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Central Venous Access Capability and Critical Care Telemedicine Decreases Inter-Hospital Transfer Among Severe Sepsis Patients: A Mixed Methods Design

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Abstract

OBJECTIVE: Severe sepsis is a complex, resource intensive, and potentially lethal condition, and rural patients have worse outcomes than urban patients. Early identification and treatment are important to improving outcomes. The objective of this study was to identify hospital-specific factors associated with inter-hospital transfer.

DESIGN: Mixed method study integrating data from a telephone survey and retrospective cohort study.

PARTICIPANTS AND PATIENTS: Survey of Iowa Emergency Department (ED) administrators between May and June 2017 and cohort of adults seen in Iowa EDs for severe sepsis and septic shock between January 2005 and December 2013.

INTERVENTIONS: None

MEASUREMENTS AND MAIN RESULTS: Multivariable logistic regression was used to identify independent predictors of inter-hospital transfer. We included 114 institutions that provided data (response rate= 99%), and responses were linked to a total of 150,845 visits for severe sepsis/septic shock. In our adjusted model, having the capability to place CVCs or having a

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subscription to a CC-telemedicine service was independently associated with lower odds of inter-hospital transfer (aOR: 0.69, 95%CI: 0.54–0.86; aOR: 0.69, 95%CI: 0.54–0.88 respectively). A facility's participation in a sepsis-specific quality improvement initiative was associated with 62% higher odds of transfer (aOR: 1.62, 95%CI: 1.10–2.39).

CONCLUSIONS: The insertion of CVCs and access to a critical care physician during sepsis treatment are important capabilities in hospitals that transfer fewer sepsis patients. In the future, hospital-specific capabilities may be used to identify institutions as regional sepsis centers.

Keywords

Emergency Department; Evaluations; Health Services; Hospitals; Rural; Outcomes; Critical Care; Sepsis

Introduction

Severe sepsis is a complex, resource-intensive and deadly condition leading to an estimated 390,000 emergency department (ED) visits in 2009 [1]. While a targeted, mechanistic therapy remains elusive, elements of the sepsis guideline bundles generated by the *Surviving Sepsis Campaign (SSC) Guidelines* [2] are effective in reducing sepsis mortality.[3–5] Early, aggressive and appropriate sepsis care is associated with improved sepsis mortality [6, 7], but this care has been challenging to implement especially in rural areas, where nearly 20% of Americans live.[8, 9]

Rural Americans living in an area served by a single critical access hospital, defined as a remote hospital with 25 acute beds and an average length of stay 96 hours,[10] bypass their local facility 5.6–60% of the time for inpatient care, and many who bypass facilities undergo inter-hospital transfer.[7, 11] Rural patients transferred to tertiary care hospitals continue to have worse outcomes than similar urban patients, possibly related to delayed and/or inappropriate early interventions.[6, 12, 13] This constellation of findings highlights the importance of improving early identification, appropriate intervention, and timely risk-stratification for appropriate definitive care.

The primary objective of this study was to identify hospital-specific factors associated with inter-hospital transfer and sepsis survival in a statewide sepsis cohort. Identifying these hospital factors was intended as the first step of a process to define hospital capabilities that could be used to stratify hospitals in sepsis treatment capabilities. This process was also intended to develop transfer trigger tools to be used in future implementation science studies.

Materials and Methods

Study Design

This study was a mixed method study applying telephone survey data of hospital characteristics to a retrospective cohort study of adults (age 18 years) presenting to EDs in a single Midwestern state with severe sepsis and septic shock. Data reporting transfer practices came from administrative claims from the state inpatient and outpatient data sets of

all medical claims from all hospitals in the cohort. This study was determined to not be “human subjects research” by the local Institutional Review Board and utilized data previously approved by the local Institutional Review Board under waiver of informed consent. The study is reported consistent with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement.[14]

Capabilities Survey

Hospitals were identified using the state hospital association ED database (n=120).[15] Hospitals were grouped into categories based on their classification assigned by the Centers for Medicare & Medicaid Services, as specifically designated critical access hospitals (CAH), rural, rural-referral, and urban facilities.[10] Federally-operated EDs and those that either closed during the study period or did not respond to the facility survey were excluded from the study.

