Pulmonary Embolism

The Weekend Effect

Rahul Nanchal, MD, FCCP; Gagan Kumar, MD; Amit Taneja, MD; Jayshil Patel, MD; Abhishek Deshmukh, MD; Sergey Tarima, PhD; Elizabeth R. Jacobs, MD, FCCP; and Jeff Whittle, MD, MPH; from the Milwaukee Initiative in Critical Care Outcomes Research (MICCOR) Group of Investigators

Background: Pulmonary embolism is a common, often fatal condition that requires timely recognition and rapid institution of therapy. Previous studies have documented worse outcomes for weekend admissions for a variety of time-sensitive medical conditions. This phenomenon has not been clearly demonstrated for pulmonary embolism.

Methods: We used the Healthcare Cost and Utilization Project Nationwide Inpatient Sample for the years 2000 to 2008 to identify people with a principal discharge diagnosis of pulmonary embolism. We classified admissions as weekend if they occurred between midnight Friday and midnight Sunday. We compared all-cause in-hospital mortality between weekend and weekday admissions and investigated the timing of inferior vena cava (IVC) filter placement and thrombolytic infusion as potential explanations for differences in mortality.

Results: Unadjusted mortality was higher for weekend admissions than weekday admissions (OR, 1.19; 95% CI, 1.13-1.24). This increase in mortality remained statistically significant after controlling for potential confounding variables (OR, 1.17; 95% CI, 1.11-1.22). Among patients who received an IVC filter, a larger proportion of those admitted on a weekday than on the weekend received it on their first hospital day (38% vs 29%, $P < .001$). The timing of thrombolytic therapy did not differ between weekday and weekend admissions.

Conclusions: Weekend admissions for pulmonary embolism were associated with higher mortality than weekday admissions. Our finding that IVC filter placement occurred later in the hospital course for patients admitted on weekends with pulmonary embolism suggests differences in the timeliness of diagnosis and treatment between weekday and weekend admissions. Regardless of cause, physicians should be aware that weekend admissions for pulmonary embolism have a 20% increased risk of death and warrant closer attention than provided during the week.

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Abbreviations: ICD-9-CM = International Classification of Diseases, Ninth Revision, Clinical Modification; IVC = inferior vena cava; NIS = National Inpatient Sample; PE = pulmonary embolism

Pulmonary embolism (PE) is a common, often fatal, acute medical condition for which timely therapy can be life saving. The average annual incidence of acute PE in the United States is about 110 in 100,000 adults. The case fatality rate in the years prior to the introduction of anticoagulant therapy exceeded 30%; current estimates of case fatality are $< 10\%$.^{1,2} The accurate diagnosis of PE relies on clinical acumen and timely use of appropriate diagnostic studies. Individuals with PE who present with shock or severe respiratory failure or who have limited cardiopulmonary reserve benefit from prompt use

of complex therapies, such as mechanical ventilation, vasopressor infusion, inferior vena cava (IVC) filter placement, and thrombolysis.

Previous studies of patients admitted with similarly time-sensitive conditions suggested that weekend admission increases the risk of poor outcomes.³⁻¹⁰ However, the evidence for a weekend effect is not well established for people admitted with PE. Therefore, we carried out the present study to determine whether people admitted with PE on the weekend have worse outcomes than those admitted during the week. To better understand such a phenomenon, we sought to

describe differences in use and timeliness of procedures, such as IVC filter placement and IV thrombolysis, that might be less available on weekend days. We used a large, nationally representative administrative database developed by the Agency for Healthcare Research and Quality to ensure sufficient sample size to detect small, but important effects and to enhance generalizability of our results.

MATERIALS AND METHODS

Data Source

We used the Healthcare Cost and Utilization Project Nationwide Inpatient Sample (NIS), a large, publicly available database of inpatient care in the United States. It is an administrative data set created by the Agency for Healthcare Research and Quality from data contributed by participating states. Each year, the NIS includes data on 5 to 8 million hospital stays from about 1,000 hospitals selected to approximate a 20% stratified sample of US hospitals. All hospital types are sampled, excluding federal (eg, Veterans Administration, Department of Defense), institutional (eg, prison hospitals), and short-term rehabilitation hospitals. The database includes a record for every hospital discharge, regardless of payer, at included hospitals during a given year. To facilitate the production of national estimates, both hospital and discharge weights are provided along with information necessary to calculate the variance of estimates.

