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Prolonged Hospital Stay and the Resident Duty Hour Rules of 2003

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Abstract

Background—Resident duty hour reforms of 2003 had the potential to create a major impact on the delivery of inpatient care.

Objective—We examine whether the reforms influenced the probability of a patient experiencing a prolonged hospital length of stay (PLOS), a measure reflecting either inefficiency of care or the development of complications that may slow the rate of discharge.

Research Design—Conditional logistic models to compare PLOS in more versus less teaching-intensive hospitals before and after the reform, adjusting for patient comorbidities, common time trends, and hospital site.

Subjects—Medicare (N=6,059,015) and Veterans Affairs (VA) (N=210,276) patients admitted for medical conditions (acute myocardial infarction, heart failure, stroke or gastrointestinal bleeding) or surgical procedures (general, orthopedic, and vascular) from July, 2000 to June, 2005.

Measures—Prolonged Length of Stay (PLOS)

Results—Modeling all medical conditions together, the odds of prolonged stay in the first year post reform at more versus less teaching intensive hospitals was 1.01 (95% CI 0.97, 1.05) for Medicare and 1.07 (0.94, 1.20) for the VA. Results were similarly negative in the second year post reform. For “combined surgery” the post-year 1 odds ratios were 1.04 (0.98, 1.09) and 0.94 (0.78, 1.14) for Medicare and the VA respectively, and similarly unchanged in post-year 2. Isolated increases in the probability of prolonged stay did occur for some vascular surgery procedures.

Conclusions—Hospitals generally found ways to cope with duty hour reform without increasing the prevalence of prolonged hospital stays, a marker of either inefficient care or complications.

Keywords

Prolonged Length of Stay; Teaching Hospitals; Difference-In-Differences

INTRODUCTION

The change in resident duty hour rules introduced in July of 2003 had the potential to have a tremendous impact on the way teaching hospitals deliver care. Hospitals that depended on residents prior to 2003 often were required to deliver care effectively with fewer resident FTEs after the reform since each resident’s allowable work hours were reduced.^{1, 2} Many observers predicted that care would suffer because of the increased number of handoffs between resident teams, and because of a potential change in the culture of being a resident (where responsibility for a patient would now change to accommodate a “shift mentality”).^{3–5} On the other hand, some argued, as did the Accreditation Council for Graduate Medical Education (ACGME), that reduced sleep deprivation would improve patient outcomes and more than offset the potentially disruptive elements of the reform.⁶

In an earlier set of studies, as part of the ongoing “Resident Duty Hours Study” (RDHS), we have reported that there was, at worst, no increase in mortality post reform in the Medicare system, and at best, some modest improvement in mortality in Veterans Affairs (VA) hospitals for selected medical conditions.^{7, 8} However, while 30-day mortality is considered a valid measure of hospital quality, it is not the only relevant measure to assess the impacts of resident hour reform. Many have suggested that non-mortality based measures be reported to obtain a more accurate picture of the true impact of the reform.^{9, 10} In this study we examined how the probability of prolonged hospital stay, a length of stay measure, was affected by the reform. As will be explained, prolonged stay may be especially sensitive to disruptions caused by the duty hour rules because this measure focuses on potential inefficiencies in care and on complications that prolong care—both of which have been suggested as potential unintended consequences of the new duty hour rules.

We examined the impact of duty hour reform on the probability of prolonged length of stay as a proxy for changes in continuity and efficiency of care in a panel of five years of data among both Medicare patients and patients treated at VA hospitals nationally.

METHODS

Approval was obtained for this study from the Institutional Review Boards of the Philadelphia Veterans Affairs Medical Center, the University of Pennsylvania, and The Children’s Hospital of Philadelphia.

Patients and Design

Details of the patient selection for the Resident Duty Hour Study (RDHS) have been described previously.^{7, 8} In short, the study included patients admitted from July 1, 2000, to

June 30, 2005, to acute care hospitals in both the non-Federal (“Medicare”) and Veterans Affairs hospital systems with a principal diagnosis of acute myocardial infarction (AMI), stroke, gastrointestinal bleeding, congestive heart failure (CHF), or a diagnosis-related group (DRG) indicating general surgery, orthopedic surgery, or vascular surgery. The initial sample included 12,052,344 Medicare patients from 5,736 acute care hospitals that contributed data for all 5 years within the 50 states or Washington, DC, and 459,391 patients in 132 VA hospitals. After excluding patients admitted to hospitals that closed during the study period, patients missing important demographic data, patients less than 66 or more than 90 years of age, patients enrolled in Medicare HMOs, and hospital admissions after the first for each patient, the study included 6,059,015 Medicare patients and 210,276 VA patients.

