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The Impact of Timing on Clinical and Economic Outcomes During Inter-ICU Transfer of Acute Respiratory Failure Patients: Time and Tide Wait for No One

IMPORTANCE AND OBJECTIVE: Approximately one in 30 patients with acute respiratory failure (ARF) undergoes an inter-ICU transfer. Our objectives are to describe inter-ICU transfer patterns and evaluate the impact of timing of transfer on patient-centered outcomes.

DESIGN: Retrospective, quasi-experimental study.

SETTING: We used the Healthcare Cost and Utilization Project State Inpatient Databases in five states (Florida, Maryland, Mississippi, New York, and Washington) during 2015–2017.

PARTICIPANTS: We selected patients with *International Classification of Diseases*, 9th and 10th Revision codes of respiratory failure and mechanical ventilation who underwent an inter-ICU transfer ($n = 6,718$), grouping as early (≤ 2 d) and later transfers ($3+ d$). To control for potential selection bias, we propensity score matched patients (1:1) to model propensity for early transfer using a priori defined patient demographic, clinical, and hospital variables.

MAIN OUTCOMES: Inhospital mortality, hospital length of stay (HLOS), and cumulative charges related to inter-ICU transfer.

RESULTS: Six-thousand seven-hundred eighteen patients with ARF underwent inter-ICU transfer, 68% of whom ($n = 4,552$) were transferred early (≤ 2 d). Propensity score matching yielded 3,774 well-matched patients for this study. Unadjusted outcomes were all superior in the early versus later transfer cohort: inhospital mortality (24.4% vs 36.1%; $p < 0.0001$), length of stay (8 vs 22 d; $p < 0.0001$), and cumulative charges (\$118,686 vs \$308,977; $p < 0.0001$). Through doubly robust multivariable modeling with random effects at the state level, we found patients who were transferred early had a 55.8% reduction in risk of inhospital mortality than those whose transfer was later (relative risk, 0.442; 95% CI, 0.403–0.497). Additionally, the early transfer cohort had lower HLOS (20.7 fewer days [13.0 vs 33.7; $p < 0.0001$]), and lower cumulative charges (\$66,201 less [\$192,182 vs \$258,383; $p < 0.0001$]).

CONCLUSIONS AND RELEVANCE: Our study is the first to use a large, multi-state sample to evaluate the practice of inter-ICU transfers in ARF and also define early and later transfers. Our findings of favorable outcomes with early transfer are vital in designing future prospective studies evaluating evidence-based transfer procedures and policies.

KEY WORDS: early; inter-intensive care unit transfer; later; outcomes; respiratory failure; timing

Acute respiratory failure (ARF) is a major health problem in the United States leading to 2.5 million ICU admissions annually (1, 2) resulting in over 30% mortality (3, 4) with an estimated cost of 27 billion dollars (5, 6). Patients with ARF have improved outcomes when treated at centers with

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greater expertise and higher case volumes (7–9) and thus may benefit from an inter-ICU transfer (i.e., referring hospital 1 to regional hub hospital 2). Current, albeit limited, data estimates that one in 30 patients with respiratory failure will undergo an inter-ICU transfer typically to receive a higher level of care (10, 11). More broadly, there is a robust and growing body of literature demonstrating that earlier access to advanced therapeutics and evidence-based care improves outcomes in critical illness (12–15). Indeed, patients transferred from a community emergency department to a tertiary care ICU have improved outcomes (16, 17) likely because smaller, low-volume hospitals have fewer critical care resources, less aggregated experience, and thus, may be less likely to provide evidence-based early management (7, 18). On the contrary, single-center studies of inter-ICU transfer have found that transferred ICU patients experience worse outcomes compared with severity-matched patients directly admitted to the tertiary care center (19, 20). This may be because inter-ICU transfers tend to occur later (21) in the course of illness; thus, mitigating the potential benefits of centers with greater expertise (10, 11, 22).

ARF patients are heterogeneous, and only some of those patients might benefit from inter-ICU transfer. However, there is currently limited data on who, why, and when ARF patients undergo an inter-ICU transfer. Thus, our objectives were to measure frequency of transfer, characterize the timing of transfer, and examine the association between transfer and clinically relevant outcomes. In this study, we hypothesize that timing of transfer is a key factor and that patients with ARF who are transferred early in their hospital course will have reduced inhospital mortality, length of stay (LOS), and hospital charges compared with matched patients with later transfer.

