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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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OBJECTIVES: 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 emergency department (ED).

DESIGN: Single-center, retrospective cohort study using ED-visit data between 2015 and 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: Dedicated bedside critical care for medical ICU patients by an ED-based intensivist following initial resuscitation by the ED team.

MEASUREMENTS AND MAIN RESULTS: Primary outcomes were inhospital mortality and the proportion of patients downgraded to non-ICU status while in the ED within 6 hours of the critical care admission order (ED downgrade <6 hr). A difference-in-differences (DiD) analysis compared the change in outcomes for patients arriving during ECCP hours (2 PM to midnight, weekdays) between the preintervention period (2015–2017) and the intervention period (2017–2019) to the change in outcomes for patients arriving during non-ECCP hours (all other hours). 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 inhospital mortality decreased by 6.0% (95% CI, –11.9 to –0.1) with largest difference in the intermediate illness severity group (DiD, –12.2%; 95% CI, –23.1 to –1.3). The increase in ED downgrade less than 6 hours was not statistically significant (DiD, 4.8%; 95% CI, –0.7 to 10.3%) except in the intermediate group (DiD, 8.8%; 95% CI, 0.2–17.4).

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

KEY WORDS: critical care medicine; emergency department critical care; emergency medicine; health care delivery models; intensive care unit triage

Critical care delivery in U.S. emergency departments (EDs) is increasing, particularly in urban hospitals (1, 2). Between 2006 and 2014, ED visits for critically ill patients increased by 80% with minimal accompanying growth in available ED capacity and ICU beds (3). The ED is not designed for longitudinal care of the critically ill; previous studies on ED boarding of

***See also p. 833.**

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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 DiD analysis showed a statistically significant 6.0% decrease in inhospital mortality and a statistically nonsignificant 4.8% increase in ED downgrade less than 6 hours. 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 less than 6 hours.

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

the critically ill have reported increased duration of mechanical ventilation, longer ICU length of stay, and higher mortality (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 (1, 2, 12).

Various alternative care models have been developed to address these issues (12–22). However, evidence of benefit on patient-centered outcomes is limited to a few programs that require a dedicated space within the ED or elsewhere in the hospital (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/management 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 inhospital 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 Institutional Review Board 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 18 years or older who received critical care admission orders within 12 hours of ED arrival were included, irrespective of whether they had a preceding non-ICU admission order in the ED. Patients who left against medical advice or were transferred to another acute care facility were excluded. Although the MICU and emergency critical care (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, or coronary care unit) were separated and defined as an alternative ICU cohort and used as an additional control group for analysis (**eFig. 1** and **eTable 1**, http://links.lww.com/CCM/H308).

The study population was stratified based on date and time of ED arrival to allow us to compare outcomes between patients arriving during the preintervention period (from 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 below.

Figure 1. Emergency department (ED) to medical ICU (MICU) workflow for baseline (preintervention period and non-Emergency Critical Care Program (ECCP) hours/intervention period) vs ECCP hours/intervention period. [a]Regardless of the disposition (including Emergency Critical Care [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 judgment 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, ECC 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. ECC nurse is a critical care-trained ED nurse who helps primary ED nurses for various patients including the critically ill. At any time, only one ECC nurse was staffed in the ED.

Intervention

The intervention consisted of a change in the ED-to-MICU workflow during ECCP hours in the intervention period (**Fig. 1**). Consultation request to ECC (during ECCP hours) or MICU (non-ECCP hours) was at the sole discretion of the ED attending, but the decision to admit was made by the ECC or MICU team. During non-ECCP hours, as in the case of all hours of the preintervention period, all consults were called to the MICU triage fellow who evaluated the patients in the ED, discussed the plan, and determined the 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 and determined the disposition. If the patient was accepted, the ECC attending provided resuscitation, facilitated diagnostic workup and consults, performed or directly supervised procedures, and managed the patient in conjunction with the MICU team until the patient was physically transferred to the MICU, downgraded to a non-ICU service, or handed off to the MICU team at midnight. Of note, the ECC attending was able to admit MICU patients with a high likelihood of downgrade within 6 hours to the ECC service and hold them in the ED for potential downgrade. The 6-hour time frame was chosen as it was felt to be both long enough to observe patients' response (or lack thereof) to interventions, and short enough to justify holding a patient in the ED even if a MICU bed was available. Full details of the ECCP have been published previously (19).

