equivalent numbers of errors. However, most of these errors were attributed to breakdowns in communication between the physician and nurse rather than to the failure of any individual caregiver. To the extent that technology can facilitate communication (eg, videoconferencing) and transfer of knowledge (eg, electronic patient records and clinical data), ICU telemedicine may be able to decrease these types of errors.

The capability for 24/7 intensivist coverage is a noted potential advantage of ICU telemedicine. However, the need for intensivist physical presence 24/7 is not well supported either way by the clinical literature,<sup>17-21</sup> and further comparative clinical study is needed to resolve the issue. A common, alternative coverage model is to use dedicated physicians (house-staff) or physician extenders (physician assistants or critical care nurses), with an intensivist rapidly available via pager. The Leapfrog Group<sup>14</sup> ICU staffing requirements are met if the intensivist can return pages within 5 minutes (at least 95% of the time) and arrange for suitable alternative staff to reach the patient within 5 minutes.

Finally, ICU initiatives aimed at medical error reduction, outcomes improvement, and resource utilization optimization can and should be studied whether or not a telemedicine system is planned.<sup>22</sup> For example, implementation of clinical pathways, protocols, and administrative policies can be used to reduce complications and ICU LOS. These steps may use some forms of electronic IT such as real-time electronic health records or availability of patient data from monitoring equipment and other hospital information systems. Reduction of medication errors and adverse drug events is another important focus of ICU safety initiatives. One study<sup>23</sup> found that the rate of preventable adverse drug events in ICUs was 19 events/1000 patient days. Because of the high number of drugs ordered in ICUs, this represented almost twice the number of adverse drug events seen among non-ICU patients. Information technologies such as bar-coded medication administration and computerized provider order entry systems are methods that hospitals have used to decrease these medication errors.<sup>24</sup>

## CLINICAL LITERATURE

Clinical studies on the efficacy and utility of ICU telemedicine were identified via a computerized search of the PubMed<sup>25</sup> (MEDLINE plus) database available through the US National Library of Medicine. Keywords searched included *ICU telemedicine* and *eICU*. Only 2 clinical trial studies were identified as of January 2006: these included an early, observational feasibility study<sup>26</sup> with the intervention conducted in late 1997 and the results published in 2000 and a larger, historically controlled observational study<sup>27</sup> conducted in 1999 to 2000 and published in 2004. Other identified clinical literature (approximately 20 articles) included anecdotal reports, technology descriptions, discussions of implementation issues, and review articles. These are referenced elsewhere throughout this article, as applicable.

The first ICU telemedicine trial involved an observational study<sup>26</sup> in a 10-bed surgical ICU (SICU) enrolling patients present at the ICU during a 16-week period with remote presence of an intensivist (n = 201) compared with 2 different baseline periods (n = 225 and n = 202) at a 450-bed, academic-affiliated community hospital. The baseline ICU care model was primarily open, with a part-time critical care-certified surgeon directing some activities such as triage and medical record review and providing as-needed consulting services (approximately 30% of patients). The telemedicine intervention model used a prototype system with cameras and computers installed in the homes of 4 intensivists who staffed the ICU around the clock 7 days a week without ever coming to the hospital. Intensivists were available but were not necessarily actively managing patients during night hours. Communications and virtual rounds were ad hoc. No new critical pathways or computerized records were implemented for the study. Results of the telemedicine intervention showed a statistically significant 46% to 68% decrease in severity-adjusted ICU mortality compared with the baseline periods. Adjusted hospital mortality also decreased by approximately 30%. The reduction in mortality was attributed to a 40% lower incidence of complications, possibly secondary to preventable adverse events. Intensive care unit LOS decreased by about 33% (by approximately 1 day). Overall, ICU costs decreased by 33%, mostly because of fewer complications, shorter LOS, and a decrease in the number of high-resource utilization outlier patients. Based partly on the results of this study,

the hospital later decided to adopt a high-intensity, on-site intensivist care model.

