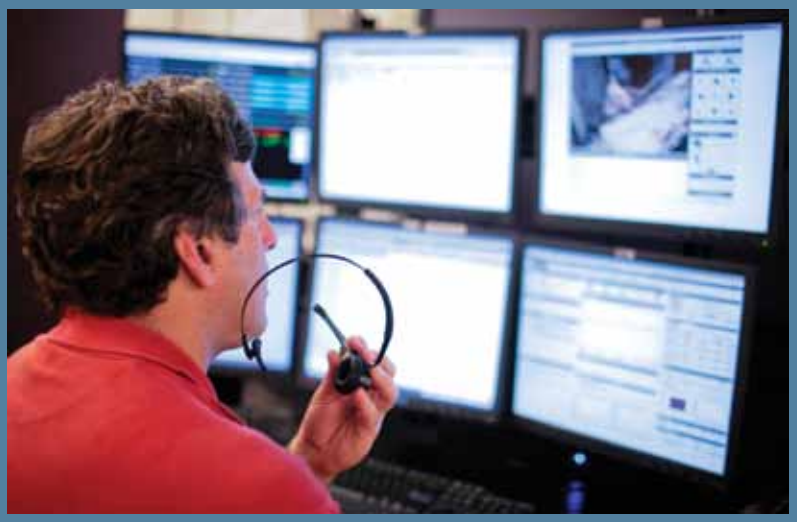
Critical Care, Critical Choices:

The Case for Tele-ICUs in Intensive Care



New England Healthcare Institute

MASSACHUSETTS TECHNOLOGY COLLABORATIVE

December 2010

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Note: Titles reflect participants' roles and organizations as they were in 2008 for the Advisory Group and in 2006 for the Expert Panel.

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Tele-ICU Study Collaboration

The Massachusetts Technology Collaborative
The Massachusetts Technology Collaborative (MTC) is a public economic development agency that fosters a more favorable environment for the formation, retention, and expansion of technology-related enterprises in Massachusetts. Through its major divisions — the John Adams Innovation Institute, the Massachusetts e-Health Institute, and the Massachusetts Broadband Institute — MTC is stimulating economic activity in every corner of the Commonwealth. The agency brings together leaders from industry, government, and academia to advance technology-based solutions that improve the healthcare system, expand high-speed Internet access, and strengthen regional economies. www.masstech.org

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The New England Healthcare Institute (NEHI) is an independent, not-for-profit organization dedicated to transforming health care for the benefit of patients and their families. In partnership with members from all across the health care system, NEHI conducts evidence-based research and stimulates policy change to improve the quality and the value of health care. Together with this unparalleled network of committed health care leaders, NEHI brings an objective, collaborative and fresh voice to health policy. www.nehi.net

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Executive Summary

If tele-ICU systems were broadly and effectively implemented in Massachusetts, it is conservatively calculated that more than 350 additional lives could be saved each year, the hospitals would benefit financially, and the potential savings for payers would exceed $122 million annually.

Intensive care units (ICUs) are a vitally important component of health care in U.S. hospitals, treating six million of the sickest and oldest patients every year. The choices about how to manage ICUs carry high stakes: ICUs have both the highest mortality and the highest costs in health care, accounting for 4.1 percent of the nation's $2.6 trillion in annual health care spending, or nearly $107 billion per year.

Adding to the complexity of these ICU management decisions is the collision of two strong trends: the increasing number and severity of critical care patients as the U.S. population ages, and the decreasing supply of critical care physicians available to manage the growing number of ICU patients.

The Promise of Tele-ICU.

Tele-ICU, a telemedicine technology, has the potential to address this critical care staffing shortage by enabling clinicians in one "command center" to remotely monitor, consult and care for ICU patients in multiple and distant locations. By increasing the number of ICU patients that critical care teams can manage, tele-ICUs effectively extend both the productivity and the reach of the specialists.

This report details the results of a demonstration project to test the clinical and financial benefits of tele-ICU technology on two important outcomes: ICU mortality and ICU length of stay. The data from the study were collected from three sites: an academic medical center (The University of Massachusetts Memorial Medical Center or "UMMMC") and two community hospitals ("Community Hospital 1" and "Community Hospital 2").

The study found that with the use of tele-ICUs:

1. **Patient mortality decreased significantly.**

   At UMMMC, ICU mortality rates decreased more than 20 percent even as the severity of the patients' conditions rose significantly, and the ICU patients' total hospital mortality rates declined 13 percent. At Community Hospital 1, ICU adjusted mortality decreased 36 percent.

2. **Patients' stays in the ICU were shorter.**

   ICU patients' length of stay (LOS) decreased dramatically under tele-ICU at UMMMC, with an average reduction of almost two days or 30 percent. Both Community Hospitals 1 and 2 also saw a reduction in ICU lengths of stay.

3. **Tele-ICUs have a rapid payback of investment for hospitals.**

   The one-time up-front investment and one-time operating costs (approximately $7.1 million for UMMMC and $400,000 for each of the community hospitals in the first year of implementation) were paid back in full in approximately one year's time.

4. **Tele-ICUs have substantial financial benefit to payers.**

   The average cost per ICU case for payers could be reduced by about $2,600 for patients treated in academic medical center ICUs. Tele-ICUs also enable community hospitals to care for a substantial portion of patients who are now transferred to teaching hospitals. Retaining these patients in community hospitals saves the payers approximately $10,000 per case.

Background and Methodology.

Despite the potential of tele-ICUs to provide remote intensivist coverage to critical care patients, the adoption of the technology by hospitals both in Massachusetts and nationally has been slow and uneven. There are a number of barriers, not only capital and operating costs, but also organizational and clinical staff resistance, technical incompatibilities, cross state licensure issues, and lack of payment for the tele-ICU services.

It is against this backdrop that the New England Healthcare Institute (NEHI) and the Massachusetts Technology Collaborative (MTC), working in collaboration with PricewaterhouseCoopers (PwC), determined that a demonstration project was warranted.

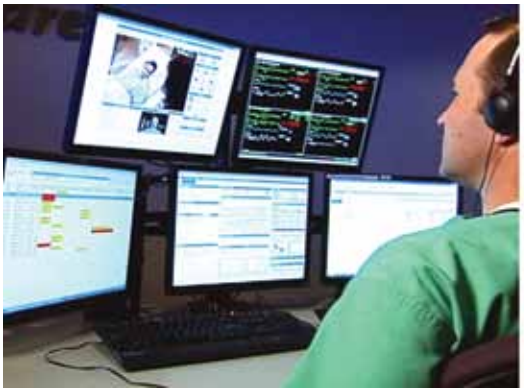
The study analyzed two clinical metrics, ICU mortality and ICU length of stay. According to these metrics, tele-ICUs would prove they had significant value if they could demonstrate a 10 percent decrease in severity adjusted ICU mortality rates coupled with an average decrease of 12 hours for an ICU length of stay.

The UMMMC provided an ideal site for the demonstration project because it had installed the only tele-ICU command center in the Commonwealth and was extending coverage to both the medical center's seven adult ICUs and to two outlying community hospitals' adult ICUs (covering a total of 116 beds). Data were collected for a six-month period both prior to and following implementation of tele-ICU coverage, thus enabling a determination of whether patient outcomes as measured in mortality and length of stay improved after the tele-ICU program became part of managing patient care.

Conclusions.

If tele-ICU systems were broadly and effectively implemented in Massachusetts, more than 350 additional lives could be saved each year, the hospitals would benefit financially, and the potential savings for payers would exceed $122 million annually.

Taken together, the clinical and financial benefits of a fully implemented tele-ICU system offer a win-win-win opportunity for patients, hospitals and payers across Massachusetts. Now that tele-ICUs have a strong reputation based on clear evidence, we must seize the chance to speed the adoption of this valuable technology in hospitals across the country. We cannot afford to lose this opportunity to improve the quality and control the costs of critical care.



Chapter One

Introduction: The Critical Care Crisis and Tele-ICUs

"…There are not and will not be enough…intensivists to staff all hospitals in the fashion that is suggested by The Leapfrog Group…thus, there must be… regionalization of intensive care services…and telemedicine."
Committee on Pulmonary and Critical Care Societies, 2000 Committee Report to Congress

"Tele-ICU can be defined as the provision of care to critically ill patients by remotely located health care professionals using audio, video and electronic links to leverage technical, informational and clinical resources."
Craig M. Lilly, MD, Director, eICU Support Center, UMMMC

Background

Choices about the management of Intensive Care Units (ICUs) are among the highest stakes in health care: both the highest mortality risks and the highest costs of care are found in the ICU. The delivery of medicine in today's ICUs is challenged by the collision of two strong trends:

- Increasing numbers and severity of critical care patients as the U.S. population ages; and
- Decreasing supplies of critical care physicians ("intensivists") to manage the growing numbers of ICU patients.[1]

The obvious result of these colliding trends is a shortfall of critical care specialists, or intensivists.

Why Intensivists? Physicians and nurses who are **not** certified in critical care medicine also work in ICUs and, in fact, represent the majority of the clinicians in those units. However, research indicates that ICU patients have lower risks of death and shorter ICU and hospital stays when an intensivist physician is on duty in the ICU and oversees patient care.[2] The presumption is that where intensivists are available to manage and monitor ICU care, patients' problems are identified sooner, leading to more rapid and complete interventions and lower mortality rates. The mortality reduction attributed to intensivist staffing varies among research findings, with the majority of findings ranging from 15 to 60 percent lower than in ICUs where there are no intensivists.[3] Similarly, average ICU and total hospital length of stay for ICU patients have been observed to be shorter in units staffed by intensivists.[4]

Who Are Intensivists?

Intensivists are physicians who are board-certified to practice critical care medicine. They may also be physicians trained as emergency physicians, pulmonologists or anesthesiologists. Critical care medicine became a recognized and certified specialty in most states during the 1980s.

In addition to physicians, critical care nurses also specialize in the delivery of ICU care. They generally take additional graduate level training to qualify for ICU assignments.

The Society for Critical Care Medicine forecasts a growing shortfall between the numbers of specialists needed by ICUs and those available to work there.

What Are Tele-ICUs and How and Why Do They Work? Tele-ICU, a telemedicine technology specifically designed to improve health care delivery in ICUs, offers a potential solution to this shortfall of intensivists: Use technologies to increase the numbers of critically ill patients that an intensivist can treat effectively. Tele-ICUs are an enabling technology that monitor ICU patients and leverage doctors and nurses who are specialists in critical care medicine to manage the care of patients in multiple distant units. Tele-ICUs hold great promise to improve the care of ICU patients, save lives, and increase both the productivity and the reach of specialists in critical care medicine. These specialists are in very short supply, and without telemedicine there are few options for expanding their coverage of ICUs.

Tele-ICUs connect a central command center staffed by intensivists with patients in distant ICUs. Continuous, real-time two-way audio, video, and electronic reports of vital signs connect the command center to the patients' bedsides. Computer-managed decision support systems track each patient's status and give alerts when negative trends are detected and when changes in treatment patterns are scheduled or indicated.[5]

Overview of the Technology. A tele-ICU system contains hardware that collects and assembles patient data and transmits it (including video and voice) from the remote ICU to the command center. The patient data include physiological status (e.g., vital signs and blood oxygenation), treatment (e.g., the infusion rate for a specific medicine or the results of laboratory tests and radiological images and interpretations), and medical records. The hardware is designed to provide the clinicians in the command center and the ICU with the same patient data. The software for a tele-ICU includes the programs that make all the monitoring and information transmission hardware function properly and efficiently.

Rapid Increase in Adult ICU Patients. The need for ICU care increases exponentially as the population of aging Americans grows. For example,

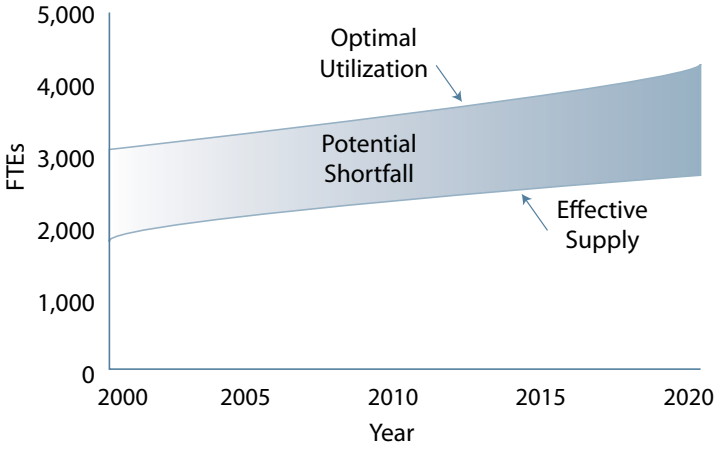
- More than half of ICU patients are over 65;

What Are Tele-ICUs?

