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ORIGINAL RESEARCH

Risk Factors for Unplanned Transfer to Intensive Care Within 24 Hours of Admission From the Emergency Department in an Integrated Healthcare System

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BACKGROUND: Emergency department (ED) ward admissions subsequently transferred to the intensive care unit (ICU) within 24 hours have higher mortality than direct ICU admissions.

DESIGN, SETTING, PATIENTS: Describe risk factors for unplanned ICU transfer within 24 hours of ward arrival from the ED.

METHODS: Evaluation of 178,315 ED non-ICU admissions to 13 US community hospitals. We tabulated the outcome of unplanned ICU transfer by patient characteristics and hospital volume. We present factors associated with unplanned ICU transfer after adjusting for patient and hospital differences in a hierarchical logistic regression.

RESULTS: There were 4,252 (2.4%) non-ICU admissions transferred to the ICU within 24 hours. Admitting diagnoses most associated with unplanned transfer, listed by descending prevalence were: pneumonia (odds ratio [OR] 1.5; 95% confidence interval [CI] 1.2–1.9), myocardial infarction (MI) (OR 1.5; 95% CI 1.2–2.0), chronic obstructive pulmonary disease (COPD) (OR 1.4; 95% CI 1.1–1.9), sepsis (OR 2.5; 95% CI 1.9–3.3), and catastrophic conditions (OR 2.3; 95% CI 1.7–3.0). Other significant predictors included: male sex, Comorbidity Points Score >145, Laboratory Acute Physiology Score ≥ 7, arriving on the ward between 11 PM and 7 AM. Decreased risk was found with admission to monitored transitional care units (OR 0.83; 95% CI 0.77–0.90) and to higher volume hospitals (OR 0.94 per 1,000 additional annual ED inpatient admissions; 95% CI 0.91–0.98).

CONCLUSIONS: ED patients admitted with respiratory conditions, MI, or sepsis are at modestly increased risk for unplanned ICU transfer and may benefit from better triage from the ED, earlier intervention, or closer monitoring to prevent acute decompensation. More research is needed to determine how intermediate care units, hospital volume, time of day, and sex affect unplanned ICU transfer. *Journal of Hospital Medicine* 2013;8:13–19. © 2012 Society of Hospital Medicine

Emergency Department (ED) patients who are hospitalized and require unplanned transfer to the intensive care unit (ICU) within 24 hours of arrival on the ward have higher mortality than direct ICU admissions.[1,2] Previous research found that 5% of ED admissions experienced unplanned ICU transfer during their hospitalization, yet these patients account for 25% of in-hospital deaths and have a longer length of stay than direct ICU admissions.[1,3] For these reasons, inpatient rapid-response teams and early warning systems have been studied to reduce the mortality of patients who rapidly deteriorate on the hospital ward.[4–10] However, there is little conclusive evidence that these interventions decrease mortality.[7–10] It is possible that with better recognition and intervention in the ED, a portion of these unplanned ICU transfers and their subsequent adverse outcomes could be prevented.[11]

Previous research on risk factors for unplanned ICU transfers among ED admissions is limited. While 2 previous studies from non-US hospitals used administrative data to identify some general populations at risk for unplanned ICU transfer,[12,13] these studies did not differentiate between transfers shortly after admission and those that occurred during a prolonged hospital stay—a critical distinction since the outcomes between these groups differs substantially.[1] Another limitation of these studies is the absence of physiologic measures at ED presentation, which have been shown to be highly predictive of mortality.[14]

In this study, we describe risk factors for unplanned transfer to the ICU within 24 hours of arrival on the ward, among a large cohort of ED hospitalizations across 13 community hospitals. Focusing on admitting

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diagnoses most at risk, our goal was to inform efforts to improve the triage of ED admissions and determine which patients may benefit from additional interventions, such as improved resuscitation, closer monitoring, or risk stratification tools. We also hypothesized that higher volume hospitals would have lower rates of unplanned ICU transfers, as these hospitals are more likely have more patient care resources on the hospital ward and a higher threshold to transfer to the ICU.

