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AWARD NUMBER: W81XWH-17-2-0010

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

PRINCIPAL INVESTIGATOR: Dr. Brian Eastridge

RECIPIENT:
National Trauma Institute d/b/a Coalition for National Trauma Research
San Antonio, TX 78230

REPORT DATE: April 2020

TYPE OF REPORT: Annual

PREPARED FOR: U.S. Army Medical Research and Materiel Command
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;
Distribution Unlimited

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

1. REPORT DATE	**2. REPORT TYPE**	**3. DATES COVERED**
April 2020	Annual- Year 3	20-03-2019 to 19-03-2020

4. TITLE AND SUBTITLE	**5a. CONTRACT NUMBER**
Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC)	**5b. GRANT NUMBER** W81XWH-17-2-0010
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	**5d. PROJECT NUMBER**
Brian Eastridge, MD	**5e. TASK NUMBER**
E-Mail: eastridge@uthscsa.edu	**5f. WORK UNIT NUMBER**
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **AND ADDRESS(ES)** National Trauma Institute 9901 IH 10, Suite 730 San Antonio, TX 78230-2258	**8. PERFORMING ORGANIZATION REPORT NUMBER**
9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES) U.S. Army Medical Research and Materiel Command Fort Detrick, Maryland 21702-5012	**10. SPONSOR/MONITOR'S ACRONYM(S)**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT
Approved for Public Release; Distribution Unlimited

13. SUPPLEMENTARY NOTES

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.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON** USAMRMC
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
Unclassified	Unclassified	Unclassified	Unclassified	497	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18

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INTRODUCTION: Narrative that briefly (one paragraph) describes the subject, purpose and scope of the research.

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.

1. **KEYWORDS:** Provide a brief list of keywords (limit to 20 words).

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

2. **ACCOMPLISHMENTS:** The PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction.

What were the major goals of the project?

List the major goals of the project as stated in the approved SOW. If the application listed milestones/target dates for important activities or phases of the project, identify these dates and show actual completion dates or the percentage of completion.

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
Milestone Achieved: Local IRB determination at UTHSCSA	3	01/31/2018	100%

Milestone Achieved: HRPO acknowledgement for all protocols and local IRB determination as NHR through Sites	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%
Milestone Achieved: Government recommendations and approval of review criteria, definitions, and procedures	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%
Milestone Achieved: Completed Study Group training	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	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%
Milestone Achieved: Profiler system is used to conduct online reviews	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		40%
Milestone Achieved: All panel reviews completed and data submitted	33		31%
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		60%
Subtask 2: Perform all analyses according to specifications, share output and finding with all investigators	6-39		20%

Milestone Achieved: Report results from data analysis			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		0%
Milestone Achieved: Dissemination materials produced	42		0%

What was accomplished under these goals?

For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results or key outcomes, including major findings, developments, or conclusions (both positive and negative); and/or 4) other achievements. Include a discussion of stated goals not met. Description shall include pertinent data and graphs in sufficient detail to explain any significant results achieved. A succinct description of the methodology used shall be provided. As the project progresses to completion, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.

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

- A reviewer update meeting was held at the AAST conference to provide reviewers with preliminary data findings and refine case adjudication process. **20-Sept-2019**
- Ongoing videoconferences are held via GoToMeeting to clarify case review process with reviewers as needed
- The study team met with forensic reviewers at the National Association of Medical Examiners conference to discuss preliminary findings and ongoing case reviews in the Profiler system.

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 NEMSIS data from each of the six states for cases in the MIMIC study that had an EMS intervention.
  -Oklahoma NEMSIS data was received on **17-Jun-2019**
  -Maryland NEMSIS is currently working on data matching and we are expecting to receive data in April 2020.
  -Washington DC is working on data matching and we are expecting to receive data in April 2020.
  -Connecticut request is pending board approval.
  -New Mexico request is pending internal review.
  -Iowa request was initially designed, but we were asked to resubmit in the Spring 2020. The case number requested of matching will not impact project if approval is not obtained. 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 continues to be entered.

- A data abstraction close-out meeting was held with the data abstraction team at the NAME conference in Kansas City, Missouri. **19-Oct-2019**

Subtask 1: Perform AIS coding

- AIS coding continues as cases are abstracted into REDCap.
- As of **01-Apr-2020,** AIS and ICD coding has been completed for 1,475 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, 1,175 cases have been sent out to reviewers to determine survivability. Cases are being 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. As of April 1, 2020, 1,175 cases have been released to panels for review. Out of those cases, 815 cases have reached consensus, 82 cases are still under adjudication, 42 have been pushed to an outside adjudication team for further review, and 236 cases are still pending initial review.

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

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.

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

- Data quality checks are ongoing. The study team has been working with data abstractors at each site to clean up data.

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.

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: No progress at the time of this report

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

If the project was not intended to provide training and professional development opportunities or there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe opportunities for training and professional development provided to anyone who worked on the project or anyone who was involved in the activities supported by the project. "Training" activities are those in which individuals with advanced professional skills and experience assist others in attaining greater proficiency. Training activities may include, for example, courses or one-on-one work with a mentor. "Professional development" activities result in increased knowledge or skill in one's area of expertise and may include workshops, conferences, seminars, study groups, and individual study. Include participation in conferences, workshops, and seminars not listed under major activities.

Nothing to Report

How were the results disseminated to communities of interest?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how the results were disseminated to communities of interest. Include any outreach activities that were undertaken to reach members of communities who are not usually aware of these project activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Nothing to Report

What do you plan to do during the next reporting period to accomplish the goals?
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.

- Continue with AIS coding, ICD coding
- Upload additional EMS data for Maryland, and Washington DC cases (NEMSIS data match)
- Continue working on case reviews
- Continue working on case adjudication
- Submit abstract to 2020 NAME conference
- Submit abstract to 2020 American Academy of Forensic Science (AAFS) conference)
- Work on program process paper to submit to TSACO

4. **IMPACT:** Describe distinctive contributions, major accomplishments, innovations, successes, or any change in practice or behavior that has come about as a result of the project relative to:

What was the impact on the development of the principal discipline(s) of the project?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research in the principal disciplinary field(s) of the project. Summarize using language that an intelligent lay audience can understand (Scientific American style).

Nothing to Report

What was the impact on other disciplines?
If there is nothing significant to report during this reporting period, state "Nothing to Report." Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

Nothing to Report

What was the impact on technology transfer?

If there is nothing significant to report during this reporting period, state "Nothing to Report."

Nothing to Report

What was the impact on society beyond science and technology?
If there is nothing significant to report during this reporting period, state "Nothing to Report." Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as:

- *improving public knowledge, attitudes, skills, and abilities;*
- *changing behavior, practices, decision making, policies (including regulatory policies), or social actions; or*
- *improving social, economic, civic, or environmental conditions.*

Nothing to Report

5. **CHANGES/PROBLEMS:** The PD/PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction. If not previously reported in writing, provide the following additional information or state, "Nothing to Report," if applicable:

Changes in approach and reasons for change *Describe any changes in approach during the reporting period and reasons for these changes. Remember that significant changes in objectives and scope require prior approval of the agency.*

Actual or anticipated problems or delays and actions or plans to resolve them
Describe problems or delays encountered during the reporting period and actions or plans to resolve them.

The project has experienced a moderate slow down of case reviews since reviewers have been focused on the COVID-19 crisis. The project team continues to work on data cleaning, coding, and publications during this time. Reviewers are urged to complete as many reviews as possible while pandemic precautions are in place.

Changes that had a significant impact on expenditures
Describe changes during the reporting period that may have had a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.

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: List any products resulting from the project during the reporting period. If there is nothing to report under a particular item, state "Nothing to Report."

- **Publications, conference papers, and presentations**
  Report only the major publication(s) resulting from the work under this award.

1. Improving the Military- Civilian Taxonomy and Process to Determine Prehospital Injury Survivability. Abstract accepted for poster presentation at the 2019 MHSRS Conference. **Mar-2019**
2. Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): Progress Update. Dr. Brian Eastridge presented to the NTI Board of Directors. **Apr-2019**
3. Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): Concept of Utilizing Medical Examiner Data to Determine Prehospital Injury Survivability. Abstract accepted for podium presentation at the 2019 NAME Conference. **Jun-2019**
4. Garon Bodor and Victoria Chavez from the New Mexico Office of the Medical Examiner created a training presentation for MIMIC designed to familiarize field deputy medical investigators with the objectives of MIMIC and how best to collect and report relevant variables. **Jul-2019**
5. Improving the Military-Civilian Taxonomy and Process to Determine Prehospital Injury Survivability. Poster presented at the 2019 MHSRS Conference. **Aug-2019**
6. MIMIC Update: Results of Round 1 and Round 2 Data. Presentation to MIMIC reviewers at the 2019 AAST Meeting in Dallas, Texas. **Sept-2019**
7. Preliminary Analysis of the Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC). Abstract submitted to the 2020 Western Trauma Association Meeting MHSRS Conference. **Oct-2019**
8. Presentation titled Prehospital Blood Utilization Increasing Survivability After Injury. Norman McSwain EMS Conference. **Oct-2019**
9. Presentation titled Potentially Survivable Injury and Potentially Preventable Deaths from Traumatic Injuries. AABB THOR Conference. **Oct-2019**
10. Presentation titled MIMIC Data Abstractor Recap Meeting. Presented to Site Data Abstractors at the 2019 NAME Meeting in Kansas City, Kansas. **Oct -2019**
11. Presentation titled Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): Concept of Utilizing Medical Examiner Data to Determine Prehospital Injury Survivability. National Association of Medical Examiners Conference. **Oct-2019**
12. Presentation titled MIMIC Update: Results of Data and Abstraction. Presentation to MIMIC Forensic and Medical Examiner reviewers at the 2019 NAME Meeting in Kansas City, Kansas. **Oct -2019**

13. Presentation titled Prehospital Mortality, The Missing Dead: Implications for the Trauma System Development. American College of Surgeons TQIP Annual Meeting. **Nov-2019**
14. Presentation titled Combat Casualty Mortality: Survivability of Injury, Preventability of Death and their Implications to the Joint Trauma System and the Warfighter. Combat Trauma Care Workshop. **Nov-2019**
15. Preliminary Analysis of the Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC). Abstract accepted for presentation to the 2020 Western Trauma Association Meeting. (*Acceptance Notice Attached*) **Nov-2019**
16. Statewide system-based geographic approach to trauma care access. Abstract submitted to 2020 AAST Conference. **Feb-2020**
17. Instituting a Multi-disciplinary Review Team to Determine Pre-Hospital Injury Survivability After Traumatic Injury. Abstract submitted to 2020 APHA Conference. **Feb-2020**
18. Podium presentation titled Multi-institutional Multidisciplinary Investigation in the Civilian Pre-hospital Environment (MIMIC). Western Trauma Association conference. **Feb-2020**
19. Paper submitted to TSACO titled Preliminary Analysis of the Multi-institutional Multidisciplinary Investigation in the Civilian Pre-hospital Environment (MIMIC). **Feb-2020**

Books or other non-periodical, one-time publications. *Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like. Identify for each one-time publication: author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (e.g., book, thesis or dissertation); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Nothing to report

Other publications, conference papers and presentations. *Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above. List presentations made during the last year (international, national, local societies, military meetings, etc.). Use an asterisk (*) if presentation produced a manuscript.*

Nothing to Report

- **Website(s) or other Internet site(s)**
  List the URL for any Internet site(s) that disseminates the results of the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.

  Nothing to Report

- **Technologies or techniques**
  Identify technologies or techniques that resulted from the research activities. Describe the technologies or techniques were shared.

  Nothing to Report

- **Inventions, patent applications, and/or licenses**
  Identify inventions, patent applications with date, and/or licenses that have resulted from the research. Submission of this information as part of an interim research performance progress report is not a substitute for any other invention reporting required under the terms and conditions of an award.

  Nothing to Report

- **Other Products**
  Identify any other reportable outcomes that were developed under this project. Reportable outcomes are defined as a research result that is or relates to a product, scientific advance, or research tool that makes a meaningful contribution toward the understanding, prevention, diagnosis, prognosis, treatment and /or rehabilitation of a disease, injury or condition, or to improve the quality of life. Examples include:

  - Nothing to Report

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate "no change".

Personnel	***Role***	***Percent Effort***
Brian Eastridge	PI	20%
Amy Flores	Controller	5% - 03/19 thru 03/20
Lizette Villarreal	Program Manager	56% - 03/19 thru 04/19 71% - 05/19 thru 06/19 81% - 07/19 thru 09/19 85% - 10/19 thru 10/19 45% - 11/19 85% - 12/19 thru 03/20
Monica Phillips	Research Operations Director	20% - 03/19 thru 10/19 20% - 12/19
Michelle Price	Research Director	10% - 03/19 thru 12/19 5% - 01/20 thru 03/20
Sharon Smith	Project Administrator	15% - 03/19 thru 10/19 15% - 12/19
Nick Medrano	GIS Analyst	100% - 03/19 thru 03/20
Ana Guerrero	Executive Assistant	10% - 03/19 thru 03/20
New Mexico Subaward	***Role***	***Percent Effort***
Kurt B. Nolte	PI/Co-I	16%
Richard Clark	Forensic Radiologist	4%
Sarah Lathrop	Epidemiologist	11%
Garon Bodor	Research Coordinator	32%
Johns Hopkins University subaward	***Role***	***Percent Effort***
Ellen Mackenzie	PI/Co-I	15%
Daniel Scharfstein	Lead Statistician	10%
Craig Remenapp	Study Manager	35%
Zebin Wang	Research Assistant	20%

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

If the active support has changed for the PD/PI(s) or senior/key personnel, then describe what the change has been. Changes may occur, for example, if a previously active grant has closed and/or if a previously pending grant is now active. Annotate this information so it is clear what has changed from the previous submission. Submission of other support information is not necessary for pending changes or for changes in the level of effort for active support reported previously. The awarding agency may require prior written approval if a change in active other support significantly impacts the effort on the project that is the subject of the project report.

Nothing to Report

What other organizations were involved as partners?
If there is nothing significant to report during this reporting period, state "Nothing to Report."

Describe partner organizations – academic institutions, other nonprofits, industrial or commercial firms, state or local governments, schools or school systems, or other organizations (foreign or domestic) – that were involved with the project. Partner organizations may have provided financial or in-kind support, supplied facilities or equipment, collaborated in the research, exchanged personnel, or otherwise contributed.

Provide the following information for each partnership:
<u>Organization Name:</u>
<u>Location of Organization: (if foreign location list country)</u>
<u>Partner's contribution to the project</u> (identify one or more)

- *Financial support;*
- *In-kind support (e.g., partner makes software, computers, equipment, etc., available to project staff);*
- *Facilities (e.g., project staff use the partner's facilities for project activities);*
- *Collaboration (e.g., partner's staff work with project staff on the project);*
- *Personnel exchanges (e.g., project staff and/or partner's staff use each other's facilities, work at each other's site); and*
- *Other.*

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: For collaborative awards, independent reports are required from BOTH the Initiating Principal Investigator (PI) and the Collaborating/Partnering PI. A duplicative report is acceptable; however, tasks shall be clearly marked with the responsible PI and research site. A report shall be submitted to **https://ers.amedd.army.mil** for each unique award.

QUAD CHARTS: If applicable, the Quad Chart (available on https://www.usamraa.army.mil) should be updated and submitted with attachments.

Quad Chart Attached

9. APPENDICES:

Attach all appendices that contain information that supplements, clarifies or supports the text. Examples include original copies of journal articles, reprints of manuscripts and abstracts, a curriculum vitae, patent applications, study questionnaires, and surveys, etc.

- Copies of the 19 Products/Reportable Outcomes are attached

Multi-institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC)
BA150629
W81XWH-17-2-0010

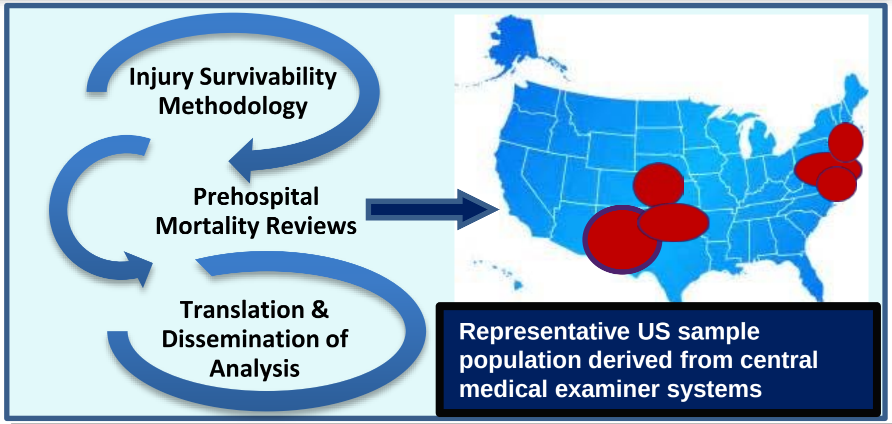
PI: Brian Eastridge **Org:** National Trauma Institute **Award Amount:** $3,979,380

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: Study case reviews by all 13 team panels consisting of eighty reviewers was launched in January 2019. To date, 1,175 cases have been sent to reviewers. Of these, 905 have been completed.

Timeline and Cost

Activities CY	17	18	19	20
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**

Updated: (16 April 2020)

Goals/Milestones

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

☑ Protocol submitted; methodology determined

CY18 Goals – Virtual Reviews commence

☑ Data abstraction

☑ Reviews in progress

CY19 Goal – Virtual Reviews continue

☑ Data abstraction

☑ Reviews in progress

CY20 Goal – Data analysis, result dissemination

☐Reviews and adjudication in progress

☐Report results from data analysis and dissemination materials produced

Comments/Challenges/Issues/Concerns

- Review slow down due to COVID-19

Budget Expenditure to Date

- Projected Expenditure: $2,732,915
- Actual Expenditure: $2,703,292 (as of 03-19-20)

Improving the Military- Civilian Taxonomy and Process to Determine Prehospital Injury Survivability

Background

In 2016, the National Academies of Science, Engineering, and Medicine convened a committee to codify the lessons learned from the nation's wartime military medical experiences. In that report entitled "A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths after Injury," several specific gaps requiring remediation were identified. One of the foundational deficiencies noted was that data linkages are incomplete or entirely missing among prehospital care; hospital-based acute care; rehabilitation; and the medical examiner. The committee also highlighted that "a critical but often neglected source of data—particularly in civilian systems—is autopsy reports on trauma deaths, which could be used to determine the preventability of fatalities based on a common, accepted lexicon."

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. Therefore, the Department of Defense (DoD) and Combat Casualty Care Research Program of the Medical Research and Material Command (MRMC) have made a significant investment to establish a dedicated research effort focused on understanding the survivability of injury in the prehospital environment. The Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC) study was funded to develop a more comprehensive understanding of the epidemiology of civilian pre-hospital injury deaths and their potential for survivability. The ultimate goal of the research is to identify liabilities in trauma systems and develop mitigation strategies with translation potential for realistic and relevant improvements in battlefield trauma systems and improvements in Warfighter survivability.

