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ORIGINAL RESEARCH

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Evaluation of an advanced practice provider emergency department critical care step-down unit

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Abstract

Objective: In response to concerns about patient care and safety, our urban, tertiary care, Level 1 trauma center adult emergency department (ED) created an advanced practice provider-staffed critical care step-down unit (CCSU). We conducted a comprehensive evaluation of the CCSU's impact on patient care, safety, and ED operations.

Methods: We compared ED length of stay, return visits to the ED within 72 hours, billing code assignments (current procedural terminology evaluation and management [CPT E&M] codes), and quality of electronic health record documentation per QNOTE for the 2 years after the CCSU was initiated (CCSU period) versus before its initiation (pre-CCSU period).

Results: There were 31,418 critical care ED patient visits in the pre-CCSU period and 33,396 in the CCSU period. Median ED length of stay did not change overall between the CCSU versus pre-CCSU period (Δ1 [95% confidence interval (CI) = −2.4, 4.4] minutes), but decreased for patients who remained in the critical care suites (Δ-4 [95% CI = −7.8, −0.2] minutes). 72-hour return ED visits also did not change overall (Δ0% [95% CI = −0.1, 0]), but decreased for patients who remained in the critical care suites (Δ0.4% [95% CI = −0.05, −0.4]). CPT E&M billing increased for highest-level visits (99,291: Δ1.3% [95% CI= 0.5, 2.0]). Quality of electronic health record documentation as measured by QNOTE also improved (Δ11.5% [95% CI = 4.9, 18.1]).

Conclusion: This ED's CCSU performance metrics indicate at least moderate improvement in ED length of stay, 72-hour return visits, critical care patient billing, and electronic health record documentation. EDs elsewhere can consider implementation of this advanced practice provider-staffed solution to improvement in critical care in ED.

KEYWORDS

critical care, emergency service, hospitals, nurse practitioners, operations research, physician assistants

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1 | INTRODUCTION

1.1 | Background

Due to continuous presentation of new patients to the critical care suites during normal operations at a large, urban, Level 1 trauma center and tertiary referral adult emergency department, patients frequently were moved from the ED critical care suites to the urgent care areas before their treatment was complete or their disposition was finalized. This arrangement strained the effectiveness of the ED critical care attending physicians and residents because they were responsible for new incoming patients as well as those moved to the urgent care areas. As a result, medical care was fragmented and length of stay was prolonged. Re-evaluation and disposition were delayed due to competing priorities. When care was transferred to clinical providers in the urgent care areas, loss of information and multiple transitions of care over time occurred. Anecdotes of lower than expected medical care and patient safety events of critical care ED patients were reported by ED staff.

1.2 | Importance

In response to concerns about patient care and safety, this ED created a critical care step-down unit (CCSU) in a former observation care area of the ED. The CCSU was created as an observation care area specifically for patients who were initially evaluated and treated in the ED critical care suites. Any ED critical care patient who was considered no longer to have immediate critical care needs but needed further evaluation and treatment before a patient disposition was made could be transferred to the CCSU. Patients who were intubated, receiving vasopressors, were considered to have autonomic instability, or otherwise required higher level of medical or nursing care were not eligible for the CCSU. Advanced practice providers (nurse practitioners and physician assistants) provided care in the CCSU. The ultimate intent of the CCSU was to improve patient care and safety and reduce risk through cooperative care with the physician critical care and advanced practice provider staff. Advanced practice providers were responsible for executing the plans for treatment and disposition of CCSU patients, which included coordination of care with the ED critical care physicians, consultants, nursing, and ancillary staff; performing procedures (eg, lumbar punctures, incision and drainage of abscesses, suturing lacerations); arranging for, reviewing the results of, and responding appropriately to laboratory testing and radiologic imaging; continuously re-evaluating each patient's medical condition and needs; communicating with family and outpatient care providers; arranging follow-up and future care; and providing discharge instructions and patient education. This advanced practice provider-staffed CCSU reflects the practice of other EDs in exploring and expanding the roles advanced practice providers play in ED clinical care, as well as calls for more formal analyses of these roles.[1-7] Although initiatives such as the CCSU appear to be promising, their value needs formal assessment before they can be recommended for implementation elsewhere.

The Bottom Line

This emergency department looked at the impact of staffing a critical care step-down unit staffed with advanced practice providers. This strategy decreased length of stay (by 29 minutes) and 72-hour return (by 0.4%) for patients within the unit while improving (by 11.5%) documentation overall.

1.3 | Goals of this investigation

We conducted a comprehensive evaluation of the impact of the CCSU on patient care, safety, and ED operations. We specifically examined changes after the CCSU was initiated (CCSU period) as compared to before its initiation (pre-CCSU period) according to ED length of stay, return visits to the ED within 72 hours, patient safety concern reports, morbidity and mortality review referrals, visit level of care and critical care billing code assignments, and quality of electronic health record documentation.

