Effects of different crash data variables on EMS response time for a rural county in alabama

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Abstract

Response time of Emergency Medical Services (EMS) is an important factor related to preventable deaths in road crash incidents. This study focuses on analyzing the effects of different independent variables on the EMS Response Time (ERT). Independent variables considered for this investigation are travel time, day of the week, crash severity, weather, time of the day, and lighting condition. Understanding outcomes resulting from variations of the considered parameters on ERT is crucial to minimize the possibility of adverse outcomes which are tied to different types of injuries, and vital to limit the prospect of fatalities. Crash data used for this study is from a rural county in Alabama where only one EMS control location is available. Results from the analysis indicate that ERT becomes larger as travel time increases. ERT is also larger on weekends than on weekdays. ERT is larger in the evening and night when compared with morning. When the weather is clear or cloudy, the ERT parameter is shorter. But when the weather is extreme, with mist, fog, or rain, the parameter is longer. When roads are dark, ERT is long. When daylight is present, the ERT is shorter. If the crash is fatal, the parameter is longer compared with situations when crash injuries are non-severe.

Keywords: Automobile collision, emergency medical services, EMS response time, global independent variables, local independent variables

Introduction

In 2015, the overall crash mortality rate within the US was 10.9 per 100,000 person-years.[1] Associated crash mortality rates for different US states ranged from 3 to 25 deaths per 100,000 person-years.[2] Because emergency medical services provide the critical link between injury and definitive critical care, the time between the occurrence of a Motor Vehicle Crash (MVC) and arrival of a patient to this care is an important element in regard to the possibility of MVC mortality.[3] According to Brown et al.,[4] early arrival of Emergency Medical Services (EMS) at a crash scene generally leads to stabilization of occupants with life threatening injuries, timely triage, and transport to a hospital. In addition, Gopalakrishnan[5] shows that most deaths from road traffic injury (RTI) happen before hospital arrival, either at the location of the accident, or as the injured individual is relocated to the hospital. Bakke et al.[6] indicate that 86% of associated deaths come about prior to trauma care center arrival, further showing that approximately 39% of these deaths can be prevented. According to several sources,[7,8] shorter EMS transportation periods leads to less likelihood of fatalities. Gonzalez et al.,[9] Trowbridge et al.,[10] and Griffin[11] provide results from related investigations, with information related to outcomes, influencing factors, interacting quantities, and associated parameters which are related to MVC's, EMS Response Time (ERT), and patient death.

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The interval between an MVC and EMS patient transport and delivery (for a particular event) is a result of time delays. The magnitude of this time is related to the number of vehicle occupants, the time of day, the volume of road activity, the urban, suburban, or rural location of the accident, and other factors. According to several sources,[9,12,13] response time (or alternatively, time of travel) is defined as the interval between first notice of a crash and the appearance of the EMS team at the place of the accident. The time taken for EMS to reach a crash site is strongly influenced by the location (rural, suburban, or urban) of the crash site.[9,14]

Eftekhari *et al*.[15] indicates that the six major challenges related to preventable deaths in RTIs in the prehospital phase include "poor management of the crash scene," "lack of adequate rules and regulations," "poor management of time," "low quality of training," "poor communication and coordination," and "low quality of victim management." Included in the investigation are recommendations to reduce preventable deaths due to RTIs, which are related to mitigation of the detrimental consequences of these challenges. He *et al*.[16] give results related to EMS availability within a low-population and remote state county. Improvements to EMS accessibility are of particular interest. Using advanced investigation analysis tools, the authors demonstrate vital connections between such improvements and EMS performance measures. Provided are innovative results which are related to EMS Service coverage and timely service performance indexes, which are developed to evaluate the positioning and service quality of each EMS station. With data from the Fatality Analysis Reporting System, Cruz and Ferenchak[17] analyze national trends in emergency response times from 1975 to 2017. Results from the study indicate that emergency response times have improved by approximately 50% over this timeframe. Of particular interest are the impacts of improved emergency response time (RT) on fatality-based traffic safety analyses. In particular, the investigators indicate that a limiting factor in analyzing RTs is accurate reporting of fatal crashes. For example, fatal crash information cannot be used for analysis if invalid or unknown emergency response times recorded.[17,18] Other recent investigations consider ERT issues related to all-terrain vehicle crash location,[19] cardiac arrest,[20] ambulance crashes,[21] and machine learning analysis approaches.[22]

