

AWARD NUMBER: W81XWH-17-2-0010

TITLE: Multi-institutional Multi-disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC)

PRINCIPAL INVESTIGATOR: Dr. Brian Eastridge

CONTRACTING ORGANIZATION:

National Trauma Institute d/b/a Coalition for National Trauma Research
San Antonio, TX

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14. ABSTRACT The purpose of this project is to focus efforts on a comprehensive review of 3,000 civilian prehospital injury deaths. A multidisciplinary study group will apply the framework and methodology that was developed to identify causes and mechanisms of death and estimate potential survivability. The study will describe the epidemiology of pre-hospital mortality in the context of trauma system development and estimate impact on society. The results will assist in the development of a blueprint for a sustained effort at public health injury mitigation strategies in the pre-hospital environment, identifying high priority areas for injury prevention, trauma systems performance improvement, and opportunities for advancements in research and development.					
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TABLE OF CONTENTS

	<u>Page</u>
1. Introduction	4
2. Keywords	4
3. Accomplishments	4
4. Impact	10
5. Changes/Problems	11
6. Products	12
7. Participants & Other Collaborating Organizations	14
8. Special Reporting Requirements	16
9. Appendices	16

1. INTRODUCTION:

Advances in care in both trauma centers and trauma systems have substantially reduced death and disability associated with injury. However, there remains a substantial opportunity to further reduce deaths in the pre-hospital setting. Potential liabilities in civilian and military pre-hospital care must be identified and remediated in order to reduce the number of potentially preventable deaths on the battlefield and in the civilian environment. The purpose of this proposal is to develop a coordinated, multidisciplinary, multi-institutional effort within the civilian clinical sector to identify and characterize the causes of mortality from trauma in the pre-hospital setting and to identify potential high yield areas for research and development in pre-hospital medical care, injury prevention, and trauma systems. This effort will conduct a review of 3,000 pre-hospital deaths in six areas of the country to develop a more comprehensive understanding of the epidemiology of pre-hospital deaths and their potential survivability with the ultimate goal of identifying liabilities in our current trauma system and improving survival of both civilian and military casualties.

2. KEYWORDS:

Prehospital deaths, survivability, preventable deaths, trauma systems, system improvements

3. ACCOMPLISHMENTS:

What were the major goals of the project?

Objective #1: Develop a framework and methodology for evaluating (i) the causes and pathophysiologic mechanisms of pre-hospital deaths; (ii) the appropriateness of EMS response and care delivered; and (iii) the potential for survivability under both optimal clinical circumstances and within the context of the actual pre-hospital environment.			
Major Task 1: Adapt Protocol for Submission and Determination	Months	Completion Date	% Complete
Subtask 1: Prepare Regulatory Documents and Research Protocol for Study	1-3	1/25/2018	100%
Coordinate with Sites for IRB protocol determination as NHR	1-3	2/7/2018	100%
Coordinate with Sites for Military 2nd level IRB review (ORP/HRPO)	1-6	N/A	N/A
Submit amendments, and protocol deviations as needed	As Needed		N/A
<i>Milestone Achieved: Local IRB determination at UTHSCSA</i>	3	01/31/2018	100%

<i>Milestone Achieved: HRPO acknowledgement for all protocols and local IRB determination as NHR through Sites</i>	6	12/28/2016	100%
Major Task 2: Development of the review criteria	Months	Completion Date	% Complete
Subtask1: Develop consensus regarding definitions and rules	1-3	09/13/2017	100%
Subtask 2: Delivery of review criteria, definitions, and procedures to the government for recommendations and approval.	4	09/18/2017	100%
<i>Milestone Achieved: Government recommendations and approval of review criteria, definitions, and procedures</i>	4	10/11/2017	100%
Objective #2: Organize and standardize a multidisciplinary, multi-institutional network of experts who will apply the methodology described above to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability. Study Group members will be trained to ensure standardization of assessments within and across panels.			
Major Task 1: Provide training to Study Group members	Months	Completion Date	% Complete
Subtask 1: Hold series of meetings by teleconference	3	01/07/2019	100%
<i>Milestone Achieved: Completed Study Group training</i>	3	01/07/2019	100%
Objective #3: Using the methodology and network of experts described above, define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths occurring in 6 regions of the country, and estimate the potential for survivability by mechanism of injury (e.g. blunt versus penetrating), geographic location of the injury (urban, suburban, rural, wilderness), the maturity of the local trauma system, and age of the decedent.			
Major Task 1: Abstract data for all cases and enter into REDCap	Months	Completion Date	% Complete
Subtask 1: Perform AIS Coding (<i>AIS coding 58% complete</i>)	2-24		100%
Major Task 2: Develop Profiler Review	Months	Completion Date	% Complete
Subtask 1: Develop Profiler Review System	8-18	08/23/2018	100%
Subtask 2: Conduct Profiler System Testing	18-23	12/10/2018	100%
<i>Milestone Achieved: Profiler system is used to conduct online reviews</i>	23	1/16/2019	100%
Major Task 3: Perform online mortality reviews	Months	Completion Date	% Complete
Subtask 1: Disseminate cases to review team monthly	24-33	7/22/2022	100%
<i>Milestone Achieved: All panel reviews completed and data submitted</i>	33		95%
Objective #4: Describe the epidemiology of pre-hospital mortality in the context of trauma system development and estimate its impact on society. The societal impact of pre-hospital deaths will be measured in terms years of potential life lost and lost productivity. Most important, estimates of potential cost savings will be derived based on the analysis of potential survivability.			
Major Task 1: Data Analysis	Months	Completion Date	% Complete
Subtask 1: Coordinate with Sites & Data Core for monitoring data collection and data quality	4-36	07/31/2022	100%
Subtask 2: Perform all analyses according to specifications, share	6-39		

output and finding with all investigators			85%
<i>Milestone Achieved: Report results from data analysis</i>			0%
Objective #5: Develop a blueprint for a sustained effort at public health injury mitigation strategies in the pre-hospital environment, identifying high priority areas for injury prevention, trauma systems performance improvement as well as opportunities for advancements in research and development.			
Major Task 1: Steering Committee analysis and results dissemination planning	Months	Completion Date	% Complete
Subtask 1: Work with data core and dissemination of findings (abstracts, presentation, publications, DOD, blueprint)	36-42		30%
<i>Milestone Achieved: Dissemination materials produced</i>	42		0%

What was accomplished under these goals?

Obj 1: Develop a framework and methodology for evaluating (i) the causes and pathophysiologic mechanisms of pre-hospital deaths; (ii) the appropriateness of EMS response and care delivered; and (iii) the potential for survivability under both optimal clinical circumstances and within the context of the actual pre-hospital environment.

Major Task 1: Adapt Protocol for Submission and Determination

Progress: Completed in Year 1

Major Task 2: Development of the Review Criteria

Progress: Completed in Year 1

Obj. 2: Organize and standardize a multidisciplinary, multi-institutional network of experts who will apply the methodology

- The current MIMIC review team consists of eighty reviewers from various disciplines including trauma surgery, pediatric trauma surgery, orthopedic surgery, neurosurgery, forensic pathology, prehospital care, EMS, and trauma systems. Representatives from both military and civilian sectors are represented on each review team. All MIMIC reviewers completed a survey via SurveyMonkey. The goal of the survey was to collect demographic and background information from each reviewer to ensure that we created multidisciplinary, multi-institutional, and diverse team compositions. The study team creates 13 team panels. Each panel has 6 team members: four surgeons, one Emergency Medicine/EMS member, and one Forensic member.

Major Task 1: Provide training to Study Group members

Progress: All reviewers completed training through various opportunities in Year 2.

