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ORIGINAL ARTICLE

Association between Weekend Admission and In-hospital Mortality among Cardiovascular Patients in Korea

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Background: Weekend admission is known for having association with increased mortality attributed by poor quality of care and severe patients. We investigated the association between hospital admission on weekends and the in-hospital mortality rates of patients with cardiovascular disease. Furthermore, we examined this association stratified by admission via emergency room or not.
Methods: We analyzed claim data provided by the Health Insurance Review & Assessment in 2013. In total, 80,817 cardiovascular patients were included in this study, which treated in-hospital mortality (early and during total length of stay) as a dependent variable. A generalized linear mixed effects model was used. We conducted subgroup analyses stratified by admission via emergency room or not.
Results: Patients who admitted on weekend showed higher in-hospital mortality both early (odds ratio [OR], 1.48; 95% confidence interval [CI], 1.23-1.78) and during total length of stay (OR, 1.17; 95% CI, 1.02-1.33) compared to those admitted on weekdays. Patients who were admitted to the hospital on a weekend by emergency room were more likely to experience early in-hospital mortality compared to those admitted on weekdays. Furthermore, we found that patients not admitted to the hospital through the emergency department were more likely to experience both early and total length of stay in-hospital mortality.
Conclusion: Our study shows higher in-hospital mortality rates for cardiovascular patients admitted on weekends. Efforts to improve the quality of care on weekend are important to mitigate the 'weekend effect' and improve patient outcomes.

Keywords: Hospitalization; Quality of health care; Hospital mortality; Hospital emergency service

INTRODUCTION

Cardiovascular disease is one of the leading cause of death. In 2013, it was accounted for an almost 32% of all global mortalities [1]. South Korea has also been facing the burden of cardiovascular disease. It is the second leading cause of death in Korea, and the mortality rate continues to increase (from 39.3% in 2005 to 55.6% in 2015) [2]. For preventing patients from negative outcomes, it is essential to find out risk factors. Among various risk factors, quality of care could be considered.

Low-quality care provided during the patient admission period, such as unsafe medical practices, may be a major cause of mortality [3]. Thus, evaluating the quality of care remains an important task for healthcare authorities. Many countries struggle to improve the quality of care provided to ensure patient safety and better outcomes [4-7] such as reducing mortality rate because mortality is considered one of the most important indicators of poor quality of care.

As part of the quality of care, the 'weekend effect' has been raised. The 'weekend effect' describes a higher rate of negative patient outcomes associated with weekend hospital admission [8]. However, previous studies exploring the 'weekend effect' have reported controversial findings. Previous studies have shown that patients admitted to hospitals on weekends had higher rates of mortality, readmission, or longer lengths of stay compared to those admitted on

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weekdays [9-12]. However, another study showed that this association differed by disease, and only the association between weekend admission and acute myocardial infarction was statistically significant [13-15].

The majority of studies exploring patient outcomes associated with the 'weekend effect' have been conducted in the United States or other countries [13-15]. Few studies have evaluated this effect in Korea and their findings remain controversial [16-20]; therefore, further studies are needed. In particular, emergency room (ER) is usually vulnerable to the worst outcome, death, due to the severity and emergency situation of patient. Thus, the characteristics of patients could derive different outcome between admission through ER or not. Therefore, it is needed to find out the difference of the association by admission route.

Thus, the main aim of this study is to investigate the association between weekend admission and the in-hospital mortality of patients with cardiovascular disease. For considering the difference in characteristics of emergency and non-emergency hospitalization, we analyzed this association stratified by admission route (via ER or not).

METHODS

1. Data source and study population

We analyzed claim data from the Health Insurance Review & Assessment dating from January 1st, 2013 to December 31st, 2013. This data consists of claims from general hospitals with more than 500 beds in Korea and includes patient diagnosis, procedures, hospital characteristics, and demographic characteristics of patients such as sex and age. In total, 94 hospitals, each with a minimum of 500 beds, were included in our analysis. Our study population included patients 18 years of age or older who were admitted to the hospital for cardiovascular disease during the study period. In total, 80,817 cardiovascular patients were included in our study.

2. Variables

Our dependent variable was in-hospital mortality. We divided in-hospital mortality into two groups: 'early' and 'total length of stay'. Death within 3 days of admission was classified as 'early in-hospital mortality,' and death during admission was classified as 'in-hospital mortality during the total length of stay.'

