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# Short-Term Clinical and Quality Outcomes Have Inconsistent Changes From a Quality Improvement Initiative to Increase Access to Physical Therapy in the Cardiovascular and Surgical ICU

Joseph E. Tonna, MD[1,2]; Joshua Johnson, DPT[3]; Angela Presson, PhD, MS[4]; Chong Zhang, MS[4]; Chris Noren, OTR/L[5]; Bryan Lohse, PT, DPT[6]; Haley Bento, PT, DPT[6]; Richard G. Barton, MD[7]; Raminder Nirula, MD, MPH[7]; Mary Mone, BS, RN[8]; Robin Marcus, PT, PhD[9]

[1]Division of Cardiothoracic Surgery, Department of Surgery, University of Utah School of Medicine, Salt Lake City, UT.

[2]Division of Emergency Medicine, Department of Surgery, University of Utah School of Medicine, Salt Lake City, UT.

[3]Department of Physical Therapy & Athletic Training, University of Utah Health, Salt Lake City, UT.

[4]Division of Epidemiology, Department of Medicine, University of Utah, Salt Lake City, UT.

[5]Department of Occupational & Recreational Therapies, University of Utah College of Health, Salt Lake City, UT.

[6]Physical Therapy, University of Utah Health, Salt Lake City, UT.

[7]Division of General Surgery, Department of Surgery, University of Utah School of Medicine, Salt Lake City, UT.

[8]Division of General Surgery, Department of Surgery, University of Utah, Salt Lake City, UT.

[9]Department of Physical Therapy & Athletic Training, University of Utah Health, Salt Lake City, UT.

ORCID: 0000-0001-8879-2628.

Dr. Tonna had full access to all the data in the study, takes responsibility for the integrity of the data, the accuracy of the data analysis, and the integrity of the submission as a whole, from inception to published article. Dr. Tonna, Mr. Noren, and Dr. Nirula conceived study design. Dr. Tonna, Mr. Noren, Mr. Lohse, Ms. Bento, and Drs. Barton, Nirula, and Marcus contributed to conduct of the trial. Drs. Tonna and Johnson, Mr. Lohse, Ms. Bento, and Drs. Barton and Nirula, Ms. Mone, and Dr. Marcus contributed to data acquisition and analysis. Drs. Tonna and Presson and Ms. Zhang drafted the work; all authors revised the article for important intellectual content, had final approval of the work to be published, and agree to be accountable to for all aspects of the work.



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For information regarding this article, E-mail: joseph.tonna@hsc.utah.edu

**Objectives:** Studies of mobility during critical illness have mostly examined transitions from immobility (passive activities) or limited mobility to active "early mobility."

**Design:** Observational analysis of a quality improvement initiative.

**Setting:** Two ICUs (surgical ICU, cardiovascular ICU) at a tertiary academic medical center.

**Patients:** Critically ill surgical and cardiovascular patients.

**Interventions:** Doubling available physical therapy.

**Measurements and Main Results:** We examined the outcomes of therapy time/patient/day, ICU and hospital length of stay, disposition location, and change in functional status. We adjusted for age, sex, illness severity, and number of surgeries. Among 1,515 patients (703 baseline, 812 quality improvement), total therapy time increased from 71,994 to 115,389 minutes and from 42,985 to 93,015 minutes, respectively, in each ICU. In the cardiovascular ICU per patient therapy increased 17% (95% CI, −4.9 to 43.9; $p = 0.13$), and in the surgical ICU, 26% (95% CI, −1 to 59.4; $p = 0.06$). In the cardiovascular ICU, there was a 27.4% decrease (95% CI, −52.5 to 10.3; $p = 0.13$)

in ICU length of stay, and a 12.4% decrease (95% CI, −37.9 to 23.3; $p = 0.45$) in total length of stay, whereas in the surgical ICU, the adjusted ICU length of stay increased 19.9% (95% CI, −31.6 to 108.6; $p = 0.52$) and total length of stay increased 52.8% (95% CI, 1.0–130.2; $p = 0.04$). The odds of a lower level of care discharge did not change in either ICU (cardiovascular ICU: 2.6 [95% CI, 0.6–12.2; $p = 0.22$]); surgical ICU: 3.6 [95% CI, 0.9–15.4; $p = 0.08$]).

**Conclusions:** Among diverse cardiothoracic and surgical patients, a quality improvement initiative doubling physical therapy shifts is associated with increased total administered therapy time, but when distributed among a greater number of patients during the quality improvement period, the increase is tempered. This was not associated with consistent changes in ICU length of stay or changes in disposition location.

