Collaborative Sciences Center for ROAD SAFETY

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Emergency Medical Services (EMS) and the California EMS Information System (CEMSIS)

Factors that influence prehospital time for EMS events related to motor vehicle collisions and recommendations to reduce this time

Outline

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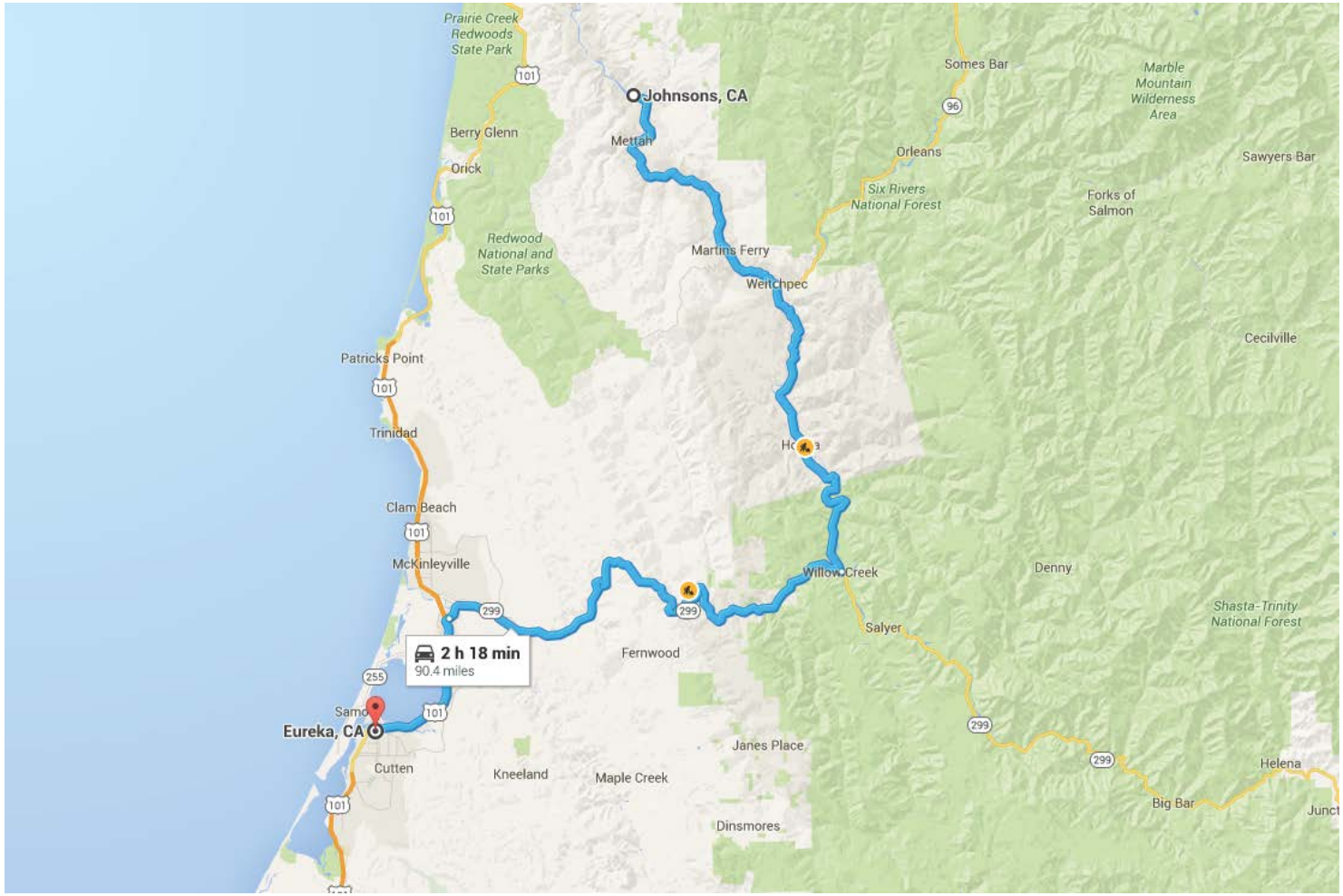
Preface
Tribal Road Safety Data Project
EMS Response and Transport Time

Example of distance/time to nearest ER for a crash on the Yurok reservation



Average Time (Minutes) from Crashes to Nearest Trauma Center – Tribes with 10+ Fatal/Severe Injury Collisions

Tribes	Average Total Time (Minutes)
Colorado River Indian Tribes	183.5
Hoopa Valley Tribe	126.5
Round Valley Indian Tribes	99.0
Quechan Tribe of the Fort Yuma Indian Reservation	63.3
La Posta Band of Diegueno Mission Indians	62.1
Campo Band of Diegueno Mission Indians	60.6
Yurok Tribe	55.6
Torres Martinez Desert Cahuilla Indians	49.4
Cahuilla Band of Mission Indians	49.3
Santa Rosa Band of Cahuilla Indians	49.2
La Jolla Band of Luiseno Indians	38.7
Barona Group of Capitan Grande Band of Mission Indians	37.0
Cabazon Band of Mission Indians	33.4
Pala Band of Luiseno Mission Indians	33.0
Sycuan Band of the Kumeyaay Nation	29.4
Rincon Band of Luiseno Mission Indians	26.3
Morongo Band of Mission Indians	23.8
Agua Caliente Band of Cahuilla Indians	7.8

