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Non-clinical delays in transfer out of the surgical ICU are associated with increased hospital length of stay and delayed progress of care

Kyan Cyrus Safavi [a,*], Jazmin Furtado [b], Ana Cecilia Zenteno Langle [c], David Scheinker [d], Ulrich Schmidt [e], Bethany Daily [c], Retsef Levi [b], Peter Francis Dunn [c]

[a] Massachusetts General Hospital, Department of Anesthesia, Critical Care and Pain Medicine, 55 Fruit Street, Boston, MA 02114, USA
[b] Massachusetts Institute of Technology, MIT Sloan School of Management, 30 Memorial Dr, Cambridge, MA 02142, USA
[c] Massachusetts General Hospital, Department of Perioperative Services, 55 Fruit Street, Boston, MA 02114, USA
[d] Lucile Packard Children's Hospital Stanford, 725 Welch Rd, Palo Alto, CA 94304, USA
[e] University of California San Diego, Department of Anesthesiology, 200 West Arbor Drive, San Diego, CA 92103, USA

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ABSTRACT

Purpose: The impact of non-clinical transfer delay (TD) from the ICU to a general care unit on the progress of the patient's care is unknown. We measured the association between TD and: (1) the patient's subsequent hospital length of stay (LOS); (2) the timing of care decisions that would advance patient care.
Methods: This was a single center retrospective study in the United States of patients admitted to the surgical and neurosurgical ICUs during 2013 and 2015. The primary outcome was hospital LOS after transfer request. The secondary outcome was the timing of provider orders representing care decisions (milestones) that would advance the patient's care. Patient, surgery, and bed covariates were accounted for in a multivariate regression and propensity matching analysis.
Results: Out of the cohort of 4,926 patients, 1,717 met inclusion criteria. 670 (39%) experienced ≥12 hours of TD. For each day of TD, there was an average increase of 0.70 days in LOS ($P < 0.001$). The last milestone occurred on average 0.35 days later ($P < 0.001$). Propensity matching analyses were confirmatory ($P < 0.001$, $P < 0.001$).
Conclusions: TD is associated with longer LOS and delays in milestone clinical decisions that progress care. Eliminating delays in milestones could mitigate TD's impact on LOS.

1. Introduction

Delays in transferring a patient from the ICU to a general care unit are common bottlenecks in hospitals. Previous studies have documented that 17 to 27% of patients spend significant amounts of time in the ICU awaiting a general care unit bed due to transfer delays (TD) unrelated to clinical needs [1-3]. Typically, >80% of delays can be attributed to a lack of general care unit bed availability [2]. The cost of TD is substantial considering that a day in the ICU is approximately three to five times the cost of a day in the general care unit [4-8]. While these patients continue to occupy ICU beds as they await transfer, patients who are in need of ICU beds cannot get into them in a timely fashion. Numerous studies have shown the negative clinical consequences of TD on the patient who is waiting for an ICU bed [9-12].

Conversely, little is known about how TD impacts the overall care of the patient in the ICU who experiences TD. Although it may be expected that a patient's care would progress regardless of their location, TD may alter the progress of the patient's care both in the ICU and the general care unit. In the ICU, the care team has to realign its efforts toward advancing the patient's floor-based care rather than providing critical care. In addition, the ongoing presence of the patient in the ICU may limit awareness that the patient needs their non-ICU care to progress in order to advance them further toward hospital discharge.

We aimed to characterize the relationship between the amount of TD from the ICU to a general care unit and the patient's progress of care. We measured the progress of care in terms of: [1] the patient's LOS subsequent to the transfer request and [2] the timing of milestone provider care decisions that would progress the care of the patient along their clinical pathway toward discharge. We hypothesized that TD was associated with prolonged subsequent LOS and a delay in milestone provider care decisions that would advance the patient along their care pathway.

* Corresponding author.
E-mail address: ksafavi@partners.org (K.C. Safavi).

