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Original Article

The impact of holiday season and weekend effect on traumatic injury mortality: Evidence from a 10-year analysis

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Abstract

Objectives: Trauma is one of the leading causes of death and its incidence increases annually. The "weekend effect" and "holiday season effect" on traumatic injury mortality remain controversial, whereby traumatic injury patients admitted during weekends and/or holiday season have a higher risk of in-hospital death. The present study is aimed to explore the association between “weekend effect” and “holiday season effect” and mortality in traumatic injury population. **Materials and Methods:** This retrospective descriptive study included patients from the Taipei Tzu Chi Hospital Trauma Database between January 2009 and June 2019. The exclusion criterion was age of < 20 years. The primary outcome was the in-hospital mortality rate. The secondary outcomes included intensive care unit (ICU) admission, ICU re-admission, length of stay (LOS) in the ICU, ICU admission duration ≥ 14 days, total hospital LOS, total hospital LOS ≥ 14 days, need for surgery, and re-operation rate. **Results:** In this study, 11,946 patients were included in the analysis, and 8143 (68.2%) patients were admitted on weekdays, 3050 (25.5%) on weekends, and 753 (6.3%) on holidays. Multivariable logistic regression revealed that the admission day was not associated with an increased risk of in-hospital mortality. In other clinical outcome analyses, we found no significant increase in the risk of in-hospital mortality, ICU admission, ICU LOS ≥ 14 days, or total LOS ≥ 14 days in the weekend and holiday season groups. The subgroup analysis showed that the association between holiday season admission and in-hospital mortality was noted only in the elderly and shock condition populations. The holiday season duration did not differ in terms of in-hospital mortality. Longer holiday season duration was also not associated with an increased risk of in-hospital mortality, ICU LOS ≥14 days, and total LOS ≥14 days. **Conclusion:** In this study, we did not find any evidence that weekend and holiday season admissions in the traumatic injury population were associated with an increased risk of mortality. In other clinical outcome analyses, there was no significant increase in the risk of in-hospital mortality, ICU admission, ICU LOS ≥ 14 days, or total LOS ≥ 14 days in the weekend and holiday season groups.

Keywords: *Holiday season effect, Mortality, Trauma, Weekend effect*

Introduction

Trauma is a leading cause of death and an annual increase in incidence worldwide [1]. In the current concept, early definite intervention was promoted in the traumatic population, especially in major traumatic injury populations, suggesting early transfer to tertiary-level hospitals. Ideally, in tertiary-level hospitals, more surgeons and medical staff provide timely intervention and good care. However, several studies reported the “weekend effect” and “holiday season effect” in time-sensitive diseases, such as pulmonary embolism [2], stroke [3,4], and acute aortic dissection [5]. Although hospitals ideally have the capacity to provide intervention, including emergent angiography and transcatheter arterial embolization (TAE), regardless of weekends or

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holidays, a reduction in medical staff has been reported in the real world. In addition, a larger patient load or more severe injury may occur during weekends and holiday seasons compared to nonholidays and weekdays. Therefore, quality of service care and delayed timely intervention may occur, which may be associated with poor clinical outcomes on weekends and holiday season admissions. However, there were few studies focused on the effect of "weekend effect" and "holiday season effect" in traumatic injury population.

The concept of golden hour in trauma was promoted, which refers to the 1st h after injury and largely determines the outcome of trauma patients. Early resuscitation and timely intervention may improve clinical outcomes in a traumatic population. In the study by Pasternack *et al*. [6], the authors found that the geriatric hip fracture population had a higher complication rate on weekend admission than on weekdays. They experienced a longer time from emergency department arrival to medical optimization and time from medical optimization to surgery. A positive association between weekend admission and 30-day mortality has been reported in a population with traumatic hip fracture [7]. Nandyala *et al*. [8] reported that patients with cervical spine trauma admitted on weekends for cervical fusion have a greater length of stay (LOS), higher total hospital costs, and higher incidence of postoperative complications, such as infection, cardiac complications, and urinary tract infection. However, in the study by Dvorak *et al*. [9], the authors included 22,451 traumatic injury patients and found that weekend admission did not have a higher risk of mortality or increased LOS in any of the hospital subgroups. In the study by Jundoria *et al*. [10], 9282 patients were admitted with lower extremity vascular trauma, and there were also no statistically significant differences in mortality, amputation, discharge home, and LOS.

Controversy seems to exist about the effect of "weekend effect" and "holiday season effect" in traumatic injury population. Therefore, we conducted a retrospective cohort study to evaluate whether "weekend" and "holiday season" may affect the mortality for traumatic injury population. We also conducted an exhaustive investigation controlling for traumatic injuries and other subgroups to overcome the limitations of previous studies on the topic.

Materials and Methods

Study setting and patients' data source

This retrospective descriptive study was conducted at Taipei Tzu Chi Hospital with approval from the Institutional Review Board of Taipei Tzu Chi Hospital (IRB number: 09-X-060). We included patients from the Taipei Tzu Chi Hospital Trauma Database between January 2009 and June 2019. The annual number of emergency department visits in Taipei Tzu Chi Hospital is shown in Figure 1. The numbers of average of annual and monthly emergency department visits during 2009 to 2019 are 75,559 and 6302 persons, respectively. The exclusion criterion was age of <20 years. A flow diagram of the patients included in our study is shown in Figure 2. In the Taipei Tzu Chi Hospital Trauma Database, patients with traumatic injury (coding ICD-9-CM codes 800–959, excluding 905–909 and 930–939, or coding ICD-10-CM codes S00–T98, excluding T15–T19 and T90–T98) with hospitalization or activation of the trauma team were included. The activation criteria for the trauma team are shown in Supplementary Table 1. Detailed demographic and clinical outcome data were collected from computerized records and charts. The collected data included age, sex, comorbid conditions, injury mechanism, types of injuries, prehospital and in-hospital vital signs, and prehospital management.