Average Time (Minutes) from Crashes to Nearest Trauma Center – Rural / Urban (California)

Crash Location	State	Tribal
Urban	14.3	19.6
Rural	50.1	61.4

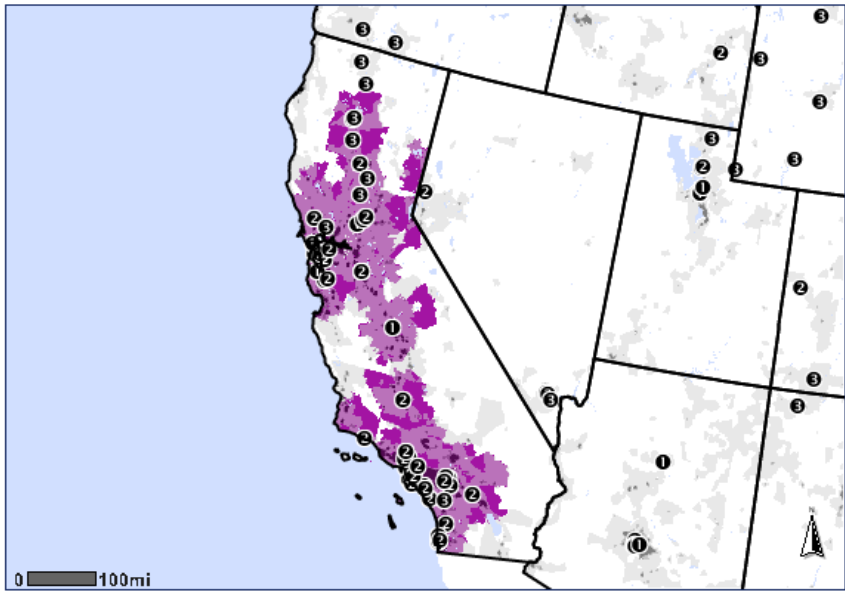
California Trauma System

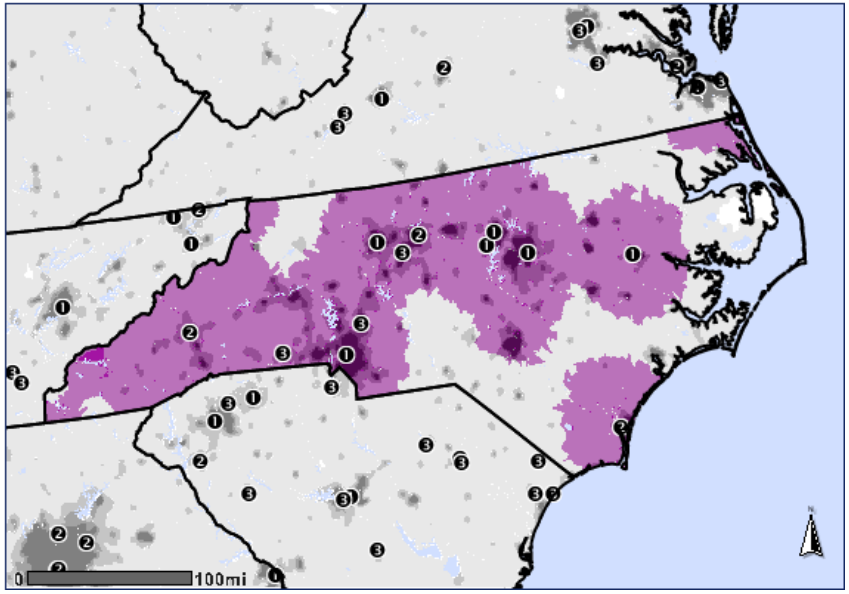
64 Trauma Centers
7 Level I
29 Level II
9 Level III
9 Level IV
10 Pediatric I/II

- Level I
- Level II
- Level III
- Level IV
- Pediatric Level I
- Pediatric Level II
- Adult Level I/Ped Level I or II
- Adult Level II/Ped Level II

Source: http://www.emsa.ca.gov/systems/trauma/map.asp

Level I-II Trauma Center Access: 1 hour (example)



