Received: 23 April 2020 | Revised: 6 July 2020 | Accepted: 8 July 2020

DOI: 10.1002/emp2.12203

JACEP OPEN WILEY

ORIGINAL RESEARCH

The Practice of Emergency Medicine

Risk factors for unplanned ICU admission after emergency department holding orders

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Funding and support: By *JACEP Open* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist.

ABSTRACT

Study hypothesis: Emergency department (ED) holding orders are used in an effort to streamline patient flow. Little research exists on the safety of this practice. Here, we report on prevalence and risk factors for upgrade of medical admissions to ICU for whom holding orders were written.

Methods: Retrospective review of holding order admissions through our ED for years 2013-2018. Pregnancy, prisoner, pediatric, surgical, and ICU admissions were excluded, as were transfers from other hospitals. Risk factors of interest included vital signs, physiologic data, laboratory markers, sequential organ failure assessment (SOFA), Quick SOFA (qSOFA), modified early warning (MEWS) scores, and Charlson Comorbidity Index (CCI). Primary outcome was ICU transfer within 24 hours of admission. Analysis was completed using multivariable logistic regression.

Results: Between 2013 and 2018, the ED had 203,374 visits. Approximately 20% (N = 54,915) were admitted, 23% of whom had holding orders (N = 12,680). A minority of those with a holding order were transferred to the ICU within 24 hours (N = 79; 0.62%). Those transferred to ICU had increased heart and respiratory rate, P/F ratio, and increased oxygen need. They also had higher MEWS, quick SOFA (qSOFA), and SOFA scores. Multivariable logistic regression demonstrated a significant association between ICU admission and FiO2 (odds ratio [OR] 1.47; 95% confidence interval [CI] 1.25-1.74), MEWS (OR 1.31; 95% CI 1.14-1.52), SOFA Score (OR 1.19; 95% CI 1.05-1.35), and gastrointestinal (OR 3.25; 95% CI: 1.50-7.03) or other combined diagnosis (OR 2.19; CI: 1.07-4.48) ($P = 0.0017$).

Conclusion: Holding orders are used for >20% of all admissions and <1% of those admissions required transfer to ICU within 24 hours.

Supervising Editor: Marna Rayl Greenberg, DO, MPH

1 | INTRODUCTION

1.1 | Background

The use of holding orders (also known as bridge or bridging orders) for admitted patients has become common in the practice of emergency medicine.[1–4] This streamlines flow for patients admitted through the emergency department. Generally, the emergency physician writes skeleton/minimal orders in order to have the patient admitted to the hospital, a bed found, and the patient moved into that bed without first seeing an admitting physician team within the ED. There is variability in the duration of effect these orders have. In some institutions these orders expire within 1 hour; however, in other institutions the orders exist until the inpatient physician sees the patient hours later. In contrast, a traditional model would have the patient seen by an admitting physician before admission. In recent years the use of holding orders has been shown to be efficacious in decreasing ED length of stay.[5,6] However, there has been little research into the safety of this practice and describing patient cohorts at risk for decompensation and ICU transfer during the first 24 hours of holding order admission.

Prior research has explored factors associated with deterioration and transfer to ICU in general ED patient cohorts without the use of holding orders. For example, abnormal vital signs at admission are associated with ICU transfer.[7] Other studies have examined scoring systems for early detection of deterioration in admitted medical and surgical patients. One such score is the Modified Early Warning Score (MEWS).[8] This simple scoring system includes parameters such as systolic blood pressure, heart rate, respiratory rate, temperature, and level of responsiveness and assigns each variable a point value.[9–13] Higher scores (defined most frequently as a score over 5) have been shown to predict patients at risk for deterioration and who may require a higher level of care or more intensive monitoring. Furthermore, a sepsis-related organ failure assessment score (SOFA score) has been shown to predict mortality from sepsis.[14] Additionally, the Charlson Comorbidity Index (CCI) has been shown to be associated with poor prognosis. The score is generated by counting comorbid conditions associated with poor prognosis. These include presence of myocardial infarction, congestive heart failure, peripheral vascular disease, stroke, and transient ischemic attack.[15,16] We hypothesized that physiologic warning scores, vital sign derangements, comorbidity indices, and illness severity scores are associated with subsequent need for ICU transfer within 24 hours after admission to the hospital in patients who have holding orders written. Determining specific factors associated with ICU transfer will permit tailoring of holding orders to patient populations less likely to decompensate. Alternatively, holding orders could incorporate time-specific assessments by physician or nursing staff to detect early decompensation.

