Assessing the Utility of ICU Readmissions as a Quality Metric

An Analysis of Changes Mediated by Residency Work-Hour Reforms

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BACKGROUND: ICU readmissions are associated with increased mortality and costs; however, it is unclear whether these outcomes are caused by readmissions or by residual confounding by illness severity. An assessment of temporal changes in ICU readmission in response to a specific policy change could help disentangle these possibilities. We sought to determine whether ICU readmission rates changed after 2003 Accreditation Council for Graduate Medical Education Resident Duty Hours reform (“reform”) and whether there were temporally corresponding changes in other ICU outcomes.

METHODS: We used a difference-in-differences approach using Project IMPACT (Improved Methods of Patient Information Access of Core Clinical Tasks). Piecewise regression models estimated changes in outcomes immediately before and after reform in 274,491 critically ill medical and surgical patients in 151 community and academic US ICUs. Outcome measures included ICU readmission, ICU mortality, and in-hospital post-ICU-discharge mortality.

RESULTS: In ICUs with residents, ICU readmissions increased before reform (OR, 1.5; 95% CI, 1.22-1.84; $P < .01$), and decreased after (OR, 0.85; 95% CI, 0.73-0.98; $P = .03$). This abrupt decline in ICU readmissions after reform differed significantly from an increase in readmissions observed in ICUs without residents at this time (difference-in-differences $P < .01$). No comparable changes in mortality were observed between ICUs with vs without residents.

CONCLUSIONS: The changes in ICU readmission rates after reform, without corresponding changes in mortality, suggest that ICU readmissions are not causally related to other untoward patient outcomes. Instead, ICU readmission rates likely reflect operational aspects of care that are not patient-centered, making them less useful indicators of ICU quality.

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ABBREVIATIONS: IMPACT = Improved Methods of Patient Information Access of Core Clinical Tasks; MPM₀-III = Mortality Prediction Model, version III

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The Centers for Medicare & Medicaid Services evaluated ICU readmissions as a candidate ICU quality indicator¹ based on evidence that readmissions are associated with increased mortality and cost²⁻¹² and because they are presumed to result from “premature” ICU discharge,¹³ bed shortages,^{14,15} or poorly orchestrated handoffs.^{10,16} However, other reports show that while patients discharged when ICUs are more strained have increased odds of ICU readmission, the risk of death is no higher, suggesting that decisions preceding ICU readmissions may not cause the excess mortality with which they are associated.¹⁷⁻¹⁹ Additionally, the performance of ICUs on ICU readmissions is not correlated with performance on other measures of ICU quality, such as mortality or process measures.^{3,18,20-24} These latter observations suggest that ICU readmissions may result from practice variations residing outside the causal pathway to other poor outcomes.^{3,18,25}

Opportunity exists to better address the question of whether ICU readmissions are causally related to downstream outcomes. If a policy change influenced ICU readmission rates, identifying temporal concordance between changes in ICU readmission rates and changes in other outcomes would support a causal association; absence of correspondence would argue against causality. We hypothesized that the 2003 Accreditation Council for Graduate Medical Education (ACGME) Common Program Requirements for Resident Duty Hours reform (“reform”) would provide this opportunity because reform increased handoffs between providers²⁶⁻²⁸ and spurred hospitals to make operational changes potentially impacting readmission rates. Changes included night-float or other cross-coverage systems²⁹ and the addition of ancillary staff such as nurse practitioners and physician assistants to perform tasks formerly performed by residents.³⁰

Materials and Methods

Data Source

We used the Project IMPACT (Improved Methods of Patient Information Access of Core Clinical Tasks) database (Cerner Corp), a voluntary, fee-based, ICU clinical information system used for benchmarking and research.³¹⁻³³ Each participating ICU employs a trained data collector who uses a standardized website-based instrument to collect data regarding individual patients, care processes, and ICU characteristics. IMPACT data have been shown to be highly reliable, and ICUs are largely representative of US ICUs.³² As in prior studies,^{18,19,25,34-36} we used a specially prepared version of this dataset in which ICU and hospital admission and discharge dates and times were available for all patients; more detailed patient data were collected on a random sample of 50% to 100% of patients.