To evaluate hospital resources availability related to acute sepsis care, a standardized questionnaire (Supplemental Digital Content, Appendix A) was designed, refined, and approved by the researchers in collaboration with two experts in the field. Facility-level respondents were identified by directly contacting the ED nurse manager by telephone from May-June 2017.

Definitions

This study defined “*resources*” as physical assets, clinical tools, protocols, staff expertise, and administrative programs. “*Capable*” was defined as having the necessary infrastructure, training, and staffing to provide an intervention. “*Central line*” was defined as an acutely placed central venous catheter exclusive of peripherally-inserted central catheters. Respondents were additionally asked if their hospital housed a formal “*intensive care unit*” (ICU), which we then compared with the Society of Critical Care Medicine (SCCM) classifications for an ICU.

For analysis, ICU status was re-categorized based on the presence of capabilities and clinicians that were consistent with the appropriate ICU level of care, as defined by the retired SCCM guidelines [Supplemental Digital Content, Appendix B].[16] In the absence of current professional guidelines, this definition was used because it incorporates elements of the current Leapfrog Group ICU staffing safety standards[17] and stratifies ICUs based on capabilities. Sepsis protocol capabilities were measured through four criteria: (1) facility implements a specific sepsis protocol, care plan, or order set; (2) facility participates in a sepsis-specific quality improvement initiative; (3) facility tracks adherence with sepsis bundles; and (4) facility implements an automated sepsis screening algorithm. The presence of all four components were identified as having a comprehensive plan.

Severe Sepsis Patient Cohort

To determine transfer practices and clinical outcomes, an administrative dataset from the state hospital association was used that included patients presenting to Iowa EDs between 2005 and 2013, as previously described.[7] Patients with severe sepsis or septic shock were defined using a previously validated definition using diagnosis codes from the *International*

Classification of Diseases, 9th Edition, Clinical Modification (ICD-9-CM), and transfer status was defined based on ED disposition.[18] The responses from the capabilities survey were then matched to patient-level cohort by a facility identification number.

Outcomes

The primary outcome of this study was inter-hospital transfer, defined from an ED discharge disposition. Tertiary hospitals were included in the analysis to accurately influence the models on the resources available at these hospitals that decrease the likelihood of transfer. A sensitivity analysis was conducted with a composite outcome which included inter-hospital transfer or death.

Data Analysis

The capabilities of each facility were reported with descriptive statistics. We analyzed each hospital characteristic individually with univariate logistic regression analysis (clustered on hospital) to evaluate the relationship with inter-hospital transfer overall. In order to identify factors that would better predict transfer, we stratified our analysis for CAH and non-CAH hospitals. The decision to stratify by this variable was driven primarily by theory; the differences in structure and reimbursement scales between CAH and non-CAH facilities may modify the relationship between the facility and patient factors on transfer status. We built two sets of models that could predict transfer within each hospital category, recognizing that critical access hospital status may be a significant effect modifier. In the first approach, we identified combinations of factors that were associated with transfer. In the second approach, we evaluated the effect of the previously reported SCCM ICU strata on transfer status as this was considered the standard classification.[16] The purpose of conducting this second analysis was to determine whether our models explained inter-hospital transfer better than the currently available ICU stratification system. For both sets of models, we evaluated the differences in the area under the curve as a comparison of independent ROC curves as a chi squared probability with 1 degree of freedom as described by Gönen.[19]

Since unanticipated deaths could be considered missed transfer opportunities, mortality at the first hospital (pre-transfer) was included in a composite outcome for sensitivity analysis. We decided *a priori* that if point estimates in our new model varied from the primary analysis by more than 10%, we would build separate models for the planned sensitivity analysis. If transfer status did not change after including patients who died in the first hospital prior to transfer, we would leave these patients in the full sample analyzed.