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2. Materials and methods

2.1. Data source

This single center, retrospective cohort study was based on data from the institution's bed management database, which contained a time-stamped log of patient bed requests, transfers, and discharges. Patient characteristics and clinical information were obtained from the institution's administrative and electronic medical record databases. A time-stamped log of all patient care orders entered electronically by a provider came from the institution's Provider Order Entry database.

Patient comorbid disease was assessed using 30 different Agency for Healthcare Research and Quality comorbidity measures and categories developed by Elixhauser et al. [13] We used the Elixhauser van Walraven Comorbidity Index (EVCI) scoring method to determine a single score for the comorbidity burden of each patient [14].

2.2. Study cohort

The study was performed at a 1034-bed quaternary care teaching hospital. We included all patients directly admitted to the surgical and neurosurgical ICUs from the operating room. The surgical ICU receives non-cardiac surgical patients and the neurosurgical ICU receives neurosurgical patients. We included patients 18 years or older who were admitted between January 1, 2013 and December 31, 2013 or between January 1, 2015 and December 31, 2015. We excluded patients whose hospital stays occurred in 2014 because the institution transitioned to a different bed management system and data could not be validated.

Patients were excluded if they: had multiple surgeries; had cardiac surgery; were readmitted to the ICU; died during their hospitalization; were discharged directly from ICU to home or facility; had no milestone order entered after the transfer request was placed; had a post-ICU length of stay >14 days. Patients with LOS >14 days were excluded because their post-operative recovery pathways were complex and not representative of patients in the study cohort.

2.3. Transfer process and delay

The general surgical and neurosurgical ICUs follow a semi-closed model in which the ICU team is primarily responsible for the care of the patient and the surgical team continues to provide management recommendations. Transfer requests are made when both the ICU and surgical teams deem that the patient is clinically appropriate for transfer. All downstream patient care beds are in general care units and there are no Step-Down beds. Appropriateness for transfer is based on institutional guidelines that include hemodynamic and respiratory stability. These determinations can be made at any time of day. Institutional policy dictates that teams are not permitted to make transfer requests before a patient has been deemed clinically appropriate for transfer. Transfer requests are cancelled if either of the teams decides that the patient is no longer clinically appropriate for transfer. We did not include transfer requests that were cancelled in the analysis as these patients had clinical reasons for requiring additional time in the ICU.

Prioritization of transfer primarily depends on when the request was placed. Several patient characteristics are taken into consideration when deciding whether a patient can be transferred to a given general care unit bed: [1] the surgical service responsible for the patient, [2] the patient's gender, [3] the patient's infection isolation status, and [4] the destination general care unit to which the request was made. These variables were accounted for in our analysis. TD was defined as the length of time from when the final transfer request was placed to when the patient arrived in the general care unit. When a patient waits in the ICU to be transferred, there is no change to the care team structure of the patient. The ICU team remains responsible for the patient's care and the surgical team continues to follow the patient and provide recommendations.

2.4. Primary outcome: subsequent hospital length of stay

The primary outcome for each patient was the hospital length of stay subsequent to the transfer request. We defined this as the length of time from when the final transfer request was made to when the patient was