Each hospitalization record includes common demographic variables, hospital characteristics, and clinical data coded using the *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM), coding system. Information about patient race is missing in about one-fifth of the study population because some participating states restrict race data. The clinical data include up to 15 diagnostic and 15 procedural codes for each record. Procedural codes are associated with the date of the procedure, which allows for determination of time to procedure in days.

Study Population

We included all adult patients aged ≥ 18 years discharged with a principal diagnosis code for PE (ICD-9-CM codes 415.11 and 415.19). The positive predictive value of these ICD-9-CM codes has been previously validated.¹¹

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Affiliations: From the Division of Pulmonary and Critical Care Medicine (Drs Nanchal, Kumar, Taneja, Patel, and Jacobs) and Division of General Internal Medicine (Dr Whittle), Department of Medicine, and Institute for Health and Society (Dr Tarima), Division of Biostatistics, Medical College of Wisconsin, Milwaukee, WI; Division of Cardiology (Dr Deshmukh), University of Arkansas for Medical Sciences, Little Rock, AR; and Primary Care Division (Dr Whittle), Clement J. Zablocki VA Medical Center, Milwaukee, WI. **Funding/Support:** The authors have reported to *CHEST* that no funding was received for this study.

Correspondence to: Rahul Nanchal, MD, FCCP, Division of Pulmonary and Critical Care Medicine, Department of Medicine, Medical College of Wisconsin, 8701 Watertown Plank Rd, Ste E5200, Milwaukee, WI 53226; e-mail: rnanchal@mcw.edu

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Definition of Independent Variables

We defined weekend admissions as those occurring between 12:01 AM Saturday through 11:59 PM on Sunday^{3,4,12,13} and considered all other admissions to be weekday admissions. We identified comorbid conditions individually using appropriate ICD-9-CM codes (see e-Appendix 1 for specific codes) and adapted standard coding to determine the Charlson-Deyo comorbidity index, which has been widely used in administrative database analyses.¹⁴ The Charlson-Deyo index uses 17 comorbid conditions with differential weighting, and the score ranges from 0 to 33, with higher scores representing greater comorbidity burden. We considered patients to have severe PE if they had ICD-9-CM codes for the use of mechanical ventilation (96.7 or 96.72), vasopressors (00.17), or thrombolytic agents (99.10) on the day of admission or the second hospital day.

NIS classifies hospitals as teaching hospitals if they have an Accreditation Council for Graduate Medical Education-approved residency program, are a member of the Council of Teaching Hospitals, or have a ratio of full-time equivalent interns and residents to beds of ≥ 0.25 . Hospital size cut points are based on number of beds, chosen so that approximately one-third of the hospitals in a given region, location, and teaching status combination would fall within each category (small, medium, and large).

Outcomes

The primary outcomes of interest were in-hospital mortality, length of stay, and total hospital charges. Additionally, we investigated the frequency and timing of IVC filter placement and thrombolytic drug infusion because these services may be less readily available on weekends but are ideally performed as soon as the need is recognized. The NIS database does not include the time of procedures but does include the day of the procedure, so we measured time to procedure in days (hospital day 1 = 0 days to procedure, etc). We considered such procedures to be timely if they occurred on the first day of hospitalization and, therefore, compared differences in the use of these therapies on the first hospital day (0 days to procedure). We also described differences in complications associated with PE (cardiogenic shock, respiratory failure requiring mechanical ventilation, cardiac arrest, GI bleed, and blood transfusions) between weekday and weekend admissions, identifying such complications using appropriate ICD-9-CM codes (e-Appendix 1).