Prolonged Stay (Definition and Motivation)

The concept of prolonged stay^{11, 12} comes from an empirical observation that as patients stay longer in the hospital, their daily rate of discharge at first increases and then declines—i.e., after a time, “the longer you have stayed, the longer you will stay.” In the early part of a hospital course, discharge rates are often increasing. At a certain point in the length of stay distribution, the rate of discharge declines. Prolongation signifies the beginning of the deceleration in the discharge rate; it does not signify an inappropriate or atypical stay. Prolongation indicates that patients who stayed beyond this point were likely to stay even longer, perhaps because the patient developed a complication or perhaps because routine care for this patient was beginning to unravel. As seen in earlier work¹¹ and as reported here, prolonged patients have a higher frequency of complications and Agency for Healthcare Research and Quality (AHRQ) Patient Safety Indicators (PSIs).^{13, 14} “Prolonged” is not a normative term: high quality care may require some, perhaps even most, patients to have a prolonged stay. Prolonged refers specifically to a decelerating discharge rate: before prolongation, each passing day brings a patient closer to discharge; after prolongation, each passing day predicts an even longer stay. Hollander and Proschan^{15, 16} defined a test statistic (“New-Worse-Than-Used Test” or “HP” test) that tests for prolongation with a view to engineering applications. We use the HP test to identify for each principal procedure and condition that time when the discharge rates begin to decline, calling the identified time the “prolongation” point. Specifically, the prolongation point is defined as the day after the Hollander-Proschan statistic becomes significant. A patient’s hospital stay is considered prolonged if it exceeds the prolongation point.^{11, 12}

The concept of prolonged stay has several properties that make this a useful outcome for evaluating potential effects from the change in regulations governing resident duty hours. A prolonged stay may be a consequence of either patient complications or disorganization in care delivery. Both of these factors tend to slow the discharge rate, and both could result from resident duty hour restrictions. Therefore, a prolonged stay may indicate that a problem has occurred with the patient, so that a relative increase in the odds of prolonged stays in more vs. less teaching intensive hospitals in conjunction with duty hour reform may suggest worsening in either the rate of complications or the efficiency of care (or both). Furthermore, prolonged stay, unlike a complication measure, does not depend on the assignment of a specific ICD-9-CM code associated with a complication, and therefore is less susceptible to bias due to differential recording of complications.¹⁷ Finally, by counting early deaths among the prolonged, we do not credit a hospital with efficiency when an early death occurs. In contrast, it is more difficult to appropriately distinguish efficiency and mortality when length of stay, rather than prolongation, is the outcome.

For each procedure and condition under study, we determined the prolongation points for Medicare and VA patients separately, and hospitalizations were defined as prolonged if they exceeded these points. For all models, we calculated the prolongation point based on data

from the year prior to reform (“Pre-1”) and utilized this prolongation point for all years. We tested for differences in the prolongation points over different years, and found that almost all conditions and procedures yielded similar points over all years of the study, with the exception of above-the-knee amputation in the VA hospitals, where we utilized a prolongation point based on the entire 3 year pre-reform period to stabilize the estimate due to low numbers.

Figure 1 illustrates the concept that patients who have prolonged lengths of stay have lower probabilities of discharge per day than patients with shorter lengths of stay, using the example of congestive heart failure (CHF) patients in the VA system. The prolongation point for CHF was 3 days. In Figure 1, Kaplan-Meier plots depict the time to discharge for overlapping groups of patients. The first group, Prolongation+0 days, consists of all patients who stayed in the hospital beyond the prolongation point (i.e., 3 days), and the curve describes additional time beyond 3 days until discharge. For all patients staying beyond the prolongation point, the average additional length of stay was 8.8 days, so that the entire length of stay averaged $3+8.8=11.8$ days in total. The second group, Prolongation+4 days, refers to the subset of prolonged patients who stayed beyond 7 ($=3+4$) days, and the curve describes the additional time beyond 7 days until discharge. Of those patients who stayed at least 4 days beyond the prolongation point, the average number of days remaining to discharge was 14.2 days, so that the entire length of stay averaged $21.2 (=3+4+14.2)$ days in total. This curve falls above the first group because the rate of discharge is lower in the second group. There are similar curves for Prolongation+8 and Prolongation+12. For those staying at least 8 days beyond the prolongation point, the average number of additional days remaining before discharge was 19.8 days, or $30.8 (=3+8+19.8)$ total days in hospital. Again, this third curve falls above the second because the rate of discharge in this third group is lower than that in the second group. Finally, for those staying at least 12 days beyond the prolongation point, the average days remaining before discharge was 25.5 days, or a total length of stay of $40.5 (=3+12+25.5)$ days in the hospital. As the prolongation point represents a transition point from accelerating to decelerating discharge that is held fixed, we ask whether the change in resident work hours changed the probability of a prolonged stay. We counted early deaths occurring before the prolongation point as being prolonged to avoid mislabeling these early deaths as reflecting efficient care. In a stability analysis in which we performed identical modeling but without recoding early deaths as being prolonged, we found similar results.

Defining Teaching Intensity Using the RB Ratio

In this study, as in our previous work,^{7, 8} and studies by others^{18–20} we utilize the Resident-to-Bed (RB) ratio as a measure of teaching intensity. The RB ratio is defined as the total number of residents at a hospital divided by the hospital’s average daily census (ADC), as reported to Medicare using Medicare Cost Reports. Typically, RB ratios are classified as follows: $RB = 0$ (non-teaching); $0 < RB < 0.05$ (very minor teaching); $.05 \leq RB < 0.25$ (minor teaching); $0.25 \leq RB < 0.6$ (major teaching hospitals); and $RB \geq 0.6$ (very major teaching hospitals).