METHODS

Study Design and Data Source

We conducted a retrospective cohort study utilizing the Agency for Healthcare Research and Quality's Healthcare Cost and Utilization Project State Inpatient Databases (HCUP-SID) (23) from five U.S. states—Florida, Maryland, Mississippi, New York, and Washington—during the years 2015–2017. We selected these states because they were geographically diverse, and these states' data allowed for longitudinal tracking of

individual patients across acute care hospitals. Our local Institutional Review Board at the Medical University of South Carolina (Pro00094124) reviewed the study and waived the need for approval based on research criteria set forth by the code of federal regulations.

Cohort Identification

All adult patients 18+ years old with an *International Classification of Diseases*, 9th and 10th Revision, Clinical Modification (ICD-9 and -10) diagnosis code corresponding to ARF (ICD-9-CM 518.81-.85, ICD-10-CM J96.00-.02), and procedure codes corresponding to mechanical ventilation (ICD-9-procedure code [PCS] 96.70-.72, ICD-10-PCS 5A1935Z, 5A1945Z, 5A1955Z) were identified. We excluded patients whose median LOS at hospital 1 was greater than 25 days as this is indicative of long-term acute care facilities (24, 25), as demonstrated in our prior study (10). In addition, we excluded patients in psychiatric hospitals to obtain our ARF cohort.

Finally, the ARF cohort was then partitioned into a transfer and a nontransfer cohort. The transfer cohort (from hospital 1 to hospital 2) was identified using two methods: first, all ARF patients with a discharge destination code of inter-facility transfer to a second acute care hospital were initially included. Second, all ARF patients discharged and then subsequently admitted to a different acute care hospital within the same calendar day were included. This strategy was used to compensate for coding errors in discharge destination. Of note, we did not use ICU revenue codes but presumed that these were all ICU transfers to a second acute care hospital as typically patients on a ventilator are cared for in an ICU setting.

In accordance with our a priori-defined statistical analysis plan, we evaluated our inter-ICU transfer cohort to understand the distribution of transfer timing in days after admission to hospital 1 to inform the definition of early versus later ICU transfer. Doing so, we discovered approximately 70% of inter-ICU transfers occurred within the first 2 calendar days of admission. Based on these preliminary analyses, we defined early transfers less than or equal to 2 days and later transfers as 3+ days (**eFig. 1**, <http://links.lww.com/CCX/A915>).

Variable Selection and Construction

Demographics. Patients were grouped by age as follows: less than 65, 65–79, and 80+ years. Race was categorized as White, Black (non-Hispanic), Hispanic,

and other/missing. Patient payer was classified as commercial, Medicare, Medicaid, and other.

Construction of Clinical Factors. Based on our prior work, we selected clinical variables that influence inter-hospital transfer (eFig. 2, <http://links.lww.com/CCX/A916>) (10). Specifically, we constructed an indicator variable for invasive mechanical ventilation (IMV) at admission to hospital 1 denoted as (early IMV < 2 d). We also constructed a variable for prolonged IMV (> 30 d). Indicators for shock (ICD-9-CM 785.5x, ICD-10-CM R57.x), dialysis (ICD-9-CM V56.x, ICD-9-PCS 39.95, ICD-10-CM Z49.x), tracheostomy (ICD-9-CM V44.0, ICD-10-CM Z93.0, clinical classification software-procedure code 34), and major surgery were also constructed using the diagnosis-related grouper (26). Finally, we constructed a categorical (0, 1–2, 3+) update to Charlson Comorbidity Index due to the right-tailed distribution of this measure (27).

Construction of Hospital Factors. Similarly, for hospital factors, we used our prior work, following the methods by Nadig et al (10). Hospitals were categorized as for-profit or not-for-profit and small (< 100 beds), medium (100–300 beds), and large (> 300 beds). The case volume of ARF (in increments of 100) was identified using ICD codes for mechanical ventilation (ICD-9-PCS 96.70-.72, ICD-10-PCS 5A1935Z, 5A1945Z, 5A1955Z). The emergency department volume was also calculated using inpatient records that indicated utilization of emergency department services. Indicators for solid organ transplant care and extracorporeal membrane oxygenation (ECMO) care (ICD-9-PCS 39.65, ICD-10-PCS 5A1522x, current procedural terminology 33946/33947) were also constructed as measures of advanced critical care resources (eFig. 2, <http://links.lww.com/CCX/A916>).

