# Impact of Weekend Versus Weekday Admission on Pediatric Trauma Patient Morbidity and Mortality

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# IMPACT OF WEEKEND VERSUS WEEKDAY ADMISSION ON PEDIATRIC TRAUMA PATIENT MORBIDITY AND MORTALITY

A Master's Thesis Presented

By

Max Devon Hazeltine, MD

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IMPACT OF WEEKEND VERSUS WEEKDAY ADMISSION ON PEDIATRIC TRAUMA PATIENT MORBIDITY AND MORTALITY

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Program
Master of Science in Clinical Investigation

April 19th, 2021

## Dedication

This achievement would not have been possible without the support of my loving wife, Amanda Hazeltine. I also want to dedicate this to my dearest children, Kai and Meilani, who have kept me centered throughout life's challenges. Finally, this work is in honor of my mother; her loss inspired me to pursue a path in service of others.

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## Abstract

**Background**

Injuries are the leading cause of death in the United States for children between the ages of 1 and 19 years. Weekend hospital admission has been associated with poor outcomes and higher mortality rates for a variety of diseases. We examined the impact of weekend versus weekday admission on in-hospital morbidity and case-fatality rates for pediatric trauma patients.

**Methods**

We performed a cross-sectional analysis on the 2016 Kids' Inpatient Database. The study population included pediatric trauma patients under the age of 19 years which were stratified by weekend vs weekday admission. Weightings were used to produce national estimates. Multiple logistic regression analyses were performed to assess the odds of in-hospital complications and death after adjusting for a variety of potentially confounding demographic and clinical factors.

**Results**

Patients admitted on a weekend were older, more frequently male, White, and privately insured. Weekend admissions had a higher Injury Severity Score (6.7 vs 5.4, $p<0.001$), as well as higher rate of intensive care unit (ICU) admission (8.5% vs 7.1%, $p<0.001$) and in-hospital case-fatality rate (1.3% vs 1.1%, $p=0.003$), but lower rate of in-hospital complications (6.1% vs 6.8%, $p<0.001$). Unadjusted logistic regression demonstrated that weekend admission was associated with higher odds of in-hospital death as compared to weekday admission (odds ratio 1.20, 95% confidence interval [CI] 1.07 – 1.35), but in the multivariable adjusted model this was no longer statistically significant (adjusted odds ratio [aOR] 1.06, 95% CI 0.94 – 1.20). Weekend admission was associated with lower odds of in-hospital complications (aOR 0.90, 95% CI 0.86 - 0.95), but higher odds of ICU admission (aOR 1.12, 95% CI 1.06 – 1.18).

**Conclusions**

Weekend admission in pediatric trauma is associated with higher odds of ICU admission. There does not appear to be an association between weekend admission and odds of in-hospital death, however it may be associated with lower odds of in-hospital complications.

**Keywords:** Pediatric trauma; Injury; Weekend admission

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Preface

Other works that will not be presented as part of this thesis:

Srinivas S, McLoughlin RJ, Hazeltine MD, Green J, Hirsh MP, Cleary MA, Aidlen JT. Pediatric snow sport injuries differ by age. J Pediatr Surg. 2021 Mar;56(3):520-525. doi: 10.1016/j.jpedsurg.2020.05.034. Epub 2020 Jun 5. PMID: 32653163.

McLoughlin RJ, Dacier BM, Hazeltine MD, Hirsh MP, Sullivan KP, Cleary MA, Aidlen JT. Intraventricular Hemorrhage and Patent Ductus Arteriosus Ligation Association with Infant Mortality. J Surg Res. 2020 Aug;252:192-199. doi: 10.1016/j.jss.2020.03.011. Epub 2020 Apr 9. PMID: 32278974.

McLoughlin RJ, Hazeltine MD, Durgin J, Schmidt A, Hirsh MP, Cleary MA, Aidlen JT. A national analysis of pediatric falls from a building. Injury. 2020 Oct 8:S0020-1383(20)30844-5. doi: 10.1016/j.injury.2020.10.044. Epub ahead of print. PMID: 33069396.

# Chapter I: Introduction

## Pediatric Trauma

Injuries are the leading cause of death for children and adolescents in the United States, accounting for almost half a million deaths since 1981 [1]. Furthermore, childhood injuries place a significant burden on the healthcare system. Childhood injuries account for approximately 10 million primary care office visits a year [2]. Long-term disability is another important consideration, with lifelong consequences of injury occurring in approximately 1 in 5 persons involved in a serious road accident [3]. The economic burden of injuries are substantial; in 2013 fatal injuries were estimated to have a combined medical and work-loss cost of $214 billion [4]. Important research and clinical efforts have been devoted to improving the care of traumatically injured children given its prevalence, significant short and long-term impact, as well as its burden on the healthcare system.

## Timing of Hospital Admission and Association with Patient Outcomes

Admissions to the hospital during the weekend versus weekday could potentially affect patient care given lower levels of staffing [5]. Weekend admission has been linked with poor outcomes and higher mortality for a variety of diseases, including ruptured abdominal aortic aneurysm, acute epiglottitis, pulmonary embolism, burns, and emergency general surgery in both adult and pediatric populations [6-10].

In the adult trauma population, a number of studies have found no association with weekend hospital admission and patient death rates [11-14]. However, a meta-analysis of all ages and causes found that weekend admission was associated with a 7% higher odds of death compared with weekday admission [15]. It has been demonstrated that pediatric trauma admissions occur at higher rates on weekends than weekdays, and these admissions may be associated with more severe injuries [16-18]. Studies of pediatric non-trauma surgical emergencies found higher rates of complications and death for weekend as compared to weekday admission [10,19]. There have been few studies, however, that have evaluated the impact of weekend as compared to weekday hospital admission on pediatric trauma morbidity and mortality rates.