Statistical Models

To study how the resident duty hour rules influenced the probability of a prolonged stay, we utilized a difference-in-difference approach parallel to our earlier work on mortality.^{7, 8} We present an overall model for medical conditions and a separate model for surgical procedures. For medical conditions we modeled acute myocardial infarction (AMI), congestive heart failure (CHF), stroke and gastrointestinal bleeding (GI bleed). For surgical procedures we examined the 3 most common procedures in general, orthopedic or vascular surgery in the VA and Medicare systems, and included the union of these procedures. In

each model we included terms for age, sex, transfer-in status, and patient comorbidities using definitions based on Elixhauser²¹ but we also utilized a 6 month look-back to better find previous comorbidities. As conditional logistic regression was utilized adjusting on the hospital, the patient severity adjustment needed only to identify changes in patient characteristics within the same hospital when comparing the pre to post reform periods. This is a far easier task than adjusting for patient severity across hospitals. We also included in the overall models a term for the patient's principal diagnosis or procedure. To model the effects of the duty hour reform, we included in the model a variable for the year of admission ("pre-3" or 3 years before the duty hour change), pre-2, pre-1 (the reference group), post-1 and post-2. These year indicators were interacted with the resident to bed ratio including pre-3 ("pre-3*RB"), pre-2*RB, post-1*RB and post-2*RB. The terms post-1*RB and post-2*RB reflect the main results of our study, and can be interpreted as follows: A significantly positive coefficient suggests that hospitals with higher RB ratios tended to have increased odds of prolonged stay (PLOS) after the reform compared to a baseline of pre-1. We used conditional logistic regression to adjust for both patient risk factors and the unchanging characteristics of each hospital. Conditional logistic regression has the advantage of allowing hospitals with very few or no prolonged-stay patients to be included in the model, whereas a standard fixed effects model cannot include hospitals with too few, or zero, prolonged-stay patients. We expect the duty hour reform to have had the greatest impact on hospitals with the highest RB ratio. Hospitals that had lower teaching intensity (including non-teaching hospitals) served as a control for temporal changes affecting all hospitals, including those of higher teaching intensity.

RESULTS

Description of Patient Population and Hospitals

Patient characteristics by diagnosis and procedure for both the Medicare and VA samples are shown in Table 1. Medicare patients were older and generally had slightly more comorbidities than the VA patients. As expected, the VA sample was comprised almost entirely of male patients, and the Medicare sample had a majority of female patients, although there was some variation across procedures. There was a great difference in the resident-to-bed (RB) ratio distribution between Medicare and VA hospitals. As described in Table 2, comparing medical facilities, approximately 3.3% of Medicare hospitals were considered to be "very major teaching" institutions whereas 30.5% were "very major" teaching hospitals in the VA system.

Construct Validity of PLOS

For surgical patients we asked whether being prolonged would increase the odds of developing a complication²² during the hospitalization, and we also asked whether being prolonged would increase the odds of developing at least one AHRQ Patient Safety Indicator (PSI)^{13, 14, 23} event for both surgical and medical patients. For surgical patients in the Medicare program, 25.6% of those whose stays were not prolonged had complications whereas 53.4% of those whose stays were prolonged had complications (OR = 3.3 [95% CI 3.2, 3.4]). Furthermore, 0.6% of surgical patients whose stays were not prolonged had one or more PSIs whereas 3.3% of patients whose stays were prolonged had at least one PSI (OR = 5.48 [95% CI 5.3, 5.6]). For medical patients, the corresponding estimates were 0.13% and 1.08%, respectively (OR = 8.3 [95% CI 7.8, 8.8]). Our results were similar when we deleted the PSIs of pressure ulcer, selected (largely vascular catheter-associated) infections, and pulmonary embolus or deep vein thrombosis, all of which may result from prolonged hospitalization with immobility. The odds ratios for VA patients were also almost identical. For surgical patients in the VA system, 20.6% of those whose stays were not prolonged had complications whereas 49.8% of patients whose stays were prolonged had complications

(OR = 3.8 [95% CI 3.7, 4.0]). Furthermore, 0.79% of VA surgical patients whose stays were not prolonged had one or more PSIs whereas 4.5% of patients whose stays were prolonged had at least one PSI (OR = 5.95 [95% CI 5.2, 6.8]). For VA medical patients, the corresponding estimates were 0.12% and 0.95%, respectively (OR = 7.86 [95% CI 5.6, 11.0]).

Unadjusted Probability of a Prolonged Hospital Stay

With a few exceptions, the probability that a patient's stay exceeded the prolongation point for each condition and procedure in the study was similar for Medicare and VA patients (Table 3). For example, a stay for AMI, CHF, stroke, or GI bleed was considered prolonged if it exceeded 3 days for both the VA and Medicare. There was considerably more variation across surgical procedures in the prolongation point, but again, the prolongation points were very similar between Medicare and VA patients. In general, the probability of having a prolonged stay was slightly higher in the Medicare population than in the VA population, despite a similar point that defined a prolonged stay. Figure 2 displays the relationship between these unadjusted probabilities of being prolonged and teaching intensity for the combined medical conditions and the combined surgical procedures for both the Medicare and VA populations. There was a general time trend that showed diminishing probabilities of being prolonged across all teaching intensity groups, with no pronounced shifts in the patterns after the introduction of the resident duty hour rule changes in July 2003.

Adjusted Analyses

The main results of the study are indicated by the post-reform year 1 and post-reform year 2 interaction terms with RB ratio shown in Table 4. These terms provide us with a formal test of how the odds of experiencing a prolonged length of stay changed over time in more vs. less teaching intensive hospitals after adjusting for patient covariates within each hospital.

