Impact of telemedicine intensive care unit coverage on patient outcomes: a systematic review and meta-analysis

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CRD summary
The authors concluded that telemedicine intensive care unit coverage was associated with lower intensive care unit mortality and length of stay, but not with lower in-hospital mortality or hospital length of stay. The authors’ conclusion reflected the evidence presented, but it should be interpreted with caution given the variation between included studies and inconsistency in findings of subgroup analyses.

Authors' objectives
To evaluate the impact of remote telemedicine intensive care unit (ICU) coverage on ICU and in-hospital mortality and length of hospital stay.

Searching
PubMed, CINAHL, Global Health, Web of Science and the Cochrane Library were searched from January 1950 to September 2010 without language restrictions. Search terms were reported in an appendix (available from the authors by request). Abstracts and presentations from major relevant scientific conferences (e.g. American College of Emergency Physicians, American Telemedicine Association) were searched from 2006 to 2010 to identify unpublished studies.

Study selection
Eligible for inclusion in the review were studies that evaluated telemedicine ICU coverage and provided mortality data. Telemedicine ICU coverage was defined as the application of telemedicine to hospital critical care units, which was further defined as the use of any telecommunication system installed in ICUs to facilitate real time access to critical care specialists (e.g. intensive care specialists, or critical care nurses). This included exclusively reactive systems (where ICU staff were available by telephone as needed) to proactive systems (where the patients were continuously monitored in real time via videoconferencing, telemetry, and access to electronic medical records). Comparators were control ICUs, which could be similar ICU concurrently lacking telemedicine coverage or the same ICU before telemedicine coverage implementation. Length of stay in ICU and hospital were defined as secondary outcomes.

It appeared that most included studies were performed in the USA, although this was not explicitly stated. Most of the studies included medical ICUs and surgical ICUs. The type of ICU access (open to patient's attending physician, closed to physicians not on the ICU staff, or mixed) varied (where reported). Most studies had proactive ICU coverage, and a hub and spoke structure (a single consulting "hub" covering multiple ICU "spokes"), where reported.

Two reviewers selected studies for inclusion in the review, with any disagreements resolved by discussion.

Assessment of study quality
Study quality was assessed using the Newcastle-Ottawa Scale for assessing non-randomised studies. This scale assessed three domains of quality (selection, comparability and exposure), with scores that ranged from 0 (lower quality) to 9 (higher quality).

Two reviewers independently assessed study quality, with any disagreements resolved by discussion.

Data extraction
Data was extracted into a pre-piloted, standardised form in order to calculate odds ratios with 95% confidence intervals (CIs) and mean differences with 95% confidence intervals.

Two reviewers independently performed data extraction.
**Methods of synthesis**

Odds ratios and 95% confidence intervals for mortality outcomes, and mean differences and 95% confidence intervals for length of hospital stay outcomes, were combined in a meta-analysis using the DerSimonian and Laird random-effects model. Heterogeneity was assessed using the $I^2$ test.

Sensitivity analysis was performed by removing one study at a time from the analysis. Subgroup analysis were defined a priori and included: high quality (7 or more on Newcastle-Ottawa scale) and lower quality studies; studies with and without author affiliation with a telemedicine ICU vendor; hospitals with and without intensive care specialists on staff; ICU with and without academic affiliation; and open and closed ICUs.

Publication bias was assessed using the Begg test.

**Results of the review**

Thirteen before-and-after studies (35 ICUs; 41,374 patients) were included in the review. Seven studies were fully published and six were conference abstracts. Overall, study quality was moderate (median 6; range 3 to 9).

**Mortality:** Telemedicine ICU coverage was associated with a reduction in ICU mortality (OR 0.80, 95% CI 0.66 to 0.97; 12 studies), but there was evidence of high heterogeneity ($I^2$=77.1%). Telecoverage was not associated with a significant reduction in in-hospital mortality (OR 0.82, 95% CI 0.65 to 1.03; 10 studies), but there was evidence of high heterogeneity ($I^2$=84.9%). In subgroup analysis of high quality studies only, telecoverage was associated with a significant reduction in in-hospital mortality (OR 0.74, 95% CI 0.60 to 0.92; five studies). For all remaining subgroup analyses, telecoverage was not associated with a reduction in either ICU mortality or in-hospital mortality. There was no evidence of publication bias.

**Length of stay:** Telemedicine ICU coverage was associated with significant reduction in ICU length of stay (mean reduction 1.26 days, 95% CI -2.21 to -0.31; seven studies), but there was a high degree of heterogeneity ($I^2$=99.8%). In subgroup analyses, there was no significant reduction in ICU length of stay when only studies without vendor affiliations were included in the analysis (three studies). Telecoverage was not associated with a significant reduction of in-hospital length of stay (mean reduction 0.64 days; 95% CI -1.52 to 0.25 days, six studies), but there was evidence of a high degree heterogeneity ($I^2$=99.8%).

**Authors’ conclusions**

Telemedicine intensive care unit coverage was associated with lower intensive care unit mortality and length of stay, but not with lower in-hospital mortality or length of hospital stay.

**CRD commentary**

The authors addressed a clear research question, which was supported by detailed inclusion criteria, although study design criteria were not explicitly stated. The search strategy included a search of appropriate databases. There were attempts to locate unpublished studies and there were no language restrictions, reducing the risk of language and publication biases. Review processes were performed in duplicate, which reduced the risk of reviewer error and bias.

Study quality was assessed using an appropriate tool for the included study design. Adequate details of primary studies were provided. Heterogeneity was assessed using various methods. Significant heterogeneity was found, so it may have been inappropriate to combine the studies using meta-analysis.

The authors’ conclusion reflects the evidence presented but, given the heterogeneity of the included studies and inconsistency in findings of subgroup analyses, it should be interpreted with caution.

**Implications of the review for practice and research**

**Practice:** The authors did not state any implications for practice.

**Research:** The authors stated that there is a need for more rigorous evaluation of telemedicine ICU coverage. Future studies should consistently disclose potential financial conflicts of interest and funding sources.
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