Special Article

MORTALITY AMONG PATIENTS ADMITTED TO HOSPITALS ON WEEKENDS AS COMPARED WITH WEEKDAYS

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ABSTRACT

Background The level of staffing in hospitals is often lower on weekends than on weekdays, despite a presumably consistent day-to-day burden of disease. It is uncertain whether in-hospital mortality rates among patients with serious conditions differ according to whether they are admitted on a weekend or on a weekday.

Methods We analyzed all acute care admissions from emergency departments in Ontario, Canada, between 1988 and 1997 (a total of 3,789,917 admissions). We compared in-hospital mortality among patients admitted on a weekend with that among patients admitted on a weekday for three prespecified diseases: ruptured abdominal aortic aneurysm (5454 admissions), acute epiglottitis (1139), and pulmonary embolism (11,686) and for three control diseases: myocardial infarction (160,220), intracerebral hemorrhage (10,987), and acute hip fracture (59,670), as well as for the 100 conditions that were the most common causes of death (accounting for 1,820,885 admissions).

Results Weekend admissions were associated with significantly higher in-hospital mortality rates than were weekday admissions among patients with ruptured abdominal aortic aneurysms (42 percent vs. 36 percent, $P<0.001$), acute epiglottitis (1.7 percent vs. 0.3 percent, $P=0.04$), and pulmonary embolism (13 percent vs. 11 percent, $P=0.009$). The differences in mortality persisted for all three diagnoses after adjustment for age, sex, and coexisting disorders. There were no significant differences in mortality between weekday and weekend admissions for the three control diagnoses. Weekend admissions were also associated with significantly higher mortality rates for 23 of the 100 leading causes of death and were not associated with significantly lower mortality rates for any of these conditions.

Conclusions Patients with some serious medical conditions are more likely to die in the hospital if they are admitted on a weekend than if they are admitted on a weekday. (N Engl J Med 2001;345:663-8.)

STAFFING levels in acute care hospitals tend to be lower on weekends than on weekdays. The reduction in clinical personnel on weekends may lead to shortfalls in care, since the incidence of many medical emergencies is similar from day to day.[1,2] Such staffing patterns may explain, in part, why surges in population-wide deaths on weekends are common in industrialized countries.[3-5]

Data from a few clinical studies suggest that hospitals function less effectively on weekends than on weekdays. Neonatal mortality is marginally higher among babies born on weekends than among those born on weekdays.[6-11] In addition, the management of acute myocardial infarction, stroke, and drug overdose may be worse for patients presenting on weekends than for those presenting on weekdays.[12-14] Even the widely publicized death of Libby Zion in 1984, which led to an examination of the quality of care in teaching hospitals, is noteworthy because she died a few hours after being admitted to a hospital on a Sunday night.[15]

We conducted a study involving all acute care hospitals in Ontario, Canada, over a 10-year period to compare the rate of death among patients admitted to hospitals on weekends with the rate among patients admitted on weekdays.

METHODS

Data Collection

We identified every patient admitted to an acute care hospital through an emergency department in Ontario between April 1, 1988, and March 31, 1997. This interval was chosen because it encompassed all the available data. Hospital-discharge data were obtained from the Canadian Institute for Health Information, regardless of whether the patient had died in the hospital, had been discharged home, or had been transferred to another facility. We excluded all elective admissions, urgent referrals, elective transfers, and births.

Consecutive patients were identified according to the day of the week when they were admitted. The weekend was defined as the period from midnight on Friday to midnight on Sunday. All other times were defined as weekdays. For patients transferred between

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hospitals, the day of admission was defined as the day they presented to the initial acute care facility. Patients were classified according to the single diagnostic code in the *International Classification of Diseases, Ninth Revision* (ICD-9), that was the primary reason for their hospital stay. (Whereas in the United States, ICD codes are assigned according to the primary reason for admission, in Canada they are assigned according to the primary reason for the entire hospital stay.) The reliability of the coding of data collected by the Canadian Institute for Health Information is 74 to 96 percent for the ICD-9 diagnosis, 97 percent for the day of admission, and more than 99 percent for death.[16,17] The patient's age and sex and any coexisting conditions were also documented.[18-23]

Prespecified Conditions

We anticipated no major difference in aggregate mortality among patients admitted on weekends and those admitted on weekdays; however, we hypothesized that there would be a difference in mortality for three prespecified conditions. These conditions were selected according to seven criteria that we theorized would accentuate the consequences of lower staffing levels on weekends. The criteria were as follows: the condition occurs frequently, the in-hospital mortality rate among patients with the condition is high, the first few days of hospitalization are critical, the condition is treatable, care involves logistic difficulties, death can be rapid, and patients with the condition typically receive a substantial amount of care in clinical settings other than a critical care unit or emergency department. The three diseases we identified that met these criteria were ruptured abdominal aortic aneurysm, acute epiglottitis, and pulmonary embolism.

