

The Impact of Weekend Admission and Patient Safety Indicator on 30-Day Mortality among Korean Long-Term Care Insurance Beneficiaries

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Background: This study investigates the impact of weekend admission with a patient safety indicator (PSI) on 30-day mortality among long-term insurance beneficiaries.

Methods: Data were obtained from the National Health Insurance Service-Senior claim database from 2002 to 2013. To obtain unbiased estimates of odds ratio, we used a nested case-control study design. The cases were individuals who had a 30-day mortality event after their last medical utilization, while controls were selected by incidence density sampling based on age and sex. We examined the interaction between the main independent variables of weekend admission and PSI by categorizing cases into four groups: weekend admission/PSI, weekend admission/non-PSI, weekday admission/PSI, and weekday admission/non-PSI.

Results: Of the 83,400 individuals in the database, there were 20,854 cases (25.0%) and 62,546 controls (75.0%). After adjusting for socioeconomic, health status, seasonality, and hospital-level factors, the odds ratios (ORs) of 30-day mortality for weekend admission/PSI (OR, 1.484; 95% confidence interval [CI], 1.371-1.606) and weekday admission/PSI (OR, 1.357; 95% CI, 1.298-1.419) were greater than for patients with weekday admission/non-PSI.

Conclusion: This study indicated that there is an increased risk of mortality after weekend admission among patients with PSI as compared with patients admitted during the weekday without a PSI. Therefore, our findings suggest that recognizing these different patterns is important to identify at-risk diagnosis to minimize the excess mortality associated with weekend admission in those with PSI.

Keywords: Admission; Ageing; Mortality; Safety

INTRODUCTION

Since the release of the seminal Institute of Medicine (IOM) report, "To err is human," improving patient safety through reduction of medical errors has become the focus of many quality improvement efforts [1]. The IOM Committee estimates that as many as 98,000 people die in any given year from medical errors in hospitals [1]. If these statistics are correct, the health care system can be considered a public health menace of epidemic proportions. In South Korea, widespread attention has begun to be paid to public issues related to ensuring patient safety, starting with the evaluation of medical institutions in 2004. Such attention has the potential to improve

patient safety/quality and reduce adverse events [2]. However, in spite of a broad awareness of older patients as a high-risk group, who tend to have greater service use and costs [3], a relatively small number of empirical studies have been conducted on adverse events in this group.

Adverse events refer to injuries caused by medical care rather than by a patient's underlying disease [4]. Growing evidence suggests that unexpected adverse events account for a significant proportion of hospital patient deaths [5]. Particularly, failure-to-rescue (e.g., mortality), which is central to understanding an adverse event [6], is more likely to occur after a weekend admission for patients with an urgent diagnosis because of reduced staffing and decreased access to specialized services [7-10].

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To better evaluate the spectrum of adverse events during inpatient care (i.e., from complications to death) and provide more information on potential in-hospital complications and adverse events, patient safety indicators (PSIs) were developed by the Agency for Healthcare Research and Quality (AHRQ) [11] and Iezzoni et al. [12]. These initial PSIs were developed using the International Classification of Disease, 9th revision (ICD-9) diagnostic codes, but the codes of the most recent iteration (the ICD-10), which is currently in use in developed countries, offer greater specificity [13]. The PSIs were selected by expert panels through an evidence-based process involving a literature review and iterative refinement of the data to limit their comprehensiveness [14]. More recently, the various limitations of existing PSIs led Southern et al. [15] to develop a new set using Canadian administrative hospital data based on a routine large-scale surveillance of hospital and health system performance. In the present analysis, we examine the in-hospital 30-day mortality of patients with a PSI and who were admitted on the weekend, and compared it with the mortality of patients admitted on weekdays and without a PSI. We hypothesized that increased mortality may be explained by both an increased number of patient safety events and a weekend admission.

METHODS

1. Study design and data source

The study data were obtained from the National Health Insurance Service-Senior (NHIS-Senior) claim database, which covers the period from 2002 to 2013. These data were released by the Korean National Health Insurance Service (KNHIS) [16]. The initial NHIS-Senior cohort data comprised 558,147 participants, or approximately 10% of the population of individuals aged 60 years and above in 2002, who were selected using stratified random sampling. The dataset also includes information on the application of these cohort members to long-term care insurance (LTCI), beginning in 2008.