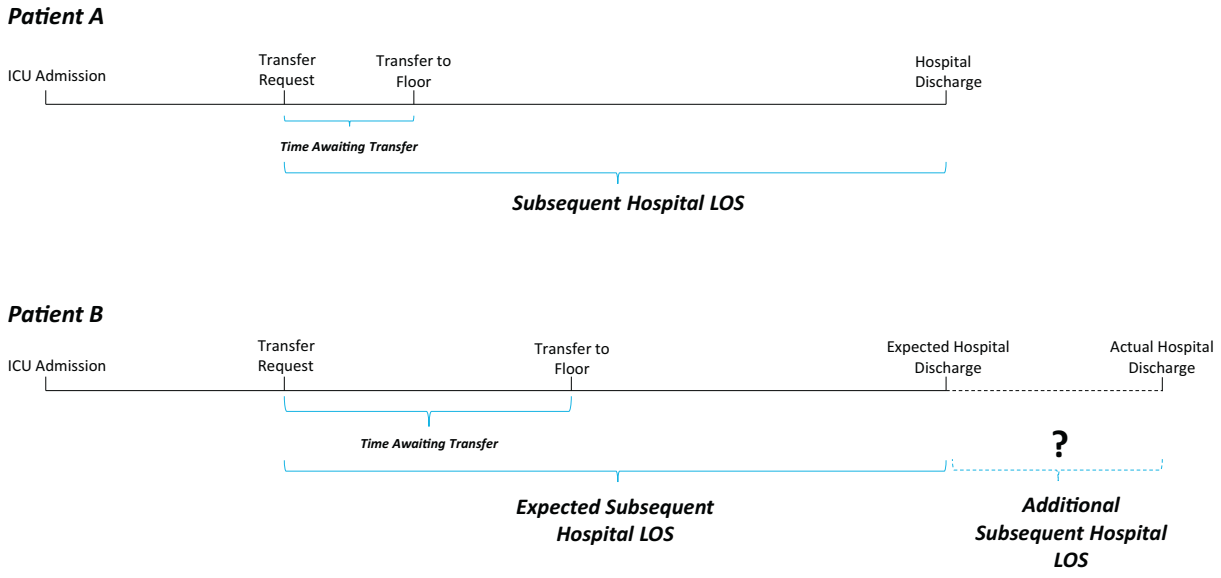

Fig. 1. ICU to General Care Unit Transfer Process. This is an illustration comparing the transfer process between two otherwise identical patients who have different amounts of time awaiting transfer. Both patients are deemed clinically appropriate for transfer at the same time, yet patient B experiences a longer period of time awaiting transfer. In both cases, the primary outcome variable being measured is the subsequent hospital LOS from transfer request to hospital discharge. For patient B, it is possible that the progress of his or her clinical care is delayed leading to additional subsequent hospital LOS beyond that which would be clinically expected.

Table 1
Provider-entered orders that represent milestones in patient progress along their clinical pathway.

General milestones
Begin oral diet
Consult physical therapy
Discontinue IV narcotics
Mobilize patient out of bed
Remove Foley catheter
Discontinue epidural medications
Consult speech and swallow pathology
Remove nasogastric tube
Remove chest tube
Milestones specific to type of surgery
Perform barium swallow study
Perform brain MRI
Perform hepatic ultrasound

IV, intravenous; MRI, magnetic resonance imaging.

discharged out of the hospital from the general care unit. We measured the length of stay from the transfer request because it represented a standardized time point indicating that both surgical and ICU teams felt that a patient was clinically appropriate for the general care unit (Fig. 1).

2.5. Secondary outcome: timing of milestone provider care decisions

The secondary outcome for each patient was the length of time from the transfer request to the time at which the final milestone care decision was made. We used patient care orders as a proxy for milestone care decisions that would advance the patient along his or her clinical pathway. Because of variability in the number and timing of milestones among different types surgeries, the last milestone care decision was chosen to normalize patient care orders to a standardized point in time.

We measured the timing of provider orders that represented milestone care decisions generalizable to multiple types of surgery (general milestones). In addition, for three common types of surgeries in our dataset (craniotomy for tumor, esophagectomy, and liver transplant), we also measured the timing of orders that represented milestone care decisions specific to the surgery (Table 1).

2.6. Statistical analyses

Patients who had <12 h of TD were compared to those who had ≥12 h of TD with regard to demographics, illness severity, and surgery characteristics. A threshold of 12 h was determined a priori by the medical and administrative members of the project team as a conservative upper limit of patient waiting time needed to prepare and execute the transfer of a patient to the general care unit bed. All continuous variables were compared using *t*-tests. Categorical variables were compared using either Pearson $\chi 2$ analysis or Fisher exact tests as appropriate. For all analyses, we considered a $P < 0.05$ to be significant.