We also identified three conditions that did not meet the seven criteria — that is, control conditions, for which we anticipated equivalent mortality rates among patients admitted on weekends and those admitted on weekdays. The first was acute myocardial infarction, which is usually managed in a critical care setting, where fluctuations in staffing levels are minimal.[24,25] The second was acute intracerebral hemorrhage, for which effective treatment is generally unavailable.[26] The third was acute hip fracture, a condition that is sometimes treated more promptly on weekends than on weekdays, because operating rooms are more available on weekends.[27-29]

Most Frequent Causes of Death

We conducted a comprehensive analysis, with no prespecified hypotheses, by ranking every ICD-9 diagnosis according to the total number of in-hospital deaths and, from this list, selecting the 100 diagnoses that caused the most deaths. We compared in-hospital mortality among patients with these diagnoses according to whether they were admitted on a weekend or a weekday. To determine whether excess mortality among patients admitted on a weekend was closely linked to weekend care, we performed additional analyses of deaths that occurred within two days after admission, again comparing the mortality rate among patients admitted on a weekend with that among patients admitted on a weekday.

Statistical Analysis

In the primary analysis, we compared the in-hospital mortality rate among patients who were admitted on a weekend with the rate among those admitted on a weekday. Logistic regression was used to test for differences in mortality rates between these two groups after adjustment for age, sex, and the score on the Charlson comorbidity index (a weighted index of the number of serious coexisting diseases on a scale of 0 to 8).[30,31] Differences in mortality rates are expressed as odds ratios for death, where appropriate. All reported P values are two-tailed.

We took special care to minimize the risk of obtaining spurious results because of multiple statistical tests. First, we examined prespecified conditions and applied the conventional criterion for statistical significance ($P<0.05$). Then we examined the 100 most frequent causes of death, without prespecified comparisons, and used two comprehensive analyses. In one analysis, based on the exact binomial distribution, we determined the proportion of conditions for which weekend mortality was higher than that which would be expected by chance.[32] In the other analysis, based on hierarchical logistic regression, we considered each condition separately.[33,34] Our rationale for using two approaches was to determine whether alternative analyses yielded similar results, with the use of a threshold criterion of 1 in a million as the standard for statistical significance ($P<1.00\times10^{-6}$).

The study was approved by the ethics committee of the Sunnybrook and Women's College Health Sciences Centre. We used protocols of the Institute for Clinical Evaluative Sciences in Ontario to maintain the confidentiality of the study data.

RESULTS

During the 10-year study period, there were 3,789,917 hospital admissions, or about 1038 per day. There were no large differences in base-line characteristics between patients admitted on weekends and those admitted on weekdays (Table 1). The mean age of the patients was 51 years, and about 1 in 10 was a child; approximately half were women. Approximately one third of the patients arrived at the hospital by ambulance, and about one fifth were admitted to a teaching hospital. Disorders of the circulatory system were the single most common category of ICD-9 diagnoses. Overall, 26.5 percent of the patients were admitted on a weekend. A total of 222,517 patients died.

Prespecified Conditions

We identified 5454 patients who were hospitalized for a ruptured abdominal aortic aneurysm. Approximately 24 percent of these patients were admitted on a weekend, and about 76 percent were admitted on a weekday. The mortality rate was higher among the patients admitted on a weekend than among those admitted on a weekday (Table 2). After adjustment for

TABLE 1. CHARACTERISTICS OF PATIENTS ADMITTED ON WEEKDAYS AND WEEKENDS.