**Key Words:** ambulation; early mobility; intensive care unit; physical therapy; rehabilitation

The consequences of prolonged immobility during critical illness and the feasibility and associated benefits of mobilization during ICU stay are increasingly established (1–6). Data are conflicting as to whether increases in therapy during critical illness consistently improve patient outcomes (7–9), and the optimal amount of therapy is not yet established. Studies demonstrate mixed results among the outcomes of independent functional status and length of stay (LOS), and reduced prevalence of delirium (7–12). Although forthcoming studies investigate the feasibility of earlier initiation of physical therapy (PT) during critical illness (13), most have examined transitioning from "no" or "minimal" therapy to increased levels of therapy.

Among published studies of "early mobility," baseline levels of activity were minimal and included PT starting a week after ICU admission (14), no PT (11, 15), passive range of motion exercises (6), less than 10 minutes of activity (16), or they did not report the amount of therapy administered as a variable or outcome (7). In comparison, the treatment groups in these mobility studies reported a wide range of therapeutic activity, including 20 minutes (11, 16), up to 7 days per week, sitting for 20 minutes tid (6), or approximately 40 minutes of therapy (8). One recent noteworthy study had an intervention arm that received up to 160 minutes of daily therapy (9), although this is the exception rather than the rule. In only a few studies was the quantity of mobility defined as a variable (8, 9, 16, 17). Most studies have focused on medical or mixed patients and less on surgical patients (10, 15, 18).

At our institution, baseline therapy in our ICUs was already comparable to the treatment groups in most published studies of early mobility during critical illness (8, 9, 16). In 2015, we implemented a quality improvement (QI) initiative designed to double available therapy time for critically ill patients from this baseline level to a level we termed "Enhanced Early Mobility." This observational study examined the attributable effects from the QI initiative on short-term patient and quality outcomes resulting from doubling available therapy shifts.

## MATERIALS AND METHODS

Our analysis is reported according to the Standards for Quality Improvement Reporting Excellence guidelines (19) (**Supplemental Table 1**, Supplemental Digital Content 1, http://links.lww.com/CCX/A110).

### Data Source

Data were extracted from the institutional electronic data warehouse (EDW) by a data scientist blinded to the goals of the analysis. EDW data at our institution includes all electronic medical record (EMR) entries, in addition to multiple other sources. It has been previously described and validated as an accurate and sufficiently complete source for research analysis in studies (20, 21). These data were then appended with a manually maintained ICU research database for additional outcomes such as comorbidities and past medical history, which has been previously described (22).

### Study Design

This study was a retrospective pre/post analysis of a QI initiative that increased available therapy staffing in two ICUs at a tertiary academic medical center. The study included a baseline period (September 8, 2014, to March 8, 2015), a 6-month period during which additional therapists were hired and trained (March 9, 2015, to September 7, 2015), and a 6-month postintervention period (September 8, 2015, to March 8, 2016). The authors sought and received Institutional Review Board approval (IRB_00084463 and AM_00025727) for observational research examining the effect of the QI intervention. The QI initiative was an increase in the quantity of current standard of care therapy within the ICUs. Accordingly, it was felt to be of probable patient benefit. Safety outcomes were monitored through the institutional safety reporting infrastructure as part of the QI process and reported as part of this analysis. No data were analyzed for this study until after the 6-month intervention period.

### Participants

Eligibility for analysis was determined by patient location and date. Subjects were included if they were greater than or equal to 18 years old admitted to the cardiovascular ICU (CVICU) or surgical ICU (SICU) at the University of Utah from September 8, 2014, to March 7, 2015. Eligible patients were identified through an EMR query (**Supplemental Fig. 1**, Supplemental Digital Content 2, http://links.lww.com/CCX/A111). Patients were excluded if they were admitted during the 6-month intervening period between baseline and QI periods, if they had a second admission, if they had an ICU LOS less than 24 hours, or did not undergo therapy.

### Treatment Interventions

The primary QI intervention was to double the number of PT shifts available to patients in the two ICUs (**Supplemental Fig. 2**, Supplemental Digital Content 3, http://links.lww.com/CCX/A112), termed "Enhanced Early Mobility." At baseline, PTs worked 14 shifts per week covering 28 beds between the two ICUs, and occupational therapists (OTs) worked eight shifts per week, resulting in approximately six PT sessions and four OT sessions of 50 minutes per patient per week. Each 50-minute therapy session included 20 minutes of physical activity plus 30 minutes of patient preparation and documentation by the therapist. The "Enhanced Early Mobility" phase consisted of doubling PT shifts.

The intervention doubled the therapy staff in the treatment ICUs from 14 to 28 PT shifts per week and from 8 to 15 OT shifts per week. The goal was to perform bid PT and once daily OT per patient per day. Details of the duration and manner in which therapy was administered was left to the judgment of the therapist. Staff were permanently assigned to the ICUs. The increase in staff was accomplished through new hires trained during the 6 months between data collection periods who were then assigned to the treatment groups. Patients were seen by PT/OT according to standard clinical practices. There were no interventions modifying the ordering or timing of therapy orders.