Univariate and multivariable analyses were conducted using generalized estimating equations. Final models were based on purposeful selection of variables based on theory or statistical criteria between the two approaches, comparison of quasi-information criterion (QIC) values to determine the most parsimonious model. While a few of the variables may exhibit collinearity, the variables in the final model were chosen based on the extent to which they influenced the model parameters and generated the best model fit. Multicollinearity in these models were assessed through analysis of the variance inflation factor (VIF). If these VIF values were closer to 1, we would rule out collinearity among the

included variables. In order to compare models on their ability to discriminate transfer status, we generated receiver operator characteristic (ROC) curves and measured the c-statistic in order to evaluate each model's set of predictive factors. All analyses were completed using SAS version 9.4 (SAS Institute, Cary, North Carolina), and statistical significance was defined as $\alpha < 0.05$ using two-tailed tests.

Results

Survey Response Rate and Patient-Level Characteristics

Of the 115 eligible facilities, 114 hospitals provided data (99% response rate) [Figure 1]. Between 2005 and 2013, 150,845 adults were seen in Iowa EDs for severe sepsis and septic shock. The cohort was 53% female, with a median age of 73 (IQR: 60–83 years). Approximately 32% of patients initially presented to hospitals across CAH, rural, or rural-referral facilities, and 73% of all transferred patients originated from these facilities (Table 1). Ten percent of patients in this cohort died overall. Most Iowa hospitals are located in rural areas (80%, median ED volume 5,057 visits/year - *data not shown*). Only 25% of these facilities had a dedicated critical care physician. Approximately 35% of facilities had Level 3 ICU capabilities, with 84% of patients overall having access to at least Level 3 capabilities. While over 80% of facilities had individual key components of protocols and quality improvement, only 69% of them had all four key components.

Inter-hospital Transfer (Main Results)

Overall—The odds of inter-hospital transfer was *greater* in hospitals that subscribed to an emergency medicine telemedicine service (uOR = 1.99, CI = 1.36–2.93) and in hospitals that had standardized transfer criteria for sepsis patients (uOR = 2.30, CI = 1.37–3.86) (Table 2). Having 24-hour physician access, tele-ICU capabilities, and the ability to place central venous catheters were most strongly associated with decreased odds of transfer. In the sensitivity analysis combining transfer and death as an outcome, the estimates for each capability or factor either 1) did not change or 2) may have attenuated the effect but was not statistically different from the outcome of transfer alone. We therefore did not exclude patients who died from subsequent analyses. Additionally, while patients who died might differ from those who were transferred, we used a composite outcome to isolate patients who were successfully treated in each hospital. The detailed analysis without incorporation of patients who died is included in Appendix D (e.g., results are unchanged).

Among protocol components, there was a 61% increase (95% CI: 1.10–2.39) in the odds of transfer among CAH facilities that participated in sepsis-specific quality improvement initiatives compared to CAH facilities that did not participate in these initiatives.

Multivariable Model—We generated a multivariable explanatory regression model to describe factors independently associated with patient transfer. That model was different in CAHs and in non-CAHs [Table 3]. In CAH hospitals, the 3 most strongly associated factors were 24 hour access to a family physician (aOR: 0.69; 95%CI: 0.55–0.86), critical care telemedicine services (aOR: 0.69; 95%CI: 0.56–0.85), and the capability to place central lines (aOR: 0.66; 95%CI: 0.52–0.85). However, CAH facilities participating in a sepsis-

specific quality improvement initiative had an increased odds of transfer (aOR: 1.65; 95%CI: 1.15–2.37). In non-CAH hospitals, independent factors associated with transfer included the availability of an infectious diseases physician [aOR: 0.41; 95%CI: 0.26–0.67], hemodialysis capable (aOR: 0.53; 95%CI: 0.35–0.80), and 24-hour critical care physicians (aOR: 0.62; 95%CI: 0.38–1.01).

Comparison with the SCCM Model—While ICU capability was not associated with inter-hospital transfer among CAHs, there was an evident decrease in trend of transfer as ICU capabilities decreased [(8.6%, 17.6%, 24.2%, and 37.0% in Level-2, Level 2 modified, Level 3, and no ICU, respectively, p-trend <0.0001) *data not shown*]. The predictive model within CAH had an AUC of 0.559 compared to the traditional ICU level model AUC of 0.514 [Figure 2a]. In predicting transfer among non-CAH facilities, the AUCs for the predictive model and the *SCCM* ICU level model were 0.610 and 0.585, respectively [Figure 2b]. Unfortunately, while our model was better than the ICU level alone in both CAH and non-CAH hospitals, neither the ICU capability nor our revised model predicted inter-hospital transfer well overall.