For medical conditions we found little or no change in the odds of having a prolonged hospital stay associated with the duty hour regulations at more versus less teaching intensive hospitals. In the Medicare population, there were no significant changes in either post-reform year 1 or 2, and in the VA hospitals, only GI bleeding displayed an increase in the odds of prolonged stay in post-reform year 1, which reverted to no significant change by post-reform year 2.

A slightly different story emerged in surgical cases. Overall, for both Medicare and VA populations, in the combined surgical group (including general surgical, orthopedic and vascular surgical cases), there was no significant increase in the odds of having a prolonged stay at more versus less teaching intensive hospitals in either year 1 or year 2 post-reform. However, there were some selected procedures for which the odds of having a prolonged stay increased more at teaching-intensive hospitals, but most of these findings were not significant. In the Medicare population, right hemicolectomy was associated with prolonged stay in post-reform year 1 with an odds ratio of 1.30 (95% CI = 1.09, 1.56), but this effect decreased to a non-significant odds ratio of 1.02 in post-reform year 2. For vascular surgery in Medicare patients, there was a strong trend toward more prolonged stays in post-reform year 1, and this trend reached significance in post-reform year 2, with an odds ratio of 1.21 (95% CI = 1.04 to 1.40). In the VA population, we also observed similar associations for vascular surgery, although smaller sample sizes contributed to a general lack of statistical significance. When all surgeries were combined into one analysis, we did not see significant changes in the odds of prolonged hospital stay for either the Medicare or VA populations.

Stability Analyses

To determine whether our main results were stable under alternate definitions of PLOS, we developed two different definitions of PLOS and re-ran all models using these definitions. The first was a new prolongation point that was twice the old point. The second definition used 7 days after the prolongation point. For both of these definitions, the prevalence of PLOS declined in each model since a longer stay was required to define a prolongation (see electronic Appendix). Results were generally similar for all three definitions. We report in Table 5 results for medical and surgical outcomes for the Medicare and VA populations using the original prolongation point (PP), a definition using twice the value of PP (PPx2) and finally PP plus 7 days (PP+7). As can be seen, there was no consistent pattern of increased prolongation at teaching intensive hospitals after duty hour change using any prolongation point definition.

To further explore the stability of our conclusions, we also examined conditional length of stay (CLOS) before and after the ACGME duty hour reforms.^{11, 12} We defined CLOS as the conditional probability of staying one more week in the hospital, given having passed the prolongation point, as previously defined. This analysis addresses whether the change in resident hour rules influenced the probability of staying one more week after already being a PLOS patient. CLOS is therefore a test of how well hospitals handle their more complex patients.^{11, 12} As shown in Table 6, the probability of staying a week beyond the prolongation point among those who had prolonged stays did not change at teaching intensive hospitals after the duty hour reforms were initiated. Table 6 displays these results for the combined medical and combined surgical groups for both Medicare and the VA.

Finally, we reran all combined medical and surgical analyses using a definition of prolonged stay that did not recode an early death as being prolonged and found our results to be unchanged for both the Medicare and VA populations (results available upon request).

DISCUSSION

Did the change in regulation of resident duty hours disrupt patient care? In previous work, there was little indication that it affected patient survival.^{7, 8, 24} We now report the results of our examination of a measure of consequential but non-lethal disruption, namely the chance of a prolonged stay. The prolongation point is the day when the discharge rate starts to decelerate. Prolonged stays may result from complications that occur in the hospital, from inefficiencies in care, from high levels of acuity, or from various combinations of these events. Did prolonged stays become more or less common at teaching-intensive hospitals once resident duty hours were restricted? Some have argued that worse continuity of care would be disruptive, and logically could lead to longer stays.^{3–5} Others have suggested that reduced duty hours would increase the workload of residents when they were on call, possibly leading to longer stays because of increased errors or omissions.²⁵ Still others have argued that more alert residents may commit fewer errors and potentially increase the discharge rate, thereby shortening length of stay.⁶

The good news from this study was that when analyzing prolonged stay we generally found results consistent with our previous mortality findings. Overall, the resident duty hour regulations of 2003 do not appear to have unfavorably changed the processes of care that lead to prolonged stays. Although some further investigation may be warranted for vascular surgery, our findings should provide reassurance that in both the non-Federal and VA hospital systems, the typical hospital had the resilience to provide services with similar efficiency despite major changes in staffing and care models that accompanied these regulatory shocks.

There are limitations to this report. Although we report on a large sample size based on administrative data, we lack detailed clinical data that may be present in the chart but not available to us for modeling. Furthermore, the VA experience may not be generalizable to the rest of the population because of differences between the VA patient population and the general US population (as was observed in Table 2) and because VA hospitals are much more teaching intensive than non-VA hospitals. However, we examined the VA system precisely because it is so resident intensive, and for this reason examined in parallel Medicare patients cared for at any acute care hospital across the country, which are representative of the US healthcare system. Furthermore, we were not able to evaluate potential mediators of the impact of the resident duty hour reforms, such as the adoption of hospitalist models or changes in nurse staffing that were intended to compensate for the reduced availability of resident physician.