Statistical Analysis

The NIS provides weights to generate national estimates of the number of admissions in each age (18-49, 50-64, and ≥ 65 years) and sex group during each year. We used χ^2 tests to compare categorical variables between patients admitted on the weekend and those admitted on weekdays and compared continuous variables using *t* tests and Wilcoxon rank sum tests as appropriate for their distribution. Because length of stay and hospital charges were not normally distributed, we log-transformed them to make their distribution more normal. We also tested the bivariable association of each patient characteristic with in-hospital mortality using χ^2 tests, *t* tests, or Wilcoxon rank sum tests, as appropriate.

We used mixed-effects modeling to determine the independent association of patient characteristics with in-hospital mortality. First, we constructed a fixed-effects model in which we included all variables that were significantly associated with mortality in the bivariable analysis at $P < .05$. We checked these variables for multicollinearity using tolerance and variance inflation factors. For the variables used in the final model, both the tolerance and the variation inflation factors were very close to unity. To account for interactions between selected variables, we examined all two-way interaction terms and included those found to be significant in the model. Information on race was missing in 20% of patients;

therefore, these missing data were grouped together as unknown. The final model included age, sex, race, primary payer type, hospital characteristics (eg, teaching status, location, bed size), individual comorbid conditions, and year. We then added the hospital teaching status and size of hospitals as random effects to exclude the possibility that a weekend effect reflected disproportionate admissions over weekends to certain hospital types. We performed subgroup analyses to explore whether certain subgroups were more prone to exhibit a weekend effect.

We used similar analyses to identify the independent effect of weekend admission on whether an IVC filter was placed, whether thrombolytic therapy was used, and whether the procedure was performed on the first hospital day. Further, we used linear regression to examine the effect of weekend admission on log-transformed length of stay and hospital charges. Stata/IC version 11.0 (StataCorp LP) statistical software was used for all analyses. This study was deemed exempt by the Institutional Review Board because the NIS is a public database with no personal identifying information.

RESULTS

We estimated that there were 1,143,707 discharges with the principal diagnosis of PE among hospitals represented in the NIS during the years 2000 to 2008. Of these, 248,592 (21.7%) were weekend admissions.

Baseline Characteristics

The demographic characteristics of patients admitted on weekdays and weekends were similar, although some were significantly different (Table 1). People admitted on weekends were more likely to have severe PE, as judged by the use of mechanical ventilation, vasopressors, or thrombolysis within the first 2 days (2.8% vs 2.3%, $P < .001$). However, severity of chronic disease as adjudicated by the Charlson-Deyo comorbidity index was higher for patients admitted on weekdays; patients admitted on weekdays were more likely to have an index of ≥ 3 .

Outcomes

The unadjusted in-hospital mortality rate was 4.1% for weekday admissions and 4.8% for weekend admissions (unadjusted OR, 1.19; 95% CI, 1.13-1.24). This increase in mortality for weekend admissions remained significant in the multivariable logistic regression model (OR, 1.16; 95% CI, 1.10-1.22) (Table 2). The OR for mortality remained unchanged, even if we used random-effects modeling with hospital type or size as independent variables. The weekend effect was similar in subgroups defined by age, sex, payer mix, comorbidity index, severity of PE, hospital characteristics, and year (Table 3).

Complications

Through the course of their hospital stay, patients admitted for PE on weekends compared to weekdays were more likely to develop cardiogenic shock

Table 1—Comparison of Demographic and Clinical Characteristics of Hospitalized Patients With Acute Pulmonary Embolism

