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**Abstract:**

Objective

To determine whether implementation of an Emergency Critical Care Program (ECCP) is associated with improved survival and early downgrade of critically ill medical patients in the ED.

Design


Setting

Tertiary academic medical center.

Patients

Adult medical patients presenting to the ED with a critical care admission order within 12 hours of arrival.

Interventions
ECCP—following initial resuscitation by the ED team, an ED-based intensivist provided dedicated bedside critical care for medical ICU patients in the same ED room.

Measurements and Main Results

Primary outcomes were in-hospital mortality and the proportion of patients downgraded to non-ICU status while still in the ED within 6 hours of the critical care admission order (ED downgrade <6 h). A difference-in-differences (DiD) analysis compared the change in outcomes for patients arriving during ECCP hours (2 pm to midnight, weekdays) between the pre-intervention period (8/14/2015-8/13/2017) and the intervention period (8/14/2017-8/13/2019) to the change in outcomes for patients arriving during non-ECCP hours (all other hours) over the same periods. Adjustment for severity of illness was performed using the emergency critical care Sequential Organ Failure Assessment (ecSOFA) score.

The primary cohort included 2,250 patients. The DiDs for the ecSOFA-adjusted in-hospital mortality and ED downgrade < 6 h were -6.0% (95% CI: -11.9 to -0.1%) and 4.8% (95% CI: -0.7 to 10.3%), respectively. The differences were largest in the intermediate severity patient group: decrease in mortality (DiD: -12.2%, 95% CI: -23.1 to -1.3); increase in ED downgrade < 6 h (DiD: 8.8%, 95% CI: 0.2 to 17.4).

Conclusions

The implementation of a novel ECCP was associated with a significant decrease in in-hospital mortality among critically ill medical ED patients. Early ED downgrades also increased, but the difference was statistically significant only among patients with intermediate severity of illness.
Title:

Association of an Emergency Critical Care Program with Survival and Early Downgrade Among Critically Ill Medical Patients in the Emergency Department

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Financial support used for the study: Critical care section fund, Stanford University School of Medicine

There are no conflicts of interest for the authors to report

Key words for indexing: Critical care medicine, emergency medicine, health care delivery models, ED critical care, ICU triage
Abstract

Objective: To determine whether implementation of an Emergency Critical Care Program (ECCP) is associated with improved survival and early downgrade of critically ill medical patients in the ED.


Setting: Tertiary academic medical center.

Patients: Adult medical patients presenting to the ED with a critical care admission order within 12 hours of arrival.

Interventions: ECCP—following initial resuscitation by the ED team, an ED-based intensivist provided dedicated bedside critical care for medical ICU patients in the same ED room.

Measurements and Main Results:

Primary outcomes were in-hospital mortality and the proportion of patients downgraded to non-ICU status while still in the ED within 6 hours of the critical care admission order (ED downgrade <6 h). A difference-in-differences (DiD) analysis compared the change in outcomes for patients arriving during ECCP hours (2 pm to midnight, weekdays) between the pre-intervention period (8/14/2015-8/13/2017) and the intervention period (8/14/2017-8/13/2019) to the change in outcomes for patients arriving during non-ECCP hours (all other hours) over the same periods. Adjustment for severity of illness was performed using the emergency critical care Sequential Organ Failure Assessment (eccSOFA) score.

The primary cohort included 2,250 patients. The DiDs for the eccSOFA-adjusted in-hospital mortality and ED downgrade < 6 h were -6.0% (95% CI: -11.9 to -0.1%) and 4.8% (95% CI: -0.7 to 10.3%), respectively. The differences were largest in the intermediate severity patient
group: decrease in mortality (DiD: -12.2%, 95% CI: -23.1 to -1.3); increase in ED downgrade < 6 h (DiD: 8.8%, 95% CI: 0.2 to 17.4).

**Conclusions:** The implementation of a novel ECCP was associated with a significant decrease in in-hospital mortality among critically ill medical ED patients. Early ED downgrades also increased, but the difference was statistically significant only among patients with intermediate severity of illness.
**Key Points**

**Question:** Does an Emergency Critical Care Program (ECCP) improve survival and ICU bed resource utilization for the critically ill in the ED?