CHARACTERISTIC	WEEKDAY ADMISSIONS (N=2,784,344)	WEEKEND ADMISSIONS (N=1,005,573)
	% of admissions	
Age*		
0–19 yr	14.5	16.3
20–39 yr	19.5	20.2
40–59 yr	19.2	18.6
60–79 yr	32.6	31.0
≥80 yr	14.3	14.0
Female sex	50.5	49.7
Arrival by ambulance	31.3	33.5
Admitted to teaching hospital†	19.6	18.9
Charlson score for comorbidity*		
0	72.2	73.1
1	16.0	15.6
2	6.3	6.1
>2	5.5	5.2
Underwent surgery	18.3	17.5

*Because of rounding, percentages do not total 100.

†A hospital was classified as a teaching hospital if it was identified as such by the Ontario Council of Teaching Hospitals.

age, sex, and the score on the Charlson comorbidity index, the odds ratio for death among patients admitted on a weekend, as compared with those admitted on a weekday, was 1.28 (95 percent confidence interval, 1.13 to 1.46); the adjusted odds ratio was similar when the analysis was restricted to deaths that occurred within two days after admission (odds ratio, 1.35; 95 percent confidence interval, 1.15 to 1.52).

For the two other prespecified conditions, acute epiglottitis and pulmonary embolism, the mortality rate was also higher among patients admitted on a weekend than among those admitted on a weekday (Table 2). Furthermore, for both conditions, the adjusted odds ratio for death was even higher in the analysis restricted to deaths that occurred within two days after admission (odds ratio for patients with epiglottitis, 10.47; 95 percent confidence interval, 1.21 to 90.65; odds ratio for patients with pulmonary embolism, 1.39; 95 percent confidence interval, 1.14 to 1.69).

There were 160,220 admissions for acute myocardial infarction, 10,987 for acute intracerebral hemorrhage, and 59,670 for acute hip fracture. For these control conditions, there was no significant difference in mortality according to whether patients were admitted on a weekend or a weekday (Table 2).

Most Frequent Causes of Death

The 100 conditions that were the most frequent causes of death accounted for 1,820,885 hospital admissions (48 percent of all admissions) and 202,798 deaths (91 percent of all deaths). The mortality rates among patients with these conditions who were admitted on a weekend, as compared with those admitted on a weekday, are available as Supplementary Appendix 1 with the full text of this article at http://www.nejm.org. For 23 of the conditions, admission on a weekend was associated with a significant increase in mortality (Table 3). Conversely, weekend admission was not associated with a significantly reduced mortality rate for any of the 100 conditions. The exact binomial distribution indicated that this pattern was unlikely to be due to chance, as did the coefficient estimate from the hierarchical logistic-regression model for an association between admission on a weekend and an increased mortality rate.

For the 100 conditions, we calculated the median odds ratio for death among patients admitted on a weekend as compared with those admitted on a weekday. The median odds ratio was similar for men and women, for teaching hospitals and nonteaching hospitals, for patients who arrived at the hospital by am-

TABLE 2. IN-HOSPITAL MORTALITY ACCORDING TO THE DAY OF ADMISSION.*

CONDITION	NO. OF ADMISSIONS	MORTALITY RATE		ODDS RATIO (95% CI)	
		WEEKDAY ADMISSION	WEEKEND ADMISSION	UNADJUSTED	ADJUSTED†
		percent			
Positive‡					
Ruptured abdominal aortic aneurysm (ICD-9 codes 4413 and 4414)	5,454	36	42§	1.32	1.28 (1.13–1.46)
Acute epiglottitis (ICD-9 code 4643)	1,139	0.3	1.7¶	5.47	5.28 (1.01–27.50)
Pulmonary embolism (ICD-9 code 4151)	11,686	11	13‖	1.25	1.19 (1.03–1.36)
Control**					
Myocardial infarction (ICD-9 code 410)	160,220	15	15	1.02	1.03 (1.00–1.06)
Intracerebral hemorrhage (ICD-9 code 431)	10,987	44	44	1.01	1.01 (0.93–1.11)
Acute hip fracture (ICD-9 code 820)	59,670	7	6	0.95	0.97 (0.90–1.04)

*Odds ratios are for death among patients admitted on a weekend as compared with those admitted on a weekday. CI denotes confidence interval, and ICD-9 *International Classification of Diseases, Ninth Revision*.

†Adjustment was made for age, sex, and the score on the Charlson comorbidity index.

‡Positive conditions were those hypothesized to be associated with a higher mortality rate among patients admitted on weekends than among those admitted on weekdays.