### Outcome Measures and Covariate Selection

The primary outcome was administered PT time (min) per patient per day. PT time was defined as a discrete field within the PT note. OT time was not analyzed for this analysis. Secondary outcomes included ICU LOS (d), hospital LOS (d), change in functional mobility status from preadmission to discharge as defined by differences in the numerical value of the Activity Measure for Post-Acute Care [AM-PAC] score, and discharge location (ordinal). Other covariates were selected based on consistently used covariates from previously published clinical trials and observational studies of mobility among critically ill patients (11, 12, 17, 23). These included age, sex, illness severity scores, Medicare Severity-Diagnosis Related Group (MS-DRG) weight, and number of surgeries (24, 25). In the analysis of change in functional mobility status, we adjusted for preadmission physical function.

Administered PT time was entered in "total" and "active" minutes in two discrete extractable fields within the EMR. Active time was time during which the patient was participating with movement (actively or passively). Total time also included patient preparation and documentation. Accuracy of each time is regularly confirmed with manual audits by Department of Physical Therapy staff. During the study, there was a change in the clinical reporting of therapy time. For consistency, affected time was manually adjusted to the baseline method of reporting for the analysis. Functional status was measured by the AM-PAC Short Form, was assessed by therapists at discharge, and was reported by patients or family for preadmission (26). The AM-PAC Short Form ("6-Clicks") is a validated measure of patient physical function and mobility, which has high inter-rater reliability among physical therapists, convergent validity with the Johns Hopkins Highest Level of Mobility score, and has been shown to accurately predict hospital discharge. However, it has limited data in ICU settings and may have a floor effect in this setting (27–30). Scores range from 6 (fully impaired) to 24 (fully functional). Injury severity scores included the Charlson Comorbidity Index, the Acute Physiology and Chronic Health Evaluation (APACHE) II, and the Simplified Acute Physiology Score (SAPS) II. The number of surgeries were pulled from a previously described and validated research database, before and after intervention (22). Discharge location was dichotomized into "favorable/low level of care" (e.g., inpatient rehabilitation or home) and "unfavorable/high level of care" (e.g., skilled nursing facility [SNF], long-term acute care [LTAC], or other hospital) as an additional way to describe patient functional independence at discharge. Safety outcomes were assessed for all patients through a query of the institutional adverse event reporting system.

### Statistical Analysis

Descriptive statistics, including mean (SD), median (interquartile range), frequency, and percent were used to summarize patient characteristics. Categorical patient characteristics were descriptively compared between preintervention and postintervention phases using chi-square or Fisher exact tests. Continuous patient characteristics were descriptively compared using independent samples *t* tests or Wilcoxon Mann-Whitney *U* tests. Generalized linear models implementing segmented regression (SR) were used to estimate the change in outcomes as a result of the intervention with and without adjusting for patient characteristics (APACHE II, Charlson, SAPS II, age, sex, MS-DRG weight, number of surgeries). We also controlled for admission AM-PAC score when modeling change in AM-PAC. Our SR approach mirrors an interrupted time-series model framework, except rather than modeling data at an aggregate level, we analyzed the data at the patient level (31). As is commonly done for SR analyses, the reported outcome is the difference in the rate of change relative to the expected rate without any intervention. 95% CIs and *p* values were obtained directly from the models. Linear regression was used for the outcomes of mean therapy time per day and AM-PAC change, gamma regression with a log link was used for ICU LOS and total LOS due to distribution skew, and logistic regression was used for discharge location. Coefficients from gamma regression models were exponentiated and reported as percent change. Statistical analyses were conducted in R v.3.4 (R Foundation for Statistical Computing; Vienna, Austria). Significance was assessed at the 0.05 level and all tests were two-tailed.

## RESULTS

### Study Population

The study included 1,515 ICU patients (Supplemental Fig. 2, Supplemental Digital Content 3, http://links.lww.com/CCX/A112). Patients increased from the baseline to the QI period by 15% overall, from 351 to 406 (CVICU), and from 352 to 406 (SICU). **Table 1** presents the patient-level outcomes of the two treatment groups, before and after the intervention, stratified by unit. Baseline characteristics were unequal between the preintervention and postintervention groups. The postintervention group in the CVICU had a significant increase in patients in the lowest SAPS II tertile (10 vs 17%; $p = 0.027$) and APACHE II tertile (10 vs 22%; $p < 0.001$).