**Findings:** This single-center retrospective cohort study utilizing a difference-in-differences analysis showed a statistically significant 6.0% decrease in in-hospital mortality and a statistically non-significant 4.8% increase in ED downgrade <6 h. The differences were largest and statistically significant in the intermediate severity of illness group: 12.2% decrease in mortality and 8.8% increase in ED downgrade <6 h.

**Meaning:** The implementation of an ECCP was associated with a significant decrease in in-hospital mortality among critically ill medical ED patients.

**Introduction**
Critical care delivery in US emergency departments (EDs) is increasing, particularly in urban hospitals.\textsuperscript{1,2} Between 2006 and 2014, ED visits for critically ill patients increased by 80% with minimal accompanying growth in available ED capacity and intensive care unit (ICU) beds.\textsuperscript{3} The ED is not designed for longitudinal care of the critically ill; previous studies on ED boarding of the critically ill have reported increased duration of mechanical ventilation, longer ICU length of stay, and higher mortality.\textsuperscript{4–11} Furthermore, ongoing care of these patients draws the emergency physician away from the care of other ED patients, which may impede overall ED throughput, contribute to ED crowding, and threaten patient safety.\textsuperscript{1,2,12}

Various alternative care models have been developed to address these issues\textsuperscript{12–22} However, the evidence of benefit of these interventions on patient-centered outcomes is limited to a few programs that require a dedicated space within the ED or elsewhere in the hospital.\textsuperscript{16,17,23,24} This limits generalizability as some hospitals may not have the physical space or financial resources to create and sustain a dedicated unit.

At Stanford Hospital, a novel Emergency Critical Care Program (ECCP) was launched in August of 2017 with the goals of improving care of the critically ill in the ED, offloading the ED team, and optimizing ICU bed utilization without the need for a dedicated physical space. In this ED-based intensivist consultation model, a dual board-certified emergency medicine-critical care physician is staffed as an intensivist during peak hours of patient volume in the ED to provide timely bedside critical care for medical ICU (MICU) patients following initial resuscitation by the ED team.
We hypothesized that implementation of the ECCP would be associated with decreased in-hospital mortality and an increase in timely and safe ED downgrades of critically ill medical patients.

Materials and Methods

Design/setting/population

This was a retrospective cohort study using electronic health record (EHR) ED-visit data between August 14, 2015 and August 13, 2019 at Stanford Hospital. During this period, the number of ED, inpatient, and ICU beds remained stable. The study was approved by the Stanford University IRB, Protocol #37542 with waiver of informed consent on May 16, 2016. The procedures were followed in accordance with the ethical standards of the responsible institutional committee on human experimentation and with the Helsinki Declaration of 1975.

All ED patients aged 18 years or older who received critical care admission orders within 12 hours of ED arrival were included. Patients who left against medical advice (AMA) or were transferred to another acute care facility were excluded. Although the MICU and ECC services are involved in the care of stroke and neurosurgery patients, these patients were also excluded as they are primarily managed by the neurocritical care and neurosurgery teams. Finally, patients admitted to non-MICU ICU services (Surgical ICU [SICU], Cardiovascular ICU
[CVICU], or Coronary Care Unit [CCU]) were separated and defined as an alternative ICU cohort and used as an additional control group for analysis (eFigure 1, eTable 1).

The ECCP was implemented on August 14, 2017. The study population was stratified based on date and time of ED arrival to allow us to compare outcomes between patients arriving during the pre-intervention period (August 14, 2015 to August 13, 2017) and intervention period (August 14, 2017 to August 13, 2019), both during ECCP hours (2 pm to midnight, Monday through Friday) and non-ECCP hours (all other hours). We used ED arrival time as a surrogate for receipt of the ECCP intervention because the time of the MICU consultation request from the ED was not captured in the EHR. We used a difference-in-differences (DiD) analysis to assess the impact of the ECCP intervention, as discussed further below.

