CALIFORNIA TECHNOLOGY ASSESSMENT FORUM℠

TITLE:	**Telemedicine in the Intensive Care Unit**
AUTHOR:	**Jeffrey A. Tice, MD** **Assistant Professor of Medicine** **Division of General Internal Medicine** **Department of Medicine** **University of California San Francisco**
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CALIFORNIA TECHNOLOGY ASSESSMENT FORUM℠

TELEMEDICINE IN THE INTENSIVE CARE UNIT

A Technology Assessment

INTRODUCTION

The California Technology Assessment Forum (CTAF) was asked to assess the evidence for the use of telemedicine in the Intensive Care Unit (ICU). Many hospitals do not have twenty-four hour coverage of their intensive care units by physicians trained in critical care medicine (intensivists) even though observational data report improved outcomes at ICUs staffed by intensivists. Demographic trends suggest that there will be more patients requiring ICU care, but not enough intensivists to meet the demand. Centers staffed by intensivists that monitor patients in multiple ICUs electronically and consult with their clinical staff offer the potential to improve access to the expertise of critical care specialists and improve patient outcomes with greater efficiency than having intensivists on site at each ICU. However, outcomes might be inferior because the intensivists are not present to directly examine patients and to perform necessary tests and procedures.

BACKGROUND

<u>The intensive care unit (ICU) and critical care specialists</u>

Intensive care units in the United States treat about six million patients annually.[1,2] Not surprisingly, patients in the ICU have higher mortality and consume more resources than those elsewhere in the hospital. For patients admitted to the ICU, their average mortality in the ICU ranges from 8 to 10%[3], their hospital mortality is approximately 16%[4], and their average 30-day mortality is approximately 18%.[5]

Studies have demonstrated that patients in the ICU have a lower risk of dying and shorter stays in both the ICU and hospital when specialists in critical care medicine (intensivists) care for the patients.[5,6] The Leapfrog Group highlighted ICU staffing as one way to decrease hospital mortality and set out guidelines for intensivist coverage of ICUs.[7,8] Intensivists are physicians trained in medicine, surgery, or anesthesia who receive an additional two to three years of training in critical care medicine.[9] Board certification in critical care medicine began in most states in the 1980s. Ideally, intensivists would be involved in the care of most patients admitted to the ICU. Unfortunately, there are insufficient intensivists to meet the demand and the imbalance between the projected supply and demand for intensivists is expected to continue through at least 2020.[9-11] ICU telemedicine has been proposed as one way to address the imbalance between the projected supply and demand for intensivists care.

Intensive Care Unit Telemedicine or the electronic ICU (eICU, Tele-ICU)

The electronic ICU is a center staffed by intensivists who provide some level of care for patients in one or more intensive care units via audio, video, and other electronic links in order to provide continuous access to highly trained specialists. The electronic ICU does not need to be physically located near the ICUs. The remote site is often referred to as the command or support center. Staff in the command center have real-time access to patients medications, vital signs, telemetry, laboratory results and radiographic imaging. In addition, there may be some form of software support triggering alerts when changes in any of the monitored parameters cross some threshold. Intensivists at the command center work closely with physicians, nurses, and staff who are physically located in the intensive care units. The staffs at the command center and at the ICU interact via two-way systems that provide full audio-visual communication.

The first tele-ICU was established in Virginia in 2000, but adoption has been slow. Several factors are thought to contribute to the slow adoption. An electronic ICU command center costs between $6 and $8 million dollars to set up and an additional $300,000 to $500,000 at each hospital.[12] Until recently there have been few published studies documenting the effectiveness of the eICU in improving outcomes and controlling costs. There may be hospital administration, physician and staff resistance to the loss of control and changes in workflow at individual institutions considering the adoption of an eICU model.[12]

TECHNOLOGY ASSESSMENT (TA)

TA Criterion 1: The technology must have final approval from the appropriate government regulatory bodies.

Monitoring systems used in electronic intensive care units are composed of networks of audiovisual communication capabilities (cameras, real-time video feeds and videoconferencing) and computer systems including clinical management software that provide 24/7 patient and surveillance information at the patient's location (hospital ICU) to the remote care location. Patient monitoring systems are generally classified as Class II devices by the U.S. Food and Drug Administration (FDA) and are approved via the 510(k) approval process. Patient monitoring systems can be found under product codes LNX (Computers and Software, Medical), MSX (Network System and Physiological Monitors, Communication) and MWI MSX

(Network System and Physiological Monitors, Communication). Some examples of eICU monitoring systems are Phillips VISICU (501k approval in 2000), MetaVision Suite (iMDsoft Ltd.) (501k approval in 2002), and the Remote Presence Robotic system (InTouch Health) (510k approval in 2008).

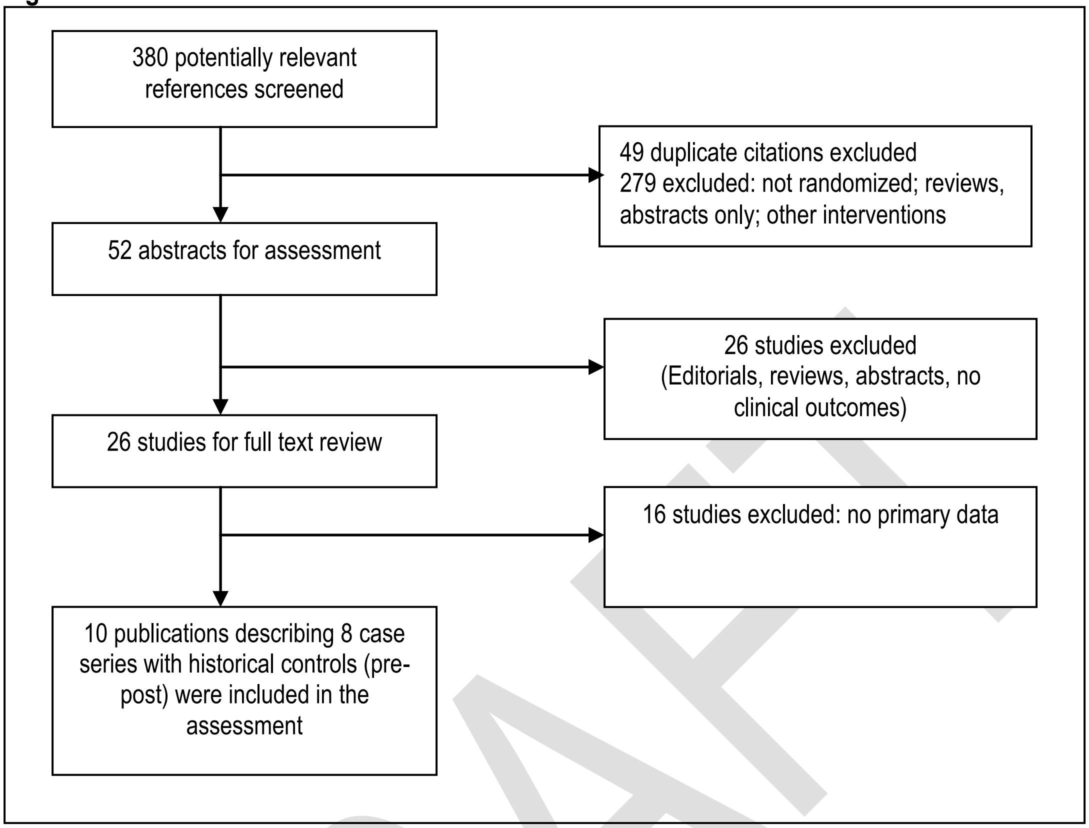
TA Criterion 1 is met.