Overview of the Kid's Inpatient Database

The Kid's Inpatient Database (KID) is a publicly available sampling of inpatient discharges for patients aged ≤ 20 years, consisting of approximately 4,200 hospitals and 6 million weighted discharges, gathering data from 46 states and the District of Columbia [20]. The hospitals that contribute to the database include non-federal hospitals, short-term stay hospitals, academic medical centers, and specialty hospitals. Federal hospitals, rehabilitation hospitals, psychiatric hospitals, and substance treatment centers do not contribute data to the KID. The KID is produced every three years by the Healthcare Cost and Utilization Project (HCUP), with the most recent iteration published in 2016. Discharge weightings are provided from HCUP and are calculated by stratifying hospitals on the same variables that were used for creating the sample and then creating weights by stratum [21]. These weightings, along with the large sample size, enhance the generalizability of results generated from the KID database. Given that this is a sampling of inpatient discharges, the KID does not capture data for outpatient or emergency room visits. Additionally, patients are not tracked across multiple admissions, thus a patient who has multiple admissions will generate a unique observation for each admission.

Specific Aims

The primary aim of this study was to examine the relationship between timing of admission (weekend vs weekday) and in-hospital case-fatality rates for pediatric trauma patients. Secondary aims included assessing the association of admission timing with patient demographics, injury mechanisms, injury patterns, procedures performed, in-hospital complications, intensive care unit admission, and discharge disposition.

## Chapter II: Methods

### Data Source

We performed a retrospective cross-sectional analysis on the 2016 iteration of the KID.

### Study Population

The study population included patients between the ages of 0 and 20 years admitted to participating study sites for a traumatic injury. Traumatic injuries were identified using *International Classification of Diseases, 10th Revision* (ICD-10) external cause of injury codes. Patients were excluded from analysis if they were aged >18 years, if the hospitalization was elective or had ICD-10 codes related to adverse effects of medical care (i.e., medical error), or if there were missing data for the following variables: gender, race, primary insurance payer, income quartile, length of stay (LOS), or in-hospital death. From the weighted sample of 6,266,285 we first excluded 5,972,878 non-trauma related hospitalizations. An additional 51,104 patients were excluded due to patient age being >18 years old. We then excluded 34,869 elective hospitalizations, 41,157 hospitalizations related to adverse effects of medical care, and an additional 17,970 patients were excluded due to missing data, with the most common reason being a lack of information about race (n=15,202). The final sample size was 148,307 (Figure 1).

### Principal Exposure Variable and Study Outcomes

The principal exposure variable was hospital admission on either a weekend (defined as Saturday or Sunday) or weekday. The primary outcome was the in-hospital case-fatality rate (CFR), which is coded from the discharge disposition of the patient by HCUP. Secondary outcomes included those previously used in the literature as well as those chosen a priori given their clinical significance [10,22-26]. These secondary endpoints included any in-hospital complication, blood transfusion, intensive care unit (ICU) admission, non-home discharge, pneumonia, sepsis, shock, and urinary tract infection. Since no ICD-10 code or variable exists for ICU admission, ICU admission was defined as requiring the use of an arterial line, ventilator, central venous catheter, or extracorporeal membrane oxygenation given that these procedures require ICU level of care. Discharge to a non-home setting was categorized as a binary outcome of home vs non-home. A variable for non-home disposition was created from creating a composite of all other disposition outcomes (transfer to short-term hospital, transfer to other type of facility, home health care, against medical advice, and discharged alive to destination unknown), and excluding those cases that were missing data or if they died during their hospitalization. Perioperative complications were defined using ICD-10 diagnosis codes or Clinical Classifications Software (CCS) codes (Supplementary Table I). HCUP developed CCS codes to more easily identify diagnoses and procedures [27]. Diagnoses, comorbidities, procedures, and mechanism of injury were identified in a similar manner.

Covariates

Covariates included for analysis included patient age, gender, race, hospital bedsize, hospital region in the United States (U.S.), season, health insurance payer, median income quartile by patient ZIP code, number of diagnoses, number of hospital procedures performed, hospital LOS, and Injury Severity Score (ISS). Season was divided into four categories – spring (March, April, May), summer (June, July, August), autumn (September, October, November) and winter (December, January, February). Health insurance payer status was consolidated into private, Medicaid, Medicare, no charge, self-pay, and other (Worker's Compensation, CHAMPUS, CHAMPVA, Title V, and other government programs). Hospital regions were defined as Midwest, Northeast, South, and West based on the U.S. Census Bureau regions [28]. Injury Severity Scores were calculated from ICD-10 codes using International Classification of Diseases (ICD) and R statistical software (ICDPIC-R) method as previously described, and the "ROCmax" method was used given it had the highest reported c-statistic [29].

Statistical Analysis

National estimates were generated using STATA 16.1 statistical software (StataCorp 2020; College Station, Texas) and weights provided by HCUP. Discharge weights are calculated by HCUP by stratifying hospitals on the same variables that were used for creating the sample and then creating weights by stratum [21]. Chi-square tests and Student's t-tests were used to analyze differences in categorical and continuous variables, respectively, between hospital admissions on a weekend vs weekday. Unadjusted logistic regression models assessed demographic and clinical variables associated with the odds of in-hospital death and developing in-hospital complications between patients who were hospitalized during the weekend as compared with weekday. Variables that met a p-value threshold of <0.20 or were chosen a priori based on clinical significance were included in the multivariable adjusted regression analyses. The adjusted logistic regression models assessed the odds of in-hospital death and developing in-hospital complications for patients hospitalized on a weekend as compared with weekday, while controlling for a variety of potentially confounding prognostic factors including: 1) Patient and hospital characteristics: Age, sex, income quartile, primary insurance, race, season, hospital bedsize, hospital region; and 2) Clinical characteristics: Injury Severity Score, burn, falls, motor vehicle crash occupant. These mechanisms were chosen given that they are the top three most common mechanisms of injury for both weekend and weekday admissions.

We analyzed the data using a complete case analysis approach, excluding observations from analyses if they were missing data on any of the critical outcomes or variables listed previously. Multicollinearity was assessed between all variables included in the adjusted model using variance inflation factors and was it deemed not problematic as none exceeded 1.2.

Ethical Considerations

The study was reviewed by the institutional review board at the University of Massachusetts Medical School and determined to not be human subjects research and exempt from institutional review board human subjects review. Per the HCUP data use agreement, information where the number of observations in a cell is ≤10 is not reported.