This study included individuals who were considered particularly vulnerable to an adverse event and who applied for the LTCI program at least once since 2008. We used data from the last medical utilization record before death. For the analysis, we conducted incidence density sampling to identify the effect of weekend admission and PSIs on

30-day mortality. All databases are linked anonymously using unique encrypted patient codes, in accordance with Korean laws on privacy. Approval from an ethics committee was not required because we were analyzing encrypted claim data [16].

2. Identification of cases and controls

We conducted a nested case-control analysis. The cases for the study were identified as individuals who had a 30-day mortality event after their last medical utilization. The event date for the cases was defined as the date of the last case event. The cases were selected between the study entry date (July 1, 2008) and the study end date (December 31, 2013).

In order to obtain unbiased estimates of relative risk, controls were selected via incidence density sampling from the study base, which involves matching each case to a sample of those who are at risk at the time of case occurrence [17,18]. Potential controls for the study were individuals who remained in the risk set on the date of the 30-day mortality event for the corresponding case during the study period. Three controls were randomly matched for each case from the pool of all eligible controls based on age and sex.

3. Independent variables

Weekend admission was investigated by determining whether patients were admitted on a Saturday or a Sunday. PSIs were determined by indicating the presence of 18 disease categories based on a study of Southern et al. [15]. Southern et al. [15] queried all hospitalizations for ICD-10-CA (Canada) diagnosis codes arising during hospital stay and a modified Delphi panel process then was undertaken to rate the extent to which each of the identified diagnosis has a potential link to suboptimal quality of care. The identified quality/safety-related diagnoses were grouped into relevant clinical categories. Lastly, he queried Alberta hospital discharge data to assess the frequency of the newly defined PSI events: (1) hospital-acquired infections, (2) decubitus ulcers, (3) endocrine and metabolic complications, (4) venous thromboembolic events, (5) cardiac complications, (6) respiratory complications, (7) hemorrhagic events, (8) drug-related adverse events, (9) adverse events related to fluid management, (10) obstetrical complications affecting mothers, (11) obstetrical complications affecting fetuses, (12) complications directly

related to surgery, (13) traumatic injury suffered in-hospital, (14) anesthesia-related complications, (15) delirium, (16) central nervous system complications, (17) gastrointestinal complications, and (18) a special category for ‘severe complications’ that are proximally threatening to life or major vital organs. The combined effects represent the difference between the weekend admission and the PSI. We categorized participants into four groups: weekend admission/PSI, weekend admission/non-PSI, weekday admission/PSI, and weekday admission/non-PSI.

4. Dependent variable

The dependent variable was all-cause mortality over a maximum follow-up period of three days after admission, which was determined by death certificates.

5. Control variables

We selected a range of individual, time, and hospital covariates. The individual covariates included residential region, insurance type, and Charlson Comorbidity Index (CCI). Residential region was categorized as metropolitan (Seoul), urban (Daejeon, Daegu, Busan, Incheon, Kwangju, or Ulsan), and rural (otherwise). Insurance type was categorized as national health insurance or medical aid. CCI was grouped as scores of 0, 1, 2, and over 3. Time variables included season and hospitalized year. Season was categorized as spring, summer, fall, and winter, while hospitalized year was categorized as 2008, 2009, 2010, 2011, 2012, and 2013. As hospital variables, we assessed organization type, hospital type, and presence of computed tomography (CT) and magnetic resonance imaging (MRI). The organization type was categorized as public, corporate, and private, while the hospital type was categorized as general hospital, hospital,