Propensity Score Matching

We elected to propensity score (PS) match due to the inherent differences that may exist in patients who are transferred earlier versus later. PS matching allowed us to pseudorandomize patients who, by all observed measures, could have been transferred earlier or later—allowing us to select the most similar patients in each group to obtain unbiased estimates of the effect of early versus later transfer. PS matching using the nearest-neighbor method with a ratio of 1:1 and a caliper distance of 0.1 was employed to match the early versus later transferred patients in order to minimize the potential impact of selection bias in this observational study design (28).

Inclusion of all of the above-mentioned demographic, clinical, and hospital factors in the greedy-match algorithm yielded an overall bias reduction of 99.54%.

Outcomes

The primary outcome was inhospital mortality at hospital 2 and was defined as the discharge destination: “deceased.” The secondary outcomes were total hospital LOS and total cost, which were estimated by including data from both hospitals 1 and 2 and using the HCUP hospital-level charge data and publicly available hospital-specific cost-to-charge ratios. These charges were inflation-adjusted to 2019 dollars using the consumer price index for all urban consumers, medical care in U.S. City average (29).

Statistical and Analytic Approach

Descriptive statistics of the transferred, nontransferred, early, and later cohorts were calculated. We conducted a power analysis based on mortality and cumulative LOS estimates in transferred ARF patients in two prior unmatched studies (30, 31), estimating a sample of 1,774 patients in each group would have 80% power to find a difference in mortality rate of 3 percentage points. Similarly, based on existing estimates of LOS variation (sd, 17–25 d) (19, 20), a sample size of 1,134 in each group would have 80% power to find at least a 2-day difference in LOS. With no prior studies estimating charges, we had no basis on which to estimate power, thus this secondary outcome was considered exploratory.

Covariate inclusion was iteratively revised using stepwise backward purposeful selection based (32) on model performance to arrive at parsimonious final models—entering all clinical, demographic, and hospital factors. Predictors with significance levels less than 0.25 were closely examined prior to their removal using guidelines of removal based on the following statistical criteria: 1) no more than 20% change in other parameter estimates after removal; 2) smaller Akaike information criterion, indicating a better model fit without the covariate; and 3) likelihood-ratio test. For all models, generalized linear mixed models using PROC GLIMMIX in SAS/STAT 14.3 (SAS Institute, Cary, NC) was used, with random effects at the state level with empirical sandwich estimates for the fixed-effect standard errors (33). For the primary outcome of inhospital mortality, a binary-distributed model

with a log link was used. For the secondary outcome of LOS, two model types were tested: Poisson and negative binomial models with a log link, with final model selection based on which model had a deviance closest to unity (1.0); ultimately, the negative binomial model was chosen. For the tertiary outcome of total charges, a gamma-distributed log-linked model was used (34). We used SAS Version 9.4 (Cary, NC) for all analyses, considering a two-sided alpha of 0.05 as the threshold for statistical significance.

RESULTS

We examined a total of 245,626 acute care hospital records (Florida, Maryland, Mississippi, New York, and Washington) with ARF, of which 9,576 (3.9%) had undergone a transfer. Specifically, the crude transfer rates ranged from 2.8% in New York, 3.5% in Washington to 4.5% in Florida, 4.6% in Mississippi, and 4.7% in Maryland (**eTable 1**, <http://links.lww.com/CCX/A917>). We excluded 2,858 patients due to incomplete data creating a total inter-ICU transfer cohort of 6,718 patients cumulatively across the five states (**Fig. 1**). (**eTable 2**, <http://links.lww.com/CCX/A918>) represents the demographic, clinical, and hospital level variables of transferred patients in each of the five states. Of note, the transferred patients in the state of Maryland were younger and more often had commercial insurance. Other notable differences included lower rates of transfer of tracheostomy patients in Mississippi and Washington. Among hospital level variables, the annual ARF volume was lower in hospitals in Mississippi and Washington.

