The Impact of Resident Duty Hour Reform on Hospital Readmission Rates Among Medicare Beneficiaries

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BACKGROUND: A key goal of resident duty hour reform by the Accreditation Council for Graduate Medical Education (ACGME) in 2003 was to improve patient outcomes.

OBJECTIVE: To assess whether the reform led to a change in readmission rates.

DESIGN: Observational study using multiple time series analysis with hospital discharge data from July 1, 2000 to June 30, 2005. Fixed effects logistic regression was used to examine the change in the odds of readmission in more versus less teaching-intensive hospitals before and after duty hour reform.

PARTICIPANTS: All unique Medicare patients (n = 8,282,802) admitted to acute-care nonfederal hospitals with principal diagnoses of acute myocardial infarction, congestive heart failure, gastrointestinal bleeding, or stroke (combined medical group), or a DRG classification of general, orthopedic, or vascular surgery (combined surgical group).

MAIN MEASURES: Primary outcome was 30-day all-cause readmission. Secondary outcomes were (1) readmission or death within 30 days of discharge, and (2) readmission, death during the index admission, or death within 30 days of discharge.

KEY RESULTS: For the combined medical group, there was no evidence of a change in readmission rates in more versus less teaching-intensive hospitals [OR = 0.99 (95% CI 0.94, 1.03) in post-reform year 1 and OR = 0.99 (95% CI 0.95, 1.04) in post-reform year 2]. There was also no evidence of relative changes in readmission rates for the combined surgical group: OR = 1.03 (95% CI 0.98, 1.08) for post-reform year 1 and OR = 1.02 (95% CI 0.98, 1.07) for post-reform year 2. Findings for the secondary outcomes combining readmission and death were similar.

CONCLUSIONS: Among Medicare beneficiaries, there were no changes in hospital readmission rates associated with resident duty hour reform.

KEY WORDS: education, medical, graduate; hospital; readmission.

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INTRODUCTION

One of the intended goals of resident duty hour reform, instituted by the Accreditation Council for Graduate Medical Education (ACGME) on July 1, 2003, was to improve outcomes of care¹. Critics of the new policy, however, were concerned that the potential for discontinuous care and frequent hand-offs would adversely affect patient outcomes^{2–4}. Earlier work from our group and others has shown no consistent effect from the reform on a variety of measures, including mortality^{5–7}, patient safety indicators⁸, the probability of a prolonged length of stay⁹, and mortality and failure-to-rescue in high-risk patients¹⁰. Slight improvements in mortality outcomes were observed only in certain subsets of patients^{6,7}.

In this study, we sought to measure the impact of the reform on another quality measure: hospital readmission. Readmissions occur frequently in US hospitals, account for substantial costs, and are thought to reflect poor transitions between care settings¹¹. While research to identify patient characteristics that predict readmission has been only moderately successful, other work has shown substandard care and insufficient discharge planning to be risk factors for unplanned readmission^{12–19}. Strategies to improve care transitions and reduce readmissions include coordinating post-hospital care, performing medication reconciliation, and engaging patients and their families in care management²⁰.

We hypothesized that readmission rates for Medicare patients hospitalized for medical and surgical conditions would increase in association with the reform. After implementation of resident duty hour reform, more frequent hand-offs between residents may have resulted in less familiarity with patients, compromising quality of care, particularly at the time of discharge. A “covering” resident, who is tasked with discharging a patient she has never met, may be less well

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equipped than the “primary” resident to carry out the aforementioned strategies that are key to a safe care transition, thereby increasing the patient’s risk for readmission. In order to test our hypothesis, we compared trends in risk-adjusted, all-cause readmission rates among more versus less teaching-intensive hospitals to examine whether readmission rates changed differentially among these groups before and after the duty hour rules went into effect.

METHODS

Approval for this study was obtained from the institutional review boards of the University of Pennsylvania and The Children’s Hospital of Philadelphia, Philadelphia, PA.