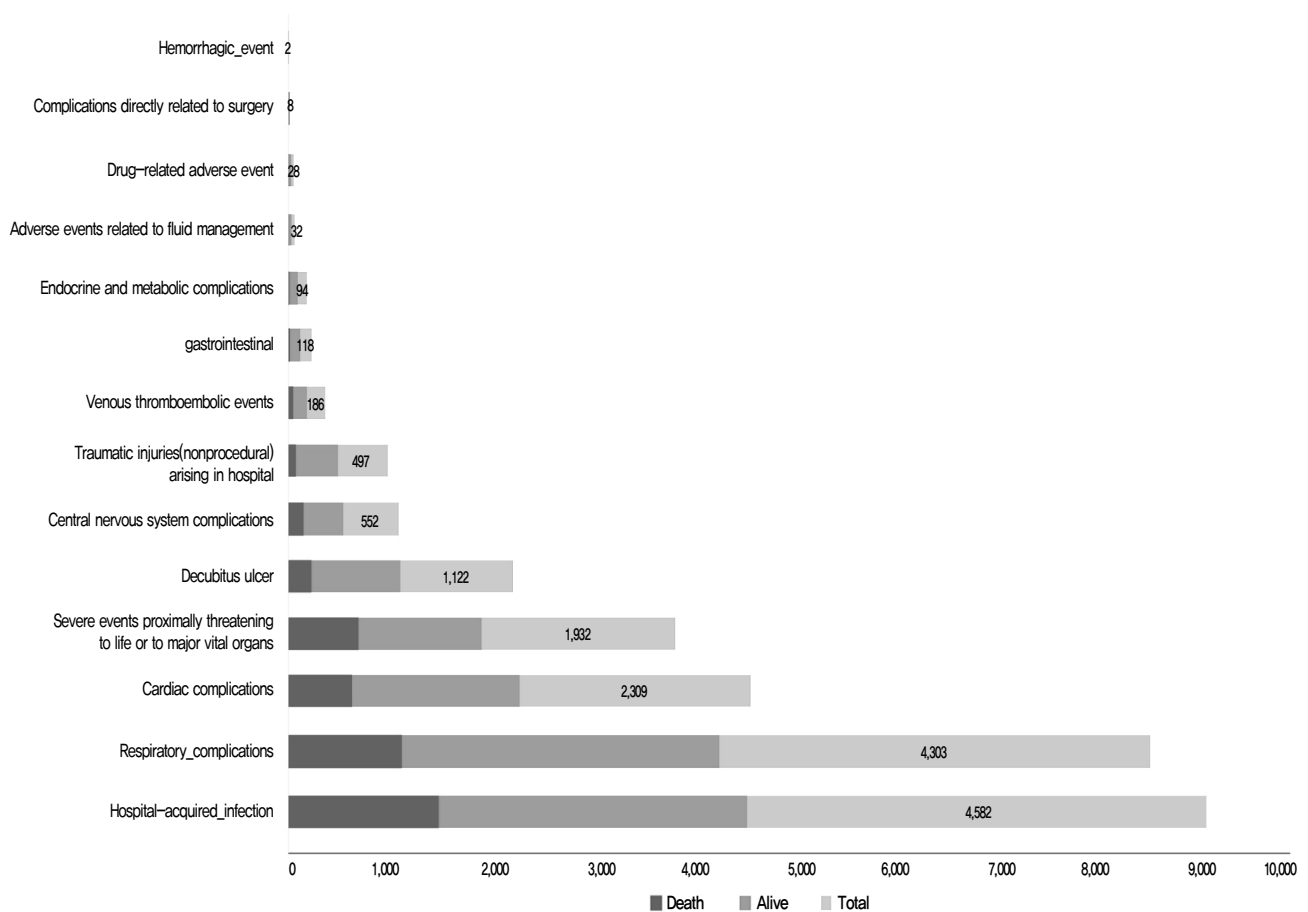


Figure 1. Composition of patient safety indicators.