TABLE 1.
Demographic Characteristics and Diagnoses of Primary Cohort

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

ECCP = Emergency Critical Care Program.

[a]No-ECCP hours: weekends and weekday not included in the ECCP hours.

[b]ECCP hours: from 2 PM to midnight, Monday through Friday.

[c]Preintervention period: from August 14, 2015, to August 13, 2017.

[d]Intervention period: from August 14, 2017, to August 13, 2019.

[e]The charts were manually reviewed (by T.M., A.J.G., or A.E.U.) when admission diagnosis was missing or a designation to the primary MICU cohort vs the alternative ICU cohort could not be determined based on admission order alone.

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, admission diagnosis, and elements required to calculate emergency critical care Sequential Organ Failure Assessment (eccSOFA) score (25) for the severity of illness measurement.

Outcomes

Coprimary outcomes were inhospital mortality and the proportion of patients who received a transfer order to a non-ICU service within 6 hours of the critical care admission order while still in the ED (ED downgrade <6 hours). Primary outcomes were analyzed both overall and stratified by prespecified 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 hours of ED arrival, ED length of stay, hospital length of stay, and proportion of ED downgrades less than 6 hours 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 preintervention and intervention periods, we used patients arriving to the ED during non-ECCP hours as a comparison group. The DiD for each outcome was calculated as a change in outcome between the preintervention period and the intervention period for patients arriving during ECCP hours minus a change in outcome over the same periods for patients arriving during non-ECCP hours. The differences in proportions are reported in absolute, not relative, terms.

Adjustment for Severity of Illness. Adjustment for severity of illness was performed using the eccSOFA score, which is a modified version of the Sequential Organ Failure Assessment score specifically adapted for ICU patients in the ED that was previously validated in our patient population (area under the receiver operating characteristic curve 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 three prespecified 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 regression (27, 28). Quantile regression was also used to adjust medians for eccSOFA score. All statistical analyses were conducted using STATA 14 (StataCorp LLC, College Station, TX).

Sensitivity Analysis. Some 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 2 pm. Similarly, patients arriving near the end of ECCP hours may have received minimal care from the ECC physician even though they were categorized in the ECCP hours group. To address this concern, we performed sensitivity analysis for the primary outcomes using earlier time cutoffs to define ECCP hours.

Subgroup Analysis. We performed a subgroup analysis for the primary outcomes by excluding all patients whose initial ED admission order was to a non-ICU service.

Falsification Test. To enhance causal inference, we performed the same DiD analysis for the primary outcomes using the alternative ICU cohort, 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

TABLE 2.
Patient Distribution by Emergency Critical Care Sequential Organ Failure Assessment Category and Primary Outcomes