Tele-ICUs are two-way audio-visual patient monitoring systems that link physicians and nurses who specialize in critical care medicine in a command center to ICU patients in multiple, distant units. The key components of tele-ICUs include:

- **Intensivists who manage care from the command center (which may also be referred to as a "support center");**
- **Monitoring systems that track patient status, send alarms when a status changes and permit full audio-visual communication between clinicians at the command center and in the ICU;**
- **Protocols and treatment reviews for patient management that are built into the monitoring and alert systems to indicate when changes in care should take place.**

Figure 1.1:
The Supply and Demand for Critical Care Physicians



Source: HRSA Report, 2006, "The Critical Care Workforce: A Study of the Supply and Demand for Critical Care Physicians."

- A patient 65 to 74 years of age is more than three times as likely to use critical care units as a middle-aged patient; and
- A patient over 85 is six times as likely to use critical care units as a middle aged patient.[6]

With the extension of U.S. life expectancy, the over-65 population has grown steadily in recent years — from 35 million in 2001 to 39 million in 2008 — and is projected to grow even more rapidly in the future. The U.S. Census projects nearly 72 million over-65 residents by 2030, and the over-85 age group is projected to triple from a reported three million in 2008 to over nine million in 2030.[7]

Thus, by 2030, the U.S. is predicted to need an ICU capacity to care for 54 million ICU case days per year. That would represent a tripling of capacity of ICU case days from 2006.[8] U.S. hospitals are currently adding ICU capacity at a pace of roughly two percent growth per year.[9] More ICU beds and new units are added to hospitals each year than in any other clinical specialty unit. ICUs cost roughly $1.5 million per bed and most hospitals cannot afford to build new beds.

More Patients, Not Enough Intensivists. Despite the growing demand for ICU specialty care, the U.S. can expect only a comparatively slow rate of growth of intensivists in the coming years. And the demands on existing intensivists are increasing: New intensivists coming into the field also are needed to staff emergency rooms and acute care units. The Society of Critical Care Physicians predicts, at best, a modest increase in the supply of critical care physicians against these multiple demands, creating a widening gap between need and supply of critical care physicians[10] (see Figure 1.1). The supply of critical care nurses is less well documented but believed to represent a substantial shortfall against the needs of ICU staffing.[11]

The data supporting the improved quality of care provided by intensivists led The Leapfrog Group, the leading national association of health care employers and purchasers focused on health care quality, safety and value, to add a standard for intensivist care in ICUs to their hospital quality rating system. The Leapfrog standard requires that:

- Intensivists are dedicated to provide care exclusively in the ICU during daytime hours.

- When intensivists are neither on site nor available via telemedicine, they must return pages at least 95 percent of the time within five minutes and also arrange for a FCCS-certified physician or physician extender to reach ICU patients within five minutes.[12]

Where and How Widely Used Are Tele-ICUs? Recognizing that there is a shortage of intensivists, The Leapfrog Group has indicated that intensivist coverage of a distant ICU from a command center facilitated by tele-ICU technology meets their standards for intensivist staffing. Yet national adoption of this technology, which extends the reach of intensivists to a greater number of patients, has been slow.

The first tele-ICU was implemented in 2000 by the Sentara hospital system in Norfolk, Virginia, to manage two adult ICUs. This tele-ICU command center was installed by VISICU, at that time the only commercial firm offering tele-ICU installations and support services in the U.S. market. Since then, two other firms, iMDsoft and Cerner have entered the U.S. market and VISICU has been acquired by Philips Electronics North America Corporation.

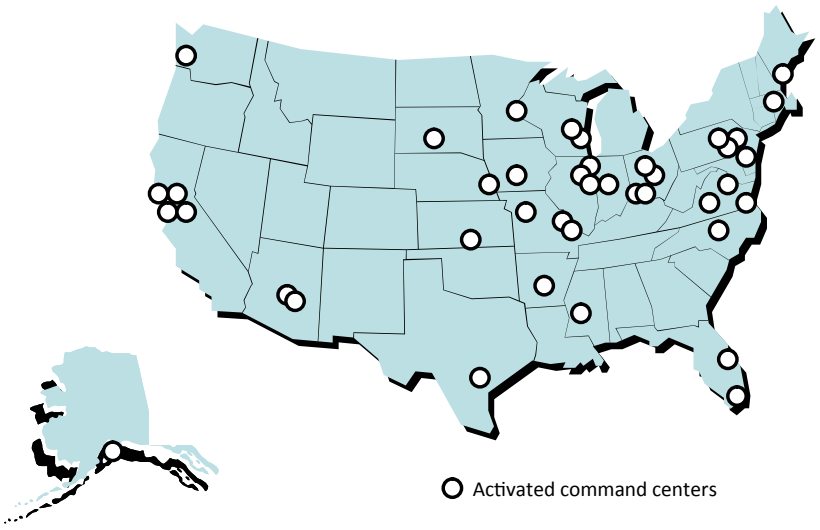
During the 10 years since the Sentara installation, a number of new command centers have been installed throughout the U.S. (see Figure 1.2). Tele-ICUs are now scattered from coast to coast. Yet the portion of adult ICU beds covered by command centers has hovered at roughly five to seven percent of U.S. adult ICU beds since the mid-1990s.

The Slow Adoption of Tele-ICUs

The dissemination of tele-ICUs can be measured in two equally useful metrics:

- The number of command centers from which intensivists and critical care nurses monitor the care of patients in multiple, geographically distant ICUs. Command centers can be licensed to monitor up to 500 adult ICU beds (regardless of numbers of units).[13]
- The numbers of adult ICU beds "covered" by these command centers and the proportion of total U.S. adult ICU beds that this number of covered beds represents.

Figure 1.2: Installations of Tele-ICU Command Centers in the U.S., 2000 to 2010



Source: NEHI, 2010

There are 41 U.S. tele-ICU command centers installed and active as of 2010. Were all of those command centers to cover their maximum 500 beds, this would yield 20,500 ICU beds under tele-ICU management, or roughly 24 percent of U.S. adult ICU beds. But in reality, the penetration of tele-ICU coverage is roughly a quarter (or 5,789 beds) of the full capacity of beds that could be monitored by currently operating command centers.

In addition, the widespread adoption of tele-ICU technology is challenged by both the slow growth of command centers and the deactivation of existing command centers (see Figure 1.3). Please note that this discussion addresses only civilian tele-ICU coverage and civilian ICU beds. While the U.S. military has substantial tele-ICU installations, this information is not available in unclassified sourcing and is not the subject of this study.

Figure 1.3: Dissemination of Tele-ICU Command Centers in the U.S.

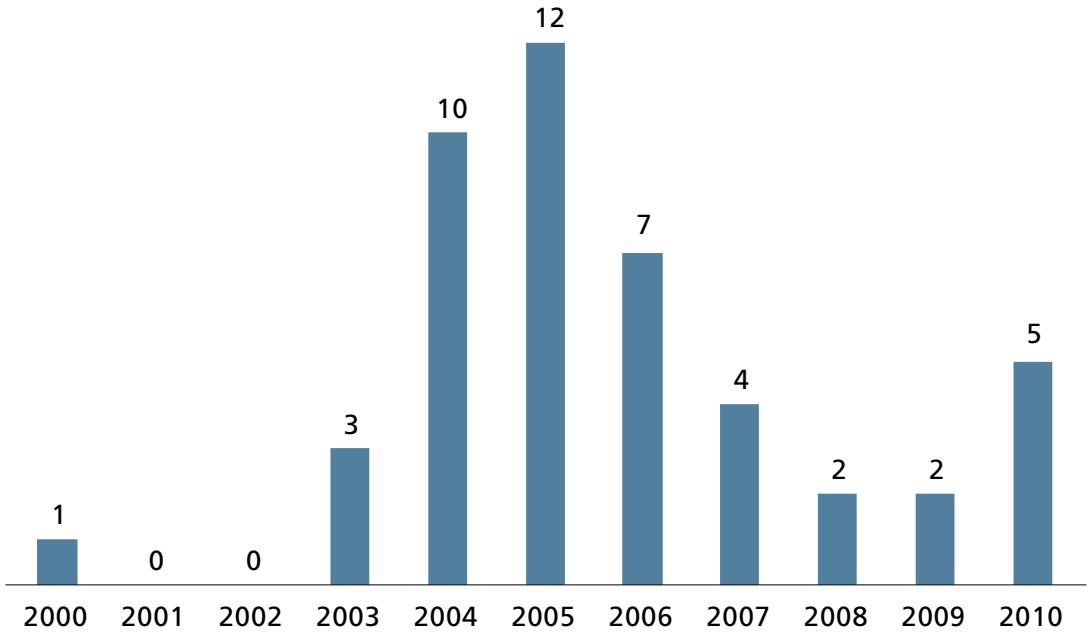
Installed	Health System	Location of Command Center	# Beds	#Hospitals
2000	Sentara Health Care	Norfolk, VA	103	5
2003	Advocate Health Care	Oak Brook, IL	272	8
2003	Sutter Health*	Sacramento, CA	405	20
2003	New York Presbyterian Healthcare System	Deactivated	0	0
2004	Avera Health	Sioux Falls, SD	105	18
2004	HCA Richmond Hospitals	Richmond, VA	102	6
2004	Health First	Rockledge, FL	107	3
2004	Inova Health System	Falls Church, VA	127	5
2004	Lehigh Valley Hospital and Health Network	Allentown, PA	140	3
2004	Swedish Medical Center	Seattle, WA	77	3
2004	University of Pennsylvania Health System	Philadelphia, PA	112	4
2004	Borgess Health Alliance	Deactivated	0	0
2004	Kaleida Health	Deactivated	0	0
2004	Memorial Hermann Healthcare System	Deactivated	0	0
2005	Aurora Health Care	Milwaukee, WI	295	12
2005	Baptist Health	Little Rock, AR	162	5
2005	Baptist Health South Florida	Doral, FL	118	5
2005	Christiana Care Health System**	Newark, DE	131	5
2005	Clarian Health Partners	Indianapolis, IN	198	4

Installed	Health System	Location of Command Center	# Beds	#Hospitals
2005	Froedtert, Bellin Health, Community Health Memorial and St. Joseph's	Menomenee Falls, WI	107	4
2005	MaineHealth	Portland, ME	120	9
2005	OhioHealth	Columbus, OH	135	4
2005	Provena Health	Bolingbrook, IL	137	6
2005	Saint Luke's Health System	Lee Summit, MO	104	8
2005	Sutter Health*	Opened San Francisco, CA hub		
2005	Jewish Hospital & St. Mary's HealthCare	Deactivated	0	0
2006	Advanced ICU Care***	St. Louis, MO	240	21
2006	Banner Health	Mesa, AZ	405	9
2006	Moses Cone Health System	Greensboro, NC	140	4
2006	Sisters of Mercy Health System	St. Louis, MO	400	10
2006	UMass Memorial Medical Center	Worcester, MA	130	5
2006	Via Christi Health System	Wichita, KS	165	4
2006	ProMedica Health System	Toledo, OH	109	7
2007	St. Joseph Health System	San Francisco, CA	42	2
2007	Alegent Health	West Omaha, NE	111	7
2007	John Muir Health	Walnut Creek, CA	82	2
2007	Resurrection Healthcare	Des Plaines, IL	193	8
2008	Mercy Health Network	Des Moines, IA	89	4
2008	The Christ Hospital	Cincinnati, OH	49	1
2009	Providence Health & Services	Anchorage, AK	29	2
2009	University of Mississippi Health Care (UMHC)	Jackson, MS	92	5
2010	Baptist Health System	San Antonio, TX	134	5
2010	Geisinger	Danville, PA	68	2
2010	Abrazzo Health	Phoenix, AZ	110	5
2010	VISN 23	Minneapolis, MN	73	5
2010	VISN 10	Cincinnati, OH	71	4
TOTAL:			**5,789**	**249**

Source: NEHI, 2010.
** Sutter Health has two command centers, one located in San Francisco and one in Sacramento. The command centers' coverage extends over a total of 405 beds in 20 hospitals.*
***The command center in Newark, DE monitors hospitals within Maryland eCare and hospitals within Christiana Care Health System.*
****Advanced ICU Care's Parkview client was scheduled to take the tele-ICU program back in-house during Summer 2010.*

Slow Growth of Command Centers. Data show that new command center installations decreased from 2005 to 2009 but that there was an increase in 2010 (see Figure 1.4).

Figure 1.4: Number of Tele-ICU Command/Support Center Installations, 2000 to 2010



Source: NEHI, 2010.

Command Center Deactivations. As noted in Figure 1.3, five command centers were installed and then deactivated.[14] The reasons for deactivation of tele-ICU command centers are not matters of public record and informal explanations from hospitals, physicians and vendors are highly subjective. Possible explanations are that some deactivations have involved resistance from physicians to both changes in patient management and to the required sharing of control over patient care to the command center in order to make the tele-ICU effective. Unexpected difficulties in moving patient electronic data to and from patient floors to tele-ICUs, lack of clinician training in work flow systems, and unexpectedly high operating costs are other possible explanations.