The present investigation is undertaken to provide information regarding the dependence of ERT and the influences on this parameter resulting from variations of a several independent variables. Of interest are alterations of travel time, day of the week, time of the day, weather, crash severity, and lighting conditions. Of particular focus are the effects of these variables on ERT for the unique rural environment of Pickens County, Alabama. Associated data collected for different crash variables are thus special because this county has a low population density, with only EMS control location. Understanding outcomes resulting from variations of the considered parameters on ERT is crucial to minimize the possibility of adverse outcomes which are tied to different types of injuries, and vital to limit the prospect of fatalities. As such, results from the present investigation are important to the practice of primary care physicians because poor management of time is a major challenge related to preventable deaths in RTIs,[15] and because management of associated time issues is of direct relevance to health care policies associated with trauma patient care.

Variable Selection, Analytic Results, and Resulting Data Trends

The county selected for consideration is positioned along the western, mid-region state boundary of Alabama, a U.S. state. Only a single facility for medical care is positioned within this county, which is also the singular dispatch location for EMS. The associated address is 241 Robert K Wilson Dr., Carrollton, AL 35447. Information on MVC accidents were obtained using the archived data associated with the Critical Analysis Reporting Environment. The period of January 2016 to December 2019 is considered, for which, records are available of 214 automobile crash events. Note that resulting data employed within the present investigation are associated only with situations wherein EMS actions were employed. Variables under consideration include ERT, crash severity, lighting condition, weather, time of the day, day of the week, and actual travel time. Here, travel time is calculated between the Pickens County hospital location and each of the crash sites using Google Maps with travel time recorded in minutes for the fastest route.

To utilize GWR4 software for data analysis, a range of varying code numbers are employed to quantify different values which are associated with each variable. If code numbers for each variable are adjusted, the resulting coefficient remains same, but the intercept value is altered. For example, changing codes from 81 to 84 to 201 to 204 for lighting condition does not change associated coefficient values after analysis. Note that using an opposite order of numbers for a particular variable results in a different sign for the associated coefficient. For example, changing codes from 81 to 84 to 504 to 501 for lighting condition, the coefficient value for lighting alters its sign, without changing the value of the associated coefficient.

Figures 1a to 6a show the ERT variation with respect to different independent variables, or with respect to the codes for the different independent variables. Within these figures, values of the dependent variable ERT, for different event occurrences, are thus provided for particular values of different independent variables. Figures 1b to 6b show histogram data of the number of crashes with respect to different independent variables, or with respect to the codes for the different independent variables. The average ERT is provided within these figures just above the associated bar, which denotes the number of crashes, for each independent variable value or code value. The code numbers for the variables are also provided in each of these figures. Travel time is determined in minutes from google maps, as the calculated time between the hospital or EMS source location and the crash site.

Figure 1a presents the variation of ERT as travel time changes. Included in this figure is a linear relationship which denotes conditions for which ERT is in quantitative agreement with

travel time. For most of the physical conditions represented by the data in Figure 1a, ERT is higher in magnitude, compared with travel time. This is a consequence of EMS personnel needs associated with extra required time for the initial communication, unit dispatch time, and scene time. In several situations, ERT is smaller in magnitude, compared with travel time. Such a situation arises when the EMS unit travels faster than normal driving limits. Alternatively, for some occasions, an EMS unit is positioned in closer proximity to the accident location, compared with the location of the dispatch center. Figure 1b histogram shows that the travel time interval for the largest number of crashes is for periods of 16 to 20 min. Average ERT within this figure generally show the expected trend of an increase with travel time, with one exception. The average ERT value is higher than expected for the 6 to 10 min travel time interval, because of anomalous events. For this situation, larger delay times are generally associated with more serious injuries and scene times which are larger than average trends. Within Figure 1c, the variation of EMS delay time with

travel time is given. For these data, the difference between ERT and travel time is the EMS delay time. A negative delay time value thus indicates that ERT is shorter than travel time. The trend of data within Figure 1c shows that, as travel time becomes larger, delay time generally becomes smaller.