Limitations

Our study is subject to several limitations. First, as a telephone survey, we relied on the accuracy and knowledge of respondents to accurately classify hospitals by capability levels. We selected well informed respondents, but any inconsistencies in our data collection would introduce error. In this regard, the reported ICU staffing closely approximates our prior work describing ICU staffing patterns (25% vs 32%).[20] Second, the data obtained from the questionnaire were conducted in 2017 while the individual-level data included sepsis cases from 2005–2013. While it may reflect changes in practice and epidemiology of sepsis over time,[21] we evaluated the impact of temporal changes in our models and found little variation in estimates of capabilities by introducing year into the model. While this temporal gap could contribute to some misclassification, there were no large-scale changes in local care practices, hospital closures, or changing referral patterns during this time, limiting the extent of bias.

Third, our observational study design allows us to draw associations, but not causation. For instance, a hospital that develops a sepsis protocol may be different from one that does not, and the protocol itself may not “cause” increased inter-hospital transfer. Fourth, drawing from administrative claims data, our study is unable to ascertain sepsis classification by definitions not available in administrative claims. The case definition we used requires infection and organ failure, so likely it will align with the previous severe sepsis definition, but we do not have clinical data upon which to calculate organ failure scores reliably. Additionally, severe sepsis and septic shock represent a continuum and they are assigned only once during the hospital stay. As a result, we could not use those codes to assign severity. These limitation are unlikely to change our conclusion given the size of our cohort, and that the epidemiologic trends track similar parameters previously reported in other developed countries. While this may be the source of the lower than expected observed mortality; however, this method has been previously validated [22, 23] and used in multiple influential studies of sepsis epidemiology and outcomes.[18, 24]

Discussion

Inter-hospital transfer is a prevalent intervention in US patients with severe sepsis or septic shock. While transfer impacts the care of more than 13% of all Americans[25], that number soars to nearly 60% in rural states when taking into account hospital bypass.[11] Despite efforts to regionalize care effectively, rural patients continue to suffer higher mortality than urban patients,[26] transferred patients continue to have higher mortality than non-transferred patients,[7, 27] and the timing[28] and destination[29] for transfer continue to influence patient outcomes. Transfer may be complicated by environmental and technical factors leading to potential delays, however, these are unlikely to change the patient's disposition, especially in Iowa where reliable aeromedical and ground transportation is accessible.[30] Although the system by which sepsis care is delivered has clearly not yet been optimized, the importance of narrowing these disparities to improve outcomes for underserved rural patients is unquestionable.

One important step in this quest to improve regional sepsis care requires a combination of (1) patient-level stratification, (2) local facility training and support, and (3) hospital-level stratification. This paper is the first to try to understand how specific hospital-level capabilities influence the decision to transfer. While the predictive capability of these models was not high, the factors that predict the ability to care for sepsis patients without transfer are informative. The ability to treat sepsis patients (outside critical access hospitals) lies principally in the people and resources of the intensive care unit, so these are factors that must be considered in the design of sepsis transfer networks. Significantly, our findings in non-Federal facilities complement and enhance those of Fortis et al who identified the reduced risk of inter-hospital transfer of patients in Federal Veteran Affairs hospitals that employed tele-CC services.[31] We hypothesize that facilities using tele-CC are employing these systems to reduce transfer, whereas facilities that employ tele-ER are likely resource limited and therefore more likely to transfer their sickest patients.