Intervention

The intervention consisted of a change in the ED-to-MICU workflow during ECCP hours in the intervention period (Figure 1). The MICU consult/admission process was identical between the pre-intervention period and during non-ECCP hours in the intervention period, with all consults called to the MICU triage fellow who evaluated the patients in the ED and discussed the assessment and disposition with a MICU attending, primarily over the phone. During ECCP hours in the intervention period, however, all new consults were called to the ECC attending who provided prompt bedside evaluation, determined the disposition, and delivered critical care in the same ED room. The ECC attending was also able to admit MICU patients with a high likelihood
of downgrade within six hours to the ECC service and hold them in the ED for potential
downgrade to optimize ICU bed utilization. Full details of the ECCP have been published
previously.¹⁹

Data collection

Clinical data were extracted from the EHR (Epic Systems, Madison, WI) by querying the
clinical data warehouse (Clarity, Epic Systems, Madison, WI). Extracted data included
demographic characteristics (age, sex, race, ethnicity), admission diagnosis, and elements
required to calculate emergency critical care Sequential Organ Failure Assessment (eccSOFA)
score²⁵ for the severity of illness measurement (discussed in detail below). When extracted
records were ambiguous or inconclusive, the charts were manually reviewed.

Outcomes

Primary outcomes were in-hospital mortality and the proportion of patients downgraded
to non-ICU status within 6 hours of the critical care admission order while still in the ED (ED
downgrade < 6 h). Primary outcomes were analyzed both overall and stratified by pre-specified
illness severity category.

Secondary outcomes included time from ED arrival to admission order entry, proportion
of patients initially admitted to a non-ICU service prior to the critical care admission order
within 12 h of ED arrival, ED length of stay, hospital length of stay, and proportion of ED
downgrades < 6 h who subsequently required ICU admission within 24 hours (“bounce-ups”).
Statistical analysis

**Difference in Differences Analysis:**

To account for potential changes over time between the pre-intervention and intervention periods, we used patients arriving to the ED during non-ECCP hours as a comparison group. The difference in differences (DiD) for each outcome was calculated as follows:

Step 1. Calculate a change in outcome between the pre-intervention period and the intervention period for patients arriving during ECCP hours.

Step 2. Calculate a change in outcome over the same periods for patients arriving during non-ECCP hours.

The DiD is the result of Step 1 minus Step 2.

**Adjustment for Severity of Illness:**

Adjustment for severity of illness was performed using the eccSOFA score, which is a version of the SOFA score specifically adapted for ICU patients in the ED (AUROC of 0.775; 95% CI: 0.753–0.797). The score was calculated using data collected at the time of the initial ED order for hospital admission. As in prior studies that used the eccSOFA score, patients were categorized into 3 pre-specified illness severity categories based on eccSOFA score: low (0-3), intermediate (4-7), and high (≥ 8). To allow for within-stratum differences in severity, the eccSOFA score was modeled using linear splines with knots at 4, 8, and 12. For binary outcomes, adjusted risk differences were calculated using a logistic regression model.
continuous outcomes, unadjusted medians and interquartile ranges were calculated first. Then, DiDs (with 95% CIs) for unadjusted medians were calculated using quantile (minimum absolute deviation) regression. Quantile regression was also used to adjust medians for eccSOFA score. All statistical analyses were conducted using STATA 14.

Falsification Test:

To enhance causal inference, we performed the same DiD analysis for in-hospital mortality using the alternative ICU cohort of SICU, CVICU, and CCU patients, who were not subject to the ECCP intervention.

Results

Patient characteristics

The initial study sample consisted of 5,761 adult ED patients who had a critical care admission order entered within 12 hours of ED arrival. After exclusions, the analytical sample included 2,250 in the primary MICU cohort and 2,621 in the alternative ICU (mainly SICU) cohort (eFigure 1).

The 2,250 patients in the primary MICU cohort were categorized based on the date and time of ED arrival: non-ECCP hours/pre-intervention period (n = 750), non-ECCP hours/intervention period (n = 631), ECCP hours/pre-intervention period (n = 430), ECCP hours/intervention period (n = 439). The number of ED visits per day was higher during the
intervention period compared to the pre-intervention period, but baseline characteristics and admission diagnoses of the four groups were similar (Table 1). The proportion of patients in each eccSOFA category was also similar among the four groups (Table 2). In the non-ECCP hours group, there was a non-significant decrease in severity of illness from the pre-intervention period to the intervention period (mean eccSOFA difference: -0.35, p = 0.065). In the ECCP hours group, severity of illness remained the same (mean eccSOFA difference: 0, p = 0.992).