We performed multivariable regression analyses to test the relationship between TD and the primary and secondary outcomes. TD was a continuous variable measured in terms of days. We chose to use a continuous variable for TD in the regression model so that we could estimate the incremental effect of increasing amounts of TD on the primary and secondary outcomes. Each regression model was adjusted for patient, surgery, and bed-related factors (Table 2). To address the skewed error distribution from ordinary least squares (OLS) regression on both response variables, we used a linear regression model that assumed a t-skew distribution of errors in the response variable.

To confirm the findings of the multivariate regression and account for weaknesses of this method, we performed a propensity matching analysis. We used matching to approximate a retrospective randomized control experiment. The rationale and methods for using propensity matching for a proposed causal exposure variable have been previously reviewed [15]. We matched patients in the treatment group (in our case patients with TD) to patients in the control group (patient with no TD) who a priori have the same likelihood to receive treatment. This likelihood is represented by propensity scores that are a function of the covariates. Covariates selected to create the propensity score included all those present in the multivariable regression, including all known variables in our institution that are taken into consideration when deciding whether a patient can be transferred to a given general care unit bed. These included: [1] the surgical service, [2] the patient's gender, [3] the patient's infection isolation status, and [4] the destination general care unit.

Since patients experienced different amounts of TD, we performed dosage matching in which we divided patients into quartiles based on the amount of TD. We generated propensity scores for each dosage group and matched patients with similar propensity scores from higher

Table 2
List of variables included in multivariable regressions.

	Variable	Variable type	Comments
Patient-related	Age	Continuous	
	Gender	Categorical	
	ASA status	Categorical	The patient's ASA status classification I - VI
	EVCI score	Continuous	The patient's Exlihauser-van Walraven Comorbidity Index score
	ICU-to-TR LOS	Continuous	The LOS from ICU admission to bed transfer request
	Pre-ICU LOS	Continuous	The LOS from hospital admission to ICU admission
Surgery-related	Surgery type	Categorical	
	Surgical team	Categorical	
	Surgical urgency	Categorical	The urgency of the surgery
Bed-related	Transfer delay	Continuous	Number of hours between transfer request to actual transfer from the ICU to the general care unit
	ICU unit	Categorical	The ICU that the patient originated from
	General care unit	Categorical	The hospital care unit the patient was transferred to from the ICU
	Day of week transfer requested	Categorical	
	Day of week transferred	Categorical	
	Discharge destination	Categorical	The patient's post-hospital destination (home or facility)
	MRSA status	Categorical	Presence of MRSA infection precautions (yes/no)

ASA indicates American Society of Anesthesiologists Physical Status Classification; EVCI score, Elixhauser-Van Walraven Comorbidity Index score; TR, transfer request; LOS, length of stay; MRSA, Methicillin-Resistant *Staphylococcus aureus*.

Table 3
Comparing patients with transfer delay across patient demographic, illness severity, and surgery type characteristics.