METHODS

Setting and Patients

The setting for this study was Kaiser Permanente Northern California (KPNC), a large integrated healthcare delivery system serving approximately 3.3 million members.[1,3,15,16] We extracted data on all adult ED admissions ($\geq$18 years old) to the hospital between 2007 and 2009. We excluded patients who went directly to the operating room or the ICU, as well as gynecological/pregnancy-related admissions, as these patients have substantially different mortality risks.[14] ED admissions to hospital wards could either go to medical–surgical units or transitional care units (TCU), an intermediate level of care between the medical–surgical units and the ICU. We chose to focus on hospitals with similar inpatient structures. Thus, 8 hospitals without TCUs were excluded, leaving 13 hospitals for analysis. The KPNC Institutional Review Board approved this study.

Main Outcome Measure

The main outcome measure was unplanned transfer to the ICU within 24 hours of arrival to the hospital ward, based upon bed history data. As in previous research, we make the assumption—which is supported by the high observed-to-expected mortality ratios found in these patients—that these transfers to the ICU were due to clinical deterioration, and thus were ''unplanned,'' rather than a ''planned'' transfer to the ICU as is more common after an elective surgical procedure.[1–3] The comparison population was patients admitted from the ED to the ward who never experienced a transfer to the ICU.

Patient and Hospital Characteristics

We extracted patient data on age, sex, admitting diagnosis, chronic illness burden, acute physiologic derangement in the ED, and hospital unit length of stay. Chronic illness was measured using the Comorbidity Point Score (COPS), and physiologic derangement was measured using the Laboratory Acute Physiology Score (LAPS) calculated from labs collected in the ED.[1,14,17] The derivation of these variables from the electronic medical record has been previously described.[14] The COPS was derived from International Classification of Diseases, Ninth Revision (ICD-9) codes for all Kaiser Permanente Medical Care Program (KPMCP) inpatient and outpatient encounters prior to hospitalization. The LAPS is based on 14 possible lab tests that could be drawn in the ED or in the 72 hours prior to hospitalization. The admitting diagnosis is the ICD-9 code assigned for the primary diagnosis determined by the admitting physician at the time when hospital admission orders are entered. We further collapsed a previously used categorization of 44 primary condition diagnoses, based on admission ICD-9 codes,[14] into 25 broad diagnostic categories based on pathophysiologic plausibility and mortality rates. We tabulated inpatient admissions originating in the ED to derive a hospital volume measure.

Statistical Analyses

We compared patient characteristics, hospital volume, and outcomes by whether or not an unplanned ICU transfer occurred. Unadjusted analyses were performed with analysis of variance (ANOVA) and chi-square tests. We calculated crude rates of unplanned ICU transfer per 1,000 ED inpatient admissions by patient characteristics and by hospital, stratified by hospital volume.

We used a hierarchical multivariate logistic regression model to estimate adjusted odds ratios for unplanned ICU transfer as a function of both patient-level variables (age, sex, COPS, LAPS, time of admission, admission to TCU vs ward, admitting diagnosis) and hospital-level variables (volume) in the model. We planned to choose the reference group for admitting diagnosis as the one with an unadjusted odds ratio closest to the null (1.00). This model addresses correlations between patients with multiple hospitalizations and clustering by hospital, by fitting random intercepts for these clusters. All analyses were performed in Stata 12 (StataCorp, College Station, TX), and statistics are presented with 95% confidence intervals (CI). The Stata program gllamm (Generalized Linear Latent and Mixed Models) was used for hierarchical modeling.[18]

RESULTS

Of 178,315 ED non-ICU hospitalizations meeting inclusion criteria, 4,252 (2.4%) were admitted to the ward and were transferred to the ICU within 24 hours of leaving the ED. There were 122,251 unique patients in our study population. Table 1 compares the characteristics of ED hospitalizations in which an unplanned transfer occurred to those that did not experience an unplanned transfer. Unplanned transfers were more likely to have a higher comorbidity burden, more deranged physiology, and more likely to arrive on the floor during the overnight shift.

