The Birth of Intensive Care Units

• Prior to 1950 hospitals had separate wards for post-operative recovery
• Modern intensive care began with Higher-risk surgeries

Enabling technologies
Cardiac Monitoring
Polio Epidemic
The Last Fifty Years

- Endotracheal intubation/positive pressure ventilation
- Advances in hemodynamic monitoring, organ support
- Intensive care as a physician specialty
Physician Staffing Patterns and Clinical Outcomes in Critically Ill Patients
A Systematic Review

Peter J. Pronovost, MD, PhD
Derek C. Angus, MB, ChB, MPH
Todd Dorma, MD
Karen A. Robinson, MSc
Tony T. Dremizov, MBA
Tammy L. Young

Approximately 1% of the US gross domestic product is consumed in the care of intensive care unit (ICU) patients. Despite this considerable investment of resources, there is wide variation in ICU organization, and

Context Intensive care unit (ICU) physician staffing varies widely, and its association with patient outcomes remains unclear.

Objective To evaluate the association between ICU physician staffing and patient outcomes.

Data Sources We searched MEDLINE (January 1, 1965, through September 30, 2001) for the following medical subject heading (MeSH) terms: intensive care units, ICU, health resources/utilization, hospitalization, medical staff, hospital organization and administration, personnel staffing and scheduling, length of stay, and LOS. We also used the following text words: staffing, intensivist, critical, care, and specialist. To identify observational studies, we added the MeSH terms case-control study and retrospective study. Although we searched for non-English-language citations, we reviewed only English-language articles. We also searched EMBASE, HealthStar (Health Services, Technology, Administration, and Research), and HSRPROJ (Health Services Research Projects in Progress) via Internet Grateful Med and The Cochrane Library and hand searched abstract proceedings from intensive care national scientific meetings (January 1, 1994, through December 31, 2001).

High intensity staffing associated with:
Lower hospital mortality RR 0.71
Lower ICU mortality  RR 0.61
Reduction in hospital LOS
Reduction in ICU LOS

Pronovost JAMA 2002;288:2151-2162
Do Intensivist Staffing Patterns Influence Hospital Mortality Following ICU Admission? A Systematic Review and Meta-Analyses*

M. Elizabeth Wilcox, MD, MSc; Christopher A. K. Y. Chong, MD;1
Daniel J. Niven, MD, MSc; Gordon D. Rubenfeld, MD, MSc; Kathryn M. Rowan, DPhil;2
Hannah Wunsch, MD, MSc;2 Eddy Fan, MD

Objective: To determine the effect of different intensivist staffing models on clinical outcomes for critically ill patients.

Data Sources: A sensitive search of electronic databases and hand-search of major critical care journals and conference proceedings was completed in October 2012.

Study Selection: Comparative observational studies examining intensivist staffing patterns and reporting hospital or ICU mortality were included.

*See also p. 2433.

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6Intensive Care National Audit and Research Centre, London, United Kingdom.
7Department of Anesthesiology, College of Physicians and Surgeons, Columbia University, New York, NY.
8Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY.

Dr. Wilcox conceived the study, searched the literature, selected studies for inclusion, abstracted data, analyzed data, wrote the first draft of the manuscript, and revised the manuscript. Drs. Chow and Fan selected studies for inclusion, abstracted data, verified analyses, and revised the manuscript. Drs. Niven and Wunsch abstracted data and revised the manuscript. Drs. Rubenfeld and Rowan provided feedback on study design and revised the manuscript. All authors approved the final manuscript.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s website (http://journals.lww.com/ccmjournal).

The authors have disclosed that they do not have any potential conflicts of interest.

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DOI: 10.1097/CCM.0b013e318292313a

The majority of ICUs in North America employ a low-intensity staffing model consisting of open units in which any physician can admit patients to the ICU and...
## Mortality

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Events</th>
<th>Control Events</th>
<th>Total</th>
<th>Weight</th>
<th>Risk Ratio M-H, Random, 95% CI</th>
</tr>
</thead>
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<tr>
<td>Al-Asadi et al 1996 (pro)</td>
<td>66</td>
<td>1005</td>
<td>55</td>
<td>1659</td>
<td>1.98 [1.40, 2.81]</td>
</tr>
<tr>
<td>Al-Asadi et al 1996 (ret)</td>
<td>66</td>
<td>1005</td>
<td>112</td>
<td>1404</td>
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</tr>
<tr>
<td>Baldock et al 2001</td>
<td>78</td>
<td>387</td>
<td>107</td>
<td>357</td>
<td>0.67 [0.52, 0.87]</td>
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<tr>
<td>Blunt et al 2001</td>
<td>93</td>
<td>393</td>
<td>113</td>
<td>328</td>
<td>0.69 [0.54, 0.87]</td>
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<tr>
<td>Brown et al 1989</td>
<td>53</td>
<td>216</td>
<td>79</td>
<td>223</td>
<td>0.69 [0.52, 0.93]</td>
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<tr>
<td>Carson et al 1996</td>
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<td>121</td>
<td>28</td>
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<td>Dimick et al 2001</td>
<td>7</td>
<td>182</td>
<td>24</td>
<td>169</td>
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<td>4</td>
<td>276</td>
<td>21</td>
<td>275</td>
<td>0.19 [0.07, 0.55]</td>
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<tr>
<td>Garland et al 1996</td>
<td>9</td>
<td>32</td>
<td>19</td>
<td>74</td>
<td>1.10 [0.56, 2.15]</td>
</tr>
<tr>
<td>Ghorra et al 1999</td>
<td>9</td>
<td>149</td>
<td>18</td>
<td>125</td>
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<tr>
<td>Goh et al 2001</td>
<td>42</td>
<td>355</td>
<td>82</td>
<td>264</td>
<td>0.38 [0.27, 0.53]</td>
</tr>
<tr>
<td>Hansen et al 1999</td>
<td>4</td>
<td>100</td>
<td>6</td>
<td>98</td>
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<td>Kim JH et al 2012</td>
<td>14</td>
<td>78</td>
<td>72</td>
<td>173</td>
<td>0.43 [0.26, 0.72]</td>
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<td>Lettieri et al 2009</td>
<td>9</td>
<td>223</td>
<td>52</td>
<td>742</td>
<td>0.58 [0.29, 1.15]</td>
</tr>
<tr>
<td>Levy et al 2008</td>
<td>3349</td>
<td>18618</td>
<td>2859</td>
<td>22870</td>
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<tr>
<td>Lin et al 2008</td>
<td>4884</td>
<td>50064</td>
<td>5707</td>
<td>37415</td>
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<td>Multz et al 1998 (pro)</td>
<td>52</td>
<td>185</td>
<td>36</td>
<td>95</td>
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<td>Multz et al 1998 (ret)</td>
<td>56</td>
<td>154</td>
<td>68</td>
<td>152</td>
<td>0.81 [0.62, 1.07]</td>
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<tr>
<td>Nathens et al 2006</td>
<td>528</td>
<td>5228</td>
<td>217</td>
<td>1561</td>
<td>0.73 [0.63, 0.84]</td>
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<tr>
<td>Pettiti et al 2012</td>
<td>52</td>
<td>1979</td>
<td>191</td>
<td>11399</td>
<td>1.57 [1.16, 2.12]</td>
</tr>
<tr>
<td>Pollack et al 1988</td>
<td>5</td>
<td>113</td>
<td>12</td>
<td>149</td>
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<tr>
<td>Pollack et al 1994</td>
<td>150</td>
<td>2036</td>
<td>115</td>
<td>2809</td>
<td>1.80 [1.42, 2.28]</td>
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<td>Pronovost et al 1999</td>
<td>131</td>
<td>2134</td>
<td>52</td>
<td>472</td>
<td>0.56 [0.41, 0.76]</td>
</tr>
<tr>
<td>Reynolds et al 1988</td>
<td>64</td>
<td>112</td>
<td>74</td>
<td>100</td>
<td>0.77 [0.63, 0.94]</td>
</tr>
<tr>
<td>Rivera et al 2009</td>
<td>20</td>
<td>115</td>
<td>22</td>
<td>105</td>
<td>0.83 [0.48, 1.43]</td>
</tr>
<tr>
<td>Sales et al 2011</td>
<td>1477</td>
<td>21287</td>
<td>664</td>
<td>12806</td>
<td>1.34 [1.22, 1.46]</td>
</tr>
<tr>
<td>Samuels et al 2011</td>
<td>98</td>
<td>386</td>
<td>85</td>
<td>317</td>
<td>0.95 [0.74, 1.22]</td>
</tr>
<tr>
<td>Singh et al 2008</td>
<td>30</td>
<td>50</td>
<td>35</td>
<td>44</td>
<td>0.75 [0.57, 0.99]</td>
</tr>
<tr>
<td>Suarez et al 2004</td>
<td>97</td>
<td>1180</td>
<td>127</td>
<td>1201</td>
<td>0.78 [0.60, 1.00]</td>
</tr>
<tr>
<td>Thurby et al 2005</td>
<td>68</td>
<td>471</td>
<td>16</td>
<td>62</td>
<td>0.56 [0.35, 0.90]</td>
</tr>
<tr>
<td>Topeli et al 2005</td>
<td>134</td>
<td>359</td>
<td>51</td>
<td>200</td>
<td>1.46 [1.11, 1.92]</td>
</tr>
<tr>
<td>Treggiari et al 2007</td>
<td>239</td>
<td>684</td>
<td>175</td>
<td>391</td>
<td>0.78 [0.67, 0.91]</td>
</tr>
<tr>
<td>Varelas et al 2004</td>
<td>116</td>
<td>1279</td>
<td>110</td>
<td>1087</td>
<td>0.90 [0.70, 1.15]</td>
</tr>
<tr>
<td>Wise et al 2012</td>
<td>97</td>
<td>528</td>
<td>61</td>
<td>828</td>
<td>2.49 [1.85, 3.37]</td>
</tr>
</tbody>
</table>