# Chapter III: Results

## Study Population and Hospitalization Characteristics

The proportion of patients admitted on a weekend (29.2%) was approximately equal to what would be expected given that two days comprise 28.6% of the week. Those admitted to the hospital on a weekend were more frequently older, male, White, and privately insured (Table 1). Patients admitted on a weekend vs weekday were more often treated at a hospital with a large number of beds, in the South, and during the autumn (Table 1). Injury Severity Score was higher for patients admitted on a weekend vs weekday.

## Mechanism of Injury, Injury and Procedure Patterns, and In-hospital Complications According to Hospitalization Timing

The most common mechanism of injury for weekend admissions was being a motor vehicle collision (MVC) occupant, which was significantly more frequent compared with weekday admissions. The second and third most common mechanisms were falls and burns (Figure 2). Patients admitted on a weekend had, on average, fewer diagnoses. The most common injuries were similar between weekend and weekday admission and were 1) Intracranial injury, 2) Upper extremity fracture, and 3) Lower extremity fracture (Table 2). Patients hospitalized on a weekend had a higher mean number of procedures performed, and the three most common procedures were relatively similar, but more frequently performed during the weekend admission, namely upper extremity fracture repair, hip or femur fracture repair, lower leg fracture repair (Table 3). The mean hospital LOS was significantly shorter for weekend admissions. Weekend admissions, as compared to patients admitted during the week, had lower rates of in-hospital complications, sepsis, urinary tract infection, and non-home discharge, but higher rates of shock and ICU admission, as well as a higher in-hospital case-fatality rate (Table 4).

Logistic Regression Analyses

Unadjusted logistic regression analyses examined the association of a weekend admission with each of our major study outcomes while controlling for a single potentially confounding variable. Each potentially confounding variable met the p-value threshold of <0.20 for multiple outcomes (i.e., in-hospital death, ICU admission) and thus was included in the adjusted models.

The multiple logistic regression models included two groups of potentially confounding sociodemographic and clinical variables, with each successive model adjusting for more variables. On unadjusted analyses, all outcomes except for blood transfusion and pneumonia were significantly associated with weekend admission (Table 5, unadjusted model). However, as more variables were adjusted for, these associations tended to become attenuated or non-significant. In-hospital death was not associated with weekend admission in the final model (Table 5, Model 2). Weekend admission, as compared to weekday admission, was associated with lower odds for in-hospital complications, blood transfusions, non-home discharge, sepsis, and urinary tract infection. However, there were higher odds of ICU admission for patients admitted on a weekend.

# Chapter IV: Discussion

Pediatric patients who experience a traumatic injury and are admitted to the hospital on a weekend are most often injured as MVC occupants, sustain intracranial injuries or extremity fractures, and frequently require operative repair of these extremity fractures. Compared to patients admitted on a weekend, those admitted on a weekend had higher Injury Severity Scores, rates of ICU admission, shock, and in-hospital CFRs, but lower rates of in-hospital complications on univariate analysis. After adjusting for a number of potentially confounding variables with multivariable logistic regression, patients admitted on a weekend had higher odds of ICU admission and lower odds of any in-hospital complications. There was no statistically significant association between the timing of weekend admission and odds of in-hospital death.

## Weekend Admission is Not Associated With Higher Morbidity and Mortality Rates

Our fully adjusted logistic regression model did not suggest elevated odds of developing various in-hospital complications or death and weekend admission. Prior data are mixed regarding the association of weekend admission with in-hospital death rates. A number of studies in adult trauma patients failed to find a higher rate of dying for those admitted on a weekend versus weekday [11-14]. However, a meta-analysis of 39 studies of all ages and causes that examined weekend admission's association with mortality rate found a 7% higher odds of dying for patients admitted on a weekend [15]. Pediatric studies in non-trauma emergency surgery have found evidence of increased rates of morbidity and mortality for patients admitted on a weekend versus weekday [10,19].

One purported explanation for worse outcomes on weekends has been the availability of resources, which may translate to less availability of diagnostic tests or specialists and delays in care [5,30]. However, studies examining the impact of weekend admission and outcomes for a number of emergency general surgery procedures found mixed results depending upon procedure type, making it less likely that resource availability adversely impacts patient outcomes [7,26]. Another consideration may be the need to transfer a patient, as this has been found to increase mortality rates [31]. It is unlikely that higher rates of severe illness on weekends are solely responsible for these outcomes, as the majority of studies have adjusted for the prognostic impact of injury or disease severity.

The trauma infrastructure and system are likely protective against these temporal variations in various patient outcomes. The structure that is in place to care for injured patients is rather unique to the trauma surgery specialty, and the *American College of Surgeons* has a rigorous verification process to ensure that particular standards are met. For example, an attending surgeon should be immediately available, participate in major resuscitations, and be actively involved in the care of critically ill patients [32]. One could make the case that trauma, as a specialty, has more standardization of care and available resources regardless of time compared to other specialties. A study of colorectal emergencies found higher morbidity and mortality rates for weekend emergencies, which may be attributable to lack of availability of specialized surgeons and resources [33].

<u>Weekend Admission is Associated with More Severe Illness</u>

We found that pediatric patients admitted on a weekend were more likely to have severe illness, as demonstrated by higher ISS, as well as higher rates of acidosis, shock, and ICU admission. Similar findings have been reported in both the adult and pediatric populations, with weekend admissions more often associated with more severe injuries and shock, more frequently requiring

ICU admission, as well as having a longer ICU length of stay [11,12,16]. One study that included ten years of data and over 70,000 pediatric trauma patients found that patients presenting to the hospital on a weekend after a road traffic injury (which included pedestrians struck as well as motorized vehicle injuries) were more severely injured and had higher rates of ICU admission [16].

The higher volume of injuries occurring on weekends may lead to a proportional increase in patients hospitalized with severe injuries [17,18,34]. However, this increase in volume was not found in our study that employed a weighted, national database. This discrepancy may be due to regional variations in volume that are mitigated when assessed at a larger scale. However, we still found higher rates of severe illness for weekend admissions despite the volume not being proportionally higher on weekends (i.e., the weekend was not simply "busier"). Weekends likely are a time when children have more exposure to activities that are higher risk of serious injury, which is intuitive given that the majority of children are in school on weekdays.

