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 Systems specific incident data covering a 5-year period, from 2010 to 2015. Specific intentions were to identify current EMS response, treatment, and transport trends.

The EMS Response Continuum
- Incident locations were partitioned into rural and urban classifications.
- Classification was determined by the population density.
- Urban: populations greater than or equal to 50,000 residents.
- Rural: populations less than 50,000.

National EMS Response Continuum Statistics
- 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.

Michigan Motor Vehicle Crash (MVC) Data
Data collected from participating EMS agencies between the years of 2006 and 2015, containing 405,973 unique incident records.

Data Reduction
- Incidents occurring outside Michigan borders were removed.
- Records outside of January 2010 and December 2015 were removed.
- Data marked as lost 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 records.

The master data, after reduction and filtering, used for analysis consisted of 283,298 unique incidents, or approximately 68% of the original MVC data provided by the State of Michigan.

Primary Data Groups & Associated Percentages
<table>
<thead>
<tr>
<th>Data Classification</th>
<th>No. of Data Records</th>
<th>Percentage of Original Data (405,973 records)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master</td>
<td>283,298</td>
<td>69%</td>
</tr>
<tr>
<td>Time of Day</td>
<td>282,743</td>
<td>69%</td>
</tr>
<tr>
<td>Response Time</td>
<td>240,473</td>
<td>59%</td>
</tr>
<tr>
<td>Scene Time</td>
<td>206,827</td>
<td>50%</td>
</tr>
<tr>
<td>Transportation Time</td>
<td>149,816</td>
<td>21%</td>
</tr>
</tbody>
</table>

Rural & Urban Classification
- Incident areas were partitioned into rural and urban classifications.
- Classification was determined by the population density.
- Urban: populations greater than or equal to 50,000 residents.
- Rural: populations less than 50,000.

Summary: Total Time of EMS Response (minutes)
- Urban
  - No. of Incidents: 44,340
  - Time Range: 6 min - 120 min
  - Average: 36 min
- Rural
  - No. of Incidents: 113,136
  - Time Range: 6 min - 120 min
  - Average: 20 min

Response Time per Year: Michigan Counties
- 2014 reporting the highest number of incidents.
- 2018 reporting the highest number of fatalities.

Scen 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 across both geographic classifications. Therefore, scene times appear to be relatively unaffected by location.

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 (range: 6 to 43 minutes).
3. There appears to be marginal increase in the average transportation time during the rush hours with a slight decrease in transportation time throughout the evening and late night (11pm – 2am) time slot.
4. Rural locations consistently exhibit higher transportation times throughout the day. A probable cause could be the spread-out and potentially limited number of responding agencies.
5. Rural transportation time per county ranged from 14 to 44 minutes, on average, while urban counted presented averages between 11 and 25 minutes.

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).
- Procedures, 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 safeguard 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 different 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.

Transport Time Data
Time associated with the transport of the patient.

Scene Time Data
Time allotted for activities performed by the EMS unit at crash site.

Incident Data
Number of Reported Incidents per Year

Unsurprisingly, the number of incidents presented spikes in occurrences during the respective rush hours, with an overall peak in incidents recorded (2017) 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.

Table: Number of Incidents by Day of Week

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 per Year: Rural Counties

For rural areas, acceptable response time thresholds were set at 2 and 15 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 for each full year of data collection.

Response Time per Year: Urban Counties

For urban areas, acceptable response time thresholds were set at 6 minutes and 120 minutes. Roughly 80% of all incidents in urban areas and 70% of all incidents in rural areas presented consistent response times at or below the specified thresholds for each full year of data collection.

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 (MDHHS). The financial support provided by OHSP and MDHHS 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, MDHHS, or Western Michigan University.

References

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