In a study conducted by Sentara HealthCare authored by Breslow et al,<sup>27</sup> the eICU was implemented in 2 adult ICUs, a 10-bed general ICU that primarily cares for high-acuity medical ICU (MICU) patients, and an 8-bed SICU that primarily cares for vascular surgery patients at a 650-bed, tertiary care teaching hospital in Virginia. This study evaluated ICU outcomes and resource utilization for patients (744 total patients, 359 MICU patients, and 385 SICU patients) admitted to either ICU during a 6-month period (January through June 2001) after the eICU was in place compared with patients (1396 total patients, 631 MICU patients, and 765 SICU patients) admitted in the year before eICU implementation. The eICU study period followed a 6-month implementation and trial phase of the technology. The eICU was implemented simultaneously in another Sentara HealthCare hospital, but these results were not included in the study because of incomplete coverage of all ICU beds in this hospital's unit and the potential for patient selection bias.

The control group ICU model of care was mixed, with an intensivist as the primary attending for teaching service patients (approximately 40% of ICU patients) in the MICU.<sup>27</sup> Nonteaching service and SICU patients had no mandatory intensivist involvement but could use an intensivist consultation if called for by the admitting physician (about 80% of MICU patients and 35% of SICU patients).

The eICU intervention group maintained the same overall care structure as before, with supplemental intensivist coverage for 19 hours per day (noon to 7 AM) from a centralized off-campus hub in a commercial office building.<sup>27</sup> The admitting physician was responsible for the overall patient care plan and determined the level of autonomy (delineated as levels 1-4) given to the off-site intensivist during off-hours. Regardless of designated care level, the off-site intensivist conducted virtual rounds on all patients at regular intervals determined by patient acuity. During off-hours, the off-site intensivist was designated as the on-site nurses' primary contact. The off-site intensivist was then charged with communicating with the admitting primary physicians. The off-site intensivist responded to all emergencies and initiated interventions if authorized to do so by the admitting physician.

Study<sup>27</sup> results showed that ICU and hospital mortality decreased during the period of remote ICU care by approximately 27% (hospital mortality, 9.4% vs 12.9%; relative risk, 0.73 [95% confidence interval, 0.55-0.95]). A statistically significant reduction in mortality was obtained among the MICU patients but not among the SICU patients. Furthermore, ICU LOS decreased by 16% overall in the eICU group (3.63 [95% confidence interval, 3.21-4.04] days vs 4.35 [95% confidence interval, 3.93-4.78] days). However, overall hospital LOS was unchanged. Subset analysis showed that ICU LOS and hospital LOS decreased among SICU patients. Among the MICU patients, the mean ICU LOS decreased by 14%, but hospital LOS was similar to that of control subjects. Patients with an ICU LOS exceeding 7 days were considered outliers.

Financial analysis showed a reduction in variable cost per case of \$2556 attributed to decreased ICU LOS and to lower daily ICU ancillary costs in the remotely managed intervention group.<sup>27</sup> Program costs (ie, hardware and software leasing, technical support, and eICU operating expenses) totaled \$248 000 for the 6-month trial period. Remote-physician staffing costs were estimated at about \$341 000 for the hospital under study. The number of ICU cases per month increased by approximately 7% (116 baseline vs 124 after eICU implementation) secondary to excess capacity created in the MICU by the LOS reductions.

Although it is implied that remote ICU coverage may result in mortality and LOS reductions, these outcomes may not be achieved in institutions with different baseline characteristics. For example, the mixed intensivist coverage models followed in this study<sup>27</sup> may be dissimilar to those used in other institutions. Multiple levels of intensivist coverage were used among different types of patients in this study before and after the intervention. Given that the clinical literature has repeatedly shown a positive effect on outcomes from the use of a dedicated intensivist and that closed ICU models with complete control transferred to the intensivist show better outcomes than open ICU models,<sup>10-12</sup> the roles of these variables in this study are unclear. Unfortunately, the authors stated that the numbers of patients in their different ICU care models were insufficient to determine an effect.

Further confounding extrapolation of these results to other institutions is the variability in the baseline level of ICU IT systems and computerized

decision support tools. In this study,<sup>27</sup> significant computer system upgrades were made that allowed all staff to view patient information, physician notes, and clinical care pathways. Whether the increased availability of this type of information affected patient outcomes is unknown. Many institutions, in pursuit of the complete patient electronic health record and other IT initiatives, have significantly upgraded IT in their ICUs. These computer-intensive environments may see less effect from implementation of a remote ICU program. The baseline hospital represented a single institution's IT status in early 1999 to 2000,<sup>27</sup> which may be different from that of hospitals in 2005 onward.