Subtask 1: Hold series of meetings by teleconference

- Study team meets ongoing with reviewers who have questions or need additional training regarding case reviews and adjudication.

Obj. 3: Using the methodology and network of experts, define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths.

- Data requests have been submitted to receive NEMESIS data from each of the six states for cases in the MIMIC study that had an EMS intervention.
 - Oklahoma NEMESIS data was received on **17-Jun-2019**
 - Maryland NEMESIS data was received on **15-Sept-2020**
 - Washington DC data was received on **05-Aug-2021**
 - New Mexico data was received on **31-Mar-2022**
 - Connecticut was unable to retrieve their data due to a data corruption loss in their state. The study team was able to work with the ME team in the state to confirm inclusion criteria was met and additional information was included for all records. The absence of EMS data for Connecticut data will not negatively impact the project. Connecticut ME office was able to provide very thorough data. EMS data is aimed at providing additional information.
 - Iowa request denied due to the small number of cases. There is no major impact to the project. Iowa ME office was able to provide very thorough data. EMS data is aimed at providing additional information.

Major Task 1: Abstract data for all cases and enter into REDCap

Progress: All six Medical Examiner sites completed case abstraction in Year 3. GIS coding of all cases was also completed in Year 3. AIS coding, and ICD coding has been completed.

Subtask 1: Perform AIS coding

- As of **March 2021**, AIS and ICD coding has been completed for all cases.

Major Task 2: Develop Profiler Review System to Conduct Online Case Reviews

Subtask 1: Develop Profiler Review System

- Development was completed and all Profiler changes were finalized in Year 2

Subtask 2: Conduct Profiler System Testing

- Progress: The development of the Profiler system was completed in Year 2 and has been successfully running. System testing occurs on an ongoing basis. The Profiler development team works closely with the MIMIC study team to ensure that reviewers are able to complete initial case reviews, and online adjudication reviews through a seamless online process. Ongoing edits are incorporated into the Profiler system to improve user experience. The study team is available to present the Profiler review system. Please let us know if you would like us to provide a demo in-person, or via webinar.

Major Task 3: Perform online mortality reviews

Progress: Case reviews are currently in progress by all 13 review team panels. To date, all 2,896 cases completed initial reviews to determine survivability. Cases were launched by panel in a rolling timeline. The dates below indicate when the first panel was released for each round. During the review process, we have included online case adjudication for cases that do not meet initial consensus. At the time of this report, 2,896 cases have been released to panels for review. Out of those cases, 168 cases are still under adjudication. Three review teams have been formed to review final case adjudication.

Subtask 1: Disseminate Cases to review Team Monthly

- Round 1 cases were launched. 16-Jan-2019
- Round 2 cases were launched. 22-March-2019
- Round 3 cases were launched. 13-Jun-2019
- Round 4 cases were launched. 27-Sept-2019
- Round 5 cases were launched. 16-Jan-2020
- Round 6 cases were launched. 27-Jul-2020
- Round 7 cases were launched. 21-Sept-2020
- Round 8 cases were launched. 18-May-2021
- Round 9 cases were launched 31-Aug-2021
- Round 10 cases were launched 22-Jul-2022

Obj. 4: Describe the epidemiology of pre-hospital mortality in the context of trauma system development and estimate its impact on society. The societal impact of pre-hospital deaths will be measured in terms years of potential life lost and lost productivity. Most important, estimates of potential cost savings will be derived based on the analysis of potential survivability.

Major Task 1: Data Analysis

Progress: Since all cases have now been abstracted, Johns Hopkins University has begun running preliminary data analysis. The study team has also developed data quality strategies that have been implemented to clean up data. JHU is currently completing data analysis on case reviews from Forensic Science Reviewers, since their work is 100% done.

Subtask 1: Coordinate with Sites & Data Core for monitoring data collection and data quality

- Data quality checks are complete.

Subtask 2: Perform all analyses according to specifications, share output and finding with all investigators

- Preliminary data findings have been shared with the MIMIC study group. The study team is drafting the main manuscript to be submitted to JAMA.

Obj. 5: Develop a blueprint for a sustained effort at public health injury mitigation strategies in the pre-hospital environment, identifying high priority areas for injury prevention, trauma systems performance improvement as well as opportunities for advancements in research and development.

***Major Task 1: Steering Committee analysis and results dissemination planning
Subtask 1: Work with data core and dissemination of findings***

- Progress: Preliminary data has been presented in several products to date. A Publications Committee was created to formalize the process of submitting papers for publication using the MIMIC data.
- MIMIC Study Group will be used on all MIMIC related publications to include authorship contribution form the entire review team.

What opportunities for training and professional development has the project provided?

Nothing to Report

How were the results disseminated to communities of interest?

Nothing to Report

If this is the final report, state “Nothing to Report.” Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

- Close out case adjudication
- Submit program process methods paper
- Finalize data analysis graphs and tables to be included in the main publication
- Data analysis

4. IMPACT:

What was the impact on the development of the principal discipline(s) of the project?

Nothing to Report

What was the impact on other disciplines?

Nothing to Report

What was the impact on technology transfer?

Nothing to Report

What was the impact on society beyond science and technology?

Nothing to Report

5. CHANGES/PROBLEMS:

Changes in approach and reasons for change

Actual or anticipated problems or delays and actions or plans to resolve them

After experiencing a major slowdown of case reviews since reviewers during the COVID-19 pandemic, reviewers were able to complete all initial case reviews. The last step is to complete case adjudication, and data analysis.

Changes that had a significant impact on expenditures

Nothing to Report

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents

Significant changes in use or care of human subjects

Not applicable

Significant changes in use or care of vertebrate animals

Not applicable

Significant changes in use of biohazards and/or select agents

Not Applicable

6. PRODUCTS:

- **Publications, conference papers, and presentations**

- CNTR created a MIMIC Publications & Presentations list to share with the entire review team
- Nicolas W. Medrano, Cynthia Lizette Villarreal, N. Clay Mann, Michelle A. Price, Kurt B Nolte, Ellen J. MacKenzie, Pam Bixby, Brian J. Eastridge & for the MIMIC Study Group (2022) Activation and on-scene intervals for severe trauma EMS interventions: An analysis of the NEMESIS database, Prehospital Emergency Care, DOI: [10.1080/10903127.2022.2053615](https://doi.org/10.1080/10903127.2022.2053615)
- Nicolas W. Medrano MS, Cynthia Lizette Villareal MA, Michelle A Price PhD, Pam Bixby MA, Eileen Bulger MD, Brian J. Eastridge MD, MIMIC Study Group. Access to Trauma Care: A Statewide System-Based Approach. Submitted to Journal of Trauma and Acute Care Surgery. (Accepted)

Journal publications.

- Nicolas W. Medrano, Cynthia Lizette Villarreal, N. Clay Mann, Michelle A. Price, Kurt B Nolte, Ellen J. MacKenzie, Pam Bixby, Brian J. Eastridge & for the MIMIC Study Group (2022) Activation and on-scene intervals for severe trauma EMS interventions: An analysis of the NEMESIS database, Prehospital Emergency Care, DOI: [10.1080/10903127.2022.2053615](https://doi.org/10.1080/10903127.2022.2053615)
- Nicolas W. Medrano MS, Cynthia Lizette Villareal MA, Michelle A Price PhD, Pam Bixby MA, Eileen Bulger MD, Brian J. Eastridge MD, MIMIC Study Group. Access to Trauma Care: A Statewide System-Based Approach. Submitted to Journal of Trauma and Acute Care Surgery. (Accepted)

Books or other non-periodical, one-time publications.

Nothing to report

Other publications, conference papers and presentations.