Table 1. General characteristics of participants

Characteristic	Total	Death (yes)	Death (no)	p-value
Weekend admission & PSI				<0.001
Weekend admission-PSI	3,204 (3.8)	962 (30.0)	2,242 (70.0)	
Weekend admission-non-PSI	14,854 (17.8)	3,727 (25.1)	11,127 (74.9)	
Weekday admission-PSI	12,561 (15.1)	3,577 (28.5)	8,984 (71.5)	
Weekday admission-non-PSI	52,781 (63.3)	12,588 (23.9)	40,193 (76.2)	
Sex				0.99
Male	30,730 (36.9)	7,685 (25.0)	23,045 (75.0)	
Female	52,670 (63.2)	13,169 (25.0)	39,501 (75.0)	
Age (yr)	83,400 (100.0)	84±7.4	84±7.4	0.93
Residential region				0.01
Metropolitan	12,622 (15.1)	3,053 (24.2)	9,569 (75.8)	
Urban	18,619 (22.3)	4,795 (25.8)	13,824 (74.3)	
Rural	52,159 (62.5)	13,006 (24.9)	39,153 (75.1)	
Insurance type				0.05
National health insurance	67,723 (81.2)	16,838 (24.9)	50,885 (75.1)	
Medical aid	15,677 (18.8)	4,016 (25.6)	11,661 (74.4)	
Charlson Comorbidity Index				0.00
0	26,345 (31.6)	6,399 (24.3)	19,946 (75.7)	
1	23,772 (28.5)	5,909 (24.9)	17,863 (75.1)	
2	14,430 (17.3)	3,705 (25.7)	10,725 (74.3)	
≥3	18,853 (22.6)	4,841 (25.7)	14,012 (74.3)	
Season				<0.001
Spring	19,066 (22.9)	4,949 (26.0)	14,117 (74.0)	
Summer	20,312 (24.4)	4,887 (24.1)	15,425 (75.9)	
Fall	24,595 (29.5)	5,704 (23.2)	18,891 (76.8)	
Winter	19,427 (23.3)	5,314 (27.4)	14,113 (72.7)	
Year				<0.001
2008	5,601 (6.7)	1,195 (21.3)	4,406 (78.7)	
2009	12,519 (15.0)	3,124 (25.0)	9,395 (75.1)	
2010	14,870 (17.8)	3,716 (25.0)	11,154 (75.0)	
2011	15,553 (18.7)	3,962 (25.5)	11,591 (74.5)	
2012	17,282 (20.7)	4,406 (25.5)	12,876 (74.5)	
2013	17,575 (21.1)	4,451 (25.3)	13,124 (74.7)	
Organization type				<0.001
Public	5,514 (6.6)	1,269 (23.0)	4,245 (77.0)	
Corporate	48,175 (57.8)	11,710 (24.3)	36,465 (75.7)	
Private	29,711 (35.6)	7,875 (26.5)	21,836 (73.5)	
Hospital type				<0.001
General hospital	32,963 (39.5)	7,240 (22.0)	25,723 (78.0)	
Hospital	17,043 (20.4)	3,950 (23.2)	13,093 (76.8)	
Others	33,394 (40.0)	9,664 (28.9)	23,730 (71.1)	
Presence of computed tomography				<0.001
Yes	48,424 (58.1)	10,890 (22.5)	37,534 (77.5)	
No	34,976 (41.9)	9,964 (28.5)	25,012 (71.5)	
Presence of magnetic resonance imaging				<0.001
Yes	40,479 (48.5)	8,901 (22.0)	31,578 (78.0)	
No	42,921 (51.5)	11,953 (27.9)	30,968 (72.2)	
Total	83,400 (100.0)	20,854 (25.0)	62,546 (75.0)	

Values are presented as number (%) or mean±standard deviation.
PSI, patient safety indicator.

and others (including clinics). The presence of CT and MRI were both categorized as yes or no.

6. Statistical analysis

In this study, all statistical analyses were conducted using SAS ver. 9.4 (SAS Institute Inc., Cary, NC, USA). We used conditional logistic regression analysis for matched case-control studies, calculating the odds ratio (ORs) and 95% confidence interval (CIs) for each exposure variable. All estimated ORs were conditional on the matching factors. Differences in covariate distribution between cases and controls were evaluated using chi-square tests and *t*-tests for categorical and continuous variables, respectively. All statistical tests were two-tailed, and the null hypothesis (suggesting no difference) was rejected if $p < 0.05$.

RESULTS

1. General characteristics of cardiovascular disease intensive care unit patients

Regarding the distribution of PSIs, 4,582 patients (29.1%) had hospital-acquired infection, among whom 1,506 patients (32.9%) had a 30-day mortality event. Furthermore, 4,303 patients (27.3%) had respiratory complications, among whom 30-day mortality events were observed in 1,136 patients (26.4%). Of the 1,932 patients (12.3%) who had severe events proximally threatening to life or major vital organs, the 30-day mortality rate was 36.2% ($n=699$) (Figure 1).

Table 1 shows the in-hospital 30-day mortality according to patients' general characteristics. Of the 83,400 patients, 20,854 cases (25.0%) experienced a 30-day mortality event in-hospital. Furthermore, of all patients, the 30-day mortality rates among patients in the weekend admission/PSI, weekday admission/PSI, and weekday admission/non-PSI groups were 30.0% ($n=962$), 28.5% ($n=3,577$), and 23.9% ($n=12,588$), respectively.

