Is There a "Weekend Effect" in Emergency General Surgery?

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Author contributions

DM designed the study, performed the initial data analyses, and drafted the manuscript. MCA updated the analysis. MCA, ARD, JH, AH, and AS contributed to the study design, data interpretation, and made critical revisions to the manuscript.

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Key words

Weekend effect; emergency general surgery; acute care surgery.

Background: Weekend admission is associated with increased mortality across a range of patient populations and healthcare systems. The aim of this study was to determine whether weekend admission is independently associated with serious adverse events (SAE), in-hospital mortality, or failure to rescue (FTR) in emergency general surgery (EGS).

Methods: An observational study using the National Inpatient Sample (NIS) 2012-2013; the largest all-payer inpatient database in the United States, which represents a 20% stratified sample of hospital discharges. The inclusion criteria were all inpatients with a primary EGS diagnosis. Outcomes were SAE, in-hospital mortality, and FTR (in-hospital mortality in the population of patients that developed an SAE). Logistic multivariable regression models were used to adjust for patient- (age, sex, race, payer status, Charlson comorbidity index) and hospital-level (trauma designation, hospital bed size) characteristics.

Results: There were 1,344,828 individual patient records (6.7 million weighted admissions). The overall rate of SAE was 15.1% (15.1% weekend, 14.9% weekday, $p<0.001$), FTR 5.9% (6.2% weekend, 5.9% weekday, $p=0.010$), and in-hospital mortality 1.4% (1.5% weekend, 1.3% weekday, $p<0.001$). Within logistic regression models, weekend admission was an independent risk factor for development of SAE (aOR 1.08, 1.07-1.09), FTR (1.05, 1.01-1.10), and in-hospital mortality (1.14, 1.10-1.18).

Conclusion: This study found evidence that outcomes coded in an administrative dataset are marginally worse for EGS patients admitted at weekends. This justifies further work using clinical datasets that can be used to better control for differences in case mix.

1. Introduction

A number of studies have reported that patients admitted at the weekend have worse outcomes than those admitted during the week[1, 2, 3, 4]. This "weekend effect" has been demonstrated across a range of different healthcare systems and clinical settings[4]. Observational studies have identified such a phenomenon in Australia, the United States, Asia, the United Kingdom, and in continental Europe[4, 5, 6]. In the United States, it has been reported across many groups of patients with urgent presentations, including acute coronary syndrome[7], intra-cerebral haemorrhage[8], pulmonary embolism[9], and lower limb vascular emergencies[10].

Only two US studies have examined weekend outcomes in the setting of emergency general surgery (EGS), both of which were based on hospital discharge data from Florida[11, 12]. They showed that weekend admission is an independent risk factor for post-operative complications, higher length of stay, and increased cost[12]. Importantly, neither study reported an association between weekend admission and mortality[11, 12], which is consistent with the findings of a third EGS study based on administrative data from the UK[13]. However, no previous study has asked whether or not there is a weekend effect for EGS patients across the US.

A number of explanations have been suggested for the weekend effects identified by previous studies. These include differences in case mix[14, 15], coding artifacts[16], and reduced service levels provided to patients at weekends[4]. If differences in staffing and hospital resources contributed to the weekend effect, national data might be expected to show higher rates of failure to rescue (FTR) for patients admitted at weekends. Failure to rescue has been defined as "death after a treatable complication"[17]. It has been widely adopted as a quality metric and is thought to reflect the ability of healthcare providers to respond effectively to complications[17, 18].

In this study, we examined a national database of US hospital discharges for evidence of a weekend effect in EGS. Our aim was to test the finding from Florida that EGS outcomes are potentially compromised at weekends[11, 12].

2. Methods

2.1 Data source

The National Inpatient Sample (NIS) is the largest all-payer inpatient database in the US and maintained by the Healthcare Cost and Utillization Project (HCUP). This study used cases between 2012 and 2013 when the NIS captured a 20% stratified sample of hospital discharges from all US hospitals. There are 5-8 million inpatient admissions within the NIS each year, which can be weighted to provide estimates for approximately 35 million hospital admissions.

2.2 Inclusion and exclusion criteria

All patients were extracted that had a primary EGS diagnosis, as per the standardized definition outlined by the American Association for the Surgery of Trauma (AAST)[19]. These cases were identified using 621 distinct ICD-9-CM diagnosis codes that have previously been published[20]. Patients transferred between institutions were excluded to ensure that each record represented a single inpatient episode.