| Total (95% CI) | 111484 | 100078 | 100.0% | 0.83 [0.70, 0.99] |

- Total events: 12139
- Heterogeneity: Tau^2 = 0.21; Chi^2 = 1054.70, df = 33 (P < 0.00001); I^2 = 97%
- Test for overall effect: Z = 2.11 (P = 0.03)
### Length of Stay

**Figure 2.** Effect of high-intensity intensivist staffing compared to low-intensity staffing on hospital mortality (A) and length of stay (B). The pooled risk ratio and weighted mean difference with 95% CI were calculated using random-effects models. Weight refers to the contribution of each study to the overall estimate of treatment effect. \( \text{M–H} = \text{Mantel-Haenszel}. \)
24 Hour vs. Daytime

<table>
<thead>
<tr>
<th>Study or Subgroup</th>
<th>Experimental Events</th>
<th>Total</th>
<th>Control Events</th>
<th>Total</th>
<th>Weight</th>
<th>Risk Ratio M-H, Random, 95% CI</th>
<th>Risk Ratio M-H, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cajic et al 2008</td>
<td>251</td>
<td>1321</td>
<td>221</td>
<td>1301</td>
<td>16.6%</td>
<td>1.12 [0.95, 1.32]</td>
<td></td>
</tr>
<tr>
<td>Garland et al 2012</td>
<td>53</td>
<td>244</td>
<td>62</td>
<td>257</td>
<td>6.1%</td>
<td>0.90 [0.65, 1.24]</td>
<td></td>
</tr>
<tr>
<td>Netzer et al 2011</td>
<td>525</td>
<td>2424</td>
<td>326</td>
<td>1263</td>
<td>22.9%</td>
<td>0.84 [0.74, 0.95]</td>
<td></td>
</tr>
<tr>
<td>Rerianzi et al 2012</td>
<td>255</td>
<td>1697</td>
<td>228</td>
<td>1584</td>
<td>16.5%</td>
<td>1.04 [0.89, 1.23]</td>
<td></td>
</tr>
<tr>
<td>Resnick et al 2010</td>
<td>17</td>
<td>245</td>
<td>13</td>
<td>225</td>
<td>1.5%</td>
<td>1.20 [0.60, 2.42]</td>
<td></td>
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<tr>
<td>Wallace et al 2012</td>
<td>1842</td>
<td>14424</td>
<td>6872</td>
<td>51328</td>
<td>36.4%</td>
<td>0.95 [0.91, 1.00]</td>
<td></td>
</tr>
</tbody>
</table>

**Total (95% CI)**

- Total Events: 20355
- Total Control: 55958
- Weight: 100.0%
- Risk Ratio: 0.97 [0.89, 1.05]

**Heterogeneity**
- Tau² = 0.00; Chi² = 9.69, df = 5 (P = 0.08); I² = 48%
- Test for overall effect: Z = 0.80 (P = 0.42)

**Figure 3.** Effect of high-intensity during daytime only intensivist staffing compared to high-intensity 24-hr (daytime and nighttime) intensivist staffing on hospital mortality. The pooled risk ratio and 95% CI were calculated using random-effects models. Weight refers to the contribution of each study to the overall estimate of treatment effect. M-H = Mantel-Haenszel.
We currently provide two levels of care:

Daytime
Nights and weekends

“We have two standards of care in our hospitals, the first during the day Monday to Friday and the second, evenings, nights and weekends”

David Shulkin M.D., CEO, NEJM
May 2008
Minority of ICUs Are Staffed by Intensivists

Daytime staffing
- 52%: None
- 25%: Full
- 21%: Partial

Nighttime staffing
- 21%: No
- 4%: Yes

Angus, CCM 2006
If we train them they won’t work where we want them to work.
Intensivists Burnout

High level burnout is estimated in 46.5%
Severity of illness NOT related
Organizational factors strongly related

Workload
• # night shifts/month
• ↑ time from last non-working week
• prior night shift

Impaired relationships (MD and/or RN)

Quality of relationships with chief nurses/nurses associated with lower burnout score

Poncet AJRCCM 2007; 175: 698-704
High Cost of Care

- **10 - 15% are ICU Beds**
  
  Reference: HRSA

- **33% of hospital costs are accounted for in the ICU**
  
  Advisory Board & SCCM 2006

- **CC accounts for 20% of all hospital days**
  
  CCM 2008 vo.26 #12 Millbrandt

- **50% of Hospital Deaths are patients treated in the ICU**
  
  Leapfrog Group

$180 billion annually
Appearing on the Horizon…

77.3 million Boomers
"Health care has safety and quality problems because it relies on outmoded systems of work. If we want safer, higher-quality care, we will need to have redesigned systems of care".

