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Emergency department imaging: are weather and calendar factors associated with imaging volume?

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AIM: To identify weather and calendar factors that would enable prediction of daily emergency department (ED) imaging volume to aid appropriate scheduling of imaging resources for efficient ED function.

MATERIALS AND METHODS: Daily ED triage and imaging volumes for radiography, computed tomography (CT), and ultrasound were obtained from hospital databases for the period between January 2011 and December 2013 at a large tertiary urban hospital with a Level II trauma centre. These data were tabulated alongside daily weather conditions (temperature, wind and precipitation), day of week, season, and holidays. Multivariate analysis was performed. Pearson correlations were used to measure the association between number of imaging studies performed and ED triage volume.

RESULTS: For every additional 50 triaged patients, the odds of having high (imaging volume $\geq$90th percentile) radiography, CT, and ultrasound volume increased by 4.3 times ($p<0.001$), 1.5 times ($p=0.02$), and 1.4 times ($p=0.02$), respectively. Tuesday was an independent predictor of high radiography volume (odds ratio=2.8) and Monday was an independent predictor of high CT volume (odds ratio=3.0). Weekday status was an independent factor increasing the odds of a high US volume compared to Saturday (odds ratios ranging from 5.6–9.8). Weather factors and other calendar variables were not independent predictors of high imaging volume. Using Pearson correlations, ED triage volume correlated with number of radiographs, CT, and ultrasound examinations with $r=0.73$, 0.37, and 0.41, respectively ($p<0.0001$).

CONCLUSION: As ED triage volume was found to be the only factor associated with imaging volume for all techniques, analysis of predictors of ED triage volumes at a particular healthcare facility would be useful to determine imaging needs. Although calendar and weather factors were found to be minor or non-significant independent predictors of ED imaging utilisation, these may be important in influencing the actual number of ED triages.

Introduction

The rapid availability of imaging is an essential component of emergency department (ED) patient evaluation. Frontline ED clinicians rely on imaging tests to provide specific and actionable diagnoses or to provide reassurance for safe discharge.[1–3] Timely imaging requires studies to be performed promptly after requested by the ED, and interpreted soon thereafter by the radiologist. The ability to predict daily ED imaging volume would be helpful to appropriately schedule imaging resources (i.e., imaging equipment, technologists, and radiologists). The aim of the present study was to identify the effect of ED triage volume,

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weather, season, holidays, and day of the week on the daily imaging volume.

Materials and methods

Setting

Institutional review board (IRB) approval was obtained for this retrospective Health Insurance Portability and Accountability Act (HIPAA)-compliant study conducted at a single adult ED within a large urban tertiary-care medical centre with a Level II trauma centre. The healthcare system is the dominant healthcare provider in the catchment area with 142 sites including three urgent-care clinics. The urgent care clinics see patients nightly until midnight and on holidays and weekends from 9.00 am to 5.00 pm. Trainees (interns and residents) were present in the ED, but all imaging requests were co-signed by attending ED faculty. The average annual ED triage volume is nearly 162,000 patients. Technician staffing of the ED computed tomography (CT) and radiography facilities was constant throughout the day, while ultrasound (US) technician staffing varied between one and six (six during the day shift, 2–3 during the evening shift, and 1–2 on weekends and overnight shifts).

Data collection

Daily (measured from 7.00 am through 6.59 am the following day) ED triage volumes from 1 January 2011 through 31 December 2013 were obtained from the hospital billing database. Daily numbers of all radiography, CT, US, and imaging studies performed in the ED during the same period were also extracted. During the study period, these techniques were available 24-hours a day, 7 days per week.

Daily weather conditions, including temperature, wind speed (mph), and amount (inches), and type of precipitation (snow or rain), were obtained from the Weather Underground website (http://www.wunderground.com). LaGuardia airport weather station data were used as it is the closest data collection centre to the catchment area. An "extreme weather" day was defined as a day when the temperature was $<0^{\circ}C$ or $>32.2^{\circ}C$, as has been defined elsewhere.[4,5] For each day, day of the week, season, and holiday status was also recorded. Seasons were defined as follows: winter from 1 December through 28/29 February, spring from 1 March through 31 May, summer from 1 June through 31 August, and autumn from 1 September through 30 November. Hospital holidays were defined as New Year's Day, Martin Luther King Day, Presidents' Day, Memorial Day, Independence Day, Labor Day, Thanksgiving, and Christmas.

Statistical analysis

High imaging volume days for a given technique was defined as daily imaging volume of the technique greater than the 90th percentile of the volume for all days during the study; the days with volume $\leq 90^{th}$ percentile were categorised as non-high imaging volume days for that technique. Bivariate associations were performed using Student's *t*-tests for continuous variables and chi-squared tests for categorical variables. Bivariate analyses were performed for the following parameters: ED triage volume, day of the week, season, holidays, presence of precipitation, amount of precipitation, maximum wind speed, extreme temperature, temperature deviation from $15.6^{\circ}C$, daily maximum temperature, daily minimum temperature, daily average temperature, day after extreme weather, and day after holiday.

Parsimonious logistic regression models with dichotomous outcomes of having high imaging volume for each technique were constructed using manual backward selection. Variables with $p<0.1$ on bivariate associations were input into the model, with the final model only containing variables with $p<0.05$. Patient volume was grouped into units of 50 in order to provide more utilisable odds ratios. Pearson correlations were used to test the association between the number of imaging studies performed and ED triage volume. All statistical analyses were performed using Stata v. 13.1 (StataCorp, College Station, TX, USA).

Results

There were 485,693 ED patients that underwent triage and 305,334 imaging studies (203,076 radiography, 66,268 CT, and 30,990 US examinations) performed during the 3-year study period. Patient age (mean±standard deviation) was 34.7±24.9 (range: newborn to 107 years). There were (mean±SD) 443±49.5 (range 227–597) episodes of patient triage, 185±25 (range 89–262) radiographs, 60.5±9.8 (range 21–93) CT examinations, and 28.3±7.3 (range 7–57) US examinations per day. Fig 1a displays the trends in daily ED patient volume and ED imaging volume. Fig 1b displays the average number of ED patients triaged and average total and technique-specific ED imaging volume stratified by day of the week.

During the 1,096 days surveyed, there were 156.6 weeks, 24 holidays, 383 days with rain only, and 70 days with snow (with or without concurrent rain). Mean precipitation was 0.13±0.39 inches per day (range 0–6.6 inches). Mean maximum wind speed was 18±5.7 mph (range 7–56 mph). There were 188 days with extreme temperatures. The mean daily average temperature was $13.9\pm9.4^{\circ}C$ (range $8.9–34.4^{\circ}C$). Maximum temperature during the time period was $39.4^{\circ}C$ and the minimum temperature was $-12.8^{\circ}C$.

Criteria for a high ED imaging volume day were days with >217 radiography, 73 CT, or 37 US examinations. High ED triage volume was defined as >506 episodes of patient triage per day. Results from the bivariate analyses are summarised in Table 1. Compared to days without high radiography volume, days with high radiography volume had higher daily triage; a higher proportion of Mondays, Tuesdays, and Wednesdays; a higher proportion of days in winter and spring; a lower incidence of days with precipitation; a lower precipitation volume; and a higher deviation from $15.6^{\circ}C$. Compared to days without high CT volume, days with high CT volume had higher daily triage; a higher proportion of Mondays, Tuesdays and Fridays; and lower

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