2.3 Variables and outcomes

Extracted patient-level characteristics were age, sex, race, payment source, admission source, median household income, disease severity, and weekend admission. Charlson comorbidity indices (CCI) were calculated from International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes using the Stata ICDPIC command[21]. CCI is the most commonly used comorbidity score for secondary analysis of administrative data and has been shown to predict mortality in EGS[22]. The threshold for household income quartiles varies by year and is determine by the NIS using residential zip codes. Disease severity is also provided by the NIS according to estimated risk of mortality along a four-point scale using All Patient Refined Diagnosis Related

Groups (APRDRGs). The hospital-level characteristics were geographic region, hospital bed size, rural location, and teaching status.

The outcomes were SAEs, FTR, and total in-hospital mortality. Significant adverse events were selected for consistency with previous studies on EGS patients in the NIS that incorporated complications[20]: pneumonia, pulmonary embolus (PE), renal failure, urinary tract infection (UTI), cerebrovascular accident (CVA), myocardial infarction (MI), cardiac arrest, acute respiratory distress syndrome (ARDS), sepsis, and septic shock. These diagnoses were discounted if coded within the NIS as present on admission.

Failure to rescue was defined as the odds of in-hospital mortality following a SAE: [mortality amongst patients with SAE]/[all patients with SAE].

2.4 Statistical analysis

Chi-squared tests were used to compare categorical variables and t-tests for continuous variables. Multivariable logistic regression models were used to adjust odds of SAE, FTR, and mortality for patient- and hospital-level factors. The covariates were determined *a priori* as age, sex, race, payer status, CCI, median household income, and hospital bed size. NIS discharge weights provided by HCUP were used to account for clustering of patients within hospitals and to determine nationally representative estimates. All results are presented as national estimates based on these discharge rates.

All analyses were conducted using Stata 13.0 (College Station, TX, USA) with an *a priori* threshold for statistical significance set at two-tailed $p<0.05$. The protocol was approved by our institutional review board.

3. Results

There were 1,344,828 individual patient records, which permitted estimates for 6.7 million weighted admissions. The mean age was 53.8. Table 1 summarizes the demographic characteristics of the cohort and shows that there were a number of significant differences between the patients admitted at weekends and during the week. Table 2 further illustrates differences in case mix by showing the proportion of patients coded as having one of the most frequently recorded EGS diagnosis: acute pancreatitis (25.8%), cellulitis and abscess (25.1%), diverticulitis of colon (20.4%), unspecified intestinal obstruction (15.0%), and hemorrhage of gastrointestinal tract (13.7%). Table 3 shows the distribution of SAEs between the two patient groups. Tables 4 and 5 show the unadjusted and adjusted outcomes by day of admission respectively.

3.1 Significant adverse events

The overall rate of SAE was 15.1%, although a slightly higher proportion was observed in patients admitted at weekends (15.1% versus 14.9% weekday, $p<0.001$, Chi squared test). Within logistic regression models, weekend admission was an independent risk factor for development of SAE (adjusted odds ratio [aOR] 1.08, 95% confidence interval [95% CI] 1.07-1.09).

3.2 Failure to rescue

The overall rate of FTR at 5.9% and this was estimated to occur more commonly at weekends than on weekdays (6.2% versus 5.9%, $p=0.010$, Chi squared test). Weekend admission was also an independent risk factor for FTR in a multivariable logistic regression model (aOR 1.05, 95% CI 1.01-1.10).

3.3 Total inpatient mortality

The in-hospital mortality rate for the whole cohort was 1.4%. Weekend admission was associated with increased mortality in both the crude (1.5% versus 1.3%, $p<0.001$, Chi squared test) and adjusted analysis (aOR 1.14, 95% CI 1.10-1.18).

4. Discussion

The findings of this national observational study are consistent with a small but appreciable weekend effect for EGS patients in US hospitals. It found evidence that SAEs, FTR, and overall inpatient mortality are higher at weekends. This study was therefore unable to refute the findings of two previous reports from Florida that found worse weekend outcomes in terms of post-operative complications, higher length of stay, and increased cost[11, 12]. However, the absolute proportions of SAEs, FTR, and in-hospital mortality in this study suggests that any weekend effect for EGS patients in the US is smaller than has been reported in other populations.