The Institute of Medicine Report, Crossing the Quality Chasm, 2001
PRESS RELEASE
Cisco Study Reveals 74 Percent of Consumers Open to Virtual Doctor Visit
Results of Global Customer Experience Report Focused on Health Care Demonstrate Shift in Consumer Attitudes Toward Personal Data, Telemedicine and Access to Medical Information

The global report conducted in early 2013, includes responses from 1,547 consumers and HCDMs across ten countries. Additionally, consumers and HCDMs were polled from a wide variety of backgrounds and ages within each country.
Recent Literature

Telemed proves cost effective, says the Commonwealth Fund

Video Consultation for Trauma and Emergency Surgical Patients

A Home Telemonitoring Program Reduced Exacerbation and Healthcare Utilization Rates in COPD Patients with Frequent Exacerbations

Special Issue
The U.S. Army Telemedicine and m-Health Program: Making a Difference at Home and Abroad

Editorial
Tales of Telemedicine—Telepsychiatry at Work
Different Systems and Formats for Tele-ICU Coverage

Designing a Tele-ICU System to Optimize Functionality and Investment

H. Neal Reynolds, MD; Joseph Bander, MD; Mary McCarthy, BSN, RN

Technology always changes, yet change or evolution within the tele-ICU has been slow. In developing a modern telemedicine system to manage acute illness, there are several concepts the developer/administrator should consider to include “scalability,” centralized/decentralized systems, open/closed architecture, inclusivity of the medical community, mobile technology, price set, and governmental regulation. The intent of this manuscript is to apply these concepts to current tele-ICU technology, explain the concepts in some depth, and finally, to speculate as to how the future tele-ICU might look. Key words: architecture, centralized, decentralized, investment, regulatory guidance, scalability, systems, tele-ICU
Tele-ICU Care Delivery Models

- Decentralized tele-ICU
- Open Architecture
- Centralized, Closed Architecture
Figure 3. Decentralized tele-ICU system. Physicians are located remotely at offices, home, or may be mobile. Physicians may connect to a single or multiple medical facilities. Physicians may use a single technology (fixed sites at home or office) or may use multiple technologies including mobile. Background “cloud” indicates Internet connectivity.
Open Architecture, Centralized Tele-ICU

Figure 5. Open architecture system for the care of the acutely ill. Multiple specialties may access either the tele-ICU or the patient directly and do so from home, office, hospital-based site, or via mobile technology.
Closed Architecture, Tele-ICU

Figure 6. Closed architecture with connectivity to the patient generally limited to those care providers stationed at the tele-ICU site. Those care providers located outside the confines of the tele-ICU will not have audio-video access to the patient and will be limited to traditional connection to the tele-ICU staff.
Tele-ICU Care Delivery Models

- On demand, episodic care
- Organized, scheduled virtual rounding with on demand episodic care
- Continuous, proactive monitoring with on demand care
The Southwestern Surgical Congress

Robotic telepresence: a helpful adjunct that is viewed favorably by critically ill surgical patients

Joseph F. Sucher, M.D. a,*, S. Rob Todd, M.D. b, Stephen L. Jones, M.D. a, Terry Throckmorton, Ph.D., R.N. a, Krista L. Turner, M.D. a, Frederick A. Moore, M.D. c

aDepartment of Surgery, The Methodist Hospital, Weill Cornell Medical College, 6550 Fannin St., Smith Tower 1661, Houston, TX 77030, USA; bDepartment of Surgery, New York University Langone Medical Center, 550 First Ave., New York, NY 10016, USA; cDepartment of Surgery, University of Florida – Gainesville, 1600 Southwest Archer Rd., Gainesville, FL 32608, USA

KEYWORDS:
Robotic telepresence;
Intensive care unit;
Telemedicine;
Tele-ICU;
Telerounding

Abstract

BACKGROUND: The purpose of this study was to assess how surgical intensive care unit (SICU) patients and their families would perceive robotic telepresence. We hypothesized that they would view such technology positively.

METHODS: This research was an Institutional Review Board–approved prospective observational study. Our robotic telepresence program augmented the SICU multidisciplinary team rounding process. We anonymously surveyed patients and their families on their perceptions. Those who interacted at least once with the robot served as our participant base.

RESULTS: Twenty-four patients and 26 family members completed the survey. Ninety-two percent of respondents were comfortable with the robot, and 84% believed communication was “easy.” Ninety percent did not perceive the robot as “annoying” and 92% did not believe that “the doctor cared less about them” because of the robot. Ninety-two percent of respondents supported the continued use of the robot.

CONCLUSIONS: Robotic telepresence was viewed positively by patients and their families in the SICU. Furthermore, they believed the robot was beneficial to their care and indicated their support for its continued use.

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Robot
Continuous, proactive monitoring with on demand care
<table>
<thead>
<tr>
<th>Nomenclature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>VISICU</td>
<td>Software company that developed this product; it was purchased by Philips</td>
</tr>
<tr>
<td>eCareManager</td>
<td>The software that we run for the ICU-EMR</td>
</tr>
<tr>
<td>eICU</td>
<td>Trademarked name by VISICU for Tele-ICU</td>
</tr>
<tr>
<td>Tele-ICU</td>
<td>Generic term for ICU care using audiovisual and data feeds to provide comprehensive ICU care from a remote location</td>
</tr>
<tr>
<td>eCARE</td>
<td>The name we use for our tele-ICU</td>
</tr>
</tbody>
</table>
Tele-ICU Program

**CLINICAL TRANSFORMATION**

**PEOPLE**
Highly leveraged, centralized intensivist-led care team

**TECHNOLOGY**
Enabling tools
Continuous monitoring

**PROCESS**
System wide approach to critical care
Tele-ICU Programs

As of March 28, 2011
Effectively Managing the Population

- **Intensivist (1)**
  - Focused clinical oversight
  - Continuous rounding
  - Code management, supervise procedures
  - Write orders and brief progress notes

- **Critical Care Nurses (2-3)**
  - Triage patients
  - Filter Smart Alerts
  - Facilitate evidenced based practice
  - Mentor new/inexperienced staff

- **Computer Intelligence**
  - Actively screen data & provide Alert Functionality

**Screening Process**

100-130 Beds
Physician Station
What Is The Spectrum Of Practice Among Tele-ICU’s?

Board certified intensivists (Univ. of Maryland)

Internists/surgeons with FCCS certification (Banner & Avera)

Critical care PAs (UMass)

Experienced ICU nurses (variable patient ratios)

Pharmacists (Aurora)
A doctor living in far eastern Oklahoma was disciplined Thursday for prescribing violations and using Skype to treat patients under his care.

By Andrew Knittle
Modified: September 12, 2013 at 10:29 pm • Published: September 13, 2013

Dr. Thomas Trow, of Park Hill, was using the online service to treat patients with mental health issues. The doctor claimed he thought Skype was a suitable communication system for the practice of telemedicine, records show.

Skype is a relatively new technology that allows users to communicate over the Internet using a webcam, microphone or a text message.

Medical board documents show that Skype is not approved as a telemedicine communication system.

In March, a representative of the Oklahoma Health Care Authority alleged that Trow was “practicing telemedicine via Skype on SoonerCare members and prescribing (controlled dangerous drugs) without ever seeing the patients in person for an initial evaluation,” according to a June 14 complaint filed by a medical board investigator.

The investigator's complaint also showed that one of Trow's patients, identified only as R.C., was treated three times for drug overdoses in less than six months.

Trow was prescribing the patient Xanax and other powerful narcotic drugs at the time of the overdoses.

The patient known as R.C. died while under Trow's care — as did two other patients during the same time — but investigators said Thursday that those deaths were not attributable to Trow.

After board members reviewed his case Thursday afternoon, Trow was placed on probation for two years and ordered to complete a course on prescribing practices.
Tele-ICU Views
Mobile Cart for ED and Other Locations
Nursing

Shared Staffing Model

eCare COR

UMMC ICU’s
Board Certified Critical Care Physicians

- 7pm to 7am 7days/week
- 24 hours/day on weekends and holidays

1 eCare Physician per 100 to 120 “patients”
Local Personnel Requirements

Physician (may be a hospitalist) or non-physician critical care provider to place an admission note in the system and to write admission orders 24/7.