Unplanned ICU transfers were more frequent in lower volume hospitals (Table 1). Figure 1 displays the inverse relationship between hospital annual ED inpatient admission volume and unplanned ICU transfers rates. The lowest volume hospital had a crude

TABLE 1. Patient Characteristics and Outcomes by Need for Unplanned ICU Transfer

Characteristics	Unplanned Transfer to ICU Within 24 h of Leaving ED? Yes N = 4,252 (2.4%)	No N = 174,063 (97.6%)	*P* Value*
Age, median (IQR)	69 (56–80)	70 (56–81)	<0.01
Male, %	51.3	45.9	<0.01
Comorbidity Points Score (COPS),† median (IQR)	100 (46–158)	89 (42–144)	<0.01
Laboratory Acute Physiology Score (LAPS),‡ median (IQR)	26 (13–42)	18 (6–33)	<0.01
Nursing shift on arrival to floor, %			
Day: 7 am–3 pm (Reference)	20.1	20.1	NS
Evening: 3 pm–11 pm	47.6	50.2	NS
Overnight: 11 pm–7 am	32.3	29.7	<0.01
Weekend admission, %	33.7	32.7	NS
Admitted to monitored bed, %	24.1	24.9	NS
Emergency department annual volume, mean (SD)	48,755 (15,379)	50,570 (15,276)	<0.01
Non-ICU annual admission volume, mean (SD)	5,562 (1,626)	5,774 (1,568)	<0.01
Admitting diagnosis, listed by descending frequency, %			NS
Pneumonia and respiratory infections	16.3	11.8	<0.01
Gastrointestinal bleeding	12.8	13.6	NS
Chest pain	7.3	10.0	<0.01
Miscellaneous conditions	5.6	6.2	NS
All other acute infections	4.7	6.0	<0.01
Seizures	4.1	5.9	<0.01
AMI	3.9	3.3	<0.05
COPD	3.8	3.0	<0.01
CHF	3.5	3.7	NS
Arrhythmias and pulmonary embolism	3.5	3.3	NS
Stroke	3.4	3.5	NS
Diabetic emergencies	3.3	2.6	<0.01
Metabolic, endocrine, electrolytes	3.0	2.9	NS
Sepsis	3.0	1.2	<0.01
Other neurology and toxicology	3.0	2.9	NS
Urinary tract infections	2.9	3.2	NS
"Catastrophic conditions"§	2.6	1.2	<0.01
Rheumatology	2.5	3.5	<0.01
Hematology and oncology	2.4	2.4	NS
Acute renal failure	1.9	1.1	<0.01
Pancreatic and liver	1.7	2.0	NS
Trauma, fractures, and dislocations	1.6	1.8	NS
Bowel obstructions and diseases	1.6	2.9	<0.01
Other cardiac conditions	1.5	1.3	NS
Other renal conditions	0.6	1.0	<0.01
Inpatient length of stay, median days (IQR)	4.7 (2.7–8.6)	2.6 (1.5–4.4)	<0.01
Died during hospitalization, %	12.7	2.4	<0.01

Abbreviations: AMI, acute myocardial infarction; CHF, congestive heart failure; COPD, chronic obstructive pulmonary disease; ED, emergency department; ICU, intensive care unit; IQR, interquartile range; NS, not statistically significant; SD, standard deviation.

*P value calculated by analysis of variance (ANOVA) or chi-square tests; P value >0.05, not statistically significant.

† With respect to a patient's preexisting comorbidity burden, the unadjusted relationship of COPS and mortality is as follows: a COPS <50 is associated with a mortality risk of <1%, <100 with a mortality risk of <5%, and >145 with a mortality risk of 10% or more. See Escobar et al[14] for additional details.

‡ With respect to a patient's physiologic derangement, the unadjusted relationship of LAPS and mortality is as follows: a LAPS <7 is associated with a mortality risk of <1%, <30 with a mortality risk of <5%, and >60 with a mortality risk of 10% or more. See Escobar et al[14] for additional details.

§ Includes aortic dissection, ruptured abdominal aortic aneurysm, all forms of shock except septic shock, and intracranial hemorrhage.

rate twice as high as the 2 highest volume hospitals (39 vs 20, per 1,000 admissions).