Further work will be required to better understand how hospitals successfully adapted to these changes, since there will, no doubt, be future calls for further changes in the workforce that cares for inpatients throughout the country. While the duty hour reforms of 2003 did not appear to have great impact on the probability of prolonged stays, we don't know whether this is because there was a counterbalancing of the beneficial effects of reduced sleep deprivation^{25–27} with the detrimental effects of worsened continuity^{28, 29} or increased work intensity.²⁵ The design of the duty hour reforms still allowed acute sleep deprivations as residents could work 30 hours in a row²⁵ and this may have contributed to the lack of observed changes in outcomes. Some hospitals reacted to the duty hour reforms by providing other caregivers to fill the gap left by the reduction in resident hours.²⁹ Future study and testing of different approaches to duty hour reform will be needed to determine how to optimize patient safety and the efficiency of care—and to determine whether these reforms have other indirect effects on our health care system, the education of our healthcare professionals, and the health and satisfaction of our patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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FIGURE 1. Conditional Length of Stay after being prolonged for Congestive Heart Failure Admissions at the Veterans Affairs Hospitals

For a typical condition, like the example shown below for CHF, the rate of discharge increases until a point in the hospital stay defined as the “prolongation point.”¹¹ For CHF the prolongation point was day 3, hence patients were considered prolonged if they exceeded a 3-day stay. Hospitals stays beyond the prolongation point display a declining rate of discharge, as displayed below. Each Kaplan-Meier curve below is based on a cohort of patients still in the hospital beyond the prolongation point, with successive curves starting at 0, 4, 8 and 12 days beyond the prolongation point. Patients who have stayed beyond the prolongation point (starting at “Prolongation + 0 days”) have a discharge curve below those who have stayed beyond the “Prolongation + 4 days” curve, suggesting the rate of discharge in the group staying at least 4 days beyond the prolongation point is lower than the group that has stayed just beyond the prolongation point. This represents the clinical situation where, after being prolonged, “the longer one has stayed, the slower one will be discharged or the longer one will stay.” After the prolongation point, each successive cohort beyond the prolongation point (that is, +4, then +8, then +12) will display curves below one another, implying a declining rate of discharge.

Figure 2.
Prolonged Stay for Medicare and VA Patients by Teaching Status by Year for Combined Medical Conditions and Combined Surgical Procedures

Table 1

Patient characteristics by diagnosis and procedure

	Number of Patients		Age (mean)		Mean Number of Comorbidities		Percentage male	
	Medicare	VA	Medicare	VA	Medicare	VA	Medicare	VA
Medical								
AMI	970,184	32,170	77.34	66.92	1.92	2.00	51.64%	99%
Stroke	933,225	25,385	78.44	68.06	2.07	1.91	42.27%	98%
GI bleed	763,765	36,035	78.46	66.87	2.55	2.33	43.89%	98%
CHF	1,196,294	50,266	78.61	69.66	2.56	2.49	44.21%	98%
Surgical								
Laparoscopic Cholecystectomy (G)	298,108	7,174	75.80	60.35	1.82	1.38	39.31%	91%
Right Hemicolectomy (G)	166,283	6,500	76.99	68.86	2.23	2.00	43.15%	98%
Sigmoidectomy (G)	103,952	4,232	75.86	64.80	1.95	1.58	40.11%	98%
Cholecystectomy (G)	83,172	4,576	76.38	64.39	1.90	1.61	50.96%	96%
Total Knee Replacement (O)	651,708	13,658	74.46	65.20	1.54	1.13	35.41%	96%
Open Reduction of Fracture with Internal Fixation, Femur (O)	300,713	3,850	81.24	72.70	2.31	2.08	25.26%	97%
Total Hip Replacement (O)	317,561	8,158	75.47	63.09	1.51	1.14	36.30%	96%
Excision Intervertebral Disc (O)	94,577	7,053	73.36	52.65	1.35	0.75	48.62%	95%
Resection of Vessel with Replacement, Aorta, Abdominal (V)	63,995	2,524	75.33	69.81	2.00	1.89	75.31%	99%
Endovascular Implantation of Graft in Abdominal Aorta (V)	43,856	1,927	76.26	71.30	2.10	1.91	82.87%	100%
Amputation Above Knee (V)	31,890	1,689	79.28	71.28	3.90	3.13	46.06%	99%
Aorta-Iliac-Femoral Bypass (V)	25,354	2,907	73.46	61.47	2.39	1.93	59.89%	99%
Toe Amputation (V)	14,378	2,172	79.28	65.57	3.46	2.56	58.19%	99%

Table 2

Hospital Characteristics: Resident-to-Bed Ratio

	Non-teaching (0)		Very Minor/Minor Teaching(>0& <0.25)		Major Teaching (≥0.25 & <0.6)		Very Major Teaching (≥0.6)	
	Medicare	VA	Medicare	VA	Medicare	VA	Medicare	VA
Medical								
N(%) of facilities	2294 (69.2%)	19 (14.5%)	719 (21.7%)	32 (24.4%)	195 (5.9%)	40 (30.5%)	109 (3.3%)	40 (30.5%)
N(%) of admissions	2,039,412 (52.8%)	8,043 (5.6%)	1,324,792 (34.3%)	23,998 (16.7%)	345,115 (8.9%)	58,262 (40.5%)	154,149 (4.0%)	53,553 (37.2%)
Surgical								
N(%) of facilities	2,253 (68.8%)	10 (8.3%)	719 (22.0%)	31 (25.6%)	194 (5.93%)	40 (33.1%)	108 (3.30%)	40 (33.1%)
N(%) of admissions	1,111,135 (50.6%)	912 (1.4%)	800,316 (36.5%)	8,539 (12.9%)	192,751 (8.8%)	28,849 (43.4%)	91,345 (4.2%)	28,120 (42.3%)