Variable measurements

Based on admission data, we classified the patients into weekdays, weekends, nonholiday seasons, and holiday season groups. The important variables in the analysis were the day of admission, including weekdays (workdays, from Monday through Friday), weekends (Saturday or Sunday), and holiday season (consecutive days of public holidays, including Chinese New Year, New Year's Day, 228 Peace Commemoration Day, Mid-Autumn Festival, Double Tenth Day, Tomb Sweeping Day, and Dragon Boat Festival). The dates of the Chinese New Year fall in January and February, but the exact dates differ each year. Therefore, we obtained the annual dates of the Chinese New Year from 2009 to 2019 from Taiwan's national holiday list. When the data overlapped on weekends and holidays, we excluded them from the weekend day but still in the holiday season group.

The basic characteristics of the trauma injury population in our study included were age, sex, underlying diseases, Glasgow coma scale (GCS) score, mechanism of injury, and site of injury. The mechanisms of injury include motor vehicle collision, low fall (falling down less than 1 m), high fall (falling down more than 1 m), and others (including drowning, burning injury, and cold injury). In-hospital variables, such as triage, activation of the trauma team, triage vital signs, and emergent treatment, were also analyzed. Injury severity was classified by four score, including Injury Severity Score (ISS), Revised Trauma Score (RTS), Trauma and injury severity score (TRISS) and New Injury Severity Score (NISS). ISS ≥16 and RTS <7 were adopted as the indices of trauma severity [11,12]. A shock index with a cutoff value greater than 1 was dichotomized into shock status [13]. Patients with an abbreviated injury scale (AIS) code limited to the head and no AIS-coded injuries in any other region were defined as having isolated head injuries.

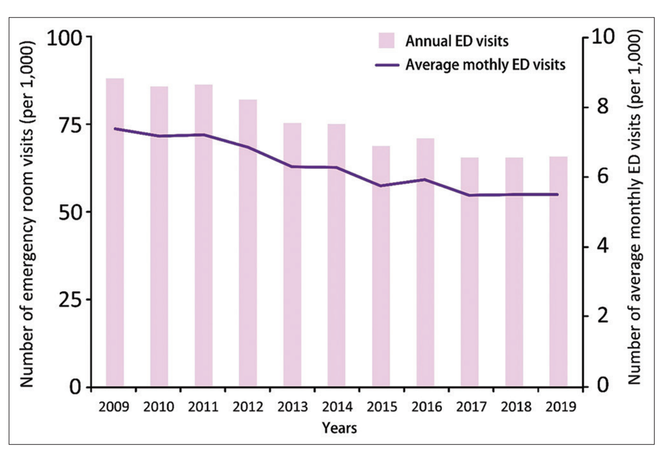

Figure 1: Annual number of emergency department visits in Taipei Tzu Chi Hospital

Table 1: Comparison of demographic characteristics of patients included in the study of in-hospital mortality

Characteristics	Total patients, *n* (%)	Weekdays, *n* (%)	Weekends, *n* (%)	Holiday, *n* (%)	*P*
Patient number	11,946 (100.0)	8143 (68.2)	3050 (25.5)	753 (6.3)	
Age (years)	59.34±20.30	59.50±20.34	59.03±19.99	58.88±21.07	0.417
Age (years)					
20-40	2376 (19.9)	1613 (19.8)	591 (19.4)	172 (22.8)	0.053
40-60	3425 (28.7)	2315 (28.4)	924 (30.3)	186 (24.7)	
60-80	3734 (31.3)	2548 (31.3)	943 (30.9)	243 (32.3)	
≥80	2411 (20.2)	1667 (20.5)	592 (19.4)	152 (20.2)	
Gender					
Female	5699 (47.7)	3889 (47.8)	1450 (47.5)	360 (47.8)	0.977
Male	6247 (52.3)	4254 (52.2)	1600 (52.5)	393 (52.2)	
Traumatic OHCA	196 (1.6)	135 (1.7)	47 (1.5)	14 (1.9)	0.808
In-hospital GCS ≤8	425 (3.6)	301 (3.7)	93 (3.0)	31 (4.1)	0.179
Shock status†	313 (2.7)	213 (2.7)	82 (2.7)	18 (2.4)	0.913
Triage					
1	881 (7.4)	603 (7.4)	219 (7.2)	59 (7.8)	0.005
2	6096 (51.0)	4211 (51.7)	1514 (49.6)	371 (49.3)	
3	4914 (41.1)	3299 (40.5)	1292 (42.4)	323 (42.9)	
4 and 5	55 (0.5)	30 (0.4)	25 (0.8)	0	
Activation of trauma team	480 (4.0)	336 (4.1)	114 (3.7)	30 (4.0)	0.647
Injury score systems					
RTS, mean	7.84 (7.84-7.84)	7.84 (7.84-7.84)	7.84 (7.84-7.84)	7.84 (7.84-7.84)	0.212
RTS <7	811 (6.8)	575 (7.1)	183 (6.0)	53 (7.0)	0.133
ISS	9 (4-9)	9 (4-9)	9 (4-9)	9 (4-9)	0.235
ISS <9	5513 (46.1)	3733 (45.8)	1446 (47.4)	334 (44.4)	0.322
9≤ ISS <16	5318 (44.5)	3632 (44.6)	1332 (43.7)	354 (47.0)	
ISS ≥16	1115 (9.3)	778 (9.6)	272 (8.9)	65 (8.6)	
NISS, mean	9 (4-9)	9 (4-9)	9 (4-9)	9 (4-9)	0.185
TRISS, mean	0.98 (0.97-0.99)	0.98 (0.97-0.99)	0.98 (0.97-0.99)	0.98 (0.97-0.99)	0.399
Isolated head injury*	1933 (16.2)	1309 (16.1)	400 (16.1)	134 (17.8)	0.462
Injury type					
Penetration	573 (4.8)	393 (4.8)	152 (5.0)	28 (3.7)	0.339
Nonpenetration	11373 (95.2)	7750 (95.2)	2898 (95.0)	725 (96.3)	
Mechanism of injury					
Motor vehicle collision	4363 (36.5)	3044 (37.4)	1051 (34.5)	268 (35.6)	0.051
Low fall	4736 (39.6)	3168 (38.9)	1248 (40.9)	320 (42.5)	
High fall	1533 (12.8)	1036 (12.7)	401 (13.1)	96 (12.7)	
Others	1314 (11.0)	895 (11.0)	350 (11.5)	69 (9.2)	
Comorbidity					
CNS diseases	749 (6.3)	516 (6.3)	190 (6.2)	43 (5.7)	0.790
Cardiovascular diseases	3593 (30.1)	2467 (30.3)	901 (29.5)	225 (29.9)	0.735
Respiratory diseases	279 (2.3)	203 (2.5)	65 (2.1)	11 (1.5)	0.137
Chronic kidney disease	377 (3.2)	256 (3.1)	98 (3.2)	23 (3.1)	0.970
Diabetes mellitus	1526 (12.8)	1055 (13.0)	375 (12.3)	96 (12.7)	0.647
ICU care					
ICU admission	1933 (16.2)	1319 (16.2)	506 (16.6)	108 (14.3)	0.324
Readmission ICU	44 (0.4)	30 (0.4)	12 (0.4)	2 (0.3)	0.874
LOS of ICU, days					
<7 days	7291 (92.8)	4913 (92.4)	1918 (93.4)	460 (94.5)	0.233
7≤ days <14	304 (3.9)	222 (4.2)	67 (3.3)	15 (3.1)	
≥14 days	262 (3.3)	182 (3.4)	68 (3.3)	12 (2.5)	
Surgical intervention					
Operation	7667 (64.2)	5190 (63.7)	1987 (65.1)	490 (65.1)	0.332
Reoperation	351 (2.9)	235 (2.9)	89 (2.9)	27 (3.6)	0.552
Surgical complications	65 (0.5)	47 (0.6)	12 (0.4)	6 (0.8)	0.312