	Transfer delay < 12 h N = 1047	Transfer delay ≥ 12 h N = 670	p Value
Age (mean)	59.4	60.7	0.09
Gender (% male)	543 (51.9)	362 (54)	0.41
ASA class (%)			
1	23 (2.2)	12 (1.8)	0.27
2	326 (31.1)	181 (27.0)	
3	587 (56.1)	400 (59.7)	
4	102 (9.7)	74 (11.0)	
5	9 (0.9)	3 (0.4)	
EVCI score (mean)	28.1	28.3	0.81
Surgical urgency (%)			
Scheduled	776 (74.1)	433 (64.6)	<0.001
Waitlist Non-urgent	142 (13.6)	135 (20.1)	
Urgent	75 (7.2)	68 (10.1)	
Emergent	54 (5.2)	34 (5.1)	
Surgery type (%)			
Open abdominal	270 (25.8)	193 (28.8)	<0.001
Intracranial	252 (24.1)	141 (21.0)	
Open thoracic	150 (14.3)	50 (7.5)	
Video-assisted thoracic	76 (7.3)	39 (5.8)	
Spine	61 (5.8)	62 (9.3)	
Other	61 (6.0)	42 (6.3)	
Catheter-based	51 (4.9)	32 (4.8)	
Orthopedic limb	30 (2.9)	50 (7.5)	
Laparoscopic abdominal	29 (2.8)	19 (2.8)	
Open peripheral vascular	16 (1.5)	10 (1.5)	
Oralmaxilofacial	16 (1.5)	7 (1.0)	
Bronchoscopic	14 (1.3)	10 (1.5)	
Skin and soft tissue	10 (1.0)	7 (1.0)	
Genitourinary tract	9 (0.9)	8 (1.2)	

ASA indicates American Society of Anesthesiologists Physical Status Classification; EVCI score, Elixhauser-Van walraven Comorbidity Index score.

quartiles of TD to patients from lower quartiles of TD. We then performed a regression across the matched sets of patients. This technique retained the entire cohort of patients (minus one) with one-to-one matching. Covariate balance was tested by comparing the covariate means between matches in higher vs lower quartiles of TD.

We performed a sensitivity analysis using Wilcoxon signed rank tests to measure the robustness of the propensity matching model to the presence of unobserved covariates that could impact the results, specifically the probability to receive treatment given the controlled covariates. We report the magnitude of the hidden bias that could be present in the model without changing the current treatment effect in the model as, Γ, for both matching analyses.

In the final models we retained all variables, including nonsignificant variables. We considered a $P < 0.05$ to be significant. We reported 95% confidence intervals for all coefficients.

In addition, we assessed the difference in the timing of the final milestone decision for patients for each day subsequent to the transfer request by comparing patients into those with TD of <12 h and those with TD of ≥12 h. Furthermore, we subdivided patients into quartiles based on the amount of delay they experienced. Comparisons were made using log-rank tests. A $P < 0.05$ was considered to be statistically significant.

All statistical analyses were performed using the integrated development environment, RStudio version 1.0.136, for the R version 3.3.2 language (R Core Team, RStudio Inc., Boston, MA, USA).

3. Results

3.1. Study population and prevalence of TD

4926 admissions to the surgical and neurosciences ICUs occurred during the study period. Excluded patients were those who: had multiple surgeries (1476); had cardiac surgery [2]; were discharged directly from the ICU to home or facility (849); were readmitted to the ICU (666), had no milestone order post-transfer request (98); and had LOS >14 days (582). The final study population was 1717 patients after all exclusion criteria were applied.

The median amount of TD was 1.3 days (interquartile range: 1.0–1.7). Patients with TD of <12 h were not statistically different from patients with TD of ≥12 h in terms of age, gender, ASA status, and EVCI score (Table 3). Patients with TD ≥12 h were more likely to have had surgeries classified as urgent. Differences in surgical case mix existed between the two groups. Differences in urgency and case mix were adjusted for in the multivariable regression and matching analysis.

3.2. Subsequent hospital LOS

The unadjusted univariate analysis comparing subsequent hospital LOS was on average 4.7 days in patients with <12 h of TD and 5.7 days in patients with ≥12 h of TD ($P < 0.001$).

In the multivariable analysis, TD independently predicted subsequent hospital LOS (Table 4). The coefficient for the TD variable indicated that for every day of delay in transfer there was a 0.70 day increase in subsequent hospital LOS. The complete output of the multivariate regression model for subsequent LOS can be found in the Appendix Table 1.