Figure 2 shows ERT variation with code for the variable—day of the week. This figure indicates that per day about that same number of crashes occur on weekdays and weekends with about 31 crashes per day each weekday and about 30 crashes per day each weekend day. However, the average ERT is 17% lower for weekdays than for weekend days.

Figure 3 shows ERT variation with code for the variable—crash severity. These data indicate that most of the crashes are associated with a suspected minor injury, and that the widest range of ERT values is also associated with a suspected minor injury. The ERT values corresponding to situations with
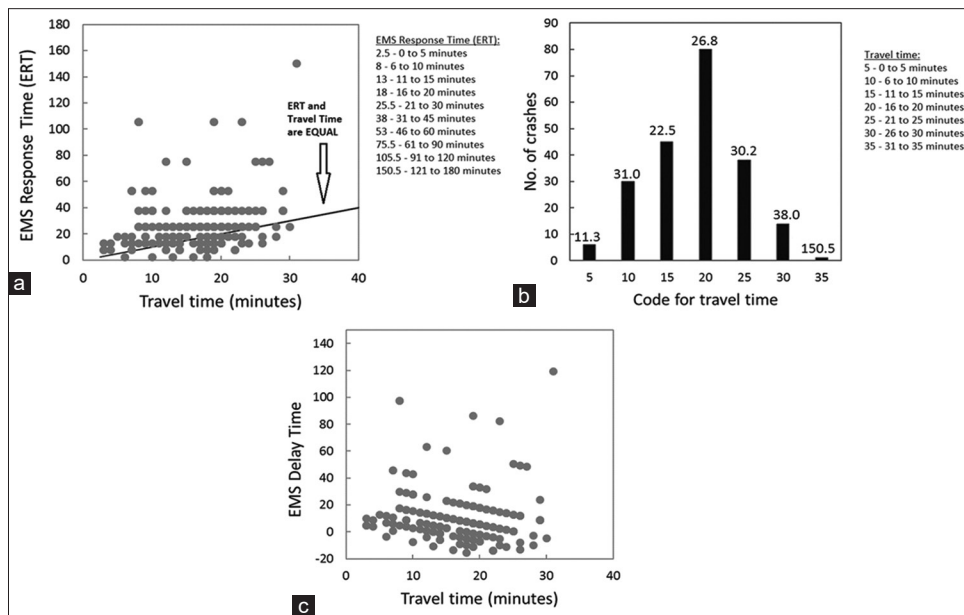

Figure 1: (a) EMS response time (ERT) variation with travel time in minutes. (b) No. of crashes variation with code for the variable and travel time. Average ERT is given above bars for each code value. (c) EMS delay time variation with travel time in minutes
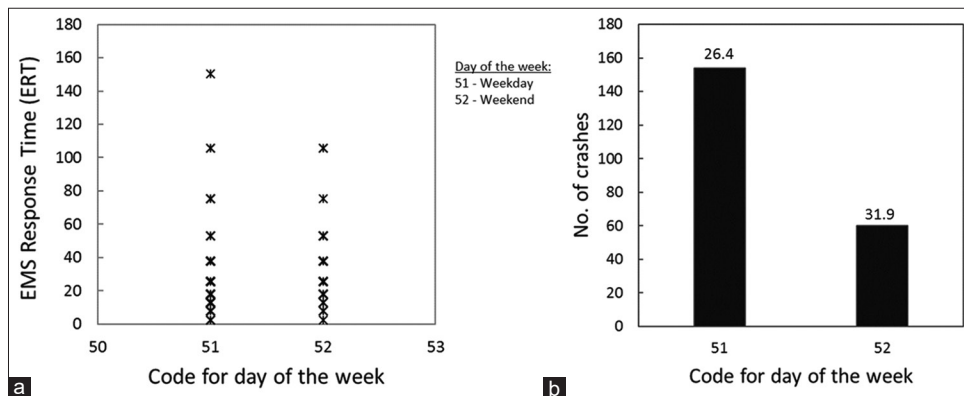

