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Weekend Versus Weekday Admission And Mortality Following Acute Pulmonary Embolism

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Abstract

Background—Optimal management of acute pulmonary embolism (PE) requires medical expertise, diagnostic testing and therapies, which may not be consistently available throughout the entire week. We sought to assess whether there are associations between weekday and weekend admission and mortality and length of hospital stay for patients hospitalized with PE.

Methods and Results—We evaluated patients discharged with a primary diagnosis of PE from 186 acute care hospitals in Pennsylvania (01/2000-11/2002). We used random-effect logistic models to study the association between weekend admission and 30-day mortality and used discrete survival models to study the association weekend admission and time to hospital discharge, adjusting for hospital (region, size, teaching status) and patient factors (race, insurance, severity of illness, use of thrombolytic therapy). Among 15,531 patient discharges with PE, 3286 (21.2%) were admitted on a weekend. Patients admitted on weekends had a higher unadjusted 30-day mortality (11.1% vs 8.8%) compared to patients admitted on weekdays, with no difference in length of stay. Patients admitted on weekends had a significantly greater adjusted odds of dying (odds ratio 1.17, 95% confidence interval: 1.03-1.34) compared to patients admitted on weekdays. The higher mortality among patients hospitalized on weekends was driven by the increased mortality rate among the most severely ill patients.

Conclusions—Patients with PE who are admitted on weekends have a significantly higher short-term mortality than patients admitted on weekdays. Quality improvement efforts should aim to ensure that there is a consistent approach to the management of PE 7 days a week.

Keywords

lung embolism; prognosis; mortality

Many acute care hospitals provide routine care on weekdays and only emergency or urgent care on weekends. Hospital staffing is often reduced on weekends, both numerically and in terms of available experience. These differences in staffing may result in differential outcomes for patients with acute medical conditions with complex diagnostic and therapeutic

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management requirements. Prior studies of patients with acute cardiovascular conditions such as cardiac arrest, myocardial infarction, heart failure, and stroke found higher short-term mortality or an increased length of hospital stay (LOS) among patients who were admitted on weekends compared to those who were admitted on weekdays.[1-4]

Acute pulmonary embolism (PE) is a major health problem. In 2004, 122,000 patients were discharged with a primary diagnosis of PE from U.S. hospitals, with an average 30-day mortality of approximately 9%.[5, 6] The diagnosis of PE is complex, requiring the timely access to sophisticated radiographic procedures such as spiral computed tomography, ventilation-perfusion lung scanning, and venous ultrasonography.[7] In addition, the quality of anticoagulant therapy, the mainstay of treatment for this condition, may depend on provider experience and the availability of specialized anticoagulation clinics.[8] Timely access to thrombolytic therapy and other measures of intensive care may also affect patient outcomes. Since it is likely that the availability and quality of these diagnostic and therapeutic procedures differ for each day in the week, it is possible that an association exists between weekend admission and outcomes in patients with PE. Given the high incidence and mortality related to this condition, even small differences in mortality between weekend and weekday admissions could translate into a substantial number of additional deaths in the population.

Using a statewide database of 15,531 patients discharged with PE, we sought to assess whether there were associations between weekday and weekend admission and mortality and LOS for patients hospitalized with PE. We hypothesized that patients admitted on weekends would have a higher short-term mortality and an increased LOS compared to patients admitted on weekdays.

METHODS

Patient Identification and Eligibility

We identified patients with PE discharged from 186 non-governmental (i.e., non-Veterans Administration) acute care hospitals in Pennsylvania (01/01/2000 to 11/30/2002) using the Pennsylvania Health Care Cost Containment Council (PHC4) database. This database contains information on demographic characteristics, insurance status, International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and procedure codes, hospital region and number of beds, and length of hospital stay for all patients.

We included inpatients aged ≥ 18 years who were discharged with a primary diagnosis of PE based on the following ICD-9-CM codes: 415.1, 415.11, 415.19, and 673.20-24. To ensure that we identified the most severely ill patients with PE as the primary reason for hospitalization, we also included inpatients with a secondary diagnosis code for PE and one of the following primary codes that may represent complications or treatments of this condition: respiratory failure (518.81), cardiogenic shock (785.51), cardiac arrest (427.5), secondary pulmonary hypertension (416.8), syncope (780.2), thrombolysis (99.10), and intubation or mechanical ventilation (96.04, 96.05, 96.70-96.72).