Methods

The research proposes to review and analyze 3,000 injury-associated pre-hospital deaths and will be conducted at six (6) centralized medical examiner offices across the United States selected to be representative of the national population. The sites chosen for the review include New Mexico, Oklahoma, Connecticut, Maryland, District of Columbia, and a region of Iowa. These sites were chosen because centralized medical examiner systems provide mortality data that is uniform and centrally located and is based upon high quality death investigations and forensic pathology services. A multi-disciplinary, multi-institutional network of subject matter experts in the disciplines of trauma surgery, neurosurgery, orthopedic surgery, emergency medicine, radiology, forensic pathology, forensic nursing, trauma systems, and emergency medical services collaborated upon the development of a consensus taxonomy relative to determination of injury survivability. This framework and methodology was developed for evaluating the causes and pathophysiologic mechanisms of pre-hospital deaths; the appropriateness of EMS response and care delivered; and the potential for survivability under both optimal clinical circumstances and within the context of each individual injury event. In order to increase the military relevance and facilitate comparisons with the combat environment, this framework and methodology was developed to be congruent with methodology used by the DoD in its landmark study of pre-hospital mortality resulting from battlefield injury along with newly released DoD lexicon on injury survivability. An electronic data tool (Profiler) with all relevant information was specifically developed for reviewers in order to make informed survivability judgements and record their determinations. This data was subsequently collected in the Research Electronic Data Capture (REDCap) system.

The MIMIC Study Group assembled consists of thirteen panels. The review team panels are composed of relevant disciplines including trauma surgery, neurosurgery, orthopedic surgery, forensic sciences, radiology and emergency medicine with a specialization in emergency medical services (EMS). Each panel consists of six members: four surgeons, one emergency medicine physician or EMS provider, and one forensic reviewer. All panels contain a minimum of two reviewers with military background and experience. All review panels of experts were trained to ensure standardization of assessments within and across panels. Data available for survivability review determinations included medical examiner autopsy data, injury codes (Abbreviated Injury Scale / AIS), geospatial data (injury location, EMS location/time, trauma center level/location /time), and National EMS Information System data when EMS was involved. Survivability determinations were developed based upon principal mechanism of death which was broken down into 13 categories: Hemorrhage-Truncal, Hemorrhage- Junctional, Hemorrhage-Peripheral, Neurological- Traumatic Brain Injury, Neurological- Spinal Cord, Tension Pneumothorax, Airway, Traumatic Asphyxia, Electrical, Burn, Massive Tissue Disruption, Unknown and, Other. Survivability determination was considered by selecting from four options: Non-Survivable, Potentially Survivable, Definitely Survivable, and Cannot Judge. For cases that are determined to be Non-Survivable, reviewers are then able to provide additional details on the nature of the injury that led to that assessment. These options are broken down into Immediate/Acute variables, and Delayed variables. All death determinations within the context of the actual scenario are followed by a reviewer analysis of characteristics/features of the EMS care, trauma system, or patient factors potentially contributing to the death that may identify strategies to mitigate prehospital injury mortality in the future.

Conclusion

The MIMIC study has developed a coordinated, multi-disciplinary, multi-institutional process 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, trauma systems and public health. The comprehensive nature of the MIMIC study has allowed the pre-hospital care research community to unify the prehospital injury survivability lexicon that will enable future studies to advance the science for the future. These efforts are critical to advancing trauma and emergency care, as injury pattern as well as circumstance and causality have significant implications for the development of mitigation strategies. Utilizing the expertise of national experts serving as MIMIC team panel reviewers, this study will serve to advance pre-hospital care and trauma systems development, which in turn which will be translatable into military medicine and the protection and care of the Wounded Warrior.

Learning Objectives:

- Discuss the military-civilian taxonomy relative to determination of injury survivability.
- Describe survivability determinations that were developed based upon principal mechanisms of death such as hemorrhage, neurological, airway, burns, etc.
- Review survivability determinations that will be used to identify strategies to mitigate prehospital injury mortality in the future.

The U. S. Army Medical Research Acquisition Activity, 820 Chandler Street, Fort Detrick MD 21702-5014 is the awarding and administering acquisition office. This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Defense Medical Research and Development Program under Award No. W81XWH-17-2-0010. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense.

MIMIC Update

NTI Board Meeting
April 2019

DoD Broad Agency Announcement (BAA) Grant

- Department of Defense (BAA $3,979,380)
- PI: Brian Eastridge, MD
  - Professor, Department of Surgery
  - Division Chief, Trauma and Emergency General Surgery
  - Jocelyn and Joe Straus Endowed Chair in Trauma Research
  - University of Texas Health Science Center at San Antonio
- Co-PI: Kurt Nolte, MD
  - Professor of Pathology
  - University of New Mexico
  - Director of Radiology-Pathology Center for Forensic Imaging
  - Chief Medical Investigator, Office of the Medical Investigator

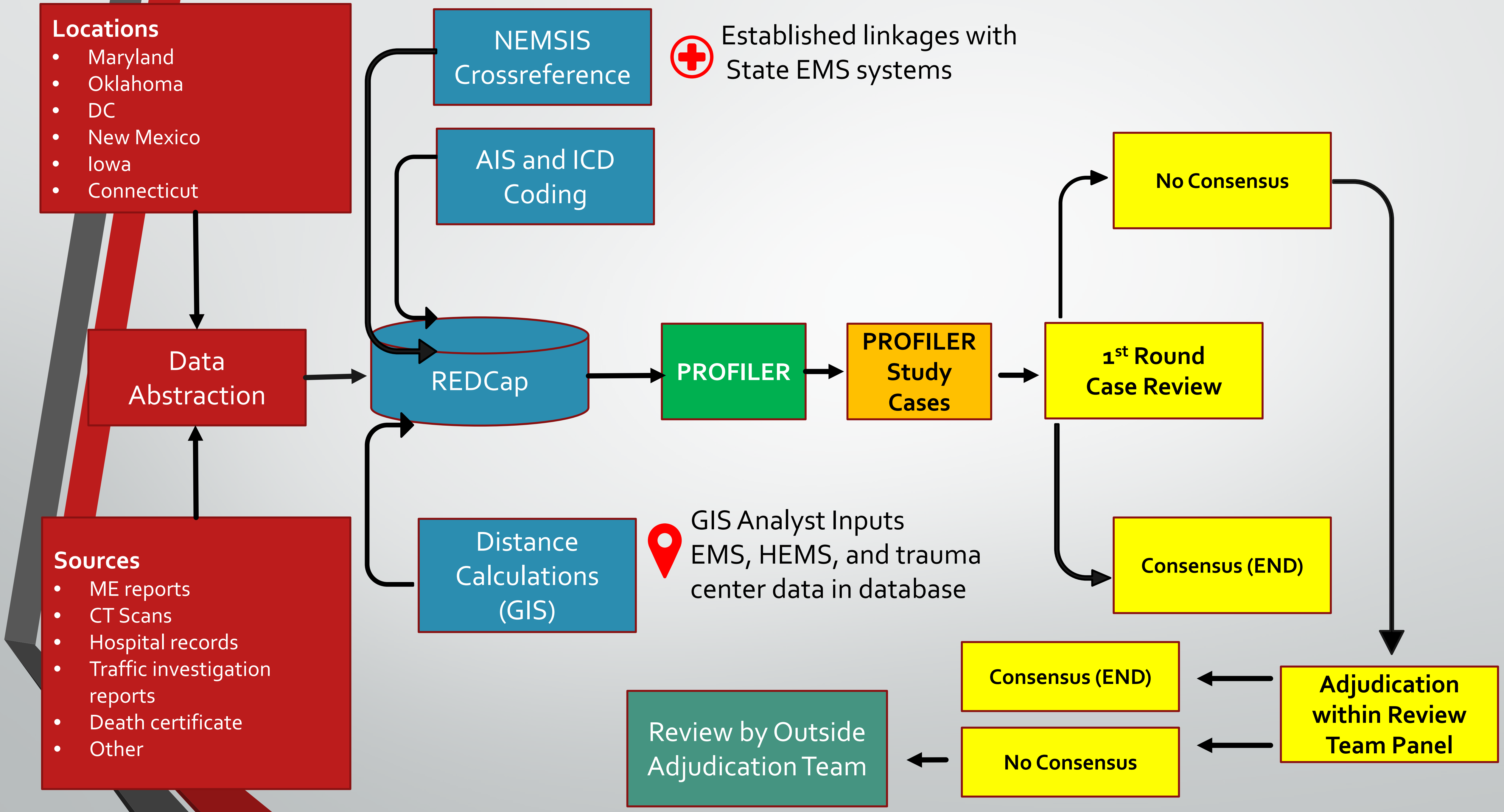
  Ellen MacKenzie, PhD
  - Dean, Johns Hopkins Bloomberg School of Public Health
  - Bloomberg Distinguished Professor

Study Hypotheses

- Substantial opportunity to further reduce deaths in 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.

MIMIC Objectives

- **Objective #1:** ***Develop a framework and methodology*** for evaluating pre-hospital deaths
- **Objective #2:** Organize and standardize a ***multidisciplinary, multi-institutional network of experts*** to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.
- **Objective #3:** ***Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths***, and estimate the potential for survivability
- **Objective #4:** ***Describe the epidemiology of pre-hospital mortality*** in the context of trauma system development and estimate its impact on society.
- **Objective #5:** ***Develop a blueprint for a sustained effort*** identifying high priority areas for injury prevention, trauma systems performance improvement and research and development.



Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages with State EMS systems
AIS and ICD Coding
Data Abstraction
REDCap
PROFILER
PROFILER Study Cases
1st Round Case Review
No Consensus
Consensus (END)
Distance Calculations (GIS)
GIS Analyst Inputs EMS, HEMS, and trauma center data in database
Sources
ME reports
CT Scans
Hospital records
Traffic investigation reports
Death certificate
Other
Consensus (END)
Adjudication within Review Team Panel
No Consensus
Review by Outside Adjudication Team

Project Update

Data Abstraction

- 1,400 cases completed

Coding

- AIS/ICD – 500 cases completed
- GIS – 1,200 cases completed

Case Reviews

- Created 13 review team panels each consisting of 4 surgeons, 1 EM/EMS reviewer, and 1 Forensic Reviewer. All panels have a reviewer with past military experience, and a minimum of 1 female reviewer on each panel.
- Case reviews were launched to the first review team panel in January 2019.
- To date, 400 cases have been released to panels.
- 220 cases have been completed.

Case Reviews

Study Round	Number of Cases Released	Case Completion	Comments
Round 1 Status *Began 1-16-2019*	260 Cases Released	200 Cases Completed	3 panels pending to close out Round 1
Round 2 Status *Began 3-25-2019*	140 Cases Released	20 Cases Completed	

- 13 review team panels
- Study will consist of 10 rounds
- Reviewers are reporting being able to complete each case review in about 10-15 minutes

Questions Used to Determine Consensus

- **Consensus must be reached on both Survivability Questions:**
  - Assume the survival status of this patient is unknown, ***with immediate access to care at a level I trauma center***, assess the survival potential of this patient.
  - Assume the survival status of this patient is unknown, ***given the conditions of the actual scenario*** in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient.

Case Consensus Definition

- 5 reviewers are used to determine consensus. The ME/Forensic reviewer is not calculated in consensus as this analysis is kept separate.
- Each variable is independent. So it must be 3 or more reviewers answering the same on one specific category. (For example: 3 agree the case is Potentially Survivable)
  - If one reviewer selects non-survivable and the other 4 select either potentially, definitely survivable, or cannot judge, that case goes to adjudication
  - If two reviewers select cannot judge, but the other three are able to make a determination, the case goes to adjudication

Case Consensus

Study Round	Number of Cases Completed	Cases That Went to Adjudication	Resolved Within Panel	Still Under Review by Team Panel	Require Outside Adjudication Team Review
Round 1	200	47	26	19	2
Round 2	20	0			

Preliminary Round 1 Data

- Q1: Based on your judgment, what was the principal mechanism(s) of death?

Principal Mechanism(s) of Death	Frequency
Neurological – Traumatic Brain Injury	161
Hemorrhage - Truncal	132
Neurological - Spinal Cord	112
Massive tissue disruption	59
Airway	36
Burn	26
Hemorrhage - Peripheral	16
Tension Pneumothorax	13
Hemorrhage - Junctional	11
Other	225
Unknown	7

Note: Using 200 cases from all reviewers. Cases with multiple causes are counted multiple times

Preliminary Round 1 Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

Immediate Access Survivability	Frequency
Non-survivable	150
Potentially Survivable	29
Definitely Survivable	2
Cannot Judge	0

Note: Using 181 cases that have reached consensus on survivability assessments

Preliminary Round 1 Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency
Non-survivable	173
Potentially Survivable	8
Definitely Survivable	0
Cannot Judge	0

Note: Using 181 cases that have reached consensus on survivability assessments

Preliminary Round 1 Data

- Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	374
Alcohol / drug	180
Seat belt	90
Airbag	36
Helmet	27
Child Restraint	6
Protective Clothing	6
Personal Flotation Device	4
Other	119

Note: Using 200 cases from all reviewers. Cases with multiple programs/devices are counted multiple times

Case Review Challenges

- Reviewers are given 3 weeks to complete case reviews. There have been delays in getting reviewers to complete their reviews by the deadline.
- Reviewers are reporting that once they log on to review cases, the time commitment is minimal. Average of 10-15 minutes per case.

NEMSIS Data Linkage Update

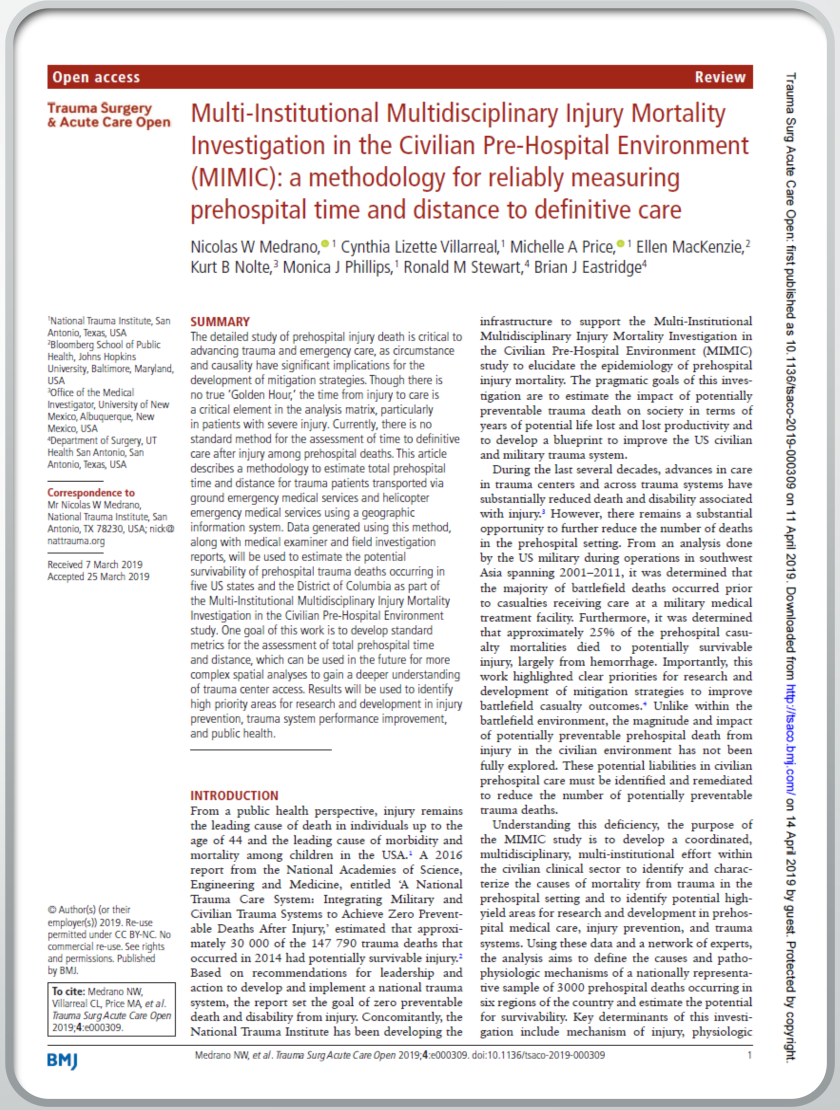
- Contact has been made with all 6 MIMIC sites
  - New Mexico - Currently working on data matching
  - Oklahoma - Currently working on data matching
  - Maryland - Finalizing Agreement utilizing NEMSIS data dictionary matching
  - Iowa - Agreement was approved, data matching will occur mid-May
  - Connecticut - Working internally to determine how to handle Non-Human Research project within the state requirements.
  - Washington DC - Working internally to determine how to handle Non-Human Research project within the state requirements.

Data Challenges

- Data agreements to match individual patient level data have to be executed with each state and data cannot be matched with the national data set.
- There is no national directory of EMS locations. The list had to be created by working with each state to receive information on base stations.
- Under Oklahoma statute they are not allowed to provide information beyond the ME autopsy report for research purposes. Other states are able to provide field investigator reports, and additional case details.

Publication

- Medrano NW, Villarreal CL, Price MA, MacKenzie E, 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. *2019; 4:e000309. doi:10.1136/tsaco-2019-000309.*



Open access Review

Trauma Surgery & Acute Care Open

Multi-Institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): a methodology for reliably measuring prehospital time and distance to definitive care

Nicolas W Medrano,[1] Cynthia Lizette Villarreal,[1] Michelle A Price,[1] Ellen MacKenzie,[2] Kurt B Nolte,[3] Monica J Phillips,[1] Ronald M Stewart,[4] Brian J Eastridge[4]

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[3]Office of the Medical Investigator, University of New Mexico, Albuquerque, New Mexico, USA
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Received 7 March 2019
Accepted 25 March 2019

To cite: Medrano NW, Villarreal CL, Price MA, *et al*. *Trauma Surg Acute Care Open* 2019;**4**:e000309.

SUMMARY

The detailed study of prehospital injury death is critical to advancing trauma and emergency care, as circumstance and causality have significant implications for the development of mitigation strategies. Though there is no true 'Golden Hour,' the time from injury to care is a critical element in the analysis matrix, particularly in patients with severe injury. Currently, there is no standard method for the assessment of time to definitive care after injury among prehospital deaths. This article describes a methodology to estimate total prehospital time and distance for trauma patients transported via ground emergency medical services and helicopter emergency medical services using a geographic information system. Data generated using this method, along with medical examiner and field investigation reports, will be used to estimate the potential survivability of prehospital trauma deaths occurring in five US states and the District of Columbia as part of the Multi-Institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment study. One goal of this work is to develop standard metrics for the assessment of total prehospital time and distance, which can be used in the future for more complex spatial analyses to gain a deeper understanding of trauma center access. Results will be used to identify high priority areas for research and development in injury prevention, trauma system performance improvement, and public health.

INTRODUCTION

From a public health perspective, 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 USA.[1] A 2016 report from the National Academies of Science, Engineering and Medicine, 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 trauma deaths that occurred in 2014 had potentially survivable injury.[2] Based on recommendations for leadership and action to develop and implement a national trauma system, the report set the goal of zero preventable death and disability from injury. Concomitantly, the National Trauma Institute has been developing the infrastructure to support the Multi-Institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC) study to elucidate the epidemiology of prehospital injury mortality. The pragmatic goals of this investigation are to estimate the impact of potentially preventable trauma death on society in terms of years of potential life lost and lost productivity and to develop a blueprint to improve the US civilian and military trauma system.

During the last several decades, advances in care in trauma centers and across trauma systems have substantially reduced death and disability associated with injury.[3] However, there remains a substantial opportunity to further reduce the number of deaths in the prehospital setting. From an analysis done by the US military during operations in southwest Asia spanning 2001–2011, it was determined that the majority of battlefield deaths occurred prior to casualties receiving care at a military medical treatment facility. Furthermore, it was determined that approximately 25% of the prehospital casualty mortalities died to potentially survivable injury, largely from hemorrhage. Importantly, this work highlighted clear priorities for research and development of mitigation strategies to improve battlefield casualty outcomes.[4] Unlike within the battlefield environment, the magnitude and impact of potentially preventable prehospital death from injury in the civilian environment has not been fully explored. These potential liabilities in civilian prehospital care must be identified and remediated to reduce the number of potentially preventable trauma deaths.