### Therapy/Mobilization

**Figure 1** shows the increase in therapy time from pre-intervention to post-intervention. The total administered therapy time during each 6-month period increased in the CVICU by 60%, from 71,994 to 115,389 minutes, and in the SICU by 116% from 42,985 to 93,015 minutes. In the CVICU, the primary outcome, mean therapy minutes per patient per day increased minimally from 50 (43.9–60) to 57.4 (43.9–73.6). In the SICU, time increased from 48.3 (42.1–60) to 59.6 (43.2–83.9) (**Table 2**). After adjusting for covariates in the regression model, the intervention in the CVICU

**TABLE 1. Patient Level Characteristics of Treatment Groups, Separated by ICU**

| Variable | Cardiovascular ICU | | | Surgical ICU | | |
|---|---|---|---|---|---|---|
| | Baseline (*n* = 351) | QI Period (*n* = 406) | *p* | Baseline (*n* = 352) | QI Period (*n* = 406) | *p* |
| Male, *n* (%) | 224 (64) | 264 (65) | 0.73 | 212 (60) | 239 (59) | 0.70 |
| Age[a] | 61.6 (15.8) | 61.2 (15.2) | 0.73 | 54 (19.6) | 55.9 (19.3) | 0.19 |
| Charlson[b] | 3 (2–6) | 1 (0–3) | < 0.001 | 2 (1–5) | 0 (0–3) | < 0.001 |
| Medicare Severity-Diagnosis Related Group weight[b] | 4.9 (2.1–7.7) | 5.1 (2.2–7.6) | 0.19 | 3.4 (1.9–5.2) | 3.4 (1.9–5.1) | 0.89 |
| Number of surgeries[b] | 1 (1–2) | 1 (1–2) | 0.55 | 1 (1–2) | 1 (1–2) | 0.78 |
| First Activity Measure for Post-Acute Care score[b] | 9 (7–13.5) | 10 (8–13) | 0.11 | 8 (6–12) | 8 (6–11) | 0.45 |
| Simplified Acute Physiology Score II, *n* (%) | | | 0.027 | | | 0.08 |
| ≤ 26 | 34 (10) | 69 (17) | – | 62 (18) | 84 (21) | – |
| 27–35 | 57 (16) | 68 (17) | – | 61 (17) | 49 (12) | – |
| ≥ 36 | 48 (14) | 53 (13) | – | 47 (13) | 71 (17) | – |
| Unknown | 212 (60) | 216 (53) | – | 182 (52) | 202 (50) | – |
| Acute Physiology and Chronic Health Evaluation II, *n* (%) | | | < 0.001 | | | 0.88 |
| ≤ 12 | 36 (10) | 89 (22) | – | 60 (17) | 76 (19) | |
| 13–17 | 61 (17) | 60 (15) | – | 56 (16) | 69 (17) | – |
| ≥ 18 | 42 (12) | 41 (10) | – | 54 (15 | 59 (15) | – |
| Unknown | 212 (60) | 216 (53) | – | 182 (52) | 202 (50) | – |

QI = quality improvement.
[a]Results are mean and SD.
[b]Results are median and interquartile range.
Cardiovascular ICU missing values: Medicare Severity-Diagnosis Related Group (MS-DRG) weight = 16. Surgical ICU missing values: MS-DRG weight = 9.
Dashes indicate no individual test of comparison was performed.

was associated with a nonstatistically significant 17% (95% CI, –4.9 to 43.9; $p = 0.13$) increase in therapy time (**Table 3**).The effect was stronger in the SICU at 26% (95% CI, –1 to 59.4; $p = 0.06$), but still not statistically significant when modeled as a percent change (**Table 4**). Covariate adjusted absolute minutes of therapy increased by 14.2 (95% CI, 1.53–26.61; $p = 0.03$) in the SICU and by 8.4 (95% CI, –2.74 to 19.24; $p = 0.13$) in the CVICU.

### Short-Term Clinical and Quality Outcomes

**Figure 2** and **Supplemental Figure 3** (Supplemental Digital Content 4, http://links.lww.com/CCX/A113) show the change in ICU and total LOS from pre-intervention to post-intervention. In the CVICU, ICU LOS nonsignificantly decreased from 4 (3–7) to 3 (2–6). In the SICU, ICU LOS nonsignificantly increased from 7 (5–12) to 8 (5–13) (Table 2). After adjusting for covariates, in the CVICU the intervention was associated with a nonsignificant 27.4% decrease (95% CI, –52.5 to 10.3; $p = 0.13$) in ICU LOS (Fig. 2), and a nonsignificant 12.4% decrease (95% CI, –37.9 to 23.3; $p = 0.45$) in total LOS (Table 3 and Fig. 2). In the SICU, the adjusted ICU LOS nonsignificantly increased 19.9% (95% CI, –31.6 to 108.6; $p = 0.52$) (Fig. 2), but total LOS significantly increased 52.8% (95% CI, 1.0–130.2; $p = 0.04$) (Table 4; and Supplemental Fig. 3, Supplemental Digital Content 4, http://links.lww.com/CCX/A113).