We excluded all other patients who had a secondary ICD-9-CM code for PE or those that were transferred from another health care facility, because such patients are more likely to have PE as a complication of hospitalization and we did not know whether PE was diagnosed and treated before the patient was transferred. We excluded follow-up records for patients who were subsequently transferred to other hospitals or hospice care or who stayed in the hospital for more than 30 days. We also excluded patients without the identifiers required for linkage to the necessary clinical data, and those for whom mortality information was not available. The Institutional Review Board at the University of Pittsburgh approved this study.

Patient and Hospital Characteristics

Patient demographic characteristics (age, gender, and race), insurance status, and the day of admission were abstracted from the PHC4 Database. Admission on weekends was defined as admission during the period from midnight on Friday to midnight on Sunday. All other times were defined as weekdays. Baseline clinical variables were obtained by linking eligible patients to the Atlas Database (MediQual, Marlborough, MA), which includes clinical findings and laboratory parameters at presentation for all inpatients treated at non-governmental acute care hospitals in Pennsylvania. The PHC4 and Atlas databases were matched by PHC4 staff using unique patient identifiers (patient date of birth, gender, and social security number); we had no access to personal patient identifiers.

Severity of illness was quantified using the Pulmonary Embolism Severity Index (PESI),[6, 9] a validated prognostic model for patients with PE that was developed and validated using these clinical data from the PHC4 and Atlas databases. Based on the PESI, each patient is classified into one of five classes (I-V), with 30-day mortality ranging from 1.1% to 24.5%.[6] To ascertain whether patients received thrombolysis, weused ICD-9-CM procedure codes (99.10) from the PHC4 and Atlas databases.

The hospital region within Pennsylvania, number of beds per hospital site, and annual number of PE admissions for each site were abstracted from the PHC4 Database. Hospital teaching status was ascertained from the Council of Teaching Hospitals of the Association of American Medical Colleges. Because 76% of teaching hospitals, but only 12% of nonteaching hospitals had at least 350 hospital beds, we created a composite hospital-level variable for our statistical modeling (i.e., small nonteaching hospitals with fewer than 350 beds, large nonteaching hospitals with at least 350 beds, and teaching hospitals).

Study Outcomes

The primary study outcome was all-cause mortality within 30 days of presentation. Mortality data were obtained by linking patients to the National Death Index (NDI) using unique patient identifiers, including social security number, name, date of birth, and sex.[10-12] The NDI has a sensitivity and specificity of over 97% for mortality.[12] The secondary study outcome was LOS. We abstracted LOS, defined as discharge minus admission dates, from the PHC4 database.

Statistical Analyses

To compare patient and hospital characteristics for weekend and weekday admissions, we performed chi-square tests for categorical variables and non-parametric Kruskal-Wallis tests for continuous variables A two-tailed *P*-value of < 0.05 was considered statistically significant. We used survival analyses and the log-rank test to compare the mortality rates in the two groups. We stratified our analyses of 30-day mortality and admission on weekdays versus weekends across the five PESI risk classes. We used logistic regression to examine the association between weekend admission and mortality within 30 days of presentation. Surviving patients were censored at 30 days. To account for the effects of clustering of patients within hospitals, we treated hospital site as a random effect. In multivariable analyses of mortality, we controlled for patient race, insurance, severity of illness using the PESI, administration of thrombolytic therapy, hospital region, and hospital size and teaching status.

As a sensitivity analysis, we performed an additional analysis of mortality by replacing the PESI risk class with the individual 11 variables comprising the PESI (age, gender, history of heart failure, chronic lung disease, or cancer, pulse $\geq$ 110/minute, systolic blood pressure $<$ 100 mm Hg, respiratory rate $\geq$ 30/minute, body temperature $<$ 36°C, altered mental status, and arterial oxygen saturation $<$ 90%) and a number of laboratory parameters (hemoglobin $<$ 12 g/

dl, sodium < 130 or > 150 mmol/l, and serum creatinine > 1.5 mg/dl) in the logistic regression model.