Understanding this deficiency, the purpose of the MIMIC study 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 prehospital setting and to identify potential high-yield areas for research and development in prehospital medical care, injury prevention, and trauma systems. Using these data and a network of experts, the analysis aims to define the causes and pathophysiologic mechanisms of a nationally representative sample of 3000 prehospital deaths occurring in six regions of the country and estimate the potential for survivability. Key determinants of this investigation include mechanism of injury, physiologic

Questions

IF YOU HAVE ANY PROJECT RELATED QUESTIONS, PLEASE DO NOT HESITATE TO REACH OUT

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LIZETTE VILLARREAL, MA

LIZETTE@NATTRAUMA.ORG

Title: Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): Concept of Utilizing Medical Examiner Data to Determine Prehospital Injury Survivability

Authors: MIMIC Steering Committee

Background

In 2016, the National Academies of Science, Engineering, and Medicine published a comprehensive assessment of U.S. trauma care systems entitled “A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths After Injury”. The report specifically noted, “a critical but often neglected source of data—particularly in civilian systems—is autopsy reports on trauma deaths, which could be used to determine the preventability of fatalities based on a common, accepted lexicon.” One foundational deficiency noted was that data linkages are incomplete or missing between prehospital care and the medical examiner (ME). The Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC) was conceptualized as a bridging strategy to develop a more comprehensive understanding of the epidemiology of civilian pre-hospital injury deaths and their potential for survivability.

Methods

The research proposes to analyze 3,000 civilian pre-hospital deaths and is being conducted at six ME offices across the United States: New Mexico, Oklahoma, Connecticut, Maryland, District of Columbia, and a region of Iowa. These sites were chosen because their centralized ME systems provide mortality investigation data that is uniform and readily accessible. A network of subject matter experts in the disciplines of forensic pathology, trauma surgery, neurosurgery, orthopedic surgery, emergency medicine, radiology, forensic nursing, trauma systems, and emergency medical services (EMS) collaborated to develop a consensus taxonomy relative to determination of potential for injury survivability. This framework and methodology were developed for evaluating the causes and pathophysiologic mechanisms of pre-hospital deaths, appropriateness of EMS response and care, and the potential for survivability under both optimal clinical circumstances and within the context of the scenario. The MIMIC Study Group consists of thirteen review panels, each including one medical examiner. Data available for survivability determinations include medical examiner autopsy data including imaging studies, field investigator reports, injury codes (Abbreviated Injury Scale / AIS), geospatial data (injury location, EMS location/time, trauma center level/location /time), and EMS data. Deaths are reviewed using an online electronic tool (Profiler) developed for this study.

Conclusion

The goal of the research is 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. The research intends to identify ways that the ME and trauma communities can improve linkages to foster in-depth reviews of trauma mortality.

Office of the Medical Investigator

MIMIC

Case Study for Field Investigations Reporting

Victoria Chavez, FDMI Sandoval County

03.13.2019

MIMIC

Study Hypothesis

How can we reduce deaths in remote areas?

MIMIC

Multi-Institutional
Multidisciplinary Injury
Mortality Investigation
in the Civilian Pre-Hospital

PROJECT OVERVIEW

- Study Hypothesis
- Study Objectives
- Potential Benefits
- Participating Offices
- Study Population

Study Hypotheses

- **Substantial opportunity to further reduce deaths in 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.

Investigators

- PI: Brian Eastridge, MD
  Division Chief Trauma and Emergency General Surgery
  University of Texas Health Science Center at San Antonio, Texas
- Co- PI: Kurt Nolte, MD
  Chief Medical Investigator
  New Mexico Office of the Medical Investigator
- Co-PI: Ellen MacKenzie, PhD
  Dean, Johns Hopkins Bloomberg School of Public Health

*MIMIC Objectives

- **Objective #1:** Develop a framework and methodology
- **Objective #2:** Organize and standardize a multidisciplinary, multi-institutional network of experts
- **Objective #3:** Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths
- **Objective #4:** Describe the epidemiology of pre-hospital mortality
- **Objective #5:** Develop a blueprint for a sustained effort

*National Trauma Institute

*System Benefits

TRAUMA

- Performance improvement
  - Engineering
  - Medical devices / procedures
  - EMS value validation
  - Injury Prevention
  - Collaboration between trauma and ME communities

*National Trauma Institute

*System Benefits

MEDICAL EXAMINER

- Funding for advanced radiological imaging
- Improve mechanistic information
- Interaction between trauma and ME communities
- Bridge the gap between ME and trauma systems data sets

*National Trauma Institute

*Study Setting Six Regions in the Country

(Centralized ME systems and utilizing electronic case management system to collect uniform data on all deaths)

1. **State of Connecticut**
2. **Johnson County, Iowa**
3. **State of Maryland**
4. **State of New Mexico**
5. **State of Oklahoma**
6. **The District of Columbia**

*National Trauma Institute

*Study Population

- **Inclusion Criteria:**
  1. Pre-hospital deaths (at scene, enroute to hospital or DOA – defined as no vitals upon arrival at hospital)
  2. Blunt, Penetrating, Thermal, and Suicides are included
- **Exclusion Criteria:**
  1. Non-mechanical causes of death – poisoning, drug overdoses, hangings, drowning (unless associated with trauma)
  2. Decomposed remains only (not fully fleshed with distinguishable organs)

*National Trauma Institute

*Estimates of Number of Injury Deaths

(Blunt Firearm and Other Sharp Forces)

*National Trauma Institute

OCME	2012	2013	2014	Total
Connecticut	684	621	692	1997
Johnson Co. Iowa	133	128	110	371
Maryland	1509	1200*	1200*	3909
Oklahoma	1044	1153	1007	3204
New Mexico	823	778	906	2507
Washington, DC	232	267	254	753
Total	4,425	4,147	4,169	12,741

*Forensic Record

ME cases may involve any of the following:

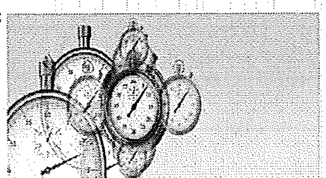
- Medical Examiner Report
  - Full Autopsy
  - Partial Autopsy
  - External Exam
- Radiographs
- Toxicology
- Photographs
- Investigator Reports

*National Trauma Institute

Additional Information Required for this study and future studies

Identify Time of arrival:

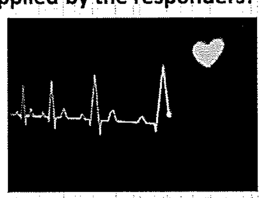
- ❑ Law Enforcement
- ❑ EMS
- ❑ Fire Department
- ❑ BIA
- ❑ FBI
- ❑ Search & Rescue



Date & Time When Decedent was first found

What interventions were applied by the responders?

- ❑ EKG Only
- ❑ CPR
- ❑ AED
- ❑ Oral Airway/Endo tube
- ❑ BVM/Supplemental O2
- ❑ Vascular Catheter (AC, intraosseous)
- ❑ **Extrication**—by whom?



Destination from scene known?

- Healthcare Facility
- Office of the Medical Investigator
- Mortuary (for external exam)

DATE & TIME OF DEPARTURE FROM SCENE

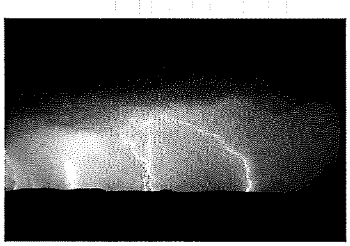
Please identify who transported the decedent

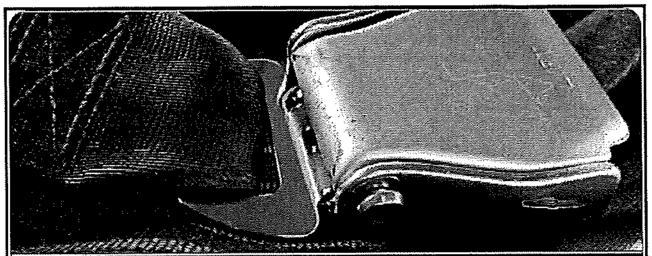
- Brookwood Transport
- Funeral Home Transport
- Other

Include date & time arrived/departed

Include Weather Conditions when applicable

- Clear skies
- Rain
- Rain & thunderstorm
- Snow or ice
- High winds





Presence of Protective Equipment

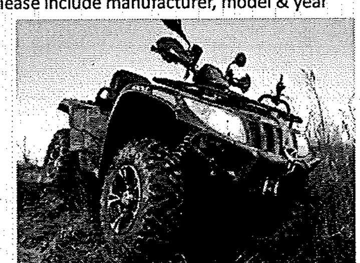
Helmet, Lap belt, Shoulder belt, Child restraint, Personal flotation device, Eye protection, Protective clothing, Airbag deployment

Was the Event Witnessed?

Motor Vehicle Type

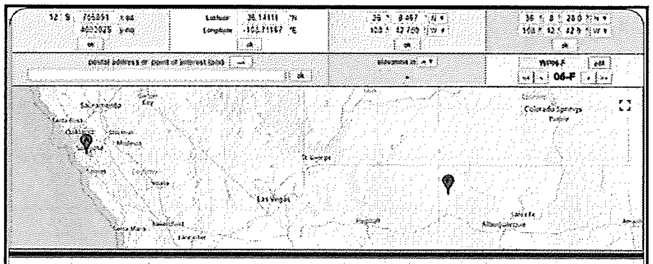
Please include manufacturer, model & year

- ☐ Car
- ☐ Light truck
- ☐ Heavy truck
- ☐ Commercial truck
- ☐ Motorcycle
- ☐ ATV
- ☐ Watercraft

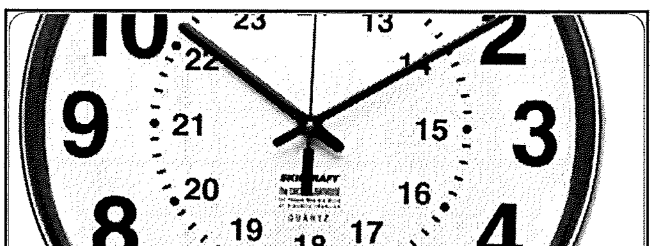


Injury Location – GPS Coordinates
MUST Use Decimal Degrees (DD):
Positive Latitude & Negative Longitude

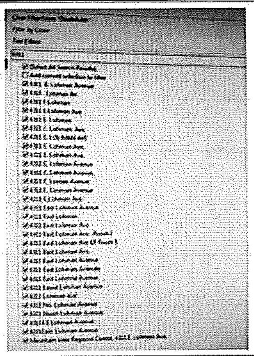
FORMAT	LATITUDE	LONGITUDE
***Decimal Degrees (DD)**	**34.19257**	**-106.06417**
Degrees Minutes Seconds (DMS)	34° 11' 33.3	106 3' 51.0
Degrees Decimal Minutes (DMM)	34° 11.554	106° 3.850



geoplaner.com
Please use this website to convert to Decimal Degrees (DD) format
Please note that Longitude is expressed as a negative value in the Western Hemisphere



Please Use Military Time



This an example of how important it is to try to be consistent whenever possible with facility names and addresses.

What is New Mexico's Key Role?

- New Mexico is leading the way in this study
- We broke ground with the first 50 case studies
- 95% of the kinks were worked out by OMI
- Our questions/suggestions were used to create the backbone of the study
- Assisted the other 5 institutions involved in, also extrapolating data from their identified cases.

A BIG THANK YOU TO ALL OF OUR INCREDIBLE INVESTIGATORS & THEIR HARD WORK!

Questions?

If you have any project related questions, please do not hesitate to reach out to

Garon Bodor, Research Coordinator
Office of the Medical Investigator
gabodor@salud.unm.edu

MIMIC

Improving the Military-Civilian Taxonomy and Process to Determine Prehospital Injury Survivability

Villarreal CL[1], Medrano NW[1], Phillips MJ[1], Price MA[1], MIMIC Steering Committee, Eastridge BE[2]
National Trauma Institute[1], The University of Texas Health Science Center at San Antonio[2]

Background

In 2016, the National Academies of Science, Engineering, and Medicine report entitled "A National Trauma Care System: Integrating Military and Civilian Trauma Systems to Achieve Zero Preventable Deaths after Injury," identified several specific trauma system gaps requiring remediation. One of the foundational deficiencies noted was that data linkages are incomplete or entirely missing among prehospital care, hospital-based acute care, rehabilitation, and the medical examiner. The committee also highlighted that "a critical but often neglected source of data—particularly in civilian systems—is autopsy reports on trauma deaths, which could be used to determine the preventability of fatalities based on a common, accepted lexicon."

Advances in care in trauma centers and systems have substantially reduced death and disability associated with injury. However, there remains a substantial opportunity to further reduce deaths in the prehospital setting. Potential liabilities in civilian and military prehospital care must be identified and remedied in order to reduce the number of potentially preventable deaths on the battlefield and in the civilian environment. Therefore, the Department of Defense (DoD) and Combat Casualty Care Research Program of the Medical Research and Material Command (MRMC) have made a significant investment to establish a dedicated research effort focused on understanding the survivability of injury in the prehospital environment. The Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Prehospital Environment (MIMIC) study was funded to develop a more comprehensive understanding of the epidemiology of civilian prehospital injury deaths and their potential for survivability. The goal of the research is to identify liabilities in trauma systems and develop mitigation strategies with translation potential for realistic and relevant improvements in battlefield trauma systems and improvements in Warfighter survivability.

Methods

- Steering Committee (Military and Civilian) defined survivability definitions and process (Figure 1)
- Expert review panels developed (~ 80 Military and Civilian reviewers)
  -6 Members per Review Team: 4 Surgeons (Trauma, Orthopedic, Neurosurgeon), 1 EM/EMS, 1 Forensic
- Electronic review and response tool created (Profiler)
- Panels review injury death cases and assign a determination of survivability to each case
- Survivability determinations were developed based upon principal mechanism of death (Figure 2)
- Non-consensus in determination of survivability secondarily reviewed by an adjudication team to determine survivability potential

Figure 1: MIMIC Process Flow Chart

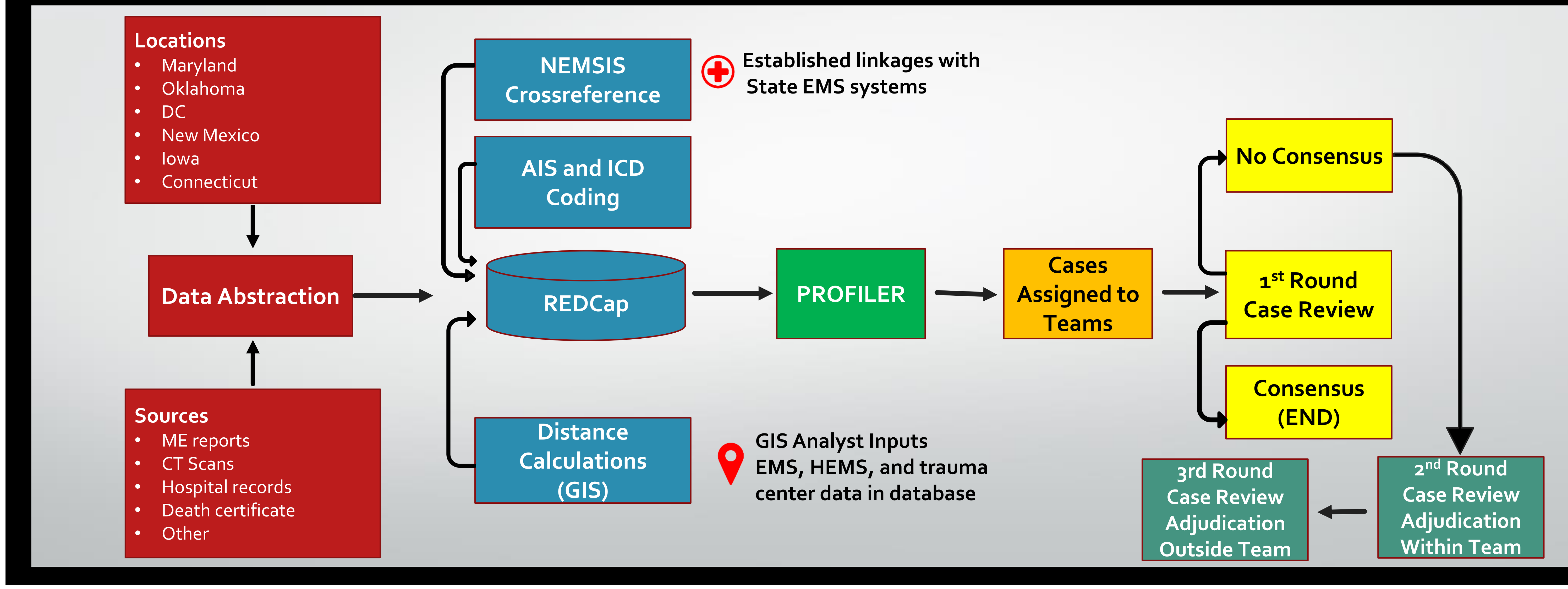
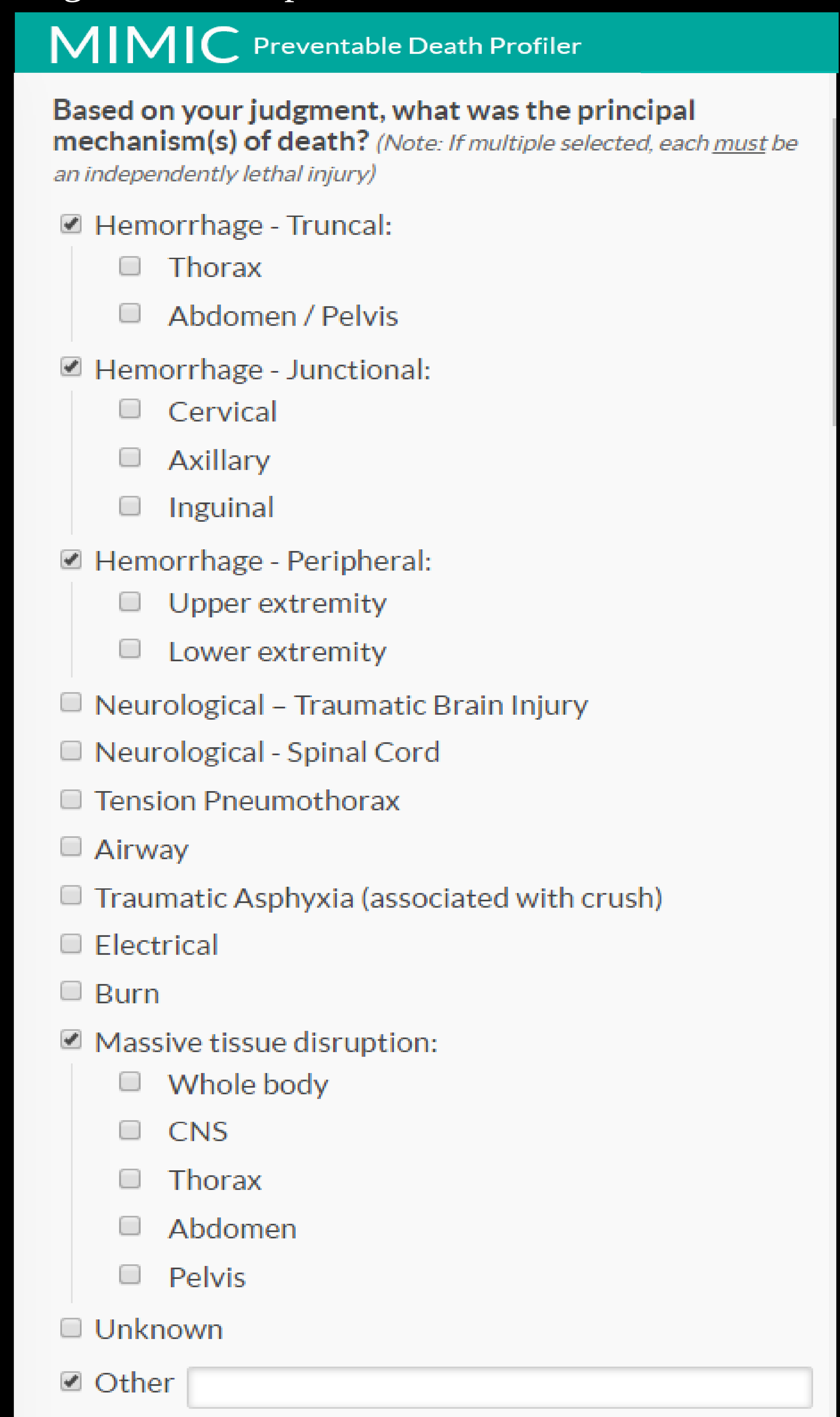


Figure 2: Principal Mechanisms of Death



MIMIC Preventable Death Profiler

Based on your judgment, what was the principal mechanism(s) of death? *(Note: If multiple selected, each must be an independently lethal injury)*

- [x] Hemorrhage - Truncal:
  - [ ] Thorax
  - [ ] Abdomen / Pelvis
- [x] Hemorrhage - Junctional:
  - [ ] Cervical
  - [ ] Axillary
  - [ ] Inguinal
- [x] Hemorrhage - Peripheral:
  - [ ] Upper extremity
  - [ ] Lower extremity
- [ ] Neurological – Traumatic Brain Injury
- [ ] Neurological - Spinal Cord
- [ ] Tension Pneumothorax
- [ ] Airway
- [ ] Traumatic Asphyxia (associated with crush)
- [ ] Electrical
- [ ] Burn
- [x] Massive tissue disruption:
  - [ ] Whole body
  - [ ] CNS
  - [ ] Thorax
  - [ ] Abdomen
  - [ ] Pelvis
- [ ] Unknown
- [x] Other

Methods continued

- Survivability Definitions
  - **Non Survivable-** Death as a result of catastrophic anatomic injuries
  - **Potentially Survivable-** Anatomic injuries that were severe but medically survivable
  - **Definitely Survivable-** Minimal anatomic injuries with a high likelihood of survival
  - **Cannot Judge-** information insufficient to make a determination

Conclusions

The comprehensive nature of the MIMIC study has allowed the prehospital care research community to unify the prehospital injury survivability lexicon that will enable future studies to advance the science. These efforts are critical to advancing trauma and emergency care as injury pattern, as well as circumstance and causality, have significant implications for the development of mitigation strategies. Utilizing the clinical and forensic judgement of national experts serving as MIMIC team panel reviewers, this study will serve to advance prehospital care and trauma systems development, which in turn will be translatable into military medicine and the protection and care of the Wounded Warrior.

