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http://dx.doi.org/10.1016/j.mayocp.2014.04.004

Long-term Effects of the 2003 ACGME Resident Duty Hour Reform on Hospital Mortality

To the Editor: In 2003, the Accreditation Council for Graduate Medical Education (ACGME) implemented resident duty hour reform that established a maximum 80-hour workweek among other provisions. Despite an important series of studies that analyzed the reform's short-term impact on mortality in teaching hospitals (2003-2005), long-term studies have been lacking.[1-4] The long-term effects of reform are important to consider because adherence to duty hour restrictions was limited in the first few years after the transition,[5] and oversight of residents since the transition may have changed. A single recent study of the long-term effects of the 2003 duty hour reforms focused on Medicare beneficiaries and found that duty hour reforms had no short-term effects on mortality for several medical and surgical conditions but were associated with long-term reductions in mortality 4 to 5 years after reform.[6] This study, however, focused on the Medicare population and did not separately study the long-term effects of duty hour reforms on patients at low vs high predicted risk of inpatient mortality. Other studies have argued that it is important to study the effects of duty hour reforms on both high- and low-risk inpatients because adverse morbidity and mortality effects of resident inexperience and increased patient handoffs attributable to duty hour restrictions may be more pronounced among high-risk inpatients.

Methods. We used the Nationwide Inpatient Sample to analyze inpatient mortality for medical patients hospitalized with acute myocardial infarction (AMI), congestive heart failure (CHF), pneumonia, or stroke during July 2000-June 2003 (prereform), July 2003-June 2006 (short-term after reform), and July 2006-June 2009 (long-term). The Nationwide Inpatient Sample is a nationally representative 20% sample of patients discharged from a rotating set of US hospitals. Hospitals were divided into 3 categories: (1) nonteaching, (2) very minor or minor (>0-0.249 residents per bed), and (3) major or very major (>0.25 residents per bed).[1,2] Data were exempt from institutional review at Harvard Medical School.

We used difference-in-difference analysis to estimate the short- and

TABLE 1. Characteristics of the Study Population[a]

Medical condition and teaching hospital status	No. of cases (% unadjusted mortality)		
	Pre-ACGME reform (July 2000-June 2003)	Post-ACMGE reform	
		Short-term (July 2003-June 2006)	Long-term (July 2006-June 2009)
Pneumonia			
Nonteaching	184,858 (6.2)	162,230 (5.2)	106,803 (4.2)
Very minor or minor teaching	65,395 (7.1)	46,190 (5.4)	30,324 (4.3)
Major or very major teaching	54,933 (7.0)	48,065 (5.4)	27,535 (3.9)
Congestive heart failure			
Nonteaching	173,963 (4.6)	148,975 (4.4)	105,393 (3.6)
Very minor or minor teaching	71,298 (4.7)	48,856 (4.3)	35,369 (3.5)
Major or very major teaching	69,656 (4.1)	64,853 (3.7)	37,784 (3.0)
Acute myocardial infarction			
Nonteaching	87,689 (10.3)	71,093 (8.7)	53,944 (7.4)
Very minor or minor teaching	47,336 (9.1)	29,720 (8.1)	19,424 (7.1)
Major or very major teaching	51,785 (7.9)	42,744 (6.8)	24,838 (5.8)
Stroke			
Nonteaching	82,570 (11.0)	65,049 (10.9)	50,489 (9.9)
Very minor or minor teaching	36,221 (11.5)	23,931 (11.0)	17,803 (10.0)
Major or very major teaching	35,837 (12.3)	32,044 (11.6)	23,433 (11.5)

[a]Table reports mortality for the overall population in each disease (ie, without discrimination between low- and high-risk patients). Teaching hospital status was obtained from the American Hospital Association. Very minor or minor teaching hospitals were those with >0-0.249 residents per bed. Major or very major teaching hospitals were those with >0.25 residents per bed. The number of hospitals of each type varied across periods. For example, in the prereform period, patients with acute myocardial infarction were admitted to 792 nonteaching hospitals, 150 very minor or minor teaching hospitals, and 101 major or very major teaching hospitals. In the long-term period (July 2006-June 2009), patients with acute myocardial infarction were admitted to 469 nonteaching hospitals, 95 very minor or minor teaching hospitals, and 58 major or very major teaching hospitals.