Our variable of interest was 'weekend admission,' which referred to patients admitted to the hospital on a Saturday or Sunday. Patients admitted to the hospital on Monday to Friday were considered weekday admissions.

Age, gender, type of insurance, and number of comorbidities were considered patient-specific variables. We used the Elixhauser comorbidity index score to control for patient comorbidities. The Elixhauser index accounts for 30 comorbidities and is based on codes included in the International Classification of Diseases. Patients were divided into the following four groups: no comorbidity, one comorbidity, two comorbidities, and three or more comorbidities.

Location of the hospital, number of beds, number of doctors per 10 beds, percentage of board-certified doctors compared to all doctors, and number of nurses per 10 beds were used as hospital-specific variables. The number of beds, doctors, nurses, and the percentage of board-certified doctors were divided into three groups based on tertile (Q1: low, Q2: middle, and Q3: high).

3. Statistical analyses

We first investigated the general characteristics of the study population using Pearson's chi-square test and a generalized linear model. We then applied a generalized linear mixed effects model (PROC GLIMMIX) for hierarchical logistic regression analysis to investigate the association between weekend admission and in-hospital mortality. This multilevel models were used to avoid possible correlations from the same hospital. Additionally, we conducted same analysis stratified by admission via ER or non-ER. All analyses were conducted using SAS ver. 9.4 (SAS Institute Inc., Cary, NC, USA).

RESULTS

The general characteristics of the study population are shown in Table 1. Of the total population (n=80,817), 0.7% (n=585) experienced early in-hospital mortality and 1.7% (n=1,356) experienced in-hospital mortality at the end of their stay. Of those admitted on weekends, 1.3% (n=167) experienced early in-hospital mortality, and 2.5% (n=316) experienced in-hospital mortality during total length of

Table 1. General characteristics of the study population by the course and the day of admission

Characteristic	Total	Early in-hospital mortality		*p*-value	In-hospital mortality		*p*-value
		Yes	No		Yes	No	
Patient characteristics							
Admission day				<0.0001			<0.0001
Weekdays	68,273 (84.5)	418 (0.6)	67,855 (99.4)		1,040 (1.5)	67,233 (98.5)	
Weekends	12,544 (15.5)	167 (1.3)	12,377 (98.7)		316 (2.5)	12,228 (97.5)	
Age group (yr)				<0.0001			<0.0001
<45	7,902 (9.8)	25 (0.3)	7,877 (99.7)		47 (0.6)	7,855 (99.4)	
45–64	32,150 (39.8)	80 (0.3)	32,070 (99.8)		186 (0.6)	31,964 (99.4)	
65–74	22,028 (27.3)	150 (0.7)	21,878 (99.3)		355 (1.6)	21,673 (98.4)	
≥75	18,737 (23.2)	330 (1.8)	18,407 (98.2)		768 (4.1)	17,969 (95.9)	
Gender				0.4739			0.1568
Male	44,771 (55.4)	315 (0.7)	44,456 (99.3)		725 (1.6)	44,046 (98.4)	
Female	36,046 (44.6)	270 (0.8)	35,776 (99.3)		631 (1.8)	35,415 (98.3)	
Admission via emergency room				<0.0001			<0.0001
No	49,584 (61.4)	73 (0.2)	49,511 (99.9)		257 (0.5)	49,327 (99.5)	
Yes	31,233 (38.7)	512 (1.6)	30,721 (98.4)		1,099 (3.5)	30,134 (96.5)	
Insurance				0.2692			0.0394
National Health Insurance	72,994 (90.3)	520 (0.7)	72,474 (99.3)		1,202 (1.7)	71,792 (98.4)	
Medical aid	7,823 (9.7)	65 (0.8)	7,758 (99.2)		154 (2.0)	7,669 (98.0)	
No. of comorbidity	1.37±1.26	1.70±1.53	1.36±1.26	<0.0001	2.37±1.82	1.35±1.24	<0.0001
Hospital characteristics							
Type of hospital				0.5666			0.1408
Tertiary hospital	49,214 (60.9)	349 (0.7)	48,865 (99.3)		799 (1.6)	48,415 (98.4)	
General hospital	31,603 (39.1)	236 (0.8)	31,367 (99.3)		557 (1.8)	31,046 (98.2)	
Location of hospital				0.9507			0.0454
Capital area	33,436 (41.4)	240 (0.7)	33,196 (99.3)		604 (1.8)	32,832 (98.2)	
Metropolitan area	28,076 (34.7)	202 (0.7)	27,874 (99.3)		455 (1.6)	27,621 (98.4)	
Non-metropolitan area	19,305 (23.9)	143 (0.7)	19,162 (99.3)		297 (1.5)	19,008 (98.5)	
No. of bed				0.6338			0.3888
Q1 (low)	13,243 (16.4)	103 (0.8)	13,140 (99.2)		229 (1.7)	13,014 (98.3)	
Q2	26,273 (32.5)	193 (0.7)	26,080 (99.3)		459 (1.8)	25,814 (98.3)	
Q3 (high)	41,301 (51.1)	289 (0.7)	41,012 (99.3)		668 (1.6)	40,633 (98.4)	
No. of doctors per 10 beds				0.0944			<0.0001
Q1 (low)	15,870 (19.6)	101 (0.6)	15,769 (99.4)		229 (1.4)	15,641 (98.6)	
Q2	23,115 (28.6)	189 (0.8)	22,926 (99.2)		459 (2.0)	22,656 (98.0)	
Q3 (high)	41,832 (51.8)	295 (0.7)	41,537 (99.3)		668 (1.6)	41,164 (98.4)	
No. of nurses per 10 beds				0.0562			0.0005
Q1 (low)	16,475 (20.4)	99 (0.6)	16,376 (99.4)		235 (1.4)	16,240 (98.6)	
Q2	23,790 (29.4)	192 (0.8)	23,598 (99.2)		457 (1.9)	23,333 (98.1)	
Q3 (high)	40,552 (50.2)	294 (0.7)	40,258 (99.3)		664 (1.6)	39,888 (98.4)	
Total	80,817 (100.0)	585 (0.7)	80,232 (99.3)		1,356 (1.7)	79,461 (98.3)	