Acknowledgement

The U. S. Army Medical Research Acquisition Activity, 820 Chandler Street, Fort Detrick MD 21702-5014 is the awarding and administering acquisition office. This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Defense Medical Research and Development Program under Award No. W81XWH-17-2-0010. Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense.

MIMIC Update

AAST Meeting
September 2019

DoD Broad Agency Announcement (BAA) Grant

- Department of Defense (BAA $3,979,380)
- PI: Brian Eastridge, MD
  - Professor, Department of Surgery
  - Division Chief, Trauma and Emergency General Surgery
  - Jocelyn and Joe Straus Endowed Chair in Trauma Research
  - University of Texas Health Science Center at San Antonio
- Co-PI: Kurt Nolte, MD
  - Professor of Pathology
  - University of New Mexico
  - Director of Radiology-Pathology Center for Forensic Imaging
  - Chief Medical Investigator, Office of the Medical Investigator

  Ellen MacKenzie, PhD
  - Dean, Johns Hopkins Bloomberg School of Public Health
  - Bloomberg Distinguished Professor

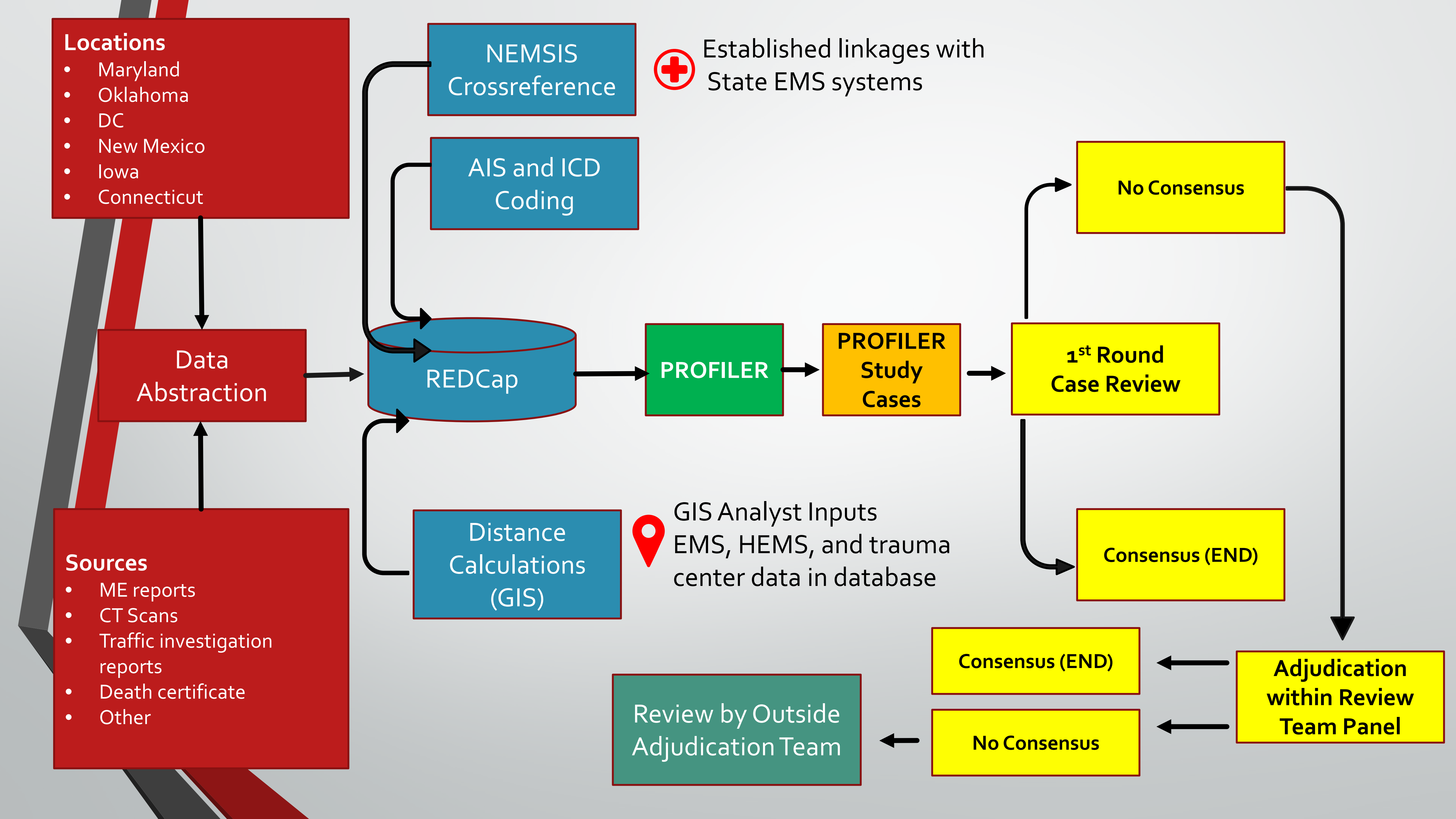
MIMIC Objectives

Completed

- **Objective #1:** ***Develop a framework and methodology*** for evaluating pre-hospital deaths
- **Objective #2:** Organize and standardize a ***multidisciplinary, multi-institutional network of experts*** to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.

In Progress

- **Objective #3:** ***Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths***, and estimate the potential for survivability
- **Objective #4:** ***Describe the epidemiology of pre-hospital mortality*** in the context of trauma system development and estimate its impact on society.
- **Objective #5:** ***Develop a blueprint for a sustained effort*** identifying high priority areas for injury prevention, trauma systems performance improvement and research and development.



Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages with State EMS systems
AIS and ICD Coding
No Consensus
Data Abstraction
REDCap
PROFILER
PROFILER Study Cases
1st Round Case Review
Sources
ME reports
CT Scans
Traffic investigation reports
Death certificate
Other
Distance Calculations (GIS)
GIS Analyst Inputs EMS, HEMS, and trauma center data in database
Consensus (END)
Consensus (END)
Adjudication within Review Team Panel
Review by Outside Adjudication Team
No Consensus

Project Update

Data Abstraction

- 2,539 of 3,000 cases have been abstracted

Coding

- AIS/ICD – 860 cases completed
- GIS – 2,587 cases completed

Case Reviews

- Created 13 review team panels each consisting of 4 surgeons, 1 EM/EMS reviewer, and 1 Forensic Reviewer. All panels have a reviewer with past military experience, and a minimum of 1 female reviewer on each panel.
- Case reviews were launched to the first review team panel in January 2019.
- To date, 775 cases have been released to panels.
- 585 cases have been completed.

Case Reviews

Study Round	Number of Cases Released	Case Completion	Comments
Round 1 Status *Began 1-16-2019*	260 Cases Released	240 Cases Completed	1 panel pending to close out Round 1
Round 2 Status *Began 3-25-2019*	240 Cases Released	220 Cases Completed	1 panel pending to close out Round 2
Round 3 Status *Began 6-13-2019*	300 Cases Released	125 Cases Completed	-1 panel pending cases to be released -other panels are completing reviews

- 13 review team panels
- Study will consist of 10 rounds
- Reviewers are reporting being able to complete each case review in about 10-15 minutes

Questions Used to Determine Consensus

- **Consensus must be reached on both Survivability Questions:**
  - Assume the survival status of this patient is unknown, ***with immediate access to care at a level I trauma center***, assess the survival potential of this patient.
  - Assume the survival status of this patient is unknown, ***given the conditions of the actual scenario*** in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient.

Case Consensus Definition

- 5 reviewers are used to determine consensus. The ME/Forensic reviewer is not calculated in consensus as this analysis is kept separate.
- Each variable is independent. So it must be 3 or more reviewers answering the same on one specific category. (For example: 3 agree the case is Potentially Survivable)
  - If one reviewer selects non-survivable and the other 4 select either potentially, definitely survivable, or cannot judge, that case goes to adjudication
  - If two reviewers select cannot judge, but the other three are able to make a determination, the case goes to adjudication

Case Adjudication

Study Round	Number of Cases That Did Not Reach Initial Consensus	Cases Resolved During Team Adjudication	Cases Still In Team Adjudication	Could Not Reach Consensus, Pushed for Outside Adjudication
Round 1 Status	61 cases	44 cases	3 cases	14 cases
Round 2 Status	49 cases	21 cases	20 cases	8 cases
Round 3 Status	36 cases	9 cases	24 cases	3 cases

- Look for adjudication email
- Provide a comment in the discussion bar
- If you are changing your response, be sure to change and then click Submit, to resubmit your case

Preliminary Round 1 and Round 2 Data

- Q1: Based on your judgment, what was the principal mechanism(s) of death?

Principal Mechanism(s) of Death	Frequency
Neurological – Traumatic Brain Injury	1342
Hemorrhage - Truncal	393
Neurological - Spinal Cord	246
Massive tissue disruption	146
Burn	133
Other	84
Airway	79
Traumatic Asphyxia	59
Unknown	51
Hemorrhage - Junctional	44
Hemorrhage - Peripheral	38
Tension Pneumothorax	32
Electrical	1

Note: Cases with multiple causes are counted multiple times. (Round 1 and 2)

Preliminary Round 1 and Round 2 Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

	Frequency
	322 (78%)
	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

Note: Using 414 cases that have reached consensus on survivability assessments

Preliminary Round 1 and Round 2 Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency
	389 (94%)
	24 (6%)
	1
Cannot Judge	0

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using 414 cases that have reached consensus on survivability assessments

Immediate Access Survivability	Frequency
Non-survivable	322 (78%)
Potentially Survivable	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	[illegible]equency
Non-survivable	[illegible]9 (94%)
Potentially Survivable	24 (6%)
Definitely Survivable	1
Cannot Judge	0

Preliminary Round 1 and Round 2 Data

- Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

***Note:** Using records from all reviewers in Round 1 and Round 2.*

NEMSIS Data Linkage Update

- Contact has been made with states from all 6 MIMIC sites
  - Oklahoma – EMS data was received, will see data in Round 4
  - Washington DC - Currently working on data matching
  - Maryland - Currently working on data matching
  - New Mexico - Currently working on finalizing agreement
  - Iowa – Initial request was denied, will resubmit in Spring 2020.
  - Connecticut - Working internally to determine how to handle Non-Human Research project within the state requirements.

Timeline

	First Panel Release	Last Panel Release	Reviews Completed
Round 4	9/27/2019	11/29/2019	12/27/2019
Round 5	12/6/2019	2/7/2020	3/6/2020
Round 6	2/14/2020	4/17/2020	5/15/2020
Round 7	4/24/2020	6/26/2020	7/24/2019
Round 8	7/3/2020	9/4/2020	10/2/2020
Round 9	9/11/2020	11/13/2020	12/11/2020
Round 10	11/20/2021	1/15/2021	2/12/2021

- ***Reviewers are given 3 weeks to complete case reviews.***
- ***Once adjudication is released, reviewers are given 1 week to complete.***

Data Challenges

- EMS data agreements to match individual patient level data have to be executed with each state since data cannot be matched with the national data set.

- Under Oklahoma statute they are not allowed to provide information beyond the ME autopsy report for research purposes. Other states are able to provide field investigator reports, and additional case details.

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Villarreal CL[1], Medrano NW[1], Phillips MJ[1], Price MA[1], MIMIC Steering Committee, Eastridge BE[2].
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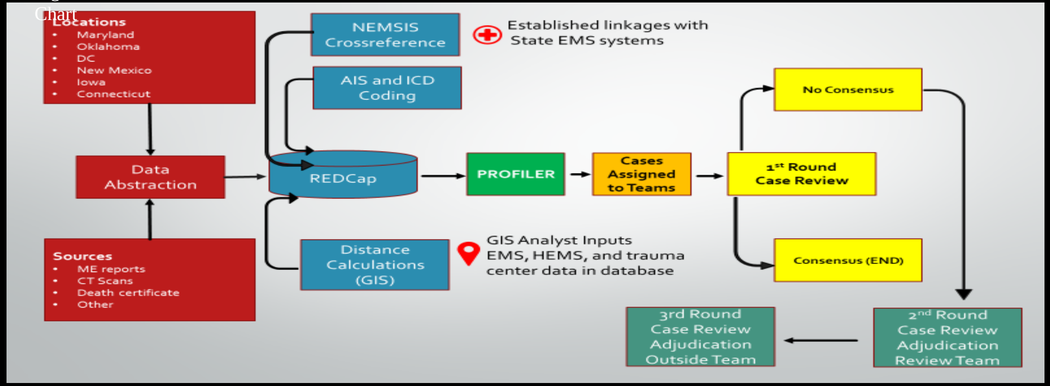
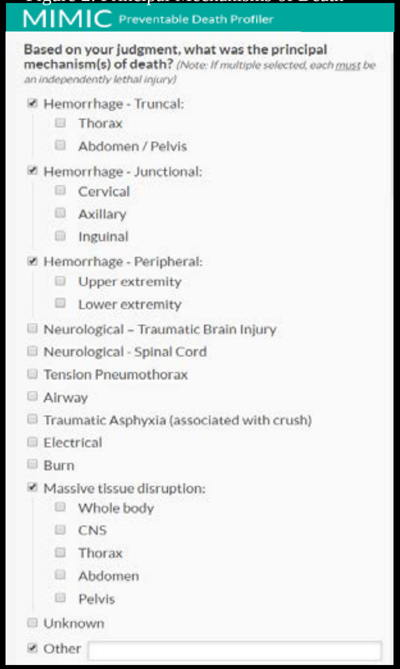


Figure 2: Principal Mechanisms of Death



Methods continued

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MIMIC

Publication on Process / Lexicon to Follow (all Reviewers will receive attribution / be cited "MIMIC Study Panel")

ary Injury Mortality
vironment (MIMIC):
Data to Determine
Injury Survivability

NAME Annual Meeting

October 2019

Other Planned MIMIC Presentations

Support Operational, Educational, and R&D Agendas

- **Advanced Law Enforcement Rapid Response Training Conference**

  Aurora, CO October 2019

- **McSwain International PreHospital Trauma Conference**

  New Orleans, LA October 2019

- **American Association of Blood Bankers**

  San Antonio, TX October 2019

Planned MIMIC Abstract Submissions

- Preliminary Analysis of MIMIC Prehospital Injury Mortality
  - Western Trauma Association 2020
- Analysis TBD
  - American Association for the Surgery of Trauma 2020

Questions

IF YOU HAVE ANY PROJECT RELATED QUESTIONS, PLEASE DO NOT HESITATE TO REACH OUT

BRIAN EASTRIDGE, MD

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LIZETTE VILLARREAL, MA

LIZETTE@NATTRAUMA.ORG

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

BJ Eastridge, K Nolte, E MacKenzie, R Stewart, JB Holcomb, CL Villarreal, N Medrano, M Price, G Davis, RT Maxson, E Mazuchowski and the MIMIC Investigator Group

Introduction: Advances in trauma centers and systems have substantially reduced death associated with injury. However, there are substantial opportunity to further reduce deaths in the prehospital setting. The goal of this research was to characterize survival potential of prehospital injury deaths in order to develop mitigation strategies and improve trauma systems.

Methods: A steering committee developed prehospital injury survivability definitions and study process. Balanced expert review panels were established from 80 military and civilian reviewers specializing in trauma surgery, orthopedics, neurosurgery, emergency medicine, EMS, and forensic pathology. Panels reviewed injury mortalities from comprehensive medical examiner systems and assigned a determination of survivability to each case based upon principal mechanism of death. Survivability determinations were made based upon the assumption of immediate access to care and in the context of the actual injury scenario. Non-consensus in determination of survivability was remediated though an online adjudication process. Data were entered into an electronic review and response tool (Profiler) for collation and analysis.

Results: 436 prehospital mortality cases were assessed by the reviewer panel. Panel consensus of survivability was reached in 414/436 cases (94.9%) (Table 1). Assuming immediate access to care, potentially / definitely survivable mortality was 22.2% .

Conclusions: This preliminary analysis of prehospital injury mortality develops a perspective of relative importance of injury mortality causation in the prehospital environment. This assessment may provide objective evidence to support the development of mitigation strategies for therapy and injury prevention to improve trauma systems.