Study Sample

The study sample was comprised of all Medicare patients admitted to short-term, acute-care, general US nonfederal hospitals from July 1, 2000 to June 30, 2005, with a principal diagnosis of acute myocardial infarction (AMI), stroke, gastrointestinal bleeding, or congestive heart failure (CHF) or with a diagnostic related group (DRG) classification of general, orthopedic, or vascular surgery. Details of the sample have been previously reported⁵. In this study, we examined data on 8,282,802 patients in 3,321 hospitals.

Each patient in the sample had a single index admission randomly selected from all admissions during the study period for one of the aforementioned diagnoses and for which there were no admissions in the prior 30 days. A 30-day look-back was instituted to ensure that readmissions were not selected as index admissions, which otherwise might have skewed readmission rates. We chose a single admission for each patient to ensure independence for the statistical tests we used. For index admissions during which there was a transfer of care from one hospital to another, the principal diagnosis was obtained from the second hospitalization since it was the hospitalization from which the patient was discharged and, therefore, was most relevant to the associated readmission.

The primary measure of teaching intensity was the resident-to-bed ratio (RB ratio), calculated as the number of interns plus residents divided by the mean number of operational beds in the year prior to the reform^{5,6,21–23}. Teaching hospitals were defined as those hospitals with RB ratios of more than 0. For the purposes of our analysis, we used the RB ratio as a continuous variable, which provided more power for assessing associations with duty hour rule implementation^{24,25}. We held the RB ratio fixed using the level in pre-reform year 1 so that any potential behavioral response to the reforms by hospitals (such as changing the number of residents) would not confound the net effects of duty hour reform.

Outcome Measures

The main outcome measure was all-cause readmission within 30 days of hospital discharge for all patients discharged alive after admission with a principal diagnosis of AMI, stroke, gastrointestinal bleeding, CHF, or after admission for general, orthopedic, or vascular surgery. Secondary outcomes included two composite measures of readmission and mortality. The first

was all-cause readmission or death within 30 days of hospital discharge. The second was all-cause readmission, death during the index admission, or death within 30 days of discharge. For this outcome, the denominator was expanded to include patients who died during the index admission. These composite measures of readmission and mortality were designed to ensure that the quality of hospitals with low readmission rates but high mortality rates would not be overstated, as it might if measured on the readmission outcome alone.

For all outcome measures, readmission was generally defined as “all-cause” (i.e., any diagnosis). However, we did use International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes to exclude some readmissions that were felt to have been scheduled or clearly unrelated to quality of care during the index admission. The excluded readmissions included rehabilitation, hospice, after-care, and—following index admissions for AMI—readmissions for percutaneous intervention or coronary artery bypass graft surgery (see [Appendix](#) for a list of these codes).

Risk Adjustment and Hospital Control Measures

We applied the risk-adjustment approach developed by Elixhauser et al.,^{26,27} which uses 27 comorbidities (excluding fluid and electrolyte disorders and coagulopathy, diagnoses that may indicate complications rather than comorbidities)^{28,29} and has been shown to achieve better discrimination than alternative approaches^{30,31}. This approach was augmented with adjustments for age and sex, as well as for source of admission (e.g., nursing home) and if the index admission was the result of a transfer from another hospital, as ascertained by admission source and discharge destination codes. For surgical patients, we also adjusted for DRGs, grouping paired DRGs with and without complications or comorbidities into one aggregated DRG to avoid adjusting for potentially iatrogenic events. We performed a 180-day look-back, including data from prior hospitalizations, to obtain more comprehensive information on comorbidities than available using the index admission alone³².

Statistical Analysis

We used a multiple time series research design,³³ also known as “difference-in-differences,” to examine whether the implementation of duty hour reform was associated with a change in the readmission outcomes, an approach that reduces potential biases from unmeasured variables^{34,35}. This research design compares each hospital to itself, before and after reform, contrasting the changes in hospitals with more residents to those in hospitals with fewer or no residents, while adjusting for observed differences in patient risk factors and trends in outcomes over time that were common to all hospitals. The advantages and limitations of this design have been previously reported^{5,6}.