General criticisms of this study<sup>27</sup> stem from its unblinded design, the use of historical controls, and the small sample size. In these types of studies, there may be an increased institutional focus on ICU care that accompanies any new technology implementation. This focus may result in improvements independent of the technology. Furthermore, knowing that a study is under way, clinicians may provide more attentive care to patients, improving care over baseline circumstances. The control and intervention groups seemed well matched in admission criteria and in Acute Physiology and Chronic Health Evaluation scores,<sup>27</sup> but there may have been subtle patient differences such as seasonal variations not captured in this trial. Finally, this trial represents 1 hospital, 2 ICUs, and 18 beds. Adding more hospitals, ICUs, and beds may push the limits of remote staff and may change care outcomes. An optimal ratio of patients to staff has not been determined, although it often approaches 50:1 to 100:1. (Reportedly, the remote hub staff also was monitoring 15 beds in an ICU in another hospital,<sup>27</sup> bringing the total to approximately 32 beds.)

### FINANCIAL IMPACT

Intensive care unit telemedicine costs will depend on, among other things, infrastructure upgrades, equipment costs, training costs, staffing costs, and the number, type, and size of the involved ICUs. For eICU implementation, manufacturer-reported discounted costs range from about \$30 000 to \$50 000 per ICU bed.<sup>28</sup> Therefore, equipping all the ICU beds in a typical academic hospital (eg, 100 beds) may cost approximately \$3 to \$5 million. Annualized operational costs may include overhead, maintenance, and staffing. Equipment operation and maintenance

costs can be estimated at approximately 20% of the purchase cost (eg, 0.20 times \$40 000 equals \$8000/bed per year) or approximately \$800 000/year for a 100-bed system. Staffing costs will depend on the hours in use (eg, nights and weekends vs 24/7) and the level of staff (eg, critical care nurses, intensivists, or a combination). Typical coverage scenarios can add approximately \$1 million to \$2 million per year in operating costs. However, net hospital costs should take into account any reduction in other operating costs as a result of eICU operation.

Financial issues related to implementation of an eICU are likely to be institution dependent. It has been suggested that if implementation reduces ICU LOS, supply and ancillary costs, therapy and medication costs, and other costs, then the net savings can offset some of the telemedicine costs. For example, findings from an accounting study<sup>28</sup> by Sentara HealthCare suggested a \$2 million eICU cost that was offset by \$3 million in net savings annually. This institution also reported extra revenue (approximately \$460 000/month) due to increased patient throughput resulting from decreased ICU LOS. Obviously, the latter finding is also institution specific, depending on current utilization patterns in a given ICU, hospital cost structures, patient acuity, and payer mix.

The most prevalent use of telemedicine systems such as the eICU seems to be by multihospital health systems. This suggests that financial considerations may be driving decision making more than clinical considerations at this stage in the technology introduction. In multi-institutional systems owned by a single entity, there are economies of scale to be realized by consolidating intensivist coverage in a single location. This financial model allows optimization of the time and services of the intensivist without redundancy of intensivist services at multiple locations, addressing the critical care medicine labor shortage. Furthermore, provision of services at multiple, geographically separate places may be a convenience to the patient, as opposed to requiring travel to a regional center. This expands the provider's reach into new markets and provides a marketing opportunity.

Billing and reimbursement for eICU services are developing issues. At this time, it is not possible to bill for the use of the system above and beyond the normal ICU system of charges. Therefore, it is not possible to recover acquisition and operating costs through billing means. However, there may be

some consideration from payers for hospitals implementing patient safety initiatives such as increased intensivist staffing models (eg, The Leapfrog Group standards<sup>14</sup>).

### IMPLEMENTATION ISSUES

Implementation of an ICU telemedicine system needs to be thoroughly planned and managed to be successful. Planning activities typically require a standing interdisciplinary committee with strong institutional support and adequate funding. Input from key end users should be solicited early in the decision-making process to maximize staff buy-in. Buy-in from all involved physicians is particularly important. Physician leaders play an important role in communicating the need for and the role of the telemedicine system, and key physician leaders should be included on the planning committee.