‘Proceduralist’ (may be a compilation of individuals) to perform:

1. Intubation
2. Central line placement (PICC lines may be an acceptable substitute in some situation).
3. Chest decompression
Deep Impact of Ultrasound in the Intensive Care Unit

The “ICU-sound” Protocol

Emilpaolo Manno, M.D.,* Mauro Navarra, M.D.,† Luciana Faccio, M.D.,† Mohtesch Motevallian, M.D.,† Luca Bertolaccini, M.D., Ph.D.,‡ Abdou Mfochivè, M.D.,† Marco Pesce, M.D.,† Andrea Evangelista, M.S.§

ABSTRACT

Background: Ultrasound can influence the diagnosis and impact the treatment plan in critical patients. The aim of this study was to determine whether, without encountering major environment- or patient-related limitations, ultrasound examination under a critical care ultrasonography protocol can be performed to detect occult anomalies, to prompt urgent changes in therapy or induce further testing or interventions, and to confirm or modify diagnosis.

Methods: One hundred and twenty-five consecutive patients admitted to a general intensive care unit were assessed under a critical care ultrasonography protocol, and the data were analyzed prospectively. Systematic ultrasound examination of the optic nerve, thorax, heart, abdomen, and venous system was performed at the bedside.

Results: Environmental conditions hampered the examination slightly in 101/125 patients (80.8%), moderately in 20/125 patients (16%), and strongly in 4/125 patients (3.2%). Ultrasonographic findings modified the admitting diagnosis in 32/125 patients (25.6%), confirmed it in 73/125 patients (58.4%), were not effective in confirming or modifying it in 17/125 patients (13.6%), and missed it in 3/125 patients (2.4%). Ultrasonographic findings prompted further testing in 23/125 patients (18.4%), led to changes in medical therapy in 22/125 patients (17.6%), and to invasive procedures in 27/125 patients (21.6%).

Conclusions: In this series of patients consecutively admitted to an intensive care unit, ultrasound examination revealed a high prevalence of unsuspected clinical abnormalities, with the highest number of new ultrasound abnormalities detected in patients with septic shock. As part of rapid global assessment of the patient on admission, our ultrasound protocol holds potential for improving healthcare quality.

What We Already Know about This Topic

- Ultrasound examination is now being utilized in the intensive care unit to detect lung abnormalities and recruitment

What This Article Tells Us That Is New

- Transthoracic ultrasound examination can be used to diagnose a multitude of abnormalities, helped modify admitting diagnoses in 26% of patients, led to changes in medical therapy in 18% of patients, and prompted invasive procedures in 22% of patients

APID and accurate diagnosis and treatment are crucial.

Manno et al., Anesthesiology 2012; 117:801–9
‘The Remote Physical Exam’

<table>
<thead>
<tr>
<th>Clinical Diagnosis</th>
<th>Ultrasound Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologic examination</td>
<td>Optic nerve sheath diameter more than 5 mm</td>
</tr>
<tr>
<td>Intracranial hypertension</td>
<td>Absence of “lung sliding,” absence of B-lines, detection of the “lung point”</td>
</tr>
<tr>
<td>Thoracic examination</td>
<td>Hypoechoic area with an air bronchogram: static or dynamic</td>
</tr>
<tr>
<td>Pneumothorax</td>
<td>More than 3 B-lines/examined area; extended from the lung bases to the medium and</td>
</tr>
<tr>
<td></td>
<td>superior fields, bilaterally, symmetrically, without pleural line abnormalities</td>
</tr>
<tr>
<td>Lung consolidation</td>
<td>Nonhomogeneous B-line distribution (more than 3 B-lines/examined area); presence</td>
</tr>
<tr>
<td></td>
<td>of spared areas and pleural line abnormalities; subpleural consolidations</td>
</tr>
<tr>
<td>Cardiogenic pulmonary edema</td>
<td>Echo-poor or echo-free space between the pleura visceralis and parietal pleura</td>
</tr>
<tr>
<td>ARDS/ALI</td>
<td>Bilateral A lines with lung sliding</td>
</tr>
<tr>
<td>Pleural effusion</td>
<td>Moderate/severe valvular insufficiency/stenosis</td>
</tr>
<tr>
<td>Asthma/COPD/Normal lung aeration</td>
<td>EF less than 35%</td>
</tr>
<tr>
<td>Heart examination</td>
<td>LA more than 5 cm, LV more than 6 cm</td>
</tr>
<tr>
<td>Valvular disease</td>
<td>Moderate/severe pericardial effusion more than 2 cm</td>
</tr>
<tr>
<td>EF &lt;35%</td>
<td>Valve vegetation</td>
</tr>
<tr>
<td>LV, LA dilatation</td>
<td></td>
</tr>
<tr>
<td>Dilated RV, RA with overload pattern</td>
<td></td>
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<tr>
<td>Pericardial effusion</td>
<td></td>
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<tr>
<td>Valve vegetation</td>
<td></td>
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<tr>
<td>LVH</td>
<td></td>
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<td>Abnormal abdomen examination</td>
<td></td>
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<tr>
<td>Abdominal distension</td>
<td></td>
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<tr>
<td>Peritoneal effusion</td>
<td></td>
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<tr>
<td>Cholecystitis</td>
<td></td>
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<tr>
<td>Hydronephrosis</td>
<td>Anechogenic or moderately echogenic pattern</td>
</tr>
<tr>
<td>Gallbladder distension, pericholecystic fluid, gallbladder</td>
<td>more than 3.5 mm, Echo-Murphy sign</td>
</tr>
<tr>
<td>Dilated pelvis and collecting system, hypoechoic area</td>
<td>in the kidney hilum</td>
</tr>
<tr>
<td>in the kidney hilum</td>
<td></td>
</tr>
<tr>
<td>Parenteral abnormalities (pancreas, spleen liver,</td>
<td>Parenchimal abnormalities, bladder assessment for retention</td>
</tr>
<tr>
<td>kidney, bladder)</td>
<td></td>
</tr>
<tr>
<td>Abnormal venous system examination</td>
<td></td>
</tr>
<tr>
<td>DVT positive vein compression test</td>
<td>Positive vein compression test</td>
</tr>
</tbody>
</table>

ALI = acute lung injury; ARDS = adult respiratory distress syndrome; COPD = chronic obstructive pulmonary disease; DVT = deep vein thrombosis; EF = ejection fraction; ICU = intensive care unit; LA = left atrium; LV = left ventricle; LVH = left ventricular hypertrophy; RA = right atrium; RV = right ventricle.
1. If the left ventricle is hyperdynamic with endsystolic effacement, there is a high probability of fluid responsiveness.
2. If the IVC is ≤ 1 cm in diameter, there is a high probability of fluid responsiveness.
3. If the IVC is ≥ 2.5 cm in diameter, there is a low probability of fluid responsiveness.
4. If the IVC is between 1 and 2.5 cm, there is an indeterminate probability of fluid responsiveness.
Protocols

eCare will utilize local protocols if already in place and current.

Adoption of common protocols is recommended if they are not already in place.

Glucose Management

Sedation

Ventilator weaning

Sepsis

Hypothermia

Electrolyte Replacement- Real Challenge for Busy Tele-ICU
Original Research
Resident Perceptions of a Tele-Intensive Care Unit Implementation

Christian Coletti, M.D., Daniel J. Elliott, M.D., MSCE, and Marc T. Zubrow, M.D., FACP, FCCP, FCCM
Christiana Care Health System, Newark, Delaware.