As part of the SR model, the rate of therapy change over time is reported. Before the intervention, in both the CVICU and in the SICU, there was no significant trend of increase or decrease in therapy over time (Tables 3 and 4). After the intervention in the SICU, the model showed a significant but minimal decrease in therapy time by 0.07 minutes (95% CI, –0.13 to 0.01; $p = 0.019$), which corresponds to a 0.13% per day decrease throughout the intervention period.

***Functional Status (AM-PAC Score)***. After adjusting for baseline functional status (AM-PAC score) and other covariates, the intervention of increasing available therapy was not associated with a significant improvement in patient functional status in either CVICU patients (–2.1 [95% CI, –5.2 to 1.1; $p = 0.20$]) or in SICU patients (–0.8 [95% CI, –3.5 to 1.9; $p = 0.55$]) (Tables 3 and 4).

***Discharge Location***. Among CVICU patients, the intervention was nonsignificantly associated with "favorable" discharge (defined as "home" or "inpatient rehabilitation" vs "LTAC" or "SNF" (odds ratio [OR], 2.6; 95% CI, 0.6–12.2; $p = 0.22$) (Table 3). Among SICU patients, the effect was stronger but still nonsignificant (OR, 3.6; 95% CI, 0.9–15.4; $p = 0.08$) (Table 4).

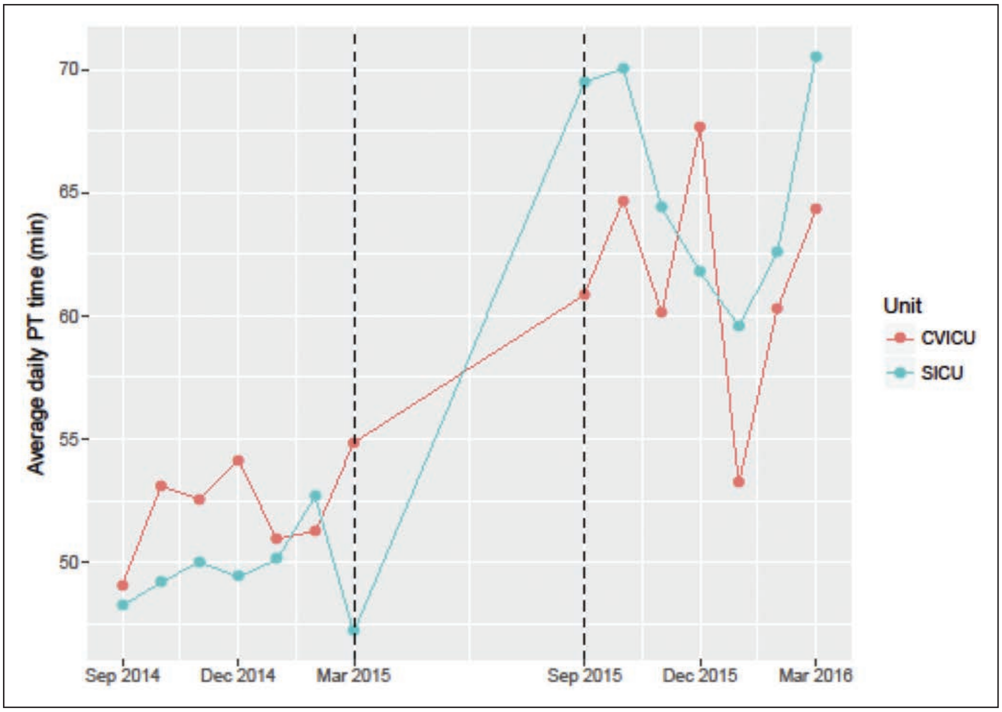


**Figure 1.** Therapy time increase. CVICU = cardiovascular ICU, PT = physical therapy, SICU = surgical ICU.

***Safety Outcomes***. In the SICU, staff-reported safety events included one fall during the baseline period, and two falls during the QI period ($p$ = 1.0). There were no events in the CVICU in either period.

## DISCUSSION

The purpose of this study was to assess the effect of doubling available therapy during critical illness, including whether there was a patient or associated outcome benefit. The population was a heterogeneous mix of general surgical and cardiothoracic surgery patients. Overall, we found that our total therapy time increased, as was expected with the increase in staffing. There was an observed 15% increase in patients in the QI compared with baseline period, and the observed primary outcome of per patient per day therapy time did achieve adequate statistical significance. Additionally, we believe that an outcome such as LOS was likely influenced by unmeasured confounders and may not be an effective outcome measure in an observational analysis with a heterogeneous population. We feel this is supported by the wide skew of the LOS data (Fig. 2; and Supplemental Fig. 3, Supplemental Digital Content 4, http://links.lww.com/CCX/A113).