Study Strengths and Limitations

A major strength of this study is the use of a large, nationally representative database. The KID has over 6 million weighted discharges from 46 states and the District of Columbia, which makes findings more generalizable and also enables the study of uncommon diseases or outcomes.

Limitations include the reliance on ICD-10 codes, as well as the lack of longitudinal data, as the KID only collects data for hospitalizations and not any visits to an emergency department or outpatient clinic. Complication timing is not specified in the KID. Thus, complications may have occurred prior to, during, or after a procedure. This information would be helpful in determining if complications occurred due to procedures, were related to a particular disease state, or if they were indeed due to timing of hospitalization. Additionally, there are outcomes of interest which may develop after the acute hospitalization period, such as thrombosis or infections, and we may not be capturing all possible cases that develop an adverse outcome. However, the trauma population is more often lost to follow up, so determining long term outcomes in this population can be challenging [35].

## Conclusions

Traumatic injury in the pediatric population is a significant cause of morbidity and mortality. Timing of hospital admission is an important factor for patient outcomes, with weekend admissions being associated with more severe injuries. However, in-hospital morbidity and CFRs were not associated with the timing of hospital admission in the pediatric trauma population. Further insights into the underlying reasons for these findings may be helpful in understanding how to mitigate poor outcomes related to weekend admissions for other medical and surgical specialties.

References


[1] Control NCfIPa. WISQARS™ — Web-based Injury Statistics Query and Reporting System. Centers for Disease Control and Prevention.

[2] Hambidge SJ, Davidson AJ, Gonzales R, Steiner JF. Epidemiology of pediatric injury-related primary care office visits in the United States. Pediatrics 2002;109(4):559-65.

[3] Weijermars W, Bos N, Stipdonk H. Health burden of serious road injuries in the Netherlands. Traffic Inj Prev 2016;17(8):863-9.

[4] Florence C, Simon T, Haegerich T, Luo F, Zhou C. Estimated Lifetime Medical and Work-Loss Costs of Fatal Injuries--United States, 2013. MMWR Morb Mortal Wkly Rep 2015;64(38):1074-7.

[5] Lamn H. The lost weekend in hospitals. N Engl J Med 1973;289(17):923.

[6] Bell CM, Redelmeier DA. Mortality among patients admitted to hospitals on weekends as compared with weekdays. N Engl J Med 2001;345(9):663-8.

[7] Hoehn RS, Go DE, Dhar VK, et al. Understanding the "Weekend Effect" for Emergency General Surgery. J Gastrointest Surg 2018;22(2):321-8.

[8] Peluso H, Abougergi MS, Caffrey J. Impact of weekend admission on mortality and other outcomes among patients with burn injury: A nationwide analysis. Burns 2017;43(8):1654-61.

[9] Takagi H, Ando T, Umemoto T. A meta-analysis of weekend admission and surgery for aortic rupture and dissection. Vasc Med 2017;22(5):398-405.

[10] Goldstein SD, Papandria DJ, Aboagye J, et al. The "weekend effect" in pediatric surgery - increased mortality for children undergoing urgent surgery during the weekend. J Pediatr Surg 2014;49(7):1087-91.

[11] Carr BG, Reilly PM, Schwab CW, Branas CC, Geiger J, Wiebe DJ. Weekend and night outcomes in a statewide trauma system. Arch Surg 2011;146(7):810-7.

[12] Giannoudis V, Panteli M, Giannoudis PV. Management of polytrauma patients in the UK: Is there a 'weekend effect'? Injury 2016;47(11):2385-90.

[13] Little Z, Bethel J, Clements J, Trompeter AJ. Major trauma: Does weekend attendance increase 30-day mortality? Injury 2019;50(2):351-7.

[14] Metcalfe D, Perry DC, Bouamra O, et al. Is there a 'weekend effect' in major trauma? Emerg Med J 2016;33(12):836-42.

[15] Honeyford K, Cecil E, Lo M, Bottle A, Aylin P. The weekend effect: does hospital mortality differ by day of the week? A systematic review and meta-analysis. BMC Health Serv Res 2018;18(1):870.

[16] Burstein B, Fauteux-Lamarre E, As AB. Increased morbidity associated with weekend paediatric road traffic injuries: 10-year analysis of trauma registry data. Injury 2016;47(6):1236-41.

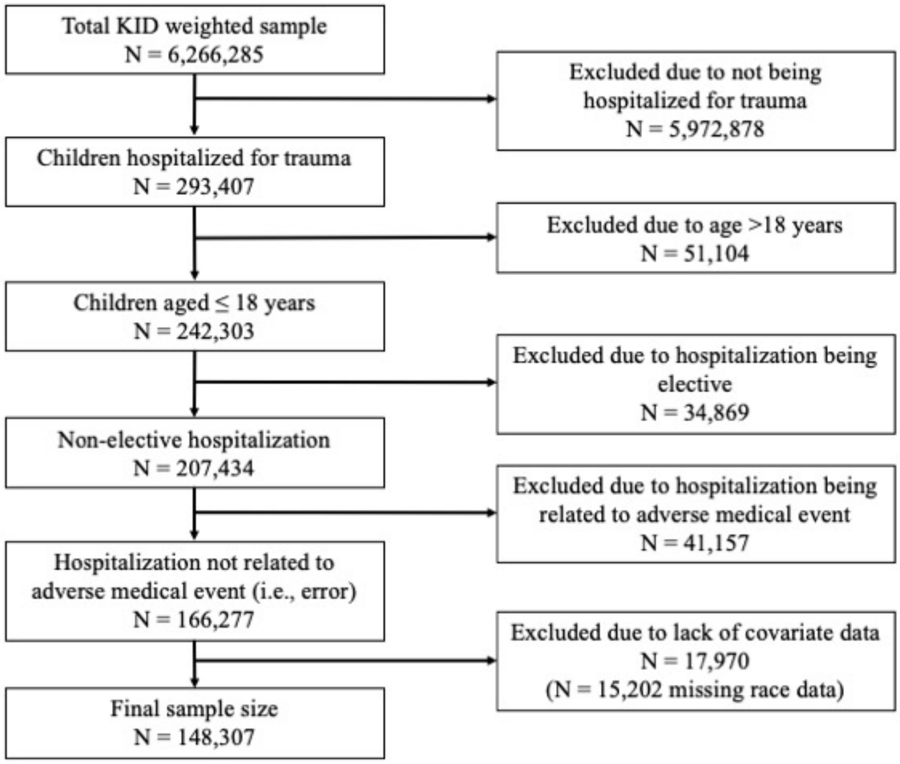
[17] Groh EM, Feingold PL, Hashimoto B, McDuffie LA, Markel TA. Temporal Variations in Pediatric Trauma: Rationale for Altered Resource Utilization. Am Surg 2018;84(6):813-9.