2 | METHODS

2.1 | Setting

The study setting is a 100 patient-bed, Level 1 trauma center, tertiary referral adult ED in the United States (Rhode Island Hospital, Providence, Rhode Island). The ED's annual census is ≈110,000 adult patient visits, of which the critical care annual patient volume is ≈16,000 patients. The ED medical staff is comprised of attending physicians, emergency medicine resident physicians, and advanced practice providers. The physician staff, emergency medicine residency program, and hospital are affiliated with the local medical school (Alpert Medical School of Brown University). The hospital institutional review board approved the study.

2.2 | Study design

This investigation consisted of analyses of administrative and clinical data from the following sources: databases on ED length of stay, ≤72-hour return ED visits, and staff-reported safety concerns; morbidity and mortality review referrals; and electronic health records of ED visits. Analyses were constructed to compare data for 2 years prior to the debut of the CCSU (March 2011–February 2013; the pre-CCSU period), and following its initiation (March 2013–February 2015; the CCSU period). The end study date of February 2015 was chosen because hospital system changed its electronic health record system the following month, which affected the clinical documentation process, and which in turn affected how data were interpreted.

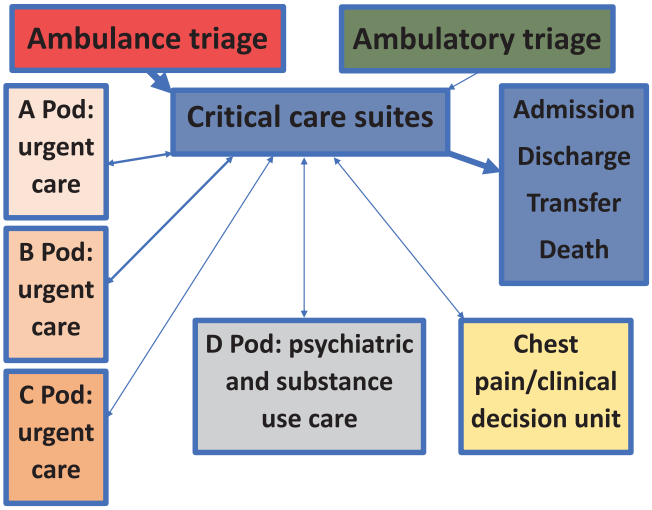

FIGURE 1 Patient bed movements in the ED relative to critical care evaluation and treatment

2.3 | Patient population and unit of analysis

Patients for this investigation included those who were evaluated in the critical care suites at any point during their stay during the study period. The unit of analysis was ED visit, instead of individual ED patients. As such, patients who had multiple visits to the ED that included a critical care stay were counted on a per visit rather than a per patient basis. ED visits were identified using the ED's electronic health record. The electronic health record was queried for visits during which patients were evaluated in the critical care suites at any point during their ED stay. We eliminated ED visits for patients who died during their ED stay; whose ED length of stay was <60 minutes or >24 hours; or were admitted to the ED psychiatric, chest pain or transient ischemic attack observation unit. These visits were eliminated because these patients likely would not be affected by the CCSU's function because such patients would not be evaluated in that unit.

2.4 | Stratification of ED visit study sample by patient bed movements

ED patient visits were stratified into 5 patient bed movement groups that reflected their acuity level and ED course through bed movements (Figure 1). The 5 patient bed movement groups consisted of patients who: (1) remained in the ED critical care suites only, (2) were moved from the critical care suites to urgent care areas of the ED, (3) were moved from the ED critical care suites to the CCSU, (4) were moved from urgent care areas to the critical care suites, or (5) experienced multiple bed movements (to/from ED critical care suites, urgent care areas, and/or CCSU). Analyses were stratified by patient bed movements because we expected that the CCSU would affect patient groups differently. We anticipated that ED operations would be affected differentially according to patient areas (eg, critical care suites, urgent care areas). For example, the CCSU might have a greater effect on ED length of stay for patients who remained in the critical care areas only, as opposed to those moved from the critical care to the urgent care areas. The CCSU could enable critical care physician staff to be able focus more on fewer critical care patients leading to quicker dispositions, but this arrangement might have a lesser effect for the urgent care medical staff.

2.5 | Review and analysis of administrative and clinical data

For all analyses, missing data were not imputed. Median length of ED stay for all critical care patients and for each of the 5 patient bed movement groups was calculated by disposition (all dispositions, admissions, discharges, other dispositions [eg, transferred, eloped, left without being seen, left against medical advice]) separately for the pre-CCSU and CCSU study periods. Differences with 95% confidence intervals (CIs) were estimated. To permit an examination of direct and indirect effects of the CCSU on ED operations, these calculations were repeated for ED visits that occurred during the 16 hours/day the CCSU was in operation and separately for the hours it was closed. Differences in the proportions of ED return visits within 72 hours were compared in a similar manner. The ED billing records database was queried for the frequencies of the following 4 current procedural terminology (CPT) evaluation and management (E&M) critical care codes were used: 99,283 (Level 3 visit), 99,284 (Level 4 visit), 99,285 (Level 5 visit) and 99,291 (critical care provided). These CPT E&M codes are used to indicate to billing agencies that more complex, time-sensitive care was provided to such patients in the ED, and hence translate into requests for higher reimbursement from insurers. Differences in proportions of visits when these 4 codes were used also were compared across study periods, patient bed movement groups, and dispositions.