Survivability Determination	Immediate Access	Actual Scenario
Non-Survivable	322 (77.8%)	389 (94.0%)
Potentially Survivable	87 (21.0%)	24 (5.8%)
Definitely Survivable	5 (1.2%)	1 (0.2%)
Cannot Determine	0 (0%)	0 (0%)

Table 1. Prehospital Injury Survivability

PREHOSPITAL BLOOD UTILIZATION INCREASING SURVIVABILITY AFTER INJURY

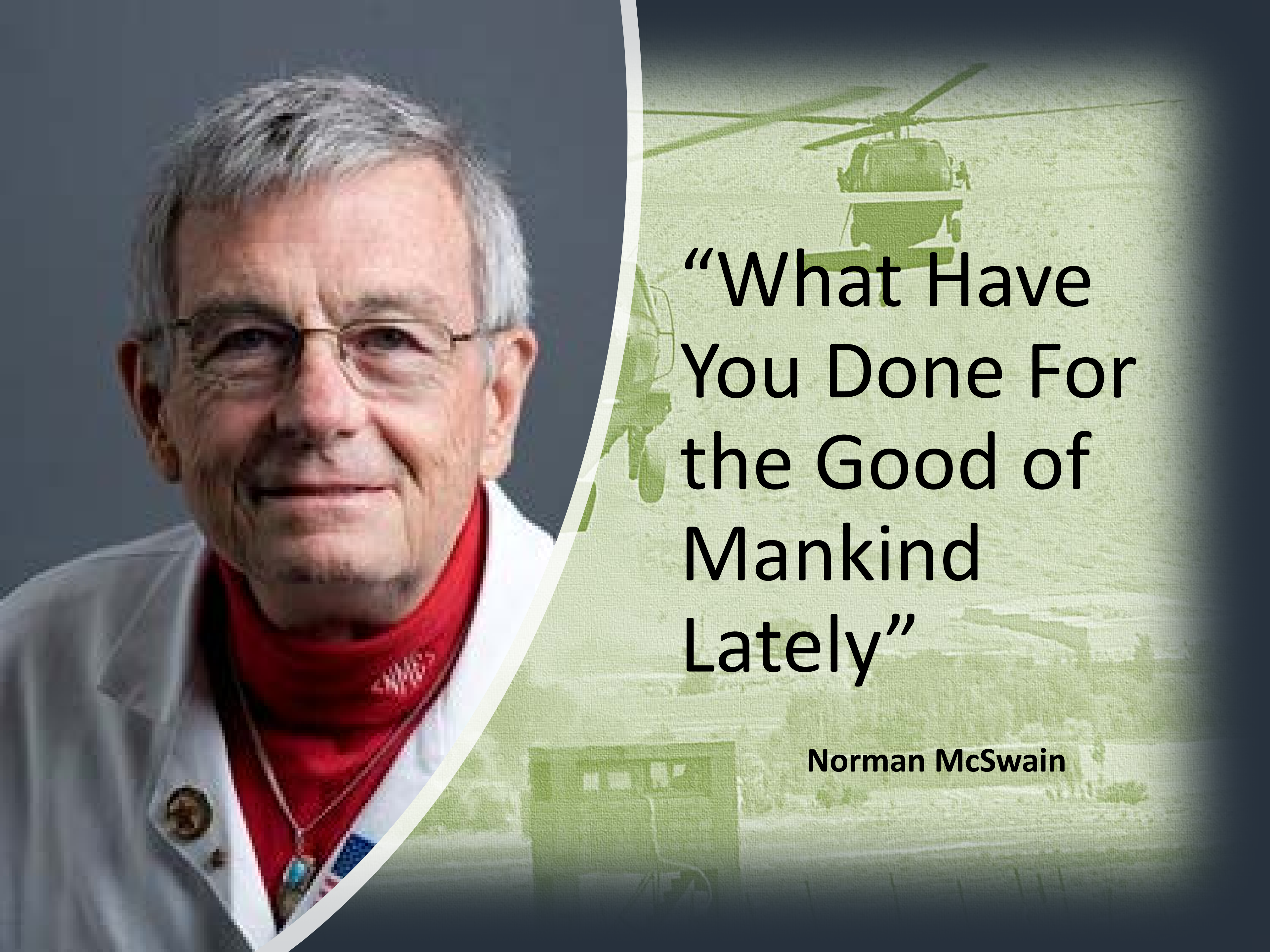
McSwain EMS Trauma Conference
7th Annual Annual Meeting
11 October 2019

Brian Eastridge, MD, FACS
COL, MC, USAR
Professor, Department of Surgery
Division of Trauma and Emergency Surgery
University of Texas Health Science Center at San Antonio

Disclosure / Disclaimer

Nothing to disclose

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.


"What Have You Done For the Good of Mankind Lately"
Norman McSwain

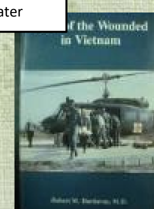
History of Battlefield Medical Innovation

World War I
- IV fluids
- Blood transfusions
- Motorized ambulances
- Topical antisepsis

World War II
- Whole blood/plasma a
- Specialty-specific surgi groups
- Antibiotics
- Fixed wing aero-medical evacuation

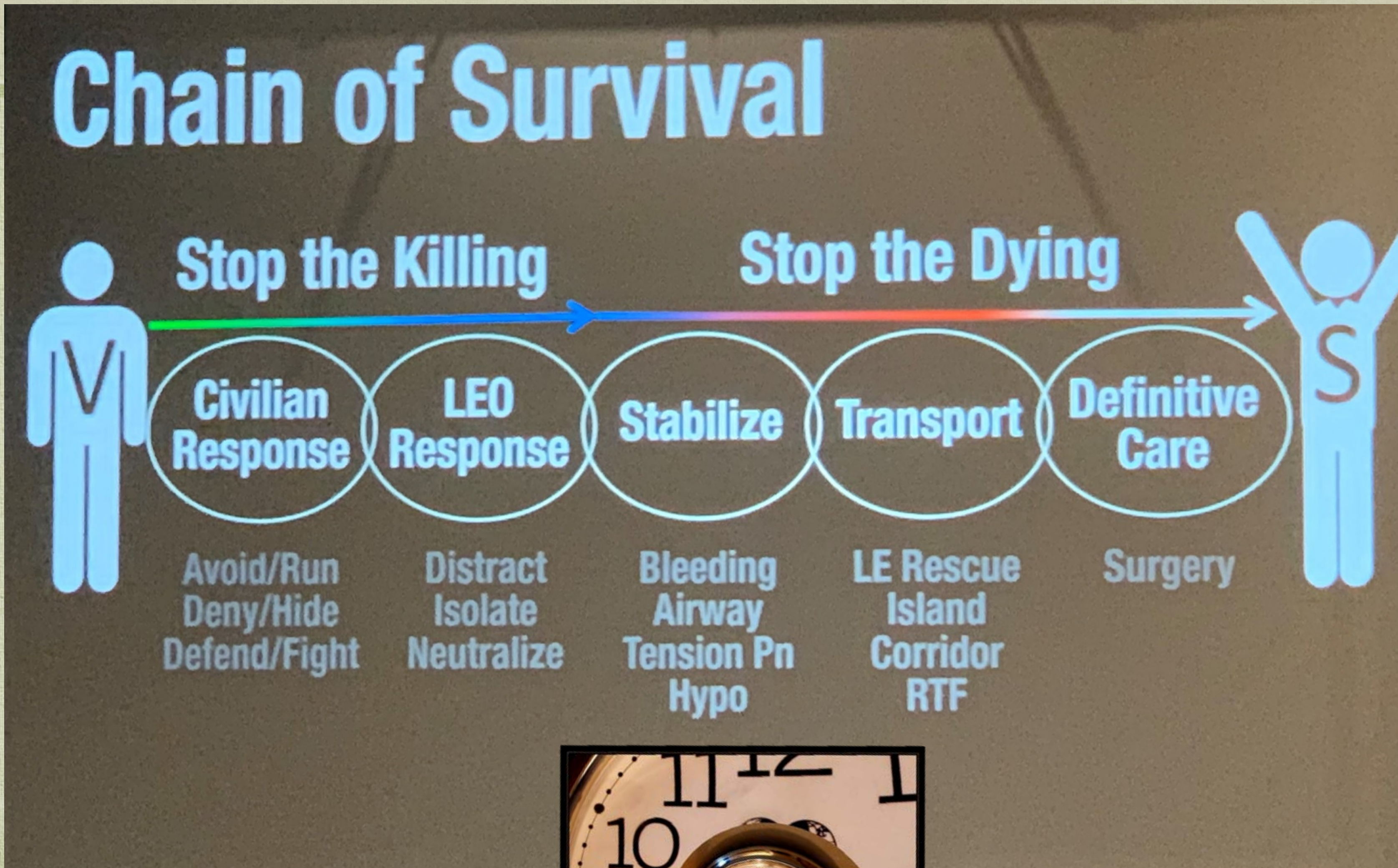
Korean Conflict
- Improved fluid resuscitation
- Forward availability of definitive surgery
- Helicopters for patient evac/transport
- Primary repair/grafts for vascular injury

Vietnam
- Improved use of helicopters
- Improved laboratory support
- Portable radiology equipment
- Mechanical ventilators in theater



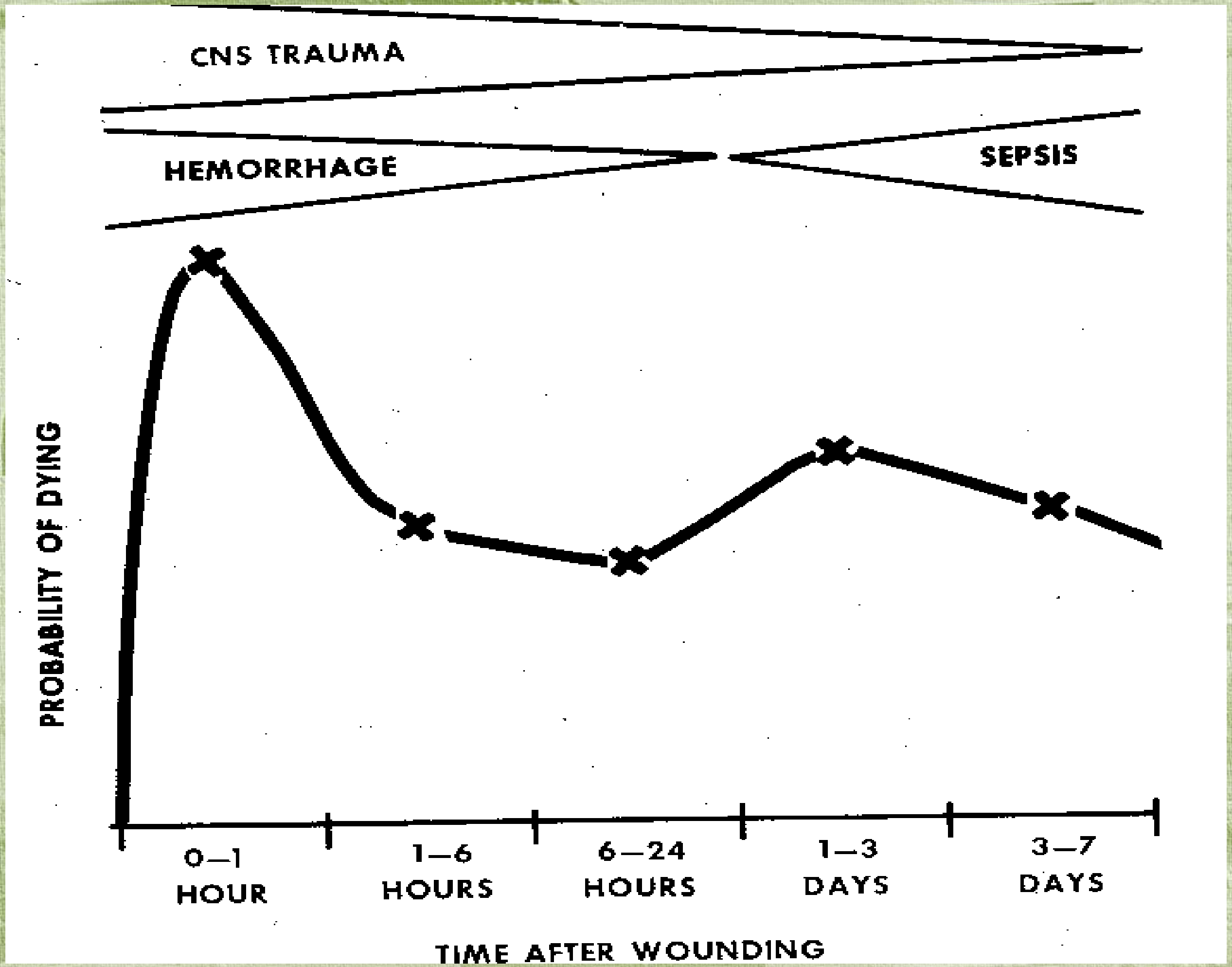
Desert Shield/Storm
- Burn team augmentation of evacuation hospitals to provide theater-wide burn care
- Intercontinental aeromedical transport of burn patients

OEF / OIF
- Military trauma system (JTS / DoDTR)
- Damage control resuscitation
- Tactical Combat Casualty Care
- Tourniquet
- Understanding of preventable death
- Combat casualty care research


Chain of Survival
Stop the Killing
Stop the Dying
V
S
Civilian Response
LEO Response
Stabilize
Transport
Definitive Care
Avoid/Run
Deny/Hide
Defend/Fight
Distract
Isolate
Neutralize
Bleeding
Airway
Tension Pn
Hypo
LE Rescue
Island
Corridor
RTF
Surgery

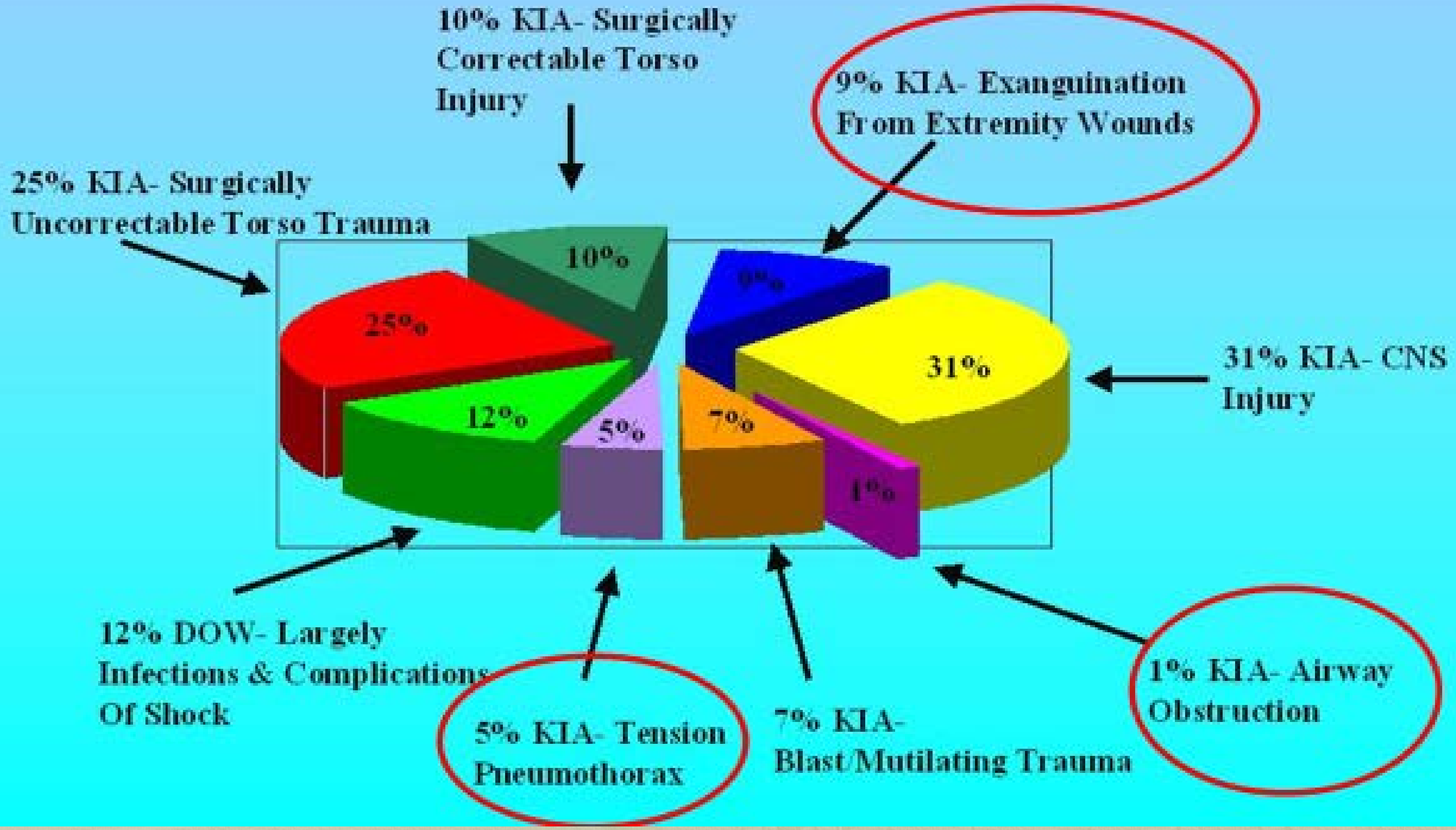
Battlefield Mortality Mechanism and Causation