In response to the noted increase in total LOS among SICU patients, we anecdotally observed that the post-ICU ("floor") therapists de-escalated therapy for post-SICU patients after the project began in order to prioritize their efforts on patients who had not been in the ICU. We suggest that this de-escalation of floor therapy may have influenced LOS. Additionally, we did not measure muscle bulk or function during the initiative. It is plausible that excessive therapy could lead to enough fatigue to prolong LOS in a population with an increased prevalence of sarcopenia, muscular weakness, and respiratory failure.

The data supporting early PT and mobility during critical illness is conflicting, with recent negative trials (7–9) and is not yet universally adopted (15, 32). Among published studies of early mobility, the control arms typically involve minimal (6, 16) to no physical activity (11, 14, 15). One recent study reported 48 minutes of PT within the control group (10), but we found no other studies with comparable activity. Likewise, within these studies, therapy within the intervention arms was at best comparable to or less than our preintervention therapy of about 20 minutes of active therapy per day (6, 11, 14, 16, 33). The recently published study by Schaller et al (10) reported 60 minutes of therapy within their treatment group, although the percentage of this time involving active patient movement was not reported.

**TABLE 2. Descriptive Summary of Outcomes**

| | Cardiovascular ICU | | Surgical ICU | |
|---|---|---|---|---|
| Variable | Baseline ($n$ = 351) | QI Period ($n$ = 406) | Baseline ($n$ = 352) | QI Period ($n$ = 406) |
| ICU LOS[a] | 4 (3–7) | 3 (2–6) | 3 (2–6) | 3 (2–6) |
| Total LOS[a] | 8 (5–12) | 7 (4.2–11) | 7 (5–12) | 8 (5–13) |
| Mean PT minutes/day[a] | 50 (43.9–60) | 57.4 (43.9–73.6) | 48.3 (42.1–60) | 59.6 (43.2–83.9) |
| Mean PT units/day[a] | 3.5 (3–4) | 4 (3–4) | 4 (3.3–4) | 4 (3.3–4.2) |
| "Favorable" discharge location, $n$ (%) | 79 (23) | 84 (21) | 122 (35) | 133 (33) |

LOS = length of stay, PT = physical therapy, QI = quality improvement.

[a]Results are median and interquartile range.

Cardiovascular ICU missing values: mean PT minutes/day = 84, PT days % = 84, mean PT units/day = 161. Surgical ICU missing values: mean PT minutes/day = 128, PT days % = 128, mean PT units/day = 263.

**TABLE 3. Segmented Regression Analysis–Cardiovascular ICU**

| Outcome | Variable | Estimates[a] (95% CI) | p[a] | Estimates[b] (95% CI) | p[b] |
|---|---|---|---|---|---|
| PT time/day (min) | Intervention period | 10.56 (–0.90 to 21.77) | 0.06 | 8.36 (–2.74 to 19.24) | 0.13 |
| | Study time | 0.00 (–0.04 to 0.04) | 0.99 | –0.00 (–0.04 to 0.03) | 0.87 |
| | Time since intervention | –0.01 (–0.07 to 0.04) | 0.66 | –0.00 (–0.06 to 0.05) | 0.93 |
| PT time/day (%) | Intervention period | 20.27 (–2.75 to 48.53) | 0.09 | 17.03 (–4.91 to 43.87) | 0.13 |
| | Study time | 0.00 (–0.07 to 0.07) | 0.99 | –0.01 (–0.08 to 0.06) | 0.87 |
| | Time since intervention | –0.02 (–0.12 to 0.08) | 0.69 | –0.01 (–0.10 to 0.09) | 0.86 |
| ICU LOS (%) | Intervention period | –17.5 (–61.4 to 73.8) | 0.61 | –27.5 (–52.5 to 10.3) | 0.13 |
| | Study time | 0.1 (–0.2 to 0.3) | 0.69 | 0.1 (–0.1 to 0.2) | 0.22 |
| | Time since intervention | –0.2 (–0.5 to 0.2) | 0.33 | –0.1 (–0.3 to 0.0) | 0.14 |
| Total LOS (%) | Intervention period | –3.6 (–44.6 to 66.7) | 0.90 | –12.4 (–37.9 to 23.3) | 0.45 |
| | Study time | –0.0 (–0.2 to 0.2) | 0.86 | 0.0 (–0.1 to 0.1) | 0.71 |
| | Time since intervention | –0.1 (–0.3 to 0.2) | 0.55 | –0.1 (–0.2 to 0.1) | 0.40 |
| "Favorable" discharge (odds ratio) | Intervention period | 2.60 (0.64–11.09) | 0.19 | 2.6 (0.6–12.2) | 0.22 |
| | Study time | 1.00 (0.99–1.00) | 0.19 | 1.0 (1.0–1.0) | 0.40 |
| | Time since intervention | 1.00 (0.99–1.01) | 0.75 | 1.0 (1.0–1.0) | 0.90 |
| Last Activity Measure for Post-Acute Care | Intervention period[c] | –2.38 (–5.62 to 0.86) | 0.15 | –2.1 (–5.2 to 1.1) | 0.20 |
| | Study time[c] | 0.01 (–0.00 to 0.02) | 0.21 | 0.0 (–0.0 to 0.0) | 0.42 |
| | Time since intervention[c] | –0.01 (–0.02 to 0.01) | 0.30 | –0.0 (–0.0 to 0.0) | 0.34 |

LOS = length of stay, PT = physical therapy.