Figure 2: (a) EMS response time (ERT) variation with code for the variable, day of the week. (b) No. of crashes variation with code for the variable and day of the week. Average ERT is given above bars for each code value
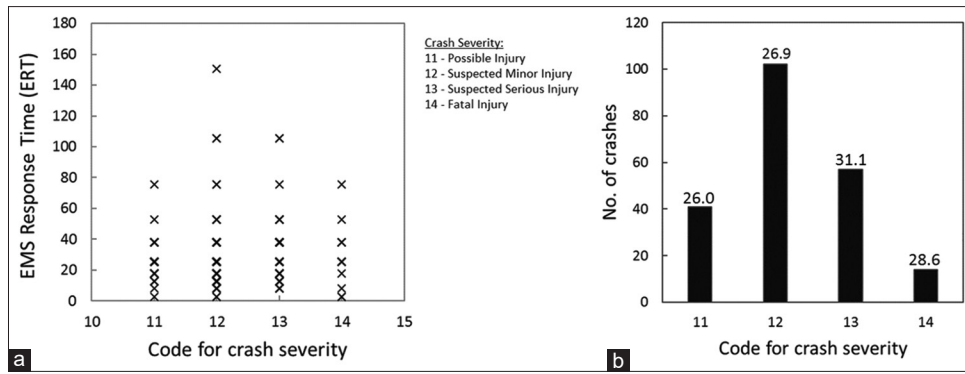
Figure 3: (a) EMS response time (ERT) variation with code for the variable, crash severity. (b) No. of crashes variation with code for the variable and crash severity. Average ERT is given above bars for each code value
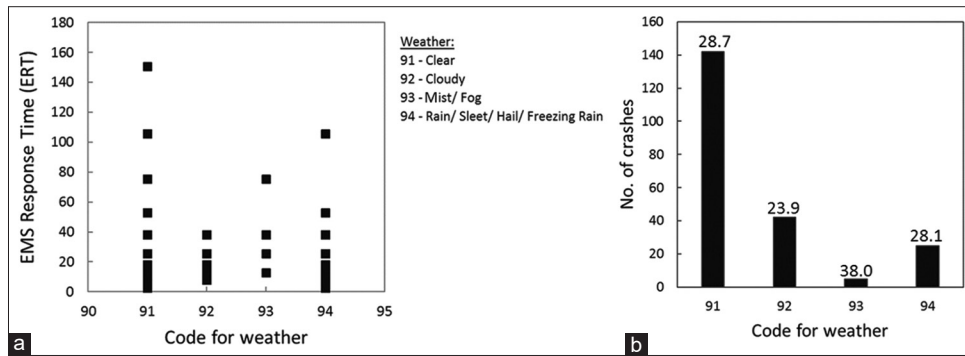

Figure 4: (a) EMS response time (ERT) variation with code for the variable, weather. (b) No. of crashes variation with code for the variable and weather. Average ERT is given above bars for each code value
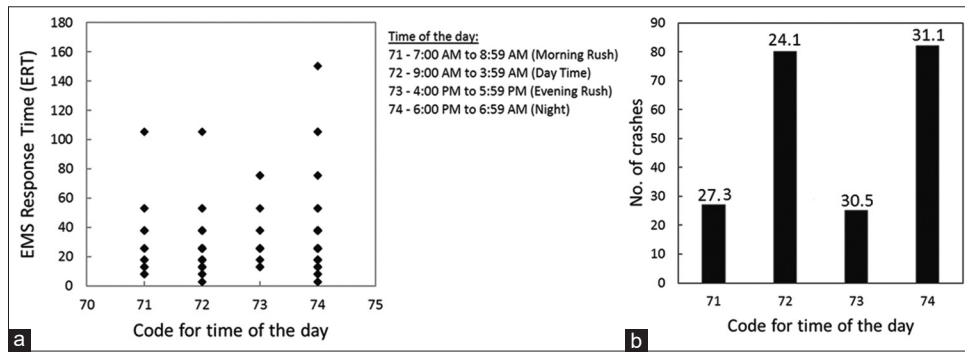

Figure 5: (a) EMS response time (ERT) variation with code for the variable, time of the day. (b) No. of crashes variation with code for the variable and time of the day. Average ERT is given above bars for each code value

suspected serious injuries and fatal injuries are higher, likely due to the crash occurring on a higher speed roadway that are farther from the dispatch location in the more rural areas of the county.