Characteristic	Weekday	Weekend
Total (N = 1,143,707)	895,115	248,592
Age group ^a		
18-34 y ^a	63,200 (7.1)	19,086 (7.7)
35-49 y ^a	149,559 (16.7)	42,491 (17.1)
50-64 y ^a	224,192 (25.0)	60,591 (24.4)
65-79 y ^a	290,156 (32.4)	770,080 (31.0)
> 80 y ^a	168,875 (18.8)	49,542 (19.9)
Sex		
Female	505,784 (56.5)	140,681 (56.6)
Race		
White	508,231 (56.7)	137,258 (55.2)
Black ^a	91,972 (10.3)	28,298 (11.4)
Hispanic	30,492 (3.4)	8,905 (3.6)
Asian	4,715 (0.5)	1,279 (0.5)
Native American	2,087 (0.2)	511 (0.2)
Other	12,367 (1.4)	3,267 (1.3)
Unknown	246,105 (27.5)	69,265 (27.8)
Primary payer		
Medicare	461,607 (51.6)	127,990 (51.5)
Medicaid ^a	60,128 (6.7)	18,366 (7.4)
Private ^a	313,433 (35.0)	84,425 (34.0)
Self-pay ^a	30,884 (3.4)	9,656 (3.9)
Other	25,171 (2.8)	6,895 (2.8)
No charge	3,123 (0.3)	1,010 (0.4)
Hospital teaching status		
Teaching	380,019 (42.5)	104,961 (42.2)
Hospital location		
Urban	764,283 (85.6)	213,229 (85.7)
Hospital bed size		
Small	103,484 (11.6)	27,437 (11.0)
Medium	224,932 (25.1)	62,178 (25.0)
Large	566,797 (63.3)	159,054 (64.0)
Charlson-Deyo comorbidity index		
0 ^a	398,422 (44.5)	111,604 (44.9)
1 ^a	239,616 (26.7)	68,135 (27.4)
2	117,102 (13.1)	33,286 (13.4)
≥ 3 ^a	140,842 (15.7)	35,766 (14.4)
Severe pulmonary embolism ^b		
No	875,621 (97.7)	241,858 (97.2)
Yes ^a	20,361 (2.3)	6,932 (2.8)

Data are presented as No. (%).

^aSignificant difference at $P < .05$, using simple χ^2 test.

^bMechanical ventilation, vasopressors, or thrombolytic infusion in first 48 h.

(OR, 1.31; 95% CI, 1.10-1.58; $P < .001$), respiratory failure requiring mechanical ventilation (OR, 1.24; 95% CI, 1.17-1.31; $P < .001$), and cardiac arrest (OR, 1.26; 95% CI, 1.14-1.39; $P < .001$). Similarly, transfusion of packed RBCs and GI hemorrhage requiring endoscopy occurred more frequently in those admitted over the weekend (Table 4).

Use of IVC Filter or Thrombolytic Therapy

The proportion of patients receiving IVC filters was similar for weekday and weekend admissions. However, a larger proportion of patients admitted on weekdays received their IVC filter on day 1 of

Table 2—Multivariate Analysis of Predictors of Mortality Among Hospitalized Patients With Pulmonary Embolism

Predictor	OR (95% CI)
Weekend ^a	1.16 (1.10-1.22)
Age group	
18-34 y	Reference
35-49 y ^a	1.47 (1.26-1.73)
50-64 y ^a	2.50 (2.15-2.91)
65-79 y ^a	3.10 (2.63-3.65)
> 80 y ^a	4.91 (4.15-5.81)
Sex ^a	
Male	Reference
Female	1.02 (0.97-1.02)
Race	
White	Reference
Black ^a	1.14 (1.05-1.22)
Hispanic ^a	1.15 (1.02-1.30)
Asian ^a	1.38 (1.07-1.78)
Native American	1.04 (0.64-1.70)
Other	0.96 (0.81-1.16)
Unknown	1.04 (0.98-1.09)
Primary payer	
Medicare	Reference
Medicaid ^a	1.23 (1.09-1.37)
Private ^a	0.88 (0.80-0.94)
Self-pay ^a	1.38 (1.20-1.61)
Other	1.26 (0.75-2.10)
No charge	0.94 (0.78-1.10)
Hospital teaching status	
Nonteaching	Reference
Teaching ^a	1.08 (1.02-1.14)
Hospital location	
Rural	Reference
Urban	0.93 (0.87-1.00)
Hospital bed size	
Small	Reference
Medium	0.96 (0.88-1.04)
Large	1.04 (0.96-1.12)
Severity of pulmonary embolism	
0	Reference
1 ^a	18.4 (17.2-19.6)
Year	
2000	Reference
2001	0.95 (0.85-1.06)
2002 ^a	0.83 (0.75-0.91)
2003 ^a	0.76 (0.67-0.83)
2004 ^a	0.69 (0.62-0.77)
2005 ^a	0.58 (0.52-0.65)
2006 ^a	0.55 (0.50-0.61)
2007 ^a	0.50 (0.45-0.55)
2008 ^a	0.51 (0.45-0.56)
Comorbid disease	
Coronary artery disease	0.94 (0.88-0.99)
Congestive heart failure	1.93 (1.82-2.04)
COPD	1.28 (1.21-1.35)
Cirrhosis	2.79 (2.40-3.10)
End-stage renal disease	1.93 (1.61-2.31)
Chronic kidney disease	1.49 (1.32-1.68)
Cancer	2.15 (2.05-2.25)
Stroke	3.44 (3.01-3.95)
Diabetes mellitus	0.92 (0.87-0.98)
Upper-GI bleed	1.83 (1.54-2.19)
Lower-GI bleed	1.31 (1.06-1.60)
Morbid obesity	0.98 (0.86-1.09)