Pneumonia/respiratory infection was the most frequent admitting condition associated with unplanned transfer (16.3%) (Table 1). There was also wide variation in crude rates for unplanned ICU transfer by admitting condition (Figure 2). Patients admitted with sepsis had the highest rate (59 per 1,000 admissions), while patients admitted with renal conditions other than acute renal failure had the lowest rates (14.3 per 1,000 admissions).

We confirmed that almost all diagnoses found to account for a disproportionately high share of unplanned ICU transfers in Table 1 were indeed independently associated with this phenomenon after adjustment for patient and hospital differences (Figure 2). Pneumonia remained the most frequent condition associated with unplanned ICU transfer (odds ratio [OR] 1.50; 95% CI 1.20–1.86). Although less frequent, sepsis had the strongest association of any condition with unplanned transfer (OR 2.51; 95% CI 1.90–3.31). However, metabolic, endocrine, and electrolyte conditions were no longer associated with unplanned transfer after adjustment, while arrhythmias and pulmonary embolism were. Other conditions confirmed to be associated with increased risk of unplanned transfer included: myocardial infarction (MI), chronic obstructive pulmonary disease (COPD), stroke, diabetic emergencies, catastrophic conditions (includes aortic catastrophes, all forms of shock except septic shock, and intracranial hemorrhage), and acute renal failure. After taking into account the frequency of admitting diagnoses, respiratory conditions (COPD, pneumonia/acute respiratory infection) comprised nearly half (47%) of all conditions associated with increased risk of unplanned ICU transfer.

Other factors confirmed to be independently associated with unplanned ICU transfer included: male sex (OR 1.20; 95% CI 1.13–1.28), high comorbidity burden as measured by COPS >145 (OR 1.13; 95% CI 1.03–1.24), increasingly abnormal physiology compared to a LAPS <7, and arrival on ward during the overnight shift (OR 1.10; 95% CI 1.01–1.21). After adjustment, we did find that admission to the TCU rather than a medical–surgical unit was associated with decreased risk of unplanned ICU transfer (OR 0.83; 95% CI 0.77–0.90). Age ≥85 was associated with decreased risk of unplanned ICU transfer relative to the youngest age group of 18–34-year-old patients (OR 0.64; 95% CI 0.53–0.77).

ED admissions to higher volume hospitals were 6% less likely to experience an unplanned transfer for each additional 1,000 annual ED hospitalizations over a lower volume hospital (OR 0.94; 95% CI 0.91–0.98). In other words, a patient admitted to a hospital with 8,000 annual ED hospitalizations had 30% decreased odds of unplanned ICU transfer compared

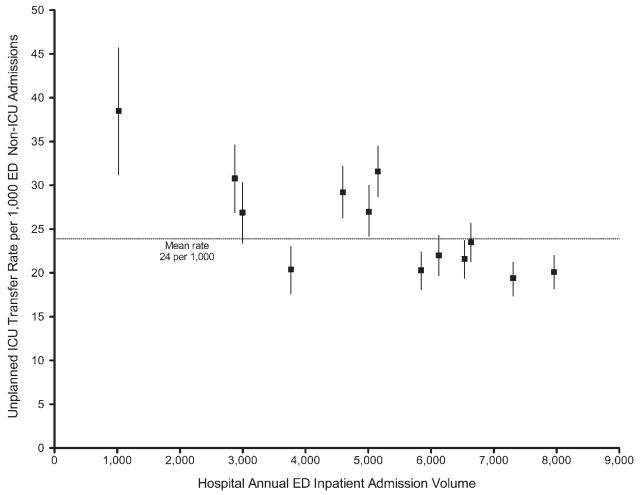

FIG. 1. Relationship between hospital volume and rate of unplanned ICU transfers within 24 hours. Abbreviations: ED, emergency department; ICU, intensive care unit. (Error bars represent 95% confidence intervals).

to a hospital with only 3,000 annual ED hospitalizations.