[18] Ramgopal S, Dunnick J, Siripong N, Conti KA, Gaines BA, Zuckerbraun NS. Seasonal, Weather, and Temporal Factors in the Prediction of Admission to a Pediatric Trauma Center. World J Surg 2019;43(9):2211-7.

[19] Desai V, Gonda D, Ryan SL, et al. The effect of weekend and after-hours surgery on morbidity and mortality rates in pediatric neurosurgery patients. J Neurosurg Pediatr 2015;16(6):726-31.
[20] Project HCaU. HCUP Kids' Inpatient Database (KID). In: Quality AfHRa, ed. Rockville, MD; 2006, 2009, 2012, and 2016.
[21] Project HCaU. Producing National HCUP Estimates, https://www.hcup-us.ahrq.gov/tech_assist/nationalestimates/508_course/508course_2018.jsp#kid; 2018 [accessed October 12, 2020.2020].
[22] De la Garza Ramos R, Longo M, Gelfand Y, et al. Weekend versus Weekday Admission in Spinal Cord Injury and Its Effect on Timing of Surgical Intervention. World Neurosurg 2019;122:e754-e8.
[23] Mahran A, Fernstrum A, Swindle M, et al. Impact of trauma center designation in pediatric renal trauma: National Trauma Data Bank analysis. J Pediatr Urol 2020;16(5):658.e1-.e9.
[24] Panhwar MS, Deo SV, Gupta T, et al. Weekend Operation and Outcomes of Patients Admitted for Nonelective Coronary Artery Bypass Surgery. Ann Thorac Surg 2020;110(1):152-7.
[25] Stewart RM, Corneille MG. Common complications following thoracic trauma: their prevention and treatment. Semin Thorac Cardiovasc Surg 2008;20(1):69-71.
[26] Zapf MA, Kothari AN, Markossian T, et al. The "weekend effect" in urgent general operative procedures. Surgery 2015;158(2):508-14.
[27] Healthcare Cost and Utilization Project. Clinical Classifications Software (CCS) for Mental Health and Substance Abuse. Rockville, MD: Agency for Healthcare Research and Quality; 2009.
[28] U.S. Census Bureau. Geographic Terms and Concepts - Census Divisions and Census Regions. 2010.
[29] Clark DE, Black AW, Skavdahl DH, Hallagan LD. Open-access programs for injury categorization using ICD-9 or ICD-10. Inj Epidemiol 2018;5(1):11.
[30] Kothari AN, Zapf MA, Blackwell RH, et al. Components of Hospital Perioperative Infrastructure Can Overcome the Weekend Effect in Urgent General Surgery Procedures. Ann Surg 2015;262(4):683-91.
[31] O'Donnell TFX, Li C, Swerdlow NJ, et al. The Weekend Effect in AAA Repair. Ann Surg 2019;269(6):1170-5.
[32] Trauma ACoSCo. Resources for Optimal Care of the Injured Patient. In: Smith MFRCCRS, ed. 6th ed.; 2014.
[33] Huijts DD, van Groningen JT, Guicherit OR, et al. Weekend Effect in Emergency Colon and Rectal Cancer Surgery: A Prospective Study Using Data From the Dutch ColoRectal Audit. J Natl Compr Canc Netw 2018;16(6):735-41.
[34] Berg P, Chestovich PJ, Jones S, et al. Pediatric Trauma Arrival Times and the Swing Shift. Pediatr Emerg Care 2020.
[35] Zelle BA, Buttacavoli FA, Shroff JB, Stirton JB. Loss of Follow-up in Orthopaedic Trauma: Who Is Getting Lost to Follow-up? J Orthop Trauma 2015;29(11):510-5.