1.2 | Importance

As the use of holding orders is in common practice today, increasing the body of knowledge surrounding the safe and appropriate use of these orders is highly relevant to the practice of emergency medicine as a whole. We hope our study will add to the body of literature by describing risk factors for ICU transfer within 24 hours of holding order use. Patients with elevated risk may benefit from closer observation, a more expedient evaluation by the admitting clinician after holding orders, more frequent reassessments following admission, or evaluation by the admitting team in the ED before being physically moved to an inpatient bed.

The Bottom Line

Holding orders are commonly used in emergency medicine, but little is known about the safety of this practice. In this retrospective study of holding orders in a rural emergency department over a 5-year period, they were quite safe with less than 1% requiring urgent transfer to ICU within 24 hours of admission.

1.3 | Goals of this investigation

The goal of this project was to determine risk factors for subsequent ICU transfer within 24 hours of a holding order. This is important as delays in ICU care are associated with higher mortality than from the disease process alone.[17]

2 | METHODS

2.1 | Study design and setting

The study was completed at a 250-bed tertiary care referral center in rural Pennsylvania. It is a level 2 trauma center and is teaching hospital with several Accreditation Council for Graduate Medical Education (ACGME) residency and fellowship programs. The health system covers a 12-county area in northern Pennsylvania and southern upstate New York. The ED during the time period in question was staffed with a mixture of board-certified, residency-trained, emergency physicians and physicians with primary care board certification and emergency medicine experience in addition to nurse practitioners (NP) and physician assistants (PA). In our institution, the term holding order specifically relates to the minimal orders that allow bed managers to start the process of finding, assigning, and moving the patient to an inpatient bed. Although the orders may contain other specific elements such as symptom relief medications, the orders typically do not consist of more than an admission assignment, diet order, vital sign frequency and whether or not the patient requires a telemetry unit. These basic orders typically do not have an expiration time. The study design was a retrospective review of aggregate de-identified data from the EPIC electronic medical record (EMR) (Epic Systems, Verona, WI) and was approved by The Guthrie Clinic Institutional Review Board (IRB).

2.2 | Selection of participants

All patients were admitted with holding orders through the ED for the calendar years 2013 through the end of 2018. Any patient initially admitted to ICU or transferred to an outside hospital were excluded. Those admitted to surgical services were excluded as they do not typically have holding orders and have different pathophysiology when compared to patients admitted to the medical service. Those admitted to the psychiatric service or who were vulnerable populations including prisoners, children, and pregnant patients were excluded from analysis per IRB requirement. The number of admissions without holding orders otherwise meeting the criteria for inclusion, as well as the number of ICU admissions within 24 hours for those patients was also collected to allow for a comparision group. Although the health system contained 4 EDs during the time period, only patients admitted at the main ED at the tertiary care referral center were included in our study. The volume for this ED is ≈36,000 visits per year.

2.3 | Measurements

2.3.1 | Outcomes

Our prespecified primary outcome was unplanned transfer to ICU within 24 hours of a holding order admission. This was defined as <24 hours having elapsed between the ED holding order placed in real time by the emergency physician, NP, or PA and the placement of a transfer order upgrading the admission to ICU, which is also placed in real time by a rapid response medical team.