We then conducted a successful 1:1 propensity matching of the early ($n = 1,887$) and later transfer ($n = 1,887$) cohorts as represented in **Table 1**. (**eTable 3**, <http://links.lww.com/CCX/A919>) showcases the two cohorts prior to propensity matching). Unadjusted outcomes were all lower in the matched early versus later transfer cohort: inhospital mortality (24.4% vs 36.1%; $p < 0.0001$), LOS (8 vs 22 d; $p < 0.0001$), and cumulative charges (118,686 vs 308,977; $p < 0.0001$) (**eTable 3**, <http://links.lww.com/CCX/A919>). In the final adjusted model, the relative risk of inhospital mortality for the early transfer cohort in comparison to the later transfer cohort was (odds ratio, 0.44; 95% CI, 0.40–0.49) (**Table 2**). This represents a 20.5% absolute risk reduction of inhospital mortality (16.2% vs 36.7% cumulative prevalence of inhospital mortality

for early vs later transfers, respectively). Additionally, patients who were transferred early had an inpatient stay that was 20.7 days shorter than those who were not (13.0 vs 33.7 d; $p < 0.0001$), after adjusting for early ventilation, major surgery, shock, Charlson score, age, payer, and whether the patient suffered an inhospital mortality (**Table 3**). Similarly, for cost, adjusting for early ventilation, major surgery, a low LOS (< median), shock, tracheostomy, age, sex, and inhospital mortality, early transfers had \$66,201 adjusted lower charges (\$192,182 vs \$258,383; $p < 0.0001$) in comparison to the later transfer cohort (Table 3).

To test if our results were robust to a specification change in early versus later ICU transfer, we redefined early transfer to be 0 or 1 day; later transfer was defined as 2+ days. We then re-PS matched using our prior methods—yielding 4,382 well-matched individuals (2,191 in each group). We then reanalyzed the primary outcome of inhospital mortality, which yielded a very similar risk ratio: 0.4251 (95% CI, 0.34–0.53). This demonstrates our findings are robust against changes in the definition in early versus later ICU transfer.

DISCUSSION

Our study is the first to use a large, multistate sample to evaluate the practice of inter-ICU transfers in ARF patients using novel techniques and detailed protocols. This definition of early and later transfers is also distinct from past work, which has more commonly analyzed all inter-ICU transfers together. The main finding of our study is that ARF patients that undergo early transfer within 2 days have an associated 20.5% absolute risk reduction of inhospital mortality than those whose transfer was greater than or equal to 3 days. Additionally, we found that early transfers were associated with shorter hospitalization and lower cumulative cost even after adjustment for inhospital mortality.

Our prior work evaluating frequency of transfer of ARF patients in Florida showcased a modest transfer rate of 2.9% (10). As a follow-up, in this study, we did observe some variation in transfer frequencies at the state level with the highest rate of transfer observed in Maryland (4.7%). This study also showcased differences in transfer frequency based on certain demographic, clinical, and hospital level characteristics. Some, expected observations, on account of population diversity included, lower median age of transferred patients

