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Weekend versus Weekday Admission and Mortality from Myocardial Infarction

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ABSTRACT

BACKGROUND

Management of acute myocardial infarction requires urgent diagnostic and therapeutic procedures, which may not be uniformly available throughout the week.

METHODS

We examined differences in mortality between patients admitted on weekends and those admitted on weekdays for a first acute myocardial infarction, using the Myocardial Infarction Data Acquisition System. All such admissions in New Jersey from 1987 to 2002 (231,164) were included and grouped in 4-year intervals.

RESULTS

There were no significant differences in demographic characteristics, coexisting conditions, or infarction site between patients admitted on weekends and those admitted on weekdays. However, patients admitted on weekends were less likely to undergo invasive cardiac procedures, especially on the first and second days of hospitalization (P<0.001). In the interval from 1999 to 2002 (59,786 admissions), mortality at 30 days was significantly higher for patients admitted on weekends (12.9% vs. 12.0%, P=0.006). The difference became significant the day after admission (3.3% vs. 2.7%, P<0.001) and persisted at 1 year (1% absolute difference in mortality). The difference in mortality at 30 days remained significant after adjustment for demographic characteristics, coexisting conditions, and site of infarction (hazard ratio, 1.048; 95% confidence interval [CI], 1.022 to 1.076; P<0.001), but it became nonsignificant after additional adjustment for invasive cardiac procedures (hazard ratio, 1.023; 95% CI, 0.997 to 1.049; P=0.09).

CONCLUSIONS

For patients with myocardial infarction, admission on weekends is associated with higher mortality and lower use of invasive cardiac procedures. Our findings suggest that the higher mortality on weekends is mediated in part by the lower rate of invasive procedures, and we speculate that better access to care on weekends could improve the outcome for patients with acute myocardial infarction.

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Although most service industries operate on a daily basis, many hospitals provide routine care on weekdays and only emergency or urgent care on weekends. Hospital staffing is reduced on weekends, both numerically and in terms of available expertise on site.[1] This difference in staffing may result in different outcomes for patients with acute conditions such as myocardial infarction, depending on whether they are admitted on weekends or weekdays. The findings of studies that compared mortality rates among patients with acute myocardial infarction who were admitted on weekends and those admitted on weekdays have been inconsistent. In a U.S. study[2] of 156,136 patients admitted to 38 intensive care units, the risk-adjusted rate of in-hospital death was 9% higher for weekend admissions, but the study excluded patients with acute myocardial infarction. Canadian investigators[3,4] reported a lower rate of use of coronary angiography but no significant increase in mortality for weekend admissions among 160,220 patients with acute myocardial infarction. In the National Registry of Myocardial Infarction database, presentation during off-hours was associated with a longer time to primary percutaneous coronary intervention (PCI) and higher mortality among patients with acute myocardial infarction.[5] Even small differences in mortality between weekday and weekend admissions of patients with acute myocardial infarction can translate to substantial numbers of additional deaths in the population because of the high incidence and case fatality rate associated with this condition.

The aims of our study were twofold: to compare mortality rates among patients admitted with acute myocardial infarction on weekends and those admitted on weekdays and to determine whether any differences in mortality could be explained by differences in the use and timing of invasive cardiac procedures, the length of the hospital stay, or characteristics of the patients.

METHODS

DATA SOURCES

We used information from the Myocardial Infarction Data Acquisition System (MIDAS) database for this study.[6-10] MIDAS contains sociodemographic and clinical data on patients who were discharged with the diagnosis of acute myocardial infarction (code 410 of the *International Classification of Diseases, 9th Revision, Clinical Modification*) from all nonfederal acute care hospitals in New Jersey. The database also includes all records of hospitalizations involving invasive cardiac procedures — cardiac catheterization, PCI, or coronary-artery bypass grafting (CABG) — or coexisting conditions. We obtained data on out-of-hospital deaths by matching the MIDAS records with the New Jersey death registration files, using automated record linkage software (Automatch, Matchware Technologies).[6,11] Outcome ascertainment was performed by means of an automated procedure, and the operator was unaware of the day and time of admission.

STUDY PATIENTS

The study included 231,164 patients admitted to New Jersey hospitals between 1987 and 2002 with acute myocardial infarction as the primary reason for admission; for all patients, this was their first admission with this diagnosis during the study period. Patients who were admitted to federal hospitals or nursing homes (less than 3% of all patients) or who sustained the infarction during an admission for another diagnosis or procedure were excluded.