2.3.2 | Analysis

For descriptive statistics, we used median and interquartile (IQR) range for continuous variables, and frequency and percentages for categorial variables. We stratified by the outcome variable of ICU admission within 24 hours. Comparison between groups was accomplished using the Wilcoxon rank-sum and Fisher's exact tests, as appropriate. To account for the requirement of a partial pressure of arterial oxygen (PaO2) to fraction of inspired oxygen (FiO2) ratio (P/F ratio) in SOFA scores, which requires an arterial oxygen measurement, all charts that did not contain an arterial blood gas measurement at the time of admission had 1 estimated from measured peripheral oxygen saturation (SpO2) using methods previously described using the Ellis equation.[18–20] Admission diagnoses were manually reviewed by a single reviewer and were categorized and collapsed in a method similar to previously conducted research.[21] Overall there was negligible missing on most variables (<0.2%). However, bilirubin was missing for 2.5% of the patients, Glasgow Coma Scale 5.7%, SOFA score 8.5%, and lastly, 41% missing CCI. To account for missing data we used multiple imputation, with a fully conditional specification method to permit imputation of both continuous and categorical variables.[22] Categorical variables were imputed with a logistic regression model whereas continuous variables used a predictive mean matching method.[23,24] The imputation procedure was performed 5 times to create 5 complete data sets for the analysis. All variables were used in the imputation process to preserve the covariance structure of the data. We used logistic regression to regress the outcome variables on the patient demographic, vitals, CCI, and severity scoring (SOFA, MEWS) variables. Vitals, CCI, and the severity scores were treated as continuous variables. To better aid in the interpretation of the effect of FiO2, we rescaled the distribution such that a 1-point differences represented a change of 10%. All variables associated with a given outcome at a P value < 0.20 was selected for inclusion in the model. A model was fit to each complete data set and then combined using the method of Rubin for final analysis.[25] We removed variables that were non-significant, and the models were refit and combined across the complete datasets. All models included age and sex regardless of level of significance. Results are presented as odds ratios (OR) with 95% confidence intervals (CI).

The data were abstracted by a data abstraction and database specialist who was blinded to the hypothesis of our study. There was no interpretation made by the abstractor, who was given the set criteria described previously, which are all fields previously populated within the electronic medical record when the patient was admitted. Variables of interest were all decided a-priori based on existing literature. A post hoc exploratory outcome of death within 24 hours, as well as a composite outcome of death or ICU admission within 24 hours was collected but is not included in this manuscript. No a priori variables were excluded collection, nor were any post hoc variables added to the analysis.

3 | RESULTS

Between 2013 and 2018, 203,374 patients were seen in the ED, with 54,915 admitted to hospital. A total of 12,680 patients (23% of all admissions) were included in the primary analysis (Figure 1). The mean overall age of the cohort was 67 (SD 17.2) years. The sex distribution was nearly equal, with males accounting for just under half of the cohort (N=6197; 49.2%). The most common grouped etiology for admission was cardiac (N=2749, 21.7%), followed by respiratory (N=1407, 11.1%). Of the 12,680 admissions who met inclusion criteria, 79 were transferred to ICU within 24 hours (0.62%). In comparision, out of 36,601 admissions who met the inclusion criteria otherwise but did not use a holding order, 129 were transferred to ICU within 24 hours (0.35% $P < 0.0001$). Those patients transferred to the ICU within 24 hours had an increased median heart rate (86 vs 89, p=0.0047), respiratory rate (18 vs 20, $P < 0.0001$), and FiO2 (21% vs 28%, $P < 0.0001$) when compared to those that were not transferred to ICU within 24 hours. Those admitted to the ICU within 24 hours also had small but statistically significantly higher MEWS and SOFA scores when compared to the group that was not admitted to ICU within 24 hours (Table 1).

Multivariable logistic regression modeling for transfer to ICU within 24 hours of holding order usage was completed. Increased FiO2 (OR 1.47, 95% CI: 1.25-1.74, $P < 0.0001$) was associated with ICU