Variables and Eligible Patients

We chose ICU readmission and two measures of mortality to assess ICU quality: ICU mortality and post-ICU-discharge hospital mortality (“postdischarge mortality”).^{12,18,19,35} ICU readmissions included patients readmitted within two calendar days to the ICU from which they were originally discharged. Readmissions to other ICUs may be more likely to be elective³⁵; readmissions after longer intervals are less likely to be related to ICU discharge circumstances.¹⁹ ICU mortality included patients dying during the first ICU admission³⁷; postdischarge mortality included all in-hospital deaths after first ICU discharge, including deaths occurring during subsequent ICU admissions.²⁵

We examined the time period from April 1, 2001, to December 31, 2007 (Fig 1). We excluded ICUs with fewer than 10 patients per year; ICUs contributing data for less than one continuous year; and city, state, and county ICUs, due to small numbers and because previous analyses suggested that outcomes may differ in these types of hospitals.³⁵ For post-ICU-discharge outcomes, we included patients discharged alive from the ICU to ward or step-down units because only these patients were eligible for in-hospital death or readmission. For ICU readmissions, we excluded patients dying on the ward before they could be readmitted and those discharged from the ICU with orders precluding life-sustaining therapies.

The primary exposure was date of ICU admission, modeled as a continuous variable. ICUs were denoted as staffing residents if they staffed residents any time of day. Among 11 ICUs missing data on resident

staffing, we assumed three ICUs in academic hospitals staffed residents. Sensitivity analyses were conducted without this assumption.

Statistical Analysis

We used mixed-effects logistic regression models with ICU-specific random intercepts.³⁸ ICU and patient covariates were included based on previous analyses using Project IMPACT reported in the literature. The complete model building strategy may be viewed in e-Appendix 1.^{18,19,25,34,35} The Mortality Prediction Model, version III (MPM₀-III) was used to model severity of illness at ICU admission.³⁹ Because MPM₀-III is not valid in patients admitted for coronary conditions, cardiac surgery, or burns, they were excluded from the analysis.³⁷ Only first ICU admissions were included because MPM₀-III has not been validated in ICU readmissions.³⁷ The model for ICU mortality omitted variables occurring after first ICU admission.

We used piecewise regression to model how ICU admission date affected outcomes prior to and following reform. Regression line slopes represented changes in the odds of each outcome over that time interval. For all outcomes, we placed a knot on July 1, 2003, the start of reform. To empirically determine the location of other knots, that is, dates on which the rate of change in the odds of each outcome changed, we graphed the date of ICU admission with respect to each outcome variable using a locally weighted, univariable smoothed scatterplot^{40,41} in ICUs with and without residents. We identified four potential knots, then assessed each knot's influence on model fit using backward deletion and likelihood ratio tests.⁴¹ Best fit for mortality outcomes was achieved with one knot at July 1, 2003. ICU readmission required one additional knot on December 31, 2005, which we included in all models to simplify data presentation.

A sensitivity analysis permitting disjointed (nonconnecting) trajectories between time periods yielded similar results (e-Fig 1). Therefore, we present only the primary models' output.

We used a difference-in-differences approach, using interaction terms between resident staffing and ICU admission date to test the hypothesis that patients discharged from ICUs staffed by residents had increased odds of ICU readmission and other outcomes following reform. Wald tests were used to (1) assess whether the slope of each line segment equaled zero (ie, whether the odds of outcomes changed over each time interval), (2) examine whether the rate of change in the odds of an outcome during one time interval equaled the rate of change in adjacent time intervals, and (3) compare whether line trajectories and changes

Project IMPACT database 4/1/2001 – 12/21/2007
158 U.S. ICUs, 351,265 admissions

Exclusion

Figure 1 – Exclusion criteria.
IMPACT = Improved Methods of
Patient Information Access of Core
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Prediction Model, version III.

between adjacent time intervals differed between ICUs with and without residents.⁴¹ Significance of interaction terms was based on a *P* value < .05.⁴²

Finally, to evaluate whether changes in the population of ICUs were responsible for changes in outcomes, we examined the subpopulation

of ICUs admitting at least 10 patients both 1 year prior to and 1 year after reform using conditional logistic regression, conditioning on ICU. All analyses were performed using STATA version 12.1 (StataCorp LP). This project was approved by the University of Pennsylvania (institutional review board, number 812174).

Results

From the full dataset of 351,265 admissions to 158 US ICUs, the eligible sample sizes in 151 ICUs (Fig 1) were 255,476 patients for ICU mortality, 200,147 patients for postdischarge mortality, and 191,550 for ICU readmission. A minority of ICUs (26%) did not staff residents before reform, decreasing to 20% following reform (Table 1).