long-term effects of ACGME reform on inpatient mortality in hospitals of varying teaching intensity.[1-4] Mortality trends in nonteaching hospitals proxied for unobserved trends affecting mortality in all hospitals. We estimated linear mortality models that adjusted for patient risk using a validated tool from the Agency for Healthcare Research and Quality (AHRQ).[7] The AHRQ tool includes risk parameters for patient age, race, sex, and relevant diagnosis codes that have been estimated from national hospital discharge data for patients hospitalized with AMI, pneumonia, heart failure, or stroke. These preestimated risk coefficients can be applied to other claims-based data such as ours to predict patient-level inpatient mortality. On the basis of existing studies, a priori, we defined patients dichotomously to be at high risk for a given condition if their predicted mortality was in the top quartile for the respective disease and at low risk if their predicted mortality was in the bottom 3 quartiles.[3,8]

Hospital fixed effects (a binary indicator variable for whether a patient was admitted to a given hospital) were included to account for unobserved time-invariant hospital factors affecting mortality. We studied whether effects of reform varied with patient risk,[3] with high-risk patients defined as the top quartile of AHRQ-predicted mortality for each condition. The 95% CIs reflect 0.025 in each tail or $P<.05$.

Results. In unadjusted analyses of patients overall (ie, without discrimination between low- and high-risk patients), ACGME reform was significantly associated with short- and long-term reductions in mortality only for patients with pneumonia (Table 1). Pneumonia mortality in major and very major teaching hospitals was 7.0% prereform, 5.4% short-term, and 3.9% long-term, and in nonteaching hospitals pneumonia mortality was 6.2% prereform, 5.2% short-term, and 4.2% long-term ($P=.01$ and $P=.02$ for short- and long-term difference-in-difference, respectively). For other conditions, unadjusted mortality declined at similar rates across hospital types, and ACGME reform was not associated with short- or long-term difference-in-difference effects on unadjusted mortality.

In adjusted analysis, reform was associated with short- and long-term inpatient mortality reductions for high-risk patients with pneumonia, CHF, and stroke in major and very major teaching hospitals (Table 2). For example, adjusted mortality for high-risk patients with pneumonia in these hospitals was 21.0% (95% CI, 20.3%-21.7%) prereform, 16.3% (95% CI, 15.6%-17.0%) short-term, and 10.9% (95% CI, 10.2%-11.6%) long-term. Adjusted mortality for these patients

TABLE 2. Short- and Long-term Effects of 2003 Duty Hour Reform on Adjusted Hospital Mortality of High-Risk Medical Inpatients[a]

Medical condition and teaching hospital status	% Adjusted mortality (95% CI)		
		Post-ACMGE reform	
	Pre-ACGME reform (July 2000-June 2003)	Short-term (July 2003-June 2006)	Long-term (July 2006-June 2009)
Pneumonia			
Nonteaching	18.6 (18.2-19.0)	15.2 (14.8-15.6)	11.7 (11.3-12.1)
Very minor or minor teaching	20.7 (20.1-21.3)	15.5 (14.8-16.2)	12.5 (11.7-13.3)
Major or very major teaching	21.0 (20.3-21.7)	16.3 (15.6-17.0)	10.9 (10.2-11.6)
Congestive heart failure			
Nonteaching	14.2 (13.8-14.6)	11.9 (11.6-12.2)	9.2 (8.9-9.5)
Very minor or minor teaching	15.2 (14.6-15.8)	11.9 (11.3-12.4)	9.1 (8.5-9.7)
Major or very major teaching	13.8 (13.2-14.4)	11.2 (10.7-11.7)	8.3 (7.7-8.9)
Acute myocardial infarction			
Nonteaching	27.4 (26.8-28.0)	23.4 (22.8-24.0)	19.7 (19.0-20.4)
Very minor or minor teaching	28.8 (28.0-29.6)	24.4 (23.4-25.4)	21.7 (20.5-22.9)
Major or very major teaching	27.7 (26.9-28.5)	23.2 (22.3-24.1)	18.9 (17.8-20.0)
Stroke			
Nonteaching	30.4 (29.7-31.1)	30.9 (30.1-31.7)	29.8 (28.9-30.7)
Very minor or minor teaching	32.1 (31.1-33.1)	30.0 (28.9-31.1)	29.4 (28.0-30.8)
Major or very major teaching	31.0 (30.1-31.9)	30.0 (29.1-30.9)	27.9 (26.8-29.0)

