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## Original Contribution

# A comparison of call volumes before, during, and after Hurricane Harvey

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## ABSTRACT

**Background:** There is currently minimal data regarding the demand placed on Emergency Medical Services in the wake of hurricanes and other natural disasters. This retrospective review provides an opportunity to analyze call volumes to EMS and their distribution before, during, and after Hurricane Harvey in one area on the Texas Gulf Coast.

**Objectives:** Call volumes from Galveston Area Ambulance Authority were reviewed to provide insights for allocation of resources during natural disasters, identifying weaknesses in the current EMS system, and recommending proactive changes for future disasters.

**Methods:** This study was conducted based on data gathered from the Galveston Area Ambulance Authority which records the call volumes to EMS as well as the paramedics' primary impression of the patients. An analysis of variance (ANOVA) was used to calculate the differences in mean number of calls among the selected days for the periods before, during, and after the hurricane. Also, a paired *t*-test was used to calculate the difference in means for calls per day and the number calls during the peak days. Statistical significance was set at  $P \leq 0.05$  with a 95% confidence interval.

**Results:** The 6 days prior to the storm had an average of  $48 \pm 6$  calls, the 6 days during the storm had an average of  $50 \pm 15$  calls, and the 6 days after the storm had an average of  $49 \pm 14$  calls ( $p = 0.95$ ). The peak number of calls between August 19–September 5 occurred the last 2 days of the storm, into the first 2 days after the storm. The average call volume for these four days was  $65 \pm 3$  calls compared to the average number of calls for the total 18 days which was  $49 \pm 12$  calls ( $p = 0.008$ ). During the peak days, there were large percentages of calls due to: injury, general pain, respiratory distress, chest pain, and generalized weakness.

**Conclusions:** EMS and emergency departments can expect peak volumes in the last days of a natural disaster as well as the first few days after the event with increases in injuries, general pain, respiratory distress, chest pain, and generalized weakness. EMS education, proper hospital staffing, and increased telemedicine/community paramedicine usage presents opportunities to increase efficiency in community healthcare during natural disasters.

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## 1. Introduction

Emergency Medical Services play a vital role in the healthcare of a community. Without EMS, many of residents would be unable to access prompt evaluation and transport to emergency care. The coordination of on-duty EMTs, in-service ambulances, and proper staffing of emergency departments is normally within an acceptable range of efficiency. However, the introduction of a natural disaster often causes the emergency system to be stressed beyond traditional limits. By studying the effects of natural disasters such as hurricanes, weaknesses in the existing system can be identified and improvements made which will provide better care for victims of future disasters. In 2017 there were approximately 17 named

storms, including 10 hurricanes and 6 major hurricanes [7]. Those impacting Texas included Tropical Storm Cindy, which occurred June 20–23, and Hurricane Harvey, which occurred August 17–September 1 [6]. These 17 storms resulted in a combined 438 fatalities with 82 fatalities from Hurricane Harvey alone. Hurricane Harvey is considered one of the largest recent natural disasters in the U.S. as it was the first category 4 hurricane to hit Texas since 1961 and the first major hurricane (meaning category 3 or greater) to strike the U.S. since 2005. It is ranked as the 17th strongest storm to make landfall with peak wind gusts of 150 MPH, peak storm surge of 12.5 ft, and progression from a tropical depression to major hurricane in just 40 h. Houston, Texas also received >60 in. of rain which led to unprecedented local and regional flooding [7]. Given these devastating facts, it is crucial to study and understand the effects of these natural disasters to be better prepared and equipped to provide efficient medical care in the community. It is an important note that the community of Galveston

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was given a voluntary evacuation for residents, and given its history of catastrophic fallout from hurricanes, it is reasonable to assume that some members of the community evacuated. According to an article by Jung, an EMT in Galveston, higher risk residents such as nursing home residents were evacuated prior to the storm [5]. By using Galveston County as a model, this study provides insight into how one area of the gulf coast was impacted by Hurricane Harvey and how this information can be translated to create effective strategies in the wake of future natural disasters.

## 2. Methods

The Galveston Area Ambulance Authority's record of calls to EMS was reviewed. The data collected includes total calls for 6 days prior to landfall, 6 days during its course affecting Texas, and 6 days after the storm. These data periods were compared with the number of calls from 2015 and 2016 to account for any typical changes in call volumes during those times of year. This data provides insight as to what to expect prior to, during, and after a natural disaster. The peak number of calls during the total 18 day range in 2017 was examined and the distribution of calls was separated by primary impression. An analysis of variance (ANOVA) was used to calculate the differences in mean calls among the selected days for the periods before, during, and after the hurricane. Also, a paired *t*-test was used to calculate the difference in means for calls per day and the number of calls during the peak days. Statistical significance was set at  $p \leq 0.05$  with a 95% confidence interval. The primary impressions are reported as a percentage of the total calls for the four day period of peak calls from August 29th to September 1st and compared to the baseline call percentages for these complaints in the previous year, 2016.