Electronic health records were evaluated for changes in the quality of provider documentation for the ED visit using the QNOTE evaluation system.[8,9] QNOTE is a systematic method of evaluating the quality of clinical notes according to 12 elements (eg, history of present illness, review of systems, physical findings) considered to form the basis of an outpatient visit note. Quality of documentation of each element is assessed according to criteria appropriate to that element (eg, for physical findings, criteria are the notes' completeness, clarity, and conciseness) and are judged as missing or present, and if present, are judged to be fully acceptable, partially acceptable, or unacceptable. For this investigation, we modified the 12 QNOTE elements to the 7 that were within the control of the ED clinicians. Random samples of critical care ED visits for the pre-CCSU and post-CCSU study periods stratified by the 5 patient bed movement groups were selected and the respective electronic health records were obtained. Research staff not involved in the QNOTE assessment removed all patient and staff identifiers as well as dates of service from the retrieved visit notes. The 3 advanced practice provider members of the investigative team independently reviewed randomly selected samples of the electronic health records. The advanced practice provider investigators were blinded to which electronic health records were drawn from the 5 patient bed move-

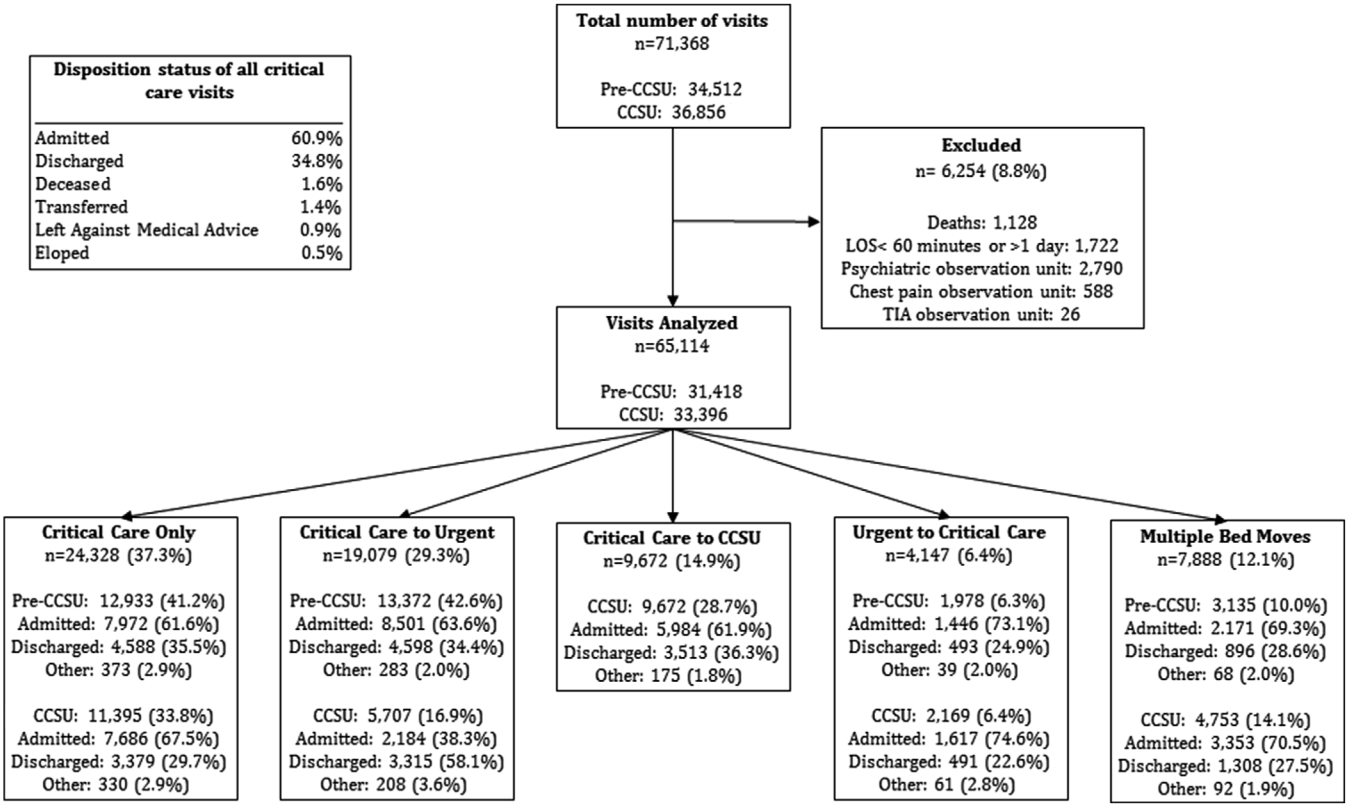

FIGURE 2 ED critical care visits and bed movements

ment groups as well as which were pre-CCSU or post-CCSU visits. Prior to conducting their reviews, the advanced practice provider investigators underwent iterative training on the QNOTE method that included a joint group review of 10 records with discussion to reach agreement on scoring criteria considerations and methodology, then an independent pilot review of 20 records with subsequent group discussion to reconcile scoring criteria differences. Based on this pilot review, sample sizes of ED visits needed by the 5 patient bed movement groups were calculated to detect a 75% improvement in QNOTE score, comparing the post-CCSU versus pre-CCSU period. The advanced practice provider investigators independently evaluated the resultant total sample size (n = 955) of visit notes using the QNOTE scoring system. Given the skewness of the data, we calculated the proportion of ED visits for which QNOTE scores were 90% or greater, and calculated the difference in proportions between the CCSU and pre-CCSU periods, along with corresponding 95% CIs.