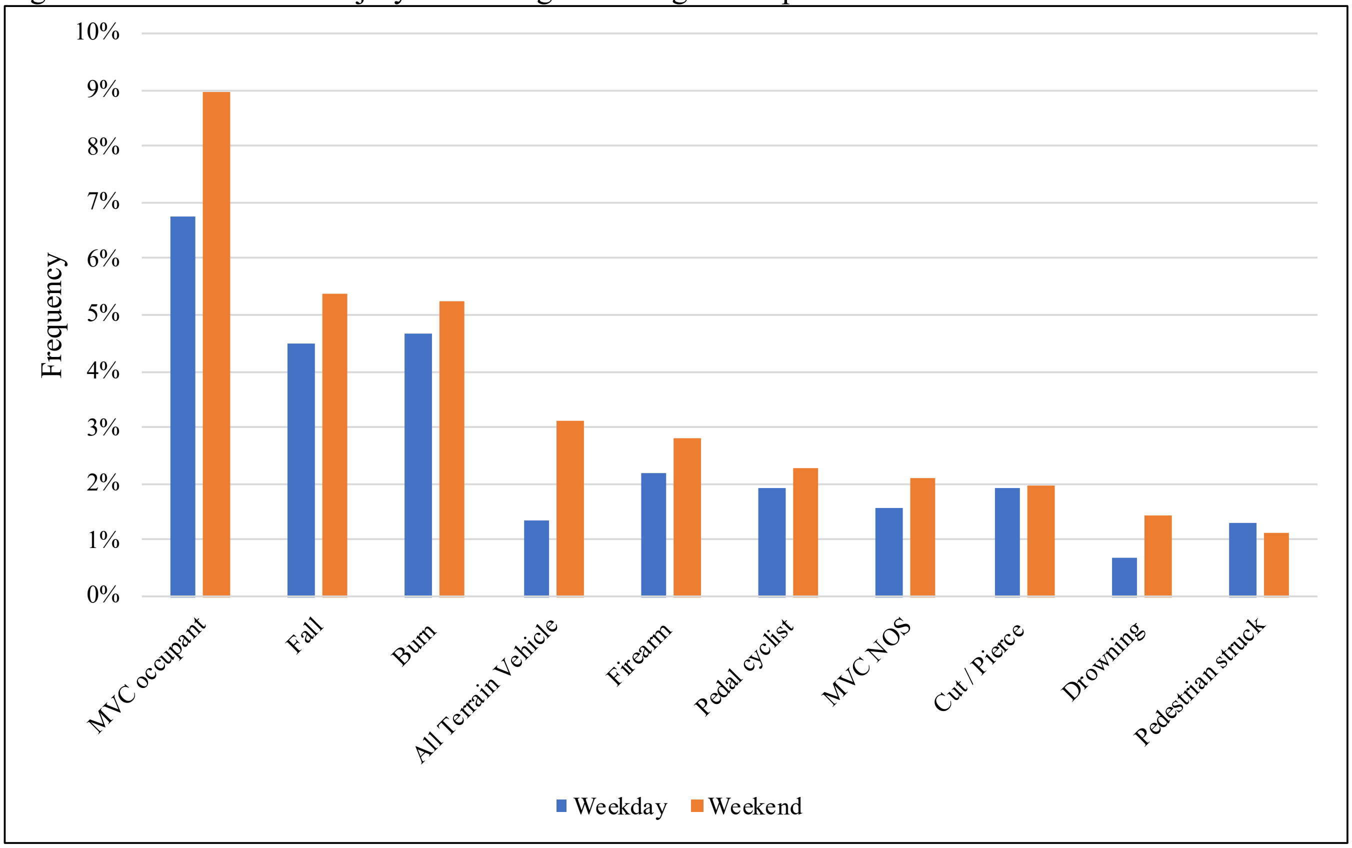
Figures & Tables

Figure 1. Flow Chart Depicting Sample Size Determination




KID: Kids' Inpatient Database

Figure 2. Mechanisms of Injury According to Timing of Hospital Admission




All p-values <0.05 except for Cut/Pierce
MVC: Motor vehicle collision
NOS: Not otherwise specified

Table 1. Study Population Characteristics According to Timing of Hospital Admission

| | Weekend (n = 43,354) | | Weekday (n = 104,953) | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Age (mean, years, SD) | 10.1 (6.3) | | 9.9 (6.4) | | <0.001 |
| Income quartile | | | | | |
| 1st (lowest) | 14,340 | 33.1 | 35,030 | 33.4 | 0.40 |
| 2nd | 10,554 | 24.3 | 25,533 | 24.3 | 0.96 |
| 3rd | 9,914 | 22.9 | 23,927 | 22.8 | 0.81 |
| 4th (highest) | 8,546 | 19.7 | 20,463 | 19.5 | 0.49 |
| Male | 26,085 | 60.2 | 59,080 | 56.3 | <0.001 |
| Primary insurance | | | | | |
| Medicaid | 21,095 | 48.7 | 54,477 | 51.9 | <0.001 |
| Medicare | 91 | 0.2 | 236 | 0.2 | 0.62 |
| No charge | 57 | 0.1 | 120 | 0.1 | 0.49 |
| Other | 2,160 | 5.0 | 5,388 | 5.1 | 0.41 |
| Private | 18,264 | 42.1 | 41,173 | 39.2 | <0.001 |
| Self-pay | 1,687 | 3.9 | 3,559 | 3.4 | <0.001 |
| Race | | | | | |
| Asian or Pacific Islander | 1,301 | 3.0 | 3,173 | 3.0 | 0.84 |
| Black | 7,634 | 17.6 | 19,281 | 18.4 | 0.008 |
| Hispanic | 9,138 | 21.1 | 22,400 | 21.3 | 0.44 |
| Native American | 411 | 1.0 | 1,033 | 1.0 | 0.58 |
| Other | 2,219 | 5.1 | 5,101 | 4.9 | 0.08 |
| White | 22,652 | 52.3 | 53,966 | 51.4 | 0.026 |
| Hospital bedsize | | | | | |
| Small | 4,347 | 10.0 | 10,993 | 10.5 | 0.13 |
| Medium | 8,837 | 20.4 | 22,200 | 21.2 | 0.046 |
| Large | 30,170 | 69.6 | 71,760 | 68.4 | 0.009 |
| Hospital region | | | | | |
| Midwest | 7,907 | 18.2 | 19,648 | 18.7 | 0.36 |
| Northeast | 7,587 | 17.5 | 19,388 | 18.5 | 0.009 |
| South | 16,348 | 37.7 | 37,977 | 36.2 | 0.005 |
| West | 11,512 | 26.6 | 27,940 | 26.6 | 0.88 |
| Season | | | | | |
| Spring | 11,313 | 26.1 | 27,183 | 25.9 | 0.49 |
| Summer | 11,521 | 26.6 | 28,679 | 27.3 | 0.012 |
| Autumn | 11,205 | 25.9 | 26,036 | 24.8 | 0.001 |
| Winter | 9,315 | 21.5 | 23,055 | 22.0 | 0.10 |

| | | | | | |
|---|---|---|---|---|---|
| Injury Severity Score (mean, SD) | 6.7 (9.8) | | 5.4 (8.9) | | <0.001 |
| Admission related to adverse effects | 8,286 | 16.1 | 28,976 | 21.6 | <0.001 |