Tracking Tele-ICU Beds. As displayed in Figure 1.5, roughly seven percent of U.S. hospital adult ICU beds were covered by tele-ICU command centers through 2010. This percent estimate is roughly the same penetration rate that was documented in 2006.[15]

Two observations may be made regarding the current adoption of tele-ICU technology:

- New tele-ICU installations declined between 2005 and 2009 but increased in 2010.

Figure 1.5: Tele-ICU Coverage of Adult ICU Beds in U.S. Hospitals, 2010			
Tele–ICU Command Centers	Number and Percent of U.S. Hospitals with Adult ICU Beds with Tele-ICU Coverage	Number and Percent of Adult ICU Beds with Tele-ICU Coverage	Estimated Average Number of Beds Covered by Each Command Center
41	249 (7.6%)[16]	5,789 (6.8%)	141

Sources: NEHI, 2010 and AHA Annual Survey of Hospitals for FY07, and AHA Annual Survey of Hospitals for FY06. Copyright: Health Forum, LLC, an affiliate of the American Hospital Association, 2009 and 2008.

- Tele-ICU command centers are at less than 30 percent of their full licensed capacity for covering adult ICU beds.

The geographic reach of tele-ICU command centers will permit most of them to extend electronic coverage to ICUs well beyond the limits of their state lines. Therefore, the most easily available and cost-efficient method of increasing tele-ICU coverage is to add more remotely monitored ICUs to an existing command center, up to the tele-ICU's maximum limit of 500 satellite beds.

Given the pressures discussed above — increasing numbers and severity of ICU patients combined with limited supplies of intensivists to care for those patients — the stalled adoption rates of tele-ICUs are puzzling. Clearly, there are barriers to the full adoption of tele-ICUs, keeping current dissemination of this promising technology to a meager seven percent of total adult ICU beds.

Barriers to Adoption of Tele-ICUs

Broader adoption of tele-ICUs is impeded by five commonly cited, pervasive barriers: high capital and operating costs, unproven return on investment, clinician resistance, lack of interoperability with legacy or electronic medical record systems, and a lack of documented outcomes.

Costs of Tele-ICUs. While tele-ICUs provide technology platforms that allow ICU specialists to support the care of greater numbers of ICU patients, the initial capital costs can be expensive.

Capital and Acquisition Costs. It is estimated that it costs from $6 million to $8 million in one-time capital costs to set up a command center, acquire and install the tele-ICU systems, and pay the initial salaries for the tele-ICU staff. The one-time capital implementation costs for a satellite hospital to acquire and install the tele-ICU technology range from $300,000 to $500,000.

Operating Costs. Annual operating costs of command centers themselves are not publicly reported and vary with the number of distant hospitals and beds covered. Informal reports from hospitals maintaining command centers have varied from $1 to $3 million per year. Operating and maintenance costs include expenses for staffing the tele-ICU command center, licensing fees for the software, and periodic upgrades to the hardware or software. For the satellite hospitals, there is an annual contracting fee for providing care from the command center that can range from $23,000 to $40,000 per bed per year. Additional costs could also be associated with implementing new standardized care processes with the health care professionals in the ICU and the tele-ICU.[17]

Unknown Return on Investment. Another barrier is the lack of studies evaluating the financial return on investment for this innovative but complex technology. Few studies have been conducted with data from tele-ICUs, and those studies that are available are difficult to generalize from the particular setting of the ICU and hospital system in which they were conducted.

As a result, hospitals have few research findings to guide them when considering whether they can afford tele-ICUs, whether they can offset their costs with savings, whether the technology would allow them to care for more ICU patients, and whether their quality of critical care could be improved and their mortality rates reduced.

Clinician Resistance. It has long been known that physician leadership is a critical factor in enabling change in health care. This is especially true when innovations disrupt the normal patterns of care or threaten traditional and familiar health care provider roles. The tele-ICU technology, when implemented in a community hospital setting, can displace the local physician because the responsibility for care is shared with the clinical staff at the command center. Although each tele-ICU command center can establish different levels of support for the satellite hospitals, the end result is that the physicians at the community hospitals must relinquish some element of autonomy in order for the technology to be successful. In situations where the hospital leadership has failed to address these issues of autonomy and independence, physicians have at times refused to participate in the tele-ICU process and have even attempted to sabotage it (in our study, one physician went so far as to put his coat over the video camera in the patient's room so that the command center staff could not see what he was doing and another ripped the camera off the wall). In the long run,

enthusiastic physician leadership and participation is critical to the adoption of this valuable innovation.

In addition to needing clinical staff acceptance of the tele-ICU system, to date the lack of an adequate payment mechanism and the absence of a demonstrated return on investment for the critical care team staffing the tele-ICU command centers has held back adoption of the technology. Although full use of the tele-ICU program can increase both the volume and the severity of the patients that a hospital can care for, and therefore can increase the hospital's revenue, to date there has been no separate mechanism to pay the physicians directly for their participation. As public and private payers move to global service fees or bundled payments, revenue-sharing models between the hospitals and the physicians may emerge that eliminate or at least decrease this problem.

Lack of Technical Interoperability. One challenge in developing tele-ICU software is to enable it to interface with and electronically accept data from other electronic information systems that serve the ICU (e.g., laboratory results, medications, nursing flow sheets, physicians' notes, etc.). As with many sophisticated software products, building connectivity with initially incompatible systems is possible but can take time and money. Furthermore, most tele-ICU systems do not yet connect seamlessly with electronic medical records used on patient floors. This system's incompatibility may require personnel to scan or to manually enter hospital records into the ICU system or the electronic health record or require the purchase of additional software to connect the two systems.

Lack of Outcome Data for Tele-ICUs. Hospitals considering investing in tele-ICUs must balance their substantial capital and operating costs against unknown returns on improved patient outcomes, reduced ICU operating costs, increased patient volumes and associated financial gains. Although roughly ten tele-ICU outcomes assessments have been published, the findings vary in terms of what outcomes are measured, what settings and conditions attend the tele-ICU use, and what gains (or losses) are realized. The findings available to date strongly suggest that a hospital and its ICUs' particular circumstances influence the outcomes that may result in post tele-ICU implementation. But hospital management giving careful consideration to what it might gain from tele-ICU coverage would be hard-pressed to project the patient and financial outcomes most likely to result for their hospital. Hospital managers can review a range of studies and reported outcomes associated with tele-ICU coverage. They would, however, have little indication of where to place their hospital

in that range or how to adjust for their hospital's particular practice patterns, ICU patient mix, hospital staffing, referral and transfer patterns, ICU occupancy rates, or other critical care providers in their market. The study conducted by MTC and NEHI was designed to project what clinical and financial outcomes are most likely for hospitals that effectively implement tele-ICU care.

Chapter Two

MTC, NEHI and a Tele-ICU Experiment

"There are advanced technologies which can dramatically lower health care costs and improve quality. The technologies are proven. The associated benefits are known. But there are barriers in the system which impede their implementation. We can change that."
Mitchell Adams, Executive Director, Massachusetts Technology Collaborative, 2003

"Hospital clinical leaders hold strong views but have little objective information on which to judge the worthiness of this innovation."
Robert Berenson, Joy Grossman and Elizabeth November, Health Affairs, 2009

MTC and NEHI: Testing the Value of Tele-ICU Technologies

The *FAST* Initiative. The Fast Adoption of Significant Technologies (*FAST*) initiative — a collaboration between MTC and NEHI — is aimed at identifying health technologies with potential for both improved quality and cost savings, yet with low adoption rates in the U.S. health care system, and speeding their adoption.

A broad slate of candidate technologies is identified and reviewed each year by a panel of health care providers, payers and policymakers. Each technology selected for further assessment is then evaluated against *FAST* criteria for potential benefit to health care quality and affordability: 1) addresses a significant patient population; 2) improves outcomes for patients; 3) generates net savings to the health care system; 4) has low dissemination in

U.S. health systems; 5) faces barriers to dissemination that *FAST* can address; and 6) has more than one manufacturer in U.S. (see Appendix I). Because the objective of *FAST* is to speed the adoption of valuable but underused technologies, *FAST* often must conduct some of the first evaluations of these candidate technologies.

Selected innovations are then carefully reviewed by an Expert Panel composed of health care leaders — clinicians, administrators, researchers and payers — who have experience in using the new technology as well as its usual care alternatives. If the Expert Panel confirms the potential value of the technology, the panelists are asked to define specifications for a prospective study testing the technology in a real-world setting and defining what outcomes should be reached to justify efforts to promote broader use of the innovation. The final review stage for a *FAST* candidate technology is a prospective study or rapid demonstration project designed to measure the value markers set by the Expert Panel.

Tele-ICU: A Candidate Technology for *FAST* Evaluation. In 2003, when there were only three operating tele-ICU command centers in the U.S., MTC and NEHI identified tele-ICUs as an early emerging technology that was an excellent candidate for *FAST* review in the future. In keeping with the *FAST* methodology described above, an Expert Panel was created in 2006 to explore whether the tele-ICU technology warranted a rapid demonstration trial to define its value (see Figure 2.1). The Tele-ICU Expert Panel was composed of five hospital administrators, two clinicians with specialties in critical care, four payers (including a representative from the Centers for Medicare and Medicaid), and three tele-ICU systems vendors. The Expert Panel helped develop the structure of a rapid demonstration project that was initiated in collaboration with UMMMC in 2008.

Figure 2:1: Tele-ICU Met *FAST* Criteria		
Criteria	**Findings for Tele-ICUs**	**Comments**
1. Addresses a significant patient population	**Yes** — Over five million critically ill patients are treated each year in U.S. adult ICUs.	Adult ICUs include medical/ surgical and cardiac care. This is one of the fastest growing hospital patient populations and is projected to keep growing as the U.S. population ages.
2. Improves outcomes for patients	**Possibly** — Intensivist management of patients is associated with roughly a 15-60 percent decrease in mortality and infection rates.	Need to study tele-intensivist management of patients to confirm or revise hypothesis that tele-intensivist care would have same effects as on-site intensivist management of ICU patients.
3. Generates net savings to the health care system	**Possibly** — Intensivist management of patients is associated with a decrease in average length of ICU stay of roughly 15 percent.	More recent research has questioned the positive effects of intensivist care. Need to test whether tele-intensivists have positive effects on ICU LOS.
4. Has low dissemination in U.S. health systems	**Yes** — A *FAST* survey in 2006 of hospitals with adult ICUs indicated that <6 percent of beds in U.S. were covered by tele-ICUs.	When *FAST* updated its tele-ICU dissemination estimate in 2010, the figure was roughly 7 percent.
5. Faces barriers to dissemination that *FAST* can address	**YES** — Capital investment and operating costs of the tele-ICU are sufficiently high to discourage many hospitals from building command centers and connections to distant ICU beds. Physicians who admit patients may resist ceding management to tele-intensivists. Hospitals have little evidence of short or long-term returns of tele-ICU or how to apply some general assumptions to their circumstances. State licensing requirements for physicians and nurses working in command centers complicate staffing of command centers that cover ICUs in multiple states and can increase the costs of extending coverage across state lines.	Opinions vary as to relative importance of these barriers. It is likely that for different hospitals considering tele-ICU, the barriers vary depending on their circumstances.
6. Has more than one manufacturer in U.S.	**Yes** — Three manufacturers.	VISICU, iMDsoft, Cerner (VISICU was later acquired by Philips Electronics North America Corporation).

The Tele-ICU Expert Panel determined that tele-ICUs should be examined further through prospective research and made the following recommendations for such a study:

- **Study Metrics:**
  - **Patient mortality rates.** A decrease of 10 percent in severity-adjusted ICU mortality rates and no increase in hospital mortality rates of patients discharged from the ICU and transferred to the hospital floor.
  - **Length of ICU stay.** A decrease of an average of one half-day or 12 hours in an ICU stay as a global metric of more efficient patient management and earlier intervention to prevent complications.
- **Study Demonstration Site:** Given the estimated capital expense of $6 to $8 million to build a new tele-ICU command center, the Expert Panel suggested that the greatest return on investment was likely to be found in extending coverage from an existing tele-ICU command center with excess capacity to more adult ICUs within its range.

The Massachusetts Experiment. In response to the Expert Panel's directive to mount a demonstration testing tele-ICU's capacity to achieve these outcomes, NEHI and MTC looked for a new tele-ICU installation where pre- and post-patient metrics could be assessed. Fortunately, in 2005, the UMMMC was just beginning the process of installing a tele-ICU command center and then extending its coverage to first its medical center's seven adult ICUs and then to two outlying community hospitals' adult ICUs (Community Hospital 1 and Community Hospital 2).