Figure 4 shows ERT variation with code for the variable—weather. Here, data show that more crashes generally occur when the weather is clear. Such a characteristic is consistent with overall weather patterns within the state of Alabama. Clear weather is also associated with the largest range of ERT magnitudes. Average ERT data are shortest with a cloudy weather condition, and longest for the mist/fog condition. The equivalence of ERT values for clear weather and for the rain/sleet/hail/freezing rain situation is in part a result of a significantly larger statistical sample of data for the clear weather condition, with a larger range of influences by other independent variables.

Figure 5 shows ERT variation with code for the variable—time of the day. More crashes occur, with a larger range of ERT values, during 6.00 PM to 6.59 AM followed by 9.00 AM to 3.59 PM. This is because of the time intervals are 13 hours and 7 hours compared with 2 hours for the other variable code values. The average ERT is longest during night time and during the evening rush time when visibility is potentially limited.

Figure 6 shows ERT variation with code for the variable—lighting condition. More crashes generally occurred, with a wider
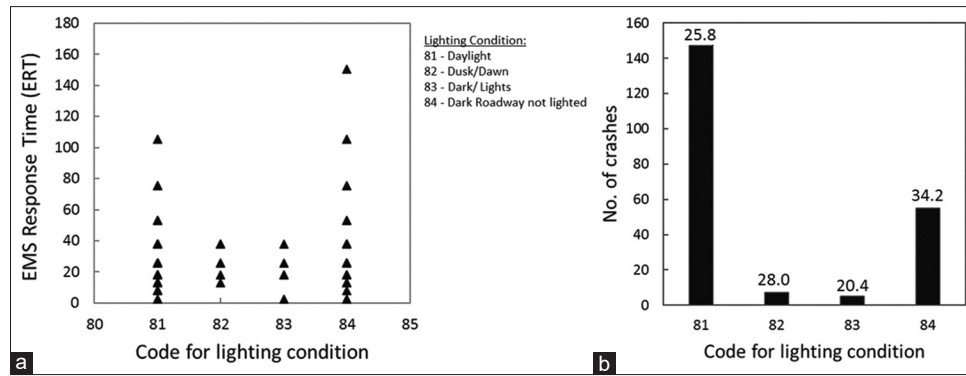
Figure 6: (a) EMS response time (ERT) variation with code for the variable, lighting condition. (b) No. of crashes variation with code for the variable and lighting condition. Average ERT is given above bars for each code value

range of ERT values, during daylight hours. Data indicate that ERT is often longer when the roadway is dark (not lighted). This is to be expected as finding the crash location in the dark is more difficult than in daylight conditions. The average ERT is shortest when roadways are dark, but lighted; characterized by improved visibility with less vehicles on the roadway.

Summary and Conclusions

This study considers the effects of different crash data variables on ERT for a rural county in Alabama. The distinctive geographic realm of Pickens County is considered for the analysis because of its low population density, and because of the very limited availability of medical services for trauma care resulting from adverse traffic events. As such, this study addresses a collection of parameters as they influence and affect ERT outcomes. On the basis of the geographical variability results, day of the week, time of the day, weather, crash severity, and lighting conditions are local independent variables, and travel time is a global independent variable. Associated results are important to the practice of primary care physicians because poor management of time is a major challenge related to preventable deaths in RTIs,[15] and because management of associated time issues is of direct relevance to health care policies associated with trauma patient care.

Overall, key points, key messages, and new knowledge from the study are summarized as follows. First, the investigation outcomes provide evidence that ERT becomes larger as the travel time increases. ERT is also larger on weekends than on weekdays. This parameter is larger in the evening and night when compared with morning. When the weather is clear or cloudy, the ERT parameter is shorter. But when the weather is extreme, with mist, fog, or rain, the parameter is longer. When roads are dark, ERT is long. When daylight is present, the ERT is shorter. If the crash is fatal, the parameter is longer compared with situations when crash injuries are non-severe.

Compliance and Permissions

No patient consents are required in relation to the present investigation. All aspects of this study and this paper are

compliant with University of Alabama in Huntsville guidelines and requirements. All data are available for public release upon written request to the corresponding author.

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Conflicts of interest

There are no conflicts of interest.

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