Disparities in emergency medical service (EMS) response time for motor vehicle crashes in Idaho

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Research Objectives

1. Evaluate the revealed accessibility of EMS for fatal and severe automobile crashes in Idaho using data from the Idaho Transportation Department.

2. Evaluate the potential accessibility of fatal and severe automobile crashes predicted using network generated travel times, EMS locations, and hospital locations.

3. Compare potential and actual response intervals to evaluate the performance of EMS in Idaho.

Introduction: Automobile Crashes and EMS

In the United States in 2017, automobile crashes resulted in 40,231 fatalities nationwide (National Vital Statistics Reports, 2019, Center for Disease Control and Prevention).

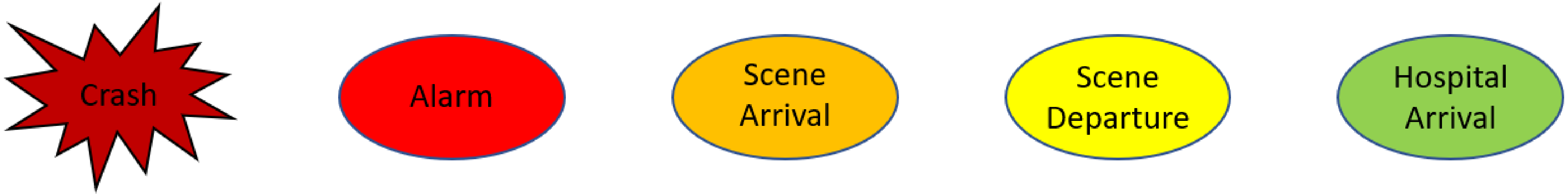
In Idaho in 2019:

- A traffic crash occurs every 20 minutes
- A person is injured every 40 minutes
- A person dies every 39 hours
- Cost estimated to be over $4.1 billion

- Emergency Medical Services (EMS) are an integrated system of public and private organizations, trained medical professionals, communication networks, and medical providers designed to provide life-saving medical care. (NHTSA, 2020)

- In 2016, Idaho had 181 licensed EMS Providers and 56 Hospitals

Introduction: Crash Response Intervals and the Golden Hour



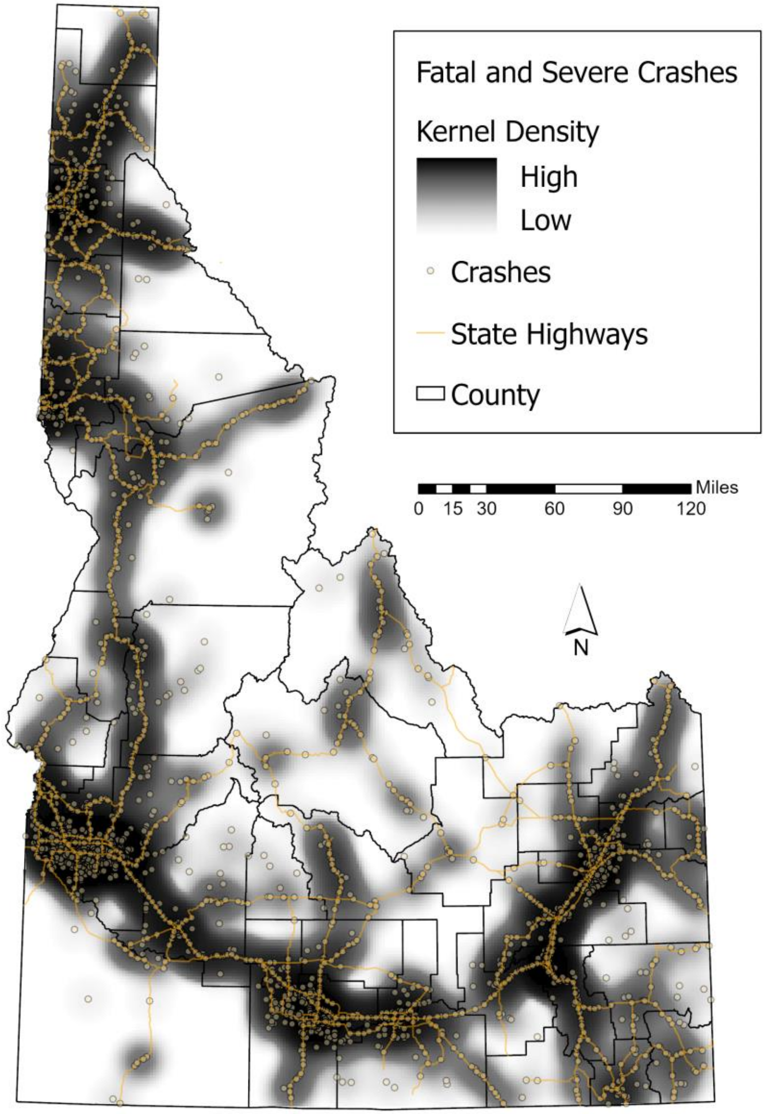
Activation Interval	Response Interval	On-Scene Interval	Transport Interval
• 911 PSAP Notification • EMS Dispatch • Reported by WebCARS	• EMS transport to Scene • Reported by WebCARS	• Patient access, triage, treatment and removal • Estimated using previous research.	• Transport to Hospital • Estimated using network analysis and previous research.