DISCUSSION

Patients admitted with respiratory conditions accounted for half of all admitting diagnoses associated with increased risk of unplanned transfer to the ICU within 24 hours of arrival to the ward. We found that 1 in 30 ED ward admissions for pneumonia, and 1 in 33 for COPD, were transferred to the ICU within 24 hours. These findings indicate that there is some room for improvement in early care of respiratory conditions, given the average unplanned transfer rate of 1 in 42, and previous research showing that patients with pneumonia and patients with COPD, who experience unplanned ICU transfer, have substantially worse mortality than those directly admitted to the ICU.[1]

Although less frequent than hospitalizations for respiratory conditions, patients admitted with sepsis were at the highest risk of unplanned ICU transfer (1 in 17 ED non-ICU hospitalizations). We also found that MI and stroke ward admissions had a higher risk of unplanned ICU transfer. However, we previously found that unplanned ICU transfers for sepsis, MI, and stroke did not have worse mortality than direct ICU admits for these conditions.[1] Therefore, quality improvement efforts to reduce excess mortality related to early decompensation in the hospital and unplanned ICU transfer would be most effective if targeted towards respiratory conditions such as pneumonia and COPD.

This is the only in-depth study, to our knowledge, to explore the association between a set of mutually exclusive diagnostic categories and risk of unplanned ICU transfer within 24 hours, and it is the first study to identify risk factors for unplanned ICU transfer in a multi-hospital cohort adjusted for patient- and hospital-level characteristics. We also identified a novel hospital volume–outcome relationship: Unplanned ICU transfers are up to twice as likely to occur in the smallest volume hospitals compared with highest volume hospitals. Hospital volume has long been proposed as a proxy for hospital resources; there are several studies showing a relationship between low-volume hospitals and worse outcomes for a number of conditions.[19,20] Possible mechanisms may include decreased ICU capacity, decreased on-call intensivists in the hospital after hours, and less experience with certain critical care conditions seen more frequently in high-volume hospitals.[21]

Patients at risk of unplanned ICU transfer were also more likely to have physiologic derangement identified on laboratory testing, high comorbidity burden, and arrive on the ward between 11 PM and 7 AM. Given the strong correlation between comorbidity burden and physiologic derangement and mortality,[14] it is not surprising that the COPS and LAPS were independent predictors of unplanned transfer. It is unclear, however, why arriving on the ward on the overnight shift is associated with higher risk. One possibility is that patients who arrive on the wards during 11 PM to 7 AM are also likely to have been in the ED during evening peak hours most associated with ED crowding.[22] High levels of ED crowding have been associated with delays in care, worse quality care, lapses in patient safety, and even increased in-hospital mortality.[22,23] Other possible reasons include decreased in-hospital staffing and longer delays in critical diagnostic tests and interventions.[24–28]

Admission to TCUs was associated with decreased risk of unplanned ICU transfer in the first 24 hours of hospitalization. This may be due to the continuous monitoring, decreased nursing-to-patient ratios, or the availability to provide some critical care interventions. In our study, age $\geq$85 was associated with lower likelihood of unplanned transfer. Unfortunately, we did not have access to data on advanced directives or patient preferences. Data on advanced directives would help to distinguish whether this phenomenon was related to end-of-life care goals versus other explanations.

Our study confirms some risk factors identified in previous studies. These include specific diagnoses such as pneumonia and COPD,[12,13,29] heavy comorbidity burden,[12,13,29] abnormal labs,[29] and male sex.[13] Pneumonia has consistently been shown to be a risk factor for unplanned ICU transfer. This may stem from the dynamic nature of this condition and its ability to rapidly progress, and the fact that some ICUs may not accept pneumonia patients unless they demonstrate a need for mechanical ventilation.[30] Recently, a prediction rule has been developed to determine which patients with pneumonia are likely to have an unplanned ICU transfer.[30] It is possible that with validation and application of this rule, unplanned transfer