We used a discrete survival approach to examine the association between weekend admission and time to discharge, adjusting for the afore-mentioned patient and hospital variables. A lower odds of discharge corresponds to a longer LOS. Patients who died in the hospital were censored at the time of death. Patients with a LOS > 30 days were censored at 30 days. All analyses were performed using Stata 10.

Statement of Responsibility

The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

RESULTS

Of the 17,733 patient discharges that met our inclusion criteria, we excluded 323 with only a secondary code indicative of PE (1.8%), 767 transfers in from another hospital (4.3%), 265 subsequent transfers to another hospital (1.5%), 777 without a match to key clinical findings (4.4%), and 70 who could not be linked to the National Death Index (0.4%). The study cohort comprised 15,531 patient discharges with a diagnosis of PE from 186 Pennsylvania hospitals; 3286 (21.2%) were admitted on a weekend.

Baseline Patient Characteristics

As shown in Table 1, patients admitted on weekends were significantly more likely to show signs of clinical instability (tachycardia, hypotension, tachypnea, altered mental status, and hypoxemia), which resulted in a somewhat higher proportion of most severely ill patients (PESI risk class V) in this group (24.8% versus 20.1%). Patients admitted on weekends were also significantly more likely to have abnormal laboratory parameters compared to patients admitted on weekdays. In contrast, patients admitted on weekends were significantly less likely to have cancer (18.1% versus 20.0%, $P = 0.02$).

Mortality by Weekend versus Weekday Admission

Overall mortality was 9.3% at 30 days. As shown in the Figure, the cumulative 30-day mortality was significantly higher among patients admitted on weekends than in patients admitted on weekdays (11.1% versus 8.8%; $P < 0.001$). Survival curves began to diverge at day 1 after admission and continued to separate over time. Stratification of mortality by severity of illness revealed a significantly increased mortality among patients admitted on weekends versus weekdays for the most severely ill patients in PESI risk class V (27.6% versus 23.2%, $P = 0.01$), with no significant differences in mortality in the other four risk classes (Table 2). Adjusted for PESI risk class, overall mortality was 1.4% higher than expected among patients admitted on weekends, compared to patients admitted on weekdays.

After adjustment for patient race, insurance, severity of illness using PESI risk class (Table 3), administration of thrombolytic therapy, hospital region, and hospital size and teaching status, the odds of 30-day mortality remained significantly increased (OR 1.17, 95% CI: 1.03-1.34). Increasing severity of illness (PESI risk class V relative to class I: OR 22.96, 95% CI: 16.32-32.31), administration of thrombolytic therapy (OR 1.75, 95% CI: 1.30-2.37), and hospital teaching status (OR 1.27, 95% CI: 1.06-1.51) were also significantly associated with 30-day mortality. Compared to patients admitted to hospitals from Pittsburgh and surroundings, patients admitted to hospitals from North Central Pennsylvania had a significantly lower odds of mortality (OR 0.73, 95% CI: 0.55-0.97) and those admitted to

hospitals from Philadelphia had a significantly higher odds of mortality (OR 1.30, 95% CI: 1.07-1.59).

To examine whether the higher mortality rate among patients admitted on weekends was driven by an increased mortality among patients with the greatest severity of illness, we performed separate logistic regression models for patients in PESI risk class V and those in risk classes I-IV. Compared to patients admitted on weekdays, the adjusted odds of dying among patients admitted on weekends were significantly higher among patients in PESI risk class V (OR 1.25, 95% CI: 1.05-1.50) whereas the odds of dying were not significantly increased among patients in risk classes I-IV (OR 1.07, 95% CI: 0.88-1.30).

When the PESI risk class was replaced in the model with the 11 variables comprising the PESI and laboratory parameters, the results were virtually unchanged. Patients admitted on weekends had a significantly higher adjusted odds of mortality compared to patients admitted on weekdays (OR 1.16, 95% CI: 1.01-1.33).