TA Criterion 2: The scientific evidence must permit conclusions concerning the effectiveness of the technology regarding health outcomes.

The Medline database, Embase, Cochrane clinical trials database, Cochrane reviews database and the Database of Abstracts of Reviews of Effects (DARE) were searched using the key words "telemedicine," "remote telemonitoring," "remote ICU," and "eICU." The results were crossed with the results from a search on "critical care" and "intensive care." The search was performed for the period from 1945 through September 2011. The detailed search criteria are shown in the Appendix. The bibliographies of systematic reviews and key articles were manually searched for additional references. References were also solicited from the manufacturers and local experts. The abstracts of citations were reviewed for relevance and all potentially relevant articles were reviewed in full.

The search identified 380 potentially relevant studies (Figure 1). After elimination of duplicate and non-relevant references including reviews and animal studies, the search identified ten articles describing eight case series.[13-22] There were no randomized trials and no studies with concurrent controls.

Figure 1: Selection of studies for inclusion in review



Level of Evidence: 4.

TA Criterion 2 is met.

TA Criterion 3: The technology must improve net health outcomes.

The most important patient-centered outcome is total mortality. Patients admitted to the ICU have very high mortality, so it is feasible to perform studies with mortality as the primary outcome. It is also important to look at hospital mortality because patients could be prematurely transferred out of the ICU, leading to lower ICU mortality, but higher hospital mortality. Similarly, it is important to examine both the length of stay (LOS) in the ICU and in the hospital as a whole, when using LOS as a measure for improved efficiency of care. Ideally, 30-day mortality would be reported as a useful way to standardize the outcome. Other important outcomes would be patient and family satisfaction with care and communication, because remote monitoring has the potential for less effective communication with the family.

All of the studies included in this assessment are non-randomized, historical cohort comparisons between patients in one or more ICUs after the adoption of remote telemonitoring and patients from the same ICUs prior to the adoption of remote telemonitoring. Table 1 summarizes the characteristics of the study. The study sites are geographically diverse and included a mix of medical ICUs, surgical ICUs and mixed medical-surgical ICUs. Some of the ICUs were located at large, urban teaching hospitals while others were located at small institutions in rural locations. Some had full time intensivists on site during the day and were using telemonitoring for coverage at night and on the weekends. Others had no intensivists on site at any time. One small study reported on rural pediatric ICUs using a consultation-as-needed model.[15] Because outcomes in these pediatric population are quite different from those in the adult population and because this study represented telemedical consultation, rather than monitoring, it will not be included in any of the summary statistics presented below. For example, the ICU mortality in the pediatric ICU was only 2.6%,[15] which is much lower than that reported by any of the other studies. There was also clinical heterogeneity among the adult ICUs studied. Prior to the intervention, mortality in the ICUs varied from a low of 6.6% to a high of 15.8% and the average length of stay varied from 2.6 to 6.4 days. The average Acute Physiology and Chronic Health Evaluation (APACHE) score for patients in the ICUs, a standard ICU risk assessment tool with higher numbers indicative of a greater risk for dying, varied from 38 to 57.

The interventions varied as well. Some interventions had intensivists taking call from home with online access to some clinical data and other information, such as progress notes, provided solely via scanned images. Other interventions had true central command centers with real-time continuous monitoring of patients 24 hours a day including live video feeds of the patients and direct access to the electronic medical record and physician order entry systems. Even when the telemonitoring systems allowed for continuous monitoring and software alerts for worrisome trends in the data, the authority of the remote intensivist to act varied widely. In some cases the intensivist could only intervene in emergency situations while in others they could initiate the evaluation of new problems, adjust the rates of intravenous fluid and drug administration, order routine medications and tests, and ensure that ICU best practices were being followed.

The primary outcomes of the studies are summarized in Table 2. In all but one case,[20] both ICU and hospital mortality and LOS decreased with implementation of the telemonitoring system. The study that failed to demonstrate a reduction in mortality (Morrison et al, 2010) had the lowest ICU mortality prior to the intervention (6.6%). The ICUs in this study were at large, urban hospitals with onsite intensivists. It is possible that they had a culture of quality improvement in place, so that best practices in ventilator management, central line antisepsis, stress ulcer prophylaxis, deep venous thrombosis prevention, and pharmacy oversight were already in place and the telemonitoring intervention had little room for improvement.

Figure 2 is a forest lot that summarizes the impact of telemonitoring on mortality in the ICU. The summary estimate (0.80, 95% CI 0.67 to 0.97) represents an overall 20% reduction in mortality. However there is significant heterogeneity among the six studies contributing to that estimate (I^2 = 65%, p=0.013). Two of the co-authors of the earliest publications[13,14] (Rosenfeld et al, 2000; Breslow et al, 2004) work for the manufacturer of one of the commercial systems for electronic ICU's and the results from these two studies appeared somewhat different from the results of the other studies, so all of the forest plots (Figures 2 through 5) will include subgroups segregating these two studies as well as the summary results that combine the results from these two studies with the others. The smaller benefits reported in subsequent studies may also reflect secular trends with improvements in the management of critically ill patients in all ICUs based on what has been learned over time and not some unrecognized bias in these studies. In the subgroup of more recent studies, the summary estimate is still statistically and clinically significant (15% reduction in mortality). The test for heterogeneity is no longer statistically significant (p=0.105), but the I^2 is still large at 51%. Figure 3 summarizes hospital mortality across the studies. Again, when all studies are combined, there is a significant 20% reduction in mortality, but significant heterogeneity. Among the more recent studies, there is a 16% reduction in hospital mortality with borderline heterogeneity.

Figures 4 and 5 summarize the ICU LOS and the total hospitalization LOS. In both cases, the two earliest studies showed much greater reductions in LOS than the more recent studies. The more recent studies failed to demonstrate significant reductions in overall LOS and had highly significant heterogeneity.