Contd...

Table 1: Contd...

Characteristics	Total patients, *n* (%)	Weekdays, *n* (%)	Weekends, *n* (%)	Holiday, *n* (%)	*P*
Total hospitalization days					
<7 days	6386 (53.5)	4308 (52.9)	1670 (54.8)	408 (54.2)	0.449
7≤ days <14	3938 (33.0)	2713 (33.3)	985 (32.3)	240 (31.9)	
≥14 days	1622 (13.6)	1122 (13.8)	395 (13.0)	105 (13.9)	
In-hospital mortality	363 (3.0)	252 (3.1)	84 (2.8)	27 (3.6)	0.430

*Isolated head injury: Patients with an AIS code limited to the head and no AIS-coded injury in any other region, †Shock status: The shock condition was defined as a shock index of >1. ISS: Injury Severity Score, RTS: Revised Trauma Score, NISS: New Injury Severity Score, TRISS: Trauma and Injury Severity Score, LOS: Length of stay, ICU: Intensive care unit, OHCA: Out-of-hospital cardiac arrest, GCS: Glasgow coma scale, AIS: Arterial ischemic stroke, CNS: Central nervous system, ICU: Intensive care unit, LOS: Length of stay

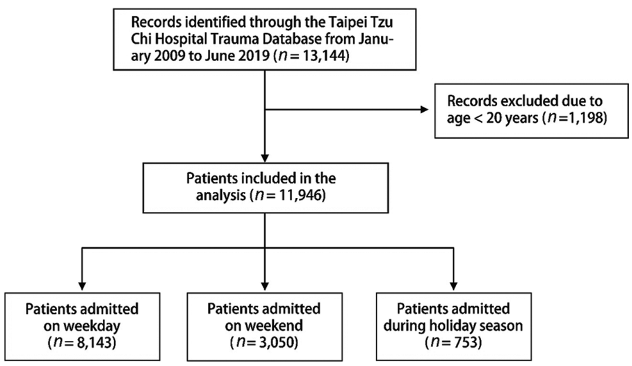

Figure 2: Flow diagram of patients included in our study

Outcome

The primary outcome was the in-hospital mortality rate. The secondary outcomes included intensive care unit (ICU) admission, ICU readmission, LOS in the ICU, ICU admission duration ≥14 days, total hospital LOS, total hospital LOS ≥14 days, need for surgery, and reoperation rate.

Statistical analysis

All continuous data were tested for normal distribution using the Kolmogorov–Smirnov test. Continuous variables were reported as mean with standard deviation (mean ± SD) and median with interquartile range (IQR). Dichotomous and categorical variables were presented as sample numbers with percentages (*n*, %). Nonparametric ANOVA or Mann–Whitney *U*-tests were used to compare continuous variables. Pearson's Chi-square test or Fisher's exact test was used to compare categorical and nominal variables. Multivariable logistic regression was used to determine the association between parameters and clinical outcomes on weekdays, weekends, nonholiday season, and holiday season. Variables with $P < 0.10$ or important factors were selected for multivariable logistic regression analysis. In multivariable logistic regression, we used the forced entry method for analysis and criteria of studentized residuals greater than 2.000 in the case-wise list to detect outliers that were excluded from the final model. Potential collinearity will be checked using the variance inflation factor for the variables in the model. The Hosmer–Lemeshow Goodness-of-Fit test was used to analyze the final model. In the subgroup analysis, multivariable logistic regression was performed using SPSS software (Version 13.0 SPSS Inc., Chicago, IL, USA) for statistical analysis. Statistical significance was defined as a $P < 0.05$.

