

Critical Care Medicine

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

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Abstract:	<p>Objective</p> <p>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.</p> <p>Design</p> <p>Single-center, retrospective cohort study using electronic health record ED-visit data between 2015-2019.</p> <p>Setting</p> <p>Tertiary academic medical center.</p> <p>Patients</p> <p>Adult medical patients presenting to the ED with a critical care admission order within 12 hours of arrival.</p> <p>Interventions</p>

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.

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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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.

Design: Single-center, retrospective cohort study using electronic health record ED-visit data between 2015-2019.

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

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4 Critical care delivery in US emergency departments (EDs) is increasing, particularly in
5 urban hospitals.^{1,2} Between 2006 and 2014, ED visits for critically ill patients increased by 80%
6 with minimal accompanying growth in available ED capacity and intensive care unit (ICU)
7 beds.³ The ED is not designed for longitudinal care of the critically ill; previous studies on ED
8 boarding of the critically ill have reported increased duration of mechanical ventilation, longer
9 ICU length of stay, and higher mortality.⁴⁻¹¹ Furthermore, ongoing care of these patients draws
10 the emergency physician away from the care of other ED patients, which may impede overall ED
11 throughput, contribute to ED crowding, and threaten patient safety.^{1,2,12}
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25 Various alternative care models have been developed to address these issues¹²⁻²²
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27 However, the evidence of benefit of these interventions on patient-centered outcomes is limited
28 to a few programs that require a dedicated space within the ED or elsewhere in the
29 hospital.^{16,17,23,24} This limits generalizability as some hospitals may not have the physical space
30 or financial resources to create and sustain a dedicated unit.
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38 At Stanford Hospital, a novel Emergency Critical Care Program (ECCP) was launched in
39 August of 2017 with the goals of improving care of the critically ill in the ED, offloading the ED
40 team, and optimizing ICU bed utilization without the need for a dedicated physical space. In this
41 ED-based intensivist consultation model, a dual board-certified emergency medicine-critical
42 care physician is staffed as an intensivist during peak hours of patient volume in the ED to
43 provide timely bedside critical care for medical ICU (MICU) patients following initial
44 resuscitation by the ED team.
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4 We hypothesized that implementation of the ECCP would be associated with
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6 decreased in-hospital mortality and an increase in timely and safe ED downgrades of
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8 critically ill medical patients.
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10 11 12 13 14 15 16 17 **Materials and Methods** 18 19

20 21 22 **Design/setting/population** 23 24 25

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27 This was a retrospective cohort study using electronic health record (EHR) ED-visit data
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29 between August 14, 2015 and August 13, 2019 at Stanford Hospital. During this period, the
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31 number of ED, inpatient, and ICU beds remained stable. The study was approved by the Stanford
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33 University IRB, Protocol #37542 with waiver of informed consent on May 16, 2016. The
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35 procedures were followed in accordance with the ethical standards of the responsible institutional
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37 committee on human experimentation and with the Helsinki Declaration of 1975.
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44 All ED patients aged 18 years or older who received critical care admission orders
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46 within 12 hours of ED arrival were included. Patients who left against medical advice (AMA) or
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48 were transferred to another acute care facility were excluded. Although the MICU and ECC
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50 services are involved in the care of stroke and neurosurgery patients, these patients were also
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52 excluded as they are primarily managed by the neurocritical care and neurosurgery teams.
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55 Finally, patients admitted to non-MICU ICU services (Surgical ICU [SICU], Cardiovascular ICU
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[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

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4 of downgrade within six hours to the ECC service and hold them in the ED for potential
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6 downgrade to optimize ICU bed utilization. Full details of the ECCP have been published
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8 previously.¹⁹
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11 12 13 14 Data collection

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19 Clinical data were extracted from the EHR (Epic Systems, Madison, WI) by querying the
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21 clinical data warehouse (Clarity, Epic Systems, Madison, WI). Extracted data included
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23 demographic characteristics (age, sex, race, ethnicity), admission diagnosis, and elements
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25 required to calculate emergency critical care Sequential Organ Failure Assessment (eccSOFA)
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27 score²⁵ for the severity of illness measurement (discussed in detail below). When extracted
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29 records were ambiguous or inconclusive, the charts were manually reviewed.
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35 36 Outcomes