§$P<0.001$ for the comparison with weekday admission.

¶$P=0.04$ for the comparison with weekday admission.

‖$P=0.009$ for the comparison with weekday admission.

**Control conditions were those hypothesized to be associated with similar mortality rates for weekend and weekday admissions.

TABLE 3. CONDITIONS FOR WHICH WEEKEND ADMISSION WAS ASSOCIATED WITH SIGNIFICANTLY HIGHER MORTALITY THAN WAS WEEKDAY ADMISSION.*

CONDITION	NO. OF ADMISSIONS	MORTALITY RATE		ODDS RATIO (95% CI)†	
		WEEKDAY ADMISSION	WEEKEND ADMISSION	UNADJUSTED	ADJUSTED‡
		percent			
Cancer of the trachea, bronchus, or lung	27,013	44	48	1.18	1.19 (1.12–1.25)
Secondary cancer of the respiratory or digestive tract	13,249	37	39	1.11	1.13 (1.04–1.23)
Chronic ischemic heart disease	52,900	8.7	9.3	1.08	1.06 (0.99–1.14)
Cardiac dysrhythmia	76,907	5.4	6.1	1.14	1.17 (1.09–1.25)
Unspecified condition requiring after care	5,912	43	64	1.36	1.28 (1.12–1.46)
Colon cancer	11,966	25	28	1.19	1.15 (1.04–1.27)
Secondary cancer at other specified sites	12,616	23	26	1.19	1.18 (1.07–1.30)
Aortic aneurysm	7,636	37	43	1.27	1.24 (1.11–1.39)
Pancreatic cancer	5,723	41	44	1.15	1.19 (1.05–1.36)
Breast cancer in women	5,192	39	48	1.47	1.37 (1.19–1.56)
General cardiovascular symptoms	7,074	28	32	1.22	1.35 (1.19–1.54)
Prostate cancer	8,369	22	25	1.25	1.21 (1.06–1.37)
Stomach cancer	4,583	36	41	1.25	1.26 (1.09–1.46)
Cancer of the rectosigmoid or anus	5,018	27	31	1.22	1.23 (1.05–1.43)
Acute pulmonary heart disease	11,920	11	13	1.25	1.20 (1.05–1.38)
Cancer of the brain	5,586	19	24	1.30	1.29 (1.11–1.50)
Cancer of the liver or intrahepatic bile ducts	2,291	45	51	1.31	1.38 (1.13–1.69)
Renal failure	3,339	30	36	1.34	1.31 (1.09–1.58)
Myeloma or immunoproliferative cancer	3,203	25	30	1.26	1.26 (1.04–1.52)
Intracranial hemorrhage (unspecified)	3,525	18	22	1.23	1.21 (0.98–1.48)
Intestinal disorder (unspecified)	10,351	4.8	6.0	1.25	1.28 (1.04–1.56)
Cardiac-conduction disorder	8,081	3.3	5.3	1.63	1.72 (1.33–2.21)
Leukemia (unspecified cell type)	779	33	43	1.52	1.60 (1.11–2.31)

*Conditions are listed in descending order according to the total number of associated deaths. The mortality rates and odds ratios for the entire list of the 100 conditions are available as Supplementary Appendix 1 with the full text of this article at http://www.nejm.org.

†Odds ratios are for death among patients admitted on a weekend as compared with those admitted on a weekday. $P<0.05$ for all unadjusted odds ratios. CI denotes confidence interval.

‡Adjustment was made for age, sex, and the score on the Charlson comorbidity index.

bulance and those who did not, for patients who underwent surgery and those who did not, and for admissions in the first half of the decade and those in the second half. The relative increase in mortality among patients admitted on a weekend was greater for diseases with high case fatality rates than for those with lower case fatality rates. For example, the median odds ratio for death associated with weekend admission was higher for conditions with a case fatality rate that exceeded 20 percent than for those with a lower case fatality rate (1.11 vs. 1.04, $P=0.01$).

Short-Term Mortality

Analyses of deaths within two days after admission, rather than total in-hospital deaths, generally showed larger relative differences in mortality between weekend and weekday admissions. When all possible diagnoses (conditions accounting for the 3,789,917 admissions) were included in the analysis, there was a small increase in mortality among patients admitted on a weekend (1.8 percent vs. 1.6 percent, $P<0.001$). When only the 100 most frequent causes of death were included in the analysis, 26 conditions were associated with a significant increase in mortality with weekend admission, and no condition was associated with a significant decrease in mortality with weekend admission.