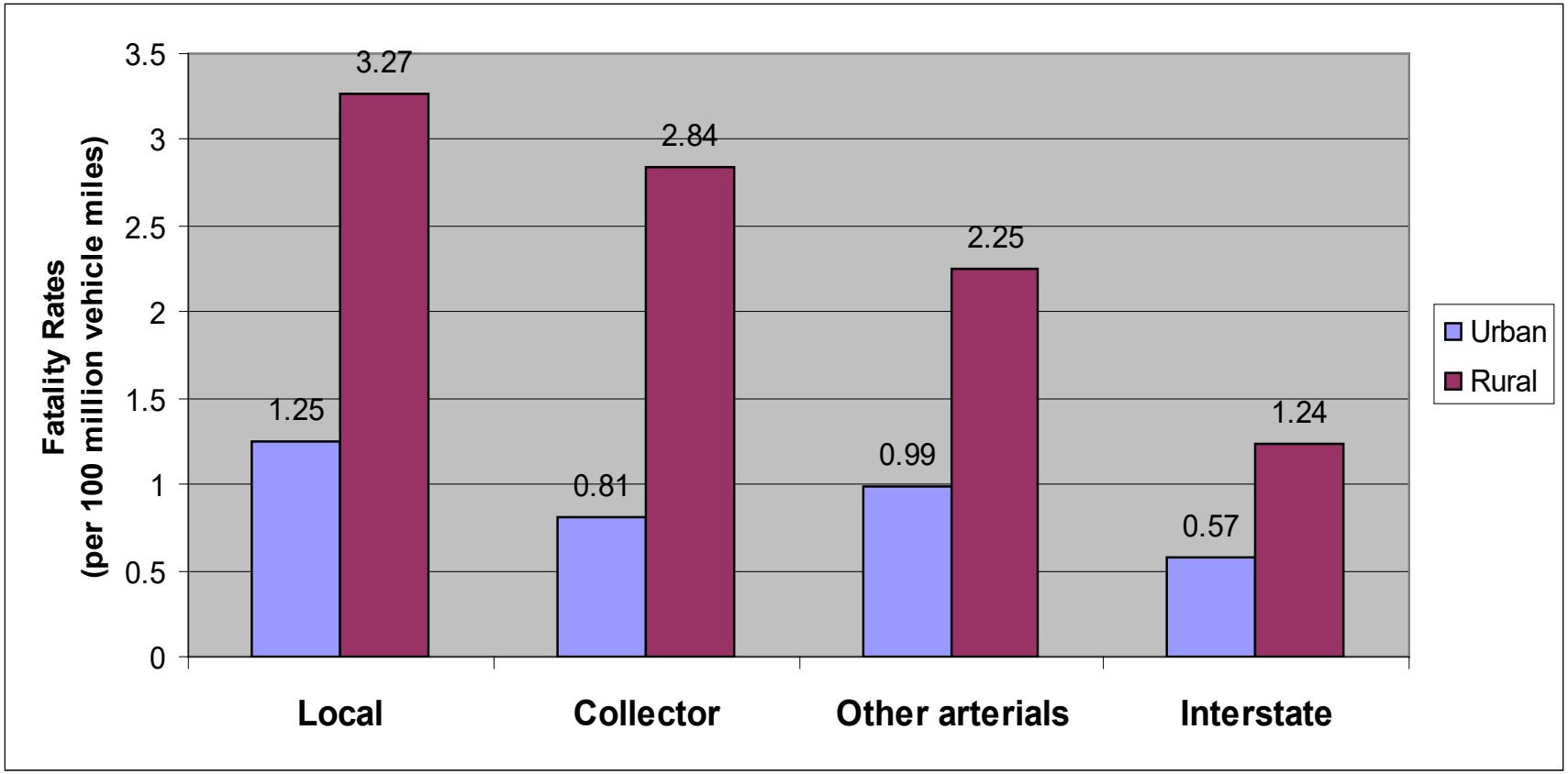


Source: American Trauma Society

Some additional Context

1. The Mileage Death Rate (MDR) on rural roads is 2+ times that for urban roads—this is true regardless of Functional Class
2. The higher MDR appears to be due to higher fatality per injury crash (e.g., Zwerling, 2005)
3. The higher fatality per injury crash may be due to (i) higher crash severity, (ii) longer EMS response or transport times, (iii) lower level of EMS treatment, or (iv) transport to lower level trauma center or ER
4. EMS response and transport times vary substantially by crash location

Fatality Rates by Functional Classification



Introduction

- This study examines data from the California EMS Information System (CEMSIS) to identify the factors that influence prehospital time (response and transport) for EMS events related to motor vehicle collisions (MVCs).

- There is widespread belief in the significance of the ‘golden hour’ immediately following an injury, during which time resuscitation, stabilization and transport to a medical facility offer the greatest chance of survival for the patient. By reducing prehospital time, more advanced medical care can be provided sooner, resulting in reduced mortality.

Introduction

- Urban sprawl has been found to be significantly associated with longer EMS response times and a greater likelihood of delayed ambulance arrival. For example:

- One study found that counties with characteristics of sprawl—low density construction, limited street connectivity, and separation of residential development from commercial areas—have a higher probability of delayed ambulance arrival than counties with smart growth features.

- The authors of this study concluded that the "integration of more comprehensive land-use metrics, such as measures of urban sprawl, into EMS dispatch algorithms may improve resource utilization and potentially response reliability."

Reports describing the study

- Doggett, S., Ragland, D. R, & Felschundneff, G. (2019). Emergency Medical Services (EMS) and the California EMS Information System (CEMSIS) Working Paper. UC Berkeley: Safe Transportation Research & Education Center. Retrieved from https://escholarship.org/uc/item/01j3411t

- Doggett, S., Ragland, D. R, & Felschundneff, G. (2018). Prehospital Response Time and Traumatic Injury—A Review. UC Berkeley: Safe Transportation Research & Education Center. Retrieved from https://escholarship.org/uc/item/8978m2pn

Background on CEMSIS

- The California EMS Information System (CEMSIS) is a secure, consolidated data system that collects information about emergency medical service calls, patients treated at hospitals, and EMS providers.