STUDY VARIABLES

The primary outcome variable was death within 30 days after admission. Both in-hospital and cumulative (inpatient or postdischarge) mortality rates for each of the first 7 days, as well as at 14, 21, 30, 180, and 365 days, were examined. We assessed length of stay and the use of catheterization, PCI, and CABG on each of the first 7 days of hospitalization, the number of days from the date of admission to the day the procedure was performed, and the use of these procedures up to 30 days from the date of admission (including procedures performed during subsequent admissions).

The primary independent variable was admission on weekends (Saturday or Sunday) versus weekdays. Covariates included patient characteristics, infarction site and type (Q-wave vs. non–Q-wave), the presence or absence of coexisting conditions (including diabetes, hypertension, chronic obstructive pulmonary disease, chronic liver disease, chronic renal disease, anemia, cerebrovascular disease, and cancer), and the presence or absence of complications. Two composite indexes of mechanical or arrhythmic complications of myocardial infarction have been defined. The first, left ventricular dysfunction, included the

Table 1. Characteristics of Patients Admitted on Weekends and Patients Admitted on Weekdays.*

Characteristic	1987–1990			1991–1994			1995–1998			1999–2002		
	Weekdays (N=42,076)	Weekends (N=15,490)	P Value	Weekdays (N=41,167)	Weekends (N=14,745)	P Value	Weekdays (N=42,525)	Weekends (N=15,375)	P Value	Weekdays (N=44,244)	Weekends (N=15,542)	P Value
Age (yr)	67.3±0.06	66.8±0.11	<0.001	67.5±0.07	67.1±0.11	0.004	68.4±0.07	68.0±0.11	0.004	69.5±0.07	69.2±0.12	0.05
Male sex (%)	60.5	61.7	0.008	60.1	61.2	0.02	59.4	59.7	0.44	57.9	58.3	0.37
White race (%)†	86.0	86.2	0.24	85.9	86.0	0.21	85.5	85.4	0.06	82.3	82.4	0.88
Location and type of myocardial infarction (%)			0.11			0.002			0.66			0.69
Anterior	31.1	30.4		26.9	27.4		24.1	24.3		17.5	17.3	
Inferior	34.1	35.0		33.3	34.3		30.0	29.9		22.4	22.7	
Lateral	2.7	2.6		2.5	2.6		2.4	2.4		1.7	1.7	
Other site	11.7	12.0		8.5	7.8		7.2	6.9		7.7	7.4	
Non–Q-wave	20.5	19.9		28.8	27.9		36.3	36.5		50.8	51.0	
Q-wave	67.9	68.1	0.21	62.7	64.4	<0.001	56.5	56.7	0.33	41.5	41.7	0.49
Coexisting conditions (%)												
Diabetes	23.8	23.5	0.53	25.0	25.4	0.38	26.6	25.8	0.06	27.8	27.4	0.49
Hypertension	36.8	36.0	0.08	41.5	40.7	0.07	48.0	47.1	0.06	53.9	53.3	0.22
Renal disease	3.9	4.1	0.50	4.8	4.6	0.32	5.8	5.7	0.60	7.2	7.4	0.57
Liver disease	0.3	0.3	0.51	0.4	0.3	0.35	0.3	0.3	0.93	0.4	0.5	0.32
Anemia	7.4	8.2	0.002	10.5	9.8	0.03	10.6	10.6	0.98	12.5	12.7	0.44
Cancer	1.8	1.8	0.95	2.2	2.2	0.83	2.7	2.5	0.16	3.3	3.1	0.37
Cerebrovascular disease	4.7	4.6	0.35	5.8	5.1	0.19	5.0	5.0	0.85	5.2	5.3	0.70
Complications (%)												
Mechanical	37.2	38.4	0.007	34.0	35.0	0.03	31.6	32.6	0.02	31.4	32.2	0.06
Arrhythmic	43.6	45.2	<0.001	39.7	41.6	<0.001	36.6	37.9	0.002	33.1	33.7	0.16
Length of stay (days)	11.6±0.05	11.7±0.09	0.24	10.5±0.05	10.4±0.08	0.24	8.1±0.04	7.9±0.06	0.02	7.4±0.03	7.2±0.06	0.03

* Plus–minus values are means ±SE.
† Race was ascertained from records of patient discharge data.