Abstract
Objective: Remote intensive care unit (ICU) monitoring (tele-ICU) may provide a means to address the shortage of intensive care physicians. However, the consequences of implementing a tele-ICU system for house staff education and clinical experience are unknown. The purpose of this study was to determine resident perceptions of the impact of a tele-ICU implementation on patient care, education, and the overall work environment. Materials and Methods: Cross-sectional survey of residents who rotated through the medical ICU within the first year after the implementation of a tele-ICU in a large, academically affiliated, community hospital. Each question was graded on a 5-point Likert scale. Results: Thirty-five of 60 residents completed the survey (58% response rate). Sixty-three percent of residents reported that tele-ICU was associated with an improved ability to focus on urgent patient issues, and 46% thought that tele-ICU helped them to feel less overwhelmed. Although most residents were neutral (51%), 37% agreed that the tele-ICU was a valuable educational experience. Seventy-seven percent reported that the tele-ICU integration was associated with improved patient safety, but many were concerned about its impact on continuity and communication. There was no perceived association with patient or family satisfaction. Conclusions: Our study suggests that a tele-ICU implementation in a medical ICU does not seem to have a negative impact on the educational experience of residents and is associated with perceived improvements in patient safety and quality. Future studies should objectively measure the educational impact of implementing a tele-ICU system.

Key words: telemedicine, information management, technology

Introduction
Intensive Care Units (ICUs) are populated with increasingly complex patients. Evidence suggests that care delivered by an intensivist is associated with improved outcomes, including decreases in medical errors, complication rates, ICU length of stay, and ICU mortality. Uniform intensivist staffing of ICUs has been projected to save >50,000 lives annually in the United States. Notably, the Leapfrog Group recommends an intensivist-led ICU team with daily rounding and 24-h availability.

Unfortunately, there is a well-recognized shortage of ICU physicians. A consensus statement by the Committee on Manpower for Pulmonary and Critical Care Societies estimates a current deficit of 30,000 intensivists to appropriately staff current U.S. ICUs, and this deficit is projected to increase in the future. Therefore, new solutions are needed to leverage the current physician supply through other care delivery systems.

Remote monitoring through technology, or tele-ICU, may provide a means to address the intensivist shortage. Tele-ICU allows for intensivists to simultaneously support bedside caregivers at multiple ICUs from a remote location. Sophisticated computer software continuously monitors all patients simultaneously and alerts the tele-ICU physician to changes in physiologic parameters and laboratory tests. Additionally, the software prompts caregivers to address quality measures in real time. Perhaps most importantly, the tele-ICU physician is immediately available with the assistance of audiovisual equipment to provide medical assessment and care to the on-site clinical team.

Tele-ICU systems have generally been associated with improved patient outcomes, though a recent multisite study suggests that this may only be applicable to the most critically ill patients. However, a key issue that may determine the ultimate expansion of this technology will be the acceptance by direct bedside providers, including resident physicians. Acceptance may hinge upon the bedside providers’ perception of benefit to patient care and, particularly for house staff, implications for the educational experience in the ICU. There is currently limited data available to assess house staff acceptance and/or perceived benefit of an implemented tele-ICU. Therefore, we conducted a cross-sectional survey of residents after implementation of a tele-ICU to determine resident perceptions of the workflow redesign, impact on patient care, resident education, and improvement in the work environment.

Methods
STUDY DESIGN AND POPULATION
We performed a cross-sectional survey of residents who rotated through the medical ICU during the 1 year after a tele-ICU implementation at a large, 1,100-bed tertiary-care community hospital. Residents were enrolled in an Emergency Medicine/Internal Medicine, Internal Medicine/Pediatrics, or Categorical Medicine programs during the 2007–2008 academic year.

RESEARCH SETTING AND TELE-ICU IMPLEMENTATION
Christiana Care Health System (CCHS) is a tertiary-care, academically affiliated, community hospital. We have 228 residents in 15 programs. The Medical ICU has a nursing ratio of 1:1 to 1:2; dedicated respiratory therapists with protocolized weaning of ventilated patients; and daily collaborative rounds with physicians, nurses,
What the Tele-ICU Program is **NOT**

**NOT** a replacement for the bedside ICU team (physicians or nurses)

**NOT** merely a slaved remote presentation of the bedside monitors intended for monitor watching

**NOT** have any impact on the ability of the bedside team to bill
Tele-ICU Physician’s Role As A Member Of The ICU Team

Think of him/her as the Intensivist on call - present and available when the regular intensivist is not there!
Impact of ICU Telemedicine Programs on Rural Health Care System

Rural Healthcare
40% of US hospitals in rural area
25% of population → 10% of physicians
Sub-specialist Care
• Urban → 134.1/100,000
• Rural → 40.1/100,000

Study Hospitals
1,000,000 pts over >1,550 sq. miles
1 tertiary care hospital (506 beds)
3 Regional Hospitals (10,6,10 ICU beds)
2 Community Hospitals (< 100 total beds)
9 Critical Access Hospital (<25 beds)

Zawada ET Post Grad Med 2009: 121; 160-170
Survey Small/Critical Access Hospitals

- The technology is easy to work with
- Patient & families are comfortable staying in our hospital with the added care
- We are more comfortable caring for critically ill patients
- Families appreciate the benefits we are providing
- Quality of care for our sickest patients is improved
- Every small or critical access hospital should have this program

-37.5% reduction in number of patients requiring transfer (cost of transfer $5815-$10,889/pt)

Zawada ET Post Grad Med 2009: 121; 160-170
Impact of Telemedicine

Rural Healthcare Financial

- LOS major determinant of ICU cost
- Calculation of ROI
- $8,000,000 total cost savings
- $1,250,000 transfer cost savings
- System start up costs → $2,757,000
- System operating cost → $2,307,000/yr

Zawada ET Post Grad Med 2009: 121; 160-170
Association of Telemedicine for Remote Monitoring of Intensive Care Patients With Mortality, Complications, and Length of Stay

Eric J. Thomas, MD, MPH
Joseph F. Lucke, PhD
Laura Wueste, RN
Lisa Weavind, MD
Bela Patel, MD

Context  Telemedicine technology, which can enable intensivists to simultaneously monitor several intensive care units (ICUs) from an off-site location, is increasingly common, but there is little evidence to support its use.

Objective  To assess the association of remote monitoring of ICU patients (ICU telemedicine [tele-ICU]) with mortality, complications, and length of stay (LOS).

Design, Setting, and Patients  Observational study conducted in 6 ICUs of 5 hospitals in a large US health care system to assess the use of tele-ICU. The study included 2034 patients in the preintervention period (January 2003 to August 2005) and 2108 patients in the postintervention period (July 2004 to July 2006).

Main Outcome Measures  Hospital and ICU mortality, complications, and hospital and ICU survivors’ LOS, with outcomes adjusted for severity of illness.

Results  Local physicians delegated full treatment authority to the tele-ICU for 655 patients (31.1%) and authority to intervene only in life-threatening events for the remainder. Observed hospital mortality rates were 12.0% (95% confidence interval [CI], 10.6% to 13.5%) in the preintervention period and 9.9% (95% CI, 8.6% to 11.2%) in the postintervention period (preintervention to postintervention decrease, 2.1%; 95% CI, 0.2% to 4.1%; P= .03); observed ICU mortality rates were 9.2% (95% CI, 8.0% to 10.5%) in the preintervention period and 7.8% (95% CI, 6.7% to 9.0%) in the postintervention period (preintervention to postintervention decrease, 1.4%; 95% CI, -0.3% to 3.2%; P= .12). After adjustment for severity of illness, there were no significant differences associated with the telemedicine intervention for hospital mortality (relative risk, 0.85; 95% CI, 0.71 to 1.02) or ICU mortality (relative risk, 0.88; 95% CI, 0.71 to 1.08). There was a significant interaction between the tele-ICU intervention and severity of illness (P < .001), in which tele-ICU was associated with improved survival in sicker patients but with no improvement or worse outcomes in less sick patients. There were no significant differences between the preintervention and postintervention periods for hospital or ICU LOS.