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41 Primary outcomes were in-hospital mortality and the proportion of patients downgraded
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43 to non-ICU status within 6 hours of the critical care admission order while still in the ED (ED
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45 downgrade < 6 h). Primary outcomes were analyzed both overall and stratified by pre-specified
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47 illness severity category.
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51 Secondary outcomes included time from ED arrival to admission order entry, proportion
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53 of patients initially admitted to a non-ICU service prior to the critical care admission order
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55 within 12 h of ED arrival, ED length of stay, hospital length of stay, and proportion of ED
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57 downgrades < 6 h who subsequently required ICU admission within 24 hours (“bounce-ups”).
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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).²⁵ 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,^{20,25} 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.²⁶ For

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.^{27,28} 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

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4 intervention period compared to the pre-intervention period, but baseline characteristics and
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6 admission diagnoses of the four groups were similar (Table 1). The proportion of patients in each
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8 eccSOFA category was also similar among the four groups (Table 2). In the non-ECCP hours
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10 group, there was a non-significant decrease in severity of illness from the pre-intervention period
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12 to the intervention period (mean eccSOFA difference: -0.35, $p = 0.065$). In the ECCP hours
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15 group, severity of illness remained the same (mean eccSOFA difference: 0, $p = 0.992$).
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21 Outcomes

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28 Overall eccSOFA-adjusted in-hospital mortality for patients arriving to the ED during
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30 non-ECCP hours increased from 15.7% to 17.9% between the pre-intervention and intervention
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32 periods, for a difference of 2.2%. In contrast, for patients arriving during ECCP hours, the
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34 eccSOFA-adjusted mortality decreased from 19.0% to 15.2% for a difference of -3.8% (Table 2,
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36 Figure 2). Thus, the DiD for overall eccSOFA-adjusted in-hospital mortality was -6.0% (95% CI:
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38 -11.9 to -0.1). This corresponds to relative risk reduction of 28.3% and number needed to treat of
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41 17 patients to prevent one in-hospital death.
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48 The analysis stratified by eccSOFA category showed a statistically significant decrease in
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50 mortality in the intermediate severity of illness (eccSOFA 4-7) group (DiD -12.2%, 95% CI: -
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52 23.1 to -1.3). However, the differences were smaller and not statistically significant in the low
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54 severity of illness group (DiD -2.5%, 95% CI: -8.4 to 3.5) or the high severity of illness group
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56 (DiD -0.8%, 95% CI: -19.7 to 18.1) (Table 2, Figure 3).
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7 A total of 2,621 patients in the alternative ICU cohort were analyzed as a falsification
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9 test. This cohort had a lower mean eccSOFA score and lower in-hospital mortality compared to
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11 our primary cohort (eTable 2). The DiD for eccSOFA-adjusted mortality in the alternative ICU
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13 cohort was neither clinically nor statistically significant: -0.1% (95% CI: -4.2 to 4.0) (Figure 2,
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15 eTable 2).
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21 *ED Downgrades*

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24 Overall eccSOFA-adjusted ED downgrade < 6 h (downgrade to non-ICU status within 6
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26 hours of the critical care admission order while still in the ED) between the pre-intervention and
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28 intervention periods increased from 7.8% to 14.5% during non-ECCP hours, and increased even
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30 more from 7.4% to 19.0% during ECCP hours (DiD 4.8 %, 95% CI: -0.7 to 10.3%) (Table 2).
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33 This occurred without an increase in the bounce-up proportion (ICU transfer order within 24
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35 hours of downgrade) (DiD -5.4%, 95% CI: -15.0 to 4.1) (Table 3). The increase in downgrades
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37 was statistically significant only in the intermediate severity group (DiD 8.8%, 95% CI: 0.2 to
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39 17.4) (Table 2). The bounce-up proportion did not increase in this group either (DiD -11.1%,
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41 95% CI: -31.7 to 9.4) (eTable 3).
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48 *Secondary outcomes*