^aSignificant at $P < .05$.**Table 3—Examining the Presence of Weekend Effect in Different Subgroups**

Predictor	OR (95% CI)	P Value
Age		
< 65 y ^a	1.20 (1.11-1.31)	.001
≥ 65 y ^a	1.16 (1.10-1.23)	.001
Sex		
Male ^a	1.19 (1.11-1.28)	.001
Female ^a	1.16 (1.09-1.23)	.001
Race		
White ^a	1.23 (1.15-1.31)	.001
Black	1.05 (0.91-1.21)	.52
Hispanic	1.09 (0.86-1.39)	.53
Primary payer		
Medicare ^a	1.13 (1.06-1.19)	.001
Medicaid ^a	1.29 (1.06-1.56)	.01
Private ^a	1.29 (1.17-1.43)	.001
Self-pay	1.12 (0.85-1.48)	.43
Charlson-Deyo comorbidity index		
< 3 ^a	1.19 (1.12-1.26)	.001
≥ 3 ^a	1.25 (1.15-1.36)	.001
Hospital teaching status		
Nonteaching ^a	1.18 (1.11-1.26)	.001
Teaching ^a	1.17 (1.08-1.25)	.001
Hospital location		
Rural ^a	1.28 (1.13-1.44)	.001
Urban ^a	1.16 (1.09-1.21)	.001
Hospital bed size		
Small	1.08 (0.93-1.24)	.32
Medium ^a	1.31 (1.19-1.44)	.001
Large ^a	1.14 (1.08-1.21)	.001
Region of hospital		
Northeast ^a	1.25 (1.11-1.39)	.001
Midwest ^a	1.26 (1.14-1.39)	.001
South ^a	1.11 (1.03-1.20)	.01
West ^a	1.17 (1.05-1.32)	.007
Severe pulmonary embolism		
No ^a	1.18 (1.11-1.24)	.001
Yes	1.12 (0.98-1.28)	.078
Year		
2000 ^a	1.16 (1.01-1.35)	.044
2001 ^a	1.16 (1.01-1.33)	.035
2002 ^a	1.19 (1.04-1.37)	.012
2003 ^a	1.21 (1.05-1.40)	.008
2004	1.14 (0.99-1.31)	.075
2005 ^a	1.15 (1.01-1.32)	.046
2006 ^a	1.26 (1.09-1.45)	.001
2007	1.13 (0.97-1.30)	.11
2008 ^a	1.15 (1.01-1.32)	.030

The analysis was adjusted for age, sex, race, primary payer type, hospital characteristics, Charlson-Deyo comorbidity index, and year.

^aSignificant at $P < .05$.

admission (38% vs 29%, $P < .001$) (Table 5). Patients admitted on weekdays and weekends were equally likely to receive thrombolytic therapy, and it was as likely to be administered on the first hospital day (Table 5).