Among all eligible patients, 21,786 patients (8.1%) died in the ICU. Among patients surviving their first ICU stay, 4,451 (2.3%) had an ICU readmission; 8,158 (4.1%) died in the hospital.

Characteristics of patients and ICUs before and after reform are described in Table 1. There was a small but significant increase after reform in the proportion of nonsurgical patients admitted to the ICU

TABLE 1] Characteristics of Patients and ICUs

Characteristics	Overall		With Residents ^a		Without Residents ^a	
	Prereform	Postreform	Prereform	Postreform	Prereform	Postreform
No. of patients	83,375	172,101	55,962	128,504	31,053	49,465
Patient characteristics						
Race, %						
Black	14.9	13.8	15.2	12.8	15.7	16.0
White	77.4	76.1	76.4	76.7	78.3	77.2
Data missing	7.7	9.6	8.4	10.4	6.0	6.8
Functional status, %						
Independent	76.0	77.2	77.9	77.9	71.4	73.3
Partially dependent	17.3	16.1	16.4	15.5	19.3	19.5
Fully dependent	6.8	6.7	5.6	6.7	9.3	7.3
Insurance, %						
Private	29.9	29.2	30.8	30.1	27.5	26.6
Medicare	53.2	59.0	51.4	48.2	56.8	55.3
Medicaid	6.7	8.9	7.0	9.4	6.2	7.3
Self-pay	7.9	9.0	8.4	9.0	7.0	8.5
Other	2.4	3.0	2.4	3.3	2.6	2.4
Source of ICU admission, %						
ED	41.8	41.3	39.6	39.6	46.9	46.0
Direct admission	4.9	7.0	5.9	7.9	2.6	4.0
Floor/step down	15.8	15.7	16.1	15.6	15.6	16.3
Procedure	33.7	31.6	34.4	31.8	31.2	30.7
Other	3.9	4.5	4.0	5.1	3.7	3.1
Patient type, %						
Elective surgery	24.0	20.7	24.3	20.7	22.8	20.7
Emergency surgery	11.1	12.2	12.1	12.7	8.7	10.5
Medical	64.9	67.1	63.6	66.6	68.6	68.8
Median predicted probability of death, ^b % (IQR)	9.3 (4.5, 16.8)	9.5 (4.8, 17.3)	9.9 (4.6, 17.1)	9.3 (4.7, 17.1)	8.9 (4.5, 15.2)	9.9 (5.2, 18.0)

(Continued)

TABLE 1] (continued)

Characteristics	Overall		With Residents ^a		Without Residents ^a	
	Prereform	Postreform	Prereform	Postreform	Prereform	Postreform
Hospital/ICU characteristics^c						
Hospital has critical care fellowship program	21.5	31.7	32.0	40.7	0.1	4.6
ICU night coverage, %						
Critical care attending	21.4	31.6	15.7	25.6	29.1	43.6
Other attending	32.3	24.4	24.7	23.5	42.1	23.9
Fellow	6.6	8.6	8.1	9.9	2.9	4.3
Resident	29.9	24.5	44.5	32.8	NA	NA
No physician coverage	9.9	10.9	6.9	8.3	25.9	28.2
ICU beds, No.						
4-12	32.3	28.3	25.2	25.5	41.3	36.1
13-15	9.2	12.1	11.8	13.4	5.9	7.3
16-18	25.6	19.3	30.9	20.8	22.2	21.1
19-24	13.2	23.3	9.8	24.0	17.8	18.9
25-66	19.8	17.0	22.3	16.3	12.8	16.6
ICU model, %						
Closed	4.2	8.5	6.1	9.8	0.3	3.9
Mandatory intensivist consult	20.3	30.3	27.5	34.9	10.7	21.0
Optional consult/no consult	75.5	61.3	66.4	55.3	89.0	75.0
Hospital organization, %						
Academic	12.5	28.0	18.6	35.6	0.0	4.1
Community	87.5	72.0	81.4	64.1	100.0	95.9
ICU step-down unit available, %	88.6	87.1	88.2	86.0	90.8	91.7

IQR = interquartile range.

^aWith and without resident categories do not add up to 1, because some ICUs switched classifications.^bOne minus Mortality Prediction Model version III score.^cPercentages of patients in these types of hospitals/ICUs.