Results

Characteristics of study objects

A total of 11,946 trauma patients (age [mean ± SD], 59.34 ± 20.30 years; 52.3%, men) were included, and their detailed characteristics are listed in Table 1. Based on the admission data, 8143 (68.2%) patients were on weekdays, 3050 (25.5%) on weekends, and 753 (6.3%) on holidays. The population was predominately 40–60 (28.7%) and 60–80 (31.3%) years old. Traumatic out-of-hospital cardiac arrest was accounted for 1.6% (196 patients), and the rate of activation of the trauma team was 4.0% (480 patients). The median ISS was low (n = 9; IQR 4–9). The major injury population (ISS ≥16 and RTS <7) did not differ among weekdays, weekends, and holidays. Injury type (penetration or nonpenetration), injury mechanism, and comorbidity were not different among the three groups. In the clinical outcome analysis, ICU admission rate, readmission ICU rate, operation rate, reoperation rate, surgical complication rate, and in-hospital mortality rate are not significantly different between the weekday, weekend, and holiday seasons. There was also no difference between the total number of hospitalization days and ICU LOS.

In-hospital mortality and other clinical outcomes

Multivariable logistic regression revealed that admission day was not associated with an increased risk of in-hospital mortality (adjusted odds ratio [aOR] of weekend: 1.086 under 95% confidence interval [CI]: 0.751–1.572, $P = 0.660$; aOR of holiday season: 1.134, 95% CI: 0.587–2.192, $P = 0.708$). Other variables associated with increased odds for mortality were older age (aOR of age at 60–80 years: 2.447, under 95% CI: 1.399–4.436, $P = 0.002$; aOR of age ≥80 years: 4.994 under 95% CI: 2.747–9.393, $P < 0.001$), major trauma (aOR of ISS ≥16: 26.712, 95% CI: 12.145–70.727, $P < 0.001$; aOR of RTS <7: 2.191, 95% CI: 1.293–3.624, $P = 0.002$), unconsciousness (aOR of GCS <8: 2.520, 95% CI: 1.487–4.356, $P < 0.001$), and isolated head injury (aOR: 2.227, 95% CI: 1.566–3.165, $P < 0.001$) [Table 2]. The area under the receiver operating characteristic curve of the multiple logistic regression model for the association between admission day and in-hospital mortality was 0.929 (95% CI 0.912–0.945), and the Hosmer–Lemeshow test showed adequate fit ($\chi^2 = 9.904$, $P = 0.272$). In other clinical outcome analyses, we found no significant increase in the risk of in-hospital mortality, ICU admission, ICU LOS ≥14 days, and total LOS ≥ 14 days in the weekend and holiday season groups [Table 3].

Subgroup analysis in in-hospital mortality

The subgroup analysis showed that weekend admission was not associated with in-hospital mortality in all subgroups analyzed, including age, sex, isolated head injury, consciousness status, and injury severity. The association between holiday season admission and in-hospital mortality was noted only in the elderly population (aOR: 1.737; 95% CI: 1.060–2.846, $P = 0.029$) and shock condition population (aOR: 4.239; 95% CI: 1.221–14.722, $P = 0.023$). There were no significant differences in male and female patients, major traumatic injury (ISS >16 or RTS <7), isolated brain injury, and unconscious population (GCS <8) [Table 4].

Table 2: Multivariable logistic regression of in-hospital mortality

Characteristics	In-hospital mortality		
	aOR	95% CI	*P*
Age			
20-40	Reference	Reference	Reference
40-60	1.165	0.625-2.204	0.631
60-80	2.447	1.399-4.436	0.002
≥80 years	4.994	2.747-9.393	<0.001
Gender			
Male	Reference	Reference	Reference
Female	0.847	0.609-1.173	0.321
Injury score system			
ISS <9	Reference	Reference	Reference
9≤ ISS <16	6.111	2.819-16.020	<0.001
ISS ≥16	26.712	12.145-70.727	<0.001
RTS ≥7	Reference	Reference	Reference
RTS <7	2.191	1.293-3.624	0.002
GCS			
GCS ≥8	Reference	Reference	Reference
GCS <8	2.520	1.487-4.356	<0.001
Isolated head injury*	2.227	1.566-3.165	<0.001
Shock status†	1.688	0.937-2.947	0.072
Injury mechanism			
MVC	Reference	Reference	Reference
Low fall	1.065	0.696-1.642	0.771
High fall	0.794	0.479-1.290	0.360
Others	0.492	0.138-1.334	0.210
Injury type			
Nonpenetration	Reference	Reference	Reference
Penetration	3.168	0.650-15.494	0.142
Activation of trauma team	1.106	0.683-1.778	0.667
Triage			
1	Reference	Reference	Reference
2	0.385	0.239-0.627	<0.001
3	0.219	0.118-0.403	<0.001
4 and 5	0.000	0.000-0.000	0.976
Admission day			
Weekday	Reference	Reference	Reference
Weekend	1.086	0.751-1.572	0.660
Holiday season	1.134	0.587-2.192	0.708

*Isolated head injury: Patients with an AIS code limited to the head and no AIS-coded injury in any other region. †Shock status: The shock condition was defined as a shock index of >1. aOR: Adjusted odds ratio, AIS: Arterial ischemic stroke, GCS: Glasgow coma scale, MVC: Motor vehicle crash, ISS: Injury Severity Score, RTS: Revised Trauma Score

The effect of holiday season duration

The holiday season duration did not differ in terms of in-hospital mortality. In other clinical outcomes, we found that the ICU admission rate was lower (9.8%, 20/205 patients) in longer holiday season durations (>5 days) than in shorter holiday season durations. There was no significant difference in readmission ICU, LOS of ICU, operation rate, reoperation rate, surgical complications, and total LOS [Table 5]. Longer holiday season duration was also not associated with an increased risk of in-hospital mortality, ICU LOS ≥14 days, and total LOS ≥14 days. Compared to a duration ≤3 days, the holiday season during 3–5 days was associated with an increased risk of ICU admission (aOR: 2.117, 95% CI: 1.229–3.646, $P = 0.007$), but not in the holiday season >5 days group (aOR: 0.713, 95% CI: 0.367–1.387, $P = 0.319$) [Table 6].