## 3. Results

There were 882 calls to EMS during the study period from August 19 to September 5 in 2017. This was more than the number of calls for the same time periods in 2016 of 837 calls and in 2015 of 865 calls. Fig. 1 shows the distribution of calls per day during the period studied for 2015, 2016, and 2017. The 6 days prior to the storm had an average of  $48 \pm 6$  calls, the 6 days during the storm had an average of  $50 \pm 15$  calls, and the 6 days after the storm had an average of  $49 \pm 14$  calls ( $p = 0.95$ ). The peak number of calls between August 19 and September 5 occurred during the last 2 days of the storm and the first 2 days after the storm. The daily average call volume for these four days was  $65 \pm 3$  calls compared to the average number of calls for the total 18 days which was  $49 \pm 12$  calls ( $p = 0.008$ ). As a result, even though there was not a statistically significant increase in daily call volumes before, during, or after the hurricane in the specified 6 day groups, there

was a significant peak in calls over a 4-day period that can be attributed to the storm. Of the 160 calls received during this time, there were large numbers of calls with complaints of: injury (21%), generalized pain (11%), respiratory distress (7.5%), chest pain (7.5%), and generalized weakness (6.9%). To gain perspective regarding this distribution of calls during the peak days of calls, we reviewed the baseline call volumes for the top five chief complaints during the storm to the percentages that these complaints were reported during the previous year. During 2016, the baseline percentages of call volumes included: injuries (13%), generalized pain (5.7%), respiratory distress (5.4%), chest pain (5.4%), and weakness (6.1%) [4]. Fig. 2 shows the top five primary impressions reported by EMS during the peak days of August 29th–September 1st as well as the percentages reported for these complaints during the previous year for a baseline reference. Knowing that there is an increase in these complaints, particularly injuries, provides support to physicians and EMTs who advocate to have an increase in the necessary resources available for proper staffing and supplies during and after the impact of a natural disaster.

## 4. Discussion

### 4.1. Peak call timeline

In order for health care services to better provide for members of the community there must be an improved understanding of how natural disasters place strain on the current system. Each time a natural disaster occurs, there is an opportunity to learn and to adapt the coordination of patient care to promote efficient and effective treatments. This study shows that natural disasters place a unique burden on both EMS and emergency departments that needs to be more fully understood. By knowing that an increase in call volumes to EMS is likely to occur toward the end of a storm, as well as in the initial days following a storm, a larger portion of resources should be allocated in anticipation of this strain. To help confirm this timeline of increased call volume, a study by Cooper found that call volumes to EMS spiked significantly the day after landfall of Hurricane Ike, a colossal storm that devastated the island of Galveston and had a large impact in and surrounding Houston, Texas. The timeline shown by Cooper reports increased call volumes lasting up to a week after Hurricane Ike [2]. Consequently, these findings demonstrate that EMS and emergency departments have a narrow window to prepare for an increased number of victims in the community due to a natural disaster. Also of note in this study is a drop in call volume immediately when a storm hits an area as seen in Fig. 1 for August 26th. This aspect is important because it raises the question if the effects of a storm are so devastating that people are completely inhibited from reaching necessary medical care. This drop in volume represents an opportunity for future studies to ensure large volumes of patients are not prohibited by these storms from making it to the hospital. This data shows when an increased patient burden should be anticipated. One viable strategy is for EMS companies outside the anticipated landfall zone to provide additional resources including ambulances, 911 coordinators, and EMTs. Similarly, emergency departments will inevitably need more physicians, PAs, nurses, respiratory therapists, and other members of the ED team on site for the days following landfall for effective preparation. By educating all members of the team in the days prior to the expected increase in call volume, anticipatory scheduling can begin that will ensure there is not a shortage of providers who are ready to assess and treat victims of these disasters. Proper tail-heavy staffing would decrease provider fatigue and increase efficiency as well. We hypothesize that the delayed presentation toward the end of a disaster likely represents a combination of factors. With large amounts of local flooding, the ability to call for EMS and to reach the hospital would be degraded. Environmental changes such as flooding of houses, lack of electricity, and contam-

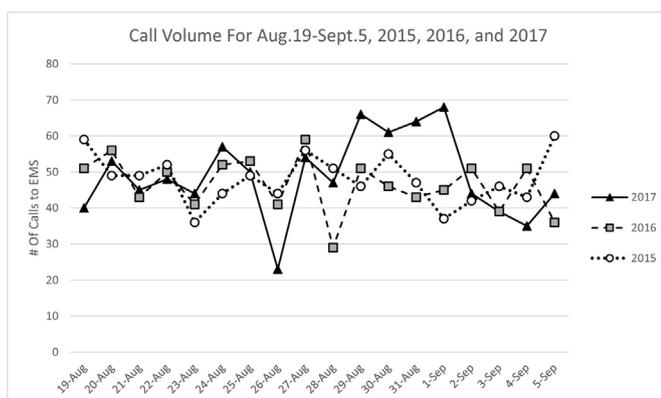


Fig. 1. Call volume Aug 19–Sept.5, 2015, 2016, 2017.