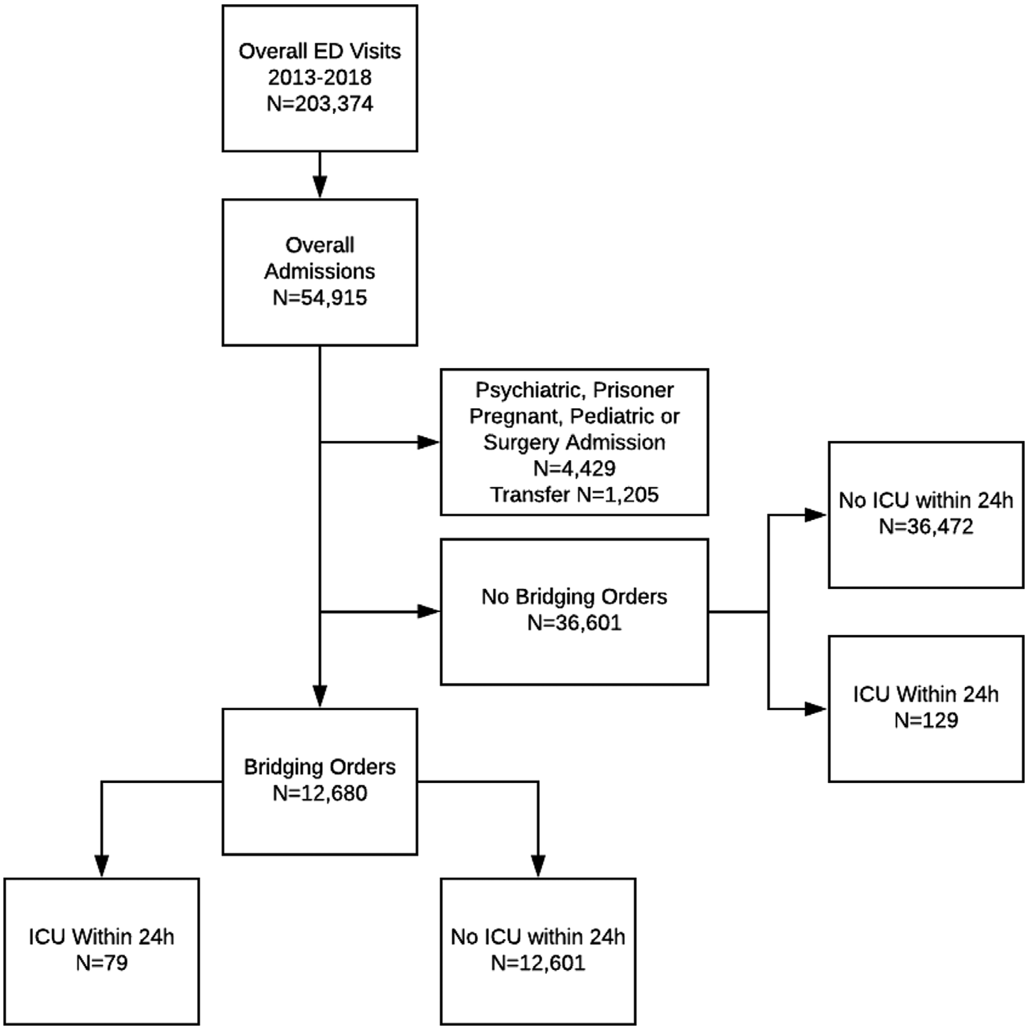

FIGURE 1 Breakdown of admissions and patient flow for years 2013-2018

transfer within 24 hours. A gastrointestinal or other combined admission diagnosis was also more likely to be transferred to the ICU within 24 hours compared to those who had a cardiac diagnosis (OR 3.25, 95% CI: 1.50-7.03 for gastrointestinal (GI), OR 2.19, CI: 1.07-4.48 for combined diagnoses respectively; $P = 0.0017$). With respect to risk scores, higher SOFA score was associated with ICU transfer within 24 hours (OR 1.19, 95% CI: 1.05-1.35, $P = 0.0057$), as was a higher MEWS (OR 1.31, 95% CI: 1.14-1.52, $P = 0.0001$). Full results of the multivariable logistic regression model are shown in Table 2.

4 | DISCUSSION

In this cohort of patients admitted with holding orders, we identified a small number of patients who required unplanned ICU transfer within 24 hours. Similar to existing literature, patients transferred to the ICU within 24 hours demonstrated an increased median heart and respiratory rate, P/F ratio, liters per minute of oxygen (LPM), and FiO2 compared to those who were not transferred to the ICU within 24 hours. These differences were small, limiting their clinical significance, but were statistically significant when examined at the cohort level. They also had small but significantly higher MEWS, qSOFA, and SOFA scores. In regression analysis, factors associated with risk for ICU transfer within 24 hours included increased FiO2, a GI admission or other combined admission diagnosis, higher SOFA scores, as well as higher MEWS. These data suggest that holding orders are safe in our facility. Although the rate of ICU transfer was higher in the holding orders group than those admitted through the use of holding orders, the overall rate is still quite low.