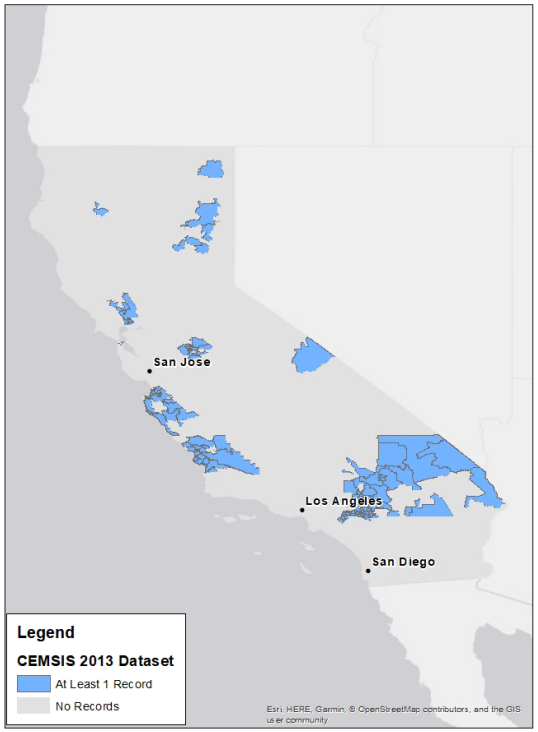
- Data are collected according to National Emergency Medical Services Information System (NEMSIS) standards. Prior to 2017, data was collected according to version 2.2.1 of the standards, and subsequently, local EMS agencies have gradually transitioned to using the current 3.4 version.

Background on CEMSIS

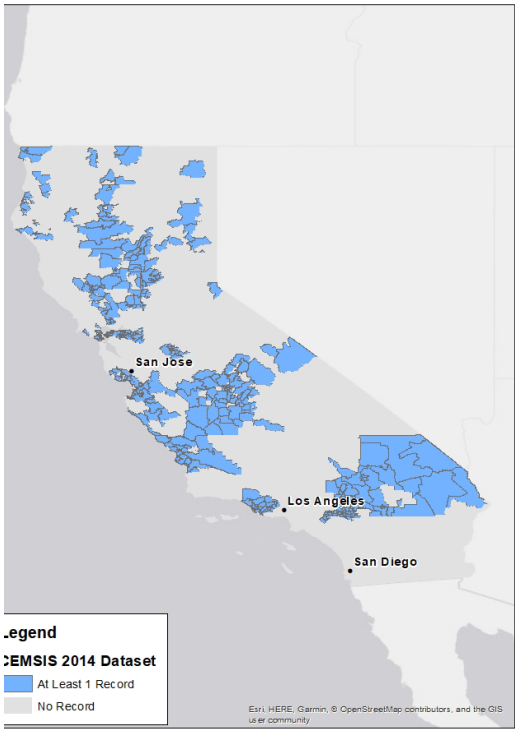
- Eventually, CEMSIS data will be used to develop and coordinate high quality emergency medical care across the state via programs that link treatments to patient care outcomes, enhancing agency collaboration across jurisdictions, and increasing public awareness of EMS services in California
- However, CEMSIS is currently a demonstration project and is not yet fully implemented throughout the state.
- CEMSIS uses the NEMSIS data dictionary, although not all variables listed in the NEMSIS dictionary are populated in the CEMSIS dataset.