Discussion

The present study explored whether injured patients presenting to the hospital during the weekend and holiday seasons experienced increased mortality or negative clinical outcomes compared to weekdays. We observed that there was no difference in all clinical outcomes, including in-hospital mortality, ICU admission rate, readmission ICU rate, operation rate, reoperation rate, surgical complication rate, total LOS, and ICU LOS between the weekday, weekend, and holiday season groups. Admission for traumatic injury on the weekend and holiday was also not associated with in-hospital mortality, ICU admission, total LOS ≥14 days, or ICU LOS ≥14 days.

The "weekend effect" and "holiday season effect" have been demonstrated in medical and surgical conditions outside of workdays, such as sepsis [14], pulmonary embolism [2], acute aortic dissection [15], which were all time-sensitive conditions. However, our results were negative in the traumatic injury population. We found no variability in mortality for patients presenting during the weekend or holiday season, and a number of secondary outcomes also showed negative results. Our results are similar to Dvorak *et al.* [9] study,

Table 3: Multivariable logistic regression of four major clinical outcomes

Variable	Weekends		Holiday season	
	Adjusted OR (95% CI)	*P*	Adjusted OR (95% CI)	*P*
In-hospital mortality	1.086 (0.751-1.572)	0.660	1.134 (0.587-2.192)	0.708
ICU admission	0.997 (0.88-1.127)	0.956	0.981 (0.870-1.107)	0.758
ICU LOS ≥14 days	0.844 (0.620-1.148)	0.280	0.812 (0.455-1.450)	0.481
Total LOS ≥14 days	0.963 (0.874-1.063)	0.457	0.935 (0.783-1.116)	0.455

The covariables used in the multivariable logistic regression included age, sex, GCS, mechanism of injury, injury type, isolated head injury, triage, shock status, Injury Severity Score, and Revised Trauma Score. GCS: Glasgow coma scale, OR: Odds ratio, CI: Confidence interval, ICU: Intensive care unit, LOS: Length of stay

Table 4: Subgroup analysis of weekends and holiday season group in mortality in different population

Variable	Analysis with weekends			Analysis with holiday season		
	n	Adjusted OR (95% CI)	*P*	*n*	Adjusted OR (95% CI)	*P*
Age						
20-40	591	1.418 (0.609-3.305)	0.418	172	1.467 (0.636-3.385)	0.369
40-60	924	0.682 (0.323-1.442)	0.316	186	1.064 (0.526-2.152)	0.863
60-80	943	0.765 (0.431-1.356)	0.359	243	0.831 (0.478-1.444)	0.511
≥80 years	592	1.577 (0.947-2.624)	0.080	152	1.737 (1.060-2.846)	0.029
Gender						
Male	1600	1.054 (0.627-1.772)	0.842	393	1.182 (0.720-1.939)	0.509
Female	1450	1.096 (0.745-1.612)	0.643	360	1.259 (0.867-1.830)	0.227
Injury score system						
ISS ≥16	272	1.044 (0.711-1.533)	0.826	65	1.236 (0.852-1.792)	0.265
ISS <16	1332	1.073 (0.635-1.814)	0.791	354	1.126 (0.682-1.860)	0.643
RTS <7	2867	1.031 (0.681-1.562)	0.885	700	1.338 (0.898-1.995)	0.153
RTS ≥7	183	1.131 (0.719-1.777)	0.595	53	1.120 (0.718-1.747)	0.617
GCS						
GCS <8	93	1.079 (0.657-1.770)	0.765	31	1.395 (0.861-2.261)	0.177
GCS ≥8	2957	1.057 (0.705-1.583)	0.789	722	1.128 (0.763-1.668)	0.547
Isolated head injury	490	1.211 (0.800-1.834)	0.365	134	1.233 (0.824-1.845)	0.308
Shock condition	82	2.898 (0.854-9.839)	0.088	18	4.239 (1.221-14.722)	0.023

The covariables used in the multivariable logistic regression included age, sex, GCS, mechanism of injury, injury type, isolated head injury, triage, shock status, Injury Severity Score, and Revised Trauma Score. GCS: Glasgow coma scale, OR: Odds ratio, CI: Confidence interval, ISS: Injury Severity Score, RTS: Revised Trauma Score

Table 5: Subgroup analysis of holiday season duration in clinical outcome

Holiday duration (days)	<4 days, *n* (%)	4≤ days <6, *n* (%)	≥6 days, *n* (%)	*P*
Patient number	318 (42.2)	230 (30.5)	205 (27.2)	
ICU care				
ICU admission	39 (12.3)	49 (21.3)	20 (9.8)	0.001
Re-admission ICU	2 (0.6)	0	0	0.254
LOS of ICU, days				
<7 days	307 (96.5)	220 (95.7)	199 (97.1)	0.719
≥7 days	11 (3.5)	10 (4.3)	6 (2.9)	
Surgical intervention				
Operation	208 (65.4)	145 (63.0)	137 (66.8)	0.701
Re-operation	13 (4.1)	7 (3.0)	7 (3.7)	0.800
Surgical complications	2 (0.6)	2 (0.9)	2 (1.0)	0.900
Total hospitalization days				
<7 days	173 (54.4)	123 (53.5)	112 (54.6)	0.890
7≤ days <14	97 (30.5)	78 (33.9)	65 (31.7)	
≥ 14 days	48 (15.1)	29 (12.6)	28 (13.7)	
In-hospital mortality	9 (2.8)	11 (4.8)	7 (3.4)	0.473