Table 3

Prolongation Points and Percentage of Patients with Prolonged Hospital Stays by Conditions and Procedures

	Prolongation Point (Hosp. Day Number)	Prolongation Point (Hosp. Day Number)	Percent Prolonged	Percent Prolonged
Conditions and Procedures	Medicare	VA	Medicare	VA
Medical				
AMI	3	3	79.7	75.4
Stroke	3	3	78.9	76.4
GI bleed	3	3	56.1	53.1
CHF	3	3	66.0	62.6
Surgical				
Laparoscopic Cholecystectomy	2	2	66.6	57.5
Right Hemicolectomy	6	6	65.7	71.9
Sigmoidectomy	6	6	72.5	74.0
Open Cholecystectomy	5	5	66.3	66.7
Total Knee Replacement	4	5	44.1	38.6
Open Reduction Femur Fx w/Int Fix	4	7	76.3	62.6
Total Hip Replacement	4	5	48.2	47.7
Excision Intervertebral Disc	2	2	38.6	42.6
Resection Abdominal Aorta	6	6	70.2	71.5
End Graft Abdominal Aorta	2	3	44.8	55.7
Above-the-Knee Amputation	5	14	81.6	44.6
Aorta-Iliac-Femoral Bypass	6	6	65.4	67.4
Toe Amputation	6	7	56.9	61.1

⁺The prolongation points refer to data from the academic year 2002–2003. We used the following ICD9 codes to define our surgical groups: General Surgery: Sigmoidectomy (4576); Laparoscopic Cholecystectomy (5123); Right Hemicolectomy (4573); Cholecystectomy (5122); Orthopedic Surgery: Total Knee Replacement (8154); Total Hip Replacement (8151); Open Reduction of Fracture with Internal Fixation, Femur (7935); Excision of Intervertebral Disc (8051); Vascular Surgery: Resection of Vessel with Replacement, Aorta, Abdominal (3844); Endovascular Implantation of Graft in Abdominal Aorta – Endovascular repair of abdominal aortic aneurysm with graft, Stent graft(s) (3971); Amputation Above Knee (8417); Aorta-Iliac-Femoral Bypass (3925); Toe Amputation (8411).

Table 4

Odds of Prolonged Stay Post Duty Hour Reform in More vs. Less Teaching Intensive Hospitals using Conditional logistic regression controlling for each hospital

Patient categories (Number of Cases Medicare/VA)	RB ratio × post-reform year 1 OR (95%CI)		RB ratio × post-reform year 2 OR (95% CI)	
Medical Conditions	Medicare	VA	Medicare	VA
Stroke (933,225/25,385)	1.01 (0.92, 1.10)	0.92 (0.66, 1.27)	1.01 (0.92, 1.10)	0.95 (0.69, 1.31)
AMI (970,184/32,170)	1.01 (0.93, 1.10)	0.96 (0.72, 1.29)	1.06 (0.97, 1.15)	0.96 (0.72, 1.28)
GI bleed (763,765/36,035)	1.06 (0.97, 1.16)	1.26 (1.00, 1.58)*	1.09 (1.00, 1.20)	1.08 (0.86, 1.36)
CHF (1,196,294/50,266)	0.99 (0.92, 1.06)	1.11 (0.92, 1.35)	1.02 (0.95, 1.10)	1.18 (0.97, 1.43)
Combined Medical (3,863,468/143,856)	1.01 (0.97, 1.05)	1.07 (0.94, 1.20)	1.04 (0.99, 1.08)	1.05 (0.93, 1.19)
Surgical Conditions				
General Surgical Conditions				
Laparoscopic Cholecystectomy (G) (298,108/7,174)	1.09 (0.91, 1.30)	0.85 (0.51, 1.43)	1.09 (0.90, 1.30)	1.11 (0.67, 1.82)
Right Hemicolectomy (G) (166,283/6,500)	1.30 (1.09, 1.56)*	1.55 (0.84, 2.86)	1.02 (0.85, 1.23)	1.37 (0.75, 2.49)
Sigmoidectomy (G) (103,952/4,232)	0.90 (0.69, 1.17)	1.43 (0.66, 3.09)	0.94 (0.72, 1.23)	0.81 (0.38, 1.76)
Cholecystectomy (G) (83,172/4,576)	1.13 (0.86, 1.49)	0.89 (0.47, 1.72)	0.95 (0.72, 1.26)	0.95 (0.49, 1.84)
Surgical combined (651,515/22,482)	1.09 (0.99, 1.21)	1.07 (0.79, 1.43)	0.94 (0.85, 1.05)	1.02 (0.76, 1.36)
Orthopedic Conditions				
Total Knee Replacement (O) (651,708/13,658)	1.07 (0.96, 1.18)	0.64 (0.41, 1.02)	0.98 (0.88, 1.08)	0.73 (0.47, 1.14)
Open Reduction of Fracture with Internal Fixation, Femur (O) (300,713/3,850)	0.97 (0.81, 1.17)	2.18 (0.82, 5.82)	0.88 (0.73, 1.06)	1.57 (0.59, 4.19)
Total Hip Replacement (O) (317,561/8,158)	1.04 (0.91, 1.18)	0.74 (0.40, 1.36)	0.94 (0.82, 1.08)	1.15 (0.63, 2.08)
Excision Invert Disc (O) (94,577/7,053)	1.29 (1.00, 1.66)	0.68 (0.28, 1.64)	1.15 (0.89, 1.49)	0.78 (0.33, 1.83)
Orthopedic combined (1,364,559/32,719)	1.03 (0.96, 1.11)	0.82 (0.61, 1.12)	0.95 (0.88, 1.02)	1.04 (0.77, 1.41)
Vascular Conditions				
Resection of Vessel with Replacement, Aorta, Abdominal (63,995/2,524)	1.33 (1.01, 1.74)*	1.07 (0.31, 3.70)	1.44 (1.08, 1.91)*	1.43 (0.42, 4.87)
Endovascular Implantation of Graft in Abdominal Aorta (43,856/1,927)	1.20 (0.93, 1.54)	0.41 (0.09, 1.88)	1.16 (0.91, 1.48)	1.26 (0.32, 4.92)
Amputation Above Knee (31,890/1,689)	0.95 (0.55, 1.64)	1.00 (0.32, 3.13)	1.18 (0.67, 2.08)	0.48 (0.14, 1.72)
Aorta-Iliac-Femoral Bypass (25,354/2,907)	1.12 (0.72, 1.73)	1.97 (0.67, 5.79)	1.52 (0.97, 2.38)	1.22 (0.41, 3.68)
Toe Amputation (14,378/2,172)	1.46 (0.84, 2.51)	1.31 (0.44, 3.88)	1.47 (0.84, 2.56)	1.13 (0.33, 3.89)
Vascular Combined (179,473/11,219)	1.16 (1.00, 1.34)	1.08 (0.66, 1.77)	1.21 (1.04, 1.40)*	1.16 (0.71, 1.91)
Combined Surgical				
(2,195,547/66,420)	1.04 (0.98, 1.09)	0.94 (0.78, 1.14)	0.96 (0.91, 1.01)	1.00 (0.83, 1.21)