An interesting theme in our prior work is that high-quality early ED care is critical to patient outcomes, even in patients transferred to high-volume centers. This fact is reinforced by observing that rural patients who bypass their local hospitals have 5.6% higher mortality than patients who were treated in rural hospitals, despite the fact that many were transferred. [7] In large-scale studies measuring the impact of hospital volume on survival, Ofoma et al showed that patients transferred to high-volume hospitals had better survival [12], but the impact of high-volume hospital care was not nearly as strong in transferred patients than in patients who presented to a high-volume hospital initially.[13] Interestingly, most of the benefit of being transferred to a higher volume hospital was observed in patients with the fewest organ failures[12], suggesting that a threshold may exist where even inter-hospital transfer cannot rescue patients from poor outcomes. We have previously observed that transferred patients have significantly lower adherence with Surviving Sepsis Campaign guidelines, suggesting that the timing of transfer and the care provided before transfer may be responsible for much of the outcome differences observed.[13]

One critical component to estimate for this regionalization scheme to work is the patient-level severity of illness. Several prior studies have attempted to accurately distinguish which

patients are likely to die given variables available in the ED.[32, 33] One of the best validated of these scores is the Mortality in Emergency Department Sepsis (MEDS) score. Originally reported by Shapiro et al, the MEDS score incorporates nine components available at the time of ED evaluation to determine the probability of mortality.[34] A significant shortcoming of this score, however, is the importance of the “limitation of life sustaining order” in its calculation. Indeed, patients who have a “Do Not Resuscitate” order or are receiving comfort care alone are at high risk of death, but this fact alone should not be used to recommend transfer to a high-volume tertiary care center. In two studies de Groot et.al demonstrated that the performance of MEDS scores is limited in advanced patient age (age > 70)[35] and is slightly inferior to the sole clinical judgement of an ED physician at a tertiary care center (AUC: 0.70 vs 0.81)[36]. Further research is needed to evaluate the performance of these risk stratification tools in the community ED setting.

Given the limitations of each of these scoring systems, we advocate for a much simpler approach. Based on the findings reported in this study, we propose a model upon which to build regional transfer networks. That model considers patient acuity and hospital capability, and proposes a 4-tiered system of stratification for hospitals. In that system, low-acuity patients with less severe disease would be managed in lower capability hospitals to preserve tertiary care beds for patients with more severe disease, and higher severity patients will be regionalized very quickly after the onset of disease (Supplemental Digital Content, Appendix C). According to data published by Seymour, et al. upon which the Sepsis-3 definition was based, patients with septic shock have the highest mortality.[37] These patients should be rapidly regionalized to Level I or Level II Sepsis Centers. Patients with lower severity of illness may be monitored at lower tier centers, but only centers capable of providing rescue from septic shock. This model is built upon the principal that inpatient inter-hospital transfer should be a rare event – patients requiring transfer should ideally be identified and transferred from the ED. Churpek et al showed that every six hour delay of ICU transfer was associated an increase in mortality compared to early transfers, as well as an adjusted 3% increase in mortality for each additional hour.[38] This suggests that identifying patients appropriate for transfer early may be superior to designing systems to provide just-in-time care. Future research should be oriented towards formally developing tiered sepsis care centers and tracking the performance of sepsis severity indices on disposition from the ED and time to transfer/admission.

Conclusions

In conclusion, we identified several hospital-level factors associated with inter-hospital transfer in a cohort of patients with severe sepsis or septic shock in a rural state. In CAHs, the ability to place and maintain a central venous catheter, having a physician available 24 hours daily, and having tele-ICU capability predicted the ability to care for patients without transfer. In non-CAH hospitals, infectious disease consultants, 24-hour critical care physicians, and the ability to perform hemodialysis predicted the ability to care for patients without transfer. Using these data to develop a model of hospital capabilities that can inform a regionalized system of sepsis care is one important step in narrowing the performance gap between rural and urban sepsis patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Flow Chart of Patients and Facilities Included in the Analysis

Figure 2.
Comparison of Predictive Model and SCCM Model for Transfer Outcomes in Patients with Severe Sepsis

Table 1.