It is possible that those patients who required transfer to ICU following holding orders, specifically those with GI diagnoses, could represent decompensation from bleeding, or represent those with a separate or additional diagnosis. It can be difficult tease apart potential differential considerations involving the upper abdomen and epigastrum.[26,27] These data show that the practice of using holding orders, which has previously been shown to decrease length of stay, increase patient satisfaction, improve adherance to guideline-directed therapy, and improve patient outcomes, appears to be relatively safe.[6,28,29]

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TABLE 1 Descriptive statistics stratified by transfer to ICU within first 24 Hours

Factor	Did not transfer to ICU	Transferred to ICU within 24 hours	*P*
N	12601	79	
Age (years)	70.00 (57.00, 80.00) (n = 12601)[a]	71.00 (62.00, 78.00) (n = 79)	0.72
Male sex	6197 (49.2%)[b]	38 (48.1%)	0.91
Blood glucose	151.00 (105.00, 202.00) (n = 12601)	151.00 (114.00, 213.00) (n = 79)	0.32
SBP	139.00 (123.00, 159.00) (n = 12577)	138.00 (124.00, 154.00) (n = 78)	0.55
DBP	74.00 (65.00, 85.00) (n = 12577)	71.00 (62.00, 82.00) (n = 78)	0.16
MAP	96.33 (85.33, 108.67) (n = 12577)	96.33 (82.00, 104.67) (n = 78)	0.29
Respiratory rate	18.00 (18.00, 20.00) (n = 12593)	20.00 (18.00, 24.00) (n = 79)	<0.0001
FiO2	0.21 (0.21, 0.28) (n = 12601)	0.28 (0.28, 0.32) (n = 79)	<0.0001
SpO2	96.00 (94.00, 98.00) (n = 12577)	96.00 (94.00, 98.00) (n = 79)	0.32
Heart rate	86.00 (74.00, 100.00) (n = 12568)	89.00 (80.00, 106.00) (n = 79)	0.0047
Bilirubin	0.60 (0.40, 0.90) (n = 12291)	0.60 (0.40, 0.90) (n = 78)	0.36
Creatinine	0.90 (0.70, 1.20) (n = 12564)	0.90 (0.70, 1.50) (n = 79)	0.96
Temperature	97.90 (97.40, 98.60) (n = 12582)	97.90 (97.40, 98.50) (n = 79)	0.64
Platelet	205.00 (160.00, 261.00) (n = 12552)	210.00 (164.00, 269.00) (n = 79)	0.71
P/F ratio	384.09 (285.99, 489.06) (n = 12577)	266.08 (214.49, 406.79) (n = 79)	<0.0001
LPM	0.00 (0.00, 2.00) (n = 12601)	2.00 (2.00, 3.00) (n = 79)	<0.0001
Admission DX group			0.0199
Cardiac	2737 (21.7%)	12 (15.2%)	
GI	1521 (12.1%)	16 (20.3%)	
Infection	2507 (19.9%)	12 (15.2%)	
Neuro	1976 (15.7%)	6 (7.6%)	
Resp	1396 (11.1%)	11 (13.9%)	
Other	2464 (19.6%)	22 (27.8%)	
Admitted PM/night	6391 (50.7%)	41 (51.9%)	0.91
Admitted on weekend	2479 (19.7%)	19 (24.1%)	0.32
CCI	4.00 (2.00, 9.00) (n = 7445)	7.00 (2.50, 11.50) (n = 48)	0.0881
GCS	15.00 (15.00, 15.00) (n = 11873)	15.00 (15.00, 15.00) (n = 79)	0.13
MEWS	1.00 (0.00, 2.00) (n = 12517)	1.00 (0.00, 3.00) (n = 79)	<0.0001
SOFA	2.00 (1.00, 3.00) (n = 11523)	2.00 (2.00, 4.00) (n = 77)	0.0001
qSOFA			0.0013
0	8350 (70.5%)	40 (51.3%)	
1	3148 (26.6%)	32 (41.0%)	
2	330 (2.8%)	6 (7.7%)	
3	22 (0.2%)	0 (0.0%)	

SBP, systolic blood pressure; DBP, diastolic blood pressure; MAP, mean arterial pressure; FiO2, fraction of inspired oxygen; SpO2, peripheral capillary oxygen saturation; P/F Ratio, partial pressure of arterial oxygen to fraction of inspired oxygen ratio; LPM, liters per minute; CCI, Charlson Comorbidity Index; GCS, Glasgow Coma Scale; MEWS, modified early warning score; SOFA, sequential organ failure assessment; qSOFA, quick sequential organ failure assessment; IQR, interquartile range; GI, gastrointestinal.