Table 1: Pre- Post Studies of ICU Telemonitoring – Study Characteristics

Study	Location # ICU sites	Type of ICU Intensivist on staff?	Telemonitoring authority Monitoring	Pre-intervention ICU mortality	Pre-intervention ICU LOS	Severity	Manufacturer support
Rosenfeld 2000	Maryland? 1	SICU Yes	Variable Continuously available	9.8%	2.7	41	Yes
Breslow 2004	Virginia 2	MICU, SICU Yes	Variable Overnight	8.6%	4.3	39	Yes
Marcin 2004	Northern CA 1	Pediatric ICU No	Consult Intermittent	2.6%	NR	NR	No
Thomas 2009	Gulf Coast 6	MICU, SICU Some yes, some no	Variable Overnight	9.2%	4.3	NR	No
Zawada 2009	Midwest 15	M/SICU No	Full authority Continuous	NR	3.8	38	No
McCambridge 2010	Pennsylvania 3	MICU Yes	Full authority Continuous	15.8%	4.1	57	No
Morrison 2010	Chicago 4	MICU, SICU, M/SICU Yes	Variable Continuous	6.6%	2.6	49	No
Lilly 2011	 7	3 MICU, 3 SICU, 1 mixed Yes	Proactive Continuous	10.7%	6.4	45	No

*** By APACHE score**

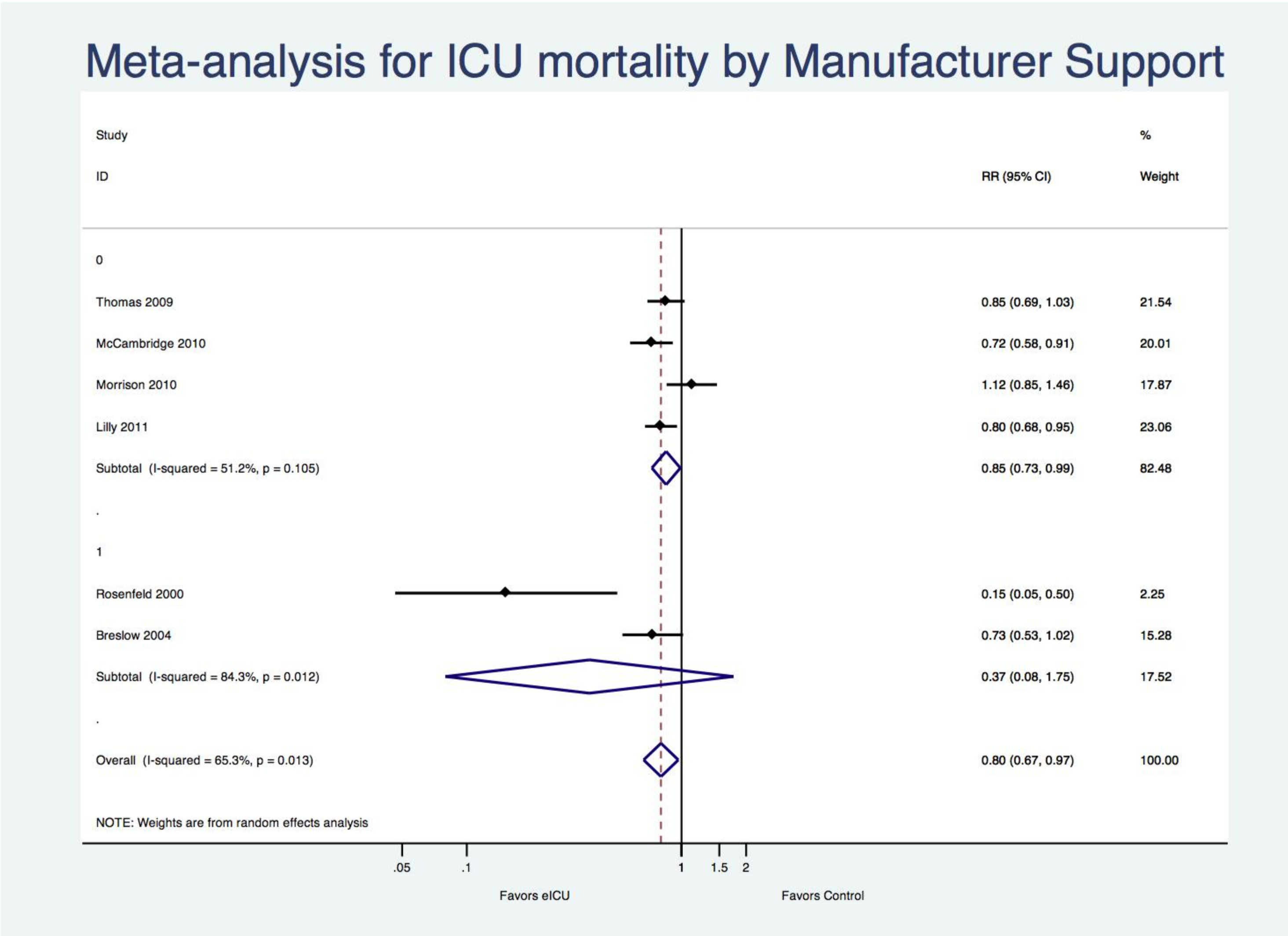
Table 2: Pre- Post Studies of ICU Telemonitoring – Study outcomes

Study	N		Months		Severity*		ICU Mortality		Hospital Mortality		ICU LOS		Hospital LOS	
	Pre	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*	*Pre*	*Post*
Rosenfeld 2000	225	201	8	4	41	38	9.8%	1.5%	11.6%	4.5%	2.7	2	9.2	9.3
Breslow 2004	1396	744	12	6	39	38	8.6%	6.3%	12.9%	9.5%	4.3	3.6	12.8	11.1
Marcin 2004	116	47	11	24	7.5	9.6	2.6%	2.1%	NR	NR	NR	NR	NR	NR
Thomas 2009	2034	2108	32	25	35	34	9.2%	7.8%	12.0%	9.9%	4.3	4.6	9.8	10.7
Zawada 2009§	188	2445	12	30	38	44	NR	NR	NR	NR	3.8	2.1	10.1	7.8
McCambridge 2010	954	959	16	10	57	58	15.8%	11.5%	21.4%	14.7%	4.1	3.8	9.1	9.2
Morrison 2010	1371	1430	4	4	49	47	6.6%	7.4%	9.9%	10.1%	2.6	3.2	7.7	7.9
Lilly 2011	1529	4761	22	13	45	58	10.7%	8.6%	13.6%	11.8%	6.4	4.5	13.3	9.8

*APACHE III score for all except Marcin 2004 (PRISM III), Thomas 2009 (SAPS II)