In addition, we performed interrupted time series analyses for all patient bed movements for all dispositions for the 4 outcomes of median ED length of stay, repeat ED visits within 72 hours, critical care visit (99,291) coding and QNOTE scores >90%. For repeat ED visits within 72 hours, critical care visit (99,291) coding and QNOTE scores, we created models using a log-link function with a random effect term to adjust for attending physician, whereas for ED median length of stay, we created a model using quantile regression with a fixed effect term to adjust for attending physician. We plotted the point estimates over time with estimated β coefficients, standard errors (SEs), and 95% CIs for the coefficients.

2.6 | Patient safety and morbidity and mortality report review and analyses

Staff-reported safety concerns submitted through the hospital's anonymous reporting system were queried for the study period. However, there were none relevant to the CCSU and so they could not be analyzed. Morbidity and mortality review requests for cases submitted to the department by any hospital staff member were examined for the pre-CCSU and CCSU periods by 2 investigators. Reports specific to critical care patients were assessed qualitatively and summarized by content. We initially intended to focus on morbidity and mortality review requests for cases related to the CCSU and advanced practice providers. However, few cases concerned advanced practice providers and none the CCSU. As a result, instead we summarized each case and provided commentary on when we believed there might have been opportunities for which advanced practice provider or CCSU involvement potentially could have improved patient care, if, counter to fact, the advanced practice providers and CCSU had been utilized in the care of those patients. We focused our commentary on opportunities for which care could have been improved by reducing risk, improving patient safety, or preventing the error.

TABLE 1 ED median length of stay by patient movement and disposition, CCSU versus pre-CCSU periods

Patient movement	Disposition	Pre-CCSU periodmedian minutes	CCSU periodmedian minutes	CCSU versus. pre-CCSU periodΔ median minutes (95% CI)
All		n = 31,418	n = 33,396	
	All dispositions	328	329	1 (−2.4, 4.4)
	Admitted	354	356	2 (−1.8, 5.8)
	Discharged	277	287	10 (5.3, 14.7)
	Other	239	258.5	19.6 (1, 38.1)
Critical care only		n =	n =	
	All dispositions	253	249	−4 (−7.8, −0.2)
	Admitted	289	285	−4 (−8.9, 0.9)
	Discharged	202	188	−14 (−19.9, −8.1)
	Other	195	200	5 (−18.9, 28.9)
Critical care to urgent		n =	n =	
	All dispositions	372	343	−29 (−34.9, −23.1)
	Admitted	38	365	−16 (−24.2, −7.8)
	Discharged	357	332.5	−24.2 (−34, −14.4)
	Other	308	290.5	−16.7 (−54.7, 21.3)
Critical care to CCSU		n =	n =	
	All dispositions	NA	358	NA
	Admitted	NA	376	NA
	Discharged	NA	326	NA
	Other	NA	310.5	NA
Urgent to critical care		n =	n =	
	All dispositions	398	375	−23 (−39.5, −6.5)
	Admitted	448	417	−31 (−49, −13)
	Discharged	281	265.5	−15.3 (−33.5, 2.9)
	Other	247	247	0.7 (−66.4, 67.7)
Multiple bed movements		n =	n =	
	All dispositions	449	438	−11 (−21.1, −0.9)
	Admitted	480	465	−15 (−30.7, 0.7)
	Discharged	377.5	377	−0.8 (−18.4, 16.7)
	Other	344	320	−24.4 (−88.1, 39.3)

CCSU, critical care step-down unit; CI, confidence interval; NA, not applicable.

3 | RESULTS

3.1 | ED length of stay, 72-hour return visits, critical care billing, and QNOTE analyses

There was a relative 6.3% increase in patient visits in the ED critical care suites in the CCSU period as compared to the pre-CCSU period (pre-CCSU 31,418 – CCSU 33,396/pre-CCSU 31,418) (Figure 2). In comparison to the pre-CCSU period, there was an 11.9% relative decrease in ED patients who remained in the critical care suites (pre-CCSU 12,933- CCSU 11,395/pre-CCSU 12,999), and a 57.3% relative decrease in those moved from the critical care suites to the urgent care areas in the CCSU period (pre-CCSU 13,372 – CCSU 5707/pre-CCSU 13,372). Patient movement from urgent care to the critical care suites increased relative 9% in the CCSU versus pre-CCSU periods (CCSU 2169 – pre-CCSU 1978/CCSU 2169).

Total median ED length of stay and as stratified by disposition changed little in the CCSU versus pre-CCSU periods with a few exceptions (Table 1). Critical care patients were discharged a median of 10 minutes later in the CCSU period. However, dispositions of critical care patients who remained in the ED critical care suites and those transferred to or from critical care had shorter lengths of stay in the CCSU period. A comparison of CCSU versus pre-CCSU ED length of stay isolated only to the hours when the CCSU was staffed by advanced practice providers showed similar trends, although patients remained in the CCSU considerably longer in the overnight hours when no advanced practice providers were assigned to staff the CCSU (Supporting Information Table S1).