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51 There were no statistically significant differences in time from ED arrival to admission
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53 order entry, ED length of stay, or hospital length of stay. There was, however, a statistically
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55 significant decrease in proportion of patients whose initial ED admission order was to a non-ICU
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57 service (DiD -6.7%, 95% CI: -13.0 to -0.4) (Table 3, eTable 4).
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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 program²⁰ or an MICU alert team consisting of a dedicated ICU nurse and physician assistant²¹ 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.¹⁷ In the same program, they also demonstrated decreased ICU utilization for ED patients with diabetic ketoacidosis.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.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.² However, ED boarding due to ICU congestion puts patients at risk for suboptimal care during these pivotal hours of resuscitation.¹⁴ ED physicians must care for all ED patients

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4 simultaneously, not just the critically ill. MICU physicians may be far removed from the ED and
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6 may have less contact with patients boarding in the ED.¹⁴ The risk increases when the care
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8 environment is under stress, as during ECCP hours in the pre-intervention period when the ED
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10 was busiest and the MICU triage fellow was responsible for evaluating more patients throughout
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12 the hospital. This may explain the higher eccSOFA-adjusted mortality for MICU patients during
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14 the ECCP hours compared with the non-ECCP hours in the pre-intervention period (19.0 vs
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16 15.7%). (Figure 2) We did not observe such a difference in the alternative ICU cohort during the
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18 pre-intervention period, likely because patients in the alternative cohort have a different set of
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20 pathologies and are subject to a different triage system and staffing structure.
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26 Reasons for improved outcomes associated with ECCP may include 1) provider factors
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28 (attending physician with dual training), 2) prompt evaluation and facilitation of time-sensitive
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30 interventions, 3) dedicated longitudinal care with frequent bedside reassessments, 4) improved
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32 communication and collaboration among providers – all provided during hours when the care
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34 environment for MICU patients in the ED was under the highest stress. It is also possible that the
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36 ECCP improved outcomes by reducing ICU mis-triage. Compared with patients who were
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38 directly admitted to the ICU from the ED, patients upgraded to the ICU within 24 hours of ED
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40 arrival have been shown to have increased in-hospital mortality.²⁹ In our study, the ECCP was
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42 associated with a 6.7% decrease in the proportion of patients whose critical care admission order
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44 was preceded by an initial non-ICU admission order (Table 3).
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53 Limitations 54 55 56 57 58 59 60 61 62 63 64 65

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4 This was an observational study; alternative explanations for our findings are possible
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6 despite the adjustment for eccSOFA, the use of DiD analysis, and the lack of similar findings in
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8 the alternative ICU cohort. Although the eccSOFA score was specifically adapted for critically
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10 ill patients in the ED and internally validated using nearly 4,000 patients,²⁵ it has not been
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12 externally validated.
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16 We used ED arrival time as a surrogate marker to distinguish patients whose care was
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18 affected by the presence of the ECC physician, as the MICU consult request time from the ED
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20 was not captured in the EHR. However, patients arriving close to the end of non-ECCP hours
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22 (e.g., 12 pm) may have received care from the ECC physician as the MICU consult request may
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24 have been initiated after 2pm. Similarly, patients arriving near the end of ECCP hours (e.g., 11
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26 pm) may have received minimum care from the ECC physician even though they were
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28 categorized in the ECCP hours group. Furthermore, ECC physicians helped with emergencies for
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30 existing MICU patients in the evening, some of whom may have originally arrived to the ED
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32 during non-ECCP hours. These factors may have contributed to a spillover effect (e.g., on ED
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34 downgrade <6 h), but it would be expected to bias results towards the null.
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41 Lastly, this is a single academic center study, and the findings may not be generalizable
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43 to hospitals with significantly different patient populations, ED staffing structures, or hospital
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45 workflows.
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50 51 **Conclusions** 52 53 54

55 The implementation of a novel ED-based intensivist consultation program was associated
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57 with a statistically significant decrease in in-hospital mortality among critically ill medical
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4 patients in the ED, with the greatest improvement in the intermediate severity of illness group. A
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7 statistically significant increase of early ED downgrades was seen among patients with
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9 intermediate severity of illness but not in the overall group.
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Figure 1. 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.