Less teaching-intensive hospitals, including all non-teaching hospitals, served as the primary control group for more teaching-intensive hospitals because they were less affected by duty hour reform but were subject to the same technological quality improvement imperatives, changes in market conditions, and Medicare-specific initiatives such as pay-for-performance. In addition, they are geographically diverse with large patient

Table 1. Characteristics of Included Hospitals

Resident-to-bed ratio, category (range)					
	Nonteaching (0)	Very minor teaching (>0–0.049)	Minor teaching (0.050–0.249)	Major teaching (0.250–0.599)	Very major teaching (0.600–1.090)
No. (%) of facilities	2,298 (69.2)	308 (9.3)	411 (12.4)	195 (5.9)	109 (3.3)
No. (%) of admissions	3,904,248 (49.7)	1,146,205 (14.6)	1,674,348 (21.3)	751,873 (9.6)	372,520 (4.8)

Note: Percentages may not total 100 due to rounding. Included 3,321 facilities and 8,282,802 admissions

populations and similar patient discharge data. Data from July 1, 2000–June 30, 2003 were used as the pre-reform period (referred to as pre-reform years 3, 2, and 1 in chronological order), and data from July 1, 2003–June 30, 2005 served as the post-reform period (referred to as post-reform years 1 and 2).

The dependent variables were readmission within 30 days of hospital discharge and death (as described above), using logistic regression to adjust for patient comorbidities, secular trends affecting all patients (e.g., due to general changes in technology), and hospital-specific fixed effects. The change in outcomes associated with duty hour reform was measured using the coefficients of the RB ratio interacted with dummy variables indicating post-reform year 1 and post-reform year 2. These coefficients, presented as odds ratios (OR), measure the degree to which readmission rates changed in more versus less teaching-intensive hospitals after adjusting for cross-sectional differences in hospital quality and general improvements in care. They were measured for each year separately because of the possibility of either delayed beneficial effects or early harmful effects. Conditions were assessed for all medical patients as a group and all surgical patients as a group.

Baseline readmission levels were allowed to differ between more and less teaching-intensive hospitals and were initially assumed to have a common time trend until implementation of the duty hour rules, after which the teaching hospital trend was

allowed to diverge. Because we noted some divergent time trends prior to the reform, post-reform results were compared to the pre-reform year 1 (July 1, 2002–June 30, 2003) as a baseline, rather than using data from the entire 3-year pre-reform period as the baseline.

To provide examples of the magnitude of the observed odds ratios in hospitals with different degrees of teaching intensity, we converted the regression coefficients into estimated probabilities of readmission for an average patient by using the mean values for each of the covariates and replacing hospital indicators by the RB ratio. The examples compared hospitals with RB ratios of 1 and 0.

We tested the stability of the results by (1) eliminating patients admitted to hospitals in New York State, due to earlier passage of the Libby Zion laws; (2) removing comorbidity adjustment to determine whether changes in the reporting of the ICD-9-CM coded comorbidities could explain the observed effects; (3) expanding the definition of index admission to include admissions preceded (within 30 days) by hospitalizations for dissimilar diagnoses; (4) removing adjustments for nursing home admission source and transfer into the index admission, as these variables might mediate any effect of duty hours reform on readmissions; (5) adding the adjustment for index admission discharge “against medical advice,” which might either confound or mediate any effect of duty hours reform on readmissions.

Table 2. Characteristics of the Study Population

	Pre-reform year			Post-reform year	
	3 (2000–2001)	2 (2001–2002)	1 (2002–2003)	1 (2003–2004)	2 (2004–2005)
Medical conditions					
Acute myocardial infarction					
No. of cases	152,910	153,741	159,167	159,466	152,001
Unadjusted readmission rate, %	19.8	19.1	18.5	18.1	17.8
Stroke					
No. of cases	153,325	149,454	148,237	145,574	138,895
Unadjusted readmission rate, %	15.8	15.7	15.2	15.3	15.6
Gastrointestinal bleeding					
No. of cases	132,671	134,252	139,694	145,917	140,337
Unadjusted readmission rate, %	15.1	14.6	14.1	13.9	13.8
Congestive heart failure					
No. of cases	247,538	237,258	251,637	255,014	247,952
Unadjusted readmission rate, %	24.1	23.2	21.9	21.3	21.0
Surgical categories					
General surgery					
No. of cases	329,010	314,289	312,171	310,889	299,854
Unadjusted readmission rate, %	11.9	12.0	11.9	12.0	12.2
Orthopedic surgery					
No. of cases	485,608	482,616	504,827	532,163	545,699
Unadjusted readmission rate, %	9.9	9.9	9.6	9.5	9.4
Vascular surgery					
No. of cases	61,678	58,283	57,006	55,857	54,204
Unadjusted readmission rate, %	20.0	19.9	19.4	18.8	18.9