ICU: Intensive care unit, LOS: Length of stay

who showed that the weekend effect is not present in trauma patients. There are several reasons for this result. First, one explanation for the weekend effect is reduced staffing levels, use of temporary clinical staff, and reduced availability of management and interventions [16,17]. In the study by Egol *et al.*, the weekend effect was the weakest at Level I and strongest at Level III/IV hospitals [18]. Compared to Level I/II centers, Level III/IV hospitals may have fewer physician and ancillary staff on weekends and holidays, making these hospitals more vulnerable to the weekend effect of trauma. It seems that Level I/II trauma centers are sufficiently well resourced to provide an equal quality of trauma service at all hours. In our hospital, a 24-h attending surgeon participated in all major trauma resuscitations within 10 min of major trauma activation. Resuscitation interventions such as transcatheter arterial embolization or surgery are available on weekends and holidays. Second, the "weekend effects" and "holiday season effect" were attenuated in all-hour services, such as the emergency and critical care departments [19,20]. Unstable traumatic injury patients are detected early in the emergency department and receive timely resuscitation to stabilize the injury condition. The weekend effect was weak and insignificant. In addition, patients with severe injury were potentially brought directly to Level I centers by prehospital emergency medical services, which may be likely to exhibit the weekend effect in Level III/IV hospitals. Third, the "weekend effect" and "holiday season effect" may be caused by differences in the case mix. The weekend effect across all patients may have been impaired because of the heterogeneity of patient characteristics. However, in our study, the differences in injury severity between the weekdays, weekdays, and holiday seasons were not significant. We used four scoring systems (RTS, ISS, NISS, and TRISS) to confirm that differences in injury severity did not exist in our traumatic population. Finally, some traumatic events may not require time-sensitive interventions, such as distal limb fractures or traumatic brain injury [21,22]. In patients with major traumatic and torso injuries, a shorter time to definitive care is positively associated with survival and functional outcomes [23]. Nonlife-threatening injuries may not require time-dependent intervention. Patients with minimal injuries are often kept overnight. Delayed surgery on weekends and holidays may not significantly impair mortality in nonlife-threatening injuries. Kato *et al.* [15] showed that the weekend effect is present in an acute aortic dissection population; only the Stanford Type A subgroup, which is the most emergent type and needs

Table 6: Multivariable logistic regression of four major clinical outcomes

Variable	aOR (95% CI)			
	In-hospital mortality	ICU admission	ICU LOS ≥14 days	Total LOS ≥14 days
Holiday season days				
<4 days	Reference	Reference	Reference	Reference
4≤ days <6	1.346 (0.200-9.048)	2.117 (1.229-3.646)**	0.628 (0.141-2.788)	0.868 (0.505-1.492)
≥ 6 days	1.141 (0.151-8.626)	0.713 (0.367-1.387)	0.421 (0.072-2.452)	0.852 (0.482-1.508)

***P*<0.05. The co-variables used in the multivariable logistic regression included age, sex, GCS, mechanism of injury, injury type, isolated head injury, triage, shock status, Injury Severity Score, and Revised Trauma Score. GCS: Glasgow Coma Scale, ICU: Intensive care unit, aOR: Adjusted odds ratio, LOS: Length of stay

timely intervention, showed a significantly increased risk of in-hospital mortality. No statistically significant difference was observed in the Stanford Type B group, which did not require timely surgical intervention. Although our results showed no statistically significant difference in mortality, wait time for getting services, such as access to counseling services and diagnostic and therapeutic intervention, would be prolonged.

Based on clinical experience, predictable increases in trauma activation during the holiday season were noted owing to increased high-energy recreational sporting activities [24,25]. Trauma centers plan their trauma team staff coverage on weekends early on. However, during longer holiday seasons, weak staff coverage may be exposed. In our study, weekends were less than 2 days, and holidays ranged from 1 to 9 days. The aOR of mortality was higher during the holiday season than during the weekends (aOR of weekend vs. holiday season: 1.086 vs. 1.134), but the difference was not significant. In the subgroup analysis, the duration of the holiday season did not affect in-hospital mortality. Longer holiday season duration was also not associated with an increased risk of in-hospital mortality, *ICU LOS* ≥14 days, and total LOS ≥14 days. In other clinical outcomes, we found that the ICU admission rate was lower in longer holiday season duration than in shorter holiday season duration. Compared to a duration <4 days, the holiday season during 4–6 days was significantly positively associated with ICU admission, but not in the holiday season >6 days group. The trauma support system in our hospital is likely responsible for overcoming the holiday season effect in the trauma population, even when the holiday duration is longer (up to 9 days). We speculate that these findings reflect that our trauma center is fully resourced and staffed, independent of the day of the holiday season.

Our subgroup analysis showed that shock population was positively associated with mortality on weekend admission with an aOR of 2.898 under 95% CI of 0.854–9.839 and on holiday season admission with an aOR of 4.239 under 95% CI of 1.221–14.722. We speculate that the weekend and holiday season effects may commonly occur under time-sensitive conditions. In critically ill patients, inadequate staffing resources and less expertise and experience of on-call teams of medical staff may have more significantly influenced the increase in mortality than in other stable injury patients. Moreover, inadequate staffing resources may have an excessive workload, which may influence mortality rates in critically ill populations.

The elderly population with less reserve capacity may not face injury stress, even though it is a relatively minor injury to the younger population. Longer times to medical optimization and surgery may have a greater impact on surgical complications and mortality rates in the elderly population. In a study by Pasternack *et al.* [6], longer times from arrival to medical optimization and from medical optimization to surgery were noted in geriatric hip fracture patients (age ≥50 years) admitted on weekends than on weekdays. In the study by Brouns *et al.* [26], elderly internal medicine patients aged ≥65 years also showed higher in-hospital mortality and 2-day mortality on weekend admission than on weekday admission. Our results showed a small holiday effect in elderly traumatic injury patients aged ≥80 years, which was not significant on weekends.