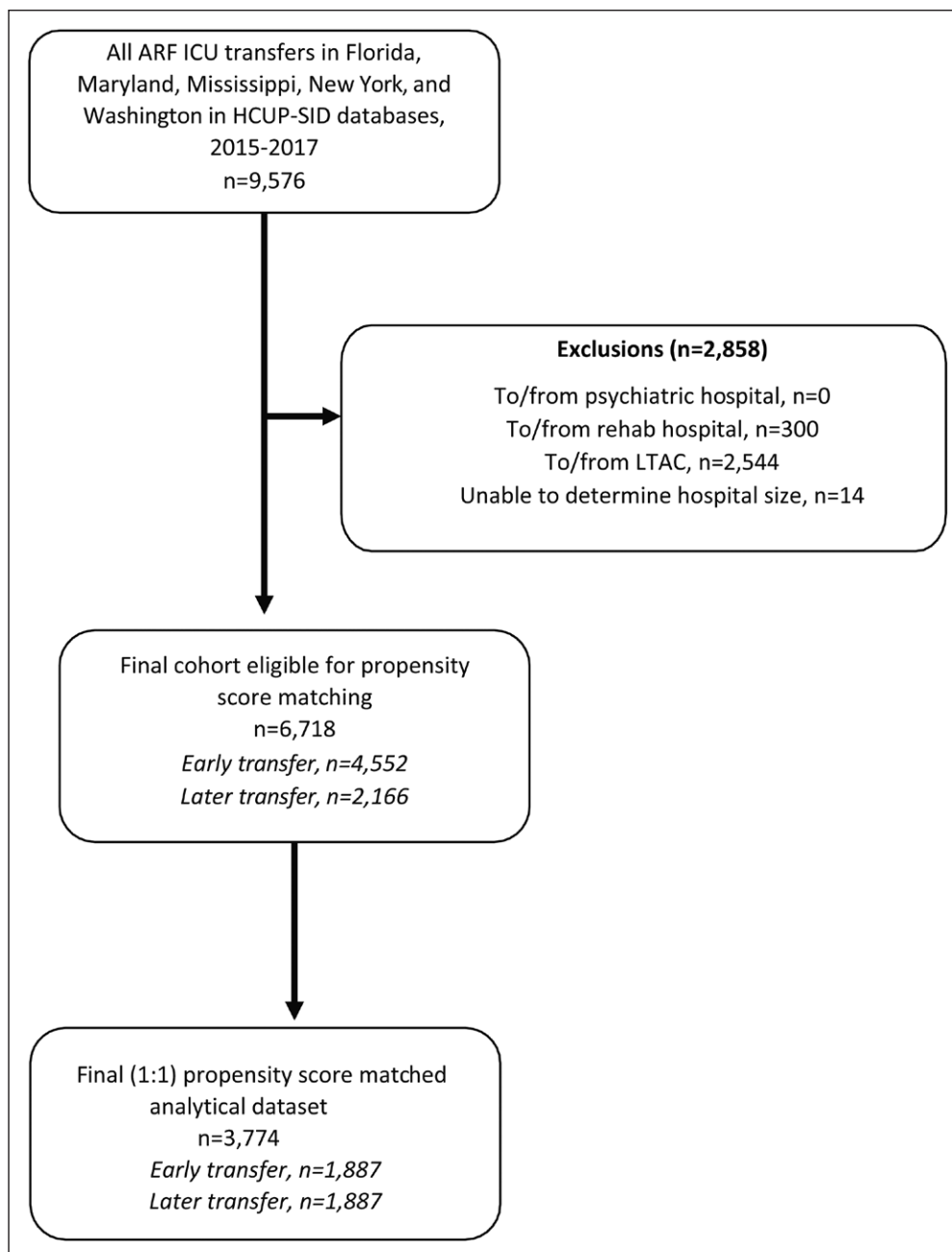


Figure 1. Consort diagram of transferred patients with acute respiratory failure (ARF) culminating in the final propensity matched cohort used for analysis. HCUP-SID = Healthcare Cost and Utilization Project State Inpatient Databases, LTAC = long-term acute care.

in Maryland and Washington in comparison to Florida (35). Similar anticipated patterns were seen with respect to higher percentage of commercially insured patients in Maryland and Washington (35). However, one interesting observation was “twice” the annual volume of ARF patients in Florida in comparison to Washington hospitals. Patients develop ARF due to several reasons but can often be linked to older age (36). Thus, we speculate that the higher percentage (48%) of

older population (over the age of 65) in Florida may be responsible for this observation of higher ARF volumes in its hospitals. Additionally, states such as Washington that have more palliative care options and proactive end-of-life initiatives may serve as another potential explanation of this noted variation (37).

Although not evaluated in this study, a practical explanation for variation in transfer practices are the heterogeneous nature of physician attitudes and practice patterns. A national survey conducted by Kahn et al (21) evaluating over 500 critical care physicians found that academic physicians practicing in large tertiary centers readily embraced critical care transfers in comparison to community physicians. Another study evaluating critical care transfer networks among Medicare beneficiaries (11) found that current transfer networks are not uniformly hierarchical, however, networks appear to systematically move patients toward larger and presumably better-resourced hospitals. Our study found that majority of

the transferred patients were initially in smaller hospitals; however, the study was not designed to evaluate the intricacies of the transfer network.