4.1 The weekend effect

Three distinct explanations have been proposed to explain the weekend effect: differences in case mix, data quality, and service provision. A number of commentaries have suggested that patient case mix varies between weekdays and weekends[1, 14, 23]. There is evidence to suggest that fewer patients are admitted for emergencies at weekends than during the week[1, 24], possibly because patients are less likely to seek hospital care outside of normal working hours. However, the threshold for hospital admission exercised by healthcare providers might also vary throughout the week. Meacock *et al* found that the threshold for hospital admission appears to be lower on weekdays[14]. In their analysis, fewer patients were admitted as emergencies at weekends. Those that *were* admitted were sicker than on weekdays and more likely to die. Importantly, mortality was higher at weekends for the subset of patients that were admitted to hospital but not the *overall* cohort of patients presenting to Emergency Departments. However, many studies have reported weekend effects despite extensive attempts to account for differences in case mix [1, 2, 3, 4].

It is also possible that data entry processes vary for patients admitted at weekends. Li and Rothwell used data from a prospective cohort study to validate an administrative dataset that had been reported to show a weekend effect amongst patients with acute stroke[16]. They found that more than a third of

patients recorded as suffering an "acute stroke" were incorrectly coded. Importantly, many patients admitted during the week for acute stroke were actually elective admissions for tests as follow-up for a *previous* stroke. The patients in this group were unsurprisingly less likely to die. The data artifact explanation is also supported by the fact that studies reporting data from clinical registries have been unable to detect a weekend effect across a number of healthcare settings[16, 25].

Finally, there remains the possibility that the weekend effect is truly a feature of worse care provided to patients outside of normal working hours. There is a widespread perception that emergency care varies in some hospitals across the week[26]. Evidence from observational studies suggests that patients admitted at weekends may receive less attention from the most senior doctors[27] and are less likely to receive optimal care[28]. Similarly, the two previous EGS studies in Florida found that those hospitals in which a weekend effect was not evident were more likely to exhibit characteristics that were suggestive of better resources, e.g. use of a comprehensive electronic medical record[11]. Our finding that weekend admission was an independent predictor for FTR is consistent with the hypothesis that such patients may encounter sub-optimal inpatient care.

4.2 Strengths and limitations

The main strength of this study is that it involved a comprehensive analysis of the largest available all-payer dataset, which was capable of projecting estimates for all EGS patients across the US. This permitted us to test for a weekend effect on a national scale and extend previous studies[11, 12] that were limited to a single state.

There were however two important limitations to our approach. First, FTR was measured indirectly as it could not be established whether or not any given complication was "treatable" with certainty from an administrative dataset. For example, treatment might have been withdrawn as a result of an appropriate clinical decision with full agreement of the patient and his/her relatives.

Although such a patient might have been managed optimally, their outcome would be recorded as FTR. Such details are not readily available without access to the medical charts and electronic patient record.

Second, large datasets will often provide "significant" p-values using statistical tools designed for hypothesis testing[29]. It is important to note that the effect sizes in this study were small and these should be interpreted carefully regardless of the very significant p-values.

Finally, administrative databases such as the NIS are potentially compromised by missing data and miscoding[16, 26]. In this study, two of the three key variables (weekend admission and in-hospital mortality) were almost universally recorded. It is however unknown whether SAEs are comprehensively recorded in the NIS. This is an unquantifiable limitation and might have had an impact on FTR rates, which would be influenced by under- or over-coding of SAEs. However, the fact that all three measures (i.e. SAEs, FTR, and in-hospital mortality) were elevated at weekends does however lend some support to the possibility that these findings reflect a weekend effect in the EGS population.

Nevertheless, it is unlikely that the NIS provided sufficient data to adequately account for confounding[4, 15, 23]. We found that there were obvious differences in case mix between the two patient groups. It is likely that the regression models were unable to adequately account for confounding. Although our findings are *consistent* with a small weekend effect, they should only be considered as a signal to stimulate further investigation.

4.3 Conclusion

This observational study found a small increase in SAEs, FTR, and in-hospital mortality for EGS patients admitted to US hospitals at weekends. This might be explained by differences in case mix, clinical coding, and/or healthcare services available to patients presenting outside of normal working hours. Further work using more granular datasets is necessary to explore this finding further.

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