Patient Distribution by eccSOFA Category and Primary Outcomes	Non-ECCP Hours[a]		ECCP Hours[b]			
	Preintervention Period[c]	Intervention Period[d]	Preintervention Period	Intervention Period	DiD	*p*
Study cohort (total = 2,250)	750	631	430	439		
By eccSOFA category, *n* (%)					DiD (95% CI)	
eccSOFA 0–3	320 (42.7)	288 (45.6)	193 (44.9)	207 (47.2)		
eccSOFA 4–7	270 (36.0)	238 (37.7)	171 (39.8)	164 (37.4)		
eccSOFA 8+	160 (21.3)	105 (16.6)	66 (15.3)	68 (15.5)		
eccSOFA score, mean (SD)	4.62 (3.64)	4.28 (3.36)	4.11 (3.05)	4.11 (3.26)	0.34 (0.24–0.91)	0.248
Inhospital death, %					DiD% (95% CI)	
Overall unadjusted	17.2	17.7	17.4	14.4	−3.6 (−9.9 to 2.7)	0.258
Overall eccSOFA-adjusted	15.7	17.9	19	15.2	−6.0 (−11.9 to −0.1)	**0.045**
eccSOFA 0–3	5	5.5	7.3	5.3	−2.5 (−8.4 to 3.5)	0.416
eccSOFA 4–7	18.5	21.4	24	14.6	−12.2 (−23.1 to −1.3)	**0.029**
eccSOFA 8+	36.6	42.4	37	42	−0.8 (−19.7 to 18.1)	0.934
Emergency department downgrade <6 hr, %[e]					DiD (95% CI)	
Overall unadjusted	7.6	14.6	7.4	19.4[f]	4.9 (−0.6 to 10.5)	0.082
Overall eccSOFA-adjusted	7.8	14.5	7.4	19	4.8 (−0.7 to 10.3)	0.085
eccSOFA 0–3	10	18.8	10.8	21.7	2.1 (−7.0 to 11.1)	0.656
eccSOFA 4–7	7.3	13.9	4.1	19.5	8.8 (0.2 to 17.4)	**0.045**
eccSOFA 8+	3	4.8	6.7	11.5	3.0 (−7.9 to 14.0)	0.588

DiD = difference in differences, ECCP = Emergency Critical Care Program, eccSOFA = emergency critical care Sequential Organ Failure Assessment.

[a]No-ECCP hours: weekends and weekday not included in the ECCP hours.

[b]ECCP hours: from 2 PM to midnight, Monday through Friday.

[c]Preintervention period: from August 14, 2015, to August 13, 2017.

[d]Intervention period: from August 14, 2017, to August 13, 2019.

[e]Downgrade to non-ICU status within 6 hr of critical care admission order while still in the emergency department.

[f]The median downgrade time was 2.9 hr for this group.

Boldface font indicates $p < 0.05$.

Within each eccSOFA category, linear adjustment has been applied.

exclusions, the analytical sample included 2,250 in the primary MICU cohort and 2,621 in the alternative ICU (mainly SICU) cohort (eFig. 1, http://links.lww.com/CCM/H308).

The 2,250 patients in the primary MICU cohort were categorized based on the date and time of ED arrival: non-ECCP hours/preintervention period, non-ECCP hours/intervention period, ECCP hours/preintervention period, and ECCP hours/intervention period. The number of ED visits per day was higher during the intervention period compared with the preintervention 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 ECCP hours group, severity of illness remained the same between the preintervention period and the intervention period (mean eccSOFA difference, 0; p = 0.992). This suggests that the ECC acceptance threshold for patients arriving during ECCP hours in the intervention period was similar to the MICU threshold for patients arriving during ECCP hours in the preintervention period.