[a]Unadjusted estimates.

[b]Adjusting for sex, age, Charlson index, Medicare Severity-Diagnosis Related Group weight, number of surgeries, Simplified Acute Physiology Score II, and Acute Physiology and Chronic Health Evaluation II.

[c]Adjusting for first Activity Measure for Post-Acute Care.

In our study, each session included an additional 30 minutes of therapist time per patient per day beyond the reported "active therapy," amounting to approximately 60 minutes of therapy per patient per day. The additional time included coordination or care with various providers, review of medical records, and documentation.

We found that unit level AM-PAC scores did not change, confirming a possible floor effect during critical illness using the AM-PAC score (23, 34). A second possibility is that subpopulations of critically ill patients significantly benefit from increased therapy, but that others experience a ceiling effect.

The lack of an effect on ICU LOS is likely influenced by the diversity of the SICU population, which includes trauma, general surgery, orthopedic surgery, obstetrics, otolaryngology, and abdominal transplant surgery. Furthermore, in this population, the total hospital LOS increased by 16%. Investigating this, we observed that the increase in ICU therapy had the unintended consequence of post-ICU therapy being de-prioritized to post-SICU patients. If this contributed to a post-ICU LOS increase, this would further support the observation that therapy leads to shortened LOS within critically ill patients. Furthermore, as the therapists adjusted per patient therapy daily, rather than applying a fixed amount of therapy, this likely led to more impaired patients getting more therapy.

The importance of our study is that it helps to answer the question: "Will ICU patients continue to benefit from increasing physical therapy?" Guidelines recommend mobility and activity during critical illness, although studies suggest that in practice this is still rare (15, 32). Recommended activities include active and passive range of motion, and coordination and balance (35, 36) daily for 30 minutes and then progressing to 45 minutes bid (37). Despite this, we found no studies that achieved this final recommendation level. One study reported that the treatment group had PT bid upon reaching the 4th of six ascending levels of function, but this outcome is not clearly reported, and patients walked 1 day earlier than their first therapy session, suggesting a healthier population (33). Finally, no studies have examined the transition from "early mobility" to increasing levels of mobility during critical illness.

This study has several limitations. The major limitation was the increase in number of patients pre- and post-intervention which functionally diminished the administered therapy per patient. The second major limitation was the use of LOS among a heterogeneous population of ICU patients. To address this, we adjusted for covariates identified in recent publications of ICU mobility, although there may have been additional uncontrolled confounders. We additionally used a SR analysis, which examined how change in outcomes over time were affected by the intervention when adjusting for patient characteristics. However, the lack of a

**TABLE 4. Segmented Regression Analysis–Surgical ICU**

| Outcome | Variable | Estimates[a] (95% CI) | p[a] | Estimates[b] (95% CI) | p[b] |
|---|---|---|---|---|---|
| PT time/day (min) | Intervention period | 15.55 (3.23–27.66) | 0.01 | 14.18 (1.53–26.61) | 0.03 |
| | Study time | 0.01 (−0.03 to 0.05) | 0.53 | 0.02 (−0.02 to 0.06) | 0.40 |
| | Time since intervention | −0.06 (−0.12 to 0.00) | 0.07 | −0.07 (−0.13 to −0.01) | 0.02 |
| PT time/day (%) | Intervention period | 29.31 (2.17–63.46) | 0.03 | 25.71 (−1.00 to 59.44) | 0.06 |
| | Study time | 0.03 (−0.06 to 0.11) | 0.54 | 0.04 (−0.04 to 0.12) | 0.38 |
| | Time since intervention | −0.09 (−0.20 to 0.01) | 0.08 | −0.13 (−0.24 to −0.02) | 0.02 |
| ICU LOS (%) | Intervention period | 105.2 (−6.7 to 343.6) | 0.06 | 19.9 (−31.6 to 108.6) | 0.52 |
| | Study time | −0.2 (−0.5 to 0.0) | 0.08 | −0.0 (−0.2 to 0.2) | 0.93 |
| | Time since intervention | 0.2 (−0.1 to 0.6) | 0.24 | −0.0 (−0.3 to 0.2) | 0.78 |
| Total LOS (%) | Intervention period | 112.5 (17.4–281.2) | 0.01 | 52.8 (1.0–130.2) | 0.04 |
| | Study time | −0.2 (−0.4 to −0.0) | 0.02 | −0.1 (−0.2 to 0.0) | 0.14 |
| | Time since intervention | 0.2 (−0.0 to 0.5) | 0.10 | 0.1 (−0.1 to 0.3) | 0.25 |
| “Favorable” discharge (odds ratio) | Intervention period | 4.64 (1.35–16.54) | 0.02 | 3.6 (0.9–15.4) | 0.08 |
| | Study time | 0.99 (0.99–1.00) | 0.01 | 1.0 (1.0–1.0) | 0.04 |
| | Time since intervention | 1.01 (1.00–1.01) | 0.04 | 1.0 (1.0–1.0) | 0.22 |
| Last Activity Measure for Post-Acute Care | Intervention period[c] | −1.35 (−4.13 to 1.44) | 0.34 | −0.8 (−3.5 to 1.9) | 0.55 |
| | Study time[c] | 0.00 (−0.01 to 0.01) | 0.40 | 0.0 (−0.0 to 0.0) | 0.71 |
| | Time since intervention[c] | 0.00 (−0.01 to 0.01) | 0.86 | 0.0 (−0.0 to 0.0) | 0.48 |