Variable	Crude Rate per 1,000 Admissions	Adjusted Odds Ratio (95% CI)
Overall Population (Baseline Rate)	23.8	
Age		
18-34 (Reference)	18.9	-
35-54	23.6	1.13 (0.96-1.35)
55-64	26.6	1.13 (0.96-1.34)
65-74	25.7	0.99 (0.83-1.18)
75-84	24.3	0.86 (0.72-1.02)
≥ 85	20.2	0.64 (0.53-0.77)
Male vs. Female	26.6	1.20 (1.13-1.28)
Comorbidity Points Score (COPS)		
<50 (Reference)	22.0	-
50-99	20.6	0.93 (0.84-1.01)
100-145	24.2	1.03 (0.93-1.13)
>145	29.0	1.13 (1.03-1.24)
Laboratory Acute Physiology Score (LAPS)		
<7 (Reference)	15.5	-
7-29	21.3	1.42 (1.30-1.56)
30-60	32.1	2.27 (2.05-2.51)
>60	50.3	3.55 (3.06-4.13)
Admission to Transitional Care Unit (TCU) vs. Medical-Surgical Unit	23.1	0.83 (0.77-0.90)
Weekend vs. Weekday Admission	24.6	1.06 (0.99-1.13)
Nursing Shift on Arrival to Floor:		
Day: 7:00 AM-3:00 PM (Reference)	23.8	-
Evening: 3:00 PM-11:00 PM	22.6	0.96 (0.88-1.04)
Overnight: 11:00 PM-7:00 AM	25.9	1.10 (1.01-1.21)
Hospital Annual ED Inpatient Admission Volume, by increasing increments of 1,000	-	0.94 (0.91-0.98)
Admitting Diagnosis, listed by descending frequency		
Pneumonia and Respiratory Infections	32.8	1.50 (1.20-1.86)
Gastrointestinal Bleeding	22.4	1.05 (0.84-1.32)
Chest Pain	17.5	0.94 (0.74-1.19)
Miscellaneous Conditions	21.6	1.00 (0.79-1.28)
All Other Acute Infections	18.9	0.82 (0.64-1.06)
Seizures	16.5	0.90 (0.69-1.16)
AMI	28.6	1.50 (1.16-1.95)
COPD	29.6	1.43 (1.10-1.85)
CHF	22.2	1.01 (0.78-1.32)
Arrhythmias and Pulmonary Embolism	24.8	1.37 (1.05-1.79)
Stroke	23.6	1.36 (1.04-1.78)
Diabetic Emergencies	29.6	1.32 (1.01-1.73)
Metabolic, Endocrine, Electrolytes	24.1	0.95 (0.73-1.25)
Sepsis	59.0	2.51 (1.90-3.31)
Other Neurology and Toxicology	24.6	1.30 (0.99-1.70)
Urinary Tract Infections	21.5	0.96 (0.73-1.27)
Catastrophic Conditions	51.4	2.29 (1.72-3.05)
Rheumatology	17.0	0.84 (0.63-1.11)
Hematology and Oncology (Reference)	23.6	-
Acute Renal Failure	39.7	1.38 (1.02-1.88)
Pancreatic and Liver	20.1	0.83 (0.61-1.14)
Trauma, Fractures, and Dislocations	21.1	1.12 (0.81-1.55)
Bowel Obstructions and Diseases	13.1	0.60 (0.43-0.82)
Other Cardiac Conditions	29.0	1.35 (0.98-1.87)
Other Renal Conditions	14.3	0.60 (0.38-0.93)