Proportion of Weekend Admissions

We also determined whether the proportion of weekend admissions differed from that which would be expected (2/7, or 28.6 percent). For all admissions, the proportion of weekend admissions was 26.5 percent. For the top 100 causes of death, the average proportion of weekend admissions was 25.5 percent (range, 21.0 to 33.8 percent); the proportion of weekend admissions was similar for the 23 conditions that were associated with an increase in mortality among patients admitted on a weekend and the 77 that were not (23.4 and 21.5 percent, respectively; P=0.85).

DISCUSSION

We examined nearly 3.8 million consecutive emergency hospitalizations of patients in Ontario, Canada, over a 10-year period. For ruptured abdominal aortic aneurysm, acute epiglottitis, and pulmonary embolism, the mortality rate among patients admitted on a weekend was higher than that among patients admitted on a weekday. Of the 100 conditions that caused the most deaths, 23 were associated with significantly higher mortality rates among patients admitted on a weekend than among those admitted on a weekday. The increase in mortality persisted after adjustment for age, sex, and the score on the Charlson comorbidity index and was greater in analyses of short-term in-hospital mortality than in analyses of total in-hospital mortality. No disease was associated with a significantly lower mortality rate among patients admitted on a weekend than among those admitted on a weekday, and the relative increase in mortality associated with weekend admission appeared to be greatest for the conditions that were especially lethal.

Are patients who are admitted on weekends sicker than those admitted on weekdays? We found that the results of both the adjusted analyses and the stratified analyses were similar to those of the crude analyses, suggesting that the findings were probably not due to unmeasured factors such as the severity of illness. In addition, we excluded elective admissions and identified conditions that were not obviously connected with lifestyle (unlike injuries from motor vehicle crashes and handguns, which are often severe and occur frequently on weekends).[3,4,35] Moreover, analyses of deaths within two days after admission yielded even larger differences in mortality between weekend and weekday admissions, a finding that supports a true difference and would not be expected if our findings were due to a general increase in the severity of conditions among patients admitted on weekends.

We cannot exclude the possibility that patients admitted on weekends are sicker than those admitted on weekdays. However, a greater severity of illness among patients admitted to acute care hospitals on weekends would still raise questions about the adequacy of medical care and staffing patterns.[36] We believe that the difference in mortality rates between weekend and weekday admissions may be most important in the case of patients with complex disorders that are associated with a high mortality rate outside of critical care settings.

The limitations of this study should be noted. We relied on administrative data that may have included coding errors. However, it is unlikely that the accuracy of coding differed between weekend and weekday admissions, and any random miscoding would have resulted in an underestimate of the magnitude of the effect of weekend admission. In addition, our analysis did not account for statutory holidays, a fact that may have blurred the observed differences. The mortality rates were similar to those in other population-based studies.[37-42] However, since our study does not account for deaths declared by paramedics outside the hospital, which are more common on weekends than on weekdays (Vermeulen M: personal communication), we may have underestimated differences in mortality. Perhaps the greatest limitation is that a focus on in-hospital mortality does not allow for consideration of the timeliness of care, patients' degree of satisfaction, and many other aspects of the quality of medical care.[43]

Our findings have several possible explanations. One concerns staffing. Fewer people work in hospitals on weekends than on weekdays.[36,44-50] Those who do work on weekends often have less seniority and experience than those who work on weekdays.[51,52] In addition, weekend staff often provide coverage for other health professionals and may be less familiar with the patients under their charge.[53] There are also fewer supervisors on weekends, and they are often responsible for overseeing the work of staff members they do not know well.[51-55]

Working on the weekend is unpopular.[56,57] Yet the uneven staffing patterns in acute care hospitals conflict with business practices in other sectors of society that strive for the same level of activity on each day of the week. Maintaining a more consistent level of activity is sometimes economical, even if staff members are paid higher wages for weekend duties.[1,58,59] Greater attention to weekend care may also reduce the commotion often seen on Monday mornings in acute care hospitals. Our findings suggest that health care providers should be concerned about the increased risk of death among patients who seek emergency care on weekends.

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