* = P<0.05 Adjustment variables include: Age, Male, Transfer-In; Congestive Heart Failure; Valvular Disease; Pulmonary Circulation Disease; Peripheral Vascular Disease; Hypertension; Paralysis; Other Neurological Disorders; Chronic Pulmonary Disease; Diabetes w/o Chronic Complications; Diabetes w/ Chronic Complications; Hypothyroidism; Renal Failure; Liver Disease; Peptic Ulcer Disease; Acquired Immune Deficiency Syndrome; Lymphoma; Metastatic Cancer; Solid Tumor w/o Metastasis; Rheumatoid Arthritis/Collagen Vascular Disease; Obesity; Weight Loss; Chronic Blood Loss Anemia; Deficiency Anemias; Alcohol Abuse; Drug Abuse; Psychoses; Depression; and each individual hospital.

Table 5

Odds of Prolonged Stay Post duty hour Reform in More vs. Less Teaching Intensive Hospitals using Conditional logistic regression controlling for each hospital (PLOS using original Prolongation Point (PP), Twice the PP (PPx2) & 7 days added to the PP (PP+7)).

Patient categories N=Number of Cases: Medicare/VA n = Num. cases prolonged: Medicare/VA	RB ratio × post-reform year 1 OR (95%CI)		RB ratio × post-reform year 2 OR (95% CI)	
	Medicare	VA	Medicare	VA
Stroke (N= 933,225 / 25,385)				
PP (n= 736,902 / 19,410)	1.01 (0.92, 1.10)	0.92 (0.66, 1.27)	1.01 (0.92, 1.10)	0.95 (0.69, 1.31)
PPx2 (n= 401,204 / 8,280)	0.97 (0.91, 1.04)	1.01 (0.74, 1.38)	0.93 (0.87, 1.10) ^a	0.83 (0.60, 1.14)
PP+7 (n= 332,991 / 5,824)	1.02 (0.95, 1.09)	1.07 (0.75, 1.52)	0.96 (0.89, 1.03)	0.93 (0.66, 1.33)
AMI (N= 970,184 / 32,170)				
PP (n= 773,465 / 24,251)	1.01 (0.93, 1.10)	0.96 (0.72, 1.29)	1.06 (0.97, 1.15)	0.96 (0.72, 1.28)
PPx2 (n= 345,817 / 9,460)	0.96 (0.89, 1.03)	1.10 (0.83, 1.45)	0.92 (0.86, 1.00) ^a	0.98 (0.74, 1.31)
PP+7 (n= 251,129 / 6,622)	0.96 (0.88, 1.04)	1.38 (1.01, 1.89) ^a	0.93 (0.86, 1.01)	0.99 (0.71, 1.38)
GI Bleed (N= 763,765 / 36,035)				
PP (n= 428,457 / 19,144)	1.06 (0.97, 1.16)	1.26 (1.00, 1.58) ^a	1.09 (1.00, 1.20)	1.08 (0.86, 1.36)
PPx2 (n= 120,959 / 5,552)	1.18 (1.05, 1.33) ^b	1.25 (0.91, 1.71)	1.04 (0.92, 1.17)	1.22 (0.89, 1.69)
PP+7 (n= 84,774 / 3,862)	1.14 (0.99, 1.30)	1.37 (0.94, 1.98)	1.00 (0.87, 1.15)	1.05 (0.71, 1.54)
CHF (N= 1,196,294 / 50,266)				
PP (n= 789,573 / 31,450)	0.99 (0.92, 1.06)	1.11 (0.92, 1.35)	1.02 (0.95, 1.10)	1.18 (0.97, 1.43)
PPx2 (n= 264,539 / 10,139)	1.00 (0.91, 1.09)	1.20 (0.95, 1.52)	1.04 (0.95, 1.17)	1.05 (0.83, 1.33)
PP+7 (n= 183,120 / 6,754)	0.98 (0.89, 1.08)	1.15 (0.87, 1.51)	1.07 (0.97, 1.18)	0.93 (0.70, 1.24)
Combined Medical (N=3,863,468 / 143,856)				