Conclusion  Remote monitoring of ICU patients was not associated with an overall improvement in mortality or LOS.

JAMA. 2009;302(24):2671-2678  www.jama.com
Figure. Observed and Adjusted Hospital Mortality Rates Among Intensive Care Units (ICUs) Before and After Implementation of Remote Monitoring of Patients (Tele-ICU)

For each ICU type, leftmost data markers indicate rates before tele-ICU implementation; rightmost data markers, rates after tele-ICU implementation. Adjusted mortality rates were adjusted for unit effects and Simplified Acute Physiology Score II values. Error bars indicate 95% confidence intervals for adjusted values.
Clinical and economic outcomes of the electronic intensive care unit: Results from two community hospitals*

Jeanette L. Morrison, MD; Qian Cai, MS, MSPH; Nancy Davis, MA; Yan Yan, MD, MS; Michael L. Berbaum, PhD; Michael Ries, MD; Glen Solomon, MD

Objective: To determine the impact of a telemedicine system, the electronic intensive care unit (eICU), on ICU, and non-ICU mortality, total mortality, total and ICU-specific length of stay, and total hospital cost at two community hospitals.

Design: Observational study with one baseline period and two comparison periods (eICU wave one and eICU wave two). Each time period was 4 months in duration.

Setting: Four ICU from two community hospitals in the metropolitan Chicago area. Hospital one is a 610-bed teaching hospital with three adult ICU (ten-bed medical ICU, ten-bed cardiac ICU, and 14-bed surgical ICU). Hospital two is a 185-bed nonteaching hospital with a ten-bed mixed medical/surgical ICU.

Patients: All patients 18 yrs or older with an ICU stay of at least 4 hrs during the specified time period were included.

Interventions: The eICU was implemented at both hospitals in April 2003.

Measurements and Main Results: Mortality, length of stay, and total cost were measured. Age, gender, race/ethnicity, trauma status, Acute Physiology and Chronic Health Evaluation III score, and physician utilization of the eICU were included as covariates.

Included in the analysis were 4088 patients (1371 at baseline, 1287 in eICU wave one, and 1430 in eICU wave two). The eICU did not have a significant effect on ICU/non-ICU/total mortality or hospital length of stay. ICU length of stay increased over time and was associated with higher physician utilization of the eICU. Although total hospital costs increased over time, the rate of increase was steeper for those patients whose physicians permitted only a low level of eICU involvement.

Conclusions: In our study of >4000 patients representing two community hospitals, we did not find a reduction in mortality, length of stay, or hospital cost attributable to the introduction of the eICU. (Crit Care Med 2010; 38:2–8)

Key Words: telemedicine; health outcomes; intensive care unit staffing

Only 21% Category III Patients
Contributing Factors for These Results

- Very low physician engagement as evidenced by the low percentage of category III physicians.
- Little administrative support in the Houston situation.
Costs and cost-effectiveness of a telemedicine intensive care unit program in 6 intensive care units in a large health care system

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Keywords:
Economic analysis;
Telemedicine;
Intensive care units

Abstract

Purpose: The purpose of this study is to estimate the costs and cost-effectiveness of a telemedicine intensive care unit (ICU) (tele-ICU) program.

Materials and Methods: We used an observational study with ICU patients cared for during the pre-tele-ICU period and ICU patients cared for during the post-tele-ICU period in 6 ICUs at 5 hospitals that are part of a large nonprofit health care system in the Gulf Coast region. We obtained data on a sample of 4142 ICU patients: 2034 in the pre-tele-ICU period and 2108 in the post-tele-ICU period. Economic outcomes were hospital costs, ICU costs and floor costs, measured for average daily costs, costs per case, and costs per patient.

Results: After the implementation of the tele-ICU, the hospital daily cost increased from $4302 to $5340 (24%); the hospital cost per case, from $21,967 to $31,318 (43%); and the cost per patient, from $20,231 to $25,846 (28%). Although the tele-ICU intervention was not cost-effective in patients with Simplified Acute Physiology Score II 50 or less, it was cost-effective in the sickest patients with Simplified Acute Physiology Score II more than 50 (17% of patients) because it decreased hospital mortality without increasing costs significantly.

Conclusions: Hospital administrators may conclude that a tele-ICU program aimed at the sickest patients is cost-effective.

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Association of Health Information Technology and Teleintensivist Coverage With Decreased Mortality and Ventilator Use in Critically Ill Patients

Matthew McCambridge, MD; Kari Jones, PhD; Hannah Paxton, RN, MPH; Kathy Baker, RN, MPH; Elliot J. Sussman, MD; Jeff Etchason, MD

Background: Little evidence exists to support implementing various health information technologies, such as telemedicine, in intensive care units.

Methods: A coordinated health information technology bundle (HITB) was implemented along with remote intensivist coverage (RIC) at a 727-bed academic community hospital. Critical care specialists provided bedside coverage during the day and RIC at night to achieve intensivist coverage 24 hours per day, 7 days per week. We evaluated the effect of HITB-RIC on mortality, ventilator and vasopressor use, and the intervention length of stay. We compared our results with those achieved at baseline.

Results: A total of 954 control patients who received care for 16 months before the implementation of HITB-RIC and 959 study patients who received care for 10 months after the implementation were included in the analysis. Mortality for the control and intervention groups were 21.4% and 14.7%, respectively. In addition, the observed mortality for the intervention group was 75.8% (P < .001) of that predicted by the Acute Physiology and Chronic Health Evaluation IV hospital mortality equations, which was 29.5% lower relative to the control group.

Regression results confirm that the hospital mortality of the intensive care unit patients was significantly lower after implementation of the intervention, controlling for predicted risk of mortality and do-not-resuscitate status. Overall, intervention patients also had significantly less (P = .001) use of mechanical ventilation, controlling for body-system diagnosis category and severity of illness.

Conclusion: The use of HITB-RIC was associated with significantly lower mortality and less ventilator use in critically ill patients.

Arch Intern Med. 2010;170(7):648-653
Lehigh Valley Health Network

ICU LOS 4.06 to 3.77 days; Ventilator use 36.1% to 31.5% (p=.001)

Arch Intern Med. 2010;170:648-653
Hospital Mortality, Length of Stay, and Preventable Complications Among Critically Ill Patients Before and After Tele-ICU Reengineering of Critical Care Processes

Craig M. Lilly, MD
Shawn Cody, MSN/MBA, RN
Huifang Zhao, PhD
Karen Landry
Stephen P. Baker, MScPH
John Mellwine, DO
M. Willis Chandler, MBA
Richard S. Irwin, MD
for the University of Massachusetts Memorial Critical Care Operations Group

Context The association of an adult tele-intensive care unit (ICU) intervention with hospital mortality, length of stay, best practice adherence, and preventable complications for an academic medical center has not been reported.

Objective To quantify the association of a tele-ICU intervention with hospital mortality, length of stay, and complications that are preventable by adherence to best practices.

Design, Setting, and Patients Prospective stepped-wedge clinical practice study of 6290 adults admitted to any of 7 ICUs (3 medical, 3 surgical, and 1 mixed cardiovascular) on 2 campuses of an 834-bed academic medical center that was performed from April 26, 2005, through September 30, 2007. Electronically supported and monitored processes for best practice adherence, care plan creation, and clinician response times to alarms were evaluated.