Outcomes

In-hospital mortality

Overall eccSOFA-adjusted in-hospital mortality for patients arriving to the ED during non-ECCP hours increased from 15.7% to 17.9% between the pre-intervention and intervention periods, for a difference of 2.2%. In contrast, for patients arriving during ECCP hours, the eccSOFA-adjusted mortality decreased from 19.0% to 15.2% for a difference of -3.8% (Table 2, Figure 2). Thus, the DiD for overall eccSOFA-adjusted in-hospital mortality was -6.0% (95% CI: -11.9 to -0.1). This corresponds to relative risk reduction of 28.3% and number needed to treat of 17 patients to prevent one in-hospital death.

The analysis stratified by eccSOFA category showed a statistically significant decrease in mortality in the intermediate severity of illness (eccSOFA 4-7) group (DiD -12.2%, 95% CI: -23.1 to -1.3). However, the differences were smaller and not statistically significant in the low severity of illness group (DiD -2.5%, 95% CI: -8.4 to 3.5) or the high severity of illness group (DiD -0.8%, 95% CI: -19.7 to 18.1) (Table 2, Figure 3).
A total of 2,621 patients in the alternative ICU cohort were analyzed as a falsification test. This cohort had a lower mean eccSOFA score and lower in-hospital mortality compared to our primary cohort (eTable 2). The DiD for eccSOFA-adjusted mortality in the alternative ICU cohort was neither clinically nor statistically significant: -0.1% (95% CI: -4.2 to 4.0) (Figure 2, eTable 2).

**ED Downgrades**

Overall eccSOFA-adjusted ED downgrade < 6 h (downgrade to non-ICU status within 6 hours of the critical care admission order while still in the ED) between the pre-intervention and intervention periods increased from 7.8% to 14.5% during non-ECCP hours, and increased even more from 7.4% to 19.0% during ECCP hours (DiD 4.8 %, 95% CI: -0.7 to 10.3%) (Table 2). This occurred without an increase in the bounce-up proportion (ICU transfer order within 24 hours of downgrade) (DiD -5.4%, 95% CI: -15.0 to 4.1) (Table 3). The increase in downgrades was statistically significant only in the intermediate severity group (DiD 8.8%, 95% CI: 0.2 to 17.4) (Table 2). The bounce-up proportion did not increase in this group either (DiD -11.1%, 95% CI: -31.7 to 9.4) (eTable 3).

**Secondary outcomes**

There were no statistically significant differences in time from ED arrival to admission order entry, ED length of stay, or hospital length of stay. There was, however, a statistically significant decrease in proportion of patients whose initial ED admission order was to a non-ICU service (DiD -6.7%, 95% CI: -13.0 to -0.4) (Table 3, eTable 4).
Discussion

We found that MICU patients who arrived to the ED during hours of ECCP operation had a statistically significant 6.0% decrease in overall eccSOFA-adjusted in-hospital mortality, despite an increased number of ED visits during the intervention period. A similar decrease did not occur in our alternative ICU cohort, which was not subject to the ECCP intervention. The main impact was seen among patients with intermediate severity of illness, who had 12.2% decrease in eccSOFA adjusted in-hospital mortality. The smaller effect on the low severity of illness group may be related to a lower baseline mortality in this group. In contrast, patients in the high severity of illness group were expedited for transfer to the ICU, leaving less opportunity for the ECC physician to make meaningful improvements in their care. It is also possible that ECCP has minimal effect on patients with severe multiorgan dysfunction.