Statewide CEMSIS Participation 2013, 2014, 2015

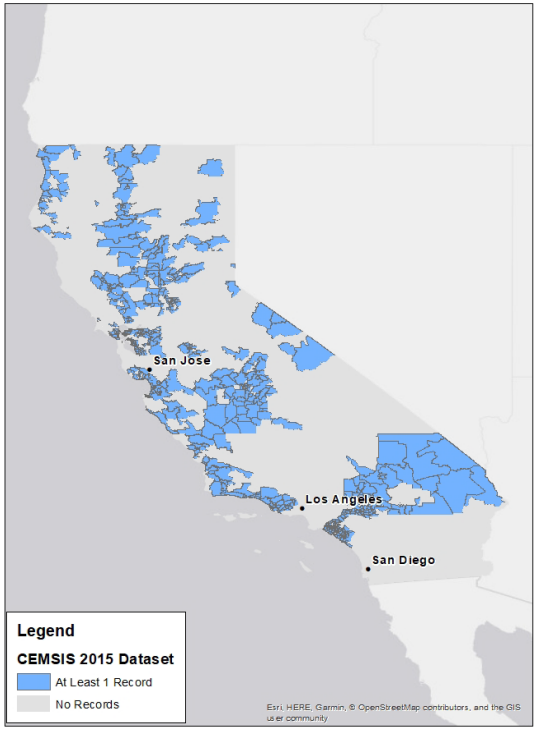
2013



2014



2015



CEMSIS Participants by Year

Table A1. Timeline of CEMSIS Participation by Local EMS Agencies in California

LEMSA	2013	2014	2015	2016	2017	2018
Alameda County			X	X	X	X
Central California*		X	X	X	X	X
Coastal Valleys**					X	X
Contra Costa County		X	X	X	X	X
El Dorado County	X	X	X	X	X	X
Imperial County	Not Participating					
Inland Counties***	X	X	X	X	X	X
Kern County					X	X
Los Angeles County	Not Participating					
Marin County		X	X	X	Not Participating	X
Merced County					X	X
Monterey County	X	X	X	X	X	X
Mountain Valley^	X	X	X	X	X	X
Napa County	X	X	X	X	X	X
North Coast^^	X	X	X	X	X	X
Northern California^^^	X	X	X	X	X	X
Orange County				X	X	X
Riverside County					X	X
Sacramento County			X	X	X	X
San Benito County		X	X	X	X	X
San Diego County					X	X
San Francisco County	X	X	X	X	X	X
San Joaquin County					X	X
San Luis Obispo County	X	X	X	X	X	X
San Mateo County	Not Participating					X
Santa Barbara County			X	X	X	X
Santa Clara County					X	x
Santa Cruz County		X	X	X	X	X
Sierra-Sacramento Valley#		X	X	X	X	X
Solano County	Not Participating					X
Tuolumne County					X	X
Ventura County		X	X	X	X	X
Yolo County		X	X	X	X	X

*Fresno, Kings, Madea, and Tulare Counties

**Sonoma and Mendocino County

***Inyo, Mono, and San Bernardino Counties

^Alpine, Amador, Calaveras, Mariposa, Stanislaus

^^Del Norte, Humboldt, and Lake Counties

^^^Lassen, Modoc, Plumas, Sierra, and Trinity Counties

#Butte, Colusa, Glenn, Nevada, Placer, Shasta, Siskiyou, Sutter, Tehama, and Yuba County

Study Methodology

For the present study, 24 variables were requested, including:

- Zip code in which the incident occurred
- Time at which an EMS unit was notified of the incident
- Time at which the EMS unit was en route to the patient
- Arrival and departure times to and from the scene
- Time when the EMS unit reached their hospital or trauma center destination

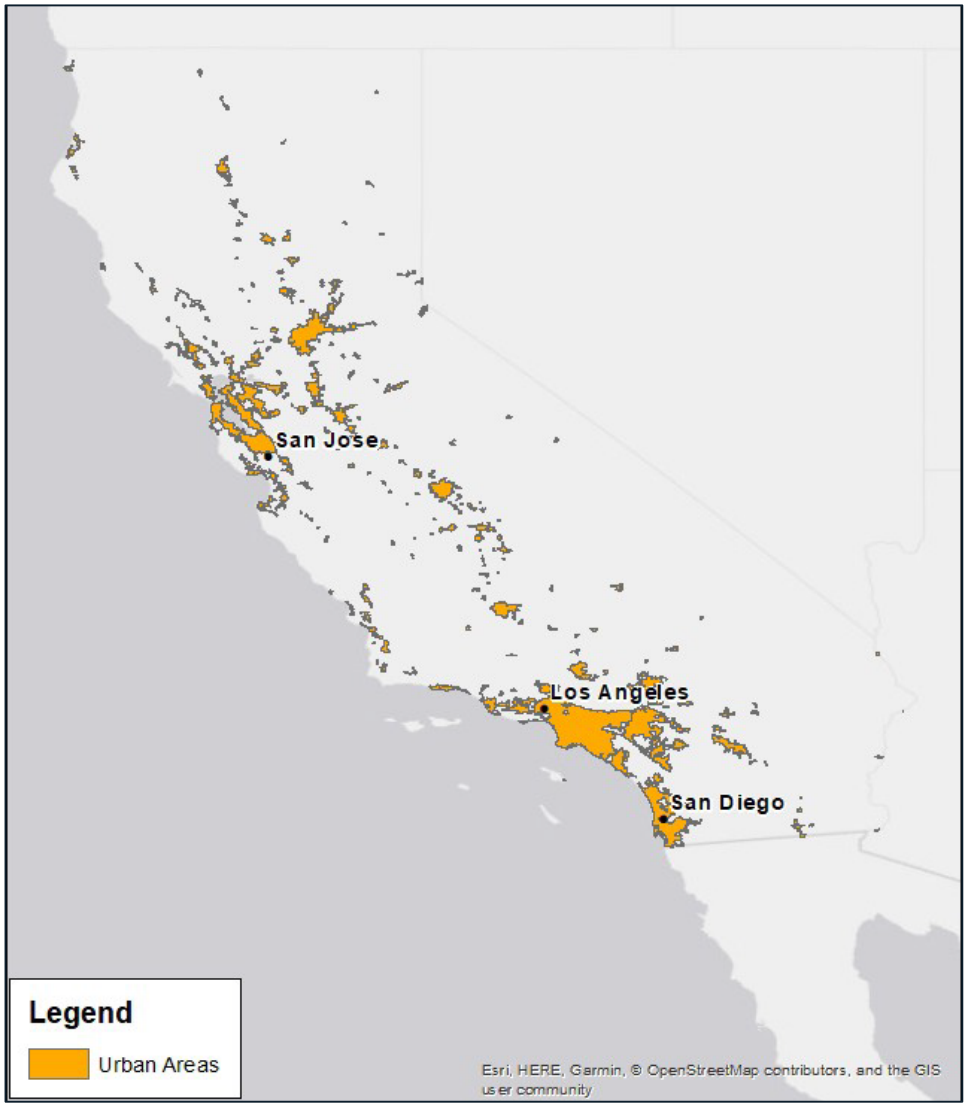
Many of the requested variables involved missing data.