TABLE 2 ED revisits within 72 hours by patient movement and disposition, CCSU versus pre-CCSU periods

Patient movement	Disposition	Pre-CCSU period %	CCSU period %	CCSU versus pre-CCSU period Δ% (95% CI)
All		n = 31,418	n = 33,396	
	All dispositions	2.6	2.5	0 (−0.1, 0)
	Admitted	1.2	1.1	−0.1 (−0.1, −0.1)
	Discharged	4.9	4.5	−0.4 (−0.5, −0.3)
	Other	7.6	10.0	2.4 (1.6, 3.2)
Critical care only		n =	n =	
	All dispositions	2.3	1.8	−0.4 (−0.5, −0.4)
	Admitted	0.8	0.5	−0.3 (−0.3, −0.3)
	Discharged	4.5	4.2	−0.3 (−0.5, −0.1)
	Other	7.5	8.1	0.6 (−0.5, 1.7)
Critical care to urgent		n =	n =	
	All dispositions	2.9	3.5	0.5 (0.4, 0.6)
	Admitted	1.5	0.9	−0.7 (−0.7, −0.6)
	Discharged	5.2	4.7	−0.5 (−0.7, −0.3)
	Other	7.7	11.5	3.8 (2.2, 5.5)
Critical care to CCSU		n =	n =	
	All dispositions	NA	2.7	NA
	Admitted	NA	1.6	NA
	Discharged	NA	4.4	NA
	Other	NA	5.9	NA
Urgent to critical care		n =	n =	
	All dispositions	2.2	2.5	0.3 (0.2, 0.5)
	Admitted	0.9	1.2	0.3 (0.2, 0.3)
	Discharged	5.3	6.3	1.1 (0.4, 1.7)
	Other	12.8	8.6	−4.2 (−8.3, −0.1)
Multiple bed movements		n =	n =	
	All dispositions	2.6	2.9	0.3 (0.2, 0.4)
	Admitted	1.3	1.6	0.3 (0.2, 0.3)
	Discharged	5.5	4.8	−0.7 (−1.1, −0.3)
	Other	4.4	22.0	17.6 (13.9, 21.3)

CCSU, critical care step-down unit; CI, confidence interval; NA, not applicable.

Repeat ED visits within 72 hours were infrequent in both the CCSU and pre-CCSU periods (Table 2), likely due to the high admission rates. 72-hour return ED visits in the CCSU period for critical care patients who were admitted or discharged from the ED decreased slightly, and decreased for those who remained in the critical care suites only or moved to critical care from the urgent care. However, 72-hour ED return visits increased for patients moved from urgent to critical care. CPT E&M coding for Level 5 and critical care visits (99,285 and 99,291) was greater overall during the CCSU period, while coding for Level 3 visits (99,284) was decreased (Table 3). Across all patient movement groups, coding for critical care visits (99,291) increased the most for patients who remained in the critical care suites. Level 3 and 4 visit (99,283, 99,284) coding was greater for patients who moved from the critical care suites to the urgent care areas. Level 5 visit coding (99,285) was greatly decreased for critical care to urgent care area patient movements, but critical care visit (99,291) coding was greater for those moved from urgent care to the critical care suites. In regard to quality of electronic health record ED visit documentation, the proportion of visits for which QNOTE scores were 90% or greater increased overall in the CCSU period and for patients who remained in the critical care suites, but not for other critical care patient visits (Table 4).

Table 5 and Figure 3 provide the results of the interrupted time series analyses for all patient movements and all dispositions from the ED for the outcomes of median ED length of stay, repeat ED visits within 72 hours, critical care visit (99,291) coding, and QNOTE scores. For median ED length of stay, there were trends of decreasing length of stay in the pre-CCSU period but increasing length of stay in the CCSU period, but no change in level of length of stay. For repeat ED visits within 72 hours, there were no trends, but a level increase in the CCSU period. For critical care visit (99,291) coding, there was a trend

TABLE 3 CPT E&M and critical care codes by bed movement and disposition, pre-CCSU versus CCSU time periods