An important part of the planning and implementation process is collecting and analyzing quantifiable metrics regarding the performance of the system. This requires collection of data from before and after eICU implementation for comparative purposes. Numerous metrics can be considered, although some are easier to collect than others. Ease of measurement, assurance of consistency of measurement across platforms, and acuity adjustments are critical to the comparative analysis.

Rollout of the telemedicine system should begin on carefully selected units. Typical rollout includes a pilot phase of implementation on a few selected units before a larger planned rollout. The eICU manufacturer reports that its system can be up and operational in a pilot phase in 4 to 6 months after contract signing.<sup>28</sup> The pilot phase includes troubleshooting of equipment and of policies and procedures that will be put in place. Patient outcomes should be monitored to ensure maintenance of quality and to ascertain whether improvements are seen. Concomitant economic studies also may be conducted at this phase. Physician, nursing, and patient satisfaction should be measured systematically as well.

Training of end users is needed before and during rollout of the new technology. This may entail general education sessions, refresher classes, and 1-on-1 user instruction. Training includes imparting familiarity with all the involved components and capabilities of the system. Physicians need to understand

the system to achieve a comfort level and to maximize the use of its strengths. Educational sessions should emphasize the need for collaboration between all users to ensure successful implementation.

Nursing issues with eICU technology is an often overlooked subject. The American Association of Critical Care Nurses is performing a work study to review the ICU clinical work of the remote registered nurse (RN) and to recommend standards. In a University HealthSystem Consortium (UHC) member eICU system, the remote RN is required to have at least 5 years of critical care experience, and all RNs are Advanced Cardiac Life Support certified (personal communication, University of Pennsylvania Health System staff). At this institution, about two thirds of the nursing positions are "shared positions," meaning that they work part time in the eICU and part time at the bedside. The other third are "dedicated positions," meaning that they work full time in the eICU. Common RN interventions performed from the eICU include the following: (1) vital sign changes (eg, notifying the bedside RN), (2) safety interventions (eg, catching a patient with his or her hands on the endotracheal tube, notifying if an oxygen source becomes disconnected, noting patients getting out of bed with intracranial pressure monitoring, catching incorrect medical record numbers, or watching patients while the on-site RN is busy with other patients), (3) laboratory follow-up (eg, critical laboratory follow-up with the RN or physician or abnormal creatinine clearance requiring follow-up with the pharmacist for a drug-dosing evaluation), (4) ventilator bundle surveillance, (5) assistance with code blue, and (6) assistance with paging physicians or members of the multidisciplinary team.

Information technology infrastructure may need to be upgraded before rollout. This process is institution dependent but may require significant outlays for communication lines and for interfacing between various hospital ITs. Space, on-site or off-site, may need to be prepared to house the hub. Servers and other computer equipment may need to be housed in areas of the ICU and in IT areas of the hospital. Emergency procedures are needed to handle planned and unplanned system downtime. These contingencies may include redundant servers and communication lines. Hospital policies need to be formulated to achieve on-site staff coverage in the event of system breakdown.

**Table 1**

Various Levels of Care That Can Be Chosen for the Electronic Intensive Care Unit Team

Level of Care	Description
I	Initiate only emergent interventions for life-threatening conditions. Notify the attending physician immediately of these events and all other situations warranting medical attention.
II	Initiate emergent interventions for life-threatening conditions and for minor nonemergent therapies. Contact the attending physician for all other situations warranting medical decisions.
III	Initiate emergent interventions for life-threatening conditions and for minor nonemergent therapies, and maintain therapies outlined in existing patient treatment plan. Contact the attending physician for clinical decisions requiring a major change in the plan and for all major events.
IV	Initiate emergent interventions for life-threatening conditions and for minor nonemergent therapies, maintain therapies as outlined, and initiate new therapies as needed. Notify the attending physician of major changes in patient status.

Privacy concerns are a key issue surrounding telemedicine. Hospitals need to take steps to ensure that patient information is not available to unauthorized persons. These steps may include password or personal identification number protection, data encryption, secure communication lines, and secure storage areas. Patients and caregivers need to be assured of privacy measures to achieve buy-in. This includes a notification system when telecommunication is occurring and assurances that no recordings are being made.