At this time, Massachusetts closely mirrored the country at large in its shortage of intensivists to staff ICUs. The Leapfrog Group had reported that only 21 percent of adult ICU patients nationally were admitted to an ICU that had intensivist staffing to meet its standards.[18] Despite the multiple academic medical centers located in Massachusetts, only a third of its hospitals met The Leapfrog Group's standards for intensivist staffing (see Figure 2.2).

The UMMMC's tele-ICU command center's coverage was extended in two stages:

- In 2005, UMMMC installed its command center and in 2006 and 2007 extended coverage to UMMMC's seven adult ICUs.
- In 2007 and 2008, UMMMC extended tele-ICU coverage from its command center to two Massachusetts community hospital ICUs.

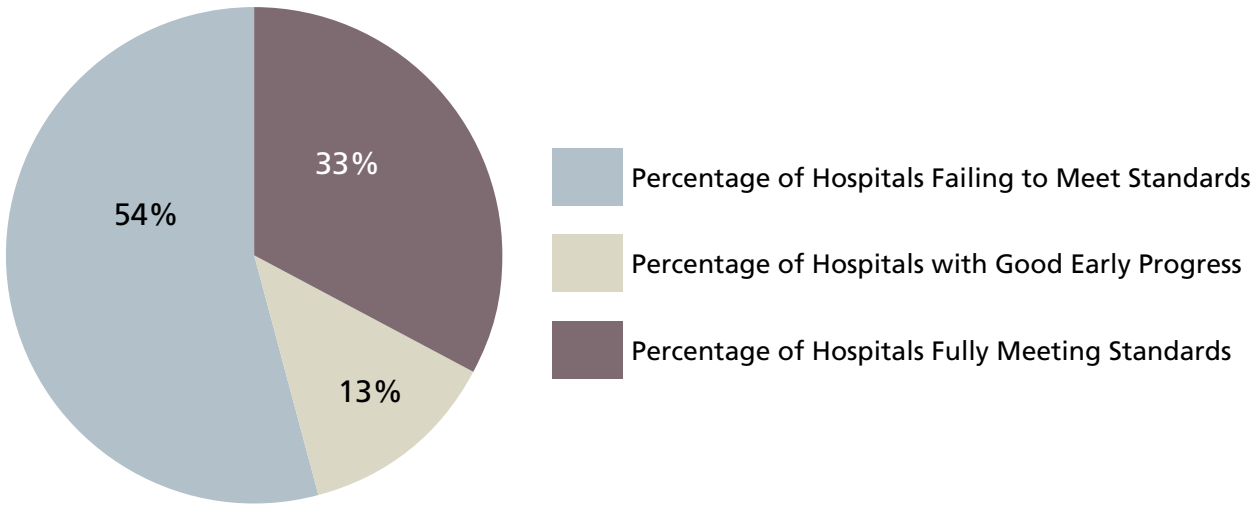
Thus, over a period of three years, one tele-ICU command center extended coverage to nine adult ICUs covering 116 ICU beds in Massachusetts.

Through the *FAST* initiative, MTC and NEHI saw a unique opportunity: UMMMC's tele-ICU command center and its coverage of nine ICUs presented a chance to compare clinical and cost outcomes before and after tele-ICU implementation. Such a study would help to fulfill the objectives of *FAST* by determining the value of the tele-ICU technology in improving patient care and reducing costs, and in promoting the adoption of tele-ICU systems should the evidence support it.

MTC and NEHI collaborated with the hospitals and PricewaterhouseCoopers to determine the clinical quality, patient outcomes and cost metrics associated with changes in ICU care after the introduction of tele-ICU coverage.

Patient outcomes, lengths of stay, and costs of care were collected in observation periods prior to and following the implementation of tele-ICU coverage in the ICUs (pre and post observation periods are listed in Appendix II). These pre and post tele-ICU data formed a unique documentation of the costs and the effects of tele-ICU coverage in nine adult ICUs in the Commonwealth. The following chapters describe the clinical and financial findings of the study.

Figure 2.2:
Distribution of Leapfrog Ratings for Intensivist Staffing in 65 Massachusetts Hospitals



Source: Angus, Derek. 2006. The author found that Leapfrog compliance may be exaggerated by "very optimistic self-reporting by ICUs."

Chapter Three

The Impact of Tele-ICU Coverage on Clinical Outcomes

"Tele-ICU is a tool to interrupt adverse trends before they become adverse outcomes."
Robert Groves, MD, Banner Health

"NEHI is taking on the assessment of tele-ICU technology because of the public health crisis posed by the shortage of intensivists. It is critical that we examine all technologies that might leverage the scarce resource of qualified intensivists practicing in intensive care units."
Wendy Everett, ScD, President, New England Healthcare Institute

Documenting Tele-ICU Outcomes in an Academic Medical Center and Two Affiliated Community Hospitals

Defining the Research Questions.

One of the many unanswered questions about tele-ICU technology has been not only what outcomes it achieves but in what settings: Can this technology improve patient outcomes only in a large, sophisticated medical center, or can it also improve outcomes in comparatively small community hospitals?

The *FAST* Expert Panel defined the key policy research question for tele-ICUs this way: Does the application of the technology save lives and shorten the length of stay in the ICU? To understand the best applications of tele-ICUs, however, it is also necessary to know where they achieve their greatest impact and have their greatest

value. Defining highest value targets is a key issue for all medical technologies.

Defining the Demonstration Hospitals. Because UMMMC and the community hospital ICUs differed in both size and patient populations, UMMMC's tele-ICU implementation offered an opportunity to evaluate outcomes associated with a single command center and command center clinical team in its coverage of two very different sets of ICUs: seven ICUs in an academic medical center and two ICUs in community hospitals. UMMMC's seven ICUs were specialized for medical, surgical and cardiac ICUs and averaged more than 13 beds each. The community hospitals averaged ten beds each and served all critical care patients in their hospitals (see Figure 3.1).

UMMMC is a tertiary care hospital that serves as a referral center for central Massachusetts. In that capacity, it receives patients at high risk of death who are transferred from community hospitals that are not staffed or equipped to provide care for extremely complex patients. The UMMMC's adult ICUs also support surgical, burn, trauma and transplant patients. The largest single group of patients in the study period was post-surgery patients.

By contrast, the two community hospitals had no surgical practices that routinely performed procedures that required post operative ICU care and a large portion of their ICU patients entered from the hospitals' emergency departments (a majority in the case of Community Hospital 2). Prior to the implementation of tele-ICUs, the most severely ill or injured patients were commonly transferred directly from the hospitals' emergency department or stabilized in the ICUs and then transferred to UMMMC. In both community hospitals, the leading ICU admission diagnoses were respiratory or cardiovascular conditions.

Despite their many differences, there were two characteristics that UMMMC

Figure 3.1: Profiles of UMMMC's and Community Hospitals' Adult ICUs in 2005

	Type of ICU(s)	Number of Beds	Occupancy Rates	Intensivist Staffing
UMMMC (7 Units)	Medical/ Surgical (M/S) and Cardiac Care Units (CCU)	96	80% M/S 90% CCU	Did not apply for Leapfrog certification
Community Hospitals (averages for both community hospitals)	Medical/Surgical	10	43%	Did not meet Leapfrog standards

Source: CY 2005 from Massachusetts Division of Health Care Finance and Policy.

Observed and Adjusted Mortality Rates for ICU Patients

Observed mortality rates are the raw data reports on mortality regardless of the severity of the patients. Adjusted mortality rates reflect the severity of the patients and their risk of death when they were admitted to the ICU. Many patients are assessed after they are admitted to the ICU using an APACHE (Acute Physiological and Chronic Health Evaluation) score. This score is a standard measure of ICU patient severity and is in its fourth iteration (APACHE IV). All patients entering an ICU are rated for their immediate risk of death based on clinical information such as diagnosis requiring ICU care, body temperature, blood pressure and heart rate. The resulting APACHE score ranges from 0 to 71, reflecting a risk of mortality from less than five percent to more than 85 percent. Patients who have an APACHE score are considered to have had a "severity adjustment".

and the community hospitals' ICUs had in common. First, their ICUs had excess capacity in 2005-2006: the UMMMC ICUs ranged from 80 to 90 percent occupancy and the two community hospitals' ICUs hovered in mid-40 percent occupancy rates. Second, none of the three hospitals' nine adult ICUs had full intensivist staffing.

Study Design. The demonstration project compared patient outcomes in the seven UMMMC ICUs and in the two community hospitals' ICUs before and after the installation of the tele-ICU coverage. The objective was to learn whether patient outcomes changed after the tele-ICU program became part of managing patient care.

This study design comparing before and after outcomes is referred to as a pre/post comparison. The pre and post tele-ICU observation periods varied in each hospital and in each of the seven UMMMC ICUs (see Appendix II for pre and post time periods). This was largely a result of the sequential roll-out of tele-ICU coverage from the command center to the seven university adult ICUs and then to first one and then a second community hospital.

Study Population. All adult patients admitted to the UMMMC and community hospital ICUs during these periods were enrolled in the study. Patients who were admitted to the ICU twice during their hospital stay were counted only once. The ICU patients in all three hospitals shared similar demographics, with mean ages in the early to late 60s and with comparable severity of illness. UMMMC's ICU patients averaged roughly equivalent

severity levels in APS (Acute Physiology Score) scores to Community Hospital 1.[19] Community Hospital 2 reported higher severity levels. Because the UMMMC and the community hospitals used differing editions of APACHE (Acute Physiology and Chronic Health Evaluation), these scores are not directly comparable. The mean severity scores of ICU patients increased significantly in all three hospitals in the post-implementation period (see Figures 3.2 and 3.3).

Figure 3.2: Study Patient Characteristics of ICU Cases in UMMMC

	Pre	Post	P value
UMMMC ICU Cases*	**n=1529**	**n=4761**	
Age (mean, SD)	62 (17)	64 (17)	0.003
Gender (female, %)	43%	43%	.77
APACHE III (mean, SD)	45 (22)	58 (27)	<0.001
APS Score (mean, SD)	33 (19)	46 (24)	<0.001

Source: C. Lilly et al., New England Healthcare Institute and U Mass. Medical School Tele-Intensive Care Unit Project, July 12, 2010.
**These cases were studied over a 22-month period (see Appendix II).*

Figure 3.3: Study Patient Characteristics of ICU Cases in Community Hospitals 1 and 2

	Pre	Post	P value
Hospital 1 ICU Cases	**n=397**	**n=569**	
Age (mean, SD)	68 (17)	68 (18)	0.62
Gender (female, %)	192 (48)	289 (51)	0.58
APACHE IV (mean, SD)	48 (22)	54.7 (25)	<0.001
APS Score (mean, SD)	34 (18)	39 (21)	<0.001
Hospital 2 ICU Cases	**n=530**	**n=808**	
Age (mean, SD)	66 (17)	63 (19)	0.006
Gender (female, %)	253 (48)	370 (46)	0.316
APACHE IV (mean, SD)	50 (21)	59 (24)	< 0.001
APS Score (mean, SD)	37 (18)	46 (20)	< 0.001

Source: C. Lilly et al., New England Healthcare Institute and U Mass. Medical School Tele-Intensive Care Unit Project, July 12, 2010.

Patient Outcomes

ICU Mortality Rates. Patient outcomes were measured against the standards set by the *FAST* Expert Panel as key outcome measures for determining the value of tele-ICU care. The experts stated that tele-ICU management of patients would demonstrate substantial value where they achieved the goals of at least:

1. A 10 percent reduction in ICU mortality rates after adjustments for severity levels and with no increase in hospital mortality rates for ICU patients transferred to the hospital floor.
2. A decrease of 12 hours in average length of stay (LOS) in the intensive care units as measures of reduced patient complications, better clinician adherence to evidence-based medicine and early interventions in the treatment process. The Expert Panel indicated that in assessing changes post tele-ICU coverage in ICU mortality and LOS adjustments for patient severity levels should be included. More severely ill patients have higher mortality and lengths of stay. A common and expected effect of tele-ICU coverage in community hospitals is an increase in patient severity levels as the hospital retains more of its more complex patients rather than transferring them to a tertiary care center.

"With the implementation of the tele-ICU coverage, ICU mortality decreased 20 percent across the UMMMC's seven ICUs, even as the severity of their conditions rose significantly."

Mortality Rates at UMMMC. In UMMMC's seven ICUs, the overall *observed* ICU mortality declined a full 20 percent with tele-ICU care. That is twice the *FAST* criterion of a 10 percent decline, even though patients' average APACHE III scores increased by 13 points from 45 to 58 (see Figure 3.4). After adjustments for this increased severity, the decrease in ICU mortality exceeded 20 percent.

In addition, the UMMMC ICU patients' observed *hospital* mortality rates declined 13 percent, again despite the significant increase in the severity and the risk of mortality of the ICU patients. Thus the introduction of the tele-ICU system met the criteria for a substantial reduction in mortality rates in the ICU with no increase in mortality for the patients' full hospital stay at the academic medical center.

