Evidence-Based Studies of ICU Staffing: Who’s Running this Show?

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Background

Greater use of Intensivists assoc'd with

- ↓ ICU and hospital mortality
- ↓ length of stay and cost

24/7 coverage is important quality indicator

- Leapfrog group
- ESICM

ACCCM (CCM 2001):

- “Additional studies needed to determine if attaining these benefits requires 24/7 in-unit coverage”
## Grading the Evidence
(2\textsuperscript{nd} ACCP Conference on Antithrombotic Rx)

<table>
<thead>
<tr>
<th>Level</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>High quality RCT</td>
</tr>
<tr>
<td>II</td>
<td>Lower quality RCT</td>
</tr>
<tr>
<td>III</td>
<td>Non-randomized trials with concurrent controls</td>
</tr>
<tr>
<td>IV</td>
<td>Non-randomized trials, historical controls or patients treated at a different institution</td>
</tr>
<tr>
<td>V</td>
<td>Case series</td>
</tr>
</tbody>
</table>

All studies on ICU staffing are Level III or IV.
If 24/7 in-unit coverage is needed:

- Mortality of patients in MICUs without 24/7 coverage should vary with time of admission:
  - Lower when Intensivists are present or readily available
  - Higher when Intensivists are not
Study Design

Overview

• Assessed mortality as a function of admission time
• With and without risk-adjustment
Study Design

Inclusion criteria:

• All patients admitted to one of two MICUs
  - Denver Health
  - University Hospital

• Cared for by MICU team
  - Eliminates surgical overflow
Study Design

Exclusion Criteria

- < 18, > 89 years (HIPPA regulations)
- Final outcome unknown
- MICU admission time unknown
- Missing data re: covariates used in risk-adjustment

Analysis done with and without transfers from other acute care hospitals

- Transfers usually occur during daytime
- Known to have ↑ mortality
Study Design

Data recorded

- Demographics
- Outcome
- D/C diagnoses
- UHC illness severity class
  - 4-point scale based on DRGs
  - Developed at Yale, modified by UHC
  - Used in multiple regression-based studies to compare outcomes in various groups

Powered for a 2.5% mortality difference
Closed units
Interns and residents
- Dedicated 24/7 in-unit coverage

Pulm/CCM Fellows during day, 7 days/wk
- 10+ hr/day on weekdays (< on weekends)
- Other times: available by page
- UH: returned to evaluate every ventilated pt
- DH: returned at fellow's prerogative

Intensivists during day, 7 days/wk
- Weekdays > weekends
Definitions

“Intensivist Present”
- 6 AM to 5 PM, Mon-Fri
- 6 AM to 2 PM, Sat-Sun

“Intensivist Absent”
- Admission at all other times
Rationale for Definitions

Start time
- AM rounds start at 7:30 AM, 7 days/wk
  - Pts admitted after 6 AM seen within a few hrs (particularly if unstable)

End time
- Intensivists generally left by 5 or 6 PM Mon-Fri and by 2 PM Sat-Sun
  - Pts admitted later generally seen next AM
  - Intensivists could return at their prerogative
Analysis repeated using **other** times

- **Mon-Fri:**
  - Start times: 7 and 8 AM
  - End times: 4 and 6 PM
- **Sat-Sun:**
  - Start times: 12 noon and 1
  - End time: 3 PM
Statistical Tests

Continuous variables
- Univariate analysis, two-sided t test
- Analysis of variance

Categorical variables
- Chi-squared test
- Fisher’s exact
Statistical Tests

Risk adjustment
- Multivariate, logistic regression
- Forward, backward, stepwise selection
  - Wald statistic
- Discrimination of adjustment model
  - c statistic
- Calibration of model
  - Hosmer-Lameshow test
Results

Population

- 5089 eligible pts
- 314 excluded (missing data)
- Cohort: 4775 pts
  - 1911: Intensivist present (40%)
  - 2864: Intensivist absent (60%)
# Demographics

<table>
<thead>
<tr>
<th></th>
<th>Intensivist Present</th>
<th>Intensivist Absent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (± SD)</td>
<td>52 ± 16</td>
<td>51 ± 16</td>
</tr>
<tr>
<td>Male (%)</td>
<td>60</td>
<td>59</td>
</tr>
<tr>
<td>ED Admit (%)*</td>
<td>69</td>
<td>76</td>
</tr>
<tr>
<td>Illness Severity (%)*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Moderate</td>
<td>34</td>
<td>36</td>
</tr>
<tr>
<td>Major</td>
<td>49</td>
<td>48</td>
</tr>
<tr>
<td>Catastrophic*</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>
Weekday Mortality