Nothing to Report

- **Website(s) or other Internet site(s)**

Nothing to Report

- **Technologies or techniques**

Nothing to Report

- **Inventions, patent applications, and/or licenses**

Nothing to Report

- **Other Products**

• Nothing to Report

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

<i>Personnel</i>	<i>Role</i>	<i>Percent Effort</i>
Brian Eastridge	PI	20%
Amy Flores	Controller	5% Mar-Jun
Lizette Villarreal	Program Manager	30%
Michelle Price	Research Director	5%
Nick Medrano	GIS Analyst	25% Mar-Jun
Ana Guerrero	Executive Assistant	5%
Ashley Moreno	Research Associate	30% Nov-Mar
<i>Johns Hopkins University</i>	<i>Role</i>	<i>Percent Effort</i>

<i>subaward</i>		
Ellen Mackenzie	PI/Co-I	5%
Daniel Scharfstein	Lead Statistician	5%
Craig Remenapp	Study Manager	60% Mar-Sept
Elias Weston-Farber	Research Assistant	5%

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

Nothing to Report

What other organizations were involved as partners?

The six states below have contributed death data to the project for the total review of 3,000 prehospital death cases.

Organization Name	Location of Organization	Contribution to the Project
Oklahoma Office of the Medical Examiner	901 North Stonewall Oklahoma City, OK 73117	Death data
Washington DC Office of the Medical Examiner	401 E. Street SW Washington, DC 20024	Death data
Maryland Office of the Medical Examiner	900 W. Baltimore Street Baltimore, MD 21223	Death data
New Mexico Office of the Medical Examiner	1101 Camino de Salud NE Albuquerque, NM 87102	Death data
Iowa Office of the Medical Examiner	5244C Roy Carver Pavilion Iowa City, IA 52242	Death data
Connecticut Office of the Medical Examiner	11 Shuttle Road Farmington, CT 06032	Death data

8. SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS:

QUAD CHARTS:

Quad Chart Attached

9. APPENDICES:

- CNTR created a MIMIC Publications & Presentations list to share with the entire review team
- Nicolas W. Medrano, Cynthia Lizette Villarreal, N. Clay Mann, Michelle A. Price, Kurt B Nolte, Ellen J. MacKenzie, Pam Bixby, Brian J. Eastridge & for the MIMIC Study Group (2022) Activation and on-scene intervals for severe trauma EMS interventions: An analysis of the NEMESIS database, Prehospital Emergency Care, DOI: [10.1080/10903127.2022.2053615](https://doi.org/10.1080/10903127.2022.2053615)
- Nicolas W. Medrano MS, Cynthia Lizette Villareal MA, Michelle A Price PhD, Pam Bixby MA, Eileen Bulger MD, Brian J. Eastridge MD, MIMIC Study Group. Access to Trauma Care: A Statewide System-Based Approach. Submitted to Journal of Trauma and Acute Care Surgery. (Accepted)

Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC)

BA150629

W81XWH-17-2-0010



PI: Brian Eastridge

Org: National Trauma Institute

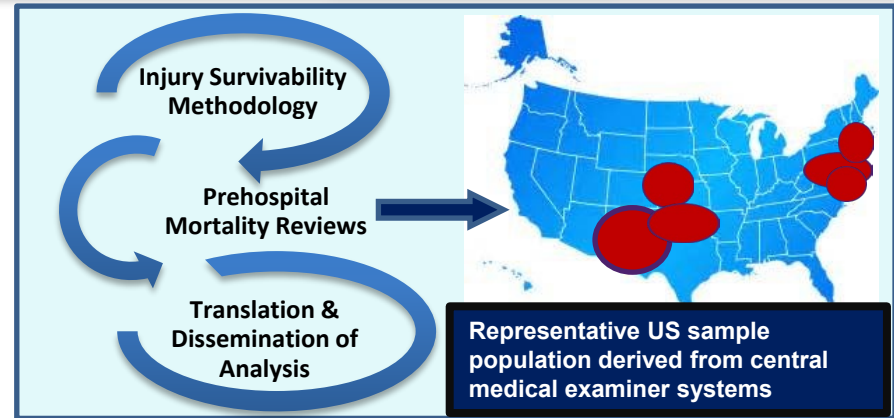
Award Amount: \$3,979,380

Study/Product Aim(s)

- Develop a framework and methodology for evaluating (i) the causes and pathophysiologic mechanisms of pre-hospital deaths; (ii) the appropriateness of EMS response and care delivered; and (iii) the potential for survivability under both optimal clinical circumstances and within the context of each individual injury event.
- Develop a blueprint for a sustained effort at public health injury mitigation strategies including injury prevention, trauma systems, and acute care.

Approach

The framework and methodology will be established by a multi-institutional network of experts who will apply the methodology in review and analysis of approximately 3,000 pre-hospital death cases at six Medical Examiner sites including those serving urban, rural, and frontier environments.



Accomplishment: All study cases reviews have been completed. The project is currently in the adjudication phase for cases that did not meet consensus within the team panel.

Timeline and Cost

Activities	CY	17	18	19	20-23
Adapt Protocol for Submission; Develop review criteria		■	■		
Provide training to reviewers; Abstract data			■	■	
Perform mortality reviews; Data analysis				■	■
Analysis and results dissemination					■
Estimated Budget (\$K)		\$1,026	\$1,198	\$1,225	\$546

Goals/Milestones

CY17 Goal – Methodology determined, reviewers trained, data abstraction and reviews begin

Protocol submitted; methodology determined

CY18, CY19, CY20, CY21 Goals – Virtual Reviews commence

Data abstraction

Reviews in progress

CY22 –CY23 Goal – Data analysis, result dissemination

Reviews and adjudication in progress

Report results from data analysis and dissemination materials produced

Comments/Challenges/Issues/Concerns

- Case adjudication being completed and data analysis

Budget Expenditure to Date

• Projected Expenditure: \$3,994,076

• Actual Expenditure: \$3,912,382.66 (as of 03-19-23)

Updated: (20 April 2023)



MIMIC Publications & Presentations

Journal Publications

- **Medrano NW, Villarreal CL, Price MA, Bixby P, Bulger E, Eastridge BJ, MIMIC Study Group. (2023). Access to Trauma Care: A Statewide System-Based Approach.** Submitted to Journal of Trauma and Acute Care Surgery. (*Accepted*)
Mini Abstract: This study provides an approach to determine more robust statewide estimates of access to care. We created a trauma system model comprised of ground EMS (GEMS), helicopter EMS (HEMS), and designated level I - V trauma centers while incorporating geographic information systems (GIS) along with traffic data and census block group data to estimate population access to trauma care within the “golden hour.” It highlights the need for a national trauma system, one in which all components of state-managed trauma systems are assembled in a national dataset to accurately identify gaps in care.
- **Medrano NW, Villarreal CL, Mann NC, Price MA, Nolte, KB, MacKenzie, EJ, Bixby P, Eastridge BJ, MIMIC Study Group (2022).** Activation and on-scene intervals for severe trauma EMS interventions: An analysis of the NEMSIS database, Prehospital Emergency Care, April 2022.
<https://doi.org/10.1080/10903127.2022.2053615>
Mini Abstract: In this article we performed a modern analysis of prehospital intervals to establish current standards and temporal patterns. We utilized NEMSIS to analyze EMS data of trauma patients. With the increasing sophistication of geospatial technologies employed to analyze access to care, these intervals are the most accurate and up-to-date and should be included in access to care models.
- **Medrano NW, Villarreal CL, Price MA, MacKenzie EJ, Nolte KB, Phillips MJ, Stewart RM, Eastridge BJ.** Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-hospital Environment (MIMIC): A methodology for reliably measuring pre-hospital time and distance to definitive care. Trauma Surgery and Acute Care Open. Vol. 4:1. January 2019; 4:e000309. doi:10.1136/tsaco-2019-000309. <https://tsaco.bmj.com/content/4/1/e000309>
Mini Abstract: This article described the methodology used to estimate total pre-hospital time and distance for trauma patients transported via ground or air EMS when EMS was not involved. Using geographic information systems (GIS), trauma networks were built for each study site and total pre-hospital time estimates were provided to reviewers when making survivability determinations.