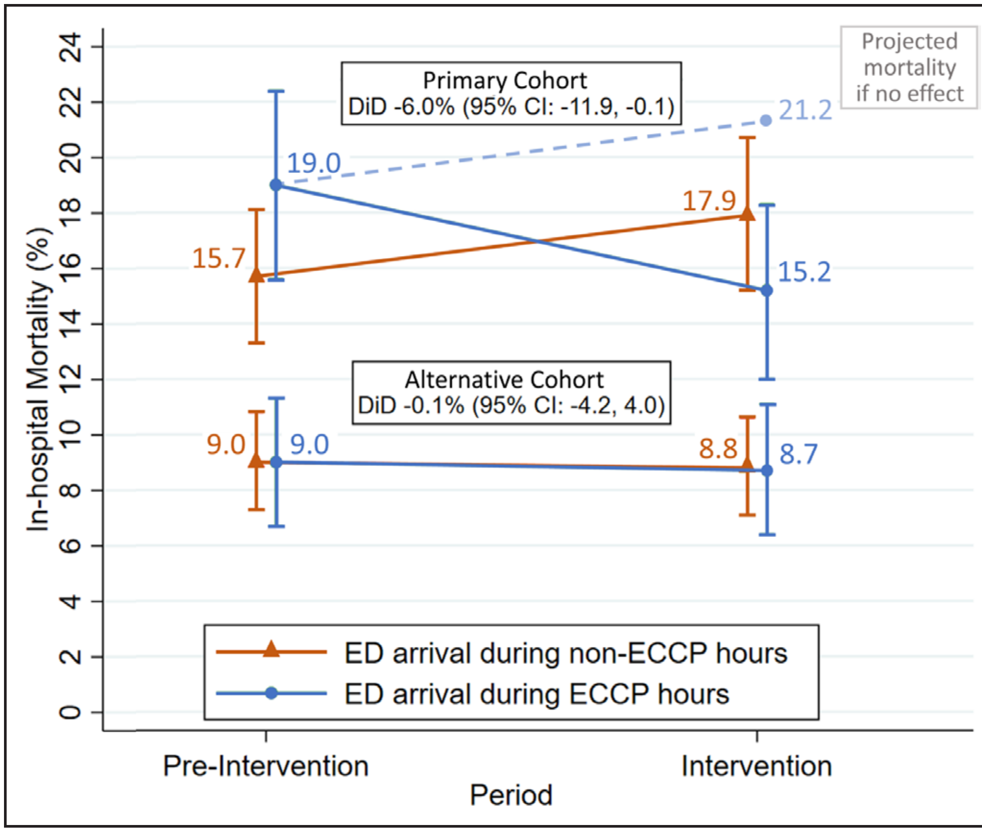

Figure 2. Overall emergency critical care Sequential Organ Failure Assessment (eccSOFA)-adjusted inhospital mortality for the primary cohort (medical ICU [MICU] patients) and the alternative ICU cohort (mainly surgical ICU [SICU] patients). *Upper lines*: the primary cohort consisted of MICU patients (n = 2,250), who were subject to the Emergency Critical Care Program (ECCP) intervention. *Dashed blue line* shows the projected mortality if the preintervention difference persisted into the intervention period. *Lower lines*: the alternative ICU cohort consisted of SICU, cardiovascular ICU, and coronary care unit patients (n = 2,621), who were not subject to the ECCP intervention. Study period definitions are explained in footnote to Table 1. DiD = Difference-in-differences, ED = emergency department.

Outcomes

Inhospital Mortality. Overall eccSOFA-adjusted inhospital mortality decreased by 6.0% (95% CI, –11.9 to –0.1) (Table 2, **Fig. 2**). This corresponds to relative risk reduction of 28.3% and number needed to treat of 17 patients to prevent one inhospital death. The analysis stratified by eccSOFA category showed a statistically significant decrease in mortality in the intermediate severity of illness 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) and the high severity of illness group (DiD, –0.8%; 95% CI, –19.7 to 18.1) (Table 2, **Fig. 3**).

ED Downgrade Less Than 6 Hours. For overall eccSOFA-adjusted ED downgrade less than 6 hours, the DiD was 4.8% (95% CI, –0.7 to 10.3), which was not statistically significant (Table 2). In the stratified analysis, the increase in downgrades was statistically significant only in the intermediate severity of illness group (DiD, 8.8%; 95% CI, 0.2–17.4) (Table 2). There was no increase in the bounce-up proportion (ICU transfer order within 24 hr of downgrade) for the overall group or the intermediate severity of illness group (**Table 3**; and **eTable 2**, http://links.lww.com/CCM/H308).

A sensitivity analysis using earlier time cutoffs to define ECC hours resulted in decreased effect on mortality and increased effect on ED downgrade less than 6 hours (**eTable 3**, http://links.lww.com/CCM/H308).

Subgroup analysis of primary outcomes after excluding all patients with preceding non-ICU admission orders prior to critical care admission order resulted in increased effect for both mortality and ED downgrade less than 6 hours (**eTable 4**, http://links.lww.com/CCM/H308).