TABLE 2] Estimates From Primary Analysis and Sensitivity Analysis Using Conditional Logistic Regression

Outcome Measure	Model	Resident Staffing	04/1/2001-07/1/2003 OR (95% CI); P Value	07/2/2003-12/30/2005 OR (95% CI); P Value	12/31/2005-12/31/2007 OR (95% CI); P Value
ICU readmissions ^a (dichotomous outcome)	Conditional logistic regression	Y	1.53 (1.23, 1.91); <.01	0.85 (0.72, 0.99); .04	1.01 (0.82, 1.26); .9
	Primary approach	N	0.7 (0.5, 0.99); .04	1.39 (1.07, 1.8); .01	0.71 (0.46, 1.1); .13
		Y	1.5 (1.22, 1.84); <.01	0.85 (0.73, 0.98); .03	1 (0.84, 1.2); .97
ICU mortality ^b (dichotomous outcome)	Primary approach	N	0.78 (0.57, 1.07); .13	1.33 (1.04, 1.7); .03	0.76 (0.5, 1.15); .19
		Y	Models did not converge	Models did not converge	Models did not converge
	Conditional logistic regression	N	Models did not converge	Models did not converge	Models did not converge
Postdischarge mortality ^a (dichotomous outcome)	Primary approach	Y	0.92 (0.82, 1.04); .17	1 (0.92, 1.09); .99	1 (0.9, 1.11); .99
		N	0.94 (0.79, 1.13); .52	0.83 (0.72, 0.96); .01	1.06 (0.84, 1.33); .64
	Conditional logistic regression	Y	1.02 (0.86, 1.2); .85	0.95 (0.84, 1.07); .39	0.74 (0.62, 0.89); <.01
		N	1.06 (0.84, 1.35); .62	0.77 (0.64, 0.93); .01	0.99 (0.71, 1.38); .94
	Primary approach	Y	0.97 (0.83, 1.13); .72	0.96 (0.86, 1.08); .52	0.8 (0.69, 0.92); <.01
		N	1.01 (0.8, 1.27); .95	0.74 (0.61, 0.88); <.01	0.96 (0.7, 1.32); .81

MPM₀-III = Mortality Prediction Model version III.

^aModels for ICU readmission and post-ICU discharge in-hospital death were adjusted for patient race (black, white, other); ICU discharge time (6:00 AM-6:00 PM, 6:00 PM-6:00 AM); functional status at ICU admission (independent, partially dependent, fully dependent); patient type (medical, scheduled surgical, unplanned surgical); ICU discharge destination (step-down unit, general care ward); ICU admission source (ED, direct admission from other hospital, general care ward, procedure, other); severity of illness at ICU admission represented by MPM₀-III (log transformed); ICU length of stay (log transformed); patient required vasopressors; patient required mechanical ventilation; code status at ICU discharge (no CPR vs full code); insurance (Medicaid, self-pay, private, other); duration of mechanical ventilation (log transformed); chronic GI disease; chronic cardiovascular disease; chronic respiratory disease; baseline creatinine level > 2.0 mg/dL; requires dialysis; chronic immunosuppression; hematologic malignancy/lymphoma; cancer with proven metastasis; solid organ tumor; number of comorbidities (log transformed); hospital location (urban, rural, suburban, age group (<65, 65-74, 75-84, 85+ y); diagnosis group (respiratory arrest/failure, cardiac arrest/failure, sepsis, surgical emergency, postoperative observation, hemorrhage, neurologic/neurosurgical, metabolic/renal, other); ICU census on the day of admission/discharge, sex.

^bModel for ICU mortality was adjusted for patient race (black, white, other); ICU admission time (6:00 AM-6:00 PM, 6:00 PM-6:00 AM); functional status at ICU admission (independent, partially dependent, fully dependent); patient type (medical, scheduled surgical, unplanned surgical); ICU admission source (ED, direct admission from other hospital, general care ward, procedure, other); severity of illness at ICU admission represented by MPM₀-III (log transformed); insurance (Medicaid, self-pay, private, other); chronic GI disease; chronic cardiovascular disease; chronic respiratory disease; baseline creatinine > 2.0 mg/dL; requires dialysis; chronic immunosuppression; hematologic malignancy/lymphoma; cancer with proven metastasis; solid organ tumor; number of comorbidities (log transformed); hospital location (urban, rural, suburban, age group (<65, 65-74, 75-84, 85+ y); diagnosis group (respiratory arrest/failure, cardiac arrest/failure, sepsis, surgical emergency, postoperative observation, hemorrhage, neurologic/neurosurgical, metabolic/renal, other); ICU census on the day of admission/discharge, sex.