Critical Interval (< 8 minutes)

Total Prehospital Interval (Golden Hour < 60 minutes)

Data Summary and Crash Distribution

Data	Description	Type	Period	Source
Crash Data	Fatal and 'A' severity crashes in Idaho	Point	2013-2018	itd.idaho.gov
Road Network	Road Centerlines	Line	2020	itd.idaho.gov
Hospitals	Hospital locations	Point	2019	dhs.gov/HIFLD
EMS Stations	EMS locations	Point	2019	dhs.gov/HIFLD
Tiger/Line Shapefiles	Census Boundaries, Urbanized Areas, Urban Clusters	Line, Polygon	2019	Census.gov
Administrative Boundaries	ITD Administrative District Boundaries	Line	2020	itd.idaho.gov



EMS Response Time Analysis

Revealed Accessibility

- Activation Interval
- Response Interval
- Critical Interval (Activation + Response)
- Calculated from actual crash data

$$H = (N-1)\frac{\sum_{i=1}^{g} n_i(\bar{r}_{i\cdot} - \bar{r})^2}{\sum_{i=1}^{g}\sum_{j=1}^{n_i}(r_{ij} - \bar{r})^2}$$

Kruskal and Wallis, 1952

Statistical analysis of mean differences

- Kruskal-Wallis test
- Mann-Whitney test

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2$$

Mann and Whitney, 1947

Rural vs. Urban

Roadway Functional Classification

Carr et al., 2006

Performed a meta-analysis of Prehospital Care Times for Trauma (49 studies over a 30-year period)

TABLE 2. Weighted Means and Standard Deviations for Prehospital Care Intervals of Helicopter and Ground Ambulance Transport of Trauma Patients

	Helicopter Ambulance	Urban Ground Ambulance	Suburban Ground Ambulance	Rural Ground Ambulance
Activation interval (mins)				
Overall	3.53 ± 3.81	1.40 ± 1.41	1.40 ± 1.41	2.89 ± 1.64
1975–1989	4.15 ± 2.53	na	na	na
1990–2005	3.26 ± 5.15	1.40 ± 1.41	1.40 ± 1.41	2.89 ± 1.64
Response interval (mins)				
Overall	22.27 ± 29.01	5.28 ± 7.46	5.23 ± 20.04	7.86 ± 7.35
1975–1989	18.39 ± 20.17	6.48 ± 4.88	7.20 ± 7.48	9.02 ± 8.97
1990–2005	23.25*	5.25 ± 8.98	5.21 ± 28.32	7.72 ± 7.82
On-Scene interval (mins)				
Overall	21.60 ± 18.90	13.50 ± 3.71	13.45 ± 21.80	15.06 ± 16.80
1975–1989	23.03 ± 21.45	18.10 ± 6.65	21.08 ± 25.49	28.57 ± 33.67
1990–2005	20.43 ± 20.98	13.40 ± 3.56	13.39 ± 22.02	14.59 ± 16.16
Transport interval (mins)				
Overall	25.50 ± 30.29	10.78 ± 4.29	10.89 ± 17.89	17.37 ± 19.40
1975–1989	14.16 ± 12.63	11.19 ± 3.34	14.24 ± 15.64	19.81 ± 22.21
1990–2005	29.80 ± 57.48	10.77 ± 4.44	10.86 ± 18.20	17.28 ± 19.70
Totals (mins)				
Overall	72.91	30.96	30.97	43.17
1975–1989	59.73	35.76	42.51	57.40
1990–2005	76.74	30.81	30.86	42.48

All mean differences between time periods were statistically significant ($p < 0.01$); na = no articles available; * one article available.

Figure used without permission from:
Carr, Brendan G., Joel M. Caplan, John P. Pryor, and Charles C. Branas. 2006. “A Meta-Analysis of Prehospital Care Times for Trauma.” *Prehospital Emergency Care* 10(2): 198–206.