Denver Health

<table>
<thead>
<tr>
<th>Admission Time (hrs)</th>
<th>Patients (N)</th>
<th>Mortality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>9:00</td>
<td>300</td>
<td>0</td>
</tr>
<tr>
<td>12:00</td>
<td>200</td>
<td>0</td>
</tr>
<tr>
<td>15:00</td>
<td>400</td>
<td>0</td>
</tr>
<tr>
<td>18:00</td>
<td>500</td>
<td>0</td>
</tr>
<tr>
<td>21:00</td>
<td>600</td>
<td>0</td>
</tr>
<tr>
<td>0:00</td>
<td>700</td>
<td>0</td>
</tr>
<tr>
<td>3:00</td>
<td>800</td>
<td>0</td>
</tr>
</tbody>
</table>

Admissions
Deaths
Mortality
Weekend Mortality

Admission Time (hrs)

Patients (N)

Mortality (%)

Admissions

Deaths

Mortality

0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250

0
2
4
6
8
10
12
14
16

0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23

6:00 9:00 12:00 15:00 18:00 21:00 0:00 3:00
# Summary of Results

<table>
<thead>
<tr>
<th></th>
<th>Intensivist Present</th>
<th>Intensivist Absent</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mortality (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>14.3</td>
<td>11.2</td>
<td>0.002</td>
</tr>
<tr>
<td>Adjusted</td>
<td>13.9</td>
<td>11.4</td>
<td>0.017</td>
</tr>
<tr>
<td>(age, illness severity)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted odds ratio</td>
<td>1.26</td>
<td></td>
<td>0.017</td>
</tr>
<tr>
<td>95% CI</td>
<td>1.04 - 1.51</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Length of stay (days)</strong></td>
<td>8.2 ± 10.8</td>
<td>7.1 ± 8.4</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td><strong>Cost ($x 10^3)</strong></td>
<td>$20 ± 31</td>
<td>$18 ± 26</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Potential Confounders

Hours used to define “Intensivist Present”
Ability of UHC illness severity score to adjust for differences in case mix
Incorrect assignment of patients to “Intensivist Present” group

- Admission during AM rounds
  - Last several hours
  - ? delayed Intensivist’s involvement
- Admission late afternoon
  - Evaluation delayed to following day

Overestimate true mortality

No differences found when choosing different start and end times
Incorrect assignment of patients to “Intensivist Absent” group
  - Admission at night and Intensivist returns to evaluate patient

Underestimate true mortality

Surveyed 14 Intensivists covering units
  - Returned at night: 3.6 ± 2.7 times/month

Small likelihood of this potential error
Intensivists not as available on weekends

- Irrespective of start and end times used

Weekday = weekend mortality

- 12.5 vs 12.4%
- Hours used to define “present” vs “absent” not important confounder
Risk Adjustment Model

Used UHC Severity of Illness score
- Well-established
- Based on demographics and DRGs

UHC
- 90 full members, 123 associates
- Benchmarking clinical and financial data

Good calibration and discrimination:
- c statistic = 0.79
- Homer-Lameshow: NS

Did not use APACHE or SAPS II

Inadequate risk adjustment?
Risk Adjustment

Morales et al (CCM, 2003)
- Assessed effect of nurse staffing and workload on mortality (AM/PM)
- Same resident, fellow and Intensivist staffing
- Used APACHE III for risk adjustment
- Higher AM mortality: 17.2 vs 13.3%
Risk Adjustment

Ensminger et al (Chest 2004)

- Weekend vs weekday mortality
- Similar resident, fellow and Intensivist staffing
- Used APACHE III for risk adjustment
- Weekend = weekday mortality
Conclusion #1

No evidence of ↑ mortality for pts admitted when Intensivists not available

- Limited to:
  - MICUs
  - 24/7 in-unit coverage by interns & residents
  - Fellows & Intensivists available on-call

Does not support Leapfrog and ESICM

- “24/7 coverage important quality indicator”
Speculations

PM MICU coverage with Hospitalists (i.e., general internists) would be safe

Benefits:
- More efficient use of Intensivists
- Lower projected Intensivist shortfall
- Cost savings
26% ↑ mortality for patients admitted when Intensivist available
Difficult to ignore
Possible explanations:
• Inadequate case-mix adjustment (doubt)
• Immediate Intensivist availability bad (doubt)
• Organizational (i.e., system) issues may be contributing to MICU mortality
Speculations

Potential system issues

- **Nursing workload > staffing**
  - Constant AM/PM nurse staffing (2:1)
  - More daytime orders, tests, transports

- **Lengthy AM rounding (doubt)**

- **Less aggressive care for pts admitted when Intensivists are absent**
  - Some patients stabilize by AM
  - ↓ overall testing, lines, transports needed
Implications