Table 2. Invasive Cardiac Procedures Performed in Patients Admitted on Weekends and on Weekdays.*

Procedure	1987–1990			1991–1994			1995–1998			1999–2002		
	Weekdays	Weekends	P Value	Weekdays	Weekends	P Value	Weekdays	Weekends	P Value	Weekdays	Weekends	P Value
Catheterization												
No. of patients	13,212	4769		19,429	6656		22,033	7887		24,851	8593	
No. of days to catheterization	6.0±0.06	6.3±0.09	0.02	4.3±0.04	4.6±0.06	<0.001	2.8±0.03	3.1±0.05	<0.001	2.1±0.02	2.5±0.04	<0.001
Day of admission (%)	1.2	0.7	<0.001	3.7	1.5	<0.001	8.3	4.1	<0.001	14.0	8.3	<0.001
Day 2 (%)	2.6	1.5	<0.001	7.6	4.1	<0.001	13.0	7.0	<0.001	20.5	12.3	<0.001
Day 3 (%)	3.4	2.6	<0.001	9.7	6.6	<0.001	16.2	12.6	<0.001	24.3	19.9	<0.001
Day 4 (%)	4.5	3.9	0.001	12.1	9.8	<0.001	20.0	18.1	<0.001	28.6	26.9	<0.001
Day 5 (%)	5.7	5.7	0.99	14.6	13.5	0.001	23.6	22.3	<0.001	32.3	30.9	0.002
Day 6 (%)	6.8	7.6	<0.001	16.8	16.9	0.77	26.1	24.8	0.001	34.4	32.9	<0.001
Day 7 (%)	8.4	8.8	0.16	19.4	18.3	0.002	27.8	25.7	<0.001	35.7	33.4	<0.001
Catheterization by day 30 (%)	31.4	30.8	0.16	47.2	45.2	<0.001	51.8	51.3	0.30	56.2	55.3	0.06
Odds ratio for catheterization by day 2 (95% CI)		0.53 (0.46–0.61)			0.51 (0.47–0.56)			0.49 (0.46–0.52)			0.51 (0.48–0.54)	
Odds ratio for catheterization by day 7 (95% CI)		1.03 (0.97–1.10)			0.93 (0.88–0.97)			0.88 (0.85–0.92)			0.89 (0.85–0.93)	
Odds ratio for catheterization by day 30 (95% CI)		0.95 (0.91–0.99)			0.89 (0.86–0.93)			0.96 (0.93–1.00)			0.95 (0.91–0.99)	
PCI												
No. of patients	3318	1187		6813	2382		10,785	3791		14,104	4897	
No. of days to PCI	5.9±0.18	6.4±0.34	0.17	4.7±0.09	5.3±0.17	<0.001	2.0±0.04	2.5±0.08	<0.001	1.2±0.03	1.6±0.05	<0.001
Day of admission (%)	0.5	0.4	0.42	1.3	0.8	<0.001	5.1	3.0	<0.001	10.0	6.7	<0.001
Day 2 (%)	0.7	0.6	0.06	2.1	1.4	<0.001	6.7	4.1	<0.001	12.9	8.6	<0.001
Day 3 (%)	0.8	0.7	0.08	2.6	1.8	<0.001	7.6	5.2	<0.001	14.1	10.9	<0.001
Day 4 (%)	0.9	0.8	0.23	3.0	2.2	<0.001	8.4	6.2	<0.001	15.1	12.3	<0.001
Day 5 (%)	1.0	1.0	0.54	3.5	2.8	<0.001	9.0	7.0	<0.001	15.8	13.1	<0.001
Day 6 (%)	1.1	1.1	0.90	3.9	3.4	0.01	9.5	7.7	<0.001	16.2	13.6	<0.001
Day 7 (%)	1.3	1.3	0.93	4.3	3.6	<0.001	10.0	8.0	<0.001	16.5	13.7	<0.001