In the dosage matching propensity analysis, baseline characteristics were balanced across quantiles of patients with higher versus lower TD (Appendix Table 2). As with the multivariable analysis, the coefficient of the TD variable was statistically significant and indicated that for every day of delay in transfer there was a 0.71 day increase in subsequent hospital LOS (Table 4). The Γ value for the Wilcoxon signed test for robustness of the model to unobserved bias was 1.25.

3.3. Timing of milestone care decisions

1690 (98.4%) patients had a milestone decision to begin an oral diet; 1417 (82.5%) to consult physical therapy; 1387 (80.8%) to discontinue IV narcotics; 1298 (75.6%) to mobilize the patient out of bed; 833 (48.5%) to remove a foley catheter; 484 (28.2%) to discontinue epidural medications; 307 (17.9%) to consult speech and swallow pathology; 192 (11.2%) to remove a nasogastric tube; 183 (10.7%) to perform a barium swallow study; 81 (4.7%) to perform a brain MRI; 72 (4.2%) to remove a chest tube; 9 (0.5%) to perform a hepatic ultrasound. Overall, 1681 (97.9%) patients had three or more milestone decisions occur from the time of transfer request to hospital discharge.

The unadjusted univariate analysis comparing time from transfer request to the last milestone decision of a patient's hospital stay was on average 1.2 days in patients with <12 h of TD and 1.9 days in patients with ≥12 h of TD ($P < 0.001$). Comparing patients with and without

Table 4
Effect of transfer delay on subsequent hospital LOS.

Analysis	Variable	Estimate (days)	95% confidence interval	P Value
Multivariable regression	Transfer delay	0.70[a]	0.56–0.77	<0.001
Propensity matching	Transfer delay	0.71	0.42–0.99	<0.001

[a] For every day of TD, the LOS from transfer request to hospital discharge is 0.70 days longer; LOS indicates length of stay.

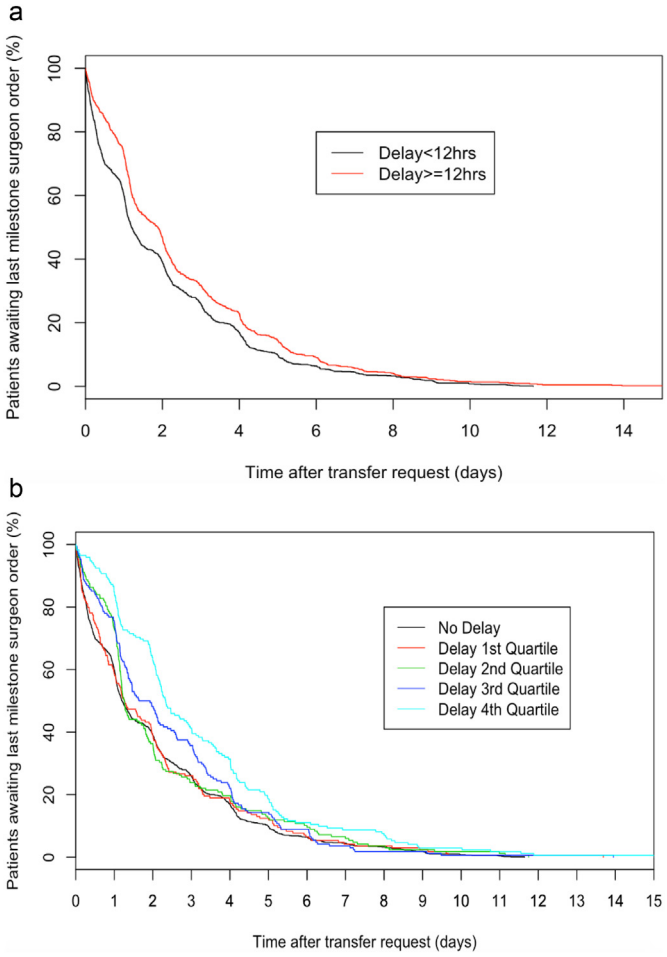

Fig. 2. a. Comparison across hospital days of progression to last milestone for patients with transfer delay (N = 670) vs no transfer delay (N = 1047). b. Comparison across hospital days of progress to last milestones for patients within different quartiles of transfer delay and no transfer delay. Delay 1st quartile (<1.02 days), delay 2nd quartile (1.02–1.32 days), delay 3rd quartile (1.33–1.73 days), and delay 4th quartile (>1.73 days).