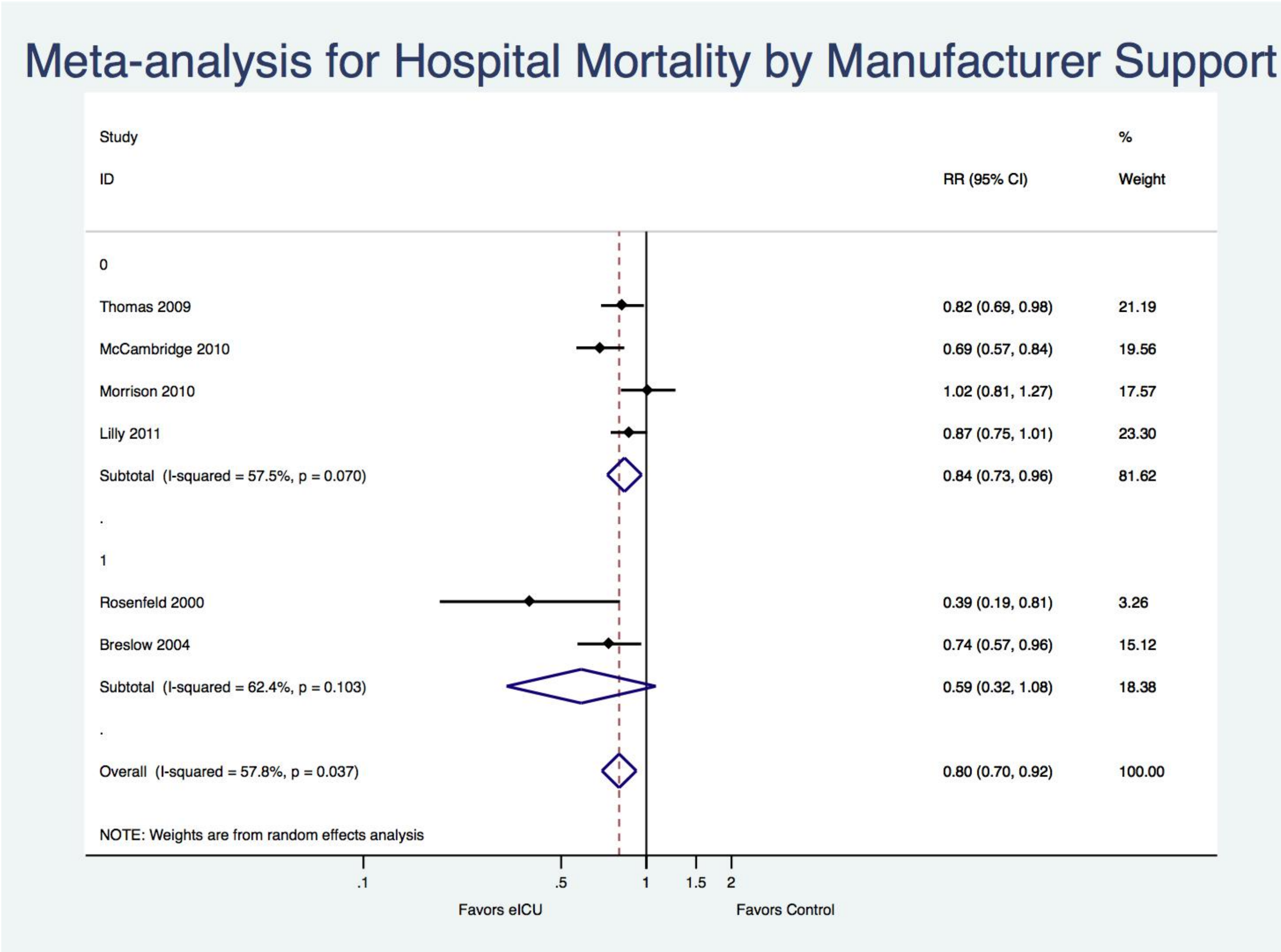
§ Only data from the tertiary care hospital could be abstracted from the paper.

Figure 2: Mortality in the intensive care unit



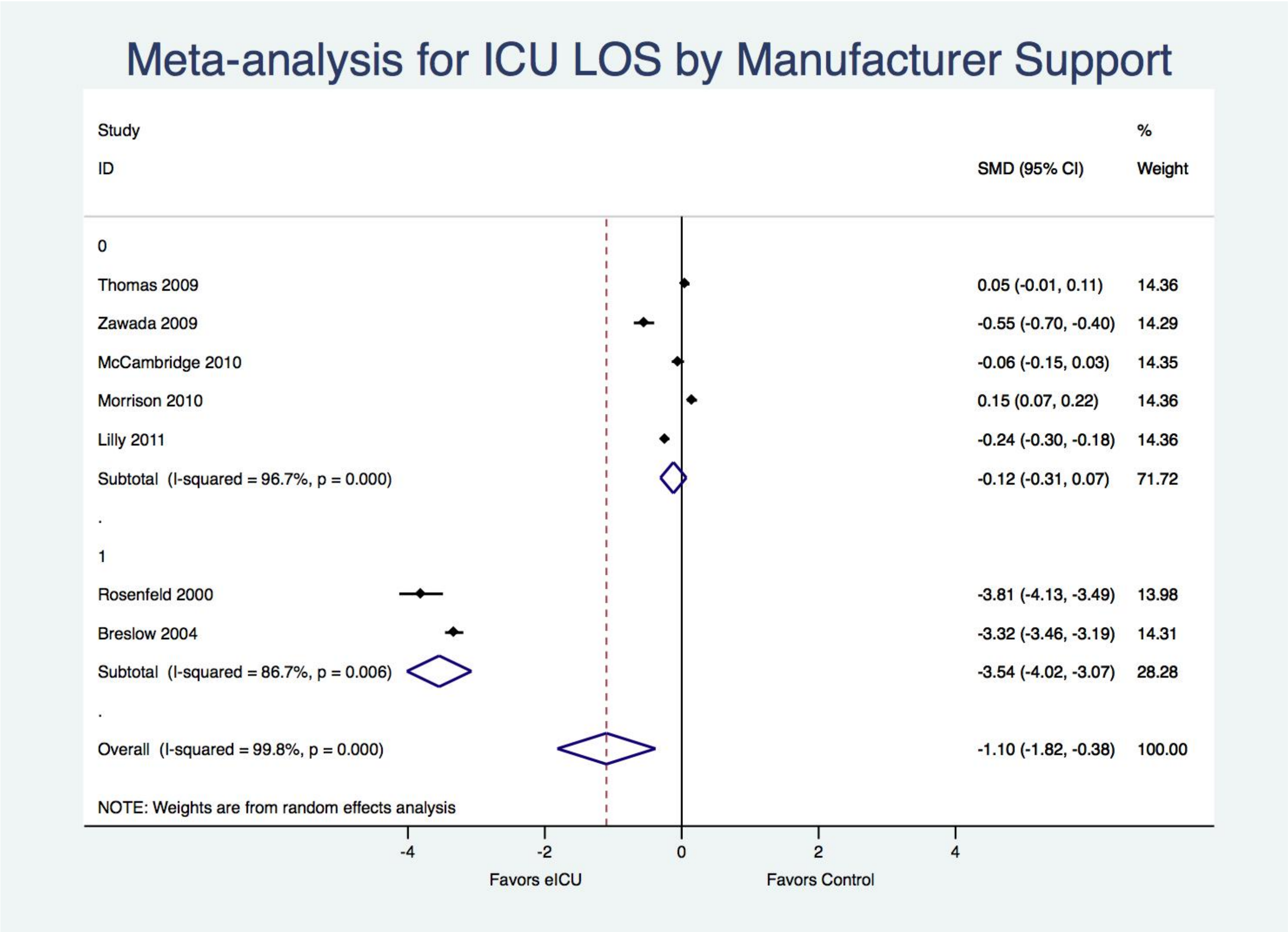
The small black diamonds represent the point estimates for the individual studies. The horizontal black line is the 95% confidence interval for the estimate. The vertical black line at relative risk of 1 indicates no difference between the two groups and the dashed vertical line represents the summary estimate for all of the included studies. Estimates to the left of that line favor the eICU. The blue diamonds represent the summary estimates for the two subgroups and for all studies combined: the midpoint is the point estimate and the left and right tips represent the 95% confidence interval. Subgroup 0 indicates the subgroup of studies without manufacturer representation among the authors; subgroup 1 indicates studies with manufacturer representation.