PCI by day 30 (%)	7.9	7.7	0.38	16.6	16.2	0.27	25.4	24.7	0.08	31.9	31.5	0.39
Odds ratio for PCI by day 2 (95% CI)		0.76 (0.60–0.97)			0.64 (0.54–0.74)			0.58 (0.53–0.63)			0.60 (0.56–0.64)	
Odds ratio for PCI by day 7 (95% CI)		0.98 (0.83–1.16)			0.84 (0.76–0.92)			0.78 (0.73–0.83)			0.78 (0.74–0.82)	
Odds ratio for PCI by day 30 (95% CI)		0.95 (0.89–1.02)			0.96 (0.91–1.02)			0.95 (0.91–0.99)			0.97 (0.93–1.02)	
CABG												
No. of patients	2635	925		4657	1510		5641	1915		6170	1987	
No. of days to CABG	8.6±0.27	9.1±0.53	0.36	6.6±0.14	7.4±0.28	0.009	4.1±0.09	5.1±0.20	<0.001	3.8±0.08	4.4±0.16	0.001
Day of admission (%)	0.1	0.0	0.13	0.3	0.1	<0.001	0.8	0.3	<0.001	0.9	0.4	<0.001
Day 2 (%)	0.2	0.1	0.003	0.7	0.4	<0.001	1.6	0.6	<0.001	2.0	0.8	<0.001
Day 3 (%)	0.2	0.2	0.34	1.1	0.7	<0.001	2.1	1.0	<0.001	2.8	1.4	<0.001
Day 4 (%)	0.3	0.3	0.22	1.4	1.0	0.003	2.6	1.5	<0.001	3.4	2.3	<0.001
Day 5 (%)	0.4	0.4	0.25	1.7	1.3	0.001	3.1	2.1	<0.001	4.1	3.1	<0.001
Day 6 (%)	0.5	0.5	0.74	2.0	1.6	0.02	3.5	2.6	<0.001	4.6	3.6	<0.001
Day 7 (%)	0.6	0.6	0.76	2.3	1.7	<0.001	3.9	2.9	<0.001	5.1	3.8	<0.001
CABG by day 30 (%)	6.3	6.0	0.20	11.3	10.2	<0.001	13.3	12.5	0.01	14.0	12.8	<0.001
Odds ratio for CABG by day 2 (95% CI)		0.40 (0.21–0.71)			0.57 (0.43–0.75)			0.36 (0.28–0.44)			0.38 (0.31–0.46)	
Odds ratio for CABG by day 7 (95% CI)		0.93 (0.72–1.19)			0.77 (0.67–0.89)			0.71 (0.64–0.79)			0.72 (0.65–0.79)	
Odds ratio for CABG by day 30 (95% CI)		0.94 (0.87–1.02)			0.89 (0.84–0.95)			0.93 (0.88–0.98)			0.90 (0.85–0.95)	

* Plus–minus values are means ±SE. Odds ratios, which are for admissions on weekends as compared with weekdays, were adjusted for age, sex, and site and type of myocardial infarction, presence or absence of coexisting conditions, and presence or absence of complications.

presence of any of the following: congestive heart failure, left heart failure, cardiomegaly, rupture of the papillary muscle, rupture of the chordae tendineae, acquired cardiac septal defects, cardiogenic shock, or ventricular aneurysm. The second index, electrical instability, included the presence of cardiac dysrhythmias, atrioventricular blocks, intraventricular blocks, or other conduction disorders. These composite indexes stratify the 30-day risk of death from myocardial infarction as follows: the absence of both types of complications, 5.0%; electrical instability alone, 13.5%; left ventricular dysfunction alone, 18.5%; and both electrical instability and left ventricular dysfunction, 29.3%.

STATISTICAL ANALYSIS

Data for the period from 1987 to 2002 were grouped into 4-year intervals (1987 to 1990, 1991 to 1994, 1995 to 1998, and 1999 to 2002). Separate analyses were performed for each calendar period, with primary emphasis on the most recent data (1999 to 2002). We compared patient characteristics and the use or nonuse of invasive cardiac procedures among patients admitted to the hospital on weekends and those admitted on weekdays. Multiple logistic-regression models were used to account for the confounding effects of patient demographics, coexisting conditions, and complications. Multiple linear regression was used to adjust for confounders in comparing length of stay between weekend and weekday admissions.

We compared weekend and weekday admissions in terms of both in-hospital and cumulative (inpatient and postdischarge) mortality. To adjust for confounders, we used Cox proportional-hazard models in comparing the risk of death associated with weekend versus weekday admissions.

We also determined whether the difference in mortality between weekend and weekday admissions could be explained by differences in the rate of invasive procedures. Invasive cardiac procedures would be considered to mediate the association between weekend and weekday admission and mortality if the hazard ratio decreased when these procedures were included in the hazard model.