Main Outcome Measures Case-mix and severity-adjusted hospital mortality. Other outcomes included hospital and ICU length of stay, best practice adherence, and complication rates.

Results The hospital mortality rate was 13.6% (95% confidence interval [CI], 11.9%-15.4%) during the pre-intervention period compared with 11.8% (95% CI, 10.9%-12.8%) during the tele-ICU intervention period (adjusted odds ratio [OR], 0.40 [95% CI, 0.31-0.52]). The tele-ICU intervention period compared with the pre-intervention period was associated with higher rates of best clinical practice adherence for the prevention of deep vein thrombosis (99% vs 85%, respectively; OR, 15.4 [95% CI, 11.3-21.1]) and prevention of stress ulcers (96% vs 83%, respectively; OR, 4.57 [95% CI, 3.91-5.77]), best practice adherence for cardiovascular protection (99% vs 80%, respectively; OR, 3.07 [95% CI, 19.3-49.2]), prevention of ventilator-associated pneumonia (52% vs 33%, respectively; OR, 2.20 [95% CI, 1.79-2.70]), lower rates of preventable complications (1.6% vs 13%, respectively, for ventilator-associated pneumonia [OR, 0.15; 95% CI, 0.09-0.23] and 0.6% vs 1.0%, respectively, for catheter-related bloodstream infection [OR, 0.60; 95% CI, 0.27-0.93]), and shorter hospital length of stay (9.8 vs 13.3 days, respectively; hazard ratio for discharge, 1.44 [95% CI, 1.33-1.56]). The results for medical, surgical, and cardiovascular ICUs were similar.

Conclusion In a single academic medical center study, implementation of a tele-ICU intervention was associated with reduced adjusted odds of mortality and reduced hospital length of stay, as well as with changes in best practice adherence and lower rates of preventable complications.
UMASS Memorial

800+ bed academic medical center with 7 adult ICUs

2004 – instituted central governance of ICUs:

- Bi-weekly CCOC meetings
- Best practice targets & checklists
- VP oversight and designated ‘head of critical care’
- Compensation tied to performance
U Mass Study
Major Outcome Data

Adjusted Odd Ratios

Hospital Mortality  ICU LOS
0.40  0.35

Lilly, C. et.al. JAMA 2011:305
## Daytime vs Off-hour Admissions

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Baseline Period</th>
<th>Tele-ICU Period</th>
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<tr>
<td></td>
<td>Daytime admission</td>
<td>Off-hours admission</td>
</tr>
<tr>
<td><strong>Hospital Mortality (%)</strong></td>
<td>11.5</td>
<td>16.1</td>
</tr>
<tr>
<td><strong>ICU Mortality (%)</strong></td>
<td>9.1</td>
<td>12.6</td>
</tr>
<tr>
<td><strong>Hospital LOS (d)</strong></td>
<td>12.4 (16.9)</td>
<td>14.2 (17.2)</td>
</tr>
<tr>
<td><strong>ICU LOS (d)</strong></td>
<td>5.5 (8.9)</td>
<td>7.7 (12.6)</td>
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<td>2.2 [1.2-5.1]</td>
<td>3.1 [1.5-8.5]</td>
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</table>

Lilly, C, et al. *JAMA* 2011, 305
Impact of Telemedicine Intensive Care Unit Coverage on Patient Outcomes

A Systematic Review and Meta-analysis

Lance Brendan Young, PhD, MBA; Paul S. Chan, MD, MSc; Xin Lu, MS; Brahmajeek K. Nallamothu, MD, MPH; Comilla Sasson, MD, MS; Peter M. Cram, MD, MBA

**Background:** Although remote intensive care unit (ICU) coverage is rapidly being adopted to enhance access to intensivists, its effect on patient outcomes is unclear. We conducted a meta-analysis to examine the impact of telemedicine ICU (tele-ICU) coverage on mortality and length of stay (LOS).

**Methods:** We conducted a systematic review of studies published from January 1, 1950, through September 30, 2010, using PubMed, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Global Health, Web of Science, the Cochrane Library, and conference abstracts. We included studies that reported data on the primary outcomes of ICU and in-hospital mortality or on the secondary outcomes of ICU and hospital LOS.

**Results:** We identified 13 eligible studies involving 35 ICUs. All the studies used a before-and-after design. The studies included 41,374 patients (15,667 pre–tele-ICU and 25,707 post–tele-ICU patients). Tele-ICU coverage was associated with a reduction in ICU mortality (pooled odds ratio, 0.80; 95% confidence interval [CI], 0.66-0.97; *P* = .02) but not in-hospital mortality for patients admitted to an ICU (pooled odds ratio, 0.82; 95% CI, 0.65-1.03; *P* = .08). Similarly, tele-ICU coverage was associated with a reduction in ICU LOS (mean difference, −1.26 days; 95% CI, −2.21 to −0.30; *P* = .01) but not hospital LOS (mean difference, −0.64; 95% CI, −1.52 to 0.25; *P* = .16).

**Conclusion:** Tele-ICU coverage is associated with lower ICU mortality and LOS but not with lower in-hospital mortality or hospital LOS.

*Arch Intern Med. 2011;171(6):498-506*
Aggregate Pre and Post-Implementation of eICU Program
21 Health Systems

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<th>Pre</th>
<th>Post</th>
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<tr>
<td>Hospital SMR</td>
<td>0.94</td>
<td>0.75</td>
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<tr>
<td>ICU LOS Ratio</td>
<td>1.26</td>
<td>0.97</td>
</tr>
<tr>
<td>Hospital LOS Ratio</td>
<td>1.01</td>
<td>0.87</td>
</tr>
</tbody>
</table>

-20% → 23%
-14%
A Multi-center Study of ICU Telemedicine Reengineering of Adult Critical Care

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Dr. McLaughlin is a salaried employee and stock holder of Pfizer Inc.

Dr. Irwin has disclosed that while his institution has purchased their tele-ICU product from VISICU, now owned by Phillips Medical Systems, neither he nor anyone else has any financial relationship with the company. Dr. Irwin discloses that the review of this manuscript and the ultimate decision to publish it was made by others without his knowledge.

All other authors have no conflicts of interest to disclose.
Unadjusted case fatality rates
Hospital
(10.8 vs. 9.9; p = 0.003)
ICU
(7.8 vs. 5.8, p < 0.01)

Unadjusted length of stays
Hospital
(10.3 ± 18.7 vs. 9.7 ± 14.1)
ICU
(4.4 ± 12.1 vs. 3.5 ± 5.5)
Both p < 0.001

All were significantly lower in the tele-ICU group than in the pre-intervention group.
Outcomes

- 26% more likely to survive the ICU;
- Discharged from the ICU 20% faster;
- 16% more likely to survive hospitalization and be discharged;
- Discharged from the hospital 15% faster.
PROPOSED MECHANISMS OF EFFECTIVENESS

1. Early intensivist management
2. Strong adherence to best practices
3. Shorter response to alarms
4. Frequent interdisciplinary rounds
Unanswered Questions; Etiology of the Successes

- Is the success related:
  a) ‘Early Warning Software’
  b) Just by having an intensivist readily available with a relatively complete data set available for review?

- Is the easy availability of the intensivist leading to more frequent communication with the bedside caregivers thus leading to more thorough and timely care of the patient?