Figure 3: Mortality in the hospital



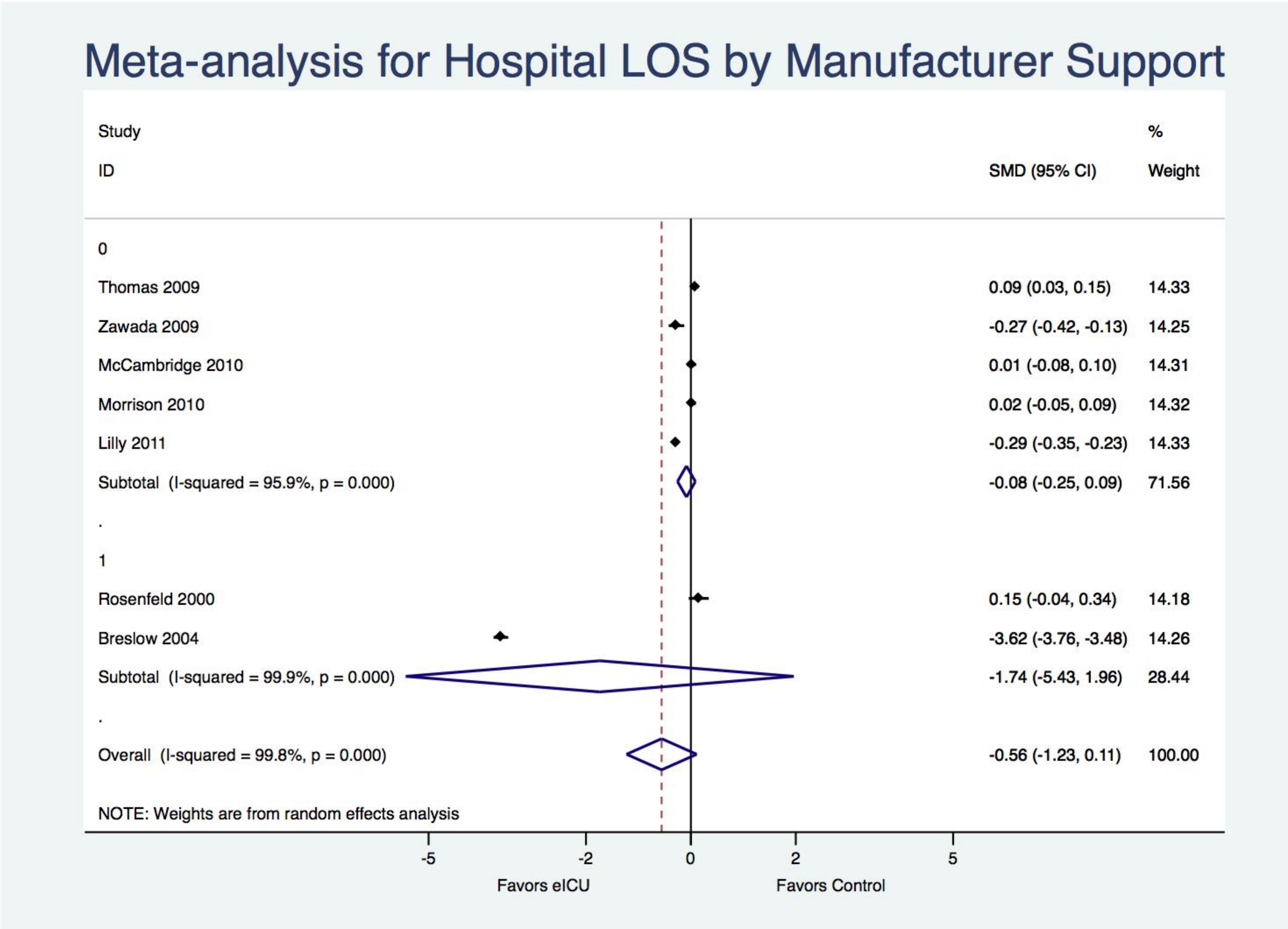
The small black diamonds represent the point estimates for the individual studies. The horizontal black line is the 95% confidence interval for the estimate. The vertical black line at relative risk of 1 indicates no difference between the two groups and the dashed vertical line represents the summary estimate for all of the included studies. Estimates to the left of that line favor the eICU. The blue diamonds represent the summary estimates for the two subgroups and for all studies combined: the midpoint is the point estimate and the left and right tips represent the 95% confidence interval. Subgroup 0 indicates the subgroup of studies without manufacturer representation among the authors; subgroup 1 indicates studies with manufacturer representation.

Figure 4: Length of stay in the intensive care unit



The small black diamonds represent the point estimates for the individual studies. The horizontal black line is the 95% confidence interval for the estimate. The vertical black line at a standardized mean difference of 0 indicates no difference between the two groups and the dashed vertical line represents the summary estimate for all of the included studies. Estimates to the left of that line favor the eICU. The blue diamonds represent the summary estimates for the two subgroups and for all studies combined: the midpoint is the point estimate and the left and right tips represent the 95% confidence interval. Subgroup 0 indicates the subgroup of studies without manufacturer representation among the authors; subgroup 1 indicates studies with manufacturer representation.

Figure 5: Length of stay in the hospital



The small black diamonds represent the point estimates for the individual studies. The horizontal black line is the 95% confidence interval for the estimate. The vertical black line at a standardized mean difference of 0 indicates no difference between the two groups and the dashed vertical line represents the summary estimate for all of the included studies. Estimates to the left of that line favor the eICU. The blue diamonds represent the summary estimates for the two subgroups and for all studies combined: the midpoint is the point estimate and the left and right tips represent the 95% confidence interval. Subgroup 0 indicates the subgroup of studies without manufacturer representation among the authors; subgroup 1 indicates studies with manufacturer representation.

A recent systematic review and meta-analysis by Young et al. came to similar conclusions.[23] Their meta-analysis summarized thirteen studies, but only seven of them were published in the peer-reviewed literature. It did not include the most recent published study included in this assessment[22] (Lilly et al, 2011) and one additional unpublished study[12] identified by the search in this assessment. They noted significant heterogeneity in the studies contributing to their summary estimates for mortality reductions and reductions in LOS.

The heterogeneity observed across these studies is undoubtedly multifactorial. There were large differences in the types of ICUs studied (rural, academic, large, small, with and without intensivists present) and in the interventions that were implemented. In one study[19], the intervention included the introduction of a new ICU electronic medical record with software for event notification, computer assisted physician order entry, barcoded electronic medication administration and other enhancements that may have been responsible for some or all of the changes observed in mortality and length of stay independent of the remote telemonitoring component.

In addition, the pre-post study design provides only weak evidence for efficacy. Changes observed in interrupted time series experiments can be due to secular trends – in this case recent improvements in ICU care that have been demonstrated to improve outcomes such as evidence-based protocols for ventilation[24-26], prophylaxis for venous thrombosis[27] and stress ulcers[28], prevention of ventilator associated pneumonia[29,30], prevention of catheter associated bacteremia,[31,32] and pharmacist-based reviews of medications.[33,34] There is clear selection bias in many of the studies: for example the APACHE severity scores increased dramatically in several studies.[18,22] Adjustment for the variation in case-mix helps, but does not address concerns about residual selection bias and confounding.