To examine the possibility that differences in transfer rates between weekend and weekday admissions could confound the results, we performed additional analyses, one confined to admissions to hospitals equipped to perform PCI and one confined to admissions of patients who were not transferred. Similarly, we conducted an analysis that was restricted to admissions of New Jersey residents (94% of all admissions). We also repeated the analyses with an expanded definition of "weekend" to include admissions after 5 p.m. on Friday.

Statistical analyses were performed with the use of SAS 9.0 and JMP 6.0 software (SAS Institute). The institutional review boards of the State of New Jersey Department of Health and Senior Services and the Robert Wood Johnson Medical School approved the study; because the study involved de-identified data acquired during routine care, informed consent was not required.

RESULTS

CHARACTERISTICS OF THE PATIENTS

During the years studied, there were increases in the age of patients and in the proportion with coexisting conditions, and there were decreases in the proportion with Q-wave infarction and in the length of stay. There were small but statistically significant differences in several baseline characteristics between patients admitted on weekends and those admitted on weekdays, including age, presence or absence of complications, and length of stay (Table 1). The distribution of myocardial infarction by anatomical site and by type (Q-wave vs. non–Q-wave) and the rates of major coexisting conditions were similar between weekend and weekday admissions.

INVASIVE CARDIAC PROCEDURES

Patients admitted on weekends were less likely to undergo invasive cardiac procedures than were patients admitted on weekdays, especially during the first few days after admission (Table 2). The probability of catheterization by the day after admission, when adjusted for demographic characteristics, site of infarction, presence or absence of coexisting illnesses, and presence or absence of complications, was significantly lower for patients admitted on weekends for all 4-year intervals ($P<0.001$ for all comparisons), with the odds ratio ranging from 0.49 to 0.53 and an odds ratio of 0.52 (95% confidence interval [CI], 0.50 to 0.54) for all intervals combined. The adjusted probability of catheterization in the first 30 days was also lower for patients admitted on weekends. The average number of days between admission and catheterization was significantly higher for patients

Table 3. Mortality among Patients Admitted on Weekends and Patients Admitted on Weekdays.*

No. of Days from Admission	1987–1990			1991–1994			1995–1998			1999–2002		
	Weekdays	Weekends	P Value	Weekdays	Weekends	P Value	Weekdays	Weekends	P Value	Weekdays	Weekends	P Value
	percent (mortality)			*percent (mortality)*			*percent (mortality)*			*percent (mortality)*		
Day of admission	2.2	2.5	0.04	1.8	1.8	0.94	1.6	1.6	0.34	1.1	1.3	0.09
Day 2	4.5	5.2	0.001	3.8	4.0	0.35	3.6	3.5	0.71	2.7	3.3	<0.001
Day 3	6.0	6.7	0.005	5.0	5.2	0.24	4.9	4.8	0.80	3.8	4.7	<0.001
Day 4	7.2	7.9	0.007	5.9	6.2	0.16	5.8	5.6	0.39	4.7	5.8	<0.001
Day 5	8.1	8.8	0.01	6.7	7.0	0.20	6.5	6.4	0.48	5.4	6.4	<0.001
Day 6	8.8	9.5	0.02	7.3	7.7	0.16	7.1	7.0	0.73	6.0	7.0	<0.001
Day 7	9.4	10.1	0.03	7.8	8.3	0.04	7.6	7.7	0.87	6.6	7.5	<0.001
In-hospital	14.5	15.1	0.11	11.8	12.2	0.20	10.4	10.2	0.41	9.3	9.9	0.03
Day 14	12.5	13.2	0.03	10.4	10.9	0.09	10.2	10.2	0.86	9.4	10.4	<0.001
Day 21	13.9	14.7	0.01	11.6	12.2	0.08	11.5	11.4	0.72	10.9	11.8	0.002
Day 30	15.1	16.0	0.009	12.6	13.1	0.10	12.6	12.4	0.69	12.0	12.9	0.006
Day 180	20.5	21.5	0.01	18.0	18.5	0.14	18.1	17.8	0.38	18.9	20.0	0.005
Day 365	23.7	24.6	0.02	21.0	21.7	0.09	21.4	21.2	0.61	22.9	23.9	0.01
Hazard ratio for day 2 mortality (95% CI)		1.075 (1.032–1.121)			1.033 (0.985–1.083)			1.007 (0.958–1.057)			1.121 (1.064–1.180)	
Hazard ratio for day 7 mortality (95% CI)		1.033 (1.004–1.063)			1.044 (1.011–1.078)			1.014 (0.982–1.048)			1.080 (1.045–1.116)	
Hazard ratio for total in-hospital mortality (95% CI)		1.034 (1.009–1.059)			1.025 (0.997–1.054)			1.015 (0.986–1.045)			1.055 (1.024–1.086)	
Hazard ratio for day 30 mortality (95% CI)		1.040 (1.016–1.065)			1.038 (1.011–1.066)			1.007 (0.981–1.034)			1.048 (1.022–1.076)	
Hazard ratio for day 365 mortality (95% CI)		1.032 (1.013–1.052)			1.033 (1.012–1.054)			1.005 (0.985–1.026)			1.037 (1.017–1.056)	