- Is the nursing staff in the COR ‘pushing’ therapy forward in collaboration with the bedside team, reducing complications, LOS, etc.?
The Costs of Critical Care Telemedicine Programs
A Systematic Review and Analysis

Gaurav Kumar, MD; Derik M. Falk, MD; Robert S. Bonello, MD; Jeremy M. Kahn, MD; Eli Perencevich, MD; and Peter Cram, MD, MBA

Background: Implementation of telemedicine programs in ICUs (tele-ICUs) may improve patient outcomes, but the costs of these programs are unknown. We performed a systematic literature review to summarize existing data on the costs of tele-ICUs and collected detailed data on the costs of implementing a tele-ICU in a network of Veterans Health Administration (VHA) hospitals.

Methods: We conducted a systematic review of studies published between January 1, 1990, and July 1, 2011, reporting costs of tele-ICUs. Studies were summarized, and key cost data were abstracted. We then obtained the costs of implementing a tele-ICU in a network of seven VHA hospitals and report these costs in light of the existing literature.

Results: Our systematic review identified eight studies reporting tele-ICU costs. These studies suggested combined implementation and first year of operation costs for a tele-ICU of $50,000 to $100,000 per monitored ICU-bed. Changes in patient care costs after tele-ICU implementation ranged from a $3,000 reduction to a $5,600 increase in hospital cost per patient. VHA data suggested a cost for implementation and first year of operation of $70,000 to $87,000 per ICU-bed, depending on the depreciation methods applied.

Conclusions: The cost of tele-ICU implementation is substantial, and the impact of these programs on hospital costs or profits is unclear. Until additional data become available, clinicians and administrators should carefully weigh the clinical and economic aspects of tele-ICUs when considering investing in this technology.

CHEST 2013; 143(1):19–29

Abbreviations: CIS = Clinical Information System; EHR = electronic health record; tele-ICU = telemedicine program in the ICU; VA = Veterans Affairs; VHA = Veterans Health Administration
### Table 4—VHA Tele-ICU Costs

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Monitoring Facility (74 Beds)</th>
<th>Hospital 1, 2 ICUs (23 Beds)</th>
<th>Hospital 2 (10 Beds)</th>
<th>Hospital 3 (6 Beds)</th>
<th>Hospital 4 (16 Beds)</th>
<th>Hospital 15 (5 Beds)</th>
<th>Hospital 6 (5 Beds)</th>
<th>Hospital 7 (9 beds)</th>
<th>System Total (8 ICUs, 74 Beds)</th>
<th>% of Grand Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardware upgrades</td>
<td>3,319,935.79</td>
<td>133,983.02</td>
<td>50,619.40</td>
<td>44,008.00</td>
<td>129,659.04</td>
<td>46,724.79</td>
<td>46,724.79</td>
<td>77,519.97</td>
<td>115,283.05</td>
<td>1,117,166.16</td>
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<td>CIS software</td>
<td>N/A</td>
<td>444,175.24</td>
<td>115,383.67</td>
<td>66,793.65</td>
<td>228,495.50</td>
<td>77,519.97</td>
<td>60,712.45</td>
<td>115,383.67</td>
<td>1,117,166.16</td>
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<tr>
<td>Telemedicine software</td>
<td>414,000.00</td>
<td>167,533.60</td>
<td>73,500.00</td>
<td>47,889.20</td>
<td>113,121.20</td>
<td>41,360.00</td>
<td>41,360.00</td>
<td>67,485.80</td>
<td>566,716.80</td>
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<tr>
<td>Installation fees</td>
<td>780,867.00</td>
<td>276,775.20</td>
<td>72,564.00</td>
<td>72,564.00</td>
<td>72,564.00</td>
<td>72,564.00</td>
<td>72,564.00</td>
<td>72,564.00</td>
<td>1,494,826.20</td>
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<tr>
<td>Equipment and networks</td>
<td>43,323.59</td>
<td>261,624.29</td>
<td>53,676.84</td>
<td>30,087.57</td>
<td>107,063.44</td>
<td>50,561.57</td>
<td>58,236.79</td>
<td>84,978.85</td>
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<td>Technology total</td>
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<td>265,996.46</td>
<td>650,583.18</td>
<td>282,636.24</td>
<td>282,636.24</td>
<td>413,149.19</td>
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<td>Physician fees/yr</td>
<td>1,576,800.00</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Nursing fees/yr</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
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<td>Technical fees/yr</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Managerial fees/yr</td>
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<td>N/A</td>
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<td>Industry training</td>
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<td>8,298.00</td>
<td>8,298.00</td>
<td>14,256.00</td>
<td>8,298.00</td>
<td>8,298.00</td>
<td>8,298.00</td>
<td>8,298.00</td>
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<td>Nonindustry training</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Travel expenditures</td>
<td>35,000</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
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<td>14,256.00</td>
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<td>8,298.00</td>
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<td>N/A</td>
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<td>Tele-ICU site design prep</td>
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<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<tr>
<td>Operating supplies/yr</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>N/A</td>
<td>N/A</td>
<td>4,000</td>
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<td>Real estate total</td>
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<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
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<td>Implementation and first year operation</td>
<td>5,400,531.17</td>
<td>1,349,857.95</td>
<td>404,733.91</td>
<td>274,264.46</td>
<td>664,859.18</td>
<td>290,934.24</td>
<td>290,934.24</td>
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<td>Implementation and first y operation total per ICU bed</td>
<td>72,980.15</td>
<td>58,689.48</td>
<td>40,473.39</td>
<td>45,710.74</td>
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<td>46,827.47</td>
<td>122,937.98</td>
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</tr>
</tbody>
</table>

Data are presented as dollars unless otherwise noted. N/A = not applicable as these components are only in the monitoring center; VHA = Veterans Health Administration. See Tables 1 and 2 legends for expansion of other abbreviations.

- Hardware upgrades: all medical device hardware, monitoring hardware and upgrades to systems needed to implement the program.
- CIS software: cost for software, interfacing, and hardware fees for the CIS.
- Telemedicine software: cost for the software, interfacing, and hardware fees for the monitoring and telemetry system.
- Installation: fixed cost from the vendor for installation of the CIS and telemedicine.
- Equipment and network: specific costs for computers, monitors, desks, networking equipment including hubs and wiring, and installation for this equipment.
Keys To Success

Very Strong Senior Leadership Support

Excellent working relationship among the management teams within the tele-ICU and local hospital ICU’s, including:

Physician

Nursing

IT
Challenges; Naming Conventions, Time Outs

For 9 hospitals we have 28 log ons each with different conventions and time outs.

• EHR
• Radiology
• EKG
• Ultrasound
Challenges - Lexicon

- Saline
- Normal Saline
- IV Saline
- Sodium Chloride
- IV Sodium Chloride
- 0.9 Sodium Chloride
Maryland eCare LLC

Consortium of 6 hospitals that contracted with eCare of Christiana Care to provide tele-ICU services for their individual hospitals.

Hospitals received financial support from CareFirst of Maryland (‘Blues’) for implementation and maintenance for the first 3 years.
Maryland eCare, LLC

Maryland eCare LLC

• Atlantic General Hospital: 4 beds
• Calvert Memorial Hospital: 6 beds
• Peninsula Regional Medical Center: 24 beds - ICU & CTICU
• St. Mary’s Hospital: 6 beds
• Meritus Medical System: 24 beds
• Union Hospital: 8 beds
eCare

Working Together to Improve Patient Care
Improving the Quality of Life for Care Providers
Future….until Tele-transportation is perfected…..Telemedicine will be here!

ICU
Psychiatry
Dermatology
Neurology
Stroke
Wound Care
Trauma
Pediatrics
OB/GYN
Sub Acute Care………→ Tele-____________?
“It’s not the progress I mind, it’s the change I don’t like”

Mark Twain
QUESTIONS