Note: Included 7,849,194 patients (discharged alive) from 3,321 hospitals. Pre-reform and post-reform years are academic years (e.g., pre-reform year 3 indicates academic year July 1, 2000 to June 30, 2001)

All p-values are two-tailed. A p-value of <0.05 was considered statistically significant. All analyses were conducted with SAS 9.1 (SAS Institute, Inc., Cary, NC).

RESULTS

Approximately 69% of the hospitals (with nearly 59% of the index admissions) were non-teaching, and about 9.2% of hospitals (with 14.4% of the index admissions) were major or very major teaching hospitals (Table 1). The number of admissions for each of the conditions changed modestly over the 5-year study period,

Figure 1. Unadjusted trends in readmission rates by hospital teaching intensity. Note: The Accreditation Council for Graduate Medical Education duty hour regulations were implemented on July 1, 2003. Pre-reform year 3 included academic year 2000–2001 (July 1, 2000–June 30, 2001); pre-reform year 2, academic year 2001–2002; pre-reform year 1, academic year 2002–2003; post-reform year 1, academic year 2003–2004; and post-reform year 2, academic year 2004–2005. Readmission rates in hospitals of different teaching intensity changed at different rates before the onset of the duty hour reform (by Wald chi-squared test; $P = 0.005$ for combined medical group and $P = 0.001$ for combined surgical group). Unadjusted readmission rates were highest in the major and very major teaching hospitals ($P < 0.0001$).

Table 3. Adjusted Odds of Readmission After Duty Hour Reform in More Versus Less Teaching-intensive Hospitals

	Resident-to-bed ratio $\times$ postreform year 1	Resident-to-bed ratio $\times$ postreform year 2
	Odds ratio (95% CI)	Odds ratio (95% CI)
Combined medical group		
Readmission	0.99 (0.94–1.03)	0.99 (0.95–1.04)
Readmission or post-discharge death	1.01 (0.96–1.05)	1.01 (0.97–1.06)
Readmission, death during index admission, or post-discharge death	0.99 (0.96–1.03)	1.02 (0.98–1.06)
Combined surgical group		
Readmission	1.03 (0.98–1.08)	1.02 (0.98–1.07)
Readmission or post-discharge death	1.03 (0.99–1.08)	1.04 (0.99–1.09)
Readmission, death during index admission, or post-discharge death	1.03 (0.99–1.08)	1.02 (0.98–1.07)

Note: The interaction terms (resident-to-bed ratio $\times$ post-reform year 1 and resident-to-bed ratio $\times$ post-reform year 2) measure whether there is any relative change in the odds of the readmission outcomes in more versus less teaching-intensive hospitals. Models are also adjusted for age, sex, comorbidities, common time trends, hospital site where treated, source of admission (e.g., nursing home), and transfer into the index admission. Units for odds ratios compare hospitals with a resident-to-bed ratio of 1 with hospitals with a resident-to-bed ratio of 0 (nonteaching). Results were all $P > 0.05$. CI, confidence interval

and the unadjusted readmission rates were similar to rates reported in other readmissions studies (Table 2)¹¹.

For the combined medical group, unadjusted readmission rates were highest in the major and very major teaching hospitals (Fig. 1). Unadjusted readmission rates for the medical group declined over time at a similar rate for hospitals in all teaching categories. For the combined surgical group, unadjusted readmission rates also were highest in the major and very major teaching hospitals (Fig. 1). The trends in unadjusted readmission rates for the surgical group were variable over time, with no obvious differences between hospital teaching categories. Cross-sectional, adjusted analyses confirmed that readmission rates were highest in the major and very major teaching hospitals for both the medical and surgical groups. In the final regression models for both the medical and surgical groups, index admissions from the emergency department and from a nursing home were both predictive of increased odds of readmission (versus admission from clinic).