[a] Median (IQR) (n)

[b] N (%)

This study is the first specifically examining the safety of using holding orders while assessing risk factors associated with unplanned ICU transfer within 24 hours. Our data support prior literature demonstrating that physiologic derangement, such as changes in vital signs, hypoxia, or abnormal blood chemistry, on admission remains associated with transfer to ICU within 24 hours. From a practicality standpoint, the MEWS seems to be the best marker for predicting the possibility of decompensation. This cohort of patients may benefit

TABLE 2 Multivariable logistic regression results of ICU transfer within 24 hours bold delineates significant predictors

Variable	OR (95% CI)	*P*
Age (years)	1.00 (0.98, 1.01)	0.9541
Male Sex	0.92 (0.59, 1.45)	0.7215
FiO2 (0.01 unit)	**1.47 (1.25, 1.74)**	**<0.0001**
Heart Rate	1.01 (0.99, 1.02)	0.2140
Admission DX Group		**0.0017**
Cardiac	**Ref**	
GI	**3.25 (1.50, 7.03)**	
Infection	**0.91 (0.41, 2.06)**	
Neuro	**1.10 (0.47, 2.58)**	
RespOther	**1.10 (0.47, 2.58)**	
	2.19 (1.07, 4.48)	
SOFA	**1.19 (1.05, 1.35)**	**0.0057**
CCI	1.02 (0.99, 1.04)	0.2365
MEWS	**1.31 (1.14, 1.52)**	**0.0001**

FiO2, fraction of inspired oxygen; GI, gastrointestinal; SOFA, sequential organ failure assessment; CCI, Charlson co-morbidity index; MEWS, modified early warning score.

from more frequent reassessment in the first hours after admission to the hospital.

This study has several important limitations. First, the retrospective nature of our study precludes drawing causal conclusions, and the risk factors represent correlation only. Additionally, there could be confounding variables not measured here that affect risk factors for unplanned ICU transfer. The outcome of transfer to ICU within 24 hours is a commonly used surrogate for patient outcomes and safety. We are unable to determine if this represents unrecognized critical illness, unexpected deterioration, or expected disease course. Furthermore, holding orders were only used ≈25% of the time. It is possible that clinicians in the ED filter out most patients who are at risk for deterioration prior to placing holding orders. During the study period there was a mixture of clinicians evaluating patients, including board certified emergency physicians, non-board-certified physicians, along with NPs and PAs. We were unable to stratify the data by what type of emergency clinician evaluated the patient, raising the possibility that the practitioner may represent a confounding variable. Additionally, we were unable to account for the potential confounder of the length of time a patient is on holding orders prior to being seen by an inpatient team member. Although the degree of missing data was low overall, it is possible that data were missing in a non-random manner, which could affect the internal validity of the results. Finally, it is difficult to generalize between our rural tertiary care referral ED and other practice settings.

In our facility, <1% of patients who had holding orders written at the time of their admission to a medical floor bed required ICU transfer within 24 hours of admission.

Risk factors included increased median heart and respiratory rate, P/F ratio, LPM, FiO2, higher MEWS, qSOFA, and SOFA scores but were all very weakly related and not reasonably predictive. SOFA or MEWS scores could be useful markers of patients who should have closer attention with more frequent viral signs and sooner reassessment following their admission to the floor bed. Further research should prospectively validate these risk factors for ICU transfer, investigate other factors associated with ICU transfer, and determine strategies to screen for those at high risk for deterioration.

AUTHORS' CONTRIBUTIONS

Zachary E. Dewar and Jon C. Rittenberger conceived of the project. Zachary E. Dewar arranged for and supervised data abstraction. Zachary E. Dewar, Jon C. Rittenberger and H. Lester Kirchner designed the analysis. H. Lester Kirchner performed the analysis and interpretation. Zachary E. Dewar was responsible for drafting the manuscript. Zachary E. Dewar, Jon C. Rittenberger and H. Lester Kirchnerwere responsible for critical revisions of the manuscript. Zachary E. Dewar, H. Lester Kirchner, and Jon C. Rittenberger were responsible for final approval of the manuscript version to be published.

ACKNOWLEDGMENTS

Jeffery Dorman, for assistance in EPIC report writing, Laura Fitzgerald and Vicky Hicky for assistance in study and IRB coordination.

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How to cite this article: Dewar ZE, Kirchner HL, Rittenberger JC. Risk factors for unplanned ICU admission after emergency department holding orders. *JACEP Open*. 2020;1:1623–1629. https://doi.org/10.1002/emp2.12203