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

^b 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.

^c 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.

^d 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.

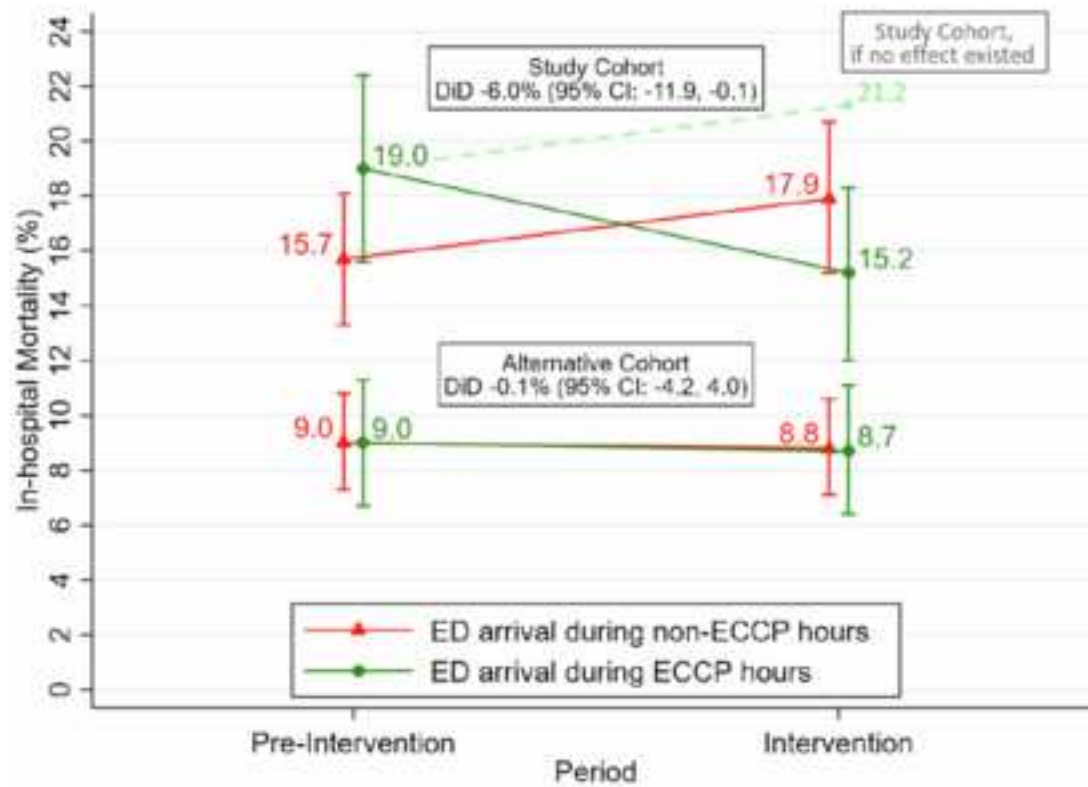
Figure 3. eccSOFA-adjusted In-Hospital Mortality for Different Illness Severity Categories.

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.