Figure 3.4: ICU Mortality Rates for UMMMC ICUs	
	UMMMC averages across 7 ICUs
Observed Mortality Pre Tele-ICU	10.7%
Observed Mortality Post Tele-ICU	8.6%
Change in ICU Mortality	-20% (p=0.01)
Hospital Mortality Pre Tele-ICU	13.6%
Hospital Mortality Rate Post Tele-ICU	11.8%
Change in Hospital Mortality	-13% (p=.07)
Mean APACHE III Severity Measure Score for Pre Period	45
Mean APACHE III Severity Measure Score for Post Period	58

Source: C. Lilly et al, Tele-ICU Enabled Reengineering of Critical Care: Effects and Mechanisms, manuscript in progress.

Mortality Rates at Community Hospital 1. In Community Hospital 1, the observed ICU mortality rate declined only slightly. However, the mean severity of ICU patients' illnesses, as measured by the APACHE IV scores, rose six points (from 48 to 54). This means that we would have *predicted* that the patient mortality rate would rise from 4 percent to 6 percent, based on the increased severity of the patients' conditions. After the mortality rates were adjusted for this increase in severity, however, the adjusted ICU mortality rate at Community Hospital 1 declined by 36 percent (see Figure 3.5).

The standard method for reporting the relationship between observed and predicted mortality rates based on severity levels is a ratio of the observed rate to the predicted rate. Thus the pre-tele-ICU ratio was 6.3 (observed) to 4.0 (predicted), or a ratio of 1.57, meaning that the observed mortality rate was higher than would have been expected based on the severity of the ICU patients. In the post tele-ICU period, that ratio was 1.0, meaning that the mortality ratio had fallen .57 and was now at a rate consistent with the severity of the patients' conditions. This drop in the ICU mortality ratio from 1.57 to 1.0 exceeded 10 percent and thus met the Expert Panel's standard.

Community Hospital 1 also met the standard for hospital mortality rates not increasing for ICU patients transferred to the hospital floor. Again, despite the significant increase in severity, the hospital mortality rate for these patients decreased.

Mortality Rates at Community Hospital 2. Community Hospital 2 saw a sharp rise in observed ICU mortality rates after the introduction of the tele-ICU. At a 2.1 percent mortality rate pre-tele-ICU, the observed ICU mortality had been exceptionally low for any intensive care unit. In the post-implementation period the observed ICU mortality rate rose to a more expected rate of 7.3 percent. This rise was due in part to a significant increase in patient severity from 50.3 to 59.3 on the

Figure 3.5: ICU Mortality Change Rates for Community Hospitals 1 and 2		
	Community Hospital 1	**Community Hospital 2**
Change in Adjusted ICU Mortality (p-value)	-36% (p=0.83)	+142% (p<.001)
Mean APACHE IV Severity Measure Score for Pre Period	48	50
Mean APACHE IV Severity Measure Score for Post Period	54	59

Source: C. Lilly et al., New England Health Care Institute and U Mass. Medical School Tele-Intensive Care Unit Project, July 12, 2010.

APACHE IV scores. But after adjusting for the severity increase the ratio still only moved from .4 to .97, meaning that mortality rates changed from much less than what would have been expected based on the patients' severity to only slightly less than would have been anticipated. Hospital mortality for ICU patients transferred to the hospital floor also increased from 8.5 percent to 10.9 percent. But, Community Hospital 2 did not meet the standards for mortality outcomes set by the Expert Panel.

Findings for ICU Length of Stay (LOS). The *FAST* Expert Panel set a decrease of 12 hours in average LOS as the second criterion for successful tele-ICU implementation.

UMMMC's Change in ICU LOS. The change in ICU LOS across the seven UMMMC ICUs more than met the goal of a drop of 12 hours, with an average LOS decrease of almost two days (1.9 days or 30 percent). If we had adjusted for the increase in mean APACHE III scores across UMMMC's ICU patients, we believe that we would have seen even greater decreases in average length of ICU stay (see Figure 3.6). We did not conduct those adjustments, however, because the raw, observed decrease in mortality more than met the Expert Panel's criteria.

Community Hospital 1's Change in ICU LOS. This hospital's observed ICU LOS rose slightly in the post tele-ICU period to 2.9 days from its average of

Figure 3.6: UMMMC's Change in ICU LOS				
Hospital	**Pre Period average ICU LOS (mean days, not adjusted for mortality)**	**Post Period average ICU LOS (mean days, not adjusted for mortality)**	**Change in LOS (mean days, not adjusted for mortality)**	
UMMMC averages across 7 ICUs	6.4	4.5	(-1.9)	-30%

Source: PricewaterhouseCoopers, NEHI and MTC Tele-ICU Care Unit Project, March 3, 2010.

Figure 3.7: Community Hospitals' Changes in ICU LOS					
Community Hospital	**Pre: Observed ICU**	**Post: Observed LOS**	**Net change pre to post in observed LOS**	**Predicted LOS based on severity increase (Pre/Post)**	**Pre: Observed LOS/ Predicted LOS ratio change**
Community Hospital 1	2.8	2.9	+4%	1.5/2.6	-42%
Community Hospital 2	3.0	2.8	-6.7%	2.7/3.0	-16%

Source: PricewaterhouseCoopers, NEHI and MTC Tele-ICU Care Unit Project, October 25, 2010.

2.8 in its pre tele-ICU period. However, when adjusted for the dramatic increase in patient severity, Community Hospital 1's adjusted ICU LOS was 42 percent less than what would have been expected given the increase in severity. The Expert Panel standard was set in terms of one-half day of average LOS in the ICU, and that standard is met by a 42 percent decrease in the ratio of actual to predicted LOS (see Figure 3.7).

Community Hospital 2's Change in ICU LOS. This hospital's observed ICU LOS decreased from an average of 3 to 2.8 days. Given the increase in patient severity in the post-implementation period, an average stay of 3 would have been expected. Thus, the tele-ICU coverage was associated with a drop to .2 below what would have been predicted and a drop of 16 percent in the ratio of actual to predicted. This finding just meets the Expert Panel standard of decreasing by one-half day (.5) (see Figure 3.7.).

Findings for Compliance with Treatment Guidelines and Patient Volume

While patient outcomes are the most vital measures of tele-ICU impact, other measures are also commonly used to gauge success and value. These other measures include the degree to which clinical practice guidelines are followed in ICU care and the overall volume of ICU patients treated.

Practice Guideline Adherence. If practice guidelines are more frequently followed, the quality of care is considered to have improved, albeit by this proxy

Figure 3.8: ICUs Change in Selected Practice Guidelines Measures				
Hospital	**Stress Ulcer Prevention**		**DVT Prevention**	
	Pre	**Post**	**Pre**	**Post**
UMMMC (average across all 7 ICUs)	83%	96%	83%	96%
Community Hospital 1	70%	87%	70%	85%
Community Hospital 2	93%	97%	91%	99%

Source: C. Lilly et al, Tele-ICU Enabled Reengineering of Critical Care: Effects and Mechanisms, manuscript in progress and C. Lilly et al., New England Health Care Institute and U Mass. Medical School Tele-Intensive Care Unit Project, July 12, 2010.

Figure 3.9: ICUs Change in Patient Volume and in Occupancy Rate					
Hospital	**Patient Volume**			**ICU Occupancy Rate**	
	Pre	**Post**	**% Change**	**Pre**	**Post**
Community Hospital 1	565	791	40%	45%	64%
Community Hospital 2	539	806	50%	44%	64%

Source: PricewaterhouseCoopers, NEHI and MTC Tele-ICU Care Unit Project, October 25, 2010.

measure. Close adherence to practice guidelines indicates that the tele-ICU staff is managing patients effectively and applying best practices to patient care, which leads to improved patient outcomes. Two commonly used measures of how well practice guidelines are followed are the percentage of candidate patients for whom steps were taken to prevent stress ulcers and to prevent deep vein thrombosis (DVT). All three hospitals' ICUs reported greater adherence to these practice guidelines in the post tele-ICU periods (see Figure 3.8).

Overall Volume of Patients Cared for in the ICU. Where ICUs are able to treat more patients with the same number of beds, this is an indicator of greater efficiency and possibly also of faster responses as patient conditions change. In both community hospitals the numbers of patients treated and the ICU occupancy rates increased in the post tele-ICU period (see Figure 3.9). Comparable data were not available for UMMMC.

Interpreting the Clinical Findings

Summing Up Across the Three Hospitals. Of the three hospitals and the nine ICUs evaluated in our study, two hospitals and eight ICUs reported very positive post tele-ICU clinical outcomes that met the *FAST* Expert Panel's standards (see Figure 3.10).

Figure 3.10: Summary Report Card for Outcomes Post Tele-ICU Across the Three Hospitals			
Expert Panel Standards for ICU Success:	**UMMMC**	**Community Hospital 1**	**Community Hospital 2**
Achieved a 10% reduction in ICU mortality	Yes	Yes	No
Reduced LOS in ICU by .5 day	Yes	Yes	Yes
Additional Standards:			
Reduced total hospital mortality	Yes	Yes	No
Increased compliance with treatment guidelines	Yes	Yes	Yes
Increased ICU patient volumes	Yes	Yes	Yes
Increased ICU occupancy rates	Yes	Yes	Yes

Source: NEHI, 2010

Targeting Tele-ICU to Hospitals Most Likely to Improve Outcomes. One of the demonstration's objectives in comparing the experiences of the nine ICUs was to look for indicators of where and under what circumstances tele-ICUs yield the most improved patient outcomes and the greatest financial efficiencies. Community Hospital 1 saw a decrease in ICU mortality and a shortened ICU length of stay in relation to the increased severity of patients' conditions. Community Hospital 2 demonstrated less improvement. Its pre-implementation ICU mortality rate was unusually low (two percent) for any ICU. The mortality rate increased, as would be expected, with the increased severity of patients in the post-implementation tele-ICU period. But its mortality rate was still higher than would have been predicted for the severity level, even given the more severe condition of its patients. Therefore tele-ICU coverage was not associated with a drop in either observed or adjusted mortality rates. Hospital 2 did report a decrease in ICU length of stay in relation to its increased severity of patients' conditions.

Community Hospital 2 presented several circumstances that may indicate where tele-ICUs are less likely to yield immediate and meaningful improvements in clinical and financial outcomes. First, post period measurement in this hospital began immediately after the tele-ICU system was implemented. There was no transition period to permit hospital and command center staff to adapt to the tele-ICU as there was in most of the UMMMC ICUs and in Community Hospital 1. Community Hospital 1 had a six -month period of adaptation to the tele-ICU before the post-implementation observation period began. The comparison of the experiences (and of the outcome measures) of these two relatively similar community hospital ICUs immediately after implementation and at six months after the installation of the tele-ICU system suggests that a half-year period may be the minimum time needed to see mortality and LOS decreases in community hospitals. Other community hospitals have reported greater mortality decreases (50 to 60 percent decreases in observed, unadjusted mortality) at one year after tele-ICU coverage.[20]

A second factor that may explain some of the mortality increase at Community Hospital 2 is that prior to the tele-ICU installation, a majority of its ICU patients were admitted directly from the emergency department. The dominant practice pattern was to send the least severe patients to the ICU and to transfer the most severely injured or ill patients to UMMMC or other academic medical centers. In the pre-tele-ICU period, 32 percent of critically ill patients were transferred to UMMMC. In the post-implementation period, Community Hospital 2's own ICU

accepted many more of these patients and the transfer rate from the emergency department to UMMMC dropped to 10 percent. This change in referral patterns is likely an indicator of the benefit of the tele-ICU system in allowing the community hospital to retain an increased number of severely ill patients — but it also contributed to the increase in mortality rates.

Third, Community Hospital 2's ICU was and remains an "open" ICU or an ICU in which physicians other than the intensivists may provide direct care to their patients. Community Hospital 1 also had an open ICU, but is staffed with hospitalists (physicians specializing in hospital care) who were more amenable to tele-intensivists' managing their patients. In Community Hospital 2 the ICU is not staffed with hospitalists. The physicians who admit patients also mange their care and were less accepting of the tele-ICU team monitoring and directing the care of their patients. Where physician acceptance of tele-ICU management is low, an open ICU is more likely to experience a dilution of the tele-ICU's benefits. Physician resistance has been mentioned earlier as a barrier to wider adoption of tele-ICU technology and it is an especially important impediment in an open ICU.

Most innovative medical technologies vary in their impact depending on the settings and the patients. Community Hospital 2's less successful post-implementation tele-ICU outcomes in comparison to those of UMMMC and Community Hospital 1 suggests that tele-ICUs will have more or less success depending upon the support of the hospital staff and the environment of the ICU to which it extends coverage. Conditions that may have negatively impacted the tele-ICU's effectiveness in Community Hospital 2 include the following:

- No transition period for staff to adjust to the innovation;
- Transfer of many ICU patients from the emergency department to an academic medical center;
- An open ICU with some medical staff who did not support the tele-ICU concept; and
- Physician resistance to tele-ICU monitoring and management of patients.