Demographic variables, such as patient gender and ethnicity, were requested but were not released due to privacy concerns. Only records that listed the cause of injury as a motor vehicle traffic accident were included in the present study.

Analysis at the Zip Code Level

- Obtained data from CEMSIS for years 2013, 2014, and 2015 (coded with version 2.2.1 of the NEMSIS code.
- Because data on EMS events were available only at the zip code level, it was necessary to conduct the present analyses at that scale. There are 843 urban and 876 rural zip codes in California. Demographic variables were aggregated from the census block group level to the zip code level, using 2016 ACS data.
- Zip codes were classified as urban or rural based on the location of their centroid. The average size of a rural zip code in the state is 170 square miles, while the average size of an urban zip code is 11 square miles.
- The Euclidean distance between the zip code centroid and the nearest trauma center location was calculated using ArcGIS's Near tool.

California Census Urban Areas



Calculation of Prehospital Time

- The average duration of various segments of prehospital time was calculated according to characteristics of the zip code in which the scene was located, including:
  - **Response Time**—The time from the notification of the EMS vehicle and the arrival of the vehicle at the scene
  - **Scene Time**—The time between the arrival of the EMS vehicle at the scene and the departure of the vehicle from the scene
  - **Transport Time**—The time between the departure of the vehicle from the scene and its arrival at the emergency room or trauma center destination.

- Overall time is comprised of these three components of prehospital time.

Results: Rural vs. Urban

- The average EMS **response time** and **scene time** for motor vehicle collisions were substantially longer when the collision occurred in a rural zip code instead of an urban zip code
- The average EMS **transport time** and **overall time** were approximately *twice* as long for rural vs. urban zip codes

Rural/Urban Differences—
Response Time, Scene Time, Transport Time, and Overall Time (in minutes)

Year:	2013		2014		2015	
Collision Location:	Rural Zip Code	Urban Zip Code	Rural Zip Code	Urban Zip Code	Rural Zip Code	Urban Zip Code
Avg. Response Time	21.2	6.8	21.4	6.8	17.9	7.2
Avg. Scene Time	27.6	19.1	26.8	18.3	23.1	17.4
Avg. Transport Time	26.2	15.1	35.2	14.6	31.3	14.9
Avg. Overall Time	73.3	40.9	85.0	39.9	79.7	39.8

Results: Presence of Trauma Centers

The difference in prehospital times is not as substantial when comparing zip codes with and without trauma centers as it is when comparing urban and rural zip codes. Average response time is approximately one minute shorter in zip codes with trauma centers than in zip codes without them.

Differences in Times Based on Presence of Trauma Centers in Zip Code (in minutes)

Year:	2013		2014		2015	
Collision Location:	No Trauma Center in Zip Code	At Least One Trauma Center in Zip Code	No Trauma Center in Zip Code	At Least One Trauma Center in Zip Code	No Trauma Center in Zip Code	At Least One Trauma Center in Zip Code
Avg. Response Time	7.8	6.8	7.9	6.6	7.8	6.7
Avg. Scene Time	19.6	19.6	19.1	18.2	17.7	18.4
Avg. Transport Time	16.2	11.1	16.7	10.5	16.3	10.6
Avg. Overall Time	43.3	37.4	44.1	35.5	42.6	36.0

Results: Presence of Emergency Rooms

- In zip codes with no emergency rooms, average response times are approximately one minute longer than in those with emergency rooms.
- Average transport times are approximately four minutes longer for zip codes without ERs than for those with them.

Differences in Times Based on Presence of ERs in Zip Code (in minutes)

Year:	2013		2014		2015	
Collision Location:	No ER in Zip Code	At Least One ER in Zip Code	No ER in Zip Code	At Least One ER in Zip Code	No ER in Zip Code	At Least One ER in Zip Code
Avg. Response Time	8.4	6.6	8.4	6.8	8.0	7.2
Avg. Scene Time	19.5	19.7	19.5	18.1	17.9	17.5
Avg. Transport Time	17.2	13.5	18.3	12.6	17.1	13.5
Avg. Overall Time	44.8	39.7	46.8	37.4	44.1	38.4

Results: Regression Modeling Results

- Regression models were generated for each year of data using the distance from the zip code centroid to the nearest trauma center and a dummy variable signifying its rural status as independent variables (both alone and together) and using either response time, scene time, transport time, or overall time as the dependent variable.
- Distance to the nearest trauma center has a significant impact on the average response time for a zip code. When rural status is controlled for the impact of distance is reduced but is still significant.
- Rural status has a significant impact on response time. When distance to the nearest trauma center is controlled the impact of rural status is reduced but still significant.
- In other words, rural status and distance have independent impacts.