These above-mentioned structural and physician practice patterns, may not only affect transfer rates, but also affect the timing of transfer, of critically ill patients. Prior literature evaluating transfer delays from the “emergency department to the ICU” (14, 38, 39) as well as from “inpatient floor to the ICU” (16, 17) have consistently shown

TABLE 1.
Demographics, Clinical, and Hospital Characteristics of the Final Propensity Score Matched Groups

Characteristic	<i>n</i>	Later ICU Transfer	Early ICU Transfer	<i>p</i>
	Total	(3+ d)	(≤ 2 d)	
	3,774	1,887	1,887	
Demographics				
Male	2,174 (57.6)	1,080 (57.2)	1,094 (58.0)	0.64
Age	63.0 (52.0–73.0)	63.0 (52.0–73.0)	63.0 (51.0–73.0)	0.49
Charlson score	2.0 (1.0–4.0)	2.0 (1.0–4.0)	2.0 (0.0–4.0)	0.12
Payer				0.93
Commercial	764 (20.2)	375 (19.9)	389 (20.6)	
Medicaid	651 (17.2)	324 (17.2)	327 (17.3)	
Medicare	2,115 (56.0)	1,066 (56.5)	1,049 (55.6)	
Other	244 (6.5)	122 (6.5)	122 (6.5)	
Race				0.70
Black	694 (18.4)	351 (18.6)	343 (18.2)	
Hispanic	379 (10.0)	192 (10.2)	187 (9.9)	
Other	289 (7.7)	135 (7.2)	154 (8.2)	
White	2,412 (63.9)	1,209 (64.1)	1,203 (63.8)	
Clinical factors				
Early ventilator initiation at hospital 1 (< 2 d)	2,927 (77.6)	1,461 (77.4)	1,466 (77.7)	0.84
Shock	800 (21.2)	390 (20.7)	410 (21.7)	0.42
Dialysis	105 (2.8)	53 (2.8)	52 (2.8)	0.92
Tracheostomy	73 (1.9)	30 (1.6)	43 (2.3)	0.12
Major surgery	314 (8.3)	148 (7.8)	166 (8.8)	0.28
Hospital factors				
Hospital size ^a				0.74
Small (FP)	49 (1.3)	24 (1.3)	25 (1.3)	
Small (NFP)	295 (7.8)	146 (7.7)	149 (7.9)	
Medium (FP)	409 (10.8)	217 (11.5)	192 (10.2)	
Medium (NFP)	1,251 (33.1)	615 (32.6)	636 (33.7)	
Large	1,770 (46.9)	885 (46.9)	885 (46.9)	
Annual emergency department volume	22,300 (12,100–33,800)	22,200 (12,400–33,800)	22,500 (11,800–24,200)	0.73
Annual acute respiratory failure volume	400 (200.0–700.0)	400 (200.0–700.0)	400 (200.0–700.0)	0.25
Solid organ transplantation	279 (7.4)	137 (7.3)	142 (7.5)	0.75
Extracorporeal membrane oxygenation	829 (22.0)	415 (22.0)	414 (21.9)	0.96

FP = for profit, NFP = non-for profit.

^aClassified as small (< 100 beds), medium (100–300 beds), and large (> 300 beds); profit status—for profit or not-for-profit).

All values expressed as *n* (%) or median (Q1–Q3).

All tests are χ^2 test for categorical variables, and Wilcoxon-Mann-Whitney *U* test for continuous variables (due to all being nonparametric distributions).

TABLE 2.
Comparison of Cumulative Incidence and Relative Risk of Inhospital Mortality

Outcomes	Cumulative Incidence (95% CI)		Relative Risk	p
	Early ICU Transfer	Later ICU Transfer		
Inhospital mortality ^a	16.2 (10.3–24.6)	36.7 (25.6–49.5)	0.442 (0.403–0.497)	< 0.0001

^aFinal generalized linear mixed model adjusted for hospital one's extracorporeal membrane oxygenation and transplant volume, dialysis, early ventilation, shock, tracheostomy, Charlson score, age, and low length of stay, with random effects at the state level.

worsened clinical outcomes for patients. The dogma of the “golden hour” well known to trauma (40) indicates that physiologic derangements should be corrected early to reduce mortality and morbidity. This “golden hour/hours” in concept applies to critical care diagnoses such as ischemic strokes (tissue plasminogen activator administration) (41), myocardial infarctions (percutaneous coronary interventions) (42), sepsis (timely antibiotics) (43), and more recently ARF (lung protective ventilation) (44). Similarly, one could speculate there exists a “golden hour” for inter-ICU transfer of ARF patients.