These factors should be considered in developing profiles for which community hospitals are likely to achieve the best outcomes and the highest levels of success when supported by tele-ICUs.

Meeting the Public Health Need for More Intensivists. It is of particular note that the two community hospitals reported substantial increases in both the numbers of patients treated and the overall severity of the patients' conditions. Patient

volume and occupancy rates increased substantially in the two ICUs with no addition of new ICU beds. The same ICUs with the same numbers of beds in the post tele-ICU period were caring for many more and much sicker patients. These numbers indicate that tele-ICUs have the potential to provide an effective solution to the urgent public health need for more critical-care trained personnel in an era where there is an ever-increasing number of older and critically ill patients.

Chapter Four

Financial Impact on Hospitals and Payers

"Advanced technologies often require substantial up-front capital investment which can impede adoption. But in many cases the financial benefit is so pronounced that payback of all costs can be realized in a short period of time while the cost of health care over-all is reduced. Tele-ICU is one of those."
Mitchell Adams, Executive Director, Massachusetts Technology Collaborative, 2010

Introduction

The implementation of tele-ICU care in the academic medical center and in the two community hospitals had pronounced financial impact in both settings. The lengths of stay and associated costs were substantially reduced at UMMMC, and the community hospitals were able to care for an increased volume of more acutely ill patients. These clinical enhancements resulted in improved financial performance in both settings. While increases in capital, one-time operating and annual operating costs for tele-ICU were substantial, improved financial performance resulted in a rapid return on investment such that *all incremental costs were recovered within about one year in both settings (payback period).* Our analyses indicate the prospect of substantial benefit to payers as well. If tele-ICU systems were broadly implemented in Massachusetts the potential benefit to payers could amount to approximately $122 million annually.

Analytic Approach. The goal of this part of the project was to assess the financial impact of tele-ICU care on community

hospitals, academic medical centers and payers in Massachusetts.

All data and analyses in this chapter were provided to PricewaterhouseCoopers by the UMMMC Healthcare Business Development Office, the Director of the UMMMC eICU Support Center and the Director of Decision Support at UMass Memorial Healthcare. Assessments were also based on interviews with key administrative and clinical staff at Community Hospitals 1 and 2. PwC assessed the analyses and data provided by the hospitals' staff showing costs and benefits associated with tele-ICU implementation.

- These costs included capital and one-time operating costs associated with implementation as well as incremental annual operating costs incurred by the hospitals.
- Cumulative costs were compared to the cumulative benefits that accrued during an annualized one-year period. These calculations permit a payback period estimate — the time required to recover all costs associated with implementation and operation.
- An estimate was then made of the financial impact of tele-ICU implementation on payers in both the academic medical center and community hospital settings. Our analysis includes an approximation of the statewide impact if these systems were implemented broadly and effectively across the state.

Financial Impact

Payback Period for UMMMC.

Implementation of the tele-ICU command center at UMMMC entailed substantial capital expenditure and one-time operating costs ($7,120,000) and requires an increment of annual operating costs of $3,150,000 (see Figure 4.1).

Length of Stay. As a result of implementation of the tele-ICU system there was a pronounced financial impact. The tele-ICU system is associated with numerous improvements in clinical care, but the change most affecting financial results was the reduction in length of stay (see Figure 4.2). A reduction in lengths of stay resulted in lower costs for both UMMMC and the payers. The net effect produced a rapid payback such that the total costs of implementation were recovered within one year.

Payback Calculation for UMMMC.

UMMMC provided data that allowed PwC to compare average revenue and variable costs per case before and after tele-ICU implementation. Average costs per case decreased by approximately 20 percent, principally due to the substantial reduction in average length of stay. Average revenue per case also decreased due to multiple factors, but was most importantly affected by the impact of a reduction in fee-based

Figure 4.1: UMMMC Capital and One-Time Costs and Ongoing Operating Costs for Tele-ICU		
UMMMC Capital and One-Time Costs for Tele-ICU		
Expense Type	**% of Total**	**$ Amount**
Tele-ICU Support Center Buildout & Servers	17%	$1,190,000
Tele-ICU Licensing and Implementation Fees	34%	$2,400,000
ICU Equipment Costs	15%	$1,100,000
Network and Infrastructure Costs	4%	$260,000
Software Costs	1%	$80,000
ICU Facility Costs (Cabling, Electrical)	7%	$470,000
Patient Monitoring System Upgrade Costs	5%	$370,000
Project Management and Consultant Costs	17%	$1,230,000
Miscellaneous (Marketing, Travel Expenses, Supplies)	0.3%	$20,000
Total Capital Costs	**100.0%**	**$7,120,000**
UMMMC Ongoing Operating Costs		
Expense Type	**% of Total**	**$ Amount**
*Tele-ICU MD, NP and PA Salary & Benefits	72%	$2,270,000
Software License Fees	7%	$230,000
Non-Clinical Tele-ICU Staff Salary & Benefits	20%	$630,000
Tele-ICU Office Supplies, Telephone, Copier Lease	1%	$20,000
Total Operating Costs	**100%**	**$3,150,000**
*MD FTEs = 4.67; NP/PA FTEs = 7.01; MD Director = .5 FTE		

Source: PricewaterhouseCoopers report to MTC, October 2010.

payments. The net effect of these changes was an improvement in net contribution margin to UMMMC of approximately $5,400 per case. On an annual volume of about 4,600 cases this amounted to nearly $25 million. *It is apparent that this improvement was sufficient to recover the $7.1 million in capital and one-time costs and the $3.1 million in increased annual operating costs in about one year.*

Payback Period for the Community Hospitals. For each of the community hospitals implementation required capital and one-time operating costs of approximately $400,000 and incremental annual operating costs of about $400,000. Operating costs at the community hospitals took the form of a contractual charge from the academic medical center.

Figure 4.2: UMMMC Length of Stay: Study Patients			
	Pre	**Post**	**% Change**
Total Hospital LOS	13.3	9.8	-26%
ICU LOS	6.4	4.5	-30%
Medical/Surgical LOS	6.9	5.3	-23%

Source: PricewaterhouseCoopers report to MTC, October 2010.

Figure 4.3: Community Hospitals 1 and 2 Capital and One-Time Costs and On-Going Operating Costs for Tele-ICU		
Community Hospital 1 and 2 Capital and One-Time Costs for Tele-ICU		
Expense Type	**Community Hospital 1**	**Community Hospital 2**
Software Licensing and Implementation Fees	$220,000	$160,000
ICU Equipment Cost Including Computers	$115,000	$85,000
Network and Infrastructure Costs	$35,000	$50,000
Non-Licensing and Implementation Software Costs	$25,000	$25,000
Project Management and Consultant Costs	$20,000	$20,000
Total Capital Costs	**$415,000**	**$340,000**
Ongoing Operating Costs		
($40,000 per ICU bed/year)	**$400,000**	**$400,000**

Source: PricewaterhouseCoopers report to MTC, October 2010.

The costs for each of the community hospitals are presented in Figure 4.3.

Increased Patient Volume. Implementation of the tele-ICU system was associated with a substantial increase in the volume of ICU cases at both community hospitals. Figure 4.4 shows annualized data indicating the increased volume of cases, daily patient count and occupancy rates at each institution.

ICU Transfers – Retention Rates. Figure 4.5 shows that both community hospitals demonstrated an increased patient retention rate in the post tele-ICU period. That is, a higher percentage of patients who presented to the community hospital were able to remain there, thus avoiding transfer to the higher cost academic medical center. Increased retention was particularly pronounced at Community Hospital 2 (52 percent to 72 percent) and accounted for the largest part of the increase in total volume of cases. In Community Hospital 1 the eight percent increase in retention was substantial, but the largest portion of increased volume was due to the increased number of patients who presented to the hospital. The average increase in retention for both hospitals is about 23 percent.

Severity. The implementation of tele-ICU was associated with an increase in the severity of ICU patients. The figures in

Figure 4.4: Community Hospital Annualized Patient Volume						
	Community Hospital 1			**Community Hospital 2**		
	Pre	**Post**	**Difference**	**Pre**	**Post**	**Difference**
Unique Number of ICU Cases	565	791	226	539	806	267
Number of Beds	10	10	N/A	10	10	N/A
ICU Average Daily Patient Count	4.5	6.4	1.9	4.4	6.4	2
ICU Occupancy Rate	45%	64%	19%	44%	64%	20%

Source: PricewaterhouseCoopers report to MTC, October 2010.

Figure 4.5: Community Hospital Annualized Patient Retention Rates*						
	Community Hospital 1			Community Hospital 2		
	Pre	Post	Difference	Pre	Post	Difference
Patients Presented to the Hospital	733	947	29%	1,030	1,120	9%
Emergent Transfers from ED	67	140	110%	162	198	23%
Elective Transfers from ED	101	15	-85%	329	116	-65%
Admitted to ICU	565	791	40%	539	806	50%
Retention	77%	84%	8%	52%	72%	38%
* In the "Difference" column the percentages are based on *annualized* data from the actual observation periods, resulting in small differences after rounding.						

Source: PricewaterhouseCoopers report to MTC, October 2010.

Appendix III reflects an increase in both volume and average APACHE IV scores for high intensity DRGs between the pre and post-implementation periods. The data in Appendix III demonstrate increased severity and increased volume at both community hospitals in the post period.

Payback Calculation for Community Hospitals. The implementation of the tele-ICU system was associated with significant increases in ICU volume at each community hospital, and an increase in the severity of patients. The net financial result was a substantial increase in contribution margin which permitted a recovery of tele-ICU costs in about one year.

PwC analyzed the financial impact of the incremental volume and the increased severity of patients at each of the community hospitals by calculating the average revenue and expenses associated with pre and post ICU cases. Revenue was defined as average total payments made by third party insurers for each ICU case. Based upon data provided by the UMMMC team, expenses were calculated by developing the average total variable cost per case. Variable costs included items such as labor, supplies, pharmaceuticals, laundry, etc. Differences in accounting methodologies between the two hospitals were adjusted to render comparable data as much as possible. The calculation results in a "contribution margin per case" number which is the contribution to fixed costs made by the average case in the pre and post periods for each hospital.

Figure 4.6: Community Hospital Contribution Margin						
	Community Hospital 1			Community Hospital 2		
	Pre	Post	Difference	Pre	Post	Difference
Annualized Number of Unique ICU Cases	565	791	226	539	806	267
Contribution Margin per Case	$3,000	$4,000	$1,000	$5,000	$9,000	$4,000
Total Contribution Margin	$1,700,000	$3,150,000	$1,450,000	$2,700,000	$7,250,000	$4,550,000

Source: PricewaterhouseCoopers report to MTC, October 2010.

As Figure 4.6 shows, in each of the hospitals the post period showed a substantial increase in total contribution margin. These improvements may have resulted in part from an overall increase in ICU patient severity which resulted in enhanced reimbursement.

While much of this improvement can be attributed to the implementation of tele-ICU, other factors contributed as well. They include:

- Changes or updates to payer reimbursement terms, thus increasing net revenue per case
- Increased ICU capacity (with the same number of beds) due to changes and upgrades in ICU staffing, including the implementation of intensivist programs at both community hospitals, allowing increased volume of high severity patients
- Increases in patient volume for seasonal illnesses or other unexplained reasons.

Note that any savings in the labor component of variable costs required important management actions to be realized.