Empiric Probability Combat Death

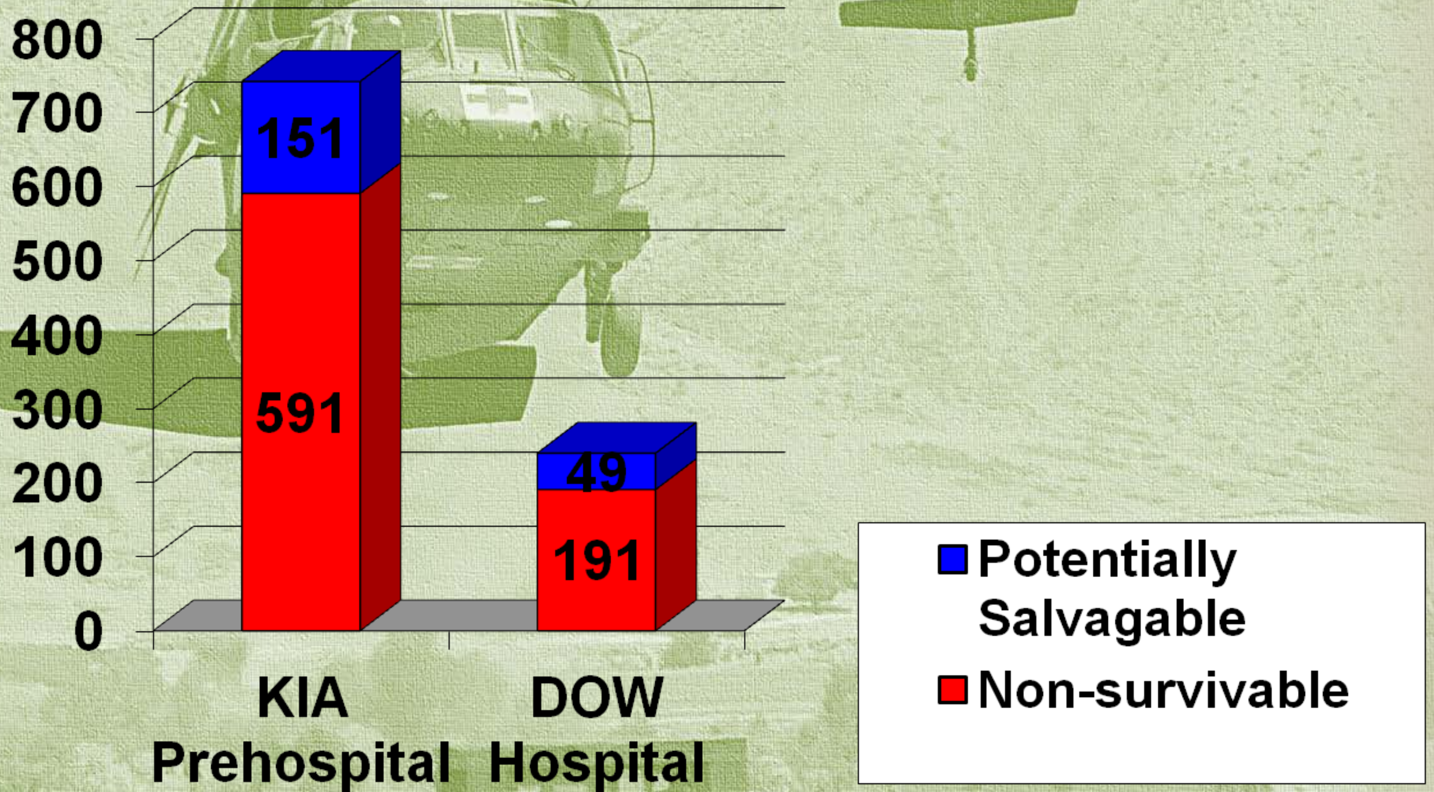


Bellamy, J Trauma, 1984

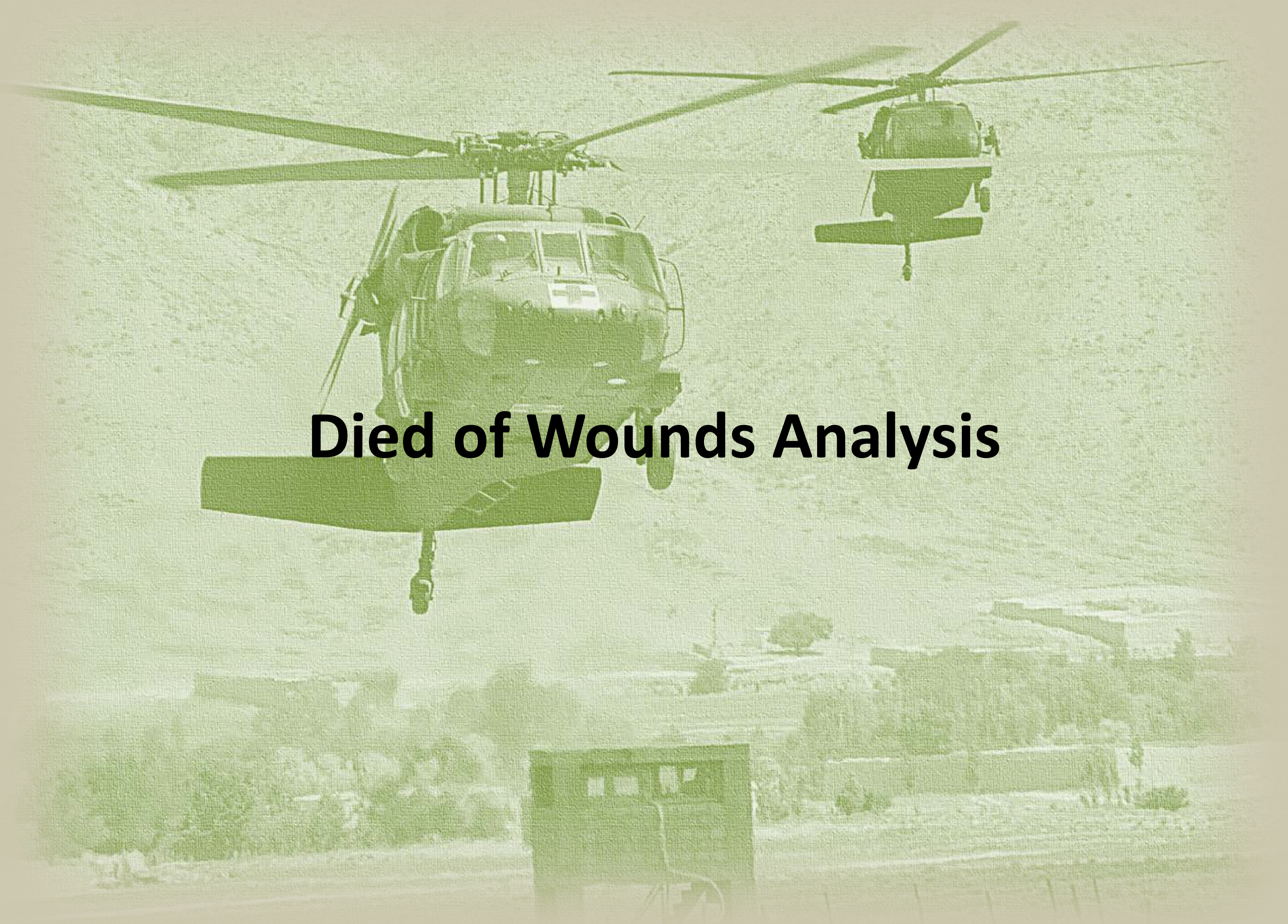
How People Die In Ground Combat (From COL Ron Bellamy)



Where can we save the most lives?



Kelly JF, et.al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 versus 2006. J Trauma



Died of Wounds Analysis

DOW Analysis

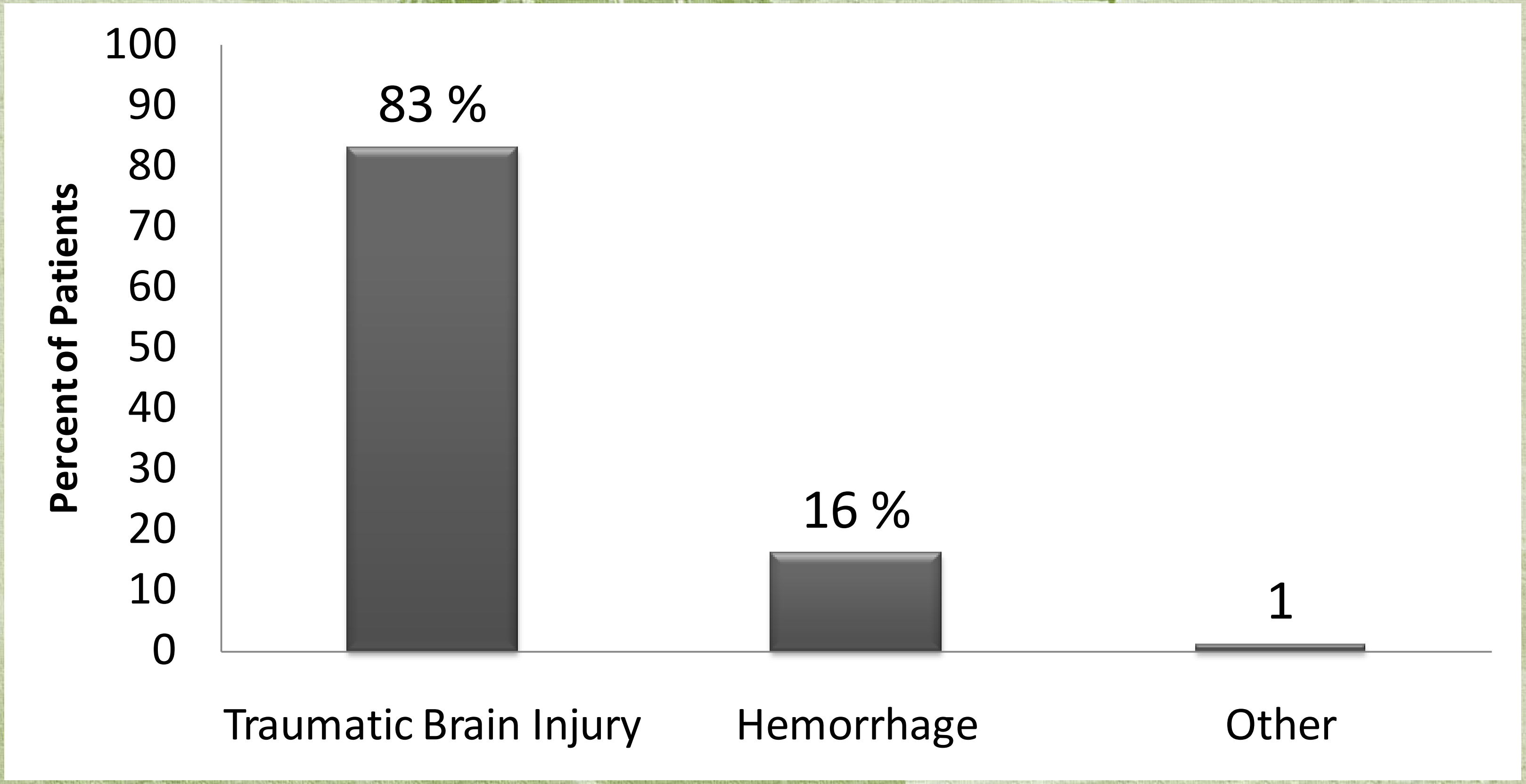
- Review died of wounds (DOW)deaths n=558
- Data sources
  - DoD Trauma Registry
  - Armed Forces Medical Examiner System (AFMES)
- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity
- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

- Goal: Identify areas for improved training, medical care, material, research and development

DOW Analysis

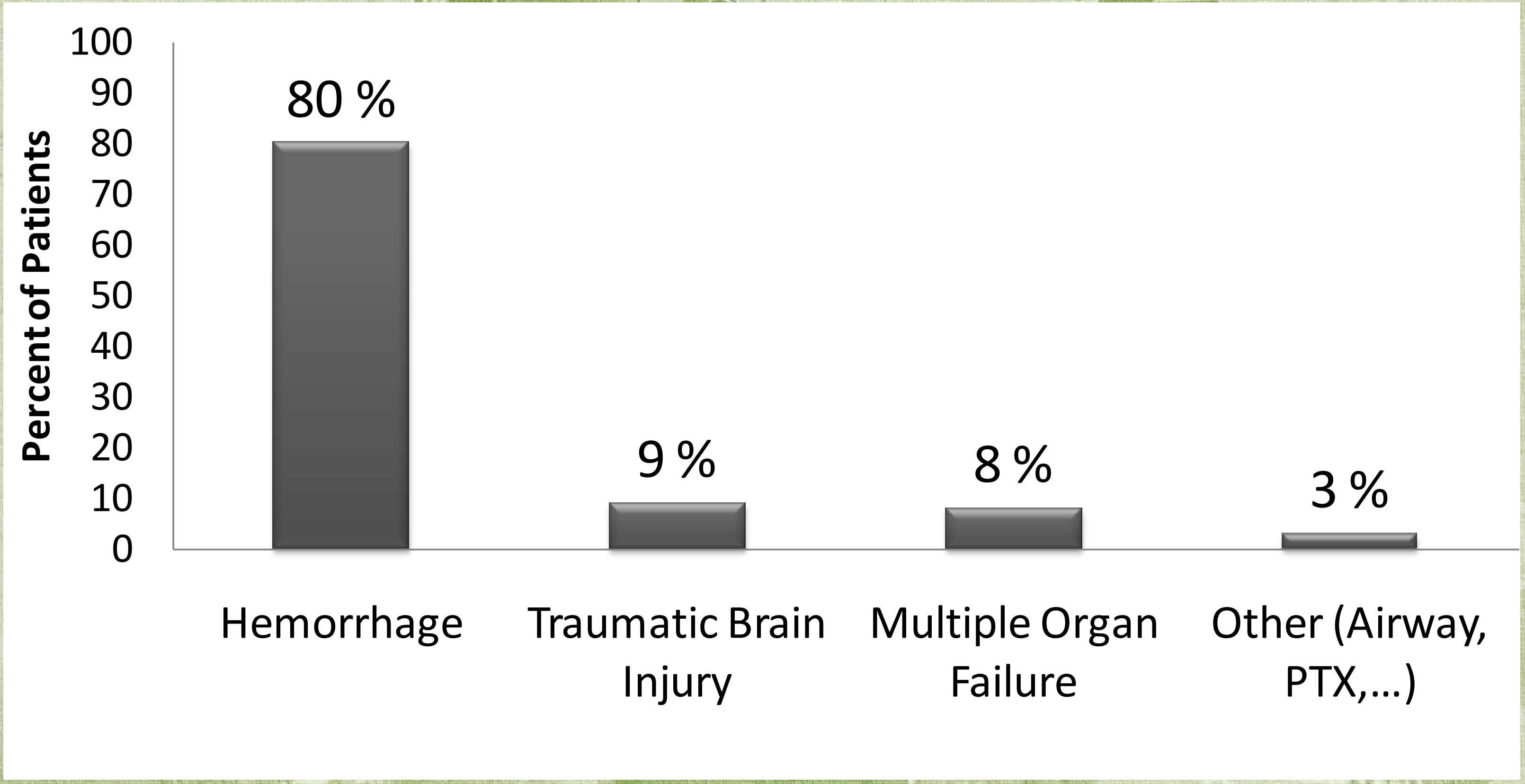
- DOW rate 4.6%
- NS in 271 (48.6%) and PS in 287 (51.4%)
- 51% presented in extremis with CPR on admission

DOW
Non-Survivable Etiology

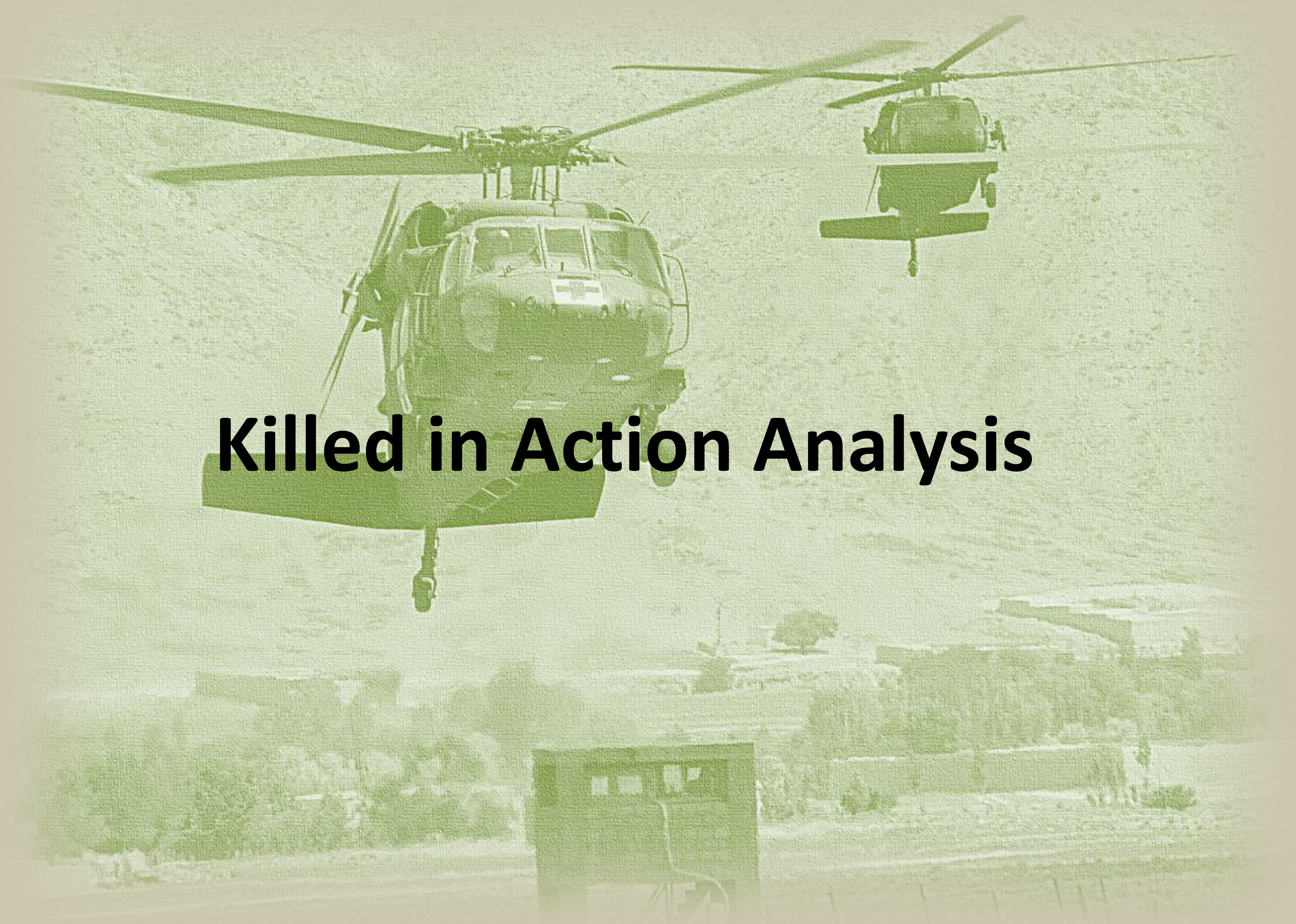


Eastridge et al: Died of Wounds on the Battlefield. J Trauma 2011

DOW
Potentially Survivable Etiology



Eastridge et al: Died of Wounds on the Battlefield. J Trauma 2011



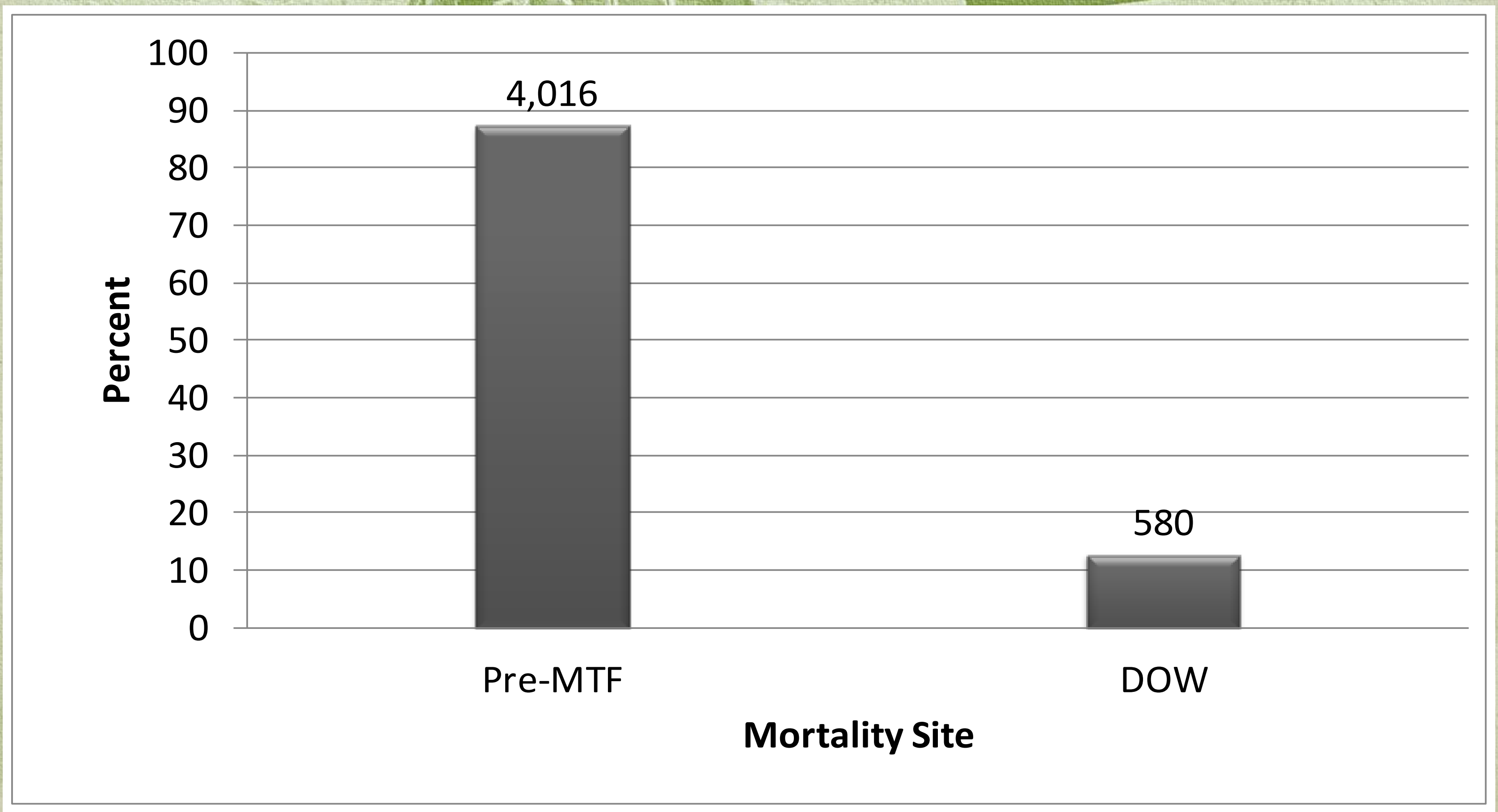
Killed in Action Analysis

KIA Analysis

- Review battlefield deaths (n=4,596)
- Data sources
  - DoD Trauma Registry
  - Armed Forces Medical Examiner System (AFMES)
- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity
- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