I cannot put it any better than a recent review by the Critical Care Societies Collaborative in July 2011 in Chest. [35] "Most studies use a before-and-after study design and are subject to numerous biases, including unmeasured changes in case mix, temporal trends, coincident interventions, and random variation. Additionally, ICU telemedicine often introduces multiple interventions at the same time, including audiovisual surveillance, staffing changes, decision-support tools, and new electronic medical records. Introducing multiple different interventions simultaneously makes it difficult to understand the specific mechanism of the effect. These studies also do not consistently describe the organization and management of participating ICUs prior to introducing the telemedicine program, making it difficult to put the research into clinical context."

In his commentary[36] on the meta-analysis of Young et al, Dr. Jeremy Kahn writes "Although questions remain about the effect of ICU telemedicine on patient mortality, additional before-and-after studies are unlikely to be helpful. Single-center before-and-after studies, although useful in some settings, do not allow for causal inference or create generalizable knowledge. Instead, we need multicenter randomized controlled clinical trials that can better speak to causation and better delineate the potential mechanism of action. These trials should carefully describe the ICU environment before the introduction of telemedicine and provide sufficient detail about the telemedicine program to allow valid comparisons across centers and sites."

The available evidence suggests that some form of ICU telemonitoring is likely to be helpful in the right setting. Telemonitoring systems established in smaller, isolated hospitals without regular access to intensivists in which the remote intensivist establishes strong communication links with local providers and is empowered to act when necessary are more likely to be successful. However, none of the studies to date have established clear criteria for successful implementation of the electronic ICU.

TA Criterion 3 is not met.

TA Criterion 4: The technology must be as beneficial as any established alternatives.

The principal established alternative to the electronic ICU is the presence of an on-site intensivist. But as outlined above, there is an insufficient supply of intensivists to meet the demand and it is unreasonable to expect round-the-clock intensivists coverage in small hospitals with relatively few patients requiring ICU-level care. Quality improvement checklists represent an efficient and promising intervention that could be implemented in any ICU and offer a reasonable comparison for future studies of the remote telemonitoring of ICU care.[37-40]. The literature to date is insufficient to establish that intensive care unit telemedicine improves net health outcomes.

TA Criterion 4 is not met.

TA Criterion 5: The improvement must be attainable outside of the investigational setting.

Telemedicine systems are complex and require diligent attention to gain acceptance with the clinical staff at the remote ICUs. The published literature suggests that local physicians and nurses feel that the systems improve both teamwork and outcomes when implemented properly.[41,42] Intensive care unit telemedicine has been established in a number of real-world settings, but no clear net benefits have been demonstrated for intensive care unit telemedicine in the observational studies performed to date.

TA Criterion 5 is not met.

CONCLUSION

Multiple studies have documented that active involvement of physicians trained in critical care medicine (intensivists) improve patient outcomes in the ICU. However the supply of trained intensivists is inadequate to meet the growing demand. The electronic ICU, a central command center staffed by specialists with comprehensive electronic access to multiple remote ICUs, has been proposed as one way to increase the efficiency and reach of trained intensivists.

The literature search identified eight non-randomized cohort studies with historical controls and an additional eight studies published as abstracts or in the non-peer reviewed literature. No level 1, 2, or 3 evidence was identified. There was significant heterogeneity in the types of ICUs studied and in the telemedical interventions studied. Not surprising, there was significant statistical heterogeneity in the results. Overall, the evidence suggests that remote telemonitoring could reduce both ICU and in hospital mortality by as much as 20%, but it remains unclear which ICUs would benefit the most from telemonitoring and what aspects of telemonitoring add significant value. Higher quality studies, as suggested by the 2011 research agenda in ICU telemedicine put forth by the Critical Care Societies Collaborative, are needed to identify the way forward along this promising path.

RECOMMENDATION

It is recommended that use of intensive care unit telemedicine not meet CTAF TA Criterion 3 through 5 for safety, effectiveness and improvement in health outcomes.

October 19, 2011

This is the first review of this technology by the California Technology Assessment Forum.

RECOMMENDATIONS OF OTHERS

Blue Cross Blue Shield Association (BCBSA)

The BCBSA Technology Evaluation Center has not conducted a review of electronic ICUs.

Centers for Medicare and Medicaid Services (CMS)

There is not a National Coverage Determination specific to the use of electronic ICUs.

American College of Critical Care Medicine (ACCM)/Society of Critical Care Medicine (SCCM)

ACCM/SCCM has been invited to provide an opinion on electronic ICUs and to send a representative to participate at the meeting.

New England Healthcare Institute (NEHI)

NEHI has been invited to provide an opinion on electronic ICUs and to send a representative to participate at the meeting.

American Telemedicine Association

The American Telemedicine Association has been invited to provide an opinion on electronic ICUs and to send a representative to participate at the meeting.

American Thoracic Society

The American Thoracic has been invited to provide an opinion on electronic ICUs and to send a representative to participate at the meeting.

ABBREVIATIONS

CTAF	California Technology Assessment Forum
DARE	Database of Abstracts of Reviews of Effects
FDA:	US Food and Drug Administration
RCT	Randomized Controlled Trial
NS	Not significant
CI	Confidence Interval
NR	Not reported
APACHE	Acute Physiology and Chronic Health Evaluation
PRISM	Pediatric Risk of Mortality
SAPS	Simplified Acute Physiology Score
ER	Emergency room
MD	Medical doctor

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APPENDIX: Search strategy

PubMed:

Search	Most Recent Queries	Time	Result
#6	Search **#4 AND #5 FINAL**	18:52:06	183
#5	Search **randomized controlled trial[pt] OR controlled clinical trial[pt] OR randomized controlled trials[mh] OR random allocation[mh] OR double-blind method[mh] OR single-blind method[mh] OR clinical trial[pt] OR clinical trials[mh] OR "clinical trial"[tw] OR ((singl*[tw] OR doubl*[tw] OR trebl*[tw] OR tripl*[tw]) AND (mask*[tw] OR blind*[tw])) OR Placebos[mh] OR placebo*[tw] OR random*[tw] OR non-randomi*[tw] OR before after study[tw] OR time series[tw] OR "case control"[tw] OR prospective*[tw] OR retrospective*[tw] OR cohort[tw] OR cross-section*[tw] OR research design[mh:noexp] OR comparative study[pt] OR evaluation studies[pt] OR follow-up studies[mh] OR prospective studies[mh] OR controlled[tw] OR control[tw] OR volunteer*[tw] OR longitud*[tw] OR descripti*[tiab] OR study[tiab] OR evaluat*[tiab] OR "odds ratio"[tw] OR "hazard ratio"[tw] OR "relative risk"[tw] OR "risk ratio"[tw] OR AOR[tiab] OR RRR[tiab] OR NNT[tiab] OR design*[tiab] OR observation stud*[tw] OR observational [tiab] OR treatment outcome OR "Outcome Assessment (Health Care)" OR systematic OR metaanalys* OR meta-analys***	18:49:59	8751545
#4	Search **#1 OR #2 OR #3**	18:48:11	365
#3	Search **"critical care"[tiab] OR "intensive care"[tiab] OR ICU[tiab] AND (telemedicine[tiab] OR telemetry[tiab] OR telemonitor*[tiab] OR remote[ti]) AND (in process[sb] OR publisher[sb] OR pubmednotmedline[sb])**	18:47:49	22
#2	Search **(eICU[tiab] AND technology[tiab]) OR "remote ICU"[tiab] OR "tele-ICU"[tiab]**	18:46:06	33
#1	Search **critical care[mh] OR intensive care units[mh] AND (telemedicine[mh] OR telemetry[mh] OR telemonitor*[tiab])**	18:45:52	337