Poster Abstract Presentations

- **Medrano NW, Villareal CL, Price MA, Eastridge BJ, MIMIC Study Group.** Statewide system-based geographic approach to trauma care access. Abstract presented as poster presentation to the 2020 AAST conference, September 2020 (virtual conference).
Mini Abstract: This study created GIS models for four MIMIC study sites to estimate statewide population access to trauma care within the “Golden-Hour”. Results show smaller geographic states (CT, MD) have more access, with the larger states (NM, OK) having much less accessibility, especially when utilizing solely ground EMS.
- **Medrano NW, Villareal CL, Price MA, Eastridge BJ, MIMIC Study Group.** Statewide system-based geographic approach to trauma care access. Graphic posted online at the ESRI 2020 User Conference (virtual conference).
Mini Abstract: Maps created for the “Statewide system-based geographic approach to trauma care access”, were displayed during the ESRI plenary session as examples of the power GIS has to support public health research.

- **Villarreal CL, Medrano NW, Remenapp CM, Wang Z, MacKenzie EJ, Nolte KB, Price MA, Eastridge BJ, MIMIC Study Group.** Evaluating Inter-rater Reliability When Determining Pre-Hospital Injury Survivability. Abstract accepted for poster presentation to the 2020 U.S. Military Health System Research Symposium (virtual conference).
Mini Abstract: This study analyzed the inter-rater reliability of survivability judgements for pre-hospital trauma deaths for the MIMIC study. In this preliminary analysis of 1,174 cases, results demonstrate significant consistency amongst multispecialty reviewers in making pre-hospital injury survivability determinations.
- **Villarreal CL, Medrano NW, Phillips MJ, Price MA, Eastridge BJ, MIMIC Steering Committee.** Improving the military-civilian taxonomy and process to determine pre-hospital injury survivability. Poster presentation at the U.S. Military Health System Research Symposium in August 2019.
Mini Abstract: This presentation describes data linkages and the formation of coordinated, multi-disciplinary, multi-institutional panels to identify and characterize the causes of mortality. Data available for survivability review determinations includes medical examiner autopsy data, AIS and ICD injury codes, geographic access to trauma care, and National EMS Information System (NEMESI) data when EMS was involved. The comprehensive nature of the MIMIC study has allowed the pre-hospital care research community to unify the pre-hospital injury survivability lexicon.

Presentations

- **Eastridge BJ.** Multi-Institutional Multidisciplinary Injury Mortality Investigation in Civilian Prehospital Environment (MIMIC): Establishing Societal Impact and Remediation Strategies. Presentation at the UT Health Think Tank Meeting, November 2021.
Mini Abstract: The Multi-Institutional Multidisciplinary Injury Mortality Investigation in Civilian Prehospital Environment (MIMIC) project is working to establish the societal impact and remediation strategies of potentially survivable deaths that occur in the prehospital environment.
- **Eastridge BJ.** Multi-institutional Multidisciplinary Injury Mortality Investigation in Civilian Prehospital Environment (MIMIC): Establishing Societal Impact and Remediation Strategies. Presentation at the 2021 Military City USA Trauma Collaborative Research Conference, October 2021.
Mini Abstract: The presentation detailed the need to understand and determine survivability of those that never reach the hospital for care. Most future opportunities to effect injury outcomes will be in the prehospital environment.
- **Eastridge BJ.** Multi-institutional Multidisciplinary Injury Mortality Investigation in Civilian Prehospital Environment (MIMIC): Trauma system Implications Civilian Prehospital Mortality. Presentation at the American College of Surgeons Committee on Trauma in Chicago, Illinois; October 2021.
Mini Abstract: This presentation showed the value of understanding battlefield mortality in military context and the translation of combat casualty care lessons to civilian injury management. The need to develop and implement mitigation strategies for therapy and injury prevention to improve trauma systems was discussed.
- **Eastridge BJ.** Civilian Prehospital Trauma Mortality. Presentation at the National Association of Emergency Medical Technicians (NAEMT) World Trauma Symposium in Atlanta, GA, October 2021.
Mini Abstract: This presentation highlighted the need to gain a more comprehensive understanding of prehospital injury mortality to make future improvements in trauma care. Discussed the need to have specific targets for future focus on research and development to improve the prehospital management and outcomes of the injured patient.
- **Eastridge BJ.** Multi-institutional Multi-disciplinary Injury Mortality Investigation in Civilian Prehospital Environment (MIMIC): Focus on Improving Prehospital Trauma Survival. American Trauma Society webinar presentation, September 2021.
Mini Abstract: This webinar detailed the goals and objectives of the MIMIC study. The plan is to establish the epidemiology of potentially survivable injury and preventable deaths after injury.

- **Eastridge, BJ.** Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC). UT Health San Antonio Research Week, Department of Surgery Podium Presentation. April 2021. <https://lsom.uthscsa.edu/office-research/research-day-2021/>
Mini Abstract: The presentation detailed the multidisciplinary, and multi-institutional approach to evaluating potentially survivable trauma deaths.
- **Medrano NW** Geographic Information System (GIS) Research in Trauma. Presentation at UT Trauma Think Tank Meeting in San Antonio, Texas, May 2020.
<https://storymaps.arcgis.com/stories/00b2884faf5648fe899c3018fb3d5e74>
Mini Abstract: This presentation acted as an introduction to GIS principles and common applications in the field of public health. Topics included access to care, incident clustering, and risk terrain modeling.
- **Villarreal CL, Medrano NW, Remenapp CM, Wang Z, MacKenzie EJ, Nolte KB, Price MA, Eastridge BJ, MIMIC Study Group.** Evaluating Inter-rater Reliability When Determining Pre-hospital Injury Survivability. Presented by Dr. Brian Eastridge at the 2020 Military City USA Trauma Collaborative Research Conference (virtual conference).
Mini Abstract: This study analyzed the inter-rater reliability of survivability judgements for pre-hospital trauma deaths for the MIMIC study. In this preliminary analysis of 1,174 cases, results demonstrate significant consistency amongst multispecialty reviewers in making pre-hospital injury survivability determinations.
- **Villarreal CL, MA, Medrano NW, Remenapp CM, Wang Z, MacKenzie EJ, Nolte KB, Price MA, Eastridge BJ, MIMIC Study Group.** Examining Differences In Injury Survivability Determinations Between Medical Examiners and Trauma Surgeons Evaluating Pre-hospital Trauma Deaths. Accepted for Podium Presentation to the 2020 National Association of Medical Examiner Conference (virtual conference).
Mini Abstract: This preliminary analysis of 607 pre-hospital mortality cases compared survivability determinations between trauma surgeon and medical examiner (ME) reviewers. Assuming immediate access to care, MEs and surgeons determined that 81% and 72%, of cases were nonsurvivable, respectively. Furthermore, MEs and surgeons determined that 13% and 23% of cases were potentially survivable, respectively. Discrepancies between these two groups indicates bias based on the different professional experience of the communities.
- **Eastridge BJ, Nolte KB, MacKenzie EJ, Stewart RM, Villarreal CL, Medrano NW, Price MA, Davis GG, Maxson RT, Mazuchowski EL, MIMIC Study Group.** Preliminary Analysis of the Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC). Podium presentation at the 2020 Western Trauma Association meeting.
Mini Abstract: This preliminary analysis of 436 pre-hospital mortality cases had 94.9% panel consensus. Assuming immediate access to care, potentially survivable mortality was 22.2%. Given the actual scenario, potentially survivable mortality was 6.0%. This preliminary analysis of pre-hospital injury mortality develops a perspective of relative importance of injury mortality causation in the pre-hospital environment.
- **Eastridge BJ.** Potentially Survivable Injury and Potentially Preventable Deaths from Traumatic Injuries. Presentation at the AABB THOR Conference, October 2019.
Mini Abstract: Presented preliminary MIMIC data of 339 cases showing 23% potential survivability assuming immediate access to care and 7% potential survivability given the actual scenario.
- **Eastridge, BJ.** Combat Casualty Mortality: Survivability of Injury, Preventability of Death and their Implications to the Joint Trauma System and the Warfighter. Combat Trauma Care Workshop, October 2019.
Mini Abstract: Presented MIMIC role in supporting research to understanding combat casualty mortality and development targets for mitigation strategies. Preliminary MIMIC data of 414 cases shows 21% potential survivability assuming immediate access to care and 6% potential survivability given the actual scenario.