Discussion: Limitations

- While the data show that there are substantial differences in response, scene, and transport times between collisions that occur in urban and rural zip codes, there are several limitations influencing interpretation of the results:
- Data on EMS response, scene, and transport times are missing for much of the state. Therefore, the data recorded in CEMSIS may not be representative of EMS events throughout California.
- Zip code level location data is insufficient for adequate study of the effects of the built environment and road network on prehospital time.
- CEMSIS, like NEMSIS, is a convenience sample, in which data are submitted voluntarily by local EMS agencies. This could lead to potential biases.

Discussion: Possible Implications of Urban/Rural Differences

- Despite the study limitations, it is very likely possible that there are significant difference for EMS response and transport times between urban and rural zip codes, even when accounting for distance. Previous research has found that longer prehospital times may negatively impact patient health.

- For example, fatality rates resulting from rural traffic collisions are nearly *twice* as high as those involving urban collisions, and that increases in EMS prehospital time appear to be associated with higher mortality rates for injuries resulting from traffic collisions in rural areas.

Recommendations to Improve Rural EMS Response Times

- The National Cooperative Highway Research Program (NCHRP) recommends the following strategies for reducing time from injury to appropriate medical care in rural areas:
  - Improve cellular telephone coverage in rural areas
  - Improve compliance of rural 9-1-1 centers with FCC wireless
  - “Phase II” automatic location capability
  - Utilize GPS technology to improve response time
  - Integrate automatic vehicle location (AVL) and computer aided navigation (CAN) technologies into all computer-aided dispatch (CAD) systems
  - Equip EMS vehicles with multi-service and/or satellite capable telephones

Comprehensive Strategies to Reduce EMS Response Time

In a survey of hospitals and local emergency medical services in California, those that did *not* report transportation delays listed three factors that contributed to their success:

1. Optimizing the ED intake process
2. Successful hospital process improvement strategies
3. Hospital and LEMSA collaboration and ongoing process improvement strategies

The first step to reducing offload delays in California involves establishing standardized definitions for data collection to address the significant variability in obtaining data from the state's 33 local agencies, hundreds of EMS provider agencies, and 320 acute care hospital emergency departments that receive 911 dispatched ambulances.

Improvements to CEMSIS Data

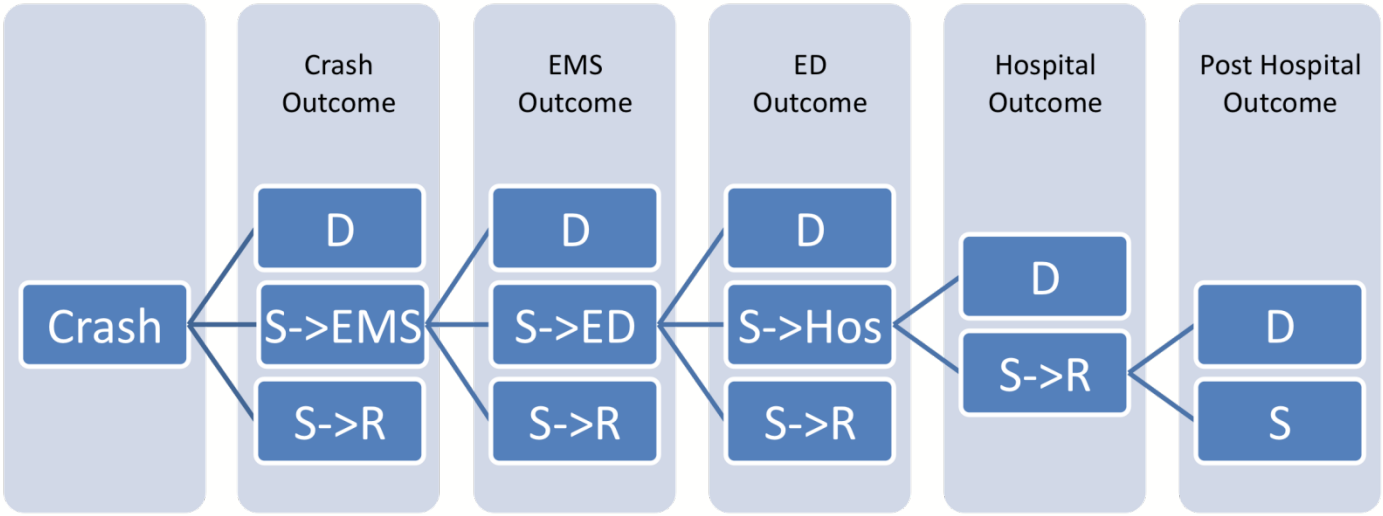
- CEMSIS should improve the coverage of their dataset and ensure that all EMS activities are recorded in its database. This will eliminate potential selection bias that is introduced by using the incomplete dataset. CEMSIS should also ensure that important fields such as patient outcome are populated with as little missing data as possible to reduce the information bias that occurs when one area populates a field more accurately than another. To expand the type of analyses that can be conducted using CEMSIS data, EMS records need to include fields that allow them to be linked to hospital and police datasets.

- When this data becomes available, new research must be conducted to determine whether prehospital time is significantly related to patient outcome following motor vehicle collisions.