- Goal: Identify areas for improved training, medical care, material, research and development

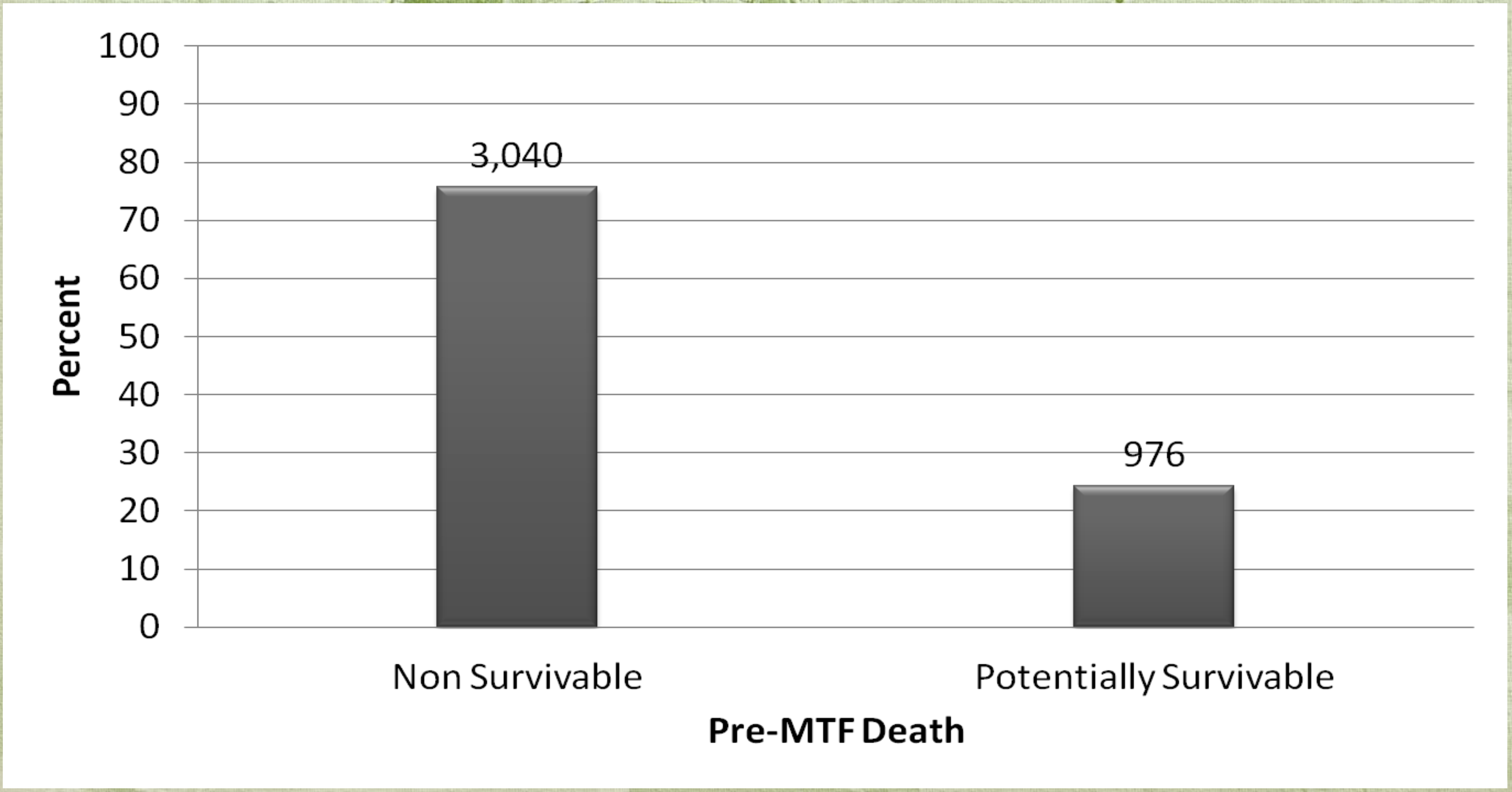
Where Battlefield Casualties Die
n=4,596



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

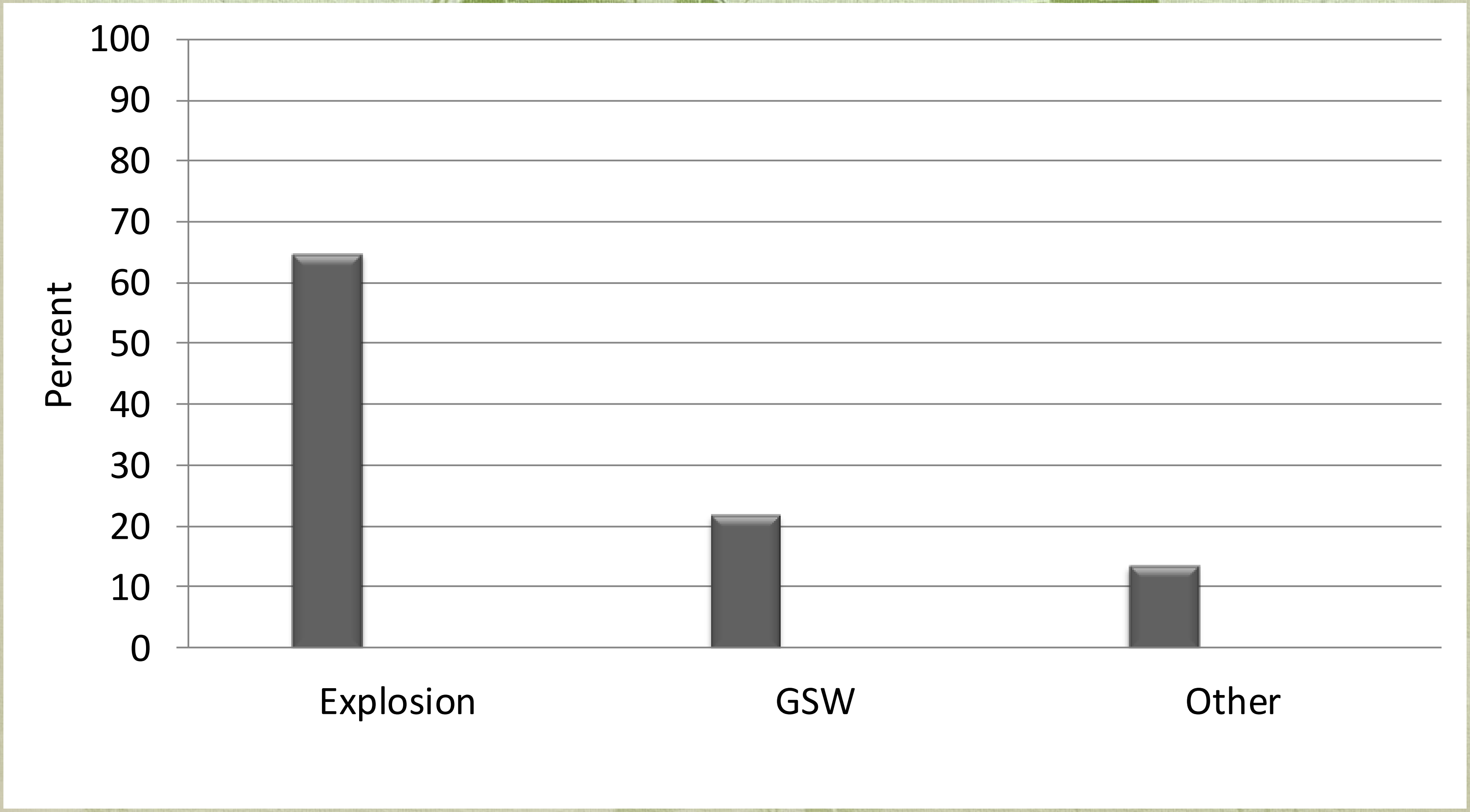
Putting it in Perspective

Battlefield Pre-Hospital Death Analysis n=4,016 (DOW excluded)



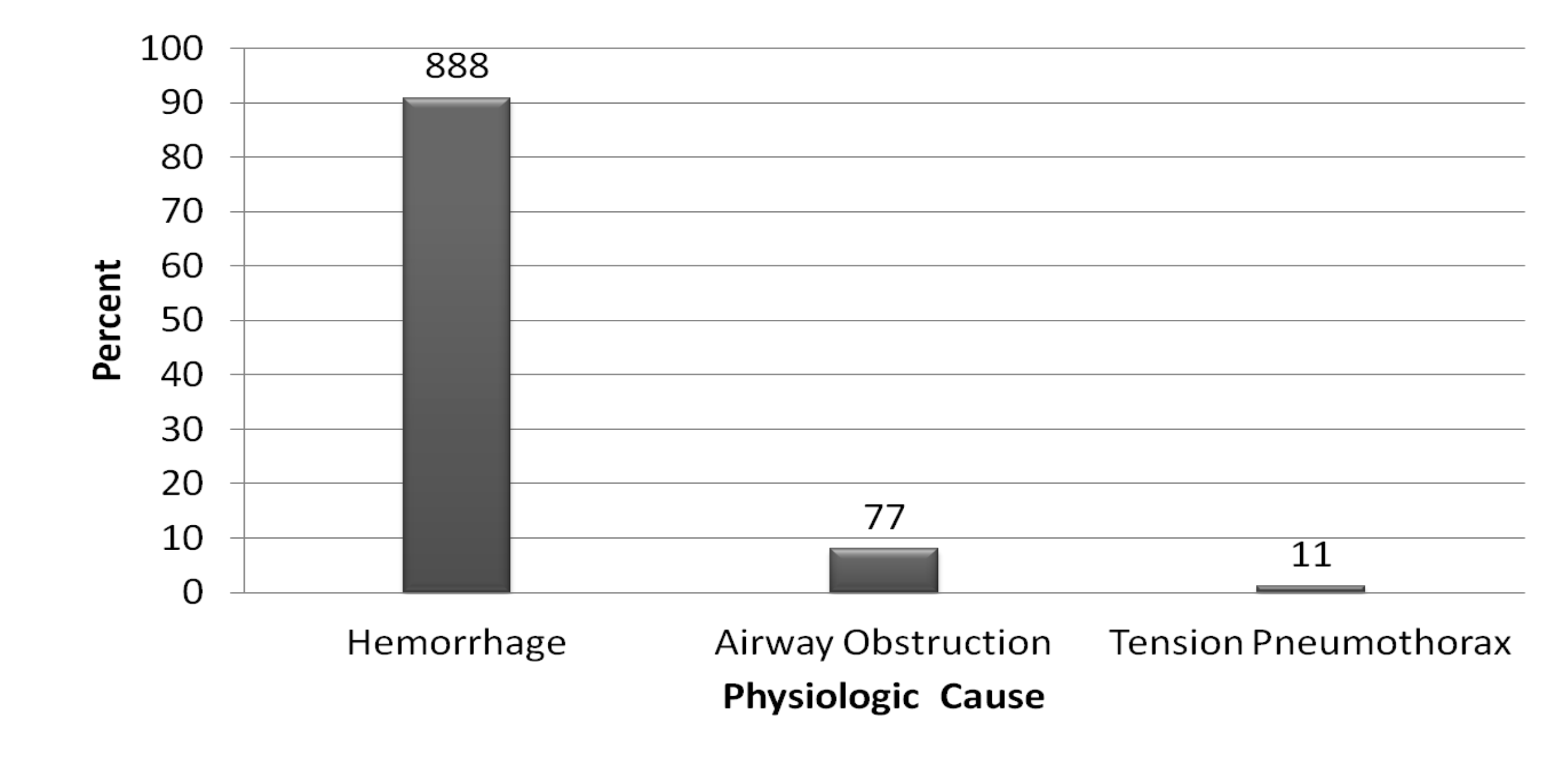
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield Pre-MTF Mortality Cause
n=4,016



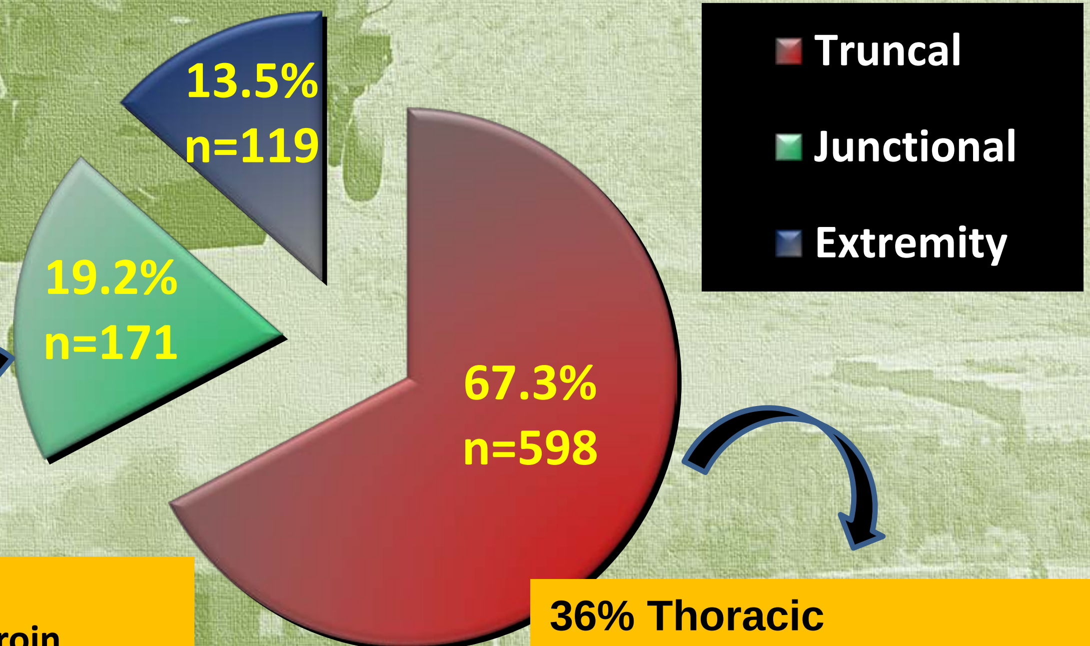
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield Acute Lethality Potentially Survivable n=976



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Anatomic / Physiologic Cause of Death

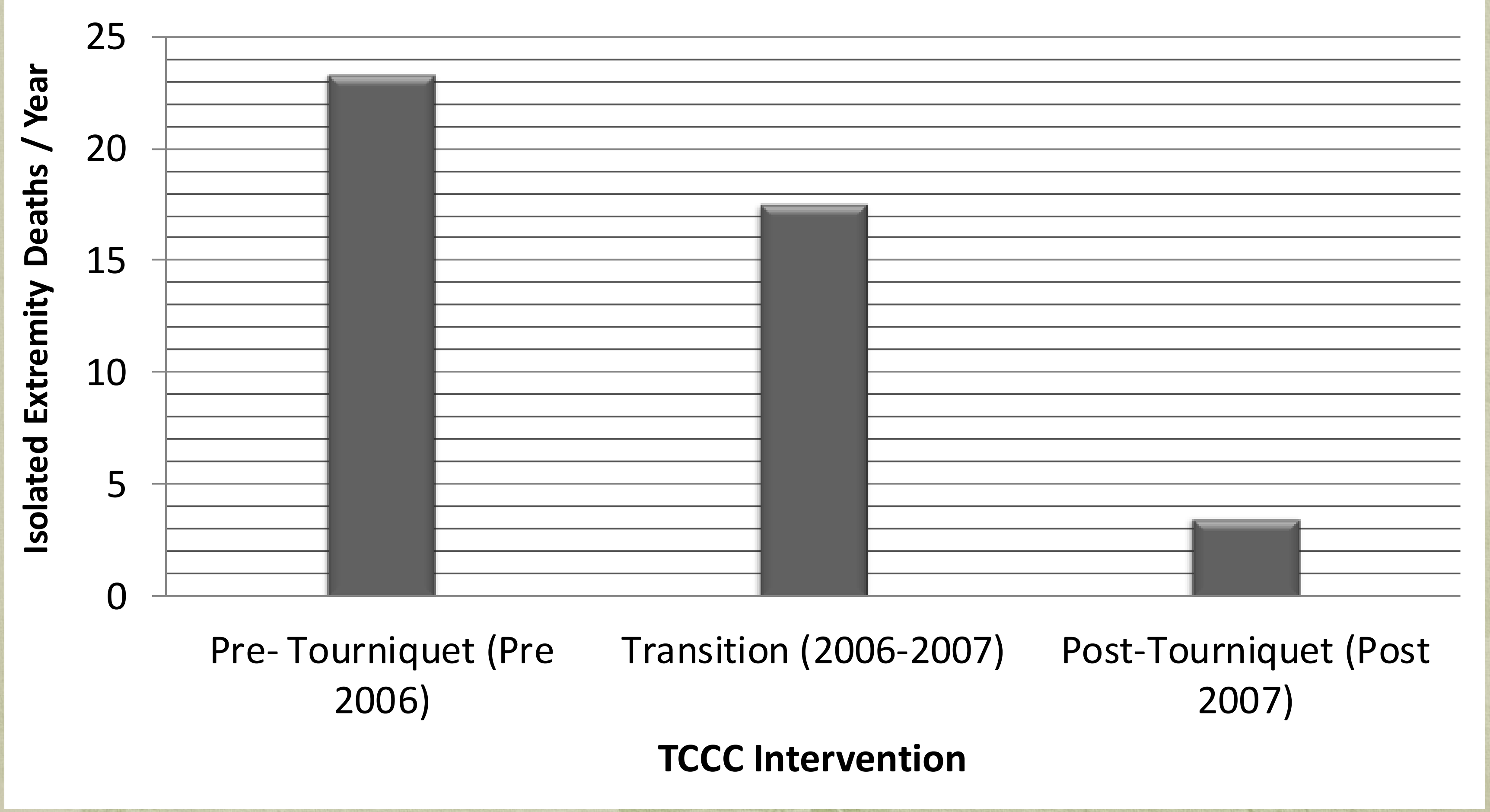


39% Cervical
61% Axilla and Groin

36% Thoracic
64% Abdominopelvic

Eastridge BJ, Mabry RL, Seguin PG, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. Journal of Trauma, 2012. In press.

Can We Have An Impact?