Charges and Length of Hospital Stay

Weekend admissions for PE incurred significantly higher charges than weekday admissions

Table 4—Complications in Pulmonary Embolism-Related Admissions

Complication	Weekday	Weekend	OR (95% CI) ^a
Upper-GI bleed ^b	13,705 (1.5)	4,093 (1.7)	1.1 (1.03-1.17)
Blood ^b	42,208 (4.7)	12,438 (5.0)	1.06 (1.02-1.11)
Cardiac arrest ^b	7,705 (0.9)	2,697 (1.1)	1.26 (1.14-1.39)
Cardiogenic shock ^b	2182 (0.24)	797 (0.32)	1.31 (1.10-1.58)
Mechanical ventilation ^b	23,371 (2.6)	8,012 (3.2)	1.24 (1.17-1.31)
Mechanical ventilation > 96 h ^b	7,887 (0.9)	2,674 (1.1)	1.22 (1.10-1.34)

Data are presented as No. (%), unless otherwise indicated.

^aUsing univariate logistic regression.

^bSignificant difference at $P < .05$ using χ^2 test.

(\$28,007 vs \$26,637). Although, the length of hospital stay was similar.

DISCUSSION

Using nationally representative data, we show that in-hospital mortality of patients given a principal diagnosis of PE between 2000 to 2008 was significantly higher if patients were admitted on a weekend compared to a weekday. This effect persisted independently from demographic characteristics, hospital characteristics, region, and number of comorbid conditions. Although hospital mortality rates for PE declined across the 9 years we studied, the magnitude of the weekend effect remained remarkably constant (Fig 1). Given the frequency of PE, this small effect suggests that there were 1,200 excess deaths associated with weekend admission for PE across the United States during 2008. This is even more remarkable when considering that the risk of in-hospital mortality after being admitted with a principal diagnosis of PE in 2008 was just one-half (OR, 0.51; 95% CI, 0.45-0.56) of that in 2000.

Our results are consistent with other studies, suggesting that outcomes are worse if patients with time-sensitive medical conditions are admitted over the weekend. Although smaller studies suggested this effect for PE,^{12,13} the present study demonstrates this in a large, nationally representative data set. Moreover, our finding that there is a delay in IVC filter placement suggests that similar delays may account for some of this increased mortality risk. Such processes of care for PE may also include restricted access to CT scan angiography and ventilation/perfusion scanning and belated achievement of anticoagulation targets.

Prior investigations suggested that staffing shortfalls may decrease the intensity of medical care provided on weekends.^{7,8,10,15} Moreover, physicians covering weekends frequently provide coverage for more patients and may be less familiar with them.¹⁶⁻¹⁹ This, combined with limited access to advanced diagnostic and therapeutic options on weekends, could lead to delayed or inappropriate diagnosis and therapy.²⁰ In support of previous observations of delays in appropriate management and timely access to important procedures for other conditions, we found that IVC filters were less likely to be placed on the first hospital day in patients admitted

Table 5—Outcomes of Pulmonary Embolism-Related Admissions

Outcome	Weekday	Weekend
Length of stay in survivors, d	6.24 ± 0.03	6.33 ± 0.37
Total charges, ^a \$	26,637 ± 386	28,007 ± 431
Thrombolysis	14,600 (1.6)	4,227 (1.7)
Percentage of all thrombolysis performed on day 1	53.1	53.5
Time to thrombolysis, d	1.22 ± 0.07	1.16 ± 0.11
IVC filter	121,462 (13.6)	33,571 (13.5)
Percentage of all IVC filters placed on day 1 ^a	38.0	29.2
Time to IVC filter, ^a d	2.82 ± 0.03	3.01 ± 0.05
Mortality	35,845 (4.1)	11,792 (4.8)
Disposition		
Home	563,706 (65.7)	148,585 (62.8)
Other hospital	20,882 (2.4)	6,332 (2.7)
Facility	132,070 (15.4)	41,221 (17.4)
Home care	136,242 (15.9)	38,578 (16.3)
AMA	5,057 (0.6)	1,725 (0.7)

Data are presented as mean ± SE or No. (%), unless otherwise indicated. AMA = against medical advice; IVC = inferior vena cava.

^aSignificant difference at $P < .05$ using χ^2 test.