Falsification Test. A total of 2,621 patients in the alternative ICU cohort were analyzed as a falsification

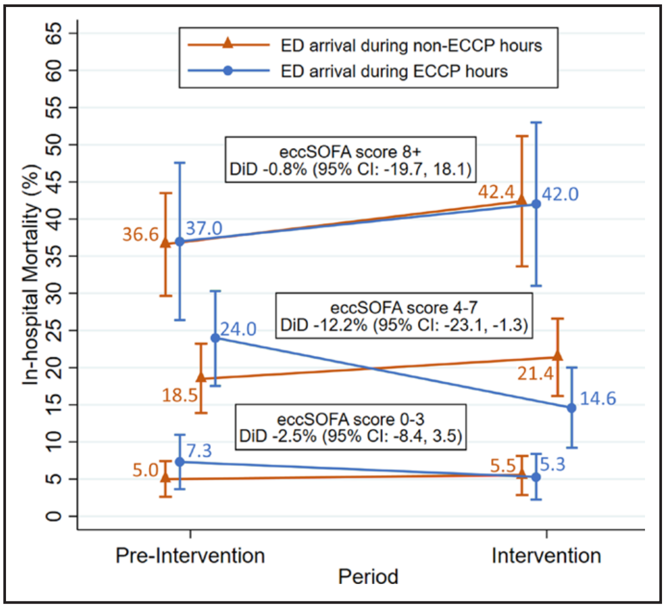

Figure 3. Emergency critical care Sequential Organ Failure Assessment (eccSOFA)-adjusted inhospital mortality for different illness severity categories. The difference-in-differences (DiD) was statistically significant in the intermediate severity of illness (eccSOFA 4–7) group, but not in the low severity of illness (eccSOFA 0–3) or the high severity of illness (eccSOFA 8+) groups. Study period definitions are explained in footnote of Table 1. ECCP = Emergency Critical Care Program, ED = emergency department.

test. This cohort had a lower mean eccSOFA score and lower inhospital mortality compared with our primary cohort (**eTable 5**, http://links.lww.com/CCM/H308). There was no significant change in eccSOFA-adjusted mortality or in ED downgrade less than 6 hours in the alternative ICU cohort (Fig. 2; and eTable 5, http://links.lww.com/CCM/H308).

Secondary Outcomes. There were no statistically significant differences in time from ED arrival to admission order entry or hospital length of stay. Importantly, there was also no increase in overall ED length of stay (DiD, –0.3 hr; 95% CI, –1.4 to 0.8). 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; and **eTable 6**, http://links.lww.com/CCM/H308).

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 inhospital mortality. A similar decrease did not occur in our alternative ICU cohort, which was not subject to the ECCP intervention. The effect on mortality was not the same for each severity of illness group (Fig. 3). The main impact was seen among patients with intermediate severity of illness, who had a 12.2% decrease in eccSOFA-adjusted inhospital mortality. This population may benefit most from additional attention in the immediate post-ED resuscitation phase. The smaller, nonsignificant effect on the low severity of illness group may be related to a lower baseline mortality in this group. The high severity of illness group had an even smaller, nonsignificant benefit, possibly because these patients were already given higher priority for management by the MICU fellow in the absence of an ECCP. In addition, perhaps patients in this group already have severe multiorgan dysfunction and are at high risk of death regardless of early interventions.

Rapidly downgrading appropriate patients from ICU level of care while still in the ED is one way to improve ICU bed utilization. Overall eccSOFA-adjusted ED downgrade less than 6 hours increased by 4.8%. Although this difference was not statistically significant, we did observe a statistically significant increase of 8.8% in the intermediate severity group. Importantly, these downgrades were not associated with increases in bounce-ups or overall ED length of stay.

The results of the subgroup analysis and falsification test support the same conclusions. However, our sensitivity analysis using earlier ED arrival-time cutoffs to define ECCP hours showed a decreased effect on mortality and increased effect on ED downgrade less than 6 hours. One explanation for this is that the MICU/ECC service is consulted shortly after the ED arrival for the most severely ill (e.g., intubated) patients with a clear need of MICU beds. Thus, it is possible that shifting the ED arrival-time cutoff earlier meant misclassification of some of these high-risk patients into the ECCP hour group when they actually received all of their care from the standard MICU team. This would bias the mortality result toward the null. Conversely, patients who get successfully downgraded less than 6 hours are usually less severely ill, and the MICU consultation request may not have been initiated until after 2 PM, even if the patient arrived at 12 PM. Thus, shifting the ED arrival-time cutoff earlier may have successfully captured these lower risk patients managed by the ECC physician, explaining an up to threefold increase in ED