Summary of Select Capabilities and Characteristics of Facilities and Patient Access to these Characteristics

Capabilities and Characteristics	Facilities (n=114)		Patients (n=150,485)		Transferred Patients (n=30,637)	
	N	%	N	%	N	%
On-Site Physician	77	67.5	142,544	94.5	24,790	80.9
Mid-level Provider on-site 24 hours	28	24.6	6,701	4.4	4,776	15.6
ICU Capabilities *						
Level 2	22	19.3	111,112	73.7	9,755	31.8
Level 2 Modified	32	28.1	119,598	79.3	11,746	38.3
Level 3	40	35.1	128,776	85.4	15,117	49.3
Dedicated Critical Care Physicians	28	24.6	112,651	74.7	10,443	34.1
Critical Care Physicians Accessible 24 hrs	41	36.0	121,318	80.4	12,967	42.3
Telemedicine Services Access (any)	82	71.9	127,193	84.3	21,970	71.7
Critical Care	13	11.4	4,976	3.3	1,632	5.3
Emergency Medicine	21	18.4	3,606	2.4	2,505	8.2
Pharmacist Capabilities						
Pharmacist Onsite 24/7	21	18.4	104,096	69.0	8,962	29.3
Pharmacist On-Call/Tele-Pharmacy	78	68.4	36,914	24.5	18,253	59.6
No Pharmacist Onsite nor On-Call 24/7	14	12.3	9,725	6.4	3,344	10.9
Medicare Class						
Critical Access Hospital	79	69.3	23,935	15.9	17,448	57.0
Rural Referral	6	5.3	19,626	13.0	3,018	9.9
Rural	7	6.1	4,900	3.2	1,765	5.8
Urban	22	19.3	102,384	67.9	8,406	27.4
Managing Patient on Mechanical Ventilator (>24 hrs)	59	51.8	135,265	89.7	19,457	63.5
Administering Vasopressor Therapy (>24 hrs)	82	71.9	140,311	93.0	22,780	74.4
Performing Hemodialysis	26	22.8	115,873	76.8	10,871	35.5
Placing Central Lines	98	86.0	147,659	97.9	28,201	92.0
Use of Continuous Capnography while Monitoring Intubated Patients	110	96.5	145,442	96.4	29,372	95.9
Use of Capnography During Procedural Sedation in the ED	84	73.7	135,055	89.5	23,571	76.9
Facility's Institutional Protocol and Quality Improvement						
Facility Implements a Specific Sepsis Protocol, CarePlan, or Order Set	101	88.6	147,674	97.9	28,488	93.0
Facility Participates in a Sepsis-Specific Quality Improvement Initiative	98	86.0	147,046	97.5	28,101	91.7
Track Adherence with Sepsis Bundles or Track Sepsis Outcomes	94	82.5	145,761	96.6	27,091	88.4
Facility Implements a Sepsis Screening Algorithm	96	84.2	138,651	91.9	26,384	86.1
Standardized Criteria Written or Unwritten in Place for Transferring Patients with Sepsis	50	43.9	32,244	21.4	11,445	37.4
Specific Arrangements for Transferring Patients with Sepsis to a Specific Hospital for Further Care	9	7.9	5,773	3.8	2,164	7.1

* ICU level indicates having at least these capabilities. For example, all facilities indicating an ICU, that have a physician on site 24 hours, and are capable of placing central lines are identified as Level 3 capable.

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Table 2.

Proportion of Transfer by Select Facility Characteristic, Capability, and Protocol Component