2. Adjusted effects for in-hospital 30-day mortality

In model 1, wherein we adjusted for individual factors such as residential region, insurance type, and CCI, the odds of 30-day mortality in patients with weekend admission and a PSI were 1.372

times greater (95% CI, 1.269–1.483) than in patients with weekday admission and no PSI. By contrast, the odds for patients with weekday admission and a PSI were 1.277 times higher (95% CI, 1.222–1.335) than for patients with weekday admission and no PSI. In model 2, after adding the time factors (season and hospitalized year) to the model 1 variables, the odds of 30-day mortality in patients with weekend admission and a PSI increased—namely, they were 1.358 times greater (95% CI, 1.256–1.469) than in patients with weekday admission and no PSI. By contrast, the odds of 30-day mortality in patients with weekday admission and a PSI were about the same, at 1.267 times higher (95% CI, 1.213–1.324) than in the reference group. Finally, in model 3, we adjusted for individual, time, and hospital factors (organization type, hospital type, and presence of CT and MRI). After adjustment, the ORs for 30-day mortality in the weekend admission/PSI (OR, 1.484; 95% CI, 1.371–1.606) and weekday admission/PSI (OR, 1.357; 95% CI, 1.298–1.419) groups were greater compared to in both models 1 and 2. Furthermore, the odds of 30-day mortality among patients in the weekend admission/non-PSI group (95% CI, 0.995–1.084) were 1.038 times greater than in the reference group, but this was not statistically significant (Table 2).

DISCUSSION

In this nationwide elderly population-based study, we found statistically significant differences exist in 30-day mortality among elderly population vulnerable to adverse events according to whether they were admitted on a weekend and had a PSI. Importantly, after adjusting for hospital-level covariates, the odds of 30-day mortality in the weekend admission/PSI and weekday admission/PSI groups increased compared to when only individual (model 1) or when both individual and time (model 2) factors were adjusted for. This suggests that the higher rate of 30-day mortality after a weekend admission might be linked to the structural and process limitations inherent to hospitals during weekends [6]. In addition, having a PSI was significantly associated with greater odds of 30-day mortality rate (OR, 1.357; 95% CI, 1.371–1.606) than was not having a PSI, and these odds further increased when individuals were admitted during a weekend (OR, 1.484; 95% CI, 1.371–1.606). Furthermore, as expected,

Table 2. Adjusted effects of all variables on 30-day mortality

Variable	Model 1	Model 2	Model 3
Weekend admission & PSI			
Weekend admission-PSI	1.372 (1.269–1.483)	1.358 (1.256–1.469)	1.484 (1.371–1.606)
Weekend admission-non-PSI	1.069 (1.024–1.115)	1.054 (1.010–1.099)	1.038 (0.995–1.084)
Weekday admission-PSI	1.277 (1.222–1.335)	1.267 (1.213–1.324)	1.357 (1.298–1.419)
Weekday admission-non-PSI	1.000	1.000	1.000
Residential region			
Metropolitan	0.965 (0.922–1.010)	0.966 (0.923–1.011)	0.970 (0.926–1.015)
Urban	1.050 (1.010–1.091)	1.045 (1.006–1.086)	1.014 (0.975–1.054)
Rural	1.000	1.000	1.000
Insurance type			
National health insurance	1.000	1.000	1.000
Medical aid	1.030 (0.989–1.072)	1.029 (0.988–1.071)	1.041 (0.999–1.084)
Charlson Comorbidity Index			
0	1.000	1.000	1.000
1	1.031 (0.989–1.074)	1.036 (0.995–1.080)	1.033 (0.991–1.076)
2	1.073 (1.024–1.125)	1.093 (1.042–1.146)	1.078 (1.027–1.131)
≥3	1.073 (1.027–1.122)	1.109 (1.060–1.161)	1.095 (1.046–1.147)
Season			
Spring		1.134 (1.085–1.186)	1.129 (1.080–1.181)
Summer		1.042 (0.997–1.089)	1.042 (0.997–1.089)
Fall		1.000	1.000
Winter		1.225 (1.173–1.279)	1.209 (1.158–1.263)
Year			
2008		1.000	1.000
2009		1.214 (1.123–1.312)	1.223 (1.131–1.322)
2010		1.228 (1.138–1.326)	1.239 (1.147–1.338)
2011		1.260 (1.167–1.360)	1.271 (1.177–1.373)
2012		1.261 (1.169–1.361)	1.258 (1.166–1.358)
2013		1.256 (1.164–1.355)	1.243 (1.152–1.342)
Organization type			
Public			1.000
Corporate			1.016 (0.950–1.087)
Private			1.026 (0.954–1.102)
Hospital type			
General hospital			1.000
Hospital			0.992 (0.934–1.054)
Others			1.318 (1.200–1.448)
Presence of computed tomography			
Yes			1.000
No			0.995 (0.921–1.076)
Presence of magnetic resonance imaging			
Yes			1.000
No			1.144 (1.063–1.230)