In risk-adjusted analyses of the combined medical group, there was no evidence of a relative increase or decrease in the odds of readmission in more versus less teaching-intensive hospitals in either post-reform year 1 [OR 0.99 (95% CI 0.94, 1.03)] or post-reform year 2 [OR 0.99 (95% CI 0.95, 1.04)] (Table 3). For the combined surgical group, risk-adjusted analyses also revealed no significant increase or decrease in the odds of readmission in either post-reform year 1 [OR 1.03 (95% CI 0.98, 1.08)] or post-reform year 2 [OR 1.02 (95% CI 0.98, 1.07)]. There also was no change after the reform in the odds of either of the composite readmission and mortality outcomes for either the combined medical or surgical groups.

Neither excluding patients admitted to hospitals in New York State nor expanding the inclusion criteria for index

admissions to include those with prior, unrelated admissions affected the results. Further, there were no significant changes in readmission rates with the addition of discharge “against medical advice” to the risk-adjustment model or with the removal of comorbidities, nursing home admission source, or transfer into the index admission from that model.

To illustrate the magnitude of the changes in readmission rates associated with duty hour reform, we used mean values of all regression covariates to estimate the adjusted risk of readmission for a hypothetical patient at a nonteaching hospital (RB ratio 0) and at a very major teaching hospital (RB ratio 1) before and after the reform (Fig. 2). In the combined medical group, the estimated probability of readmission in the nonteaching hospital decreased 0.5 percentage points (17.5% in pre-reform year 1 versus 17.0% in post-reform year 2), whereas it decreased 0.7 percentage points (from 20.6% to 19.9%) in the very major teaching hospital, representing a comparative decrease of 0.2 percentage points (1.0% relative decrease). For a patient in the combined surgical group, the probability of readmission in the nonteaching hospital decreased from 10.1% in pre-reform year 1 to 10.0% in post-reform year 2, while it increased in very major

teaching hospitals from 12.5% to 12.7%, representing a comparative increase of 0.3 percentage points (2.4% relative increase).

DISCUSSION

In this national study of Medicare patients, readmission rates neither improved nor worsened in association with ACGME duty hour reform. Any potential adverse consequences of the reform on continuity of care did not lead to observable changes in readmission rates for either medical or surgical patients. These findings were robust to the use of composite measures of readmission and mortality, changes in patient selection criteria, and alterations in severity adjustment.

We had hypothesized that readmission rates would increase in teaching hospitals following the duty hour reform because the increased frequency of handoffs would adversely affect continuity of care during index admissions. As a result, quality of care, and in particular effective discharge planning, would suffer. The link between readmission rates and the quality of hospital care has been debated^{12,36}. But recent work has pointed to the role of inadequate discharge planning and poor coordination of post-discharge care in readmissions^{11,18}. In addition, several trials of improved services around the time of patient discharge have reduced readmission rates^{37–39}.

The fact that readmission rates did not increase in teaching hospitals in the 2 years after the reform is encouraging; however, there are several other possible explanations for our findings. First, physician familiarity with patients at discharge may have minimal influence on the overall quality of the discharge process and therefore on the likelihood of readmission. Second, there are other factors that are part of the care transitions process and that might influence the risk of readmission, such as adequate social support and timely primary care follow-up^{40,41}. But the extent to which factors like these can be ensured by inpatient physicians, regardless of the level of their continuity of care, may be somewhat limited. Third, disruptions in continuity of care caused by the work hour rules may have been mitigated by alternative work force resources, such as increased presence of attending physicians. Fourth, residents are still permitted to work 30 consecutive hours, allowing them to participate in the morning discharge process. Fifth, the deleterious effects of increasing care handoffs may have been offset by the beneficial effects of reducing resident fatigue. Lastly, lack of compliance in the first year of the duty hour rules has been reported and would have undermined the reform's effect on outcomes⁴².