Values are presented as number (%) or mean±standard deviation.

stay. Regarding weekdays admission, 0.6% (n=418) experienced early in-hospital mortality, and 1.5% (n=1,040) experienced in-hospital mortality during total length of stay.

Table 2 shows the association between weekend admission and in-hospital mortality by using the hierarchical logistic regression model. Those who admitted on weekend showed higher in-hospital

Table 2. The factors associated with in-hospital mortality

Variable	Early in-hospital mortality	In-hospital mortality within total length of stay
Patient characteristics		
Weekend admission		
Yes	1.48 (1.23–1.78)	1.17 (1.02–1.33)
No	1.00	1.00
Age group (yr)		
<45	1.00	1.00
45–64	0.98 (0.62–1.54)	0.97 (0.70–1.34)
65–74	2.87 (1.86–4.41)	2.43 (1.78–3.32)
≥75	5.81 (3.82–8.83)	4.74 (3.50–6.42)
Gender		
Male	1.00	1.00
Female	0.75 (0.63–0.88)	0.78 (0.69–0.87)
Insurance		
National Health Insurance	1.00	1.00
Medical aid	0.95 (0.72–1.24)	0.83 (0.69–0.99)
Admission route of index admission		
Via emergency room	11.08 (8.46–14.52)	6.55 (5.61–7.64)
Via non-emergency room	1.00	1.00
Elixhauser Index Score	1.01 (0.94–1.07)	1.47 (1.41–1.52)
Hospital characteristics		
Type of hospital		
Tertiary hospital	1.00	1.00
General hospital	1.13 (0.76–1.69)	1.01 (0.71–1.43)
Location of hospital		
Capital area	1.00	1.00
Metropolitan area	1.19 (0.89–1.59)	0.97 (0.75–1.26)
Non-metropolitan area	1.28 (0.90–1.82)	0.85 (0.62–1.18)
No. of bed		
Q1 (low)	1.00	1.00
Q2	0.58 (0.40–0.86)	0.84 (0.60–1.18)
Q3 (high)	0.50 (0.32–0.79)	0.70 (0.47–1.05)
No. of doctors per 10 beds		
Q1 (low)	1.00	1.00
Q2	1.31 (0.85–2.01)	1.24 (0.85–1.81)
Q3 (high)	1.50 (0.76–2.96)	1.14 (0.63–2.07)
No. of nurses per 10 beds		
Q1 (low)	1.00	1.00
Q2	1.01 (0.69–1.48)	0.83 (0.60–1.16)
Q3 (high)	1.03 (0.66–1.59)	0.92 (0.62–1.34)

Values are presented as adjusted odds ratio (confidence interval).

mortality than those who admitted on weekdays (early: odds ratio [OR], 1.48; 95% confidence interval [CI], 1.23–1.78; total length of stay: OR, 1.17; 95% CI, 1.01–1.33). Additionally, our results shows that those who admitted via ER showed higher in-hospital mortality than those who admitted via non-ER (early: OR, 11.08; 95% CI, 8.46–14.52; total length of stay: OR, 6.55; 95% CI, 5.61–7.64).