Note:

These terms= 0 relevant refs: Remote monitor*, CCU, electronic*[ti], Tele-ICUs

Set #4 minus set #6 = 182 refs Gloria looked thru 182 = 0 relevant

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The Cochrane Library, run date 9/16/11

ID	Search	Hits	Edit	Delete
#1	(critical care OR intensive care OR intensive care unit OR intensive care units OR ICU):ti,ab,kw and (telemedicine OR telemetry OR telemonitor* OR remote):ti,ab,kw	48	edit	delete
#2	(critical care OR intensive care OR intensive care unit OR intensive care units OR ICU):ti,ab,kw and (electronic*):ti	12	edit	delete
#3	(#1 OR #2) FINAL	58	edit	delete

Show Results in:
Cochrane Reviews [1] | Other Reviews [1] | Clinical Trials [50] | Methods Studies [2] | Technology Assessments [1] | Economic Evaluations [3] | Cochrane Groups [0]

File ending in 96.txt contains "Other Reviews[1]"
File ending in 39.txt contains "Clinical Trials[50]"
File ending in 99.txt contains "Technology Assessments[1]"
File ending in 56.txt contains "Economic Evaluations[3]"

Did not send
"Cochrane Reviews[1]" because the one ref is a protocol titled **Telemedicine for the support of parents of high risk newborn infants**.
"Methods Studies[2]" because refs weren't relevant.

Note:

ID	Search	Hits	Edit	Delete
#1	(eicu OR "remote icu" OR "tele icu")	3	edit	delete

Did not retrieve anything new

EMBASE

No.	Query	Results	Date
#8	#6 OR #7 FINAL	139	17 Sep 2011
#7	#5 AND (morbidity OR mortality OR 'length of stay' OR 'treatment outcome')	100	17 Sep 2011
#6	#5 AND ('cohort analysis'/de OR 'controlled clinical trial'/de OR 'controlled study'/de OR 'evidence based practice'/de OR 'intermethod comparison'/de OR 'major clinical study'/de OR 'medical audit'/de OR 'observational study'/de OR 'prospective study'/de OR 'randomized controlled trial'/de OR 'retrospective study'/de OR 'total quality management'/de)	82	17 Sep 2011
#5	#3 NOT #4	407	17 Sep 2011
#4	#1 AND #2 AND ('conference abstract'/it OR 'editorial'/it OR 'note'/it)	123	17 Sep 2011
#3	#1 AND #2	530	17 Sep 2011
#2	'telehealth'/de OR 'telemedicine'/exp OR 'telemetry'/exp OR 'telecommunication'/de	36650	17 Sep 2011
#1	'intensive care'/de OR 'intensive care unit'/de	117066	17 Sep 2011

Note:

Search Queries

Access the Embase Info site if you have questions about this message or other features of this service. Please do not reply to this email.

No.	Query	Results	Date
#19	#15 OR #16 NOT ('conference abstract'/it OR 'editorial'/it OR 'note'/it) looked thru 1st 125 refs, nothing relevant	293	17 Sep 2011
#18	#15 OR #16	360	17 Sep 2011
#16	#13 NOT #5 AND (morbidity OR mortality OR 'length of stay' OR 'treatment outcome')	167	17 Sep 2011
#15	#13 NOT #5 AND ('cohort analysis'/de OR 'controlled clinical trial'/de OR 'controlled study'/de OR 'evidence based practice'/de OR 'intermethod comparison'/de OR 'major clinical study'/de OR 'medical audit'/de OR 'observational study'/de OR 'prospective study'/de OR 'randomized controlled trial'/de OR 'retrospective study'/de OR 'total quality management'/de)	262	17 Sep 2011

#14	#13 NOT #5	1145	17 Sep 2011
#13	'intensive care'/exp/mj AND #2	1263	17 Sep 2011
#11	#10 NOT #5 nothing relevant	32	17 Sep 2011
#10	('eicu' NOT 'emergency intensive') OR 'remote icu' OR 'tele-icu'	71	17 Sep 2011
#9	#5 NOT #8 looked at all, nothing relevant	268	17 Sep 2011

REFERENCES

1. Halpern NA, Pastores SM. Critical care medicine in the United States 2000-2005: an analysis of bed numbers, occupancy rates, payer mix, and costs. *Critical Care Medicine.* Jan 2010;38(1):65-71.

2. Halpern NA, Pastores SM, Greenstein RJ. Critical care medicine in the United States 1985-2000: an analysis of bed numbers, use, and costs. *Critical Care Medicine.* Jun 2004;32(6):1254-1259.

3. Angus DC, Linde-Zwirble WT, Sirio CA, et al. The effect of managed care on ICU length of stay: implications for medicare. *JAMA : the journal of the American Medical Association.* Oct 2 1996;276(13):1075-1082.

4. Wunsch H, Angus DC, Harrison DA, Linde-Zwirble WT, Rowan KM. Comparison of medical admissions to intensive care units in the United States and United Kingdom. *American journal of respiratory and critical care medicine.* Jun 15 2011;183(12):1666-1673.

5. Kim MM, Barnato AE, Angus DC, Fleisher LA, Kahn JM. The effect of multidisciplinary care teams on intensive care unit mortality. *Archives of internal medicine.* Feb 22 2010;170(4):369-376.

6. Pronovost PJ, Angus DC, Dorman T, Robinson KA, Dremsizov TT, Young TL. Physician staffing patterns and clinical outcomes in critically ill patients: a systematic review. *JAMA : the journal of the American Medical Association.* Nov 6 2002;288(17):2151-2162.

7. Milstein A, Galvin RS, Delbanco SF, Salber P, Buck CR, Jr. Improving the safety of health care: the leapfrog initiative. *Eff Clin Pract.* Nov-Dec 2000;3(6):313-316.

8. Young MP, Birkmeyer JD. Potential reduction in mortality rates using an intensivist model to manage intensive care units. *Eff Clin Pract.* Nov-Dec 2000;3(6):284-289.

9. Health Resources and Services Administration (HRSA). The critical care workforce: A study of supply and demand for critical care physicians. In: (HRSA) HRaSA, ed. Vol Senate Report 108-81. Washington, DC2006.

10. Angus DC, Shorr AF, White A, Dremsizov TT, Schmitz RJ, Kelley MA. Critical care delivery in the United States: distribution of services and compliance with Leapfrog recommendations. *Critical Care Medicine.* Apr 2006;34(4):1016-1024.