TD, an analysis performed across hospital days demonstrated a statistically significant difference in the proportion of patients for whom a last milestone decision was made (Fig. 2**a**, $P < 0.001$). In addition, we repeated the analysis but divided patients with TD into quartiles based on the amount of delay they experienced (Fig. 2b, $P < 0.001$).

In the multivariable analysis, TD was a statistically significant independent predictor of the time from transfer request to the last milestone decision of a patient's hospital stay ($P < 0.001$, Table 5). The coefficient for the transfer delay variable indicated that for every day of delay in transfer there was a 0.35 day increase in the length of time from transfer request to the last milestone decision. The complete output of the multivariate regression model for the timing of the last milestone decision can be found in the Appendix Table 3.

As with the multivariable analysis, in the dosage matching analysis the coefficient for the TD variable was statistically significant ($P < 0.001$, Table 5). The Γ value for the Wilcoxon signed test for robustness of the model to unobserved bias was 1.05.

4. Discussion

In this study of surgical patients admitted to the ICU postoperatively, we observed that a non-clinical delay in transfer from the ICU to the general care unit was associated with a delay in the progress of the patient's clinical care. There was a significant difference in the hospital LOS after the transfer request based on the amount of time the patient spent waiting in the ICU for a bed. Controlling for patient, surgery, and bed-related factors, we found that for each day in the ICU spent waiting for a general care unit bed, the patient's LOS from transfer request to hospital discharge was incrementally longer.

In addition, the milestone care decisions that would progress the care of the patient along their clinical pathway were delayed and may explain why patients with a delay in transfer experience longer subsequent hospital LOS. Similar to the analysis on subsequent LOS, for every day spent waiting for a general care unit bed, the amount of time from the transfer request to the final milestone decision in the patient's care pathway was incrementally longer.

The significance of these findings was confirmed by a propensity matching analysis which accounted for the possibility of non-random assignment of treatment and imbalanced covariates between patients who experienced high amounts of TD versus those who did not. Moreover, we believe that the 'treatment assignment mechanism' (experiencing TD) is well understood and controlled by the observed covariates. Specifically, the variables that influence whether a patient will be delayed in receiving a bed are identifiable in our institution and were included in the analysis. The results are further strengthened by sensitivity analysis that indicates that the results of the propensity matching analysis for LOS are relatively robust to the presence of potential unobserved covariates.

The findings of this study are applicable across different types of patients and surgeries. Our cohort contained patients from both surgical and neurosurgical ICUs, representing surgeries across 14 surgical specialties that included open, laparoscopic, and catheter-based procedures.

Our findings indicate a potential vicious cycle in bed availability and transfer delay. A patient who experiences TD will have a longer subsequent hospital LOS. As a result, it is possible that general care unit beds already in short supply will be tied up for a longer period of time by patients who experienced TD and were transferred out the ICU. This leads to continued difficulty of the ICU finding beds available to transfer patients to, leading to more patients experiencing TD, and the cycle repeats itself. Meanwhile, patients needing ICU care cannot get into ICU beds in a timely manner, whether from the ED or from outside hospital transfer.