Facility Characteristic, Capability, and Protocol Component	CAH Facilities Only		Non-CAH Facilities ^a	
	uOR	95% CI	uOR	95% CI
On-Site Physician	1.19	0.94–1.53		
ICU Level 2	1.44	1.27–1.63	0.35	0.21–0.59
ICU Level 2 Modified	0.98	0.69–1.39	0.34	0.19–0.59
ICU Level 3	0.92	0.70–1.20	0.26	0.12–0.57
Infectious Disease Specialist Accessible 24 hrs	0.94	0.83–1.06	0.30	0.19–0.47
Family Medicine Specialist Accessible 24 hrs	0.60	0.49–0.74	0.54	0.15–1.92
Dedicated Critical Care Physicians	0.90	0.60–1.35	0.38	0.22–0.64
Critical Care Physicians Accessible 24 hrs	0.88	0.67–1.14	0.34	0.19–0.59
Telemedicine Services - Critical Care	0.73	0.56–0.96	1.15	0.53–2.48
Telemedicine Services - Emergency Medicine	0.91	0.70–1.18	1.94	1.41–2.65
Pharmacist Onsite 24/7 vs none	1.34	1.04–1.71	0.52	0.29–0.91
Pharmacist On-Call/Tele-Pharmacy vs none.	0.92	0.69–1.21	1.74	0.91–3.32
Managing Patient on Mechanical Ventilator (>24 hrs)	0.97	0.76–1.22	0.16	0.12–0.21
<i>Performed within Past Month</i>	<i>1.26</i>	<i>1.00–1.59</i>	<i>0.49</i>	<i>0.24–1.04</i>
Administering Vasopressor Therapy (>24 hrs)	0.88	0.69–1.13		
<i>Performed within Past Month</i>	<i>1.31</i>	<i>0.93–1.83</i>	<i>0.35</i>	<i>0.17–0.74</i>
Performing Hemodialysis	1.34	1.14–1.57	0.38	0.22–0.66
Placing Central Lines	0.72	0.58–0.88		
<i>Performed within Past Month</i>	<i>1.14</i>	<i>0.91–1.44</i>	<i>0.78</i>	<i>0.37–1.68</i>
<i>Placed by Intensivist</i>	<i>1.44</i>	<i>1.27–1.63</i>	<i>0.39</i>	<i>0.20–0.60</i>
<i>Placed by Emergency Physician</i>	<i>0.94</i>	<i>0.72–1.23</i>	<i>0.69</i>	<i>0.37–1.27</i>
<i>Placed by Generalist</i>	<i>0.95</i>	<i>0.70–1.29</i>	<i>1.21</i>	<i>0.64–2.31</i>
<i>Placed by Advanced Practice Provider</i>	<i>0.90</i>	<i>0.60–1.34</i>	<i>0.77</i>	<i>0.36–1.64</i>
<i>Placed by Surgeon</i>	<i>0.65</i>	<i>0.52–0.81</i>	<i>1.67</i>	<i>0.91–3.43</i>
Use of Continuous Capnography while Monitoring Intubated Patients	1.22	1.07–1.39	1.07	0.60–1.93
Use of Capnography During Procedural Sedation in the ED	0.91	0.72–1.15	0.68	0.42–1.09
Standardized Criteria Written or Unwritten in Place for Transferring Patients with Sepsis	0.97	0.76–1.23	1.02	0.52–1.99
Specific Arrangements for Transferring Patients with Sepsis to a Specific Hospital for Further Care	0.95	0.68–1.33	1.03	0.33–3.20

^a Black boxes indicate capabilities where all facilities had access; as a result, we could not model transfer as an outcome based on capability.

Table 3.

Final Models Predicting Transfer among CAH and non-CAH Facilities

Model and Predictors		CAH Facilities		Model and Predictors		Non-CAH Facilities	
Risk Factor Model [AUC = 0.559]		aOR	95%CI	Risk Factor Model [AUC = 0.610]		aOR	95%CI
Capable of Placing Central Lines		0.66	0.52–0.85	Infectious Disease Specialist Accessible 24 hrs		0.41	0.26–0.67
Telemedicine Services Access - Critical Care		0.69	0.56–0.85	Capable of Performing Hemodialysis		0.53	0.35–0.80
Family Medicine Specialist Accessible 24 hrs		0.69	0.55–0.86	Critical Care Physicians Accessible 24 hrs		0.62	0.38–1.01
Facility Participates in a Sepsis-Specific Quality Improvement Initiative		1.65	1.15–2.37				
Standard Model [AUC = 0.514]		aOR	95%CI	Standard Model [AUC = 0.585]		aOR	95%CI
No ICU		Ref		No ICU		Ref	
Level 2 modified		0.83	0.62–1.12	Level 2 modified		0.40	0.16–1.03
Level 2		1.42	1.23–1.64	Level 2		0.18	0.08–0.40
Level 3		0.88	0.62–1.25	Level 3		0.53	0.23–1.21
Level 4		1.00	0.75–1.33	Level 4 ^a		NA	

^aNo Level 4 ICU among non-CAH facilities