Values are presented as odds ratio (95% confidence interval).
PSI, patient safety indicator.

the mortality rate was higher with an increased CCI, during particular seasons, and in smaller hospitals. Therefore, we suggested that higher rates of 30-day mortality can be partially explained by weekend admission and PSIs. In addition to the risk of increased mortality, many previous studies have shown that there is a higher risk of increased readmission [19], longer hospital stays [20,21], and higher hospital charges [22] among those who experience a PSI or hospital-acquired complication as standard hospital performance measures.

In this study, we employed newly developed PSIs constructed from a comprehensive set of ICD-10 diagnosis codes. These new PSIs have better coverage of the entire spectrum of preventable adverse events, which overcome one of the primary limitations of the AHRQ PSIs—namely, the relatively narrow clinical scope of adverse events.

Despite 2 decades' worth of papers on the topic, the weekend effect continues to be observed, and is likely the result of cost-saving strategies or hospital staffing preferences. Several possible explanations for the present findings include fewer clinical staff working in hospitals on weekends, and those who do work often have less experience, familiarity with patients [23,24], and access to resources [25]. In addition, poor handover is a major preventable cause of patient harm, and is often attributed to poor communication and systemic error [26].

Acute conditions such as stroke and acute kidney injury seem more vulnerable than the effects of weekend care. One explanation could be the presence of unmeasured differences in the cases such as stroke severity. To account for differences in patient characteristics (e.g., age, sex, type of health insurance, income), we adjusted the rates using patient-level regression models. Despite these efforts to mitigate any bias in the case mix, the underlying data had only limited information.

Further studies have shown that the mortality rate is much greater if the patient is admitted over the weekend [23,27,28]. In contrast, several studies of weekend admission for patients with acute gastrointestinal bleeding failed to show increased mortality rates [29,30]. In our research sample, relatively few had a PSI for gastrointestinal-related disease (0.7%), so their presence would not likely change our results.

This study has a number of limitations. First, we had no information on patient severity for risk adjustment, as with other previous studies that used administrative databases. However, we adjusted for patient

age and comorbid conditions using the CCI. Second, the accuracy of the PSI diagnosis might have reduced the accuracy of our results. We used nationwide cohort data based on information contained in the anonymized database of the KNHIS. Therefore, it is difficult to validate the individual ICD codes, which makes them susceptible to coding errors. Third, there are likely to be several unmeasured confounders, such as information regarding the care process; such confounders might have contributed to the reported differences between patients admitted on weekends and those admitted on weekdays. Finally, when PSI is analyzed as claim database, it is difficult to distinguish whether the diagnosis was made before or after admission.

This study adds to research on patient safety and quality by estimating and comparing the impact of weekend admission and new PSIs. Further research should build on the findings of this study and address some of its limitations. Future studies should also aim to understand how workforce schedules and resource availability might influence the weekend effect after the occurrence of a PSI. It will also be important to check for the existence of multiple PSIs during the follow-up period, which we expect is likely. Thus, this study has great potential to inform future approaches to monitoring health system performance and quality/safety improvement.

In conclusion, our study revealed a higher rate of mortality for patients admitted on the weekend and with a PSI as compared with those admitted on a weekday without a PSI. Thus, our findings suggest that recognizing these different patterns is important to identify at-risk diagnosis to minimize the excess mortality associated with weekend admission in those with PSI. Efforts to better pinpoint the breakdowns in weekend care by the occurrence of PSIs related to failure-to-rescue might help in substantially reducing mortality.

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