LOS by Weekend versus Weekday Admission

The median LOS was identical among patients admitted on weekends and weekdays (6.0 days, interquartile range: 4.0-8.0 days; $P = 0.93$). The adjusted odds of discharge on a given day were not significantly different among patients admitted on weekends and those admitted on weekdays (OR 0.99, 95% CI: 0.95-1.04).

DISCUSSION

After adjusting for potential patient and hospital related confounders and the administration of thrombolytic therapy, we found that patients with PE who were admitted on weekends had a significantly higher 30-day mortality than patients who were admitted on weekdays. The higher mortality for patients hospitalized on weekends was driven by the increased mortality rate among patients within the highest severity of illness risk class at presentation. In contrast, we observed no significant association between weekend admission and LOS.

There are several possible explanations for the association between weekend admission and increased 30-day mortality, particularly among the most severely ill patients. Fewer medical providers and professional staff tend to work in hospitals on weekends than on weekdays,[13, 14] and those who do work on weekends may have less clinical experience.[15, 16] There are also fewer supervisors on weekends, and they are often responsible for supervising the work of staff members they do not know as well.[17] Understaffing in the emergency and radiology departments, numerically and in terms of expertise, could potentially result in delayed diagnosis and treatment of PE, with an unfavorable impact on patient prognosis. Provision of care by covering physicians and/or more junior physicians may lead to the underuse of recommended processes of care for PE that are associated with improved patient outcomes. These processes of care include the use of validated algorithms for diagnosing PE and anticoagulation-related procedures such as an overlap of heparin and warfarin therapy of 4 days or more before heparin is stopped.[7, 18] Moreover, specialized services with positive impact on anticoagulation quality and outcomes,[8] such as anticoagulation clinics, may be temporarily unavailable during weekends. Inadequate professional staffing and medical coverage during the weekend may also delay the detection of potentially fatal, early complications (e.g., cardiogenic shock, anticoagulation-related bleeding). The relative contributions of these possible explanations to higher mortality among weekend admissions are not known but the impact falls most heavily on the most severely ill patients with PE. Further research is warranted on the associations between professional staffing, medical coverage, processes of care, and outcomes for patients with PE. If understaffing or medical coverage contributed to lower quality of care or worse outcomes, possible solutions would be

to increase staffing and medical coverage during weekends or regionalize PE care in higher-volume hospitals where continuous coverage can be provided by personnel experienced in the management of PE.[19]

We found that the survival curves of patients admitted on weekends and patients admitted on weekdays began to diverge early and continued to separate over time. One possible explanation for this finding is that suboptimal care in the early phase of PE may also bring dire consequences later in the course of the illness. In a prior study, patients who did not reach a therapeutic activated partial thromboplastin time within 24 hours had a three-fold higher risk of recurrent venous thromboembolism throughout a three-month follow-up period of than those who did.[20]

Our findings have important public health implications. Extrapolating from our data, we estimate that, each year, about 26,000 patients with a primary diagnosis of PE are admitted on weekends in the United States.[5] Based on an excess 30-day mortality of 1.4% among weekend admissions with PE compared to patients admitted on weekdays, about 364 additional deaths would be potentially attributable to weekend admissions in the United States annually, or about 3 additional deaths per 1000 admissions for PE.

Our results are consistent with a prior Canadian study of 11,686 patients with PE that found a significantly higher in-hospital mortality among patients who were admitted on weekends relative to patients admitted on weekdays during the 1988-1997 period (OR 1.19, 95% CI: 1.03-1.36), after adjusting for age, sex, and the Charlson comorbidity index.[21] However, a small Scottish study enrolling of 137 patients with PE did not find a significant association between weekend admission and in-hospital mortality or LOS,[22] possibly due to a lack of power.