Our study included 10-year (2009–2019) period for analysis. However, our hospital was not certificated as a heavy emergency responsibility hospital during 2009 to 2012. Although it does not affect the inclusion criteria in our study, it may impair the emergency medical systems dispatching. The results can only be confirmed by prehospital data in New Taipei City. Our hospital provided high quality of trauma care even our hospital is not a heavy emergency responsibility hospital. We believed that the dispatch center would transport the patient to our hospital which equipped with trauma care ability to handle it. In addition, we conducted a subgroup analysis which showed the patients were older and had higher trauma injury severity (the proportion of RTS <7 or ISS ≥16 were higher, P < 0.001), and higher proportion of activation of trauma team after certificated as a heavy emergency responsibility hospital. Indeed, therapy strategies of trauma care were different after implementation of hospital emergency capacity accreditation by level, including establishment and activation of trauma team. In our prognostic analysis, the rate of ICU admission was higher and the LOS of total hospitalization and ICU were higher. However, there was no significant difference in mortality rate. In theory, annual differences may affect the weekdays, weekends, holidays, and nonholidays at the same time. Therefore, interannual differences would not cause intergroup differences.

This study had several strengths. First, our study investigated the "weekend effect" and "holiday season effect" in an Asian population with traumatic injury, which has not been widely investigated in previous studies. Second, our study adjusted for many confounders in the multivariate logistic regression, including injury mechanism and injury severity. However, in this study, we did not adjust the time to definitive care for survival in trauma patients because of the limitations of our dataset. In previous studies, delay in the time to definitive care may impair functional outcomes and is positively associated with the mortality rate in the traumatic population [23,27]. Third, our study used subgroup analysis to show the association between "weekend effect" and "holiday season effect" and mortality in the elder population and shock condition population, as a useful guild for emergency physician to early alert. Finally, we provide strong evidence that there is no association between the day of admission and mortality.

Our study has some limitations. First, it reported in-hospital mortality as the primary outcome. There was a lack of 7-day mortality, 30-day mortality, and functional outcomes due to the limitations of the dataset. Second, there was a lack of medical and nonmedical staff, intervention types, and delayed surgical or intervention times. Our dataset does not contain time information from admission to operation and LOS information at the emergency department. The reasons of delay surgical intervention are important to confirm "weekend effect" and "holiday season effect." The delay in time may be caused by disease progression or nonmedical waiting time. Third, due to the retrospective nature of the cohort study, there may be inherent issues. Although the large sample size is a strength of this study, there is a lack of solid granularity, which may induce bias or error. Forth, we did not have physiological data, which may be useful to reflect the risk adjustment of more severe patients presenting on weekends or holiday seasons. Despite our analysis showing results similar to those of previous studies in that there was no association between admission day and clinical outcomes, this was a single-center report that cannot accurately reflect whole hospital performance in Taipei City and New Taipei City. Finally, we did not investigate the impact of shift work. Emergency physicians and nurses had different work time. Moreover, in our emergency department, one physician worked from 10 A.M. to 10 P.M. which was overlapping to other physicians. The impact of shift work may be not clearly distinguished. In the future, further studies are required to verify our results and focused on impact of work shift in trauma injury population.

Conclusions

In this study, we did not find any evidence that weekend and holiday season admissions in the traumatic injury population are associated with an increased risk of mortality. In other clinical outcome analyses, there was no significant increase in the risk of in-hospital mortality, ICU admission, ICU LOS >14 days, or total LOS >14 days in the weekend and holiday season groups. Longer holiday season duration was not associated with an increased risk of in-hospital mortality, ICU LOS >14 days, and total LOS >14 days, and the principal conclusion from our results is that the association between admission day and mortality does not occur at our trauma center.

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Conflicts of interest

Dr. Giou-Teng Yiang, an editorial board member at *Tzu Chi Medical Journal*, had no role in the peer review process of or decision to publish this article. The other authors declared no conflicts of interest in writing this paper.