* Hazard ratios are adjusted for age, sex, site of myocardial infarction, and coexisting conditions.

admitted on weekends in all four calendar periods (Table 2).

The proportion of patients undergoing PCI was significantly lower for weekend admissions than for weekday admissions during the first week after admission (P<0.001 overall), and this difference diminished at 30 days after admission (Table 2). The pattern was clearly seen during the years 1991 to 2002, and adjustment for important confounders did not change the results. PCI performed by the day after admission was significantly less likely for patients admitted on weekends during this period (P<0.001) (Table 2) and, after adjustment, for all four time intervals, with the adjusted odds ratio ranging from 0.58 to 0.76 and an overall adjusted odds ratio of 0.62 (95% CI, 0.59 to 0.65). The average number of days from admission to PCI decreased for both weekend and weekday admissions over the entire study period, but the interval was significantly longer for patients admitted on weekends in the period from 1991 to 2002 (P<0.001).

Patients admitted on the weekend were less likely to undergo CABG during the first week (P<0.001) and during the first 30 days after admission (P<0.01) in the three 4-year periods from 1991 to 2002 (Table 2). The adjusted probability of undergoing CABG during the first 30 days after admission was significantly lower and the number of days from admission to CABG was longer for patients admitted on weekends within the same period.

MORTALITY

Overall, mortality 30 days after admission was significantly higher for patients admitted on weekends than for those admitted on weekdays (P<0.001) (Table 3). During the 1999–2002 calendar period, the cumulative frequency of deaths at 30 days was 12.9% for weekend admissions, as compared with 12.0% for weekday admissions, an absolute difference of 0.9% (relative difference, 7.5%). This difference became significant the day after admission (3.3% vs. 2.7%, P<0.001) and persisted at 1 year (absolute difference, 1.0%; P=0.01) (Fig. 1 and Table 3). The relative risk of death for weekend as compared with weekday admission was highest on the day of admission (1.18) and on the second day (1.22), third day (1.24), and fourth day (1.23) after admission. Mortality remained significantly higher after adjustment for demographic characteristics, the site of infarction, and the presence or absence of coexisting conditions, with hazard ratios of 1.121 on the day after admission, 1.080 at 7 days, 1.048 at 30 days, and 1.037 at 1 year (Table 3). This relationship was attenuated when factors that may explain the higher mortality associated with weekend admission were successively included in the proportional-hazards model. When invasive procedures were added to the model, the relationship between weekend admission and mortality was no longer significant (Table 4). A similar pattern of higher mortality among patients admitted on weekends was also seen in the years before 1999 (Table 3).

When the analysis was restricted to admissions to hospitals equipped to perform PCI (20,627 admissions), the adjusted risk of death at 30 days remained increased (hazard ratio, 1.080; 95% CI, 1.027 to 1.135) for weekend admission, and after additional adjustment for invasive cardiac procedures, the difference was no longer significant (hazard ratio, 1.013; 95% CI, 0.963 to 1.065). An analysis confined to patients who were not transferred to another acute care hospital yielded similar results. Analyses restricted to New Jersey residents yielded results nearly identical to those in Table 4: an increase in the adjusted 30-day risk of death among patients admitted on weekends (hazard ratio, 1.049; 95% CI, 1.013 to 1.067), with a difference that was no longer significant after adjustment for invasive procedures (hazard ratio, 1.024; 95% CI, 0.998 to 1.051). When the definition of "weekend" was expanded (to include Friday after 5 p.m. as well as Saturday and Sunday), the adjusted 30-day risk of death was similar to that in the original analysis (hazard ratio, 1.054; 95% CI, 1.029 to 1.080).