	Pre-intervention period and non-ECCP hours/intervention period		ECCP hours/intervention period	
Initial evaluation and resuscitation	ED team		ED team	
Who to contact for MICU consult	MICU fellow with a triage phone		ECC attending	
Disposition options ^a	MICU admit	Recommending admission to other ICU or ward team	MICU admit	ECC service admit ^b Recommending admission to other team
Responsible party after critical care admission order entry in the ED	MICU team		ECC attending ^c	
Nursing support	Primary ED nurse ^d + ECC nurse		Primary ED nurse + ECC nurse	



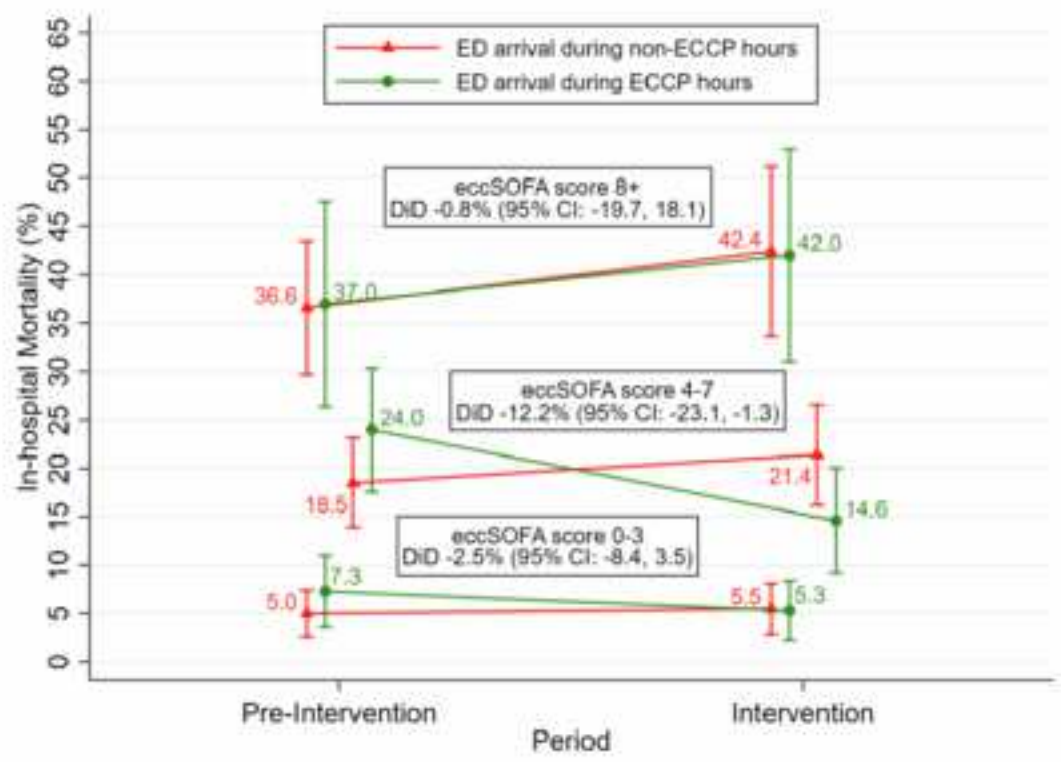


Table 1: Demographic Characteristics and Diagnoses of Primary Cohort

Characteristics	Non-ECCP hours ^a		ECCP hours ^b	
	Pre-Intervention Period ^c	Intervention Period ^d	Pre-Intervention Period	Intervention Period
ED Visits per Day	115	121	113	122
Study cohort [Total=2,250]	750	631	430	439
Age , mean (SD) in years	61 (19)	64 (20)	63 (19)	63 (19)
	% (n)	% (n)	% (n)	% (n)
Male Sex	51 (385)	52 (327)	52 (225)	56 (245)
Race				
White	51 (383)	47 (295)	51 (219)	49 (215)
Asian	16 (117)	15 (96)	16 (68)	15 (66)
Black	8 (60)	9 (58)	8 (34)	8 (33)
Other or unknown	25 (190)	29 (182)	25 (109)	28 (125)
Ethnicity				
Hispanic	18 (138)	19 (119)	18 (76)	22 (95)
Non-Hispanic	81 (604)	80 (503)	81 (347)	78 (341)
Unknown	1 (8)	1 (9)	2 (7)	1 (3)
Top 5 Primary Diagnoses				
Respiratory distress/pneumonia	17 (127)	18 (112)	20 (86)	19 (83)
Sepsis/septic shock	16 (123)	14 (89)	13 (58)	14 (61)
Altered mental status	6 (45)	5 (31)	6 (26)	5 (22)
Diabetic ketoacidosis	6 (44)	8 (50)	4 (18)	5 (21)
Gastrointestinal bleed	6 (42)	5 (33)	4 (17)	5 (24)
Other diagnoses	49 (369)	49 (309)	52 (225)	52 (228)