There are many options for integrating ICU telemedicine services into the ICU care model. Hospital, physician, and nursing goals need to be reconciled via a consensus process to achieve administrative order and clinical flexibility. The use of ICU telemedicine services can range from consultant-only services to empowering the team to provide all care (ie, category I [monitor my patients but do not write any orders without permission] to category IV [assume all management but keep me informed of any significant clinical changes] [Table 1]). Level I and level II services may be used in the early phases of rollout to acclimate the staff and to build confidence in the level of care. Higher levels of care may be needed before changes in morbidity, mortality, or LOS outcomes are seen. Use of telemedicine services

**Table 2**

The Leapfrog Group Requirements for Telemonitoring

1. An intensivist who is physically present in the ICU performs a daily comprehensive review of each patient and establishes or revises a care plan.
2. A tele-intensivist is available whenever an on-site intensivist is not.
3. A tele-intensivist has immediate access to key patient data, including medications, bedside monitor data, laboratory orders, and results.
4. Data links between tele-intensivists and the ICU are reliable and secure.
5. Audiovisual support is clear enough for tele-intensivists to assess a patient's breathing pattern and to communicate with on-site personnel at bedside.
6. Written standards for remote care are established, including credentials and certification in critical care medicine, as well as explicit policies on roles and responsibilities.
7. Tele-intensive care unit care is proactive, with routine review of all patients at a frequency appropriate to severity of illness.
8. A tele-intensivist's workload permits completion of a comprehensive patient assessment within 5 minutes of a request for assistance.
9. A written process of communication is established between a tele-intensivist and an on-site care team.
10. A tele-intensivist documents patient care activities, and documentation is incorporated into the patient record.

From The Leapfrog Group.<sup>29</sup> ICU = intensive care unit.

24/7 or to fill gaps in on-site coverage will be an institution-specific decision based on current levels of coverage.

Implementation of telemedicine services should achieve high quality of care. The Leapfrog Group<sup>29</sup> has published standards for telemedicine systems to meet to operate successfully (Table 2). Telemedicine systems that meet these requirements may qualify for additional reimbursement via The Leapfrog Group policies and procedures.

**ICU TELEMEDICINE TASK FORCE**

The UHC is an alliance of more than 90 US academic health centers. As a membership organization, the UHC provides its members with products and services to improve clinical, operational, and financial performance. The mission of the UHC is to advance knowledge, foster collaboration, and promote change to help members succeed (<http://www.uhc.edu>).

An October 2005 list serve survey of the UHC members identified 4 institutions (approximately 4% of all UHC members) as having implemented ICU telemedicine. However, many more institutions indicated a great interest in the technology, and several responded that pilot projects were planned. In October 2005, a UHC-member ICU Telemedicine task force was formed to advise the UHC staff on the available technology and the surrounding issues of importance. Selection of task force members was based on the following factors: (1) interested individuals at institutions who had experience with the eICU, (2) broad geographical representation, and (3) multidisciplinary composition. Members of the task force included nurses, physicians, IT specialists, and administrators. The UHC staff managed the project; no financial remuneration was provided to participants. The group convened via conference calls several times in 2005 to discuss issues and to provide guidance to the UHC staff. After group discussions, general consensus by all task force members resulted in administrative, technology, planning, and implementation recommendations. Task force members also participated as contributing reviewers to the final report. The consensus recommendations of the task force follow.

### Administrative Recommendations

- For hospitals with small ICU capacity, stand-alone ICU telemedicine will most likely offer minimal efficiency advantages. Consideration should be given to partnering with a larger center to provide ICU telemedicine oversight of critical care patients.
- The use of on-site full-time or part-time intensivists is the most efficient first step in ensuring the quality of care provided for critical care patients. Implementing ICU telemedicine is an important second option when on-site intensivists are not available or as a mechanism to provide additional oversight and 24/7 intensivist coverage.
- For any institution considering the implementation of an ICU telemedicine system, it is critical to develop a written institutionwide or systemwide strategic plan for technology assessment, with clear goals and objectives for improving overall patient safety and clinical effectiveness. Intensive care unit telemedicine should be considered a component of this plan.