TABLE 3.
Secondary Outcomes

	Non-ECCP Hours		ECCP Hours			
	Preintervention Period, *n* (%)	**Intervention Period, *n* (%)**	**Preintervention Period, *n* (%)**	**Intervention Period, *n* (%)**	**DiD% (95% CI)**	***p***
Proportion of patients initially admitted to non-ICU service[a]	122 (16.3)	102 (16.2)	86 (20.0)	58 (13.2)	−6.7 (−13.0 to −0.4)	**0.037**
Bounce-up[b] proportion for ED downgrade <6 hr	3 (5.3)	12 (13.0)	0 (0.0)	2 (2.4)	−5.4 (−15.0 to 4.1)	0.266
	Preintervention Period, Median (IQR)	**Preintervention Period, Median (IQR)**	**Preintervention Period, Median (IQR)**	**Preintervention Period, Median (IQR)**	**DiD (95% CI)**	***p***
ED arrival to admit order, overall unadjusted in hours	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 to 0.1)	0.145
ED length of stay, overall unadjusted in hours	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 to 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 to 1.4)	0.575

DiD = difference in differences, ECCP = Emergency Critical Care Program, ED = emergency department, IQR = interquartile range.

[a]All patients received subsequent ICU transfer order within 12 hr of ED arrival. Denominator for this proportion is the total number in the study cohort.

[b]Bounce-up is defined as reentry of admission order to ICU within 24 hr of ED downgrade to non-ICU status. Denominator for this proportion is the number of unadjusted ED downgrade <6 hr.

Study period definitions are explained in footnote to Table 1.

DiD CIs are based on minimum absolute difference regression.

downgrade less than 6 hours observed in our sensitivity analysis.

To our knowledge, we are the first institution to implement an ED-based intensivist consultation/management model and demonstrate its impact 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-hour ECC nursing program (20) or an MICU alert team consisting of a dedicated ICU nurse and physician assistant (21) was 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 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 (14).

Risk of poor outcomes may increase when the care environment is under greater stress. Stress on the care environment for MICU patients was likely higher during ECCP hours relative to non-ECCP hours due to higher MICU consult load in the ED and throughout the hospital. Similarly, based on the increasing hospital, ICU, and ED census, the MICU triage fellow was likely evaluating and managing more patients throughout the hospital during the intervention period than during the preintervention period. These factors may explain the higher eccSOFA-adjusted mortality for MICU patients during the ECCP hours compared with the non-ECCP hours in the preintervention period (19.0% vs 15.7%) as well as the mortality increase during the non-ECCP hours from preintervention to intervention (15.7% vs 17.9%) (Fig. 2). On the other hand, patients in the alternative cohort have a different set of pathologies and are subject to a different triage system and staffing structure. This may explain why we did not observe similar findings in this group.

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, and 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.

Not all the potential benefits of ECCP were captured in this analysis. Bedside assessment by ECC physicians may have helped many ED patients safely avoid the ECC or MICU admission through early comprehensive goals of care discussions and management recommendations. The ECCP may have also improved outcomes or ED length of stay for other ED patients by shifting the care burden from the ED physician to the ECC physician. Future research could explore these areas of uncertainty including financial impact of the ECCP model.

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 internally validated using nearly 4,000 patients (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, the findings in our sensitivity analysis suggest the presence of spillover effect where successful ED downgrades less than 6 hours by the ECCP were counted toward non-ECCP hours due to the probable time lag between ED arrival and the MICU/ECC consult request for patients who are less severely ill, biasing 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 ECCP was associated with a statistically significant decrease in inhospital mortality among critically ill medical patients in the ED, with the greatest improvement in the intermediate severity of illness group. A statistically significant increase in early ED downgrades was seen among patients with intermediate severity of illness but not in the overall group.

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