Our study has several limitations. First, patients in our sample were identified using ICD-9-CM codes for PE rather than standardized radiographic criteria, and patient eligibility may therefore be subject to study selection biases due to hospital coding procedures. In prior studies, up to 96% of patients with specific codes for PE had objectively documented disease on the basis of chart review criteria,[23-25] but little is known about the sensitivity of these codes for detecting this condition. In one previous study, the ICD-9-CM codes missed 13% of patients with PE.[26] Thus, we cannot entirely exclude the possibility that the potential for variation in the sensitivity of coding across study centres represents a threat to the validity of our findings (misclassification bias). Second, although we used several techniques to adjust for severity of illness, it is possible that the observed mortality difference between weekend and weekday admissions may be due to unmeasured, residual confounding. Third, we could not assess whether differences in the duration of symptoms, appropriateness and timeliness of diagnosis or anticoagulation-related processes of care would explain differences in outcomes between patients admitted on weekends and weekdays. Moreover, we had no information on physician-level (e.g., experience, specialty training and annual volume of PE cases per physician) and system-level (e.g., staff volume and availability of anticoagulation clinics) factors with a potential impact on the recommended processes of care and outcomes of PE. Thus, we could not explore whether these factors are associated with the higher observed mortality among patients admitted on weekends. Fourth, our study does not account for deaths declared by paramedics before hospital admission.[21] Because these deaths may be more common on weekends than on weekdays,[21] our study may have underestimated the difference in mortality. Finally, because our study patients were hospitalized during the 2000-2002 period, we cannot exclude the possibility that changing practice patterns, such as earlier diagnosis of PE using spiral computed tomography or increasing use of low-molecular-weight heparins rather than unfractionated heparin could have influenced our results.

In conclusion, our results demonstrate that patients with PE who are admitted on weekends have a significantly higher short-term mortality than patients admitted on weekdays, even when adjusted for potentially confounding patient and hospital characteristics. The impact of weekend admission on mortality is strongest among the most severely ill patients. Further research is needed to investigate the reasons for this observed difference in mortality for weekend and weekday admissions that informs future strategies to ensure that there is a consistent approach to management of PE 7 days a week.

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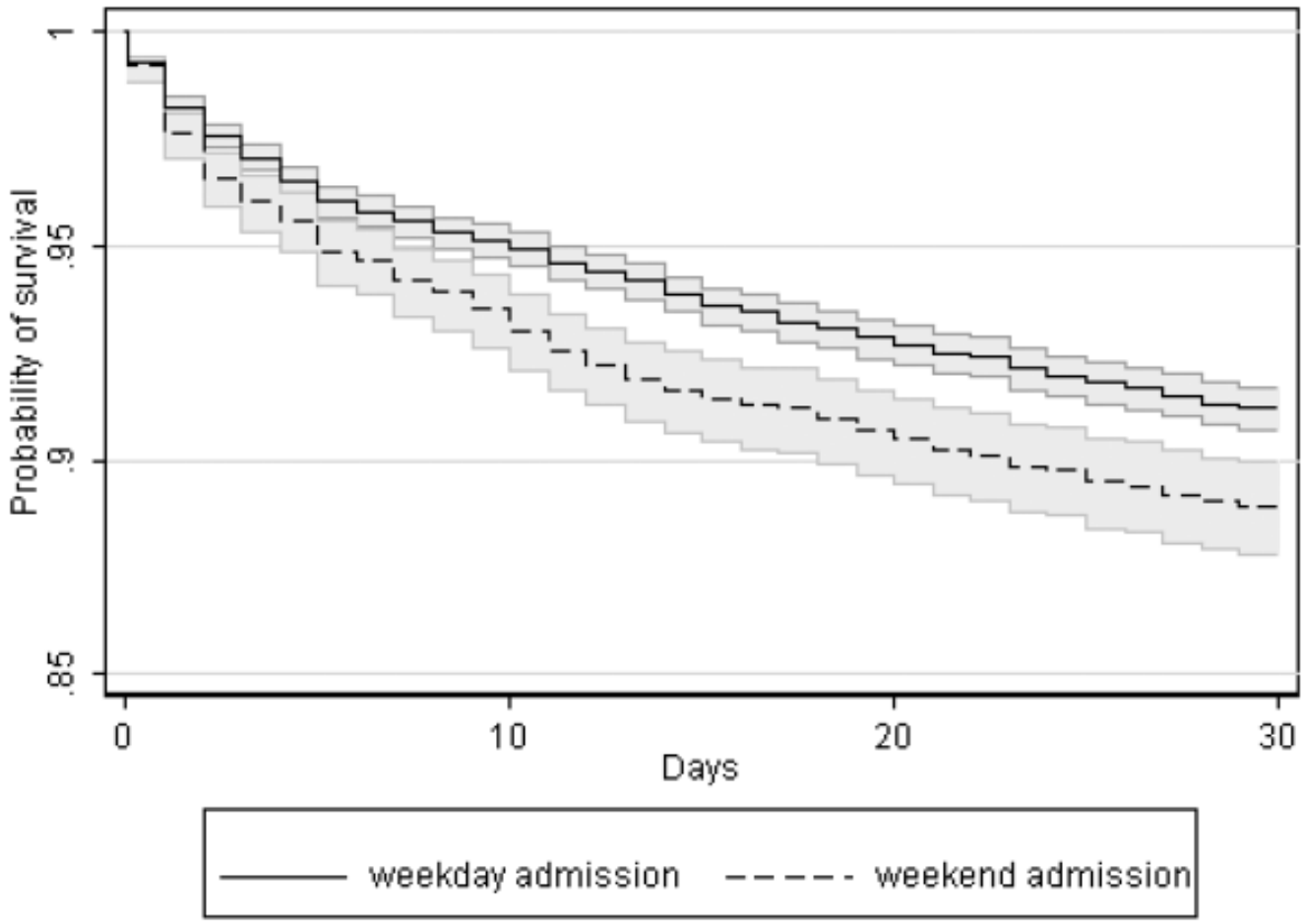