SD: Standard deviation

Table 2. Injuries Sustained According to Timing of Hospital Admission

| | Weekend (n = 43,354) | | Weekday (n = 104,953) | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Number of diagnoses (mean, SD) | 6.1 (5.1) | | 6.4 (5.2) | | <0.001 |
| Intracranial injury | 7,201 | 16.6 | 14,874 | 14.2 | <0.001 |
| Upper extremity fracture | 6,001 | 13.8 | 12,357 | 11.8 | <0.001 |
| Lower extremity fracture | 5,924 | 13.7 | 12,183 | 11.6 | <0.001 |
| Skull or face fracture | 4,959 | 11.4 | 10,376 | 9.9 | <0.001 |
| Extremity open wound | 3,940 | 9.1 | 9,869 | 9.4 | 0.18 |
| Lung injury | 2,818 | 6.5 | 4,836 | 4.6 | <0.001 |
| Acidosis | 1,516 | 3.5 | 3,337 | 3.2 | 0.016 |
| Traumatic pneumothorax | 1,261 | 2.9 | 2,143 | 2.0 | <0.001 |
| Spleen injury | 1,150 | 2.7 | 2,013 | 1.9 | <0.001 |
| Paralysis | 776 | 1.8 | 2,154 | 2.1 | 0.003 |

SD: Standard deviation

Table 3. Procedures Performed According to Timing of Hospital Admission

| | Weekend (n = 43,354) | | Weekday (n = 104,953) | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Number of procedures (mean, SD) | 1.7 (2.6) | | 1.6 (2.6) | | <0.001 |
| Upper extremity fracture repair | 4,154 | 9.6 | 8,570 | 8.2 | <0.001 |
| Hip or femur fracture repair | 2,864 | 6.6 | 5,450 | 5.2 | <0.001 |
| Lower leg fracture repair | 2,489 | 5.7 | 4,993 | 4.8 | <0.001 |
| Intubation | 1,691 | 3.9 | 3,580 | 3.4 | <0.001 |
| Face or skull fracture repair | 857 | 2.0 | 1,784 | 1.7 | 0.002 |
| Chest tube | 811 | 1.9 | 1,586 | 1.5 | <0.001 |
| Pelvis fracture repair | 363 | 0.8 | 688 | 0.7 | 0.003 |
| Gastrostomy tube | 261 | 0.6 | 621 | 0.6 | 0.82 |
| Tracheostomy | 251 | 0.6 | 514 | 0.5 | 0.07 |
| Intracranial pressure monitor | 217 | 0.5 | 441 | 0.4 | 0.13 |

SD: Standard deviation

Table 4. In-Hospital Complications According to Timing of Hospital Admission

| | Weekend n = 43,354 | | Weekday n = 104,953 | | p-value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Acute kidney injury | 784 | 1.8 | 1,969 | 1.9 | 0.45 |
| Blood transfusion | 1,523 | 3.5 | 3,941 | 3.8 | 0.09 |
| ICU admission | 3,675 | 8.5 | 7,442 | 7.1 | <0.001 |
| In-hospital CFR | 565 | 1.3 | 1,144 | 1.1 | 0.003 |
| In-hospital complication | 2,638 | 6.1 | 7,171 | 6.8 | <0.001 |
| Length of stay (mean, days, SD) | 4.5 (10.4) | | 5.2 (11.9) | | <0.001 |
| Non-home discharge | 5,656 | 13.1 | 14,343 | 13.7 | 0.012 |
| Pneumonia | 1,095 | 2.5 | 2,853 | 2.7 | 0.06 |
| Sepsis | 628 | 1.5 | 1,781 | 1.7 | 0.001 |
| Shock | 859 | 2.0 | 1,822 | 1.7 | 0.005 |
| Urinary tract infection | 656 | 1.5 | 1,959 | 1.9 | <0.001 |

CFR: Case-fatality rate
ICU: Intensive care unit
SD: Standard deviation

Table 5. Logistic Regression Models Assessing Odds of In-Hospital Death or Complications for Weekend as Compared to Weekday Hospital Admission

| | In-hospital death | In-hospital complication | Blood transfusion | ICU admission | Non-home discharge | Pneumonia | Shock | Sepsis | UTI |
|---|---|---|---|---|---|---|---|---|---|
| Unadjusted model | ***1.20 (1.07 - 1.35)*** | ***0.88 (0.84 - 0.93)*** | 0.93 (0.86 - 1.01) | ***1.21 (1.15 - 1.28)*** | ***0.93 (0.89 - 0.97)*** | 0.93 (0.86 - 1.00) | ***1.14 (1.04 - 1.25)*** | ***0.85 (0.77 - 0.94)*** | ***0.81 (0.73 - 0.90)*** |
| Model 1 | ***1.18 (1.06 - 1.33)*** | ***0.89 (0.85 - 0.94)*** | 0.94 (0.87 - 1.01) | ***1.21 (1.15 - 1.27)*** | ***0.94 (0.90 - 0.98)*** | 0.94 (0.87 - 1.02) | ***1.13 (1.03 - 1.24)*** | ***0.87 (0.79 - 0.96)*** | ***0.85 (0.77 - 0.95)*** |
| Model 2 | 1.06 (0.94 - 1.20) | ***0.90 (0.86 - 0.95)*** | ***0.89 (0.83 - 0.96)*** | ***1.12 (1.06 - 1.18)*** | ***0.91 (0.87 - 0.95)*** | 0.95 (0.88 - 1.03) | 1.03 (0.94 - 1.13) | ***0.90 (0.82 - 0.99)*** | ***0.86 (0.77 - 0.95)*** |

Data shown are OR (95% CI)
Bold & italicized: 95% CI does not cross 1.00

Model 1 Patient and hospital characteristics
Model 2 Patient and hospital characteristics + Clinical characteristics

Patient and hospital characteristics: Age, sex, income quartile, primary insurance, race, season, hospital bedsize, hospital region
Clinical characteristics: Injury Severity Score, burn, falls, motor vehicle crash occupant

CI: Confidence interval
ICU: Intensive care unit
OR: Odds ratio
UTI: Urinary tract infection