The implementation of tele-ICU care is associated with a substantial increase in contribution margin at both community hospitals. While not all of this improvement can be directly attributed to the implementation of the new systems, *it was apparent that the total capital and one-time operating costs of $400,000 and incremental annual operating costs of about $400,000 were fully recovered in one year's operation.*

Financial Impact on Payers

UMMMC. The tele-ICU system demonstrated financial benefit to payers as well. The reduction in average length of stay reduces payments associated with those reimbursement arrangements that are based on per diem or fee-for-service charges. Although payments for patients covered under DRG arrangements are not changed, the overall effect is that **the average of all payments** were significantly reduced by approximately $2,600 per case based upon the payer mix at the time of the study. On a base of about 4,600 annual ICU cases at UMMMC these changes result in a benefit to payers of approximately *$12 million each year.*

This financial impact could be extrapolated to other academic medical centers in Massachusetts. If tele-ICUs were extended beyond UMMMC to all other academic medical centers the benefit to payers could be substantial. Since these institutions care for a total of about 18,500 ICU cases annually, this potential additional benefit

can be calculated. Assuming a similar payer mix, variable cost structure and ability to reduce LOS, the additional savings to payers can be estimated at 18,500 cases times $2,600 or *$48 million annually.*

Community Hospitals 1 and 2. Tele-ICU systems helped both community hospitals accommodate an increased volume of more acutely ill patients. The hospitals were able to increase their rate of retention of patients who would otherwise have been transferred to an academic medical center by an average of 23 percent (see Figure 4.5). PwC was provided data to analyze the cost and revenue associated with 449 matched cases. Each of these matched cases consisted of a patient treated at the academic medical center and a patient treated in the community hospital, and patients were matched on the basis of DRG, age and timeframe of hospitalization. The average net revenue per case (cost to the payers) for those patients treated in the academic medical center setting was approximately $10,000 greater than in the community hospital setting. Based on this differential cost to payers the increased volume of patients at Community Hospitals 1 and 2 due to increased retention of patients resulted in an annual savings to payers of approximately *$2.6 million.*

This financial benefit could be extrapolated to the 33 community hospitals in Massachusetts with ICU units of 10 or more beds each, the size most appropriate for inclusion in a tele-ICU program. Total annual admissions to these ICUs is about 35,000 annually. Based solely on the improved retention experience of the two community hospitals in this study it is estimated that tele-ICU implementation in all of these hospitals' ICUs would permit an increase in ICU admissions (due to increased retention in the community hospitals) of about 8,000 cases annually. If a similar $10,000 cost differential between the academic and community hospital setting were applied to the 33 other community hospitals in the state, the total benefit could amount to savings to payers of about *$80 million annually.*

Potential State-Wide Impact. If tele-ICUs were extended beyond UMMMC and Community Hospitals 1 and 2 to ICUs in all of the academic medical centers and the targeted community hospitals in Massachusetts, the combined financial benefit to payers could be substantial. The savings to payers due to retention of patients in the community could amount to $80 million annually as indicated. The benefit on the academic medical center side would amount to the $48 million described above, less the benefit attributable to the

8,000 patients who would be retained in the community hospitals (8,000 patients x $2,600 = $21 million) — resulting in a net savings of $27 million. The total benefit to payers can be calculated as follows:

- UMMMC — $12 million;
- Community Hospitals 1 and 2 — $2.6 million;
- Other academic medical centers (net of transfers) — $27 million; and
- Other community hospitals — $80 million.

Taken together the benefit to payers would total *approximately $122 million.*

Chapter Five

Conclusions and Policy Recommendations

"Recognizing that our country is facing a severe critical care workforce shortage is the first step in addressing this immense burden on the nation's health-care system. The time for comprehensive policy discussions on this issue is overdue. Congress and the appropriate Federal agencies must act now to avert this crisis."
W. Michael Alberts, MD, MBA, FCCP, President, American College of Chest Physicians, Report to Congress, May 2006

"Tele-ICUs can improve the quality and lower the costs of intensive care. Together, these benefits can offer a win-win-win opportunity for patients, hospitals and payers across the country."
Wendy Everett, ScD, President, New England Healthcare Institute

Summary Conclusions

The Massachusetts Technology Collaborative, the New England Healthcare Institute, the University of Massachusetts Memorial Medical Center and PricewaterhouseCoopers worked collaboratively to evaluate the clinical and financial benefits of tele-ICU care. This study, conducted in an academic medical center and two community hospitals in Massachusetts, found improvements in the quality of care, overall decreases in mortality rates and in lengths of stay, and substantial reductions in hospital charges for patients in intensive care units after the introduction of a tele-ICU system. Building on the core research of Dr. Craig Lilly at UMMMC, we were able to document

gains in the volume of patients who can be cared for in community hospital ICUs without any major effects on mortality. We also found an increase in the proportion of physicians who practice according to evidence-based guidelines and, very importantly, a substantial reduction in costs associated with the care of ICU patients.

In the years ahead, the expected surge of the over-65 population in Massachusetts will triple the demand for ICU beds. The expanded capacity of tele-ICU care is one very efficient and cost-effective way to meet that demand.

System and Patient Outcome Improvements

Academic Medical Center Effects. After full installation of the tele-ICU system in all seven of UMMMC's ICUs, there were substantial improvements in patient care: the observed mortality rate for ICU patients decreased by 20 percent and the overall hospital mortality rate declined by 13 percent — a remarkable and extremely beneficial outcome for the patients. In addition, the average LOS for patients in the ICUs decreased by 1.9 days (30 percent), driving significant financial savings to the institution. Finally, the adherence to best practice guidelines by physicians increased from the low 80 percent range to the high 90s, accompanied by fewer ventilator-acquired pneumonias and better cardioprotection for the patients, and much improved care planning through an increase in well-documented admission reviews.

Community Hospital Effects. After implementation of the tele-ICU technology there were substantial increases in the volume of patients who were admitted to community hospital intensive care units. Community Hospital 1 had a 40 percent annualized increase in case volume, while Community Hospital 2 had a 50 percent increase. This expanded capacity to provide care for critically ill patients at their local hospitals not only raised the hospitals' occupancy rates by 20 percent, but also allowed patients to remain close to their families and homes. With support from the tele-ICU system, the two community hospitals were able to keep patients who would otherwise have been transferred to an academic medical center for care. The retention rates for these intensive care units increased on average by 23 percent.

With the tele-ICU technology, there were also substantial increases in the severity levels of patients who were admitted to community hospital intensive care units. As measured by APACHE IV scores, the patient severity scores increased from 48.3 to 54.7 in Community Hospital 1 and from 50.3 to 59.3 in Community Hospital 2. Taking into account the fact that sicker patients were now being treated at the two community hospitals, there was no substantial increase in the absolute total hospital length of stay and there was a

substantial *decrease* in the predicted to observed hospital LOS.

While across the country academic medical centers that have "closed" ICUs staffed with intensivists and hospitalists appear to experience reductions in ICU mortality rates within a range of 15 to 25 percent, the mortality changes for community hospitals are much more variable. Where conditions are favorable to tele-ICU care in community hospitals (there are intensivists, the command center has shared decision-making authority, and there is adequate staff training), community hospitals report ICU mortality decreases of greater than 30 percent. However, when such conditions are *not* present, community hospitals may see flat or even increased mortality rates.

With tele-ICU, physician adherence to best practices was significantly higher for the prevention of stress ulcers, thromboembolisms and ventilator-assisted pneumonias. While our community hospital study did not test the results of such improved adherence on lower patient complication rates, such results have been found in many other studies.

Cost Reductions

UMMMC Effects. Full installation of the tele-ICU command center at UMMMC entailed substantial capital expenditures and one-time implementation costs of $7,120,000 and required an increase in the medical center's annual operating cost of $3,150,000. As noted above, the reduction in total average length of stay resulted in lower costs for UMMMC such that there was a significant increase in net contribution to their fixed costs. This financial improvement resulted in a recovery of *all* incremental costs within one year.

Community Hospitals 1 and 2 Effects. The implementation of tele-ICUs in the community hospitals resulted in improved financial performance, even with the substantial capital and operating costs associated with the purchase and installation of the technology. Each of the community hospitals incurred capital and one-time operating costs of approximately $400,000 and had additional annual operating costs of about $400,000. However, the tele-ICU technology gave the hospitals the ability to manage a 40 to 50 percent increase in the volume of high-severity patients. This volume increase resulted in an improved contribution to their fixed costs and as with UMMMC, this led to a full recovery of *all* additional costs related to tele-ICU for both hospitals within one year.

Payer Effects: UMMMC. The reduction in average length of stay drove much of the savings for payers at UMMMC. On average payments were reduced by approximately $2,600 per case based upon the payer mix at the time of the study. Calculating the savings based on 4,600 UMMMC ICU

cases, the payers would save approximately $12 million annually.

Payer Effects: Community Hospitals 1 and 2. Tele-ICU systems helped both community hospitals accommodate an increased volume of more acutely ill patients. The hospitals in turn demonstrated the ability to substantially increase the retention rate of patients who would otherwise have been transferred to an academic medical center. Using the cost differential shown in our analysis of the 449 matched cases, these patients cost payers approximately $10,000 per case less than they would have cost in the academic medical center setting. For Community Hospitals 1 and 2 this resulted in savings to payers of $2.6 million annually.

Statewide Benefits of Tele-ICU Adoption

Academic Medical Center Benefits. If we extrapolate UMMMC's yearly savings to the 18,500 ICU cases in all of the other academic medical centers in the state, then the potential annual benefit for payers would be in the order of $48 million.

Community Hospital Benefits. The use of tele-ICU technology enabled the two community hospitals to be able to care for a larger volume of high severity, critically ill adults while either decreasing their mortality rates or maintaining them at a level consistent with those of an academic medical center. As detailed above, the effective implementation of a tele-ICU system lowered the costs of providing care to ICU patients, resulting in higher margins for the hospitals and lower costs of care for all payers.

If we were able to expand tele-ICU care to the 33 community hospitals in Massachusetts with 10 or more ICU beds and relatively low occupancy rates, then approximately 8,000 additional ICU patients could be safely cared for in these community hospitals, rather than being transferred to academic medical centers. Assuming the same $10,000 differential per case, this would provide a savings of $80 million annually to payers throughout the Commonwealth.

All of these financial savings estimates are very conservative, as we did not include two additional major system-wide savings:

- The cost reductions from not having to physically transfer 23 percent of the patients from community hospitals to academic medical centers;
- The cost savings that would result from not having to build new ICU beds (at a cost of $1.5 million per bed) because the ICU lengths of stay have been substantially decreased and the occupancy rates have increased.

For the patients who are treated in academic medical center ICUs, there is the potential to reduce the total mortality rate by 13 percent using tele-ICU technology. On an annualized basis, this would save

about 350 more lives in the state. Although there wasn't an immediate reduction in mortality in Community Hospital 2, there is the potential to reduce mortality by more than 30 percent in a community hospital with a mature tele-ICU system, as has been demonstrated in Community Hospital 1 and in many community hospitals in other parts of the country.

An important caveat to obtaining these clinical and financial benefits is that each hospital must be willing to make the organizational and structural changes in critical care that are commensurate with the benefits that were seen at these study hospitals — and at other successful hospitals around the country. The probability of achieving these improved outcomes and return on the financial investment is completely dependent on the thoughtful, effective and efficient deployment of the technology.

Barriers to Adoption

Access to Capital. Although access to capital can be a recurring problem for many community hospitals, the very short-term (approximately one year) payback period for tele-ICU capital and operating costs (driven by an increased volume of high severity patients coupled with lower costs and increased revenues) significantly reduces the impact of this perceived barrier.

Cross-state Professional Licensure. For academic medical centers that plan to become command centers, the physicians, nurse practitioners, advanced practice nurses, and pharmacists who manage the tele-ICU care currently need to be licensed in each state where they are contracting with satellite hospitals to provide services. This can be a problem for tele-ICU command centers in smaller states that have an opportunity to provide remote monitoring services to ICU patients in other states (for example, Massachusetts to Vermont, New Hampshire, and Connecticut). Although the American Telemedicine Association has made resolving this problem a high priority, to date there has been little progress in obtaining a broader, inter-state or federal approach to medical, nursing, and pharmacist licensure.

Physician Culture and Acceptance. Finally, and most importantly, is the barrier of community physician acceptance of tele-ICU care. Remote monitoring of community hospital patients by critical care specialists in a distant command center can be perceived as a serious threat to the autonomy of the patients' primary care and consulting physicians. Involving and engaging the community physicians is a critical element that is necessary to have in place if a tele-ICU installation is to be successful.

