

Analysis of Emergency Medical Services Response Continuum for Motor Vehicle Crashes in Michigan

Anil Kumar, Osama Abudayyeh, Tycho Fredericks, Megan Kuk, Michelle Valente, Kaylie Butt
Civil and Construction Engineering / Industrial and Entrepreneurial Engineering & Engineering Management



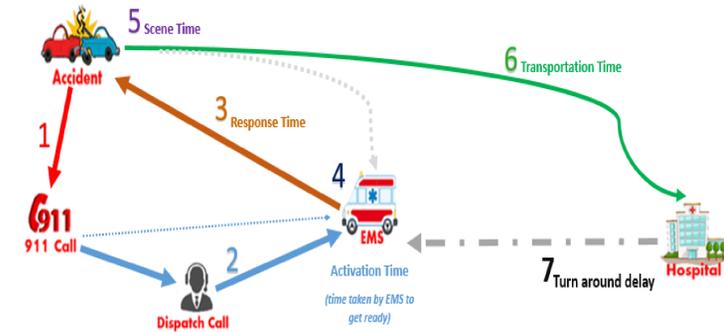
WESTERN MICHIGAN UNIVERSITY



Introduction

Timely response of Emergency Medical Services (EMS) personnel at a crash site may help prevent loss of life and thereby impact the quality of life for an individual at risk. This study was conducted to review The Michigan Department of Community Health, Emergency Medical Services Section data collected over a 5-year period beginning in 2010. Specific intentions were to identify current EMS response, treatment, and transport trends.

The EMS Response Continuum



National Emergency Medical Systems Information Services (3)

1. Dispatch: Time associated with the dispatch of incident information to EMS unit (3).
2. Response Time: Time interval between initial reporting of crash and the arrival of EMS unit at the scene (2, 5, 6).
3. Scene Time: Time allotted for activities performed by the EMS unit at crash site (3).
4. Transport Time: Time associated with the transport of the patient (3).
5. Turn-Around: Time interval for the EMS unit to indicate readiness for the next EMS call (3).

National EMS Response Continuum Statistics

		Rural	Urban
Dispatch	Avg. time elapse between crash and EMS notification (percentage) involving fatalities (4)	6 min (45%)	4 min (43%)
Response Time	Avg. time elapse between notification and EMS arrival (percentage) involving fatalities (4)	13 min (51%)	7 min (44%)
	Percentage of incidents, involving fatalities, responded to in less than 10 minutes (4)	52%	84%
Scene Time	EMS spent less time on scene when provided protocols indicating specific scene time limits as compared to general instructions (7)		
	Avg. time elapse between EMS arrival and departure from scenes involving fatalities (2)	19 min	11 min
Transport Time	Avg. time elapse from scene to arrival at final destination (percentage) involving fatalities (1)	61-120 min (37%)	21-30 min (29%)

Michigan Motor Vehicle Crash (MVC) Data

Data collected from participating EMS agencies between the years of 2008 and 2015, containing 409,973 unique incident records.

Data Reduction

- Incidents occurring outside Michigan borders were removed
- Records outside of January 2010 and February 2015 were removed
- Data marked as *test* and/or *training* were removed
- Data with inconsistent records such as no agency match were excluded
- Non-MVC incidents were removed, including misclassified MVC records when cross-checked with the EMS personnel *Run-Time Narratives*

The master data, after reduction and filtration, used for analysis consisted of 283,298 unique incidents, or approximately 69% of the original MVC data provided by the State of Michigan.

Primary Data Groups & Associated Percentages

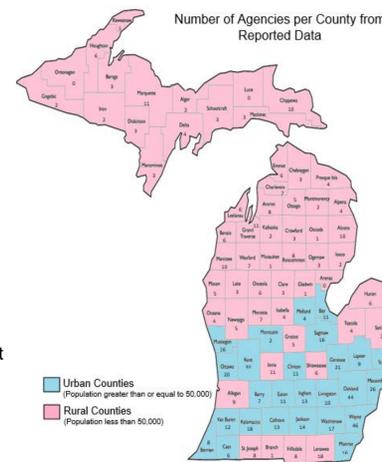
Data Classification	No. of Data Records	Percentage of Original Data (409,973 records)
Master	283,298	69%
Time of Day	282,743	69%
Response Time	240,473	59%
Scene Time	206,827	50%
Transportation Time	149,816	37%

Rural & Urban Classification

- Incident locations were partitioned into rural or urban classifications.
- Classification was determined by population density
- Urban: populations greater than or equal to 50,000 residents (8).
- Rural: populations less than 50,000 (8).