11. Angus DC, Kelley MA, Schmitz RJ, White A, Popovich J, Jr. Caring for the critically ill patient. Current and projected workforce requirements for care of the critically ill and patients with pulmonary disease: can we meet the requirements of an aging population? *JAMA : the journal of the American Medical Association.* Dec 6 2000;284(21):2762-2770.

12. Massachusetts Technology Collaborative and New England Healthcare Institute. *Critical Care, Critical Choices: The case for Tele-ICUs in Intensive Care*: Massachusetts Technology Park Corporation;2010.

13. Rosenfeld BA, Dorman T, Breslow MJ, et al. Intensive care unit telemedicine: alternate paradigm for providing continuous intensivist care. *Crit Care Med.* Dec 2000;28(12):3925-3931.

14. Breslow MJ, Rosenfeld BA, Doerfler M, et al. Effect of a multiple-site intensive care unit telemedicine program on clinical and economic outcomes: an alternative paradigm for intensivist staffing. *Crit Care Med.* Jan 2004;32(1):31-38.

15. Marcin JP, Nesbitt TS, Kallas HJ, Struve SN, Traugott CA, Dimand RJ. Use of telemedicine to provide pediatric critical care inpatient consultations to underserved rural Northern California. *J Pediatr.* Mar 2004;144(3):375-380.

16. Zawada ET, Jr., Kapaska D, Herr P, et al. Prognostic outcomes after the initiation of an electronic telemedicine intensive care unit (eICU) in a rural health system. *S D Med.* Sep 2006;59(9):391-393.

17. Thomas EJ, Lucke JF, Wueste L, Weavind L, Patel B. Association of telemedicine for remote monitoring of intensive care patients with mortality, complications, and length of stay. *JAMA.* Dec 23 2009;302(24):2671-2678.

18. Zawada ET, Jr., Herr P, Larson D, Fromm R, Kapaska D, Erickson D. Impact of an intensive care unit telemedicine program on a rural health care system. *Postgrad Med.* May 2009;121(3):160-170.

19. McCambridge M, Jones K, Paxton H, Baker K, Sussman EJ, Etchason J. Association of health information technology and teleintensivist coverage with decreased mortality and ventilator use in critically ill patients. *Arch Intern Med.* Apr 12 2010;170(7):648-653.

20. Morrison JL, Cai Q, Davis N, et al. Clinical and economic outcomes of the electronic intensive care unit: results from two community hospitals. *Crit Care Med.* Jan 2010;38(1):2-8.

21. Franzini L, Sail KR, Thomas EJ, Wueste L. Costs and cost-effectiveness of a telemedicine intensive care unit program in 6 intensive care units in a large health care system. *J Crit Care.* Jun 2011;26(3):329 e321-326.

22. Lilly CM, Cody S, Zhao H, et al. Hospital mortality, length of stay, and preventable complications among critically ill patients before and after tele-ICU reengineering of critical care processes. *JAMA.* Jun 1 2011;305(21):2175-2183.

23. Young LB, Chan PS, Lu X, Nallamothu BK, Sasson C, Cram PM. Impact of telemedicine intensive care unit coverage on patient outcomes: a systematic review and meta-analysis. *Arch Intern Med.* Mar 28 2011;171(6):498-506.

24. Checkley W, Brower R, Korpak A, Thompson BT. Effects of a clinical trial on mechanical ventilation practices in patients with acute lung injury. *Am J Respir Crit Care Med.* Jun 1 2008;177(11):1215-1222.

25. Esteban A, Ferguson ND, Meade MO, et al. Evolution of mechanical ventilation in response to clinical research. *Am J Respir Crit Care Med.* Jan 15 2008;177(2):170-177.

26. Meade MO, Cook DJ, Guyatt GH, et al. Ventilation strategy using low tidal volumes, recruitment maneuvers, and high positive end-expiratory pressure for acute lung injury and acute respiratory distress syndrome: a randomized controlled trial. *JAMA.* Feb 13 2008;299(6):637-645.

27. Hirsh J, Dalen J, Guyatt G. The sixth (2000) ACCP guidelines for antithrombotic therapy for prevention and treatment of thrombosis. American College of Chest Physicians. *Chest.* Jan 2001;119(1 Suppl):1S-2S.

28. Harty RF, Ancha HB. Stress ulcer bleeding. *Curr Treat Options Gastroenterol.* Apr 2006;9(2):157-166.

29. Collard HR, Saint S, Matthay MA. Prevention of ventilator-associated pneumonia: an evidence-based systematic review. *Ann Intern Med.* Mar 18 2003;138(6):494-501.

30. Isakow W, Kollef MH. Preventing ventilator-associated pneumonia: an evidence-based approach of modifiable risk factors. *Semin Respir Crit Care Med.* Feb 2006;27(1):5-17.

31. Pronovost P, Needham D, Berenholtz S, et al. An intervention to decrease catheter-related bloodstream infections in the ICU. *N Engl J Med.* Dec 28 2006;355(26):2725-2732.

32. Pronovost PJ, Goeschel CA, Colantuoni E, et al. Sustaining reductions in catheter related bloodstream infections in Michigan intensive care units: observational study. *BMJ.* 2010;340:c309.

33. Klopotowska JE, Kuiper R, van Kan HJ, et al. On-ward participation of a hospital pharmacist in a Dutch intensive care unit reduces prescribing errors and related patient harm: an intervention study. *Crit Care.* 2010;14(5):R174.

34. Leape LL, Cullen DJ, Clapp MD, et al. Pharmacist participation on physician rounds and adverse drug events in the intensive care unit. *JAMA.* Jul 21 1999;282(3):267-270.

35. Kahn JM, Hill NS, Lilly CM, et al. The research agenda in ICU telemedicine: a statement from the Critical Care Societies Collaborative. *Chest.* Jul 2011;140(1):230-238.

36. Kahn JM. Intensive care unit telemedicine: promises and pitfalls. *Arch Intern Med.* Mar 28 2011;171(6):495-496.

37. Byrnes MC, Schuerer DJ, Schallom ME, et al. Implementation of a mandatory checklist of protocols and objectives improves compliance with a wide range of evidence-based intensive care unit practices. *Crit Care Med.* Oct 2009;37(10):2775-2781.

38. Krimsky WS, Mroz IB, McIlwaine JK, et al. A model for increasing patient safety in the intensive care unit: increasing the implementation rates of proven safety measures. *Qual Saf Health Care.* Feb 2009;18(1):74-80.

39. Simpson SQ, Peterson DA, O'Brien-Ladner AR. Development and implementation of an ICU quality improvement checklist. *AACN Adv Crit Care.* Apr-Jun 2007;18(2):183-189.

40. Stahl K, Palileo A, Schulman CI, et al. Enhancing patient safety in the trauma/surgical intensive care unit. *J Trauma.* Sep 2009;67(3):430-433; discussion 433-435.

41. Chu-Weininger MY, Wueste L, Lucke JF, Weavind L, Mazabob J, Thomas EJ. The impact of a tele-ICU on provider attitudes about teamwork and safety climate. *Qual Saf Health Care.* Dec 2010;19(6):e39.

42. Young LB, Chan PS, Cram P. Staff acceptance of tele-ICU coverage: a systematic review. *Chest.* Feb 2011;139(2):279-288.