- **Eastridge, BJ.** Pre-hospital Mortality, The Missing Dead: Implications for the Trauma System Development. Presentation at the American College of Surgeons TQIP Annual Meeting, October 2019.
Mini Abstract: Presented preliminary MIMIC data of 414 cases showing 21% potential survivability assuming immediate access to care and 6% potential survivability given the actual scenario.
- **Eastridge BJ.** Pre-hospital Blood Utilization Increasing Survivability After Injury. Presentation at the Norman McSwain EMS Conference, October 2019.
Mini Abstract: Presented data demonstrating high mortality rate in trauma patients who require MTP, recommended development and implementation of a prehospital whole blood transfusion program.
- **Villarreal CL, Medrano NW, Phillips MJ, Price MA, MIMIC Steering Committee, Eastridge BJ.** Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): Concept of Utilizing Medical Examiner Data to Determine Pre-hospital Injury Survivability. Podium presentation at the National Association of Medical Examiners annual meeting, October 2019.
Mini Abstract: This presentation given to forensic pathologists emphasized the need for increased partnership and collaboration between the ME and trauma system communities. It detailed the extent to which the MIMIC project is utilizing a wide array of data sources and created a multi-disciplinary cohort of professionals from the ME, EMS, and trauma communities.
- **Eastridge BJ.** Medical Examiner Role in Trauma System Development. Podium presentation at National Association of Medical Examiner Conference in West Palm Beach, Florida, October 2018.
Mini Abstract: This presentation emphasized the need to identify liabilities in trauma systems and develop mitigation strategies with translation potential for realistic and relevant improvements in trauma systems and medical examiner systems.
- **Eastridge BJ.** Traumatic Hemorrhagic Shock Outcomes and Preventable Death Epidemiology: MIMIC. Podium presentation at the Trauma Hemostasis and Oxygenation Research (THOR) RDCR Symposium in Norway, June 2018.
Mini Abstract: This presentation described the epidemiology of potentially survivable injury and preventable deaths after injury in adults and children Enhance and improve the quality of clinical practice in order to improve outcomes for patients with hemorrhagic shock.
- **Eastridge BJ.** Injury Mortality Surveillance System: Rationale and Development of Preventable Death Analysis in Civilian Environment. Podium presentation at the Southwest Texas Advisory Council for Trauma (STRAC) meeting, November 2017.
Mini Abstract: Presentation on the need for conducting a preventable death analysis in the prehospital environment. Demonstrated the importance of developing an injury mortality surveillance system in the civilian environment.
- **Eastridge BJ.** Trauma Surgeon and the Forensic Pathologist. Podium presentation at the National Association of Medical Examiners (NAME) Conference, October 2017.
Mini Abstract: The research intends to identify ways that the ME and trauma communities can improve linkages to foster in-depth reviews of trauma mortality.



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

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Activation and On-Scene Intervals for Severe Trauma EMS Interventions: An Analysis of the NEMSIS Database

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ABSTRACT

Objective: Time to care is a determinant of trauma patient outcomes, and timely delivery of trauma care to severely injured patients is critical in reducing mortality. Numerous studies have analyzed access to care using prehospital intervals from a Carr et al. meta-analysis of studies from 1975 to 2005. Carr et al.'s research sought to determine national mean activation and on-scene intervals for trauma patients using contemporary emergency medical services (EMS) records. Since the Carr et al. meta-analysis was published, the National Highway Traffic Safety Administration (NHTSA) created and refined the National Emergency Medical Services Information System (NEMSIS) database. We sought to perform a modern analysis of prehospital intervals to establish current standards and temporal patterns.

Methods: We utilized NEMSIS to analyze EMS data of trauma patients from 2016 to 2019. The dataset comprises more than 94 million EMS records, which we filtered to select for severe trauma and stratified by type of transport and rurality to calculate mean activation and on-scene intervals. Furthermore, we explored the impact of basic life support (BLS) and advanced life support (ALS) of ground units on activation and on-scene time intervals.

Results: Mean activation and on-scene intervals for ground transport were statistically different when stratified by rurality. Urban, suburban, and rural ground activation intervals were 2.60 ± 3.94 , 2.88 ± 3.89 , and 3.33 ± 4.58 minutes, respectively. On-scene intervals were 15.50 ± 10.46 , 17.56 ± 11.27 , and 18.07 ± 16.13 minutes, respectively. Mean helicopter transport activation time was 13.75 ± 7.44 minutes and on-scene time was 19.42 ± 16.09 minutes. This analysis provides an empirically defined mean for activation and on-scene times for trauma patients based on transport type and rurality. Results from this analysis proved to be significantly longer than the previous analysis, except for helicopter transport on-scene time. Shorter mean intervals were seen in ALS compared to BLS for activation intervals, however ALS on-scene intervals were marginally longer than BLS.

Conclusions: With the increasing sophistication of geospatial technologies employed to analyze access to care, these intervals are the most accurate and up-to-date and should be included in access to care models.

ARTICLE HISTORY

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Introduction

Injury remains the leading cause of death in individuals up to the age of 44 and the leading cause of morbidity and mortality among children in the U.S. (1). Of these trauma deaths, between 200,000 and 300,000 over 10 years would be potentially preventable if the patients received rapid and high-quality trauma care (2, 3). Furthermore, a 2016 report from the National Academies of Science, Engineering and Medicine (NASEM), entitled "A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury," estimated that approximately 30,000 of the 147,790 people who died as a result of trauma in 2014 had potentially survivable injuries (4). During the last several decades, advances in care in trauma centers and across trauma systems have substantially

reduced death and disability associated with injury (5, 6). However, there remains a substantial opportunity to further reduce the number of deaths in the prehospital setting.

The first hour after traumatic injury is historically known as the "golden hour" and is the period of care following an injury in which rapid assessment and resuscitation are fundamental to survival (7). Though there is no true golden hour, the time lapse between injury and care is a critical element for patients with severe injury (8–12), with longer prehospital transport times likely contributing to higher mortality rates in more severely injured patients. This effect is more prominent among rural trauma patients than similarly injured urban patients (13–17). To substantiate this assertion, it has been demonstrated that states with poor trauma care access have more prehospital deaths,

Table 1. Data elements used for trauma case selection.