Downgrading appropriate patients from ICU level of care in under 6 hours while still in the ED is one way to improve ICU bed utilization. Overall eccSOFA-adjusted ED downgrade < 6 h increased by 4.8%. While this difference was not statistically significant, we did observe a statistically significant increase in ED downgrade < 6 h of 8.8 % in the intermediate severity group. Successful early downgrades were likely due to aggressive early resuscitation and frequent bedside monitoring by ECC physicians. Importantly, these downgrades were not associated with increases in bounce-ups or overall ED length of stay.
To our knowledge, this is the first study to demonstrate the impact of an ED-based intensivist consultation model on patient outcomes. Few studies have reported the clinical impact of alternative models to deliver early longitudinal critical care for patients from or in the ED. Implementation of a 24 h ECC nursing program\textsuperscript{20} or an MICU alert team consisting of a dedicated ICU nurse and physician assistant\textsuperscript{21} were not associated with improved mortality for critically ill patients in the ED. Neither program involved dedicated physicians to provide ongoing bedside care in the ED. The EC3 program at University of Michigan, which has dedicated physicians and space, was associated with a decrease in the 30-day mortality (from 2.13\% to 1.83\%) and the risk-adjusted rate of ED admission to ICU (from 3.2\% to 2.7\%) for all ED patients.\textsuperscript{17} In the same program, they also demonstrated decreased ICU utilization for ED patients with diabetic ketoacidosis.\textsuperscript{23} Lastly, the Critical Care Resuscitation Unit at the University of Maryland was associated with a decrease in time from outside ED transfer requests to ICU arrival and lower mortality.\textsuperscript{24}

The results of these prior studies and ours suggest that timely bedside care by a dedicated critical care-trained physician outside of the traditional ICU space can help improve patient outcomes and ICU bed utilization. Our program is unique in that it does not require a dedicated physical space, and it can be tailored to the needs and resources of each hospital. We also found that, in our hospital, the intervention had its largest effect on patients with intermediate severity of illness.

The immediate post-ED resuscitation phase is an important time for critically ill medical patients as time-sensitive diagnostics, interventions, and specialty consultation may be needed.\textsuperscript{2} However, ED boarding due to ICU congestion puts patients at risk for suboptimal care during these pivotal hours of resuscitation.\textsuperscript{14} ED physicians must care for all ED patients
simultaneously, not just the critically ill. MICU physicians may be far removed from the ED and may have less contact with patients boarding in the ED. The risk increases when the care environment is under stress, as during ECCP hours in the pre-intervention period when the ED was busiest and the MICU triage fellow was responsible for evaluating more patients throughout the hospital. This may explain the higher eccSOFA-adjusted mortality for MICU patients during the ECCP hours compared with the non-ECCP hours in the pre-intervention period (19.0 vs 15.7%). (Figure 2) We did not observe such a difference in the alternative ICU cohort during the pre-intervention period, likely because patients in the alternative cohort have a different set of pathologies and are subject to a different triage system and staffing structure.

Reasons for improved outcomes associated with ECCP may include 1) provider factors (attending physician with dual training), 2) prompt evaluation and facilitation of time-sensitive interventions, 3) dedicated longitudinal care with frequent bedside reassessments, 4) improved communication and collaboration among providers – all provided during hours when the care environment for MICU patients in the ED was under the highest stress. It is also possible that the ECCP improved outcomes by reducing ICU mis-triage. Compared with patients who were directly admitted to the ICU from the ED, patients upgraded to the ICU within 24 hours of ED arrival have been shown to have increased in-hospital mortality. In our study, the ECCP was associated with a 6.7% decrease in the proportion of patients whose critical care admission order was preceded by an initial non-ICU admission order (Table 3).

Limitations
This was an observational study; alternative explanations for our findings are possible despite the adjustment for eccSOFA, the use of DiD analysis, and the lack of similar findings in the alternative ICU cohort. Although the eccSOFA score was specifically adapted for critically ill patients in the ED and internally validated using nearly 4,000 patients,\textsuperscript{25} it has not been externally validated.

We used ED arrival time as a surrogate marker to distinguish patients whose care was affected by the presence of the ECC physician, as the MICU consult request time from the ED was not captured in the EHR. However, patients arriving close to the end of non-ECCP hours (e.g., 12 pm) may have received care from the ECC physician as the MICU consult request may have been initiated after 2pm. Similarly, patients arriving near the end of ECCP hours (e.g., 11 pm) may have received minimum care from the ECC physician even though they were categorized in the ECCP hours group. Furthermore, ECC physicians helped with emergencies for existing MICU patients in the evening, some of whom may have originally arrived to the ED during non-ECCP hours. These factors may have contributed to a spillover effect (e.g., on ED downgrade <6 h), but it would be expected to bias results towards the null.