Figure. Survival among patients admitted on weekdays and weekends

Cumulative survival curve for patients with pulmonary embolism who were admitted on weekdays (full line) and on weekends (dashed line). The gray zones represent the 95% confidence intervals. The cumulative 30-day mortality was significantly higher among patients admitted on weekends than in patients admitted on weekdays (11.1% versus 8.8%; $P < 0.001$ by the log-rank test). Survival curves began to diverge at day 1 after admission and continued to separate throughout the 30-day follow-up period.

Table 1

Baseline patient characteristics for admissions on weekdays versus weekends

Characteristic	All N = 15,531	Weekdays N = 12,245	Weekends N = 3,286	*P*-Value
	Percentage or Median (Interquartile Range)			
Demographics				
Age, years	67.0 (52.0-77.0)	67.0 (52.0-77.0)	67.0 (51.0-78.0)	0.28
Male sex	40.1	40.2	39.6	0.54
Race				0.06
White	80.8	81.1	79.7	
Black	11.0	10.6	12.1	
Other or unknown	8.2	8.2	8.2	
Insurance status				0.85
Government	55.1	55.0	55.3	
Medicaid	7.6	7.5	7.7	
Private	35.8	36.0	35.3	
None or unknown	1.5	1.5	1.6	
Comorbid diseases				
History of cancer	19.6	20.0	18.1	0.02
Chronic lung disease	18.5	18.2	19.3	0.17
Heart failure	15.8	15.6	16.8	0.09
Physical examination findings				
Pulse ≥ 110/minute	17.7	16.8	20.7	< 0.001
Systolic blood pressure < 100 mm Hg	10.5	9.9	12.5	< 0.001
Respiratory rate ≥ 30/minute	14.6	13.7	17.7	< 0.001
Body temperature < 36°C	16.6	16.6	16.5	0.88
Altered mental status*	7.3	6.9	8.6	0.001
Oxygen saturation < 90%†	8.0	7.5	9.7	< 0.001
PESI risk class				< 0.001
Class I	19.5	19.7	18.7	
Class II	21.4	21.9	19.5	
Class III	21.8	22.0	21.1	
Class IV	16.2	16.3	15.9	
Class V	21.1	20.1	24.8	
Laboratory parameters				
Hemoglobin < 12 g/dl	30.2	29.8	31.7	0.04
Serum sodium < 130 or > 150 mmol/l	2.4	2.3	3.0	0.008
Serum creatinine > 1.5 mg/dl	11.7	11.5	12.8	0.04
Thrombolysis	2.3	2.2	2.7	0.13
Hospital region				0.006
Pittsburgh and Surrounding	23.3	23.0	24.4	
Northwest Pennsylvania	7.0	7.0	7.1	
Southern Laurel Highlands	5.1	4.8	6.1	

