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The relationship between emergency department volume and patient complexity

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ABSTRACT

Introduction: Forecasting emergency department (ED) visits is a well-studied topic. The importance of understanding the complexity of patients along with the days and times of varying patient volumes is critical for planning medical and ancillary staffing. Though multiple studies stratify their results based on severity of disease, severity was determined by triage status. The goal of this study was to utilize a novel method to evaluate the correlation between daily emergency department patient complexity, based on Current Procedure Terminology (CPT) code, and day of the week.

Methods: This was a retrospective study of subjects presenting to the ED between January 1, 2010 and December 31, 2015. We identified the correlation between subjects with each CPT code who were evaluated on a specific day of the week and evaluated the day before, the day of and the day after a legal holiday.

Results: During the study period 312,550 (48% male and 336,348 (52% female subjects were identified. No correlation between daily ED patient complexity, based on CPT code, and day of the week ($p = 0.75$) or any legal holidays were identified. Individual significant differences were noted among day of the week and particular CPT code as well as legal holiday and particular CPT code with no appreciable trend or pattern.

Conclusions: There was no correlation between daily ED patient complexity based on CPT code and day of the week or daily ED patient acuity and legal holiday. In light of these data, emergency department staffing and resource allocation patterns may need to be revisited.

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1. Introduction

Forecasting emergency department (ED) visits is a well-studied topic and one with obvious practical implications. As American EDs are inundated with increasing patient volumes, the importance of understanding the complexity of patients, along with the days and times of varying patient volumes, is critical for planning medical and ancillary staffing. The American College of Emergency Physicians has referred to the problem of overcrowding in the ED as a “crisis.” [1] Though the causes of this predicament are multi-factorial and include issues such as boarding inpatients in the ED, staffing may also significantly affect throughput in the ED. Multiple studies reviewing volume based on such factors as day of the week, proximity to holiday, air temperature, pollution index, and others have been published.

Many investigators have attempted to forecast ED visits. In a study in Singapore, Yan Sun et al. used time series analysis to predict ED workload based on temporal factors as well as weather and ambient air quality. This data was stratified based on a three-pronged acuity scale determined upon presentation to the ED. They concluded that patient

volume in the ED is a predictable variable by time though not by temperature. They further determined different patterns based on varying levels of acuity. Specifically, P1 (most acute) arrivals were not temporally related while P2 and P3 (less severe) arrivals were more highly correlated with day of the week, month of the year, and holidays [2]. Another Singapore study by Ong et al. similarly determined that patterns of patient volume based on temporal factors are highly predictable. They have adjusted their staffing accordingly [3]. An earlier Australian study by Richardson et al. designed primarily to determine the relationship between ED activity and triage category concluded that there is no correlation between these two elements. However, like other studies, they did note a temporal pattern to ED volume in general [4].

A 2005 UK study by W.G. Atherton et al. studied admissions to a trauma unit based on temperatures, sunshine hours, day of the week and month of the year, and determined correlation of trauma admissions to both weather and temporal factors. According to this study, Monday was found to be the busiest day for all adult admissions [5].

An Israeli study by Rotstein et al. used a time series analysis over 3 years to predict patient volume based on day of the week, month, and type of day (holiday vs. regular day). They noted a lower patient volume on holidays [6]. Tandberg et al. similarly used time series analysis to provide accurate ED volume forecasts in an American ED. In this study, acuity was also determined and stratified. The authors

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concluded that there are predictable temporal variations that can practically affect staffing decisions. Unlike some of the above studies, they determined that patient acuity monitoring does not contribute useful information for staffing purposes [7]. McCarthy et al. employed an extensive list of variables in predicting ED volume. These include ones seen frequently in other studies such as temporal, seasonal, climatic, and triage variables but also include novel variables such as patient age, gender, mode of arrival, ambulance diversion status, and insurance status. The most important predictor of ED volume was determined to be hour of day. Additionally, there was found to be an increase of patient visits on Mondays, a trend seen in other studies as well [8].

An Australian study by Champion et al., compares statistical models for forecasting number of patients by month in a regional ED. They determined little variation by month and found that the various statistical models employed yielded similar results [9]. Jones et al. also compares multiple statistical models for best accuracy in determining ED visits based on seasonal and weekly variation. Much like the above studies cited, they found seasonal and weekly patterns of patient volume. For example, there was a direct correlation between maximum daily temperatures and daily ED volume. They also determined that more advanced statistical analysis tools did not improve prediction of this pattern as compared to standard statistical models [10]. Schweiger et al. reports a diurnal variation in busiest times in the ED during the day with the highest volume, predictably, later in the day. Both statistical models that they employed served to forecast these variations well.

