Project Title:	Measuring the Value of Remote Intensive Care Unit Monitoring
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Organization:	University of Texas Health Science Center at Houston
Mechanism:	RFA: HS04-012: Demonstrating the Value of Health Information Technology (THQIT)
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AHRQ Funding Amount:	$873,108
Summary Status as of:	September 2008, Conclusion of Grant

Strategic Goal: Develop and disseminate health IT evidence and evidence-based tools to improve the quality and safety of medication management via the integration and utilization of medication management systems and technologies.

Business Goal: Knowledge Creation

Summary: Patients in adult intensive care units (ICUs) require close monitoring, frequent invasive procedures, multiple medications, complicated decisionmaking processes, and multidisciplinary care. This complex care coupled with inadequate nurse-patient ratios, provider fatigue, on-the-job training, and poor communication can result in substantial morbidity, mortality, and costs. A powerful influence on the quality of ICU care is the presence of critical care physicians (intensivists) in the unit. Telemedicine, a common form of health information technology (IT), has been used to provide remote intensivist monitoring for ICUs. Remote ICUs connected via telemedicine technology (tele-ICUs) allow intensivists to simultaneously monitor more patients than possible by standard onsite care, and to extend intensivist care to patients in ICUs where intensivists would otherwise be unavailable, such as rural and small community hospitals. Furthermore, tele-ICUs may have decision support software to help identify subtle trends like rising creatinine and falling oxygen saturation that need to be addressed to prevent complications. The tele-ICU also makes intensivists more available to nurses.

A preliminary study was conducted over a 4-week period between November and December 2005 to determine how changes to the user interface in a tele-ICU could be improved. An ICU remote monitoring facility affiliated with a large health care system located in the Gulf Coast region was selected. The facility had been using the proprietary eICU® technology developed by VISICU, Inc., for 21 months and remotely monitored nine ICUs with a total of 132 beds in five of the health care system's hospitals at the time of the study. An electronic data collection tool was developed and implemented as a Microsoft Access Form application and installed on a tablet PC. The information collected included time-stamped tasks and activities, information resources (i.e., artifacts), participants, and any additional information manually entered by the observer. The survey of attitudes about safety and teamwork was given to the three ICUs that implemented the system at or around the beginning of the project—several others had either adopted the system earlier or had no plans to do so during the term of the grant. The results were compared with a baseline established by safety surveys administered annually to the whole network of hospitals. Quantitative data were captured, as well, highlighting the effect of tele-ICU on patient outcomes, including length of stay, conditions developed while admitted, and mortality rates (controlled for differences in severity of the initial diagnosis), as well as on hospital costs.

Specific Aims

- Use human factors engineering techniques to determine how changes to the user interface of the tele-ICU may increase the value of the technology. **(Achieved)**
- Measure changes in health care provider attitudes about teamwork and safety climate after implementation of the tele-ICU. **(Achieved)**
- Measure the effect of a tele-ICU on mortality, complications, and length of stay in ICUs in a tertiary care teaching hospital, and in seven community (including two "small") hospitals using a before-and-after study design. **(Achieved)**
- Measure the cost-effectiveness of the tele-ICU. (**Achieved)**

2008 Activities: Analyses of the data concluded in 2008, and papers were prepared for publication.

Impact and Findings: The preliminary study of tele-ICU workflows was valuable in familiarizing researchers with the function of the remote monitoring unit. It did not lead to changes made to the interface. The teamwork and safety surveys demonstrated significant improvements, which recommend this model for larger-scale trial implementations. The initial sample for patient outcomes consisted of 4,167 subjects. Elimination of cases with missing data yielded a final sample of 4,142 subjects, of whom 2,034 were pre-tele-ICU and 2,108 were post-tele-ICU. The crude ICU mortality rates were 12 percent pre- and 9.9 percent post-tele-ICU (p = .03). The dominant variable was severity of initial diagnosis, as measured by the Simplified Acute Physiologic Score (SAPS) II standards for intensive care, which assigns a value ranging from 0 to 150 to each patient, with higher numbers indicating more serious diagnoses. Patients with SAPS II > 50 (17 percent of the sample) had approximately 20 to 50 percent reduction in risk of hospital mortality depending upon the precise SAPS II score. These improvements in mortality did not hold for patients with SAPS II < 50.

Of the 4,142 patients, the 3,789 patients who survived to ICU transfer were analyzed for ICU length of stay (LOS). The crude mean hospital LOS for survivors in the pre-tele-ICU group was 9.8 days versus 10.7 days for the post-tele-ICU group (p = .006). The tele-ICU effect (p = .19) was moderated by linear and quadratic SAPS components ($p = 3.8\times10^{-6}$) such that only surviving patients with SAPS > 70 had shorter hospital LOS in the post-tele-ICU intervention. Secular trends toward declining mortality among ICU patients could have accounted for the reductions observed here. However, the fact that the observed mortality reduction occurred only among the patients most likely to benefit from this intervention (the most severely ill patients), and the large magnitude of the reduction, argues against the secular trend hypothesis and supports the hypothesis that the tele-ICU intervention caused the reduction in mortality. The sickest patients are those most likely to have unexpected changes in their medical condition that require rapid intervention (arrhythmia, hypotension, sepsis, hypoxia). The tele-ICU can provide this rapid response due to the constant monitoring (including computerized alerts for changes in key physiologic parameters) and availability of nurse and physician intensivists. Even among the sickest patients, this research needs replication, and there is a need to compare use of tele-ICU technology with less expensive, but also powerful, quality improvement interventions.

Selected Outputs

Chu-Weininger M, Wueste L, Lucke J, et al. The impact of a tele-ICU on provider attitudes about teamwork and safety climate. Qual Saf Health Care. 2010 Apr 27. [Epub ahead of print]

Thomas EJ, Lucke JF, Wueste L, et al. Association of telemedicine for remote monitoring of intensive care patients with mortality, complications, and length of stay. JAMA 2009;302(24):2671-8.

Tang Z, Weavind L, Mazabob J, et al. Workflow in intensive care unit remote monitoring: a time-and-motion study. Crit Care Med 2007;35(9):2057–63.

Grantee's Most Recent Self-Reported Quarterly Status: The project has completed.

Milestones: Progress is mostly on track.

Budget: Somewhat underspent, approximately 5 to 20 percent.