Actual Intervals for EMS response in Rural and Urban Areas

Classification	No. of FA MVC	No. of Fatalities	No. of Injuries	Activation time (min)		Response time (min)		Critical time (min)	
				Mean	Variance	Mean	Variance	Mean	Variance
Rural	3383	931	5357	3.85	67.36	13.14	108.6	16.99	203.53
Urban	3427	293	5661	2.39	25.1	5.37	14.87	7.76	42.03
Rural and Urban	6810	1224	11018	3.11	46.61	9.23	76.52	12.34	143.53
Mann-Whitney test									
Z-Score				6766900***		9427200***		9307100***	
p-value				< 0.001		< 0.001		< 0.001	

Actual Intervals for EMS response in Rural and Urban Areas by Road Classification

Road Classification	No. of FA MVC	No. of Fatalities	No. of Injuries	Activation time (min)		Response time (min)		Critical time (min)	
Rural Crashes				Mean	Variance	Mean	Variance	Mean	Variance
Local	491	155	665	5.8	210	15.3	171	21.1	453
Minor Collector	136	30	209	4.9	47	18.3	261	23.2	326
Major Collector	684	178	1040	3.25	48.15	12.7	92	15.9	150
Minor Arterial	500	131	772	3.5	51	12.0	79	15.4	144
Principal Arterial	1010	271	1734	3.6	38	12.6	107	16.2	176
Interstate	562	166	937	3.4	34	12.7	56	16.1	96
Kruskall-Wallis test (df= 5) (Chi-square/p-value)				19.255**		41.655***		50.801***	
				0.002		< 0.001		< 0.001	

Road Classification	No. of FA MVC	No. of Fatalities	No. of Injuries	Activation time (min)		Response time (min)		Critical time (min)	
Urban Crashes				Mean	Variance	Mean	Variance	Mean	Variance
Local	330	30	416	2.7	23	5.4	10	8.1	30
Major Collector	311	18	500	2.4	33	5.3	12	7.7	48
Minor Arterial	950	69	1597	2.5	29	5.5	26	8.0	56
Principal Arterial	1836	176	3148	2.3	22	5.3	10	7.6	36
Kruskall-Wallis test (df= 3) (Chi-square/p-value)				14.642**		1.036		7.961*	
				0.002		0.793		0.047	

Potential Accessibility

- Generated using the Network Analyst in ArcGIS Pro.
- Roads classified as Urban or Rural according to whether they are located within an Urbanized Area or Urbanized Cluster.
- Average Urban/Rural travel speeds of 20.1 and 56.4 MPH (Carr et al. 2006, 2009)
- Total Pre-Hospital time was calculated using the following equations:

$$TotalPrehospital_{minutes} = Activation + Response + OnScene + Transport$$
$$TotalPrehospital_{Urban} = 2.39 + PredictedResponse + 13.5 + PredictedTransport$$
$$TotalPrehospital_{Rural} = 3.85 + PredictedResponse + 15.1 + PredictedTransport$$