Data element	V2 code	V3 code	Code description	
Type of service	30	2205001	911 response	
Response mode to scene	390	2224015	Lights and sirens	
Complaint reported by dispatch	410	2301005	Animal bite	
	415	2301007	Assault	
	N/A	2301009	Automated crash notification	
	430	2301015	Burns	
	470	2301029	Electrocution	
	475	2301031	Eye problem	
	480	2301033	Fall victim	
	495	2301045	Heat/cold exposure	
	500	4301043	Hemorrhage/laceration	
	505	2301047	Industrial accident	
	530	2301063	Stab/gunshot wound	
	540	2301069	Traffic accident	
	545	2301073	Traumatic injury	
Possible injury	1	9922005	Yes	
Transport mode from scene	4965	4218011	Lights and sirens	
Type of destination	7280	4221003	Hospital	
Unit transport and equipment	7340	4221015	Other EMS responder	
	1030	2207011	Air transport-helicopter	
		2207003	Ground transport	
	990	2215001	BLS – first responder	
	995	2215003	BLS – basic/EMT	
		2215005	BLS – AEMT	
		2215007	BLS – intermediate	
		2215023	BLS – community paramedicine	
		1000	2215009	
		1005	2215011	ALS – AEMT
	1010	2215013	ALS – intermediate	
		2215015	ALS – paramedic	
		2215017	ALS – community paramedicine	
		2215019	ALS – nurse	
			ALS – physician	

contributing to higher overall injury mortality (9). Because of the “access effect” on mortality and morbidity rates, having an accurate understanding of prehospital intervals is imperative to identifying geographic “trauma care deserts,” where there is decreased access to immediate care.

Numerous researchers have created models to analyze access to trauma care in recent years, breaking the total prehospital time into four time intervals: activation, response, on-scene, and transport. The activation interval is defined as the time from emergency call to ambulance dispatch. The response interval is the time from ambulance dispatch to arrival at the scene. The on-scene interval is the time from ambulance arrival at the scene to the time the ambulance departs from the scene. Finally, the transport interval is the time from ambulance departure from the scene to arrival at the hospital. Many of the models created to estimate access to care have used mean activation and on-scene intervals calculated from a 2005 meta-analysis conducted by Carr et al. (18). Some models combine mean activation and on-scene times from this meta-analysis with mean driving speeds based on rurality (19–22), while more recent studies have begun utilizing geographic information systems (GIS) and road networks built with actual traffic data (23–26). Results from the 2005 meta-analysis (18) of 49 observational studies have been immensely valuable; however, we believe mean activation and on-scene intervals derived from more current datasets will be more applicable to the current era of trauma care and systems and would better support future access to care research. This study aimed to recalculate and update activation and on-scene prehospital intervals using datasets from a single data source, the National

Emergency Medical Services Information System (NEMSIS). In doing so, our goal was to produce empirically derived prehospital means from more contemporary data to support future access to care models and provide a blueprint for future utilization of the NEMSIS dataset for time analyses.

Methods

Data Collection

National Emergency Medical Services Information System records were obtained for 2016–2019, accounting for approximately 94.5 million EMS events over four years. The NEMSIS database is a product of the National Highway Traffic Safety Administration’s (NHTSA) Office of EMS, which uses a universal standard for patient care information resulting from an emergency 911 call for assistance. The NEMSIS is a collaborative system created to improve patient care through standardization, aggregation, and utilization of point of care EMS data at a local, state, and national level. The data was submitted by more than 11,000 participating EMS agencies in 49 states. In 2017, the NEMSIS Version 2 data dictionary standard officially closed, and states migrated to Version 3. Therefore, this analysis comprises data from Version 2 and Version 3 data dictionaries (27).

Case Selection

Each year’s dataset was imported into SAS 9.4 for analysis, where data elements were used to select EMS responses for

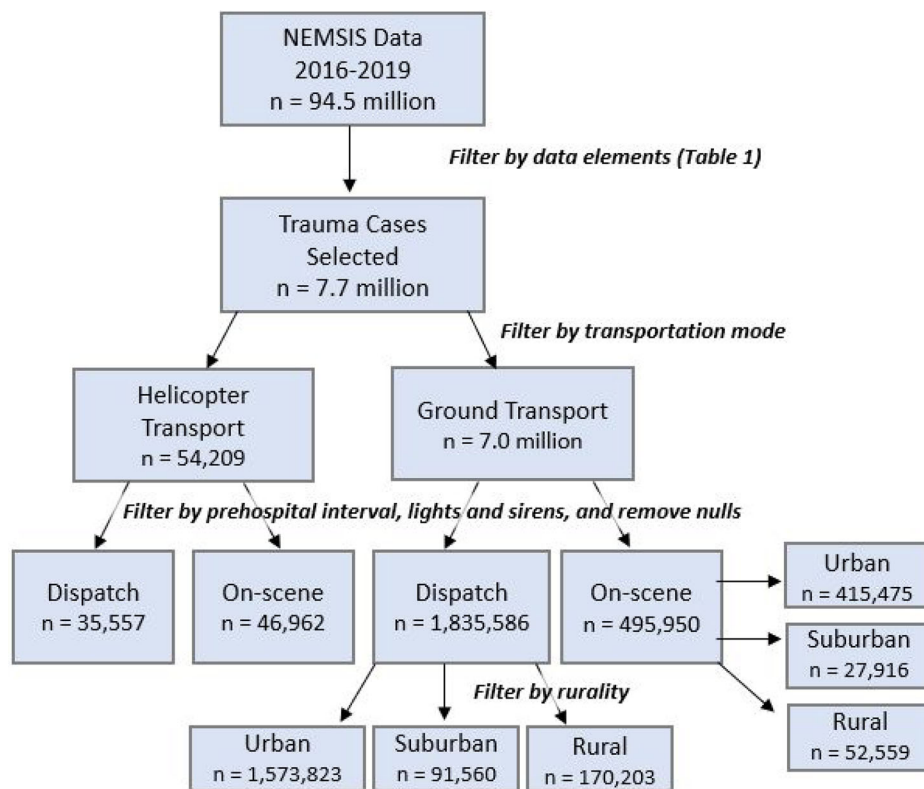


Figure 1. Filter diagram of NEMSIS data.

severe traumatic injury. We defined trauma cases through a combination of data elements: type of service, response mode to scene, complaint reported by dispatch, possible injury, transport mode from scene, and type of destination (Table 1). Lights and sirens being utilized for response mode to scene and transport mode from scene was used to identify time-sensitive severe trauma cases where EMS responders facilitated patient transport in an urgent manner.

After the selection of severe trauma cases, records were filtered by transportation type, level of care basic life support (BLS) and advanced life support (ALS), and rurality. Due to their lower frequency, helicopter transport cases were not stratified by rurality. Rurality in NEMSIS is categorized by USDA Urban Influence Codes that form a classification scheme distinguishing metropolitan counties by population size of the metro area, and nonmetropolitan counties by the size of the largest city or town and proximity to metro areas (28). Ground transport cases were stratified by rurality into urban, suburban, and rural cohorts. This is an important qualification, as EMS infrastructure, resources, and operations vary significantly among these environments. Events coded as frontier/wilderness were also classified as rural. Finally, the NEMSIS data element *EMSSceneTime* was used for mean on-scene interval; and the elapsed time intervals *EMSDispatchCenterTime* and *EMSchuteTime* were summed for the mean activation interval. *EMSDispatchCenterTime* represents the time difference between when the 911 call is received by dispatch and when the ambulance unit is notified. *EMSchuteTime* represents the time difference between when the ambulance unit is notified and when it is en route. For activation intervals, lights and sirens were required for

the response interval to meet inclusion criteria. For the on-scene interval, lights and sirens were required for the transport interval to meet inclusion criteria (Figure 1).