LOS = length of stay, PT = physical therapy.

[a]Unadjusted estimates.

[b]Adjusting for sex, age, Charlson index, Medicare Severity-Diagnosis Related Group weight, number of surgeries, Simplified Acute Physiology Score II, and Acute Physiology and Chronic Health Evaluation II.

[c]Adjusting for first Activity Measure for Post-Acute Care.

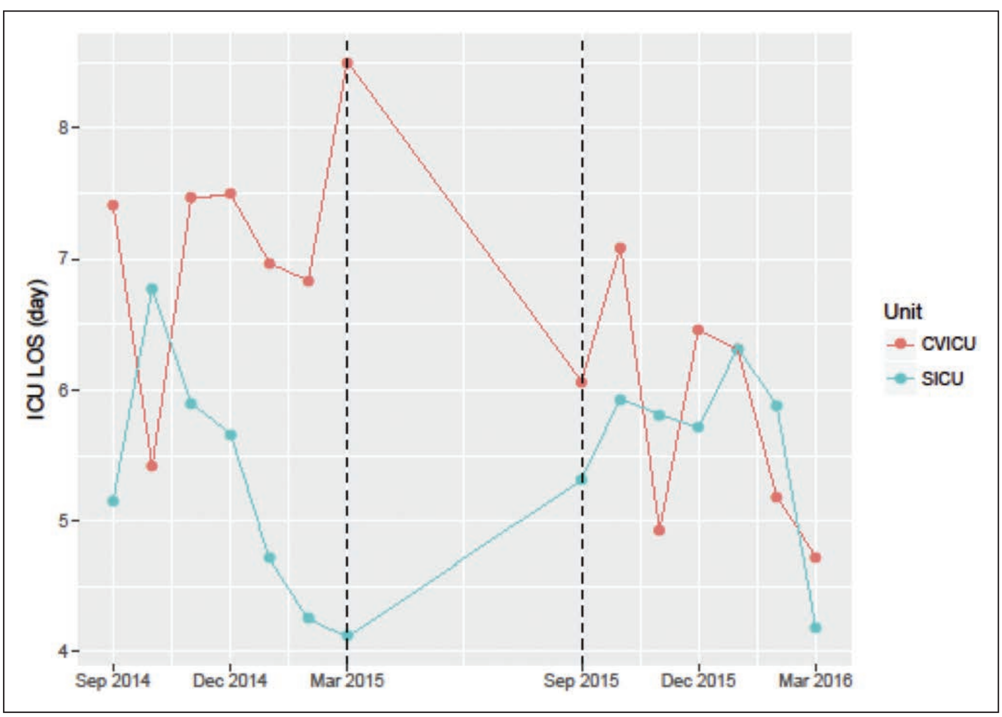


**Figure 2.** ICU length of stay (LOS). CVICU = cardiovascular ICU, SICU = surgical ICU.

significant change in LOS may simply mirror the negative outcomes of multiple recent controlled trials of increasing therapy during critical illness. We excluded patients who did not have therapy documented. Although this was a limitation that could bias our results because we only analyzed patients who received the therapy, the QI initiative targeted treatment of every patient every day. We additionally excluded LOS less than 24 hours, and the incidence of a patient being admitted for 2 days without therapy was low.

## CONCLUSIONS

Our study shows that among diverse cardiothoracic and surgical patients, doubling PT shifts is associated with increased total administered therapy time, but when distributed among a greater number of patients during the

QI period, the increase per patient is tempered. Increasing therapy from a baseline of 50 minutes per patient per day was not associated with consistent changes in ICU LOS and no changes in disposition location.

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