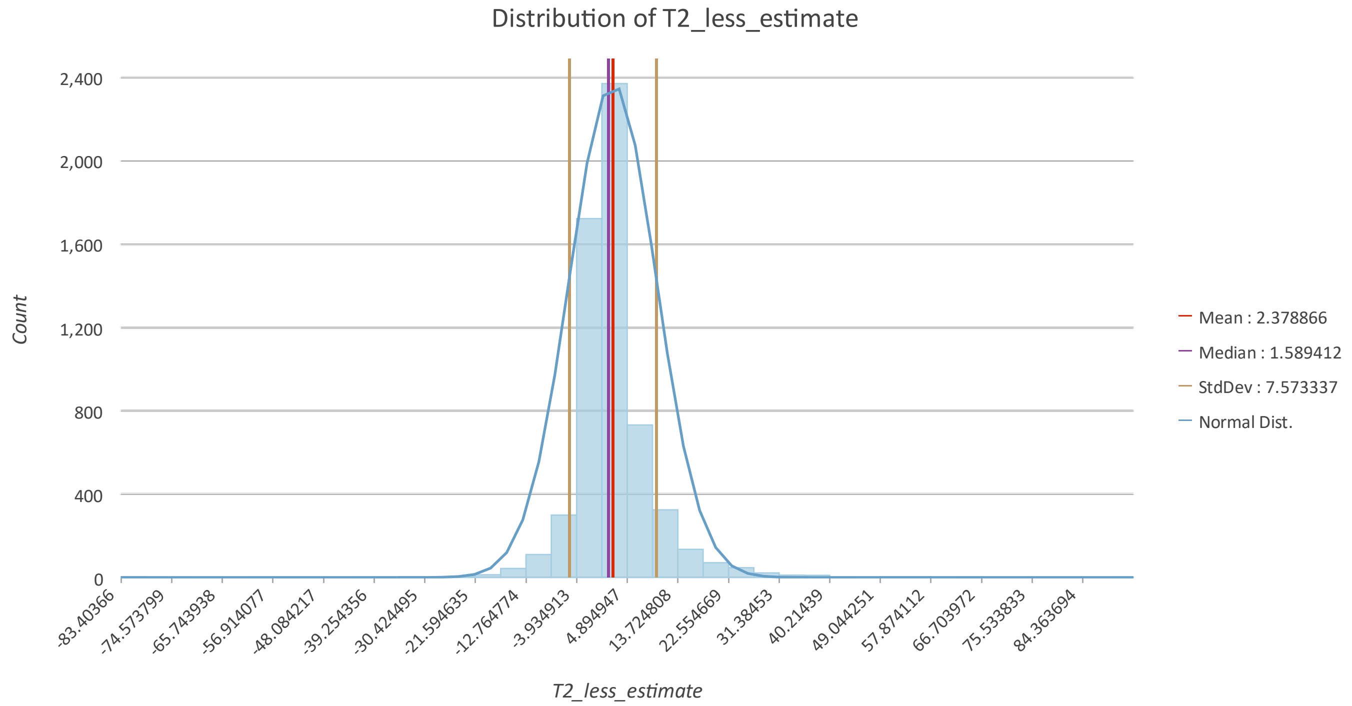
Activation is equal to the actual mean activation time for Rural and Urban areas using the Idaho data.
OnScene is equal to the predicted mean on-scene time for Rural and Urban areas (Carr et al., 2006)

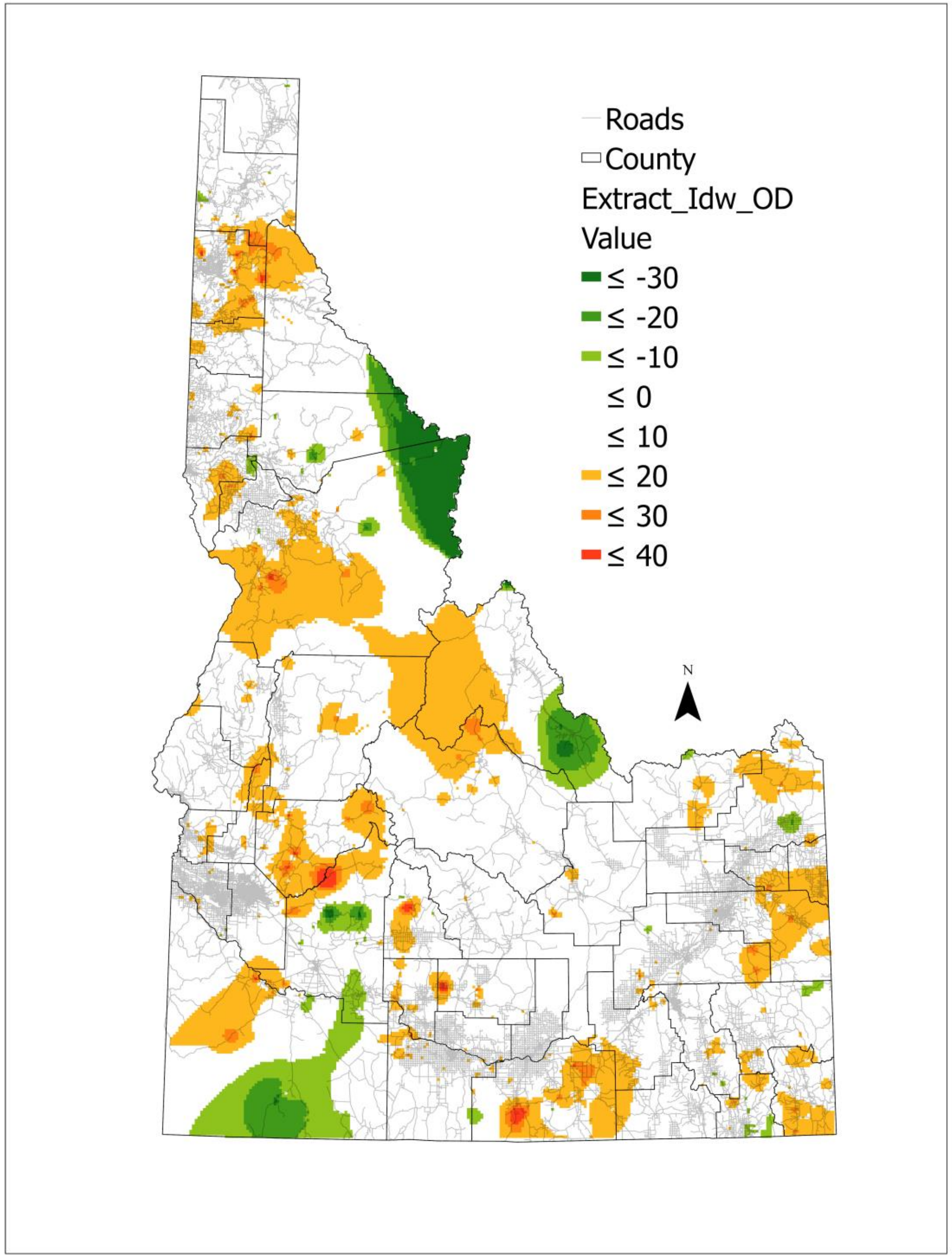
Predicted Intervals for Transport and Total Prehospital Response for Rural and Urban Areas