Changes in the outcome measures over time

ICUs staffing residents - - - - -

ICUs not staffing residents —————

1) Significant decline or increase over that time period *

2) Significant change in trajectory from previous time period at that knot X

3) Significant difference in trajectory displayed between ICUs with and without residents

4) Significant difference in change in trajectory between ICUs with and without residents at that inflection point #

Figure 2 – Changes in odds of ICU mortality, ICU readmission, and post-ICU discharge in-hospital death were adjusted for patient race (black, white, other); ICU discharge time (6:00 AM-6:00 PM, 6:00 PM-6:00 AM); functional status at ICU admission (independent, partially dependent, fully dependent); patient type (medical, scheduled surgical, unplanned surgical); ICU discharge destination (step-down unit, general care ward); ICU admission source (ED, direct admission from other hospital, general care ward, procedure, other); severity of illness at ICU admission represented by MPM₀-III (log transformed); ICU length of stay (log transformed); patient required vasopressors; patient required mechanical ventilation; code status at ICU discharge (no CPR vs full code); insurance (Medicare, Medicaid, self-pay, private, other); duration of mechanical ventilation (log transformed); ICU has critical care fellowship program (yes/no); hospital organization (academic, community); nighttime

(67.1% vs 64.9%) and no change in predicted probability of death (9.3% vs 9.5%). A greater proportion of ICUs used a closed staffing model after reform (8.5% vs 4.2%), and were located in academic hospitals (28.0% vs 12.5%).

Effects of Work-Hour Reform on ICU Readmissions

Before reform (April 1, 2001, to July 1, 2003), the odds of ICU readmission increased in ICUs with residents (OR, 1.50; 95% CI, 1.22-1.84; $P < .01$) (Fig 2, Table 2), with no corresponding increase in ICUs without residents ($P = .13$). There was a significant downward deflection in the trajectory of change in ICU readmission odds in ICUs with compared with ICUs without residents on July 1, 2003 (difference-in-differences $P < .01$). After reform (July 1, 2003, to December 31, 2005), the odds of ICU readmission decreased in ICUs with residents (OR, 0.85; 95% CI, 0.73-0.98; $P = .03$), and increased in ICUs without residents (OR, 1.33; 95% CI, 1.04-1.70; $P = .03$).

Effects of Work-Hour Reform on Mortality

Before reform, ICU mortality did not change in ICUs with ($P = .17$) or without residents ($P = .52$). After reform, ICU mortality decreased in ICUs without residents (OR, 0.83; 95% CI, 0.72-0.96; $P = .01$); but not in ICUs with residents ($P = .99$). There was no difference in the effect of reform on the rate of change in ICU mortality between ICUs with and without residents (difference-in-differences $P = .22$). ICU mortality did not change over the study period as a whole (April 1, 2001, to December 31, 2007) in ICUs with residents ($P = .22$) or without ($P = .11$).

Before reform, postdischarge mortality did not change in ICUs with ($P = .72$) or without residents ($P = .95$). After reform, postdischarge mortality decreased (OR, 0.74; 95% CI, 0.61-0.88; $P < .01$) in ICUs without residents, but not in ICUs with residents ($P = .52$). There was no difference in the effect of reform on the rate of change of postdischarge mortality between ICUs with and without residents ($P = .16$). Postdischarge mortality declined 35% (OR, 0.75; 95% CI, 0.63-0.89;

$P < .01$) and 39% (OR, 0.71 (95% CI, 0.52-0.98; $P = .04$) over the study period as a whole (April 1, 2001, to December 31, 2007) in ICUs with and without residents, respectively.

Sensitivity Analyses

Restricting the sample to ICUs contributing patients both before and after reform did not change results (Table 2). Results also did not change substantively when resident staffing was not inferred from academic medical center status among ICUs missing these data.

Discussion

In this study, we hypothesized that the policy change of residency work-hour reform would independently influence ICU readmission rates, enabling tests of whether exogenously induced changes in readmissions were accompanied by changes in other outcomes. We found that reform was, indeed, associated with changes in ICU readmission rates. The fact that ICUs without residents did not experience comparable changes in ICU readmissions over this time period suggests that this relationship may be causal.