Table 3 shows the association between weekend admission and in-hospital mortality stratified by admission route. Our results shows that patients admitted via an ER on weekends experienced a higher rate of early in-hospital mortality compared to those admitted on

weekdays (OR, 1.40; 95% CI, 1.16–1.70). However, in-hospital mortality over the entire hospital stay did not show a significant association with weekend admission. Patients admitted on weekends through non-ER routes more commonly experienced in-hospital mortality both early (OR, 2.82; 95% CI, 1.60–4.99) and total length of stay (OR, 1.50; 95% CI, 1.04–2.17).

DISCUSSION

In this study, we found that patients admitted to the hospital on weekends more commonly experienced in-hospital mortality. This association was also shown regardless of their course of hospitalization. Admission from the ER on weekends was associated with early in-hospital mortality; this tendency was also observed for in-hospital mortality during the total stay, although it did not reach

Table 3. The association between weekend admission and in-hospital mortality stratified by admission route of index admission

Variable	Admission via emergency room		Admission via non-emergency room	
	Early in-hospital mortality	In-hospital mortality within total length of stay	Early in-hospital mortality	In-hospital mortality within total length of stay
Patient characteristics				
Weekend admission				
Yes	1.40 (1.16–1.70)	1.13 (0.98–1.31)	2.82 (1.60–4.99)	1.50 (1.04–2.17)
No	1.00	1.00	1.00	1.00
Age group (yr)				
<45	1.00	1.00	1.00	1.00
45–64	1.09 (0.67–1.76)	1.03 (0.73–1.45)	0.47 (0.12–1.82)	0.99 (0.38–2.58)
65–74	3.10 (1.96–4.91)	2.59 (1.86–3.61)	1.78 (0.52–6.12)	2.59 (1.04–6.49)
≥75	5.79 (3.70–9.05)	4.45 (3.22–6.16)	6.02 (1.82–19.92)	7.90 (3.20–19.47)
Gender				
Male	1.00	1.00	1.00	1.00
Female	0.74 (0.62–0.88)	0.75 (0.66–0.85)	0.85 (0.53–1.36)	0.95 (0.73–1.23)
Insurance				
National Health Insurance	1.00	1.00	1.00	1.00
Medical aid	0.95 (0.71–1.27)	0.84 (0.68–1.03)	0.95 (0.46–1.97)	0.74 (0.49–1.11)
Elixhauser Index Score	1.00 (0.94–1.07)	1.40 (1.35–1.46)	1.05 (0.87–1.26)	1.63 (1.51–1.77)
Hospital characteristics				
Location of hospital				
Capital area	1.00	1.00	1.00	1.00
Metropolitan area	1.03 (0.79–1.35)	0.94 (0.72–1.23)	3.06 (1.36–6.90)	1.11 (0.72–1.73)
Non-metropolitan area	1.07 (0.78–1.48)	0.86 (0.63–1.18)	3.01 (1.13–8.02)	0.73 (0.41–1.31)
No. of bed				
Q1 (low)	1.00	1.00	1.00	1.00
Q2	0.69 (0.48–0.99)	1.01 (0.71–1.43)	0.35 (0.11–1.14)	0.52 (0.28–0.98)
Q3 (high)	0.59 (0.38–0.91)	0.79 (0.52–1.19)	0.38 (0.11–1.35)	0.46 (0.23–0.94)
No. of doctors per 10 beds				
Q1 (low)	1.00	1.00	1.00	1.00
Q2	1.34 (0.91–1.96)	1.29 (0.90–1.84)	1.50 (0.42–5.31)	1.28 (0.65–2.53)
Q3 (high)	1.37 (0.85–2.20)	1.20 (0.76–1.88)	1.63 (0.33–8.05)	1.25 (0.52–3.02)
No. of nurses per 10 beds				
Q1 (low)	1.00	1.00	1.00	1.00
Q2	1.15 (0.80–1.66)	0.88 (0.63–1.24)	1.07 (0.33–3.48)	1.07 (0.59–1.93)
Q3 (high)	1.14 (0.76–1.70)	0.98 (0.67–1.44)	0.98 (0.25–3.90)	0.95 (0.46–1.95)

Values are presented as adjusted odds ratio (confidence interval).

statistical significance. Admission via non-ER alternative routes was significantly associated with in-hospital mortality both early and during the total stay.