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

Patient distribution and primary outcomes	Non-ECCP hours		ECCP hours		Difference in Differences (DiD)	<i>P</i> value
	Pre-Intervention Period	Intervention Period	Pre-Intervention Period	Intervention Period		
Study cohort [Total=2,250]	750	631	430	439		
	% (n)	% (n)	% (n)	% (n)	DiD [95% CI]	
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 <i>mean (SD)</i>	4.62 (3.64)	4.28 (3.36)	4.11 (3.05)	4.11 (3.26)	0.34 [-0.24, 0.91]	0.248
In-hospital death						
Overall unadjusted	17.2 (129)	17.7 (112)	17.4 (75)	14.4 (63)	-3.6 [-9.9, 2.7]	0.258
Overall eccSOFA-adjusted	15.7	17.9	19.0	15.2	-6.0 [-11.9, -0.1]	0.045
eccSOFA 0-3	5.0	5.5	7.3	5.3	-2.5 [-8.4, 3.5]	0.416
eccSOFA 4-7	18.5	21.4	24.0	14.6	-12.2 [-23.1, -1.3]	0.029
eccSOFA 8+	36.6	42.4	37.0	42.0	-0.8 [-19.7, 18.1]	0.934
ED downgrade < 6 h^a						
Overall unadjusted	7.6 (57)	14.6 (92)	7.4 (32)	19.4 (85)	4.9 [-0.6, 10.5]	0.082
Overall eccSOFA-adjusted	7.8	14.5	7.4	19.0	4.8 [-0.7, 10.3]	0.085
eccSOFA 0-3	10.0	18.8	10.8	21.7	2.1 [-7.0, 11.1]	0.656
eccSOFA 4-7	7.3	13.9	4.1	19.5	8.8 [0.2, 17.4]	0.045
eccSOFA 8+	3.0	4.8	6.7	11.5	3.0 [-7.9, 14.0]	0.588

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.

^a Downgrade to non-ICU status within 6 hours of critical care admission order while still in ED.

Table 3

Table 3: Secondary Outcomes

Secondary outcomes	Non-ECCP hours		ECCP hours		Difference in differences (DiD)	<i>P</i> value
	Pre-Intervention Period	Intervention Period	Pre-Intervention Period	Intervention Period		
	% (n)	% (n)	% (n)	% (n)	DiD [95% CI]	
Proportion of patients initially admitted to non-ICU service ^a	16.3 (122)	16.2 (102)	20.0 (86)	13.2 (58)	-6.7 [-13.0, -0.4]	0.037
Bounce-up ^b proportion for ED downgrade < 6 h	5.3 (3)	13.0 (12)	0.0 (0)	2.4 (2)	-5.4 [-15.0, 4.1]	0.266
	median (IQR)	median (IQR)	median (IQR)	median (IQR)		
ED arrival to admit order, overall unadjusted in h	2.9 (2, 4.2)	3.0 (2.2, 4.5)	3.0 (2, 4.2)	2.9 (1.8, 4.3)	-0.3[-0.6, 0.1]	0.145
ED length of stay, overall unadjusted in h	8.2 (5.2, 12.8)	7.8 (5.3, 11.9)	8.4 (5.4, 17.6)	7.7 (5.1, 13.5)	-0.3[-1.4, 0.8]	0.639
Hospital length of stay, overall unadjusted in days	4.9 (2.7, 9.2)	4.3 (2.3, 7.7)	4.8 (2.8, 9.5)	4.7 (2.6, 7.8)	0.5[-0.4, 1.4]	0.575

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.



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7.29 CCM ECCP Supplemental Figures and Tables
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