DISCUSSION

Our analysis of the MIDAS data on acute myocardial infarction showed the temporal changes in patient characteristics, length of stay, invasive procedures, complications, and mortality that have been reported previously.[12-17] Our study also showed that after adjustment for confounders, the mortality was higher among patients admitted on weekends than among those admitted on weekdays. In a study of admissions for acute myocardial infarction, Cram and colleagues found a significant increase in hospital mortality among patients admitted on weekends as compared with those admitted on weekdays (risk-adjusted odds ra-

tio, 1.09 [95% CI, 1.00 to 1.17]).[18] The rate of admission and the severity of acute myocardial infarction may vary according to the day of the week.[19,20] However, in our study, it is unlikely that differences in patient characteristics can explain the increased mortality among patients admitted on the weekend, since the difference persisted after adjustment for demographic characteristics, Q-wave versus non–Q-wave infarction, presence or absence of coexisting conditions, presence or absence of complications, and length of stay.

Patients admitted on weekends were less likely to undergo invasive cardiac procedures than were those admitted on weekdays. Also, the time between admission and performance of procedures was longer for patients admitted on weekends. The percentage of patients who underwent a procedure on the day of admission (possibly reflecting primary PCI) was also lower on weekends. Quaas and colleagues found that patients admitted on weekends were one fourth as likely to undergo coronary angiography as were those admitted on weekdays.[21] Observational data and randomized trials have shown a survival benefit of both PCI and CABG in at least some subgroups of patients.[8,22-25] In our study, invasive procedures were also associated with a lower adjusted 30-day mortality. Our finding that the increase in mortality was no longer significant after additional adjustment for invasive procedures implies that the worse outcome of weekend admissions may be due in part to a lower rate of invasive intervention.

In our analysis of the MIDAS data, the length of the hospital stay was not significantly different between weekend and weekday admissions. Ellis and colleagues, studying hospital charges associated with PCI, identified weekend delays as a factor associated with higher costs,[26] and Sheng and colleagues reported that the hospital stay was 19% longer among patients admitted late in the week (Thursday through Saturday) than among those admitted earlier in the week (Sunday through Tuesday), after adjustment for the severity of illness.[27] It is possible that vigorous utilization review prevented delays in the discharge of patients admitted on weekends.

The principal limitation of this study is that unmeasured confounders may have contributed to the reported differences in mortality between patients admitted on weekends and those admitted on weekdays. For example, the database does not include data on the time from the onset of symptoms to presentation, infarct size, hemodynamic status at presentation, or medications administered during hospitalization. It is possible that differential administration of beta-blockers, aspirin, and other pharmacologic agents can explain some of the observed differences between weekend and weekday admissions. Patients admitted on weekends tended to be slightly younger, which would be associated with lower mortality, and had slightly higher rates of complications, which would be associated with higher mortality. Although small differences were noted in certain baseline characteristics between weekend and weekday admissions, these were included in the multivariate analysis, and differences in adjusted mortality were still observed.

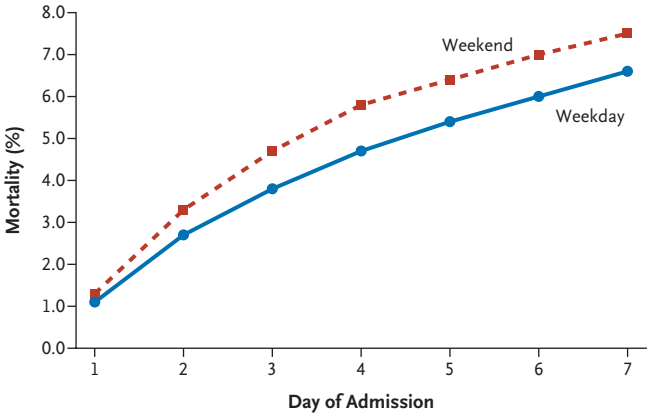

Figure 1. Mortality for Weekend versus Weekday Admissions According to Day of Admission, 1999–2002.

An additional limitation is that a smaller proportion of patients was admitted to hospitals equipped to perform PCI on weekends (22.4%) than on weekdays (25.4%). However, this cannot be the sole explanation for the increased mortality among patients admitted on weekends, because the increased risk of death persisted after additional adjustment for the availability of PCI at the hospital of admission (hazard ratio, 1.045); the increased risk also persisted in a separate analysis confined to hospitals that were equipped to perform PCI (hazard ratio, 1.080). It is also possible that some patients died after they had changed their state of residence (and such deaths may therefore not have been recorded in the database), but this type of move would be unlikely to occur soon after infarction.