The possible explanations for the association between weekend admission and in-hospital mortality include the following: (1) lower quality of care which may stem from reduced availability as well as limited resources availability is provided on weekends [8,9,21-23], and (2) patients admitted on weekends have more severe conditions than patients admitted on weekdays [22,24,25].

It may be that a lower quality of care is provided on weekends as a result of the relative lack of human resources available on weekends compared to weekdays; this reduced staffing could lead to the 'weekend effect' [9]. In practice, Kostis et al. [23] found an association between limited staffing and reduced access to examinations and procedures on weekends with an increased risk of in-hospital mortality. Furthermore, as there are limited numbers of staff members on weekends, the workload may be greater for each staff member, which may lead to lower quality of care [26]. Additionally, previous studies have suggested that less experienced and less senior staff members are scheduled on weekends, which also could lead to this 'weekend effect' [21].

Low-quality care may also result from a lack of services available to patients on weekends. The first day of admission to the hospital is important as it defines the initial responses to the presenting symptoms (e.g., examination, emergency treatment, and diagnosis), which are imperative to the subsequent care. However, fewer examinations are conducted and fewer treatments are administered on weekends compared to on weekdays [22]. Therefore, reduced access to procedures or tests on weekends may lead to negative patient outcomes. In summary, the 'weekend effect' is a combination of reduced staffing, limited availability of resources, and/or certain procedural characteristic of weekends [8].

Differences in patient characteristics on weekends compared to weekdays could also explain our results. Based on a previous report, patients admitted to hospitals and those who underwent procedures on a weekend generally had more severe health issues than those admitted on weekdays [24]. These findings may be explained based on a patient's preference for seeking medical attention. Mohammed et al. [25] proposed that patients with less severe illnesses prefer to visit hospitals on weekdays. Additionally, patients admitted to hospitals after business hours may be at a higher risk of death as a result of increased severity of illness compared to those admitted within regular business hours [22]. Thus, the severity of illnesses on weekends may be associated with the significant difference in mortality rates between weekday and weekend admissions.

In terms of patient characteristics, increased age was associated with higher in-hospital mortality, which is in agreement with previous reports [27,28]. Among patients admitted to the hospital via the ER, males showed a higher in-hospital mortality rate. Previous studies have shown that hospitals located in metropolitan or non-metropolitan areas had higher early in-hospital mortality rates compared to those in capital areas [10]. However, these findings are limited to patients admitted to hospitals through non-ER departments. Additionally, we observed a negative correlation between number of beds and in-hospital mortality. However, the numbers of doctors and nurses were not significantly associated with in-hospital mortality.

Differences in the association between the route of hospitalization and weekend admission were observed in the present study, and those who were admitted through non-ER departments showed a higher rate of in-hospital mortality than those who were admitted through the ER. A study performed in England also showed that patients admitted on weekends and patients undergoing elective admission on weekends had higher mortality rates [25]. These findings may be explained by the discrepancy in patient characteristics, including baseline mortality risk. It is believed that baseline mortality risk is greater for patients admitted in the ER [29]. Thus, it is possible that the difference in the mortality rates of weekday and weekend admissions through the ER is minimal. On the other hand, patients admitted through non-ER departments show a decreased mortality risk baseline. Thus, the difference in the mortality rates of non-ER admissions occurring on weekdays and weekends may be higher than the difference between weekday and weekend emergency admissions.

There are several limitations to our study. First, time of hospital admission, such as during the night, may have an effect similar to that of weekend admission. However, due to limitations in the available dataset, we were unable to explore 'off-hour' admissions. Second, income may play an important role in patient outcomes, and this was not analyzed in our study. However, we did account for the type of insurance, which may partially address this limitation. Third, we

included only those patients admitted to hospitals with a minimum of 500 beds due to data limitation.

In the present study, we investigated the association between weekend hospital admission and in-hospital mortality. Our study showed that patients admitted on weekends had higher in-hospital mortality rates compared to those admitted on weekdays, and this association was apparent for ER and non-ER admissions. The combination of decreased staff, the limited availability of invasive procedures, and differences in patient illness severity may explain the difference in mortality rates between weekday and weekend admissions [8,30]. Thus, it is important to increase the quality of care provided on weekends. Further studies are required to explore differences in in-hospital mortality between ER and non-ER admissions.

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