Recommendations

The following recommendations are suggested to further the goals of improving the quality of patient care and reducing health care costs in the Commonwealth:

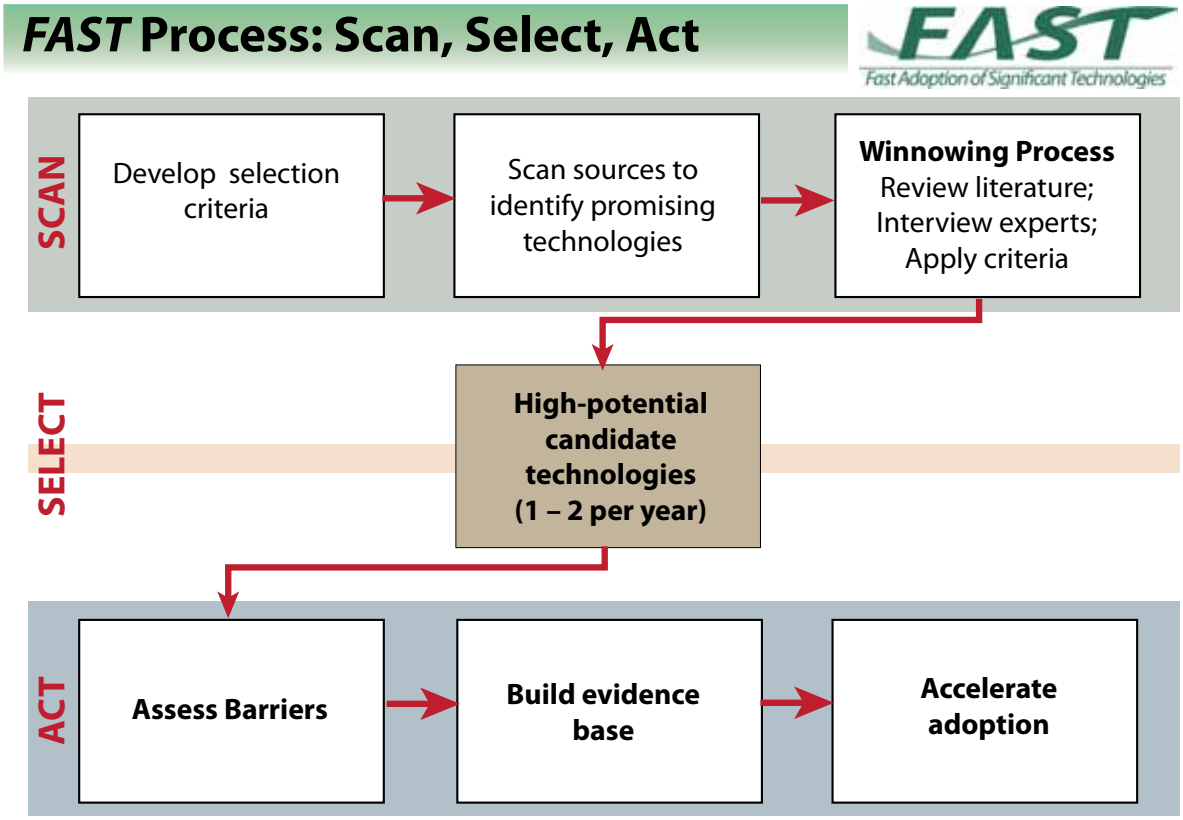
- All Massachusetts academic medical centers should implement tele-ICU systems in their primary and affiliated hospitals within the three year period 2011-2014.
- All community hospitals in Massachusetts that meet the criteria of having 10 or more ICU beds and an ICU occupancy rate of at least 45 percent should adopt tele-ICU care by 2015.
- All tele-ICU centers in Massachusetts should expand to full capacity (500 covered beds) by extending coverage to all appropriate ICU beds in the state. This will enable the Commonwealth to achieve the best possible clinical and financial outcomes for patients and the health care system.
- An Expert Tele-ICU Advisory Board, consisting of Massachusetts stakeholders (including payers, academic medical center and community hospitals, state government, quality organizations, and other interested and appropriate experts), should establish the criteria that define target hospitals' success factors and track the implementation results to refine those targeting criteria.
- NEHI and MTC should work with The Leapfrog Group to analyze these study findings and explore modifying Leapfrog's standards for intensivist staffing of ICUs to include tele-ICU care.
- The Commonwealth of Massachusetts should continue to support the search for, and the evaluation of, innovative technologies that improve patient care and reduce costs.

The implementation of tele-ICU in the academic medical center and in the community hospital setting resulted in substantial improvements in patient care. Length of stay and associated costs were substantially reduced at UMMMC, and the community hospitals were able to care for an increased volume of more acutely ill patients in their own communities. These clinical enhancements resulted in improved financial performance in both settings. While increases in capital and one-time operating costs and annual operating costs for tele-ICU

were significant, improved financial performance resulted in a rapid payback period such that all incremental costs potentially could be recovered within about one year in both settings. Our analysis indicates the prospect of substantial benefit to payers as well.

Given the extremely positive system and financial improvements resulting from remote monitoring of intensive care patients by critical care specialists, the effective implementation of tele-ICU technology will result in a win-win-win for patients, hospitals and payers in Massachusetts and in hospitals around the country. All of the important stakeholders and beneficiaries of this innovative technology should move forward with determination and haste to speed its adoption in every appropriate setting.

Appendix I:
Overview of the *FAST* Process



Source: NEHI.

Appendix II:
Observation Periods at UMMMC and Community Hospitals 1 and 2

Observation Periods at UMMMC

UMMMC							
		Pre Period			Post Period		
ICU Unit	Go-Live Date for Tele-ICU	First Admit	Last Admit	Days in Period	First Admit	Last Admit	Days in Period
1	6/30/2006	12/20/2005	6/26/2006	188	9/5/2006	9/28/2007	388
2	7/15/2006	9/30/2005	6/20/2006	263	8/17/2006	9/25/2007	404
3	1/7/2007	12/20/2005	2/10/2006	52	10/4/2006	9/27/2007	358
4	11/7/2006	12/22/2005	7/8/2006	208	12/2/2006	9/26/2007	298
5	11/2/2006	12/11/2005	7/8/2006	209	11/24/2006	9/27/2007	307
6	4/16/2007	2/13/2006	12/26/2006	316	8/6/2006	9/28/2007	418
7	4/16/2007	12/29/2005	7/1/2006	184	12/28/2006	9/29/2007	275

Source: PricewaterhouseCoopers, NEHI and MTC Tele-ICU Care Unit Project, March 3, 2010.

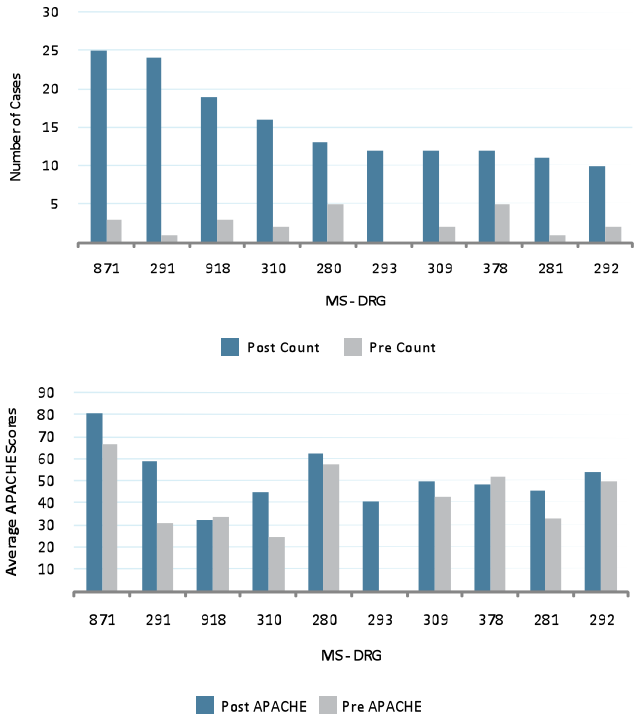
Observation Periods at Community Hospitals 1 and 2

	Pre Period				Post Period		
	Go-Live Date for Tele-ICU	First Admit	Last Admit	Days in Period	First Admit	Last Admit	Days in Period
Community Hospital 1	11/1/2007	2/15/2007	10/29/2007	256	4/19/2008	12/31/2008	256
Community Hospital 2	5/25/2008	6/4/2007	5/25/2008	356	6/4/2008	5/27/2009	357

Source: PricewaterhouseCoopers, NEHI and MTC Tele-ICU Care Unit Project, March 3, 2010.

Appendix III:
Top 10 High Volume DRG Comparisons in Community Hospitals 1 and 2

Community Hospital 1 – Top 10 High Volume DRG Comparisons

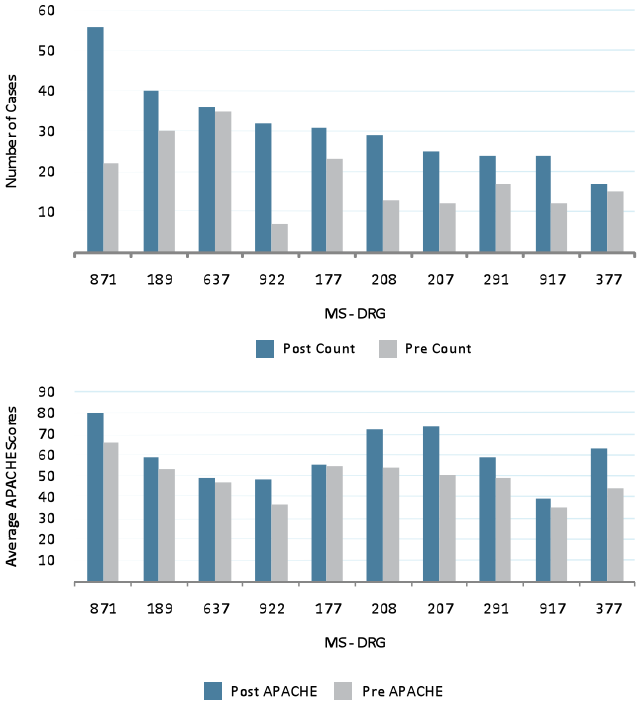


871	Septicemia or severe sepsis w/o MV 96+ hours w MCC
291	Heart failure & shock w MCC
918	Poisoning & toxic effects of drugs w/o MCC
310	Cardiac arrhythmia & conduction disorders w/o CC/MCC
280	Acute myocardial infarction, discharged alive w MCC
293	Heart failure & shock w/o CC/MCC
309	Cardiac arrhythmia & conduction disorders w CC
378	G.I. hemorrhage w CC
281	Acute myocardial infarction, discharged alive w CC
292	Heart failure & shock w CC

DRG 999 and NULL DRGs were excluded from this analysis.

Source: NEHI and MTC: Tele-Intensive Care Unit Project, March 2010

Community Hospital 2 – Top 10 High Volume DRG Comparisons



871	Septicemia or severe sepsis w/o MV 96+ hours w MCC
189	Pulmonary edema & respiratory failure
637	Diabetes w MCC
922	Other injury, poisoning & toxic effect diag w MCC
177	Respiratory infections & inflammations w MCC
208	Respiratory system diagnosis w ventilator support <96 hours
207	Respiratory system diagnosis w ventilator support 96+ hours
291	Heart failure & shock w MCC
917	Poisoning & toxic effects of drugs w MCC
377	G.I. hemorrhage w MCC

DRG 999 and NULL DRGs were excluded from this analysis.

Source: NEHI and MTC: Tele-Intensive Care Unit Project, March 2010

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Endnotes

1 Intensivists are physicians who specialize in critical care medicine. There are varying definitions of which physicians qualify as intensivists as board certification for intensivists only became available in the 1980s. The Leapfrog Group defines intensivists as board certified in critical care medicine, or in emergency medicine, or in select other specialties prior to 1987 and who have provided at least six weeks of full-time ICU care annually since 1987.

2 Pronovost PJ, et al. Physician staffing patterns and clinical outcomes in critically ill patients: A systematic review. JAMA. 2002;288(17):2151-62.

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12 See The Leapfrog Group's fact sheet on ICU Physician Staffing, available at http://www.leapfroggroup.org/media/file/FactSheet_IPS.pdf.

13 Personal communication from Brian Rosenfeld, MD, Philips VISICU, to NEHI, August, 2010.

14 The hospitals that installed and deactivated command centers were the following: Borgess Health Alliance, Jewish Hospital & St. Mary's HealthCare, Kaleida Health, Memorial Hermann Healthcare System, and New York Presbyterian Healthcare System.

15 NEHI surveyed hospitals to collect data on the number of hospitals with tele-ICU technology and the number of adult ICU beds being monitored by command centers. NEHI conducted surveys for calendar year 2006, 2009 and 2010. NEHI called U.S. hospitals and health systems believed to operate tele-ICU command centers to obtain data on the number of hospitals and adult ICU beds covered by the command centers. Senior administrative staff responded to telephone and e-mail inquiries with confirmations of the current operations of the command/support systems or data was retrieved online through press releases and/or health systems' websites.

16 AHA data is from FY06 and FY07, the most current data available. To estimate the percentage of hospitals in the U.S. with tele-ICU coverage, as well as the percentage of adult ICU beds with tele-ICU coverage, NEHI utilized hospital and ICU data from the American Hospital Association. See AHA Annual Survey of Hospitals for FY07, and AHA Annual Survey of Hospitals for FY06. Copyright: Health Forum, LLC, an affiliate of the American Hospital Association, 2009 and 2008.

17 Hospitals do not publish the costs of their tele-ICUs, but a few journal articles do offer examples. One published study of a tele-ICU managing two units calculated 6 month operating costs of $248,000 for hardware and software leasing, technical support, and operating expenses, with physician staffing costs adding an additional $624,000. Other hospitals and health systems have verbally reported higher operating costs of upwards of $1.5 million per year.

18 The Leapfrog Group's Patient Safety Practices, 2003: The Potential Benefits of Universal Adoption, February, 2004. Research Director: John D. Birkmeyer, MD.

19 Personal communication with Dr. C. Lilly, March 2010. Dr. Lilly stated that the University's ICU patient mean severity levels were lowered by the general surgery patients whose severity is much lower than trauma, cardiac or other specialized ICUs. Dr Lilly was not able to provide specific patient profile data for the individual university ICUs.

20 Personal communication with Dr. Mary Jo Gorman of Advanced ICU Care, August 2010.

NOTES

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