[a]Table reports results of difference-in-difference analyses of the short- and long-term effects of ACGME reform on inpatient mortality in hospitals of varying teaching intensity. Very minor or minor teaching hospitals were those with >0-0.249 residents per bed. Major or very major teaching hospitals were those with >0.25 residents per bed. We estimated linear mortality models that adjusted for patient risk using a validated tool from the Agency for Healthcare Research and Quality (see text for details). We defined patients dichotomously to be at high risk for a given condition if their predicted mortality was in the top quartile for the respective disease and at low risk if their predicted mortality was in the bottom 3 quartiles. Results for high-risk patients are shown in this table; results for low-risk patients are shown in Supplemental Table 1, available online at http://www.mayoclinicproceedings.org. Model included hospital fixed effects to account for unobserved time-invariant hospital factors affecting mortality.

also declined in nonteaching hospitals but more gradually (18.6% [95% CI, 18.2%-19.0%] mortality prereform, 15.2% [95% CI, 14.8%-15.6%] short-term, and 11.7% [95% CI, 11.3%-12.1%] long-term; $P=.02$ and $P=.001$ for short- and long-term difference-in-difference, respectively). Compared with trends in nonteaching hospitals, reform was not associated with changes in adjusted mortality in very minor or minor teaching hospitals for high-risk patients with AMI, CHF, or stroke. However, reform was associated with short- and long-term reductions in adjusted inpatient mortality for high-risk patients with pneumonia in very minor or minor teaching hospitals ($P=.02$ and $P=.02$ for short- and long-term difference-in-difference, respectively, compared with nonteaching hospitals). Reform was not associated with changes in mortality for low-risk patients (Supplemental Table, available online at http://www.mayoclinicproceedings.org).

Discussion. Our study found that the 2003 ACGME reforms were associated with similar short- and long-term reductions in inpatient mortality for high-risk patients with pneumonia, CHF, and stroke in major and very major teaching hospitals, consistent with the hypothesis that reductions in resident fatigue may improve outcomes among high-risk patients who are plausibly most susceptible to fatigue-associated errors.[3] Alternatively, implementation of hospital safeguards such as intensive care unit intensivist staffing may contribute to our findings. Previous studies have suggested that older medical patients with specific comorbidities experienced larger reductions in mortality after duty hour reform[4]; other investigations have suggested no effect for the highest-risk patients.[3] Although our study was limited by a primary outcome of inpatient (rather than 30-day) mortality and an inability to account for multiple hospitalizations of the same individual over time,[4] our findings are reassuring that ACGME reform has not had long-term adverse impacts on hospital mortality and instead may have benefited high-risk medical patients.

Acknowledgements. Dr Romley had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Drs Jena, Prasad, and Romley contributed to the design and conduct of the study, data collection and management, interpretation of the data, and preparation, review, or approval of the article.

The funding sources had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; and preparation, review, or approval of the article.

Supplemental Online Material. Supplemental material can be found online at http://www.mayoclinicproceedings.org.

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Grant Support: This study was supported by grant 1DP5OD017897-01 (A.B.J.) from the Office of the Director, National Institutes of Health; grant 1R03AG031990-A1 (J.A.R.) from the National Institute on Aging; and funding from the Leonard Schaeffer Center for Health Policy and Economics at the University of Southern California, Los Angeles (J.A.R.).

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http://dx.doi.org/10.1016/j.mayocp.2014.05.001

Adverse Cardiac Effects of Bisphosphonates

To the Editor: Pittman et al[1] recently reported that bisphosphonate use was associated with an increased risk of incident acute myocardial infarction (AMI) in their observational study of elderly veterans with a history of osteoporotic fractures. Of note, they also reported that "the timing of AMI correlated closely with the timing of bisphosphonate therapy initiation."

In 2012, Boonen et al[2] reported that annual intravenous infusion of 5 mg of the bisphosphonate zoledronic acid was associated with significantly more AMI events than placebo in men over age 50 with osteoporosis ($P=.03$) but stated that "none of the events were considered by the investigator to be related to the study drug." It was not explained