Lastly, this is a single academic center study, and the findings may not be generalizable to hospitals with significantly different patient populations, ED staffing structures, or hospital workflows.

**Conclusions**

The implementation of a novel ED-based intensivist consultation program was associated with a statistically significant decrease in in-hospital mortality among critically ill medical
patients in the ED, with the greatest improvement in the intermediate severity of illness group. A statistically significant increase of early ED downgrades was seen among patients with intermediate severity of illness but not in the overall group.
References


ED to MICU Workflow for Baseline (Pre-Intervention Period and Non-ECCP Hours/Intervention Period) vs. ECCP hours/Intervention Period

ECC nurse = Critical care trained ED nurse who helped primary ED nurses for various patients including the critically ill. At any time, only one ECC nurse was staffed in the ED.

Regardless of the disposition (including ECC service admit), the patients could stay in the same room to receive further care while in the ED.

Admission to ECC service was considered for undifferentiated patients, MICU patients with no available ICU beds, and MICU patients with a high likelihood of downgrade to a non-ICU service within six hours (based on the initial judgement by the ECC physician). Patients with high likelihood of downgrade within six hours were kept in the ED even if there was an open ICU bed to avoid unnecessary ICU admissions. However, as soon as these patients demonstrated sufficient stability for downgrade or, alternatively, a need for MICU admission, appropriate beds were requested immediately.

ECC patients remaining in the ED at midnight were admitted to the MICU and handed off to the MICU team. Of note, ECCP physicians did not see other ED patients, but they helped with emergencies and procedures in the ICUs, attended code blues, and staffed all new MICU admissions in the evening. They also provided teaching to house staff and nurses between patient care.

Once the critical care admission order was entered in the ED, the primary nurse-to-patient ratio became 1:2.
Figure 2. Overall eccSOFA-adjusted In-Hospital Mortality for the Primary Cohort (MICU patients) and the Alternative ICU Cohort (mainly SICU patients).

Upper Lines: The primary cohort consisted of MICU patients (n=2,250), who were subject to the ECCP intervention. Dashed green line shows the projected mortality if the intervention had no effect.

Lower Lines: The alternative ICU cohort consisted of SICU, CVICU, and CCU patients (n=2,621), who were not subject to the ECCP intervention.

Abbreviation: eccSOFA, emergency critical care Sequential Organ Failure Assessment; DiD, difference-in-differences

Study period definitions are explained in footnote to Table 1.
Figure 3. eccSOFA-adjusted In-Hospital Mortality for Different Illness Severity Categories.

The difference-in-differences (DiD) was statistically significant in the intermediate severity of illness (eccSOFA 4-7) group, but not in the low severity of illness (eccSOFA 0-3) or the high severity of illness (eccSOFA 8+) groups.

Abbreviation: eccSOFA, emergency critical care Sequential Organ Failure Assessment

Study period definitions are explained in footnote to Table 1.
Figure 2

The figure shows a comparison of in-hospital mortality rates between pre-intervention and intervention periods for two cohorts:
- **Study Cohort**: DID -6.0% (95% CI: -11.9, -0.1)
- **Alternative Cohort**: DID -0.1% (95% CI: -4.2, 4.0)

The data is categorized by ED arrival times:
- **ED arrival during non-ECCP hours**
- **ED arrival during ECCP hours**

The graph illustrates the percent change in mortality rates over time for these categories.
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<td>14 (89)</td>
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<tr>
<td>Altered mental status</td>
<td>6 (45)</td>
<td>5 (31)</td>
</tr>
<tr>
<td>Diabetic ketoacidosis</td>
<td>6 (44)</td>
<td>8 (50)</td>
</tr>
<tr>
<td>Gastrointestinal bleed</td>
<td>6 (42)</td>
<td>5 (33)</td>
</tr>
<tr>
<td>Other diagnoses</td>
<td>49 (369)</td>
<td>49 (309)</td>
</tr>
</tbody>
</table>

Abbreviation: ECCP, Emergency Critical Care Program; SD, Standard Deviation.