None of the above limitations, however, de-

Table 4. Adjusted Risk of Death by 30 Days after Admission among Patients Admitted on Weekends and Those Admitted on Weekdays, 1999–2002.*

Term in Cox Model	Hazard Ratio (95% Confidence Interval)				
Weekend admission	1.039 (1.012–1.066)	1.048 (1.022–1.076)	1.047 (1.021–1.074)	1.031 (1.005–1.058)	1.023 (0.997–1.049)
Age		1.058 (1.056–1.060)	1.049 (1.047–1.051)	1.053 (1.050–1.055)	1.032 (1.030–1.035)
Female sex		1.088 (1.062–1.115)	1.087 (1.061–1.113)	1.114 (1.087–1.141)	1.066 (1.040–1.092)
Q-wave myocardial infarction		1.025 (0.992–1.059)	1.046 (1.012–1.081)	1.080 (1.045–1.116)	1.201 (1.162–1.241)
Non–Q-wave myocardial infarction		0.561 (0.543–0.580)	0.566 (0.548–0.585)	0.581 (0.562–0.600)	0.561 (0.543–0.580)
Diabetes		1.019 (0.993–1.046)	1.010 (0.984–1.037)	0.996 (0.970–1.023)	0.991 (0.965–1.018)
Hypertension		0.821 (0.802–0.841)	0.865 (0.845–0.886)	0.836 (0.817–0.856)	0.853 (0.834–0.874)
Renal disease		1.680 (1.633–1.730)	1.568 (1.523–1.614)	1.831 (1.777–1.887)	1.696 (1.646–1.747)
Liver disease		1.534 (1.354–1.737)	1.528 (1.349–1.730)	1.600 (1.412–1.812)	1.371 (1.210–1.553)
Anemia		0.877 (0.848–0.907)	0.889 (0.860–0.919)	0.937 (0.906–0.970)	0.908 (0.878–0.939)
Cancer		1.329 (1.267–1.393)	1.347 (1.284–1.412)	1.419 (1.353–1.488)	1.310 (1.249–1.373)
Cerebrovascular disease		1.220 (1.173–1.269)	1.232 (1.185–1.281)	1.358 (1.305–1.413)	1.243 (1.195–1.293)
Mechanical complications			1.329 (1.297–1.362)	1.480 (1.444–1.518)	1.381 (1.347–1.416)
Arrhythmic complications			1.265 (1.235–1.295)	1.347 (1.316–1.379)	1.313 (1.283–1.345)
Length of stay				0.896 (0.890–0.901)	0.893 (0.888–0.898)
No catheterization within 30 days					1.660 (1.602–1.721)
No PCI within 30 days					1.715 (1.632–1.802)
No CABG within 30 days					1.382 (1.297–1.473)

* Data are for 59,767 patients. The hazard ratios are derived from sequential Cox proportional-hazard models that included variables that may affect 30-day mortality.

tract from the fact that mortality was higher and the rate of invasive procedures was lower for weekend admissions. In addition, this study has important strengths, including a large sample and the absence of patient selection, since virtually all patients admitted to a New Jersey hospital over a 16-year period for a first myocardial infarction were included. The fact that analyses restricted to PCI-equipped hospitals, to patients who were not transferred, and to New Jersey residents yielded similar results — as did an analysis that incorporated admissions on Friday after 5 p.m. as part of the weekend admissions — strengthens the conclusions of the study. Also, we examined mortality up to 1 year and included all invasive cardiac procedures performed up to 1 month after admission. Finally, two random samples were audited,[6,10] corroborating the reliability and integrity of the data. Overall, our study suggests that a hospital workweek of Monday through Friday is not optimal for the care of patients with acute myocardial infarction. Since our data were collected between 1987 and 2002, it is possible that current practices in hospitals have already improved. For example, more emphasis on the benefits of primary PCI may have resulted in hospital staffing patterns that are more uniform across the days of the week.

The observation of a significant and clinically relevant increase in mortality among patients with a first myocardial infarction who were admitted on a weekend rather than a weekday — representing 9 to 10 additional deaths per 1000 admissions per year — has important implications for clinical care. The increase in mortality, which may persist for more than a year, could account for several thousand deaths annually in the United States. More appropriate hospital staffing or regionalization of the care of patients with acute myocardial infarction may prevent some of these deaths.

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An interview with Dr. Thomas Lee on increased mortality with weekend admissions can be heard at www.nejm.org.