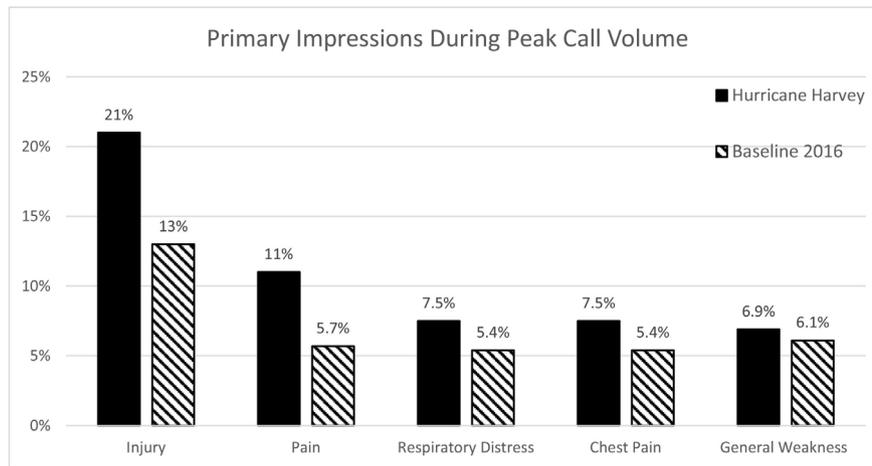


Fig. 2. Primary impressions during peak call volume.

inated water, likely contribute to delayed presentations to the ED. Lastly, an increased burden might be placed upon emergency departments because of patients' inability to access pharmacies and dialysis centers. These hypotheses are supported by the study conducted by ACEP following Hurricane Sandy. This study based on numerous surveys found that power loss, transportation issues, compromised water supply, poor air quality, communication issues, flooding, lack of proper staffing, and the need for hospitals to provide dialysis all contributed to the strain placed on the healthcare system in the wake of natural disasters [1]. By continuing to study the effects of these storms and the system strains, we hope to provide valuable insight into disaster preparedness.

#### 4.2. Anticipation of chief complaints

The combination of knowing the temporal distribution of increased call volumes as well as the types of complaints to be encountered will lead to a better understanding of the stresses placed on the healthcare system. This study shows that a large portion of patients will present with injuries, general pain, respiratory distress, chest pain, and general weakness. The study by Cooper corroborates these findings showing the largest increases in calls to be for problems such as respiratory complaints, falls, and chest pain [2]. In a study by Davis, breathing emergencies and hazardous situations were also found to be increased in the wake of Hurricanes Katrina and Wilma [3]. Consequently, triage personnel should be educated in recognizing these complaints and anticipating this increased volume. Likewise, having equipment such as extra BiPAP machines, ventilators, and corresponding medications at the ready will undoubtedly improve patient care. Also of benefit would be ensuring staffing of ICU and interventional cardiology staff for critical patients. In anticipation for the increased number of injuries, having more operating rooms staffed and trauma surgeons available will likely reduce the burden of the increased number of calls during this condensed period and add to the efficiency of caring for victims of natural disasters. Hospital systems should also have the ability to utilize mobile dialysis units in order to divert this special subsection of patients from needing to activate EMS. Also of interest would be having emergency access to oxygen for people who are oxygen dependent but have no electricity. This would prevent hospitalizations for chronically oxygen dependent individuals and free up resources. Not only is having the correct number of resources vital but educational scenarios to act as refresher activities in areas such as triage, recognition of serious injuries, and acute respiratory distress may help to organize the congestion in the emergency departments. Additional education

of pre-hospital providers could also be encouraged. This would present a unique and useful avenue to use local telemedicine and pre-hospital telemedicine to triage patients during the high call burden times identified. This would also provide an advantage for systems with pre-hospital paramedicine programs to treat patients who do not need transport to the emergency department for definitive care.

#### 5. Conclusions

In anticipation of future natural disasters, this study provides insight that call volume to EMS will likely peak during the last few days of a storm and into the first few days to follow soon thereafter. We further anticipate large volumes of patients requiring interventions due to emergencies involving injuries, generalized pain, respiratory distress, chest pain, and generalized weakness. Staffing of EMS and emergency departments should become a top priority well in advance of these disasters and preparing for the need of ancillary services for specific emergencies is critical. Opportunities exist in implementing telemedicine and community paramedicine before natural disasters occur. By combining effective preparation of resources and staff, as well as increasing public awareness of these findings, our healthcare system will be better able to tolerate the strain placed by natural disasters and lead to improved patient outcomes.

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