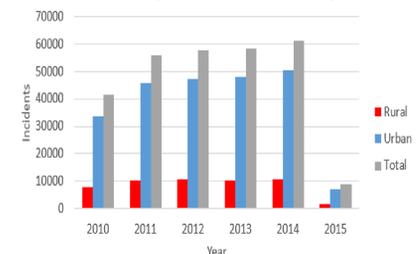
83 counties in Michigan's borders. 57 counties classified as rural. 26 counties classified as urban.

The ratio of agencies serving the population for the largest counties (primarily urban) is approximately eight times larger than that of the smallest counties (primarily rural).



Incident Data

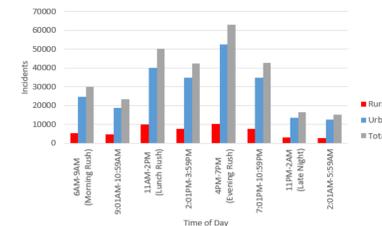
Number of Reported Incidents per Year



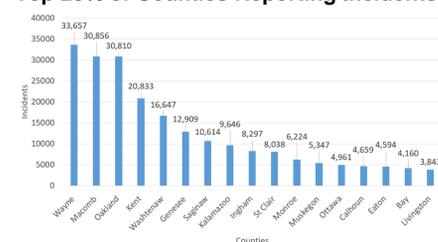
- Gradual increase in incidents over the five-year period
- 2014 reporting the highest number of incidents
- Plausible that the increase in incidents is related to the increased/improved reporting practices
- 704/933 different agencies reported incidents
- Peak reporting from 667 agencies in 2014.

Unsurprisingly, the number of incidents presented spikes in occurrences during the respective *rush hours*, with an overall peak in incidents (62,927) during the heavily congested evening rush period from 4pm to 7pm. Contributing factors may include fatigue of driver and/or high traffic volumes from commuters.

Number of Incidents by Time of Day



Top 20% of Counties Reporting Incidents



Pareto Principle: roughly 80% of effects are associated with 20% of the causes.

The top 20% of counties with the highest incident frequencies accounted for 76% of the incidents from the dataset.

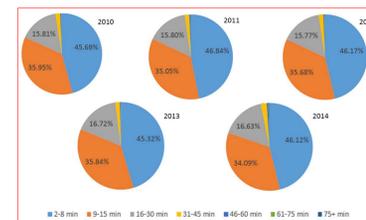
Response Time Data

Agencies with the longest and shortest response times, on average, were compared and evaluated to investigate the potential differences among rural and urban response time on an agency basis.

	Response Time Range	No. of Incidents Range
Longest Times on Average	Rural: 37-42 min	35-1953
	Urban: 18-66 min	3-754
Shortest Times on Average	Rural: 3-5 min	1-2,909
	Urban: 2-4 min	3-324

Response times for the geographical classifications were delineated based on thresholds provided a subject matter expert on the Michigan NEMSIS data.

Response Time per Year: Rural Counties



Response Time per Year: Urban Counties

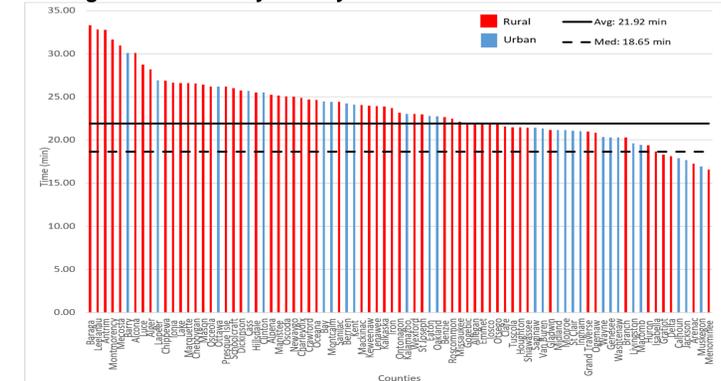


For rural areas, acceptable response time thresholds were set at 2 and 15 minutes, and for urban regions, between 2 and 8 minutes. Roughly 80% of all incidents in rural areas and 70% of all incidents in urban areas presented consistent response times at or below the specified thresholds each full year of data collection.

Scene Time Data

Average scene time per county was calculated across the five-year period. As noted above, rural areas had fewer incidents and higher average response times; however, we see relatively consistent scene times for both geographic classifications. Therefore, scene time appears to be relatively unaffected by location.