Despite these policy-induced changes in readmissions, contemporary changes in other outcomes did not manifest. The odds of postdischarge death declined both in ICUs that staffed residents and in those that did not. Decreases in ICU mortality after reform occurred only among ICUs without residents and, therefore, were not attributable to reform; ICU mortality did not change in ICUs with residents over this time period. Our findings are consistent with studies showing that in-hospital outcomes for patients in the ICU improved over this time period independent of work-hour reforms.⁴³⁻⁵⁴ Taken together, these results support the view that an ICU's readmission rate reflects operational policies or practice variation not in the causal pathway to mortality. This conclusion is supported by complementary data indicating that the readmission rate of an ICU is uncorrelated with performance on other measures of ICU quality.^{3,18,20,22,24,25}

staffing (critical care attending, other attending, fellow, resident, no physician staffing); ICU model (closed, open with mandatory intensivist consultation, open with optional intensivist consultation, or no intensivist available); hospital has burn unit, transplant; or cardiac surgery available (yes/no); hospital uses hospitalists (yes/no); an ICU step-down unit is available (yes/no); number of hospital beds (quintiles); and number of ICU beds (quintiles). Model for ICU mortality was adjusted for patient race (black, white, other); ICU admission time (6:00 AM-6:00 PM, 6:00 PM-6:00 AM); functional status at ICU admission (independent, partially dependent, fully dependent); patient type (medical, scheduled surgical, unplanned surgical); ICU admission source (ED, direct admission from other hospital, general care ward, procedure, other); severity of illness at ICU admission represented by MPM₀-III (log transformed); insurance (Medicare, Medicaid, self-pay, private, other); ICU has critical care fellowship program (yes/no); hospital organization (academic, community); nighttime staffing (critical care attending, other attending, fellow, resident, no physician staffing); ICU model (closed, open with mandatory intensivist consultation, open with optional intensivist consultation, or no intensivist available); hospital has burn unit, transplant, or cardiac surgery available (yes/no); hospital uses hospitalists (yes/no); an ICU step-down unit is available (yes/no); number of hospital beds (quintiles), and number of ICU beds (quintiles). Models treated ICU as a random intercept. See Figure 1 for expansion of abbreviation.

This study has limitations. First, although we measured the temporal association of ICU readmission with the initiation of work-hour reform, we have only basic data regarding staffing changes implemented by specific ICUs to accommodate these requirements, and no data describing policy or process changes taking place over this period of time. Therefore, this study cannot determine which operational changes contributed to changes in ICU readmission rates.

Second, in ICUs without residents, ICU readmissions appear inversely correlated with mortality in the period of time following reform; however, it is unlikely that work-hour reform itself caused these changes, since these ICUs lack residents entirely. It is possible that unmeasured secular changes influenced outcomes in these ICUs; however, given the lack of a parallel association in ICUs with residents, any evidence that increases in ICU readmission caused decreases in mortality in ICUs without residents is weak at best.

Third, ICUs voluntarily participate in Project IMPACT,³² and those that do may have a greater investment in patient safety than nonparticipating ICUs. Given the difference-in-differences approach we used, this should not threaten the internal validity of the results, but may limit generalizability. Nonetheless, Project IMPACT contains data on a large and diverse sample of US ICUs; more diverse samples presently do not exist. Project

IMPACT does not include outcomes subsequent to hospital discharge, which could influence observed in-hospital outcomes.⁵⁵ However discharge locations were stable over time, limiting the influence of this potential bias.

Finally, our severity adjustment for patients discharged from ICUs was limited to severity of illness at ICU admission and proxies for severity of illness at ICU discharge, such as duration of mechanical ventilation and whether patients had do-not-resuscitate orders in place at ICU discharge. However, the direction of bias attributable to suboptimal severity adjustment would likely be similar over the study period and nondifferential across ICUs. Thus, this limitation is unlikely to have altered our main results.

Conclusions

The 2003 ACGME Resident Duty Hours Reform provided a natural experiment that showed that policy changes in hospitals and ICUs led to decreases in ICU readmission rates accompanied by no change in mortality. This suggests that ICU readmissions are not in the causal pathway to mortality and, instead, may reflect operational practices not impacting overall quality of ICU or hospital care. This finding complements several other recent studies questioning the utility of ICU readmissions as an ICU quality indicator. Future studies are needed to determine which measurable features of ICU care truly reflect ICU quality.

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