PP (n= 2,728,397 / 94,255)	1.01 (0.97, 1.05)	1.07 (0.94, 1.20)	1.04 (0.99, 1.08)	1.05 (0.93, 1.19)
PPx2 (n= 1,132,519 / 33,341)	1.01 (0.97, 1.05)	1.13 (0.98, 1.30)	0.98 (0.94, 1.02)	1.01 (0.88, 1.17)
PP+7 (n= 852,014 / 23,062)	1.01 (0.97, 1.05)	1.21 (1.03, 1.42) ^a	0.99 (0.95, 1.03)	0.98 (0.83, 1.16)
General Surgery (N=651,515 / 22,482)				
PP (n= 433,353 / 14,979)	1.09 (0.99, 1.21)	1.07 (0.79, 1.43)	0.94 (0.85, 1.05)	1.02 (0.76, 1.36)
PPx2 (n= 130,292 / 4,232)	1.08 (0.95, 1.23)	1.18 (0.82, 1.72)	1.08 (0.95, 1.24)	0.95 (0.65, 1.38)
PP+7 (n= 74,884 / 2,773)	1.06 (0.91, 1.24)	1.17 (0.75, 1.84)	1.05 (0.90, 1.23)	0.90 (0.57, 1.42)
Orthopedic (N= 1,364,559 / 32,719)				
PP (n= 706,271 / 14,577)	1.03 (0.96, 1.10)	0.82 (0.61, 1.12)	0.94 (0.88, 1.01)	1.04 (0.77, 1.41)
PPx2 (n= 204,871 / 2,098)	1.11 (1.02, 1.21) ^a	1.21 (0.63, 2.30)	0.95 (0.87, 1.04)	1.52 (0.80, 2.88)
PP+7 (n= 129,708 / 1,402)	1.12 (1.00, 1.24) ^a	1.86 (0.86, 4.02)	0.91 (0.82, 1.01)	2.03 (0.93, 4.39)
Vascular (N= 179, 473 / 11,219)				
PP (n= 108,215 / 6,291)	1.16 (1.00, 1.34)	1.08 (0.66, 1.77)	1.21 (1.04, 1.40) ^a	1.16 (0.71, 1.91)
PPx2 (n= 39,145 / 1,853)	1.02 (0.86, 1.21)	1.11 (0.57, 2.15)	1.03 (0.87, 1.23)	1.45 (0.74, 2.83)

Patient categories N=Number of Cases: Medicare/VA n = Num. cases prolonged: Medicare/VA	RB ratio × post-reform year 1 OR (95%CI)		RB ratio × post-reform year 2 OR (95% CI)	
	Medicare	VA	Medicare	VA
PP+7 (n= 33,504 / 1,704)	0.95 (0.79, 1.15)	0.95 (0.48, 1.87)	1.01 (0.83, 1.22)	1.50 (0.75, 3.00)
Combined Surgical (N=2,195,547 / 66,420)				
PP (n= 1,259,989 / 36,477)	1.04 (0.98, 1.09)	0.94 (0.78, 1.14)	0.96 (0.91, 1.01)	1.00 (0.83, 1.21)
PPx2 (n= 374,308 / 8,183)	1.06 (0.99, 1.13)	1.22 (0.91, 1.62)	0.98 (0.92, 1.05)	1.12 (0.84, 1.50)
PP+7 (n= 238,096 / 5,879)	1.04 (0.97, 1.13)	1.22 (0.88, 1.71)	0.95 (0.88, 1.03)	1.12 (0.80, 1.57)

^a
p<0.05

^b
p<0.01

^c
p<0.001

^d
p<0.0005

^e
p<0.0001

Table 6

Odds of Conditional Length of Stay (CLOS) 7 Days After Being Prolonged Post Duty Hour Reform in More vs. Less Teaching Intensive Hospitals using Conditional logistic regression controlling for each hospital.

Patient categories (Number of Cases Medicare/VA)	RB ratio × post-reform year 1 OR (95%CI)		RB ratio × post-reform year 2 OR (95% CI)	
	Medicare	VA	Medicare	VA
Combined Medical (n=2,728,397 / 71,193)	1.01 (0.97, 1.06)	1.19 (1.01, 1.40) ^a	0.98 (0.93, 1.03)	1.04 (0.89, 1.22)
Combined Surgical (n=1,259,989 / 30,598)	1.05 (0.97, 1.14)	1.19 (0.84, 1.69)	0.97 (0.89, 1.05)	1.09 (0.77, 1.55)

^a p<0.05

^b p<0.01

^c p<0.001

^d p<0.0005

^e p<0.0001