Supplementary Table I. Diagnosis and Procedure Codes

| Diagnosis/Procedure Description | Code (CCS code or ICD-10 code) |
|---|---|
| **Diagnoses** | |
| Adverse effects of medical care or of medical drugs | *Clinical Classifications Software code*<br><br>2616, 2617 |
| Acidosis | *ICD-10 code*<br><br>E872 |
| Extremity open wound | *Clinical Classifications Software code*<br><br>236 |
| Intracranial injury | *Clinical Classifications Software code*<br><br>233 |
| Lower extremity fracture | *Clinical Classifications Software code*<br><br>230 |
| Lung injury | *ICD-10 code*<br><br>S27301, S27302, S27309, S27321, S27322, S27329, S27331, S27332, S27339, S27391, S27392, S27399 |
| Paralysis | *Clinical Classifications Software code*<br><br>82 |
| Skull or face fracture | *Clinical Classifications Software code*<br><br>228 |
| Spleen injury | *ICD-10 code*<br><br>S3600X, S36020, S36021, S36029-S36032, S36039, S3609X |
| Trauma | *ICD-10 code*<br><br>Any external cause of injury code (V00-Y99) |
| Traumatic pneumothorax | *ICD-10 code*<br><br>S270XX |
| Upper extremity fracture | *Clinical Classifications Software code*<br><br>229 |
| **Mechanisms** | |
| All terrain or other off-road vehicle related | *ICD-10 code*<br><br>V8669XA, V8659XA, V8699XA |
| Burn | *Clinical Classifications Software code*<br><br>240 |
| Cut/pierce related | *Clinical Classifications Software code*<br><br>2601 |
| Drowning | *Clinical Classifications Software code*<br><br>2602 |

| | |
|---|---|
| Fall | *ICD-10 code*<br><br>W01118A, W03XXXA, W091XXA, W1789XA, W130XXA, W16021A, W16532A, W16611A, W16822A, W1802XA, W1809XA |
| Firearm related | *Clinical Classifications Software code*<br><br>2605 |
| Motor vehicle collision (MVC) occupant | *ICD-10 code*<br><br>V400XXA - V699XXA (A codes only); V4950XA, V4988XA, V4752XA, V485XXA, V4940XA, V499XXA, V4988XA, V4959XA, V4950XA, V4940XA, V4949XA, V4960XA, V4900XA, V493XXA, V4352XA, V4762XA, V4353XA, V4363XA, V4702XA, V475XXA, V5949XA |
| MVC not otherwise specified (NOS) | *ICD-10 code*<br><br>V890XXA, V892XXA, V899XXA |
| Pedal cyclist | *ICD-10 code*<br><br>V100XXA - V199XXA (A codes only); V1988XA |
| Pedestrian struck | *ICD-10 code*<br><br>V0310XA, V0929XA, V0300XA, V0319XA, V0920XA |
| **Procedures** | |
| Chest tube | *ICD-10 code*<br><br>0B9N30Z, 0B9N3ZZ, 0B9P30Z, 0B9P3ZZ, 0W9900Z, 0W9930Z, 0W993ZZ, 0W9B00Z, 0W9B30Z, 0W9B3ZZ |
| Face or skull fracture repair | *ICD-10 code*<br><br>0NH, 0NS, 0NW, 0RGC, 0RGD, 0RSC, 0RSD |
| Gastrostomy tube | *ICD-10 code*<br><br>0DH60UZ, 0DH63UZ, 0DH64UZ |
| Hip or femur fracture repair | *Clinical Classifications Software code*<br><br>146 |
| Intracranial pressure monitor | *ICD-10 code*<br><br>4A003BD, 4A007BD, 4A008BD, 4A103BD, 4A107BD, 4A108BD |
| Intubation | *ICD-10 code*<br><br>0BH17EZ |
| Lower leg fracture repair | *Clinical Classifications Software code*<br><br>147 |
| Pelvis fracture repair | *ICD-10 code*<br><br>0QH1-5, 0QHS, 0QP0-3, 0QPS, 0QS0-5, 0QSS, 0QW0-5, 0QWS, 0SS3, 0SS5-8 |
| Tracheostomy | *Clinical Classifications Software code*<br><br>34 |
| Upper extremity fracture repair | *ICD-10 code*<br><br>0PH5-9, 0PHB-V, 0PS5-9, 0PSB-V, 0PW5-9, 0PWB-V, 0RSL-X |

| Complications | |
|---|---|
| Acute kidney injury | *Clinical Classifications Software code*<br><br>157 |
| Blood transfusion | *Clinical Classifications Software code*<br><br>222 |
| In-hospital complication | Please see associated excel file<br>“Appendix complication codes revised 20210409” |
| ICU admission | *ICD-10 code*<br><br>Arterial line - 4A133B1, 4A130B1<br><br>Central venous catheter – 05HN03Z, 05HN0DZ, 05HN33Z, 05HN3DZ, 05HN43Z, 05HN4DZ, 05HM03Z, 05HM0DZ, 05HM33Z, 05HM3DZ, 05HM43Z, 05HM4DZ, 05H603Z, 05H60DZ, 05H633Z, 05H63DZ, 05H643Z, 05H64DZ, 05H503Z, 05H50DZ, 05H533Z, 05H53DZ, 05H543Z, 05H54DZ, 06HN03Z, 06HN0DZ, 06HN33Z, 06HN3DZ, 06HN43Z, 06HN4DZ, 06HM03Z, 06HM0DZ, 06HM33Z, 06HM3DZ, 06HM43Z, 06HM4DZ<br><br>ECMO - 5A1522F, 5A1522G, 5A1522H, 5A05121, 5A0512C, 5A05221, 5A0522C<br><br>Ventilator use - 5A1935Z, 5A1945Z, 5A1955Z |
| Pneumonia | *Clinical Classifications Software code*<br><br>122 |
| Sepsis | *Clinical Classifications Software code*<br><br>122<br><br>*ICD-10 code*<br><br>T8144XA, R6521 |
| Shock | *ICD-10 code*<br><br>R570, R571, R578, R579, R6521, T782XXA, T794XXA, T8110XA, T8111XA, T8112XA, T8119XA, T882XXA |
| Urinary tract infection | *Clinical Classifications Software code*<br><br>159 |

CCS: Clinical Classifications Software
ECMO: Extracorporeal membrane oxygenation
ICD-10: International Classification of Diseases, 10th Revision
ICU: Intensive care unit
MVC: Motor vehicle collision
NOS: Not otherwise specified