\(^a\) Non-ECCP hours: Weekends and weekday not included in the ECCP hours.

\(^b\) ECCP hours: From 2pm to midnight, Monday through Friday

\(^c\) Pre-Intervention Period: 8/14/2015-8/13/2017

\(^d\) Intervention Period: 8/14/2017-8/13/2019
Table 2: Patient Distribution by eccSOFA Category and Primary Outcomes

<table>
<thead>
<tr>
<th>Patient distribution and primary outcomes</th>
<th>Non-ECCP hours</th>
<th>ECCP hours</th>
<th>Difference in Differences (DiD)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Intervention Period</td>
<td>Intervention Period</td>
<td>Pre-Intervention Period</td>
<td>Intervention Period</td>
</tr>
<tr>
<td>Study cohort [Total=2,250]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>750</td>
<td>631</td>
<td>430</td>
<td>439</td>
</tr>
</tbody>
</table>

By eccSOFA category

| eccSOFA 0-3 | 42.7 (320) | 45.6 (288) | 44.9 (193) | 47.2 (207) |                        |         |
| eccSOFA 4-7 | 36.0 (270) | 37.7 (238) | 39.8 (171) | 37.4 (164) |                        |         |
| eccSOFA 8+  | 21.3 (160) | 16.6 (105) | 15.3 (66)  | 15.5 (68)  |                        |         |

eccSOFA score mean (SD)

<table>
<thead>
<tr>
<th>By eccSOFA category</th>
<th>% (n)</th>
<th>% (n)</th>
<th>% (n)</th>
<th>% (n)</th>
<th>DiD [95% CI]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>eccSOFA 0-3</td>
<td>4.62 (3.64)</td>
<td>4.28 (3.36)</td>
<td>4.11 (3.05)</td>
<td>4.11 (3.26)</td>
<td>0.34 [-0.24, 0.91]</td>
<td>0.248</td>
</tr>
</tbody>
</table>

In-hospital death

<table>
<thead>
<tr>
<th>In-hospital death</th>
<th>% (n)</th>
<th>% (n)</th>
<th>% (n)</th>
<th>% (n)</th>
<th>DiD [95% CI]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall unadjusted</td>
<td>17.2 (129)</td>
<td>17.7 (112)</td>
<td>17.4 (75)</td>
<td>14.4 (63)</td>
<td>-3.6 [-9.9, 2.7]</td>
<td>0.258</td>
</tr>
<tr>
<td>Overall eccSOFA-adjusted</td>
<td>15.7</td>
<td>17.9</td>
<td>19.0</td>
<td>15.2</td>
<td>-6.0 [-11.9, -0.1]</td>
<td>0.045</td>
</tr>
<tr>
<td>eccSOFA 0-3</td>
<td>5.0</td>
<td>5.5</td>
<td>7.3</td>
<td>5.3</td>
<td>-2.5 [-8.4, 3.5]</td>
<td>0.416</td>
</tr>
<tr>
<td>eccSOFA 4-7</td>
<td>18.5</td>
<td>21.4</td>
<td>24.0</td>
<td>14.6</td>
<td>-12.2 [-23.1, -1.3]</td>
<td>0.029</td>
</tr>
<tr>
<td>eccSOFA 8+</td>
<td>36.6</td>
<td>42.4</td>
<td>37.0</td>
<td>42.0</td>
<td>-0.8 [-19.7, 18.1]</td>
<td>0.934</td>
</tr>
</tbody>
</table>