Patient movement	Pre-CCSU period %	CCSU period %	CCSU versus pre-CCSU period Δ% (95% CI)
All	n = 31,418	n = 33,396	
99,283	3.6	3.6	0 (−0.3, 0.4)
99,284	18.3	16.1	−2.2 (−2.9, −1.6)
99,285	56.4	57.3	1.0 (0.1, 1.8)
99,291	21.7	23.0	1.3 (0.5, 2.0)
Critical care only	n =	n =	
99,283	4.6	3.5	−1.1 (−1.7, −0.6)
99,284	16.6	12.0	−4.7 (−5.6, −3.7)
99,285	48.3	47.9	−0.4 (−1.8, 0.9)
99,291	30.4	36.6	6.2 (4.9, 7.5)
Critical care to urgent	n =	n =	
99,283	3.0	9.3	6.2 (5.5, 7.2)
99,284	20.1	30.0	9.9 (8.4, 11.4)
99,285	63.9	47.8	−16.1 (−17.7, −14.4)
99,291	13.0	12.9	0.1 (−1.3, 1.0)
Critical care to CCSU	n =	n =	
99,283	NA	1.0	NA
99,284	NA	14.1	NA
99,285	NA	71.8	NA
99,291	NA	13.1	NA
Urgent to critical care	n =	n =	
99,283	3.2	4.2	1.0 (−0.3, 2.3)
99,284	17.8	11.6	−6.2 (−8.6, −3.8)
99,285	48.8	48.1	−0.7 (−4.0, 2.7)
99,291	30.3	36.1	5.9 (2.7, 9.0)
Multiple bed movements	n =	n =	
99,283	2.1	2.4	0.3 (−0.5, 1.0)
99,284	18.1	15.3	−2.8 (−4.7, 0.9)
99,285	64.0	65.3	1.3 (−1.2, 3.7)
99,291	15.8	17.0	1.3 (−0.6, 3.1)

CCSU, critical care step-down unit; CI, confidence interval; CPT, current procedural terminology; E&M, evaluation and management; NA, not applicable.

of decreasing coding in the pre-CCSU period, no trend in the CCSU period, but a level increase in the CCSU period. There were no trends or level changes for QNOTE scores.

3.2 | Morbidity and mortality referrals review

The summary of the morbidity and mortality referrals for the pre-CCSU and post-CCSU cases is provided in Table 6, as well as our commentary of how potential CCSU use might have mitigated or reduced the concerns raised about these cases or the case outcomes. The predominant themes based on our assessment of how CCSU care might have led to better patient care and safety included the potential for re-evaluation of patient complaints, re-examination of patients, more careful reviews of diagnostic imaging orders and results, initiation of appropriate consultations, and changes in patient disposition from the ED. Our assessment results further suggest that by reducing the crowding of the critical care suites, some patients might have had more rapid response to critical care needs, diagnoses could have been made sooner, patients from the urgent care areas could have been evaluated sooner in the critical care areas, and medical errors could have been reduced.

4 | LIMITATIONS

First, the CCSU was initiated and evaluated at 1 ED. As such, there was no comparison group except for the ED itself. The impact of implementing related initiatives cannot therefore be directly inferred to other EDs, especially with dissimilar ED operations and physical plants, staffing models, payor complements, and patient clinical and demographic characteristics. Second, pre- versus post-initiation of the CCSU was limited by the matching electronic health record periods; CCSU impact after the change in electronic health record was not directly comparable. Third, inadequate documentation in the electronic health records overall limited the QNOTE assessment. Furthermore, better documentation in the CCSU period does not necessarily mean better medical care was provided. Fourth, improvements might reflect changes in practice not related to the CCSU, such as providers who improved their documentation practices resulting in higher CPT E&M coding. Fifth, some changes by patient bed movement group might reflect changes in the patient mix due to the CCSU, instead of improvements due to the CCSU, such as higher billing codes for patients who remained in the critical care areas. Sixth, given that there were no morbidity and mortality referral requests relevant to the CCSU, the analyses of these cases were limited to commentary, which reflected the beliefs of the study authors.

5 | DISCUSSION

Our assessment of morbidity and mortality referrals suggested that had the CCSU been used more, fewer adverse patient incidents might have occurred. However, decision makers typically are more interested in performance metrics as indicators of the value of new ED operation initiatives. The data indicate at least a moderate positive benefit of the CCSU on ED operations. Median length of stay decreased in general for critical care patients in the critical care suites and urgent care areas, likely because patients were diverted to the CCSU and enabled the medical team to concentrate on fewer patients and facilitate their dispositions more quickly. Although low due to the higher acuity of these patients, 72-hour return visits did not increase in the CCSU period,

TABLE 4 ED critical care patient visits with QNOTE scores 90% or greater by patient movement, pre-CCSU versus CCSU time periods

Patient movement	n	Pre-CCSU period %	n	Post-CCSU period %	CCSU versus pre-CCSU period Δ% (95% CI)
All		73.6		85.2	11.5 (4.9, 18.1)
Critical care only		70.1		87.4	17.3 (10.3, 24.3)
Critical care to urgent		75.4		82.5	7.0 (−8.1, 22.1)
Critical care to CCSU		NA		84.2	NA
Urgent to critical care		76.4		89.8	13.5 (−0.003, 27.2)
Multiple bed moves		78.8		83.0	4.1 (−7.7, 15.9)

CCSU, critical care step-down unit; CI, confidence interval; NA, not applicable.