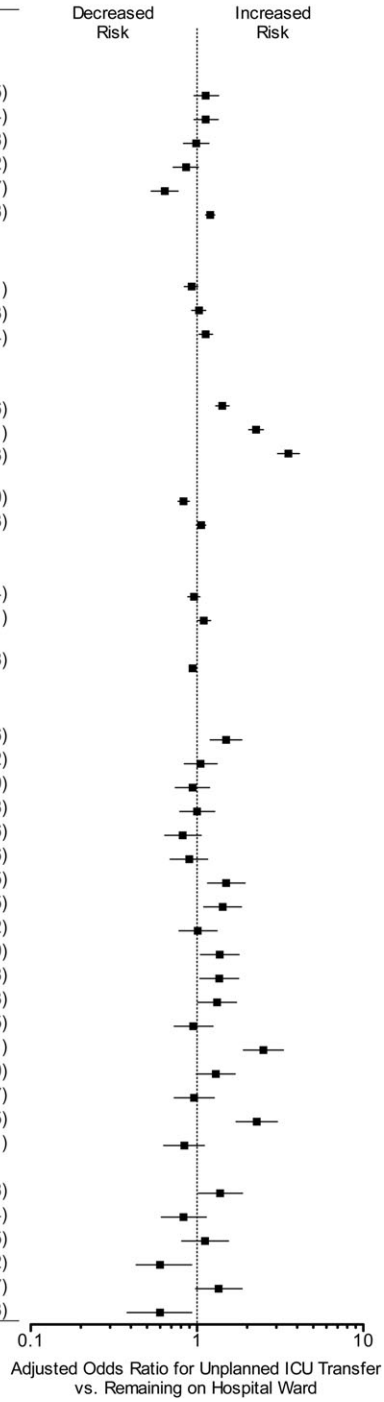

FIG. 2. Association between patient characteristics, hospital volume, and risk of unplanned ICU transfer within 24 hours in a hierarchical logistic regression model. Abbreviations: AMI, acute myocardial infarction; CHF, congestive heart failure; CI, confidence interval; COPD, chronic obstructive pulmonary disease; ED, emergency department; ICU, intensive care unit. (Error bars represent 95% confidence intervals).

rates for pneumonia could be reduced. It is unclear whether males have unmeasured factors associated with increased risk of unplanned transfer or whether a true gender disparity exists.

Our findings should be interpreted within the context of this study's limitations. First, this study was not designed to distinguish the underlying cause of the unplanned transfer such as under-recognition of illness severity in the ED, evolving clinical disease after leaving the ED, or delays in critical interventions on the ward. These are a focus of our ongoing research efforts. Second, while previous studies have demonstrated that our automated risk adjustment variables can accurately predict in-hospital mortality (0.88 area under curve in external populations),[17] additional data on vital signs and mental status could further

improve risk adjustment. However, using automated data allowed us to study risk factors for unplanned transfer in a multi-hospital cohort with a much larger population than has been previously studied. Serial data on vital signs and mental status both in the ED and during hospitalization could also be helpful in determining which unplanned transfers could be prevented with earlier recognition and intervention. Finally, all patient care occurred within an integrated healthcare delivery system. Thus, differences in case-mix, hospital resources, ICU structure, and geographic location should be considered when applying our results to other healthcare systems.

This study raises several new areas for future research. With access to richer data becoming available in electronic medical records, prediction rules should be developed to enable better triage to appropriate levels of care for ED admissions. Future research should also analyze the comparative effectiveness of intermediate monitored units versus non-monitored wards for preventing clinical deterioration by admitting diagnosis. Diagnoses that have been shown to have an increased risk of death after unplanned ICU transfer, such as pneumonia/respiratory infection and COPD,[1] should be prioritized in this research. Better understanding is needed on the diagnosis-specific differences and the differences in ED triage process and ICU structure that may explain why high-volume hospitals have significantly lower rates of early unplanned ICU transfers compared with low-volume hospitals. In particular, determining the effect of TCU and ICU capacities and census at the time of admission, and comparing patient risk characteristics across hospital-volume strata would be very useful. Finally, more work is needed to determine whether the higher rate of unplanned transfers during overnight nursing shifts is related to decreased resource availability, preceding ED crowding, or other organizational causes.

In conclusion, patients admitted with respiratory conditions, sepsis, MI, high comorbidity, and abnormal labs are at modestly increased risk of unplanned ICU transfer within 24 hours of admission from the ED. Patients admitted with respiratory conditions (pneumonia/respiratory infections and COPD) accounted for half of the admitting diagnoses that are at increased risk for unplanned ICU transfer. These patients may benefit from better inpatient triage from the ED, earlier intervention, or closer monitoring. More research is needed to determine the specific aspects of care associated with admission to intermediate care units and high-volume hospitals that reduce the risk of unplanned ICU transfer.

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