Data Analysis

Case removal was required for records with null values for any time element, times less than or equal to zero, and outliers. Derived elapsed time elements were excluded from the analysis if outside the standardized range set by NEMSIS (29). This includes dispatch times greater than, or equal to, one hour and on scene times greater than, or equal to, one day. Median, mean and standard deviation was calculated for both activation intervals, and on-scene intervals, and Student's *t-Tests* were performed for statistical comparisons between transportation type and rurality. Finally, an Independent Samples *t-Test* was used to compare this NEMSIS analysis with Carr et al.'s meta-analysis results.

Results

In total, approximately 1.9 million records were identified for activation interval analysis, represented by 35,557 air transport and 1,835,586 ground transport activations. Urban EMS activations accounted for most ground transport findings, with 1,573,823 events. For the on-scene interval, 542,912 EMS activations were identified, represented by 46,962 helicopter transport and 495,950 ground transport events. Urban EMS on-scene events accounted for most ground transport findings, with 415,475 events. The EMS activations provided from the NEMSIS analysis were more

Table 2. Number of activations for prehospital intervals of helicopter and ground transport of trauma patients.

	Helicopter transport	Urban ground transport	Suburban ground transport	Rural ground transport
Activation interval				
NEMSIS	35,557	1,573,823	91,560	170,203
Carr et al	2,281	105,145	105,145	6,846
On-scene interval				
NEMSIS	46,962	415,475	27,916	52,559
Carr et al	4,047	139,866	127,850	30,047

robust than Carr et al., except for suburban ground data (Table 2).

Helicopter transport mean activation and on-scene time intervals were significantly longer than those for ground transport, regardless of rurality ($p < 0.01$) (Table 3). Statistically significant differences were noted between all mean ground intervals, with urban total activation and on-scene intervals being significantly shorter than suburban and rural ($p < 0.01$). Furthermore, while *EMSDispatchCenterTime* was quite similar between all ground units, *EMSchuteTime* varied, with rural being more than two times longer than urban.

When comparing NEMSIS data to the meta-analysis data, there were mixed results. Mean activation intervals for all NEMSIS data were significantly longer than those from Carr et al. ($p < 0.01$) (Table 3). The difference in the helicopter transport mean activation interval was quite stark. The NEMSIS interval was more than three times longer than the interval calculated from Carr et al. Alternatively, the mean helicopter interval for on-scene time was significantly less for the NEMSIS data ($p < 0.01$). All other NEMSIS mean on-scene intervals were significantly longer than those provided by Carr et al. ($p < 0.01$).

An extensive analysis evaluating the impact of advanced life support (ALS) and basic life support (BLS) of ground units showed mixed results. Shorter mean times were seen in ALS compared to BLS for all activation intervals across all ruralities ($p < 0.01$). The largest difference between ALS and BLS for the total activation interval was seen in the rural environment (3.10 ± 4.31 and 4.84 ± 5.86 respectively). Conversely, overall mean on-scene intervals were quite similar, with marginally longer intervals for ALS ($p < 0.01$). Intervals between ALS and BLS were quite similar in urban environments (15.54 ± 10.73 and 15.38 ± 9.47 minutes respectively) but varied substantially for suburban (18.02 ± 11.60 and 16.03 ± 9.93 minutes) and rural (18.67 ± 15.18 and 16.31 ± 18.57 minutes) responses (Table 4).

Discussion

Our analysis of EMS elapsed service times calculated activation and on-scene prehospital intervals using datasets from a single modern and uniform data source. These empirically derived prehospital intervals provide valuable data for future access to care models and serve as a blueprint for future utilization of the NEMSIS dataset. With longer prehospital times contributing to higher mortality rates in severely injured patients, making sure patients have timely access to trauma care is an essential component of reaching the goal of “Zero Preventable Deaths After Injury” set by the NASEM report (4). Therefore, accurately estimating trauma

care accessibility is of utmost importance when identifying trauma care deserts, where timely access to care is absent.

Prehospital Intervals

Surprisingly, except for helicopter transport on-scene times, NEMSIS time intervals were significantly longer than results from the meta-analysis completed by Carr et al. We believe this may be due to a few reasons. First, as stated in the analysis by Carr et al., “... strict definitions of prehospital time intervals and conformity to existing definitions could not be controlled as inconsistencies exist with the literature reviewed for this analysis.” This limitation should be minimized with the current analysis due to the standardization present within the NEMSIS database. Also, all cases with a time of zero were removed from this analysis, as these are not possible or useful when determining mean time intervals. If an EMS provider reported the same time for arrival and departure from a scene, we considered this a data reporting error or an instance when EMS did not provide aid. It is possible that some articles in the meta-analysis included times of zero and, therefore, lowered the mean time intervals. Second, the significantly longer times calculated from the NEMSIS dataset are due to a difference in the activation interval definition. According to Carr et al., the activation interval is defined as “the time from call was received to time of alarm.” This assumes the ambulance is en route to the scene instantaneously at the time of notification. The two-component time definition of the activation interval is more accurate and realistic because it includes the time from the 911 call to unit notification and the time between when the unit is notified and when the unit is en route.

While all activation and on-scene times from our analysis are statistically different from one another, it was quite surprising to see such similarities, especially regarding all ground unit *EMSDispatchCenterTime* and on-scene time between suburban and rural communities. Furthermore, analysis of the two activation components suggests the activation interval variability among ruralities is mainly due to *EMSchuteTime*, the time from EMS notification until the unit is en route. We suspect this difference is due to the volunteer-based systems more commonly found in rural communities. Finally, if total activation and on-scene intervals are summed, more stark differences between the ruralities begin to emerge.

The analysis of the NEMSIS dataset showed considerable differences in activation intervals, but on-scene intervals were comparable. There was a difference of 1.47 minutes between BLS and ALS for total activation time, with ALS

Table 3. Mean and standard deviations for activation and on-scene intervals (mins) of helicopter and ground units for trauma responses.

	Helicopter transport	Urban ground transport	Suburban ground transport	Rural ground transport
Activation Interval				
NEMSIS				
<i>EMSDispatchCenterTime</i>	5.19 ± 6.79	1.59 ± 3.65	1.55 ± 3.31	1.36 ± 3.40
<i>EMSchuteTime</i>	8.57 ± 4.90	1.01 ± 1.56	1.34 ± 2.14	1.97 ± 3.00
Total activation interval	13.75 ± 7.44	2.60 ± 3.94	2.88 ± 3.89	3.33 ± 4.58
Median	12.00	1.68	2.00	2.00
Carr et al.	3.53 ± 3.81	1.40 ± 1.41	1.40 ± 1.41	2.89 ± 1.64
On-Scene Interval				
NEMSIS				
Median	16.00	14.00	16.00	15.92
Mean & SD	19.42 ± 16.09	15.50 ± 10.46	17.56 ± 11.27	18.07 ± 16.13
Carr et al.	21.60 ± 18.90	13.50 ± 3.71	13.45 ± 21.80	15.06 ± 16.80

Table 4. Mean and standard deviations for activation and on-scene intervals for BLS and ALS ground units for trauma responses.