TABLE 5 Interrupted time series analyses models for all patient movements and all dispositions for ED median length of stay, ED revisits within 72 hours, critical care (99,291) billing, and QNOTE scores >90%

		β	SE	95% CI
ED median length of stay	Trend before CCSU	−0.54	0.14	−0.82, −0.26
	Level change	0.93	1.07	−3.03, 1.17
	Trend after CCSU	0.04	0.02	0.002, 0.09
ED revisits within 72 hours	Trend before CCSU	−0.003	0.004	−0.011, 0.006
	Level change	0.09	0.03	0.04, 0.14
	Trend after CCSU	−0.002	0.001	−0.003, −0.001
Critical care (99,291) billing	Trend before CCSU	−0.05	0.01	−0.06, −0.03
	Level change	0.11	0.03	0.05, 0.17
	Trend after CCSU	−0.001	0.001	−0.001, 0.0004
QNOTE scores >90%	Trend before CCSU	−0.005	0.06	−0.13, 0.12
	Level change	0.17	0.20	−0.22, 0.56
	Trend after CCSU	−0.004	0.003	−0.01, 0.003

n.b. 72-hour ED visits, critical care billing, and QNOTE scores modeled using a log-link function with a random effect for attending physician, while ED median length of stay modeled using quantile regression with a fixed effect for attending physician. CCSU, critical care step-down unit; CI, confidence interval; ED, emergency department; SE, standard error.

and in fact decreased slightly for admitted and discharged patients. Critical care CPT E&M billing increased in the CCSU period, perhaps because medical staff in the CCSU and critical care areas could devote more time to medical record documentation. This explanation is supported by the finding that documentation quality improved in the CCSU period, as measured through QNOTE. There were as expected compensatory decreases in coding levels among those patients who were moved to the urgent care areas instead of remaining in the critical care suites.

Previous research on improving critical care delivery in the emergency medicine setting generally has concerned disease or condition-specific initiatives (eg, coronary disease, sepsis, stroke, and trauma). Structural changes for critical care in the ED, such as the CCSU described in this manuscript, have been reported infrequently, although none involve step-down critical care provided by advanced practice providers. The University of Michigan Medical Center opened a 9-bed intensive care unit adjacent to its adult ED in 2015 with a medical staff consisting of emergency medicine physicians and residents, critical care fellows and physician assistants.[10] Study authors reported a decrease in risk-adjusted 30-day mortality among all ED patients. In 2013, the R. Adams Cowley Shock Trauma Center of the University of Maryland Medical Center created a 9-bed, in ED critical care resuscitation unit.[11] The research team observed that time elapsed from ED presentation to the operating room or further inpatient care was reduced after the unit was initiated. Koran et al[12] examined the effects of the creation of an admission unit for patients awaiting inpatient beds at a community hospital. Comparing the 2 months after versus before the unit opened, there were fewer instances for which patients who had been destined for intensive care unit transfers received slower responses from nursing staff for critical care needs. The authors attributed this improvement to reduction in ED crowding due to this structural change.

The impact of advanced practice providers on ED operations has been investigated in several studies, although in the context of general instead of critical care. Carter et al[13] performed a systematic review of studies from Australia, the United Kingdom, and the United States

TABLE 6 Summary of morbidity and mortality referrals for pre-CCSU and CCSU periods and potential for CCSU use for mitigating its occurrence

Morbidity and mortality classification	Description of patient presentation	Adverse outcome	Potential for CCSU use
Pre-CCSU period			
Missed treatment	Patient with chainsaw injury to leg	No tetanus administered. Patient developed a possible tetanus infection	If the patient was transferred to the CCSU once stabilized, the advanced practice provider could have recognized the failure to administer a tetanus shot and provided it
Missed diagnosis	Patient with fall down stairs while in wheelchair	Patient had a missed ulnar fracture and incomplete spinal cord injury	Missed injuries might have been recognized during CCSU re-evaluation and observation
Missed diagnosis	Patient with facial laceration after walking into tree branch	Wood in wound missed and delayed in removal until after discharge. CT in ED had shown air in the orbit	Missed injuries might have been recognized, CT finding clarified, and appropriate consultation obtained during CCSU re-evaluation and observation
Missed diagnosis	Patient fell from ladder	Missed pneumothorax while patient was in critical care. Delayed recognition after patient transferred to urgent care areas of ED	Radiology review could have been conducted during CCSU re-evaluation and pneumothorax discovered sooner
Missed diagnosis	Restrained driver in motor vehicle collision with abdominal pain, per nursing notes but not physician notes	No initial pelvic x-ray ordered. Patient later found to have small bowel injury and splenic laceration requiring operation	CCSU re-evaluation of patient complaints, examination, nursing notes and diagnostic studies ordered might have led to sooner diagnosis
Missed diagnosis	Patient with recent myocardial infarction who returned to ED with back pain=	CT scan in ED showed possible pericardial effusion. Patient had a ventricular wall rupture	CCSU re-evaluation of CT findings and initiation of appropriate consultations might have led to sooner diagnosis
Missed diagnosis	Patient who fell and diagnosed with clavicular fracture, radius fracture, and subdural hemorrhage	Patient returned to ED after discharge and diagnosed with a thoracic burst fracture	CCSU re-examination of patient might have led to sooner diagnosis
CCSU period			
Missed diagnosis	Driver involved in motor vehicle collision	Patient returned to ED 3 days later with hemoptysis, pneumothorax, and multiple rib fractures	CCSU re-examination of patient and re-evaluation of radiologic imaging ordered might have led to sooner diagnosis
Missed diagnosis	Intoxicated patient with suspected trauma	Initial CT normal, but patient later returned for abdominal pain and subsequent CT revealed splenic rupture	CCSU re-evaluation of patient after sobriety might have led to repeat CT scan and earlier diagnosis
Inadequate care	Motorized scooter operator hit by a moving car	Patient did not receive full assessment of his wounds, lack of adequate wound care, incomplete orthopedic evaluation, and lack of addressing his mobility; required admission 3 days later	CCSU stay could have permitted evaluation of wound care needs, appropriate consultation, and admission