- Adequate funding and time should be allocated to allow for the comprehensive evaluation of current critical care processes and information management systems before ICU telemedicine implementation planning.
- Dedicated multidisciplinary committees are critical to the evaluation and successful implementation of ICU telemedicine, with participation from bedside staff from critical care medicine, nursing, and pharmacy, along with representatives from senior hospital administration, finance, quality and risk management, medical informatics, and IT services at the table.
- All critical care areas are candidates for ICU telemedicine monitoring, including surgical, cardiac, medical, pediatric, neurology, neonatal, burn, and other postoperative units.
- The ultimate goal of intensivist ICU coverage is 24/7 coverage, and this goal may be supported through the use of ICU telemedicine.
- Intensive care unit telemedicine will likely be a standard of care in critical care units in 10 years, so all hospitals should begin planning the budget, staffing, technology, and infrastructure needs for future implementation now.

### Technology Recommendations

- All existing IT infrastructure should be evaluated and updated to handle real-time communication, with careful consideration given to effective interface and integration of essential information with ICU telemedicine technology.
- When evaluating systems, multisite installations in similar types of hospitals should be studied.
- Leasing equipment (eg, monitors and computers) should be considered in financial planning because hardware advancements will be significant during the next 5 years.

### Planning and Implementation Recommendations

- A strong communication strategy should be in place for all affected staff throughout the planning and implementation period.
- Determine, collect, and study selected monitoring metrics at least 6 months before implementation, after implementation, and after upgrades to evaluate the effects of ICU telemedicine technology

on patient care, ICU telemedicine objectives, and return on investment expectations.

- A phased rollout (3-6 months) assessing operational processes and confirming interface links with clinical decision support, laboratory, pharmacy, nursing, respiratory, imaging, other ancillary departments, associated clinical databases, computerized provider order entry, and the electronic medical record should be planned for a limited number of units.
- Clinical decision support rules should have medical and nursing staff approval and buy-in before ICU telemedicine “goes live,” with a process implemented for regular expert review and revision of clinical decision support rules.
- The level of ICU telemedicine staff intervention should be clear to all clinical staff. If necessary, amend medical staff policies and bylaws to reflect that ICU telemedicine is part of the organization’s care of critical patients and that all providers must accept a defined level of oversight and intervention in the care of their ICU patients.
- Patients and their families need to be informed of ICU telemedicine monitoring as part of the standard orientation to the unit.
- Preimplementation and postimplementation staff training programs need to be developed and systematically deployed. On-site experts (including physicians and nurses) should be available 24/7 to assist bedside and remote ICU staff during implementation and major upgrade periods.
- It is desirable to have some dedicated “core” ICU telemedicine intensivist and nursing staff. Allowing bedside ICU nurses and attending and resident intensivists to routinely rotate through ICU telemedicine shifts may also help gain buy-in for the technology and facilitate the incorporation of ICU telemedicine care into the organization’s critical care practices.

### FUTURE DEVELOPMENTS

Telemedicine use has been growing rapidly in health care for many years, in large part because of the concomitantly growing fields of telecommunications and IT. Advancements in the Internet, mobile connection technologies, and new software applications are expected to continue to expand the frontiers of telemedicine in the foreseeable future. Many of these advances are likely to be incremental

advances in telemedicine that, while small in comparison to full-package implementable ICU telemedicine systems, are nonetheless pushing the frontiers of patient care from remote locations. For example, as more patient information is digitized, is available in real-time 24/7, and is accessible through secure Internet protocols, caregivers are likely to access it from their homes, offices, and cell phones and via other media. If they then call in instructions to on-site caregivers based on these data, this is telemedicine. As these capabilities become cheaper, more user friendly, faster, and more convenient, the use of telemedicine is expanded.

Furthermore, ICU telemedicine-like systems may be expanded for use outside of the ICU on stepdown units and in the emergency department. These areas are a natural progression, as they are closely related to the ICU service and often have patients with similar acuity needs requiring intensive monitoring. One can readily envision taking the technology to other patient care areas such as routine inpatient hospital rooms. However, at this time, cost restraints are of major concern. For patients with fewer monitoring needs and less need for physician intervention or nursing support, the added technology may not justify the return on investment.

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