Average Scene Time by County



Transportation Time Data

Main insights from transportation time analysis:

1. Urban location of incident yields a lower transportation time when compared with rural regions, potentially due to proximity to hospitals.
2. Rural areas, on average, have longer transport times than urban, 21 to 14 minutes respectively.
3. There appears to be marginal increase in the average transportation time during the rush hours with a higher increase in time throughout the evening and late night (11pm – 2am) time slot.
4. Rural locations consistently exhibited higher transportation times throughout the day. A probable cause could be the sprawled out and potentially limited resources within those locations.
5. Rural transportation time per county ranged from 14 to 44 minutes, on average, while urban counted presented averages between 11 and 25 minutes.

Summary: Total Time of EMS Response (minutes)

Urban/Rural	Classification	Response	Scene	Transportation	Total Time
Rural (51,116)	No. of Incidents	44,340	41,139	30,979	
	Avg. Time	11	24	21	56
	Med. Time	8	20	15	43
Urban (232,182)	No. of Incidents	196,133	162,688	118,837	
	Avg. Time	7	22	14	43
	Med. Time	6	18	11	35
All (283,298)	No. of Incidents	240,473	203,827	149,816	
	Avg. Time	8	22	16	46
	Med. Time	6	19	12	37

Concluding Remarks

- Michigan EMS Agency data was provided on a voluntary basis (there is no mandate that requires agencies to provide the data to a central agency).
- Procedurally, forms are completed using agency selected software from several existing software vendors, and must be provided within 30 days of the incident.
- A considerable amount of resources were used to salvage records for this study, which is evident in the reported data reduction sets.

- Integrating crash databases maintained by EMS and police departments is highly desirable.
- Two sets of data reside in two distinct databases for the same incident, it is very challenging to link the databases to extract useful information.
- It is very beneficial to unify the incident ID among all responding agencies.

- The current data analysis indicates a total time of approximately 1 hour for completed EMS operation.
- Are EMS personnel and equipment ready to be deployed for the next call at the end of this hour?

Acknowledgment

This work was funded by the Office of Highway Safety Planning (OHSP) of the Michigan State Police and the Bureau of EMS Trauma and Preparedness of the Michigan Department of Health and Human Services (MIDHHS). The financial support provided by OHSP and MIDHHS are acknowledged and greatly appreciated. Any opinions, findings, conclusions, or recommendations expressed in this article are those of the authors and do not necessarily reflect the views of OHSP, MIDHHS, or Western Michigan University.

References

1. National Highway Traffic Safety Administration (NHTSA). 2014. www.fars.nhtsa.dot.gov/main/index/apx. Accessed June 2015.
2. Gonzalez, R.P., G.R. Cummings, H.A. Phelan, M.S. Mulekar, and C.B. Rodning. Does increased emergency medical services prehospital times affect patient mortality in rural motor vehicle crashes? A statewide analysis. *The American Journal of Surgery*, Vol. 197, No.1, 2009, pp. 30-34.
3. National Emergency Medical Services Information System (NEMSIS). (2015). *Data Dictionary*. https://www.nemsis.org/v2/downloads/documents/NEMSIS_Data_Dictionary_v2.2_1_04092012.pdf. Accessed June 2015.
4. National Highway Traffic Safety Administration (NHTSA). *Traffic Safety Facts 2013*, 2015 <http://www.nrd.nhtsa.dot.gov/Pubs/812139.pdf>. Accessed June 2015.
5. Lambert, T.E., and P.B. Meyer. Ex-urban sprawl as a factor in traffic fatalities and EMS response times in the southeastern United States. *Journal of Economic Issues*, Vol. 40, No.4, 2006, pp. 941-953.
6. Pons, P.T., J.S. Haukoos, W. Bludworth, T. Cribley, K.A. Pons, and V.J. Markovchick. Paramedic response time: does it affect patient survival?. *Academic Emergency Medicine*, Vol. 12, No.7, 2005, pp.594-600.
7. Patel, A.B., N.M. Walters, I.E. Blanchard, C.J. Doig, and W.A. Ghali, A validation of ground ambulance pre-hospital times modeled using geographic information systems. *International Journal of Health Geographics*, Vol. 11, No.1, 2012, pp.42.
8. United States Department of Agriculture (USDA). (2015). *Rural Definitions: Data Documentation and Methods*. http://www.ers.usda.gov/datafiles/Rural_Definitions/StateLevel_Maps/MI.pdf. Accessed June 2015.