of nurse practitioners on cost, quality of care, and wait times in the emergency medicine setting. Quality of care was concluded to be at least on par with resident physicians, patient satisfaction generally was high, and wait times reduced when nurse practitioners were added to current staffing. In their systematic review, Halter et al[14] reported the findings from 6 US studies and 1 Canadian study on physician assistant care provided in the ED. Of the 3 studies that examined patient waiting times, 2 indicated that physician assistants reduced overall waiting time when added to staffing, but had slightly longer patient length of stays as compared to physicians. A systematic review by Doan et al[15] had similar results on patient waiting time as the Halter et al[14] investigation. The authors also noted there had been 2

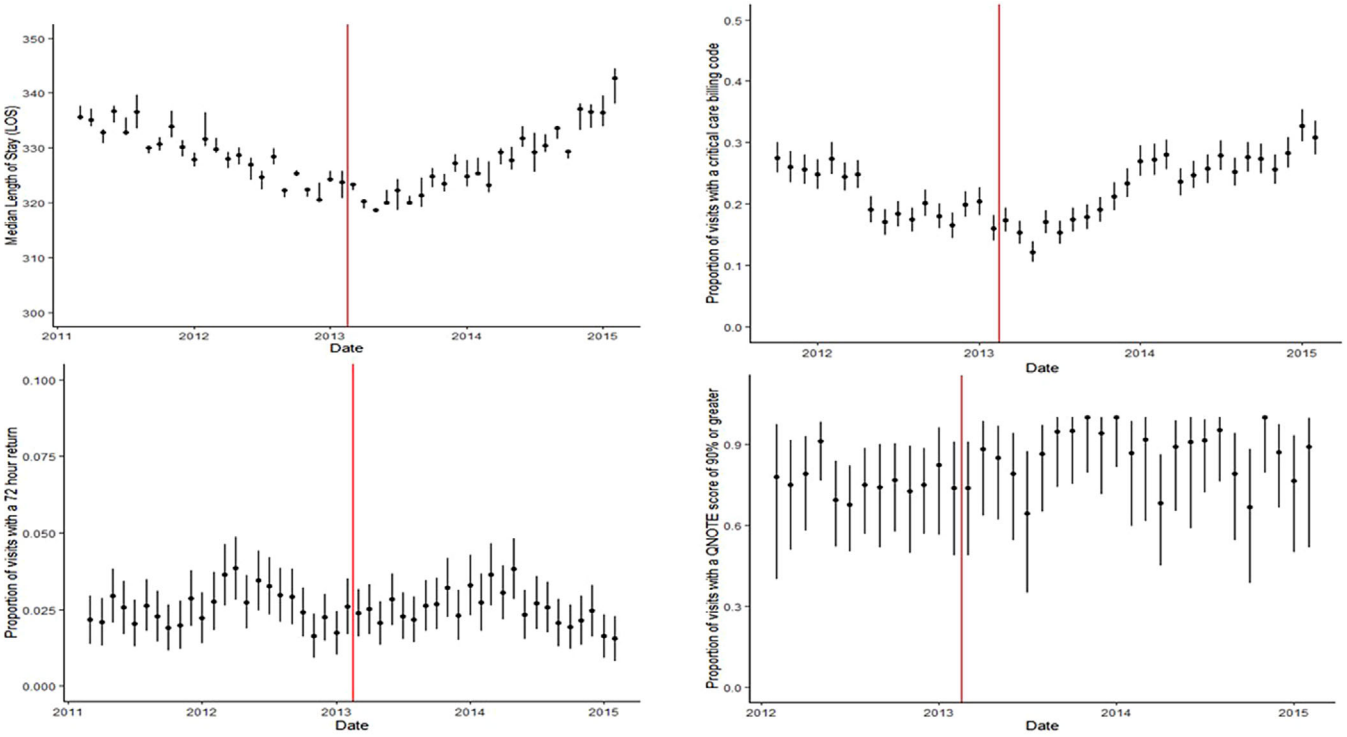

FIGURE 3 Interupted time-series analyses graphs. CCSU, critical care step-down unit; LOS, length of stay; TIA, transient ischemic attack

studies indicating similar cosmetic outcomes and complications from wound care provided by physician assistants and physicians, and no differences in essential medical documentation between these types of providers in another study.[15]

In conclusion, this ED's performance metrics indicate at least moderate improvement in ED length of stay, 72-hour return visits, patient billing, and electronic health record documentation. EDs elsewhere can consider implementation of this advanced practice provider-staffed solution to improvement in critical care in ED.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

LM, GP, and LP were responsible for the initiation of the project and assisted in the study design, data collection, and analysis. MA assisted in the data collection and analysis. SM conducted the biostatistical analyses. RM oversaw the study design through its analysis and takes final responsibility for this manuscript. All investigators assisted in the production of the manuscript.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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