Our study is the first to examine the association between duty hour reform and hospital readmissions on a national scale. Two prior studies reported no change in readmission rates, but these analyses were limited to single institution experiences^{43,44}.

Our results add to the evidence that the reform in 2003 did not generally improve or worsen patient outcomes. Some critics have argued that the regulations, and resulting disruptions in continuity of care, would worsen patient outcomes. These data suggest that outcomes neither suffered as feared, nor improved as intended, after the reform. The fact that the reform has, to date, failed to accomplish one of its original objectives (to improve outcomes) should be

Figure 2. Estimated probability of readmission for an average patient in hospitals of different teaching intensity for combined medical and surgical groups. Note: Plots show the adjusted risk of readmission for a hypothetical patient at hospitals with RB ratios of 1 (very major teaching hospital) and 0 (nonteaching hospital), using mean values of all the covariates.

factored into current deliberations on how to refine or extend the regulations⁴⁵.

Our study has limitations. We only evaluated Medicare fee-for-service beneficiaries, and therefore the results may not be generalizable to other populations. As with any observational study of this type, there may be unmeasured confounders. However, by comparing outcomes over time within each hospital, in more versus less teaching-intensive hospitals, potential bias from unmeasured cofounders is diminished. Our ability to adjust for differences in the severity of illness (i.e., risk of readmission) using administrative data is limited, but our difference-in-differences analysis essentially treated each hospital as its own control, factoring out inter-hospital differences in ICD-9-CM coding practices and severity of illness that were consistent over time.

In conclusion, our study showed that the ACGME duty hour rules had no systematic impact on readmission rates among Medicare fee-for-service patients admitted for major medical conditions or surgical procedures. Despite this finding, potential future disruptions in continuity of care resulting from further contemplated duty hour reform remain a valid concern⁴⁶. Our findings may provide reassurance that recent reforms have not had an adverse effect on quality of care, but they also underscore the importance of continued monitoring to identify which approaches to duty hour regulation are most likely to improve patient outcomes in the future.

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APPENDIX

Appendix 1: ICD-9-CM codes for excluded readmissions

1. Either primary diagnosis of any of the following ICD-9-CM V codes (aftercare) or primary diagnosis ICD-9-CM code 438 (late effects code) and secondary diagnosis of any of the following V codes:
 - a. V52.xx Fitting and adjustment of prosthetic device and implant
 - b. V53.xx Fitting and adjustment of other device
 - c. V54.xx Other orthopedic aftercare
 - d. V55.xx Attention to artificial openings
 - e. V56.xx Encounter for dialysis and dialysis catheter care
 - f. V57.xx Care involving the use of rehabilitation procedures
 - g. V58.0 Radiotherapy
 - h. V58.11 Encounter for antineoplastic chemotherapy
 - i. V58.12 Encounter for antineoplastic immunotherapy
 - j. V58.3x Attention to dressings and sutures
 - k. V58.41 Encounter for planned postoperative wound closure
 - l. V58.42 Aftercare, surgery, neoplasm
 - m. V58.43 Aftercare, surgery, trauma
 - n. V58.44 Aftercare involving organ transplant
 - o. V58.49 Other specified aftercare following surgery
 - p. V58.7x Aftercare following surgery
 - q. V58.81 Fitting and adjustment of vascular catheter
 - r. V58.82 Fitting and adjustment of non-vascular catheter
 - s. V58.83 Monitoring therapeutic drug
 - t. V58.89 Other specified aftercare
2. DRG code 462 (rehabilitation)
3. Primary diagnosis ICD-9-CM code V66 (hospice)
4. Readmissions following acute myocardial infarction index admissions with: Procedure codes 00.66, 36.01, 36.02, 36.05, 36.06, 36.07 (PCI) or 36.10–36.16 (CABG), unless the principal diagnosis is 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 428.xx (heart failure), 410.xx except 410.x2 (AMI), 411.xx (unstable angina), 427.xx except 427.5 (arrhythmia), or 427.5 (cardiac arrest)⁴⁷