In a real-world scenario, small/less-resourced hospitals often admit ARF patients and those patients will likely progress over three paths in 48 hours: 1) improve, 2) do not improve, or 3) get worse. Our study was unfortunately not designed to decipher the characteristics of patients in each path; however, in clinical practice, patients in paths 2 and 3 are presumably different from patients in path 1 and may be the ones typically transferred. However, the more complex question is whether the timing of transfer alters outcomes for these patients in paths 2 and 3. Prior literature (7) has shown that patients with ARF have improved outcomes in high-volume/high-resource hospitals; however, it does not clarify if the patients have to be initially admitted to a high volume hospital or if they can be transferred from

another hospital early in the course of their illness. A matched study of H1N1 patients with acute respiratory distress syndrome in the United Kingdom (45) revealed that patients had improved outcomes when referred to ECMO treatment centers even if they did not end up requiring ECMO, which brings up the question of not only timing of transfer but also early implementation of evidence-based best practices which are more likely to occur in high-volume/high-resource hospitals (46).

Unfortunately, there are no evidence-based guidelines for inter-ICU transfer of ARF patients. Guidelines framed in 2004 from the American College of Critical Care Medicine (47) predominantly focuses on patient safety during transfer with no guidance on the cross-sectoral nature of the inter-ICU transfer process that typically has multiple stakeholders including patients, families, physicians, and health systems.

Our study found that early transfers affect patient-centered outcomes (mortality) as well as health system outcomes (LOS and cost). While the retrospective nature of our study cannot be taken as causal, the fact that all outcomes demonstrated a robust favorable association with early transfer is quite compelling. Unfortunately, a randomized study about early and later transfer of ARF patients is challenging; however, a multicenter study prospectively evaluating early and later transfers could

TABLE 3.
Comparison of Adjusted Secondary Outcomes Between the Early and Later Transfer Cohorts

Outcomes	Early ICU Transfer (n = 1,887)	Later ICU Transfer (n = 1,887)	p
Cumulative length of stay ^a	13.0 (9.2–18.3)	33.7 (24.1–47.0)	< 0.0001
Cumulative charges ^b	\$192,182 (76,313–483,932)	\$258,383 (101,783–655,858)	< 0.0001

^aThe length of stay final generalized linear mixed model adjusted for hospital one's extracorporeal membrane oxygenation (ECMO) and transplant volume, hospital one's size, dialysis, early ventilation, major surgery, shock, tracheostomy, Charlson score, age, sex, race, and inhospital mortality, with random effects at the state level.

^bThe charges final generalized linear mixed model adjusted for hospital one's ECMO, transplant, emergency department, and acute respiratory failure volume, hospital one's size, dialysis, early ventilation, major surgery, shock, tracheostomy, Charlson score, age, sex, race, and inhospital mortality, with random effects at the state level.

be a next step as we try to understand the structural and process measures that affect these outcomes.

The present work has several limitations. Our study includes only five states, with omission of midwestern and southwestern states. The constraints of HCUP data include variability in coding practices; limitations in diagnosis codes to differentiate comorbidity versus complications, inability of billing codes to verify objective patient information such as the cause of respiratory failure, associated treatments, or estimate precise cost benefit. Additionally, there is no information on clinically derived illness severity scores, stakeholder reports of the reason(s) for transfer, cost of actual transfer process, ICU capacity strain, staffing models, or regionalized hub and spoke models of care. However, the strengths of utilizing administrative data include large samples, availability at low cost, and representativeness of the population to improve generalizability. Our study evaluates transfer patterns between the years of 2015–2017, and hence is not relevant to the care of COVID-19 patients with limitations in ICU beds and ventilatory support. While we have demonstrated that early transfers may have better outcomes, further work remains to estimate the inherent variation in implementation of best practices in ARF care in transferring hospitals. Due to the retrospective nature of the data, one could speculate that the later transfer cohort could be inherently different from the early transfer cohort. However, many of these weaknesses are counteracted by using PS matching methods to accomplish pseudorandomization—creating two cohorts that are similar on all measured clinical, hospital, and demographic factors. In conclusion, this study provides only observational results but sheds light on future planning of pragmatic/prospective studies evaluating early and later transfers.

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