One important consideration in interpreting the results of our study is whether patients with greater illness severity may in fact be more likely to experience TD and therefore impact subsequent LOS. For example, it is conceivable that teams are more likely to withhold the transfer of a patient who is more clinically tenuous. This phenomenon is unlikely to have impacted our results. First, we adjusted for illness severity using both ASA status and EVCI comorbidity scores. Second, it is important to

Table 5
Effect of transfer delay on time from transfer request to final milestone provider decision

Analysis	Variable	Estimate (days)	95% confidence interval	P Value
Multivariable regression	Transfer delay	0.35[a]	0.24–0.40	<0.0001
Propensity matching	Transfer delay	0.59	0.34–0.83	<0.0001

[a] For every day of TD, the final milestone provider decision occurs 0.35 days later; LOS indicates length of stay

note that in our institution once the clinical teams have placed a transfer request, they do not have a choice in whom they may transfer. Rather, bed management makes this decision based on factors that were controlled for in this study, including gender, surgical specialty, contact isolation status, and the destination care unit. The only manner in which a clinical team could withhold a transfer is to cancel the transfer request. If the team did this, we did not include the transfer request in our data. We only included the last transfer request preceding the patient's actual transfer.

Our findings related to TD in the ICU setting parallel studies in the ED that have demonstrated that TD causes further delays in the progress of patient care. Consistent with the findings of this study, patients in the Emergency Department (ED) experiencing TD also have longer hospital LOS the longer they wait [16,17]. Delays in transfer from the ED to an inpatient bed have attracted the attention of The Joint Commission, which in 2014 created a requirement for hospitals to explicitly measure the number of patients experiencing delays and to set goals for managing these patients [18].

Our study supports the importance of alleviating problems in bed availability that result in TD, but also indicates that attention is needed to ensure that ICU and surgical teams continue to advance the care of the patient while the patient waits in the ICU. Further study is required to explain why patients experiencing TD also experience a delay in decisions that would advance their care, such as initiation of an oral diet, consultation with physical therapy, or removal of chest tubes. We hypothesize that this is because aspects of the patient's care, such as starting an oral diet or mobilizing the patient, are not typically aspects of care that ICUs focus on. ICU teams may need to shift their primary focus in patients with TD from hemodynamic and respiratory stabilization to those aspects of care that would continue to mark the patient's recovery toward discharge. It is possible that transfer delay impacts subsequent LOS and care decisions in a dose-dependent manner because the longer that the ICU team is responsible for the patient's floor-based care, the greater the impact is on the patient's care progression. Interestingly, we did not find that the surgical team's specialty or type of surgery was significantly associated with the impact of TD on LOS or milestone care decisions. This may support the hypothesis that the ICU team is most responsible for driving forward the patient's care as they await a general care unit bed in the ICU.

4.1. Limitations

This was a single center study and thus the generalizability of our findings is uncertain. It is possible that differences among hospitals in the structure of the care team and potential care paths may affect the impact of TD. For example, at the study hospital the surgical and neurosurgical ICUs follow a semi-closed model while other hospitals may use an open model in which the surgery team would be primarily responsible for the patient's care during the ICU stay. In addition, the study site was a large, quaternary care teaching hospital which may have care processes in transitioning patients from the ICU to the general care units that differ from other hospitals. These processes could alter the impact of TD on the outcome variables studied.

We measured the relationship between TD and the timing of the provider orders, but data was not available on when the subsequent action resulting from the order occurred. We believe that because most orders precede the intended action, the action is at least as delayed as the order related to it. In addition, we do not have reason to believe that documentation of orders would be better or worse based on whether the patient experience TD or not. Thus, we do not expect that our results would be biased by this.

Although we had inconsistent access to physiologic data such as vital signs or lab results, we accounted for differences in illness severity among patients in the regression analyses using ASA status, age, and a validated comorbidity index. We opted to use the EVCI as it includes over 30 patient comorbidities and has modestly outperformed other comorbidity indices in critically ill patients [14,27-30].

5. Conclusions

Patients with non-clinical delays in transfer from the ICU to the general care unit experienced increased hospital LOS and delays in clinical decisions that would progress their care. Future work should focus on preventing TD and ensuring that patients with TD continue to progress along their care pathway without interruption.

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcrc.2018.11.025.

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