Next Steps

- Obtain additional three years of CEMSIS data.
- Obtain additional data listed in the NEMSIS Uniform EMS Dataset as needed from CEMSIS to explore how factors such as location of EMS unit, type of treatment provided at the scene, etc. impact time elements.
- Prepare a detailed report showing EMS response times as a function of crash location, ED/trauma center location, and other factors. Highlight the factors that might be modified (e.g., cell phone coverage, placement of EMS response unites, etc.) to improve EMS response. This could take the form of a statistical model of EMS response in California that can identify the factors most likely to have a beneficial impact on improved injury outcomes.
- As a subpart of the above goals, look specifically at EMS response times in tribal areas in California (note: in a study of traffic safety in tribal areas in California, EMS response has been noted as a particular issue)

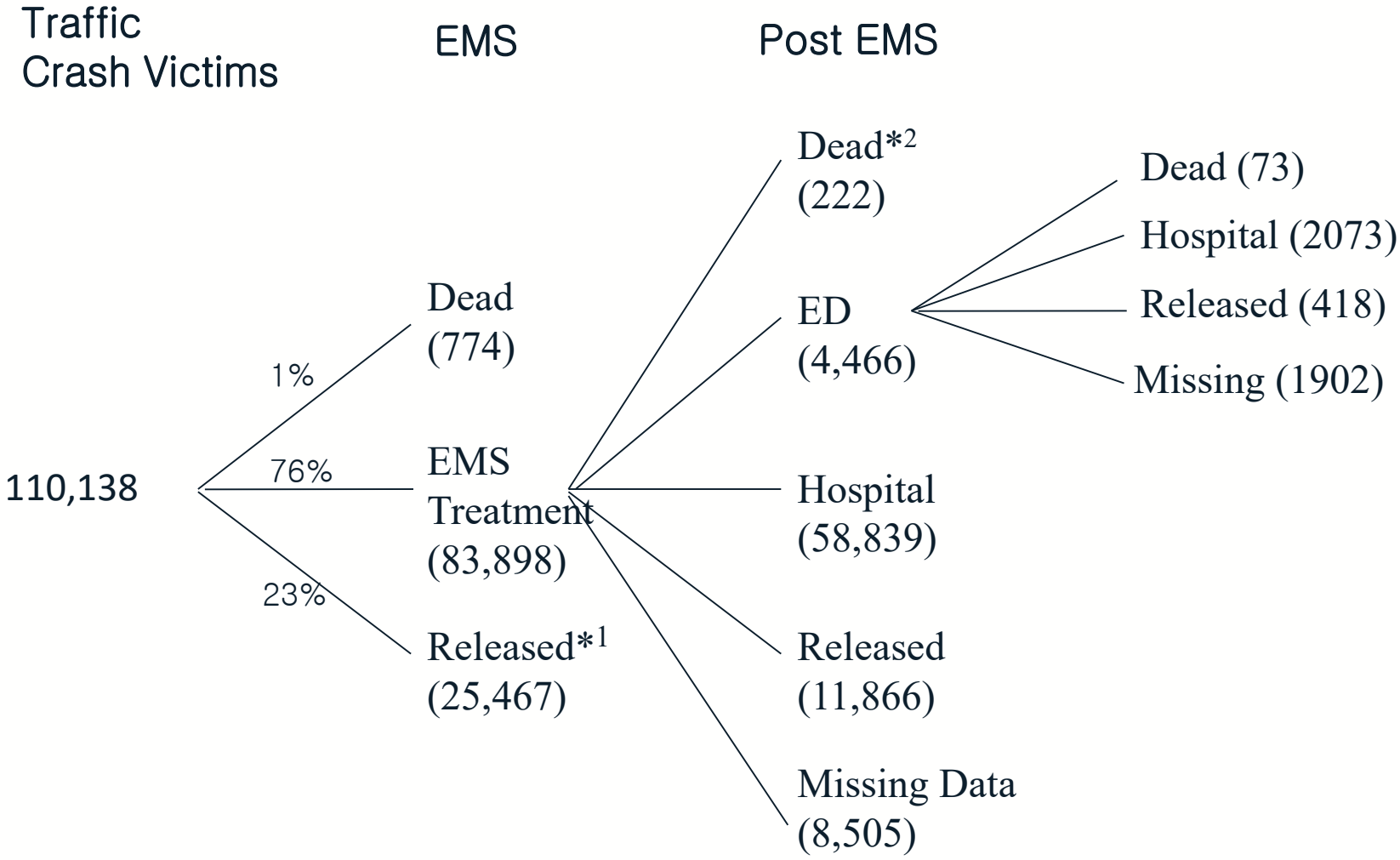
EMS Outcome Matrix



Data	SWITRS	NEMSIS ED Intake	ED discharge	Hospital discharge	Vital status (e.g., NDI)
Fatality	X	X	X	X	X
Morbidity/Disability		X	X	X	
Hospitalization				X	X
QALYS				X	X
Cost		X	X	X	X

D=Died, S=Survived, R=Released

ED = Emergency Department, Hos = Hospitalized



*1: Released includes cancelled calls(500), no patient found(104), no treatment required that didn't go to Morgue (2221), and patient refused care (22641)

*2: Dead at EMS includes patients treated by EMS and transferred to morgue