	No. of FA MVC	No. of Fatalities	No. of Injuries	Transport Time (min)		Total Prehospital time (min)	
				Mean	Variance	Mean	Variance
Rural	3383	931	5357	31.6	519	50.54	519.34
Urban	3427	293	5661	12.47	66.01	28.36	66.01
Rural and Urban	6810	1224	11018	21.99	383.14	39.4	414.75
Mann-Whitney test Z/p-value)				9984300*** < 0.001		10437000*** < 0.001	

EMS Response Time

- Difference in revealed and potential accessibility for response interval .
- Expected travel times estimated from Origin-Destination Matrix.





Selected References

- Branas, Charles C. et al. 2005. “Access to Trauma Centers in the United States.” *Journal of the American Medical Association* No. 21: 8.
- Call, David A., Richard M. Medina, and Alan W. Black. 2019. “Causes of Weather-Related Crashes in Salt Lake County, Utah.” *The Professional Geographer* 71(2): 253–64.
- Carr, Brendan G. et al. 2009. “Access to Emergency Care in the United States.” *Annals of Emergency Medicine* 54(2): 261–69.
- Carr, Brendan G., Joel M. Caplan, John P. Pryor, and Charles C. Branas. 2006. “A Meta-Analysis of Prehospital Care Times for Trauma.” *Prehospital Emergency Care* 10(2): 198–206.
- Gonzalez, Richard P. et al. 2009. “Does Increased Emergency Medical Services Prehospital Time Affect Patient Mortality in Rural Motor Vehicle Crashes? A Statewide Analysis.” *American Journal of Surgery* 197(1): 30–34.
- Guagliardo, Mark F. 2004. “Spatial Accessibility of Primary Care: Concepts, Methods and Challenges.” *International Journal of Health Geographics*: 13.
- Hajameeran, Alima Jafreen. 2019. “A System-Wide Planning Tool to Evaluate Access from Crash Sites to Medical Facilities in Virginia.”
- Lu, Yongmei, and Aja Davidson. 2017. “Fatal Motor Vehicle Crashes in Texas: Needs for and Access to Emergency Medical Services.” *Annals of GIS* 23(1): 41–54.
- Minge, Erik D. 2013. *Emergency Medical Services Response to Motor Vehicle Crashes in Rural Areas*.
- Neutens, Tijs. 2015. “Accessibility, Equity and Health Care: Review and Research Directions for Transport Geographers.” *Journal of Transport Geography* 43: 14–27.
- Newgard, Craig D. et al. 2010. “Emergency Medical Services Intervals and Survival in Trauma: Assessment of the ‘Golden Hour’ in a North American Prospective Cohort.” *Annals of Emergency Medicine* 55(3): 235-246.e4.
- Nunn, Samuel, and William Newby. 2015. “Landscapes of Risk: The Geography of Fatal Traffic Collisions in Indiana, 2003 to 2011.” *The Professional Geographer* 67(2): 269–81.
- O’Keeffe, C., J. Nicholl, J. Turner, and S. Goodacre. 2011. “Role of Ambulance Response Times in the Survival of Patients with Out-of-Hospital Cardiac Arrest.” *Emergency Medicine Journal* 28(8): 703–6.
- Patel, Alka B. et al. 2012. “A Validation of Ground Ambulance Pre-Hospital Times Modeled Using Geographic Information Systems.” *International Journal of Health Geographics* 11(1): 42.

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THANK YOU!

QUESTIONS?