Luyt et al, CCM 2007
- 51,643 pts, 65.6% during off-hours

<table>
<thead>
<tr>
<th>Group</th>
<th>OR</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime vs off-hours</td>
<td>1.18</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>APACHE II adjustment</td>
<td>1.42</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

- 101,832 patients, 123 ICUs
- Mortality:

<table>
<thead>
<tr>
<th>Group</th>
<th>OR</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCM vs no CCM</td>
<td>2.13</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SAPS II adjustment</td>
<td>1.42</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Conclusion

Evidence addressing ICU staffing is poor (level 4 or 5)
  • Insufficient to mandate practice change
Observational studies
  • Mixed results
  • 3 show worse outcomes when intensivists are present
Acute Care Nurse Practitioners

History (JAMA, 1968 Colorado)

- Advance practice RN,
  - Rural primary care pediatric services
- Family, Geriatric, Adult, Occupational NP
- Acute Care NP started in 1995 (N = 115,000)
  - National certification
  - > 17,000 in ICU
- Driving forces
  - ↑ ICU admissions
  - Leapfrog
  - Intensivist and resident shortages
  - Resident work hour mandates
Use in teaching hospitals

- Example (UCSF):
  - 29 beds, open unit with co-management
  - NPs mixed in with residents
  - Night and weekend coverage
  - 1 CCM fellow, 1 resident, 3 NPs
  - Favorably reviewed by residents

- US, UK, Netherlands
Acute Care Nurse Practitioners

Duties

- Hx and PEx, entering into EMR
- Progress notes into EMR
- Entering orders, implementing bundles
- Rounding and presenting
- Consulting for admitting services
- Guide residents, precept NP students
- Respond to code blues and RR
- Committee work
- Sedation and pain management
- Attend all conferences
Procedures

- Central lines with U/S
- Arterial lines with U/S
- Intubation
- Procedural sedation
- Ventilator management
Outcomes

- Ventilator weaning
- Rx of pneumonia
- Use of lab tests
- Use of radiology
- UTIs and skin breakdown
- Readmissions
- Guideline compliance
- ICU readmissions
- Radiology interpretation

- Charting
- Epilepsy care
- Trauma care
- ICU occupancy
- LOS
- Mortality
- Cost of care
- Cardiac arrests
- ICP placement
Acute Care Nurse Practitioners

Results

- **Only 2 RCTs, both in ED setting**
  - Both showed no difference in outcomes
  - 1 showed better patient satisfaction

- **18 studies in ICUs**
  - All observational
  - 12 showed better outcomes
  - 6 showed no difference
  - 0 showed worse outcomes
Benefits (vs Residents and Intensivists)

- More free time for communication
- Continuity of care?
- Greater willingness to use protocols?
- Teaching rotating residents
- More procedure experience
Acute Care Nurse Practitioners

Disadvantages
- 40 hr work week
  - 3 x 12 therefore limited continuity
- Less likelihood to deviate from protocols when problems arise
- Documentation and billing issues
- Competition with residents for procedures
Conclusions

- NPs are increasingly used in ICUs
  - Mainly driven by cost
- All studies show no difference or better care
  - None are level I evidence

Question:
- You’ve got septic shock from pyelo and develop ARDS. Would you want to be cared for by a
  - NP vs a resident (with attending supervision)?
  - NP vs Intensivist
## Similarities

<table>
<thead>
<tr>
<th>Ours (4/05)</th>
<th>Theirs (1/07)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater use of board-certified intensivists in intensive care units (ICUs) is associated with reduced ICU and hospital mortality and shorter lengths of stays (1).</td>
<td>Greater use of trained intensivists is associated with reduced intensive care unit (ICU) and in-hospital mortality and with shorter lengths of stay (1)</td>
</tr>
<tr>
<td>...physician and nurse evaluations and treatment of patients admitted during daytime hours are delayed to a greater extent than occurs at other times</td>
<td>...physician and nurse evaluations and treatments of patients admitted during day shifts could be delayed more than during off hours</td>
</tr>
</tbody>
</table>
## Similarities

<table>
<thead>
<tr>
<th>Ours (4/05)</th>
<th>Theirs (1/07)</th>
</tr>
</thead>
<tbody>
<tr>
<td>...nursing workloads might be excessive during daytime hours because of the greater volume of new orders and the need to assist with more procedures and patient transports...</td>
<td>...nursing workloads might be heavier relative to the nurse/patient staffing ratio because of the higher volume of new orders and the need to assist in more procedures and patient transports.</td>
</tr>
</tbody>
</table>

Although it is not possible to estimate the potential frequency of these misclassifications our results were unchanged when different times were used to define intensivist presence.  

Although is was not possible to estimate the potential frequency of these misclassifications we do not think that they could have altered our findings because the results remained unchanged when different times were used to define off hours.