References

1. Haagsma JA, Graetz N, Bolliger I, Naghavi M, Higashi H, Mullany EC, et al. The global burden of injury: Incidence, mortality, disability-adjusted life years and time trends from the Global Burden of Disease study 2013. Inj Prev 2016;22:3-18.
2. Hung DP, Lin SM, Liu PP, Su IM, Hsu JY, Wu TY, et al. Evaluating the "holiday season effect" of hospital care on the risk of mortality from pulmonary embolism: A nationwide analysis in Taiwan. Sci Rep 2021;11:19376.
3. Sipilä J, Ruuskanen JO, Rautava P, Kytö V. Effect of the summer holiday season on ischaemic stroke care in Finland. J Neurol Sci 2016;367:363-4.
4. Huang HK, Chang WC, Hsu JY, Wang JH, Liu PS, Lin SM, et al. Holiday season and weekend effects on stroke mortality: A nationwide cohort study controlling for stroke severity. J Am Heart Assoc 2019;8:e011888.
5. Su IM, Huang HK, Liu PP, Hsu JY, Lin SM, Loh CH. Mortality risk from acute aortic dissection among hospital admissions during weekends and holiday season. PLoS One 2021;16:e0255942.
6. Pasternack JB, Ciminero ML, Silver M, Chang J, Simon RJ, Kang KK. Effect of weekend admission on geriatric hip fractures. World J Orthop 2020;11:391-9.
7. Thomas CJ, Smith RP, Uzoigwe CE, Braybrooke JR. The weekend effect: Short-term mortality following admission with a hip fracture. Bone Joint J 2014;96-B: 373-8.
8. Nandyala SV, Marquez-Lara A, Fineberg SJ, Schmitt DR, Singh K. Comparison of perioperative outcomes and cost of spinal fusion for cervical trauma: Weekday versus weekend admissions. Spine (Phila Pa 1976) 2013;38:2178-83.
9. Dvorak JE, Lester EL, Maluso PJ, Tatebe LC, Bokhari F. There is no weekend effect in the trauma patient. J Surg Res 2021;258:195-9.
10. Jundoria AK, Grant B, Olufajo OA, De La Cruz E, Metcalfe D, Williams M, et al. Assessment of the "weekend effect" in lower extremity vascular trauma. Ann Vasc Surg 2020;66:233-41.e4.
11. Jeong JH, Park YJ, Kim DH, Kim TY, Kang C, Lee SH, et al. The new trauma score (NTS): A modification of the revised trauma score for better trauma mortality prediction. BMC Surg 2017;17:77.
12. Boyd CR, Tolson MA, Copes WS. Evaluating trauma care: The TRISS method. Trauma Score and the Injury Severity Score. J Trauma 1987;27:370-8.
13. Koch E, Lovett S, Nghiem T, Riggs RA, Rech MA. Shock index in the emergency department: Utility and limitations. Open Access Emerg Med 2019;11:179-99.
14. Shih YN, Chen YT, Shih CJ, Ou SM, Hsu YT, Chen RC, et al. Association of weekend effect with early mortality in severe sepsis patients over time. J Infect 2017;74:345-51.
15. Kato K, Otsuka T, Nakai M, Sumita Y, Seino Y, Kawada T. Effect of holiday admission for acute aortic dissection on in-hospital mortality in Japan: A nationwide study. PLoS One 2021;16:e0260152.
16. Skinner CA, Riordan RL, Fraser KL, Buchanan JD, Goulston KJ. The challenge of locum working arrangements in New South Wales public hospitals. Med J Aust 2006;185:276-8.
17. Palmer WL, Bottle A, Davie C, Vincent CA, Aylin P. Dying for the weekend: A retrospective cohort study on the association between day of hospital presentation and the quality and safety of stroke care. Arch Neurol 2012;69:1296-302.
18. Egol KA, Tolisano AM, Spratt KF, Koval KJ. Mortality rates following trauma: The difference is night and day. J Emerg Trauma Shock

2011;4:178-83.
19. Schmulewitz L, Proudfoot A, Bell D. The impact of weekends on outcome for emergency patients. Clin Med (Lond) 2005;5:621-5.
20. Ensminger SA, Morales IJ, Peters SG, Keegan MT, Finkielman JD, Lymp JF, et al. The hospital mortality of patients admitted to the ICU on weekends. Chest 2004;126:1292-8.
21. Newgard CD, Meier EN, Bulger EM, Buick J, Sheehan K, Lin S, et al. Revisiting the "golden hour": An evaluation of out-of-hospital time in shock and traumatic brain injury. Ann Emerg Med 2015;66:30-41.e1-3.
22. Kotwal RS, Howard JT, Orman JA, Tarpey BW, Bailey JA, Champion HR, et al. The effect of a golden hour policy on the morbidity and mortality of combat casualties. JAMA Surg 2016;151:15-24.
23. Hsieh SL, Hsiao CH, Chiang WC, Shin SD, Jamaluddin SF, Son DN, et al. Association between the time to definitive care and trauma patient outcomes: Every minute in the golden hour matters. Eur J Trauma Emerg Surg 2022;48:2709-16.
24. Roberts DJ, Ouellet JF, McBeth PB, Kirkpatrick AW, Dixon E, Ball CG. The "weekend warrior": Fact or fiction for major trauma? Can J Surg 2014;57:E62-8.
25. Grossman DC, Kim A, Macdonald SC, Klein P, Copass MK, Maier RV. Urban-rural differences in prehospital care of major trauma. J Trauma 1997;42:723-9.
26. Brouns SH, Wachelder JJ, Jonkers FS, Lambooij SL, Dieleman JP, Haak HR. Outcome of elderly emergency department patients hospitalised on weekends – A retrospective cohort study. BMC Emerg Med 2018;18:9.
27. Chen CH, Shin SD, Sun JT, Jamaluddin SF, Tanaka H, Song KJ, et al. Association between prehospital time and outcome of trauma patients in 4 Asian countries: A cross-national, multicenter cohort study. PLoS Med 2020;17:e1003360.

Supplementary Material

Supplementary Table 1: Trauma team activation criteria

Trauma team activation criteria
Physiological (absolute indications)
Triage level I with mechanism of injury
Cardiac/respiratory arrest
Immediate risk to airway: Impending arrest
Respiratory rate <10
SBP <80 (adult) or severely shocked child/infant
Unresponsive or responds to pain only (GCS <9)
Ongoing/prolonged seizure
Drug overdose and unresponsive or hypoventilation
Severe behavioral disorder with immediate threat of dangerous violence
EMS judgment of major trauma
Unstable vital sign with mechanism of injury
Respiratory impairment
Respiratory rate <10/min or >29/min
Airway obstruction
Inability to protect airway
Cyanosis or air hunger
Paradoxical chest motion
Hypotension: SBP <90 mmHg
Altered consciousness or neurological impairment: GCS <8
Mechanism of major traumatic injury (relative indications)
Fall from 2 storey or 6 m
Ejection from vehicle, death in same vehicle
High-speed road traffic collisions >40 km/h
Crush injuries torso
Penetrating trauma proximal to elbow or knee
Specific injuries (relative indications)
Severe pelvic fracture with obvious deformity/instability >2 systems injury
Altered consciousness or neurological impairment with traumatic injury: GCS ≤12 or neurological focal sign
Others

SBP: Systolic blood pressure, GCS: Glasgow coma scale, EMS: Emergency medical services