Characteristic	All N = 15,531	Weekdays N = 12,245	Weekends N = 3,286	*P*-Value
	Percentage or Median (Interquartile Range)			
North Central Pennsylvania	6.7	6.9	5.9	
South Central Pennsylvania	15.7	16.0	14.7	
Northeast Pennsylvania	6.0	6.0	6.3	
Eastern Pennsylvania	9.8	10.0	9.3	
Surrounding Philadelphia	14.3	14.4	13.6	
Philadelphia	12.1	11.9	12.6	
Mean annual number of PE, quartiles				0.11
< 10	5.3	5.3	5.5	
10-20	11.2	11.6	10.1	
> 20-42	25.6	25.6	25.5	
> 42	57.8	57.5	58.9	
Size and teaching status				0.39
Large nonteaching (≥ 350 beds)	19.5	19.3	20.4	
Small nonteaching (< 350 beds)	54.4	54.6	53.8	
Teaching	26.0	26.1	25.9	

Abbreviations: PE = pulmonary embolism; PESI = Pulmonary Embolism Severity Index.

[*] Defined as disorientation, lethargy, stupor, or coma.

[†] With or without supplemental oxygen.

Table 2

30-day mortality by severity of illness for patients admitted on weekdays versus weekends

PESI Risk Class	Weekday Mortality	Weekend Mortality	*P*-Value
	n/N (%)		
I	30/2413 (1.2)	9/614 (1.5)	0.66
II	85/2682 (3.2)	23/640 (3.6)	0.59
III	183/2695 (6.8)	43/694 (6.2)	0.58
IV	205/1990 (10.3)	64/522 (12.3)	0.20
V	572/2465 (23.2)	225/816 (27.6)	0.01
All	1075/12245 (8.8)	364/3286 (11.1)	

Abbreviation: PESI = Pulmonary Embolism Severity Index.

Table 3

Adjusted odds ratio for 30-day mortality for patients admitted on weekends compared to weekdays

Characteristic	Adjusted Odds Ratio for 30-Day Mortality*	95% Confidence Interval	*P*-Value
Weekend admission	1.17	1.03-1.34	0.02
Race			0.18
White	1.00	-	
Black	1.10	0.90-1.34	
Other or unknown	1.19	0.97-1.46	
Insurance type			0.13
Private	1.00	-	
Government	1.09	0.95-1.27	
Medicaid	1.07	0.80-1.42	
None/unknown	0.45	0.19-1.04	
PESI risk class*			< 0.001
I	1.00	-	
II	2.53	1.74-3.67	
III	5.22	3.67-7.42	
IV	8.83	6.21-12.56	
V	22.96	16.32-32.31	
Thrombolysis	1.75	1.30-2.37	< 0.001
Hospital region			0.03
Pittsburgh and surrounding	1.00	-	
Northwest Pennsylvania	0.95	0.73-1.23	
Southern Laurel Highlands	1.22	0.93-1.61	
North Central Pennsylvania	0.73	0.55-0.97	
South Central Pennsylvania	1.01	0.83-1.23	
Northeast Pennsylvania	1.08	0.83-1.41	
Eastern Pennsylvania	1.03	0.83-1.29	
Surrounding Philadelphia	1.00	0.82-1.22	
Philadelphia	1.30	1.07-1.59	
Size and teaching status			0.01
Large nonteaching (≥ 350 beds)	1.00	-	
Small nonteaching (< 350 beds)	1.04	0.89-1.22	
Teaching	1.27	1.06-1.51	

Abbreviations: PESI = Pulmonary Embolism Severity Index.

* The model was adjusted for patient race, insurance type, severity of illness using the Pulmonary Embolism Severity Index (including age, gender, history of cancer, chronic lung disease, or heart failure, systolic arterial blood pressure < 100 mm Hg, pulse ≥ 110/min., respiratory rate ≥ 30 breaths/min., body temperature < 36°C, arterial oxygen saturation < 90%, altered mental status), administration of thrombolysis, hospital region within Pennsylvania, and hospital size and teaching status.