	Urban BLS	Urban ALS	Suburban BLS	Suburban ALS	Rural BLS	Rural ALS	All BLS	All ALS
Activation Interval								
NEMSIS								
<i>EMSDispatchCenterTime</i>	2.48 ± 5.32	1.49 ± 3.40	1.96 ± 3.68	1.50 ± 3.27	1.61 ± 3.92	1.31 ± 3.32	2.35 ± 5.11	1.47 ± 3.39
<i>EMSchuteTime</i>	1.37 ± 2.15	0.97 ± 1.48	2.35 ± 3.56	1.22 ± 1.87	3.22 ± 4.26	1.78 ± 2.70	1.64 ± 2.65	1.06 ± 1.66
Total activation interval	3.86 ± 5.60	2.46 ± 3.69	4.30 ± 4.80	2.72 ± 3.73	4.84 ± 5.86	3.10 ± 4.31	4.00 ± 5.60	2.53 ± 3.75
Median	2.18	1.62	3.00	2.00	3.00	2.00	2.32	1.68
<i>n</i>	157,853	1,415,970	9,540	82,020	22,746	147,457	190,139	1,645,447
On-Scene Interval								
Median	13.92	14.00	14.00	16.00	14.00	16.00	14.00	14.25
Mean & SD	15.38 ± 9.47	15.54 ± 10.73	16.03 ± 9.93	18.02 ± 11.60	16.31 ± 18.57	18.67 ± 15.18	15.52 ± 10.93	16.00 ± 11.38
<i>n</i>	96,402	319,073	6,394	21,522	13,296	39,263	116,092	379,858

being 58% faster than BLS at getting en route to the scene. In urban environments, this discrepancy was driven by *EMSDispatchCenterTime*, while in suburban and rural environments it was caused more by *EMSchuteTime*. It is possible that the more expeditious ALS response were due to differences in injury severity, with ALS being utilized more frequently for severe injuries, and therefore urgency is prioritized. While total on-scene times were very similar, on-scene time for ALS was longer than BLS for all ruralities. These differences are very minor in urban environments but become substantial in suburban and rural locations. We believe this is due to the increased capabilities and invasive methods used by ALS.

Limitations

There are limitations associated with the NEMSIS dataset that must be acknowledged. First, the dataset is a large convenience sample, consisting solely of data submitted by participating EMS agencies and may not represent the entire U.S. population. It likely includes a disproportionate number of EMS agencies with the resources and leadership necessary to participate in the program. This may explain the large number of urban results compared to suburban and rural environments. While under the Census Bureau designation, roughly 23 percent of the population is considered rural, only approximately 10 percent of the sample was represented by rural EMS providers. Second, while the NEMSIS database contains data from a wide array of states, the authors cannot say for certain how many states are represented once case selection was completed. The NEMSIS public-release research does not disclose the state in which the record was generated. However, results include activations from all nine U.S. Census Divisions, representing a

diverse geographic sample. Third, NEMSIS contains records from two-tier EMS response systems consisting of a first responder crew and transporting crew. In these two-tier systems, the transporting crew is often not required to respond with the same urgency as the first responding crew. There is no definitive way to identify records from these systems, and therefore both are potentially included, resulting in longer dispatch intervals. Finally, due to differences in inclusion/exclusion criteria, potential selection bias could have occurred and affected case selection during the filtering process (29).

Conclusion

As GIS technology is becoming more widely utilized in this field, accurate activation and on-scene intervals are essential for geospatial models analyzing access to trauma care. The values derived from this analysis represent a more accurate and up-to-date representation of prehospital intervals from EMS systems currently in place. This analysis more effectively defines the EMS activation and on-scene intervals by utilizing the national standardized data protocol from EMS agencies across the nation. In addition to establishing the modern baseline metric for these critical prehospital care intervals, these data will be important to identifying and quantifying areas for focused process improvement, enhancing access to care, and assessing the impact of any such interventions by comparing pre and post-intervention interval times.

Disclaimer

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Disclosure Statement

No interest to declare.

Data Availability

The data that support the findings of this study are openly available in the Harvard Dataverse Repository.

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Appendix 1

Albrecht, RM	University of Oklahoma Health Sciences Center
Bailey, JA	Uniformed Services University of the Health Sciences
Benjamin, ER	Emory University / Grady Memorial Hospital
Bernard, AC	University of Kentucky
Blackwell, TH	University of South Carolina School of Medicine Greenville
Braithwaite, SA	Washington University in St Louis
Brasel, KJ	Oregon Health & Science University
Brice, JH	University of North Carolina
Bulger, EM	University of Washington
Burlew, CC	Denver Health Medical Center
Butler, FK	DSO Medical Associates
Callaway, DW	Atrium Health
Cannon, JW	University of Pennsylvania
Champion, HR	SimQuest
Chang, M	University of South Alabama
Coimbra, RS	Riverside University Health System & Loma Linda University
Davis, GG	University of Alabama at Birmingham, Jefferson County Medical Examiner Office
Demarest, GB	University of New Mexico School of Medicine
Dorlac, WC	University of Colorado
Drake, SA	Texas A&M University
Eastman, AL	United States Department of Homeland Security
Eastridge, BJ	University of Texas Health Science Center at San Antonio
Elster, EA	Uniformed Services University of the Health Sciences
Epley, E	Southwest Texas Regional Advisory Council
Esposito, TJ	University of Illinois College of Medicine
Ficke, JR	Johns Hopkins University
Fisher, AD	University of New Mexico School of Medicine
Fowler, DR	Maryland Office of the Chief Medical Examiner
Gaines, BA	University of Pittsburgh, Children's Hospital of Pittsburgh
Gallagher, JM	Wichita/Sedgwick County EMS System
Gary, JL	Keck School of Medicine of the University of Southern California
Gestring, ML	University of Rochester
Gill, JR	Connecticut Office of the Chief Medical Examiner
Goodloe, JM	University of Oklahoma School of Community Medicine
Gurney, JM	Joint Trauma System / Institute of Surgical Research
Harrell, AJ	University of New Mexico School of Medicine
Henry, SM	University of Maryland
Holcomb, JB	University of Alabama at Birmingham
Hunt, JL	University of New Mexico
Jenkins, DH	University of Texas Health Science Center at San Antonio
Johannigman, JA	Brooke Army Medical Center
Kerby, JD	University of Alabama at Birmingham
Kharod, CU	Joint Trauma System, Defense Health Agency
Kotwal, RS	Joint Trauma System, Defense Health Agency
Kozar, RA	Shock Trauma, University of Maryland School of Medicine
Kuhls, DA	University of Nevada Las Vegas
Lathrop, SL	University of New Mexico
Latimer, AJ	University of Washington Department of Emergency Medicine
Levy, M	University of Alaska Anchorage
Mabry, RL	Special Operations Command - Fort Bragg
MacKenzie, EJ	Johns Hopkins University Bloomberg School of Public Health
Martin, MJ	Scripps Mercy Hospital
Maxson, RT	Arkansas Children's Hospital
Mazuchowski, EL	Armed Forces Medical Examiner System
Medrano, NW	Coalition for National Trauma Research
Minei, JP	UT Southwestern Medical Center
Mitchell, RA	Washington DC Office of the Chief Medical Examiner
Moore, EE	Ernest E Moore Shock Trauma Center at Denver Health
Moore, LE	Uniformed Services University of the Health Sciences, University of Virginia
Nashelsky, MB	University of Iowa Hospitals and Clinics
Nathens, AB	Sunnybrook Health Sciences Center & University of Toronto
Nolte, KB	University of New Mexico School of Medicine
O'Keefe, GE	University of Washington
Phillips, MJ	Coalition for National Trauma Research
Price, MA	Coalition for National Trauma Research
Robinson, JL	Spectrum Retirement Communities, LLC / International Association of EMS Chiefs
Sagraves, SG	Baylor Scott & White Health
Scalea, TM	University of Maryland
Schenarts, PJ	Creighton University & Des Moines University
Schreiber, MA	Oregon Health & Science University
Shackelford, SA	Joint Trauma System
Sperry, JL	University of Pittsburgh

(continued)

Stassen, NA	University of Rochester
Staudenmayer, KL	Stanford University
Stewart, RM	University of Texas Health Science Center at San Antonio
Stuke, LE	Louisiana State University
Valadka, AB	Virginia Commonwealth University
Villarreal, CL	Coalition for National Trauma Research
Winchell, RJ	Weill Cornell Medicine
Zonies, D	Oregon Health & Science University
Yelon, JA	EMF Great Lakes

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