Multiple studies have attempted to identify severity of disease in addition to hourly and daily patient volumes. The thought process behind this approach is that variation in volumes may be meaningless if the complexity is all very high or low. For example, a day with lower patient volumes but much higher complexities may require more staffing due to greater time demand and resource utilization, as opposed to a day with higher patient volumes but all with much lower patient complexities. Although these studies stratified their results based on severity of disease, severity was determined by triage status. There are no studies to date that correlate ED resource utilization and actual severity of disease determined after the patient has been evaluated and has had a disposition established. The Current Procedure Terminology (CPT) is a code set used to standardize the description of medical services rendered based on complexity. Meaning, a low 99281 CPT code would correspond to a visit for an uncomplicated insect bite while a more complex 99285 corresponds to visits for such entities as severe burns or chest pain, requiring more extensive diagnostic and therapeutic interventions. Upon disposition, CPT codes are assigned to each patient's chart and designating the complexity. Therefore, CPT codes are a precise and standardized way to classify patient acuity.

The goal of this study was to evaluate the correlation between daily ED patient complexity, based on CPT code, and day of the week. Secondary goals include determining the correlation between daily emergency department patient acuity and legal holidays.

2. Methods

2.1. Study design

This was a retrospective, observational study of all patients presenting to the ED between January 1, 2010 and December 31, 2015. This study was approved by the Institutional Review Board at our institution.

2.2. Study setting and population

The study was conducted at XXXXX, a 700-bed, tertiary-care teaching hospital in XXXXX, XX. The ED has separate adult and pediatric departments.

Information was extracted from a computer database. All adult patients over 18 years of age were included. Patients were de-identified and assigned a study number. The CPT code for each patient visit,

along with demographic data, including age and sex, was recorded. ED CPT codes, in order of increasing patient complexity include 99281, 99282, 99283, 99284, 99285. Critical care CPT codes are time-based and include 99291 and 99292. At our institution, CPT coding is performed entirely by LogixHealth (Bedford, MA), an independent coding and billing service. LogixHealth utilizes proprietary software to ensure accuracy and consistency in coding charts.

2.3. Outcome measures

The database was evaluated to determine the number of subjects with each CPT code who were;

[1] evaluated on a specific day of the week and [2] evaluated the day before, the day of and the day after a legal holiday. Labor Day, Memorial Day and Thanksgiving all occur on the same day of the week each year. Therefore, the average number of visits over the entire study period was analyzed for these holidays. Since Thanksgiving is the only holiday which routinely occurs on a Thursday, the Monday after Thanksgiving was also analyzed. As Christmas, New Years and Independence Day all occur on different days of the week, each year was analyzed individually.

2.4. Data analysis

Summary statistics for demographic characteristics are presented for all patients. Categorical data is summarized using frequency counts and percentages. Continuous variables are summarized by descriptive statistics, including mean and standard deviation.

The primary objective of the study was to evaluate the association between day of the week and ED patient complexity. The association of ED patient complexity with legal holidays will be also explored. The Chi-square test was used to evaluate the general association of each of the independent variables and ED patient complexity and as a test of heterogeneity among multiple proportions.

All statistical tests are two-sided and conducted at the 0.05 level of significance. Data analyses was conducted using SAS (Statistical Analysis System) software Version 9.3.

3. Results

During the study period between January 1, 2010 and December 31, 2015, 644,532 adult patient visits over 18 years of age were identified. All subjects were included in the final analysis. 310,209 (48%) were male and 334,323 (52%) were female. The mean age was 49.40 (standard deviation, 19.80).

Table 1 displays the total patient volumes per day over the study period as well as the distribution of CPT codes on each day.

Days of the week with the highest patient volumes were Friday then Saturday. Days with the lowest patient volumes were Monday then Sunday. No statistically significant difference was noted between patient volume and day of the week. The trends in CPT codes based on day of the week can also be seen in Fig. 1.

Days of the week that demonstrated a significant difference in CPT codes are listed in Table 2. Legal holidays that demonstrated a significant difference in CPT codes are listed in Table 3. In these tables, CPT codes corresponding to each individual day are compared to the same CPT codes corresponding to a composite of all other days of the week. *P* values in each table are only listed for significant differences. All other comparisons were not statistically significant. Since documentation of CPT codes 99281 and 99292 were so small as to approach zero, these codes were not significant.

4. Discussion

This 6-year retrospective study evaluated the relationship between patient volume, complexity, and the temporal factors of days of the

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