FIGURE 1. Trends of mortality from 2000 to 2008, comparing weekday and weekend admissions.

over the weekend. Of note, we also found that differences in mortality between weekday and weekend admissions for patients who received invasive mechanical ventilation, vasopressor infusion, or thrombolytic therapy within the first 2 days of their admission did not reach statistical significance. All of the aforementioned therapies would likely be administered in the ICU, an environment that delivers higher levels of care and where staffing patterns, access to complex therapies, and intensity of medical care would perhaps be similar throughout the week. Thus, the admission by day of the week may be less likely to influence outcomes in critical care settings, a hypothesis that is supported by prior investigations.²¹⁻²³

Our study can be compared with prior investigations by Aujesky et al¹² and Bell and Redelmeier.¹³ Aujesky et al¹² showed an adjusted OR of 1.17 (95% CI, 1.03-1.34) for mortality from PE on the weekend in a Pennsylvania health-care database from 2000 to 2002. Bell and Redelmeier¹³ studied the weekend effect in patients admitted to the hospital for various acute diseases in Canada and reported significantly higher adjusted mortality on the weekends for PE (OR, 1.19; 95% CI, 1.03-1.36). We arrived at remarkably similar conclusions using nationally representative data over a 9-year period during which overall mortality rates for PE declined significantly. We also found that the weekend effect persisted in subgroups defined by region of the United States; teaching status or size of the hospital; and patient age, sex, or insurance type.

Our study has several limitations. First, we identified the study population on the basis of the presence of ICD-9-CM codes for PE. Coding is likely to vary among hospitals, but such coding practices are unlikely to differ between weekdays and weekends in a given hospital. Second, we considered as weekend admissions only those occurring from midnight Friday to

midnight Sunday, which discounts the fact that delivery of health-care services on a Friday evening or in the early morning hours on Monday (ie, 12:00-6:00 AM) are likely more similar to those provided on a Saturday or Sunday, respectively. However, such misclassification would bias the results toward finding no difference between weekend and weekday admissions.

Finally, despite multivariable adjustment, we cannot exclude unmeasured confounders as a cause for the results. In particular, although we used a well-characterized administrative database, we cannot exclude unmeasured differences in severity of illness as an explanation for the findings. We found that patients admitted over the weekend incurred higher hospital charges and were more likely to have a severe PE as defined by the need for mechanical ventilation, thrombolytic therapy use, or infusion of vasopressors during the first 2 hospital days. Further, only 20% of admissions for PE were on weekends, where one would expect two of seven or 28%. These findings are consistent with a higher measured burden of illness among patients admitted over the weekend; unmeasured differences may also exist. Although we have tried to identify patients with severe PE by using mechanical ventilation, vasopressors, and thrombolysis as surrogates, these procedures may have been needed for other reasons and unrelated to PE severity.

The ability to determine a reason for the mortality difference is also limited by our data sources. For example, we do not have data regarding ED waiting times, ICU availability, delays in diagnostic testing or initiation of anticoagulation, achievement of anticoagulation targets, and more clinically detailed severity-of-illness scores. Data limitations also prevent us from identifying readmissions for PE; NIS does not include a patient identifier, so patients cannot be tracked across hospital stays.

Despite these limitations, the study extends previous findings regarding the mortality effect of weekend admission for PE. Regardless of the causes, whether socioeconomic, due to stoicism, or due to poorer and less-timely medical care over the weekend, physicians should be aware that patients admitted over the weekend have an approximate 20% increased risk of dying and warrant particular care. Health-care planners should consider the possible impact of current hospital workflow systems. Future studies that capture these more-detailed prognostic and process variables are required to better understand the relations among time of admission, processes of care, and clinical outcomes. Such studies should focus on health-care practices amenable to improvement, including timely diagnostic testing; adequate, prompt anticoagulation; and appropriate use and timing of IVC placement and thrombolysis.²⁴ Examination of staffing models and measures to improve access to timely

diagnostic and therapeutic modalities over weekends may be necessary.

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Dr Nanchal: contributed to the study design, statistical analysis, and writing of the manuscript.

Dr Kumar: contributed to the study design, statistical analysis, and writing of the manuscript.

Dr Taneja: contributed to the critical review and revision of the manuscript.

Dr Patel: contributed to the critical review and revision of the manuscript.

Dr Deshmukh: contributed to the critical review and revision of the manuscript.

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Additional information: The e-Appendix can be found in the "Supplemental Materials" area of the online article.

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