ED downgrade < 6 h<sup>a</sup>

<table>
<thead>
<tr>
<th>ED downgrade &lt; 6 h&lt;sup&gt;a&lt;/sup&gt;</th>
<th>% (n)</th>
<th>% (n)</th>
<th>% (n)</th>
<th>% (n)</th>
<th>DiD [95% CI]</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall unadjusted</td>
<td>7.6 (57)</td>
<td>14.6 (92)</td>
<td>7.4 (32)</td>
<td>19.4 (85)</td>
<td>4.9 [-0.6, 10.5]</td>
<td>0.082</td>
</tr>
<tr>
<td>Overall eccSOFA-adjusted</td>
<td>7.8</td>
<td>14.5</td>
<td>7.4</td>
<td>19.0</td>
<td>4.8 [-0.7, 10.3]</td>
<td>0.085</td>
</tr>
<tr>
<td>eccSOFA 0-3</td>
<td>10.0</td>
<td>18.8</td>
<td>10.8</td>
<td>21.7</td>
<td>2.1 [-7.0, 11.1]</td>
<td>0.656</td>
</tr>
<tr>
<td>eccSOFA 4-7</td>
<td>7.3</td>
<td>13.9</td>
<td>4.1</td>
<td>19.5</td>
<td>8.8 [0.2, 17.4]</td>
<td>0.045</td>
</tr>
<tr>
<td>eccSOFA 8+</td>
<td>3.0</td>
<td>4.8</td>
<td>6.7</td>
<td>11.5</td>
<td>3.0 [-7.9, 14.0]</td>
<td>0.588</td>
</tr>
</tbody>
</table>

Abbreviations:

ECCP, Emergency Critical Care Program;
eccSOFA, emergency critical care Sequential Organ Failure Assessment;
CI, Confidence Interval.

Within each eccSOFA category, linear adjustment has been applied.

Study period definitions are explained in footnote to Table 1.

<sup>a</sup> Downgrade to non-ICU status within 6 hours of critical care admission order while still in ED.
### Table 3: Secondary Outcomes

<table>
<thead>
<tr>
<th>Secondary outcomes</th>
<th>Non-ECCP hours</th>
<th>ECCP hours</th>
<th>Difference in differences (DiD)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre-Intervention Period</td>
<td>Intervention Period</td>
<td>Pre-Intervention Period</td>
<td>Intervention Period</td>
</tr>
<tr>
<td>Proportion of patients initially admitted to non-ICU service (^a)</td>
<td>% (n)</td>
<td>% (n)</td>
<td>% (n)</td>
<td>% (n)</td>
</tr>
<tr>
<td>16.3 (122)</td>
<td>16.2 (102)</td>
<td>20.0 (86)</td>
<td>13.2 (58)</td>
<td>-6.7 [-13.0, -0.4]</td>
</tr>
<tr>
<td>Bounce-up (^b) proportion for ED downgrade &lt; 6 h</td>
<td>5.3 (3)</td>
<td>13.0 (12)</td>
<td>0.0 (0)</td>
<td>2.4 (2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>median (IQR)</th>
<th>median (IQR)</th>
<th>median (IQR)</th>
<th>median (IQR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED arrival to admit order, overall unadjusted in h</td>
<td>2.9 (2, 4.2)</td>
<td>3.0 (2.2, 4.5)</td>
<td>3.0 (2, 4.2)</td>
<td>2.9 (1.8, 4.3)</td>
</tr>
<tr>
<td>ED length of stay, overall unadjusted in h</td>
<td>8.2 (5.2, 12.8)</td>
<td>7.8 (5.3, 11.9)</td>
<td>8.4 (5.4, 17.6)</td>
<td>7.7 (5.1, 13.5)</td>
</tr>
<tr>
<td>Hospital length of stay, overall unadjusted in days</td>
<td>4.9 (2.7, 9.2)</td>
<td>4.3 (2.3, 7.7)</td>
<td>4.8 (2.8, 9.5)</td>
<td>4.7 (2.6, 7.8)</td>
</tr>
</tbody>
</table>

Study period definitions are explained in footnote to Table 1. DiD confidence intervals are based on minimum absolute difference regression. Abbreviation: IQR, Interquartile range; h, hours. 
\(^a\) All patients received subsequent ICU transfer order within 12 hours of ED arrival. Denominator for this proportion is the total number in the study cohort. 
\(^b\) Bounce-up is defined as re-entry of admission order to ICU within 24 hours of ED downgrade to non-ICU status. Denominator for this proportion is the total number of ED downgrade < 6h in Table 2.