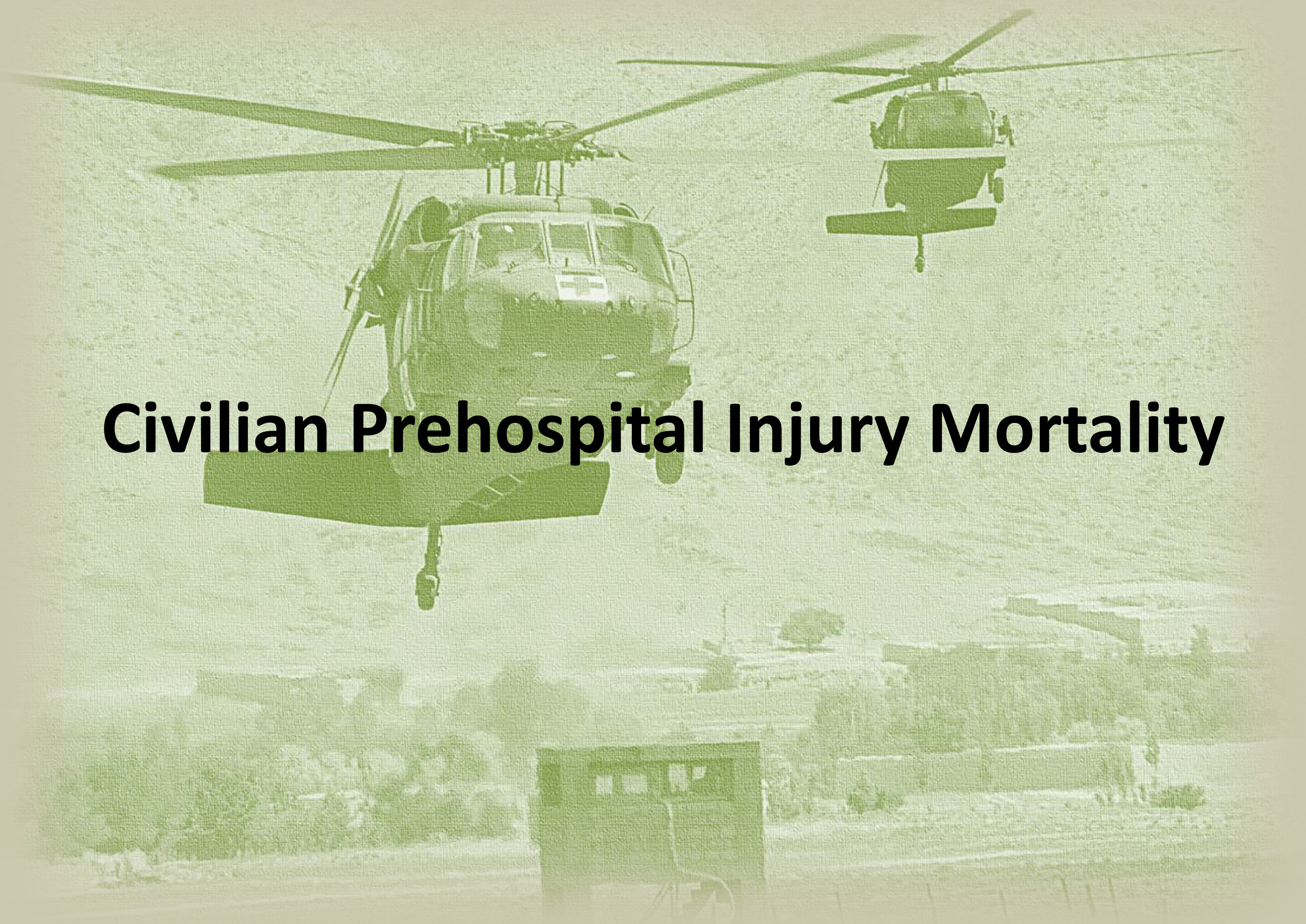
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Translation of Combat Casualty Care Lessons to Civilian Injury Management

Interventions with potential to impact injury mortality

- Pre-injury prevention
  - oz prevention = lb cure (therapeutic revolution)
- Trauma system development
  - EMS (pre-hospital intervention high yield)
  - Acute care
  - Regional networks / collaboration
- Novel interventions for hemorrhagic shock
  - NTI – Increased funding for trauma research
- Performance Improvement
  - Preventable death registry

Civilian Prehospital Injury Mortality

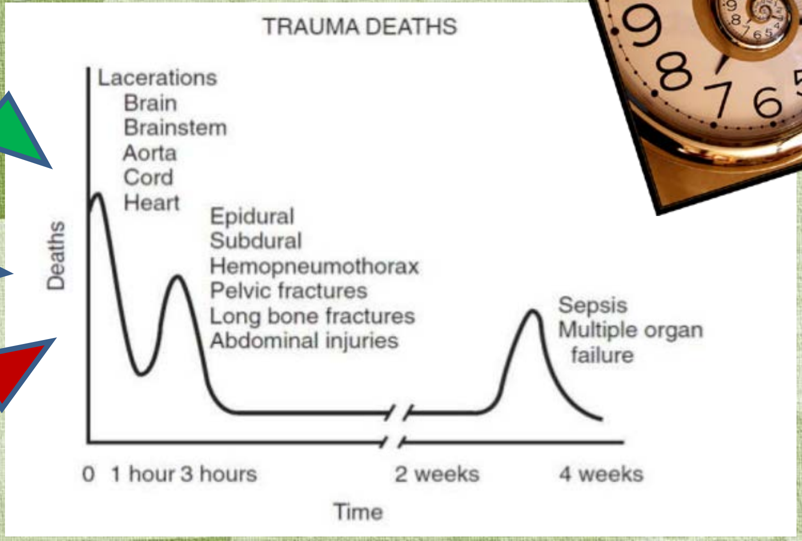


Background/Scientific Rationale
Pre-Hospital Mortality Civilian

Impact Not Well Quantitated

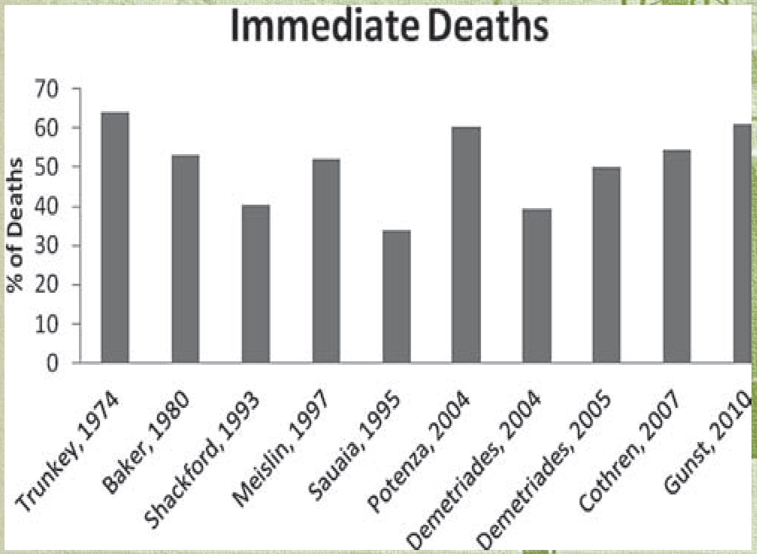
Potential Survivability Poorly Defined

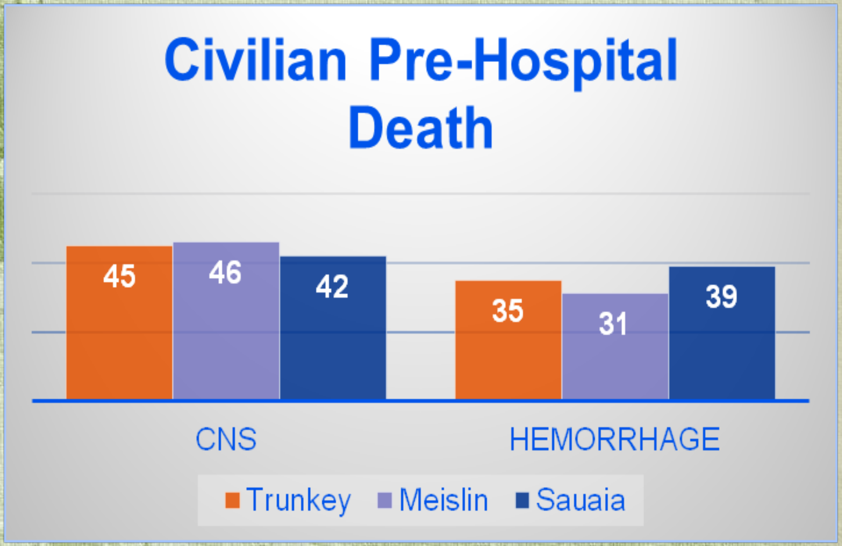
NASEM Report Emphasis



Case Fatality Rate (CFR) ~ 4.1% /
2-5 % Hospital Mortality Potentially Preventable

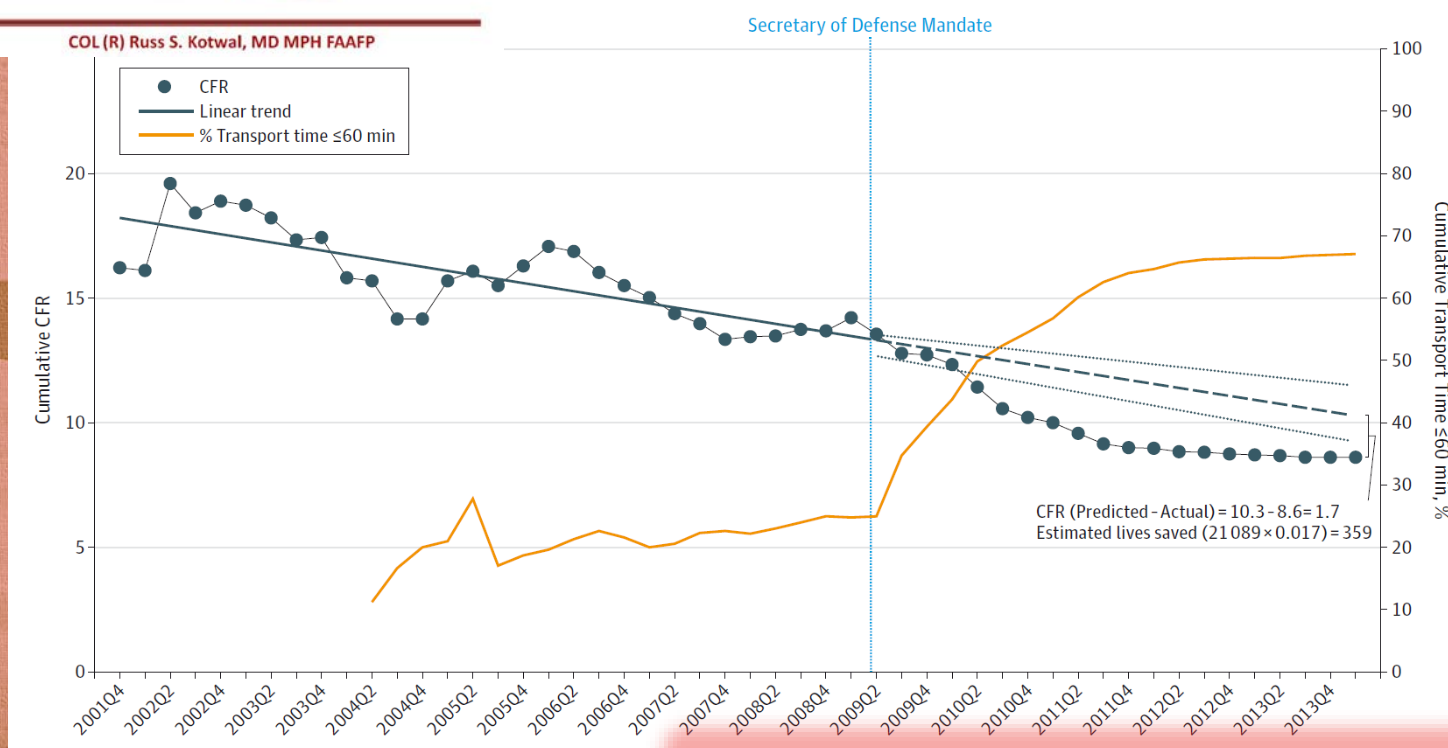
Civilian Injury Death Pre-Hospital





Sauaia A, Moore FA, Moore EE, Moser KS, Brennan R, Read RA, Pons PT. Epidemiology of trauma deaths: a reassessment. *J Trauma*1995;38(2):185–193.
Meislin H, Criss EA, Judkins D, Berger R, Conroy C, Parks B, Spaite DW, Valenzuela TD. Fatal trauma: the modal distribution of time to death is a function of patient demographics and regional resources. *J Trauma*
1997;43(3):433–440.
Trunkey DD, Lim RC. Analysis of 425 consecutive trauma fatalities: anautopsy study. *J Am Coll Emerg Phys* 1974;3(6):368–371.

Gates Effect



Conclusions

A 2009 mandate by Secretary of Defense Gates reduced the time between critical injury and definitive care for combat casualties in Afghanistan. Despite evidence of increased severity and complexity of wounds from explosive devices, the combination of reduced prehospital transport time and increased treatment capability are likely contributors of casualty survival.

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.ajconline.org

Southwestern Surgical Congress

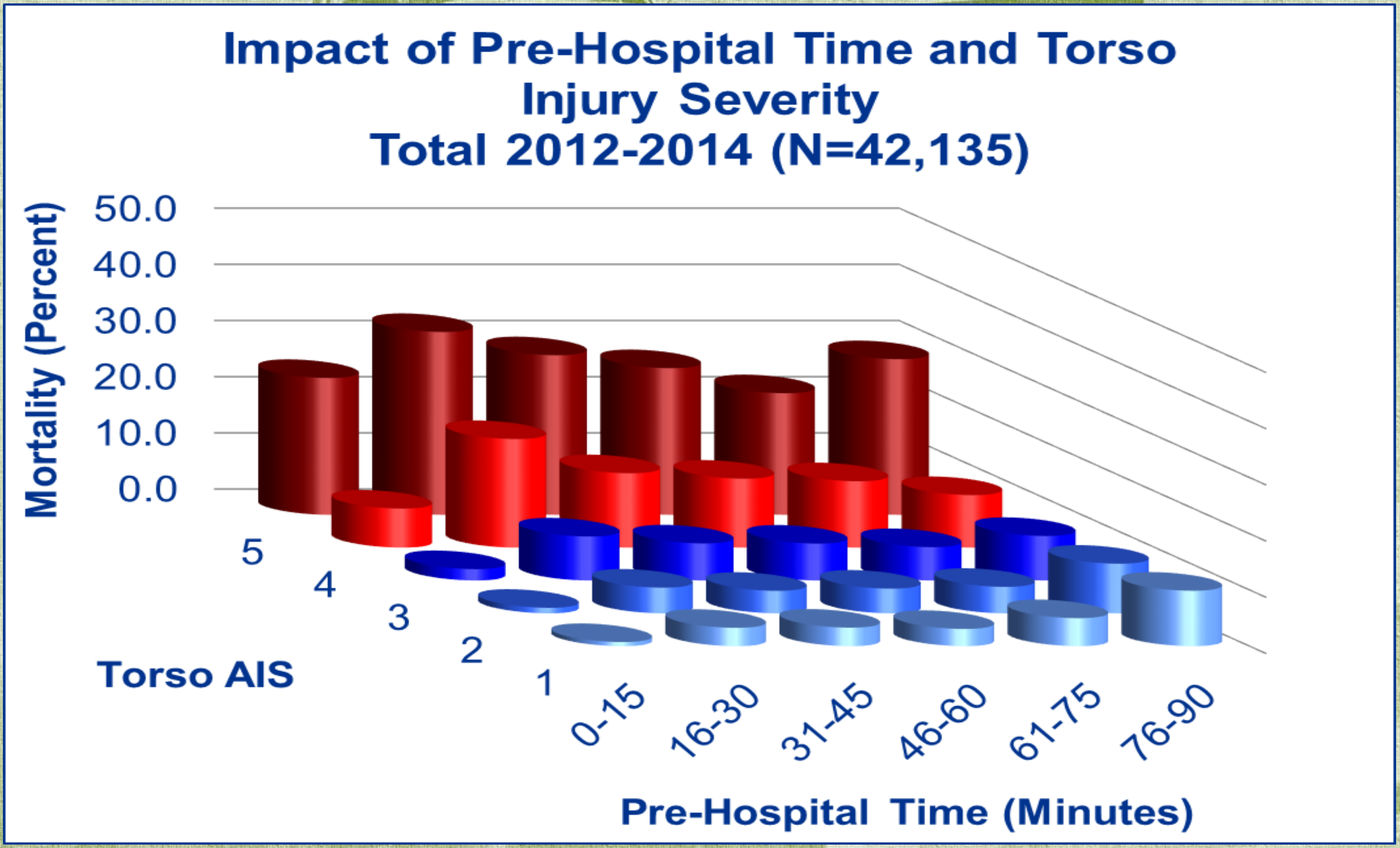
Time is the enemy: Mortality in trauma patients with hemorrhage from torso injury occurs long before the "golden hour"

A.Q. Alarhayem [a], J.G. Myers [a], D. Dent [a], L. Liao [a], M. Muir [a], D. Mueller [a], S. Nicholson [a], R. Cestero [a], M.C. Johnson [a], R. Stewart [a], Grant O'Keefe [b], B.J. Eastridge [a,*]

[a] The University of Texas Health Science Center at San Antonio, Department of Surgery, Division of Trauma, Critical Care, and Acute Care Surgery, United States

[b] University of Washington, Department of Surgery, Division of Trauma and Acute Care Surgery, United States

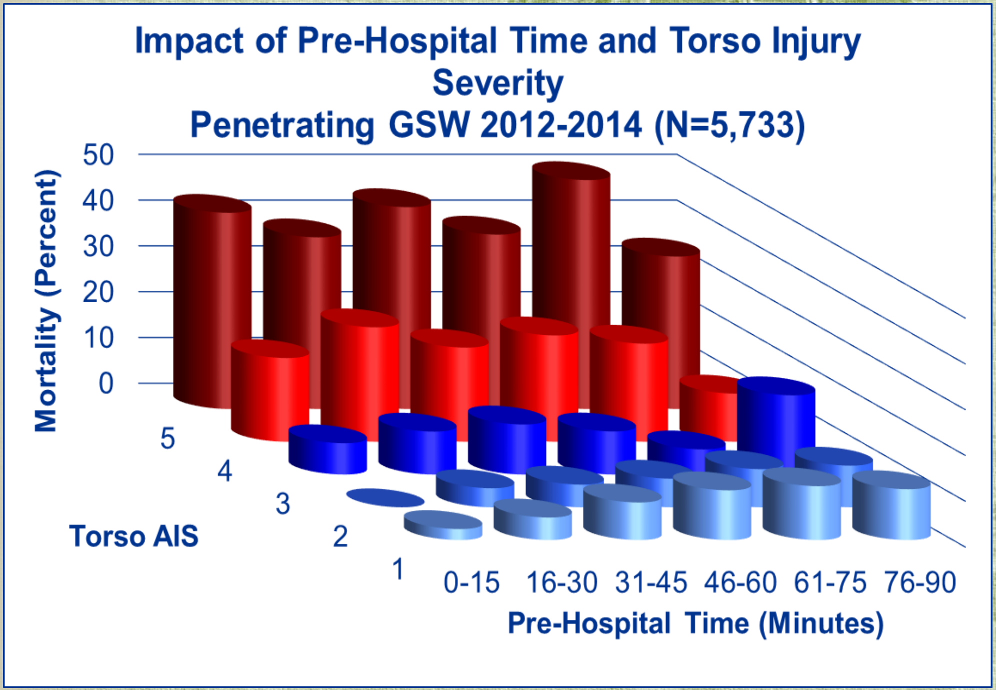
Prehospital Time
Noncompressible Torso Hemorrhage (All)



Alarhayem, Eastridge, et al: Mortality in Trauma Patients with Hemorrhage from Torso Injury Occurs Long Before the "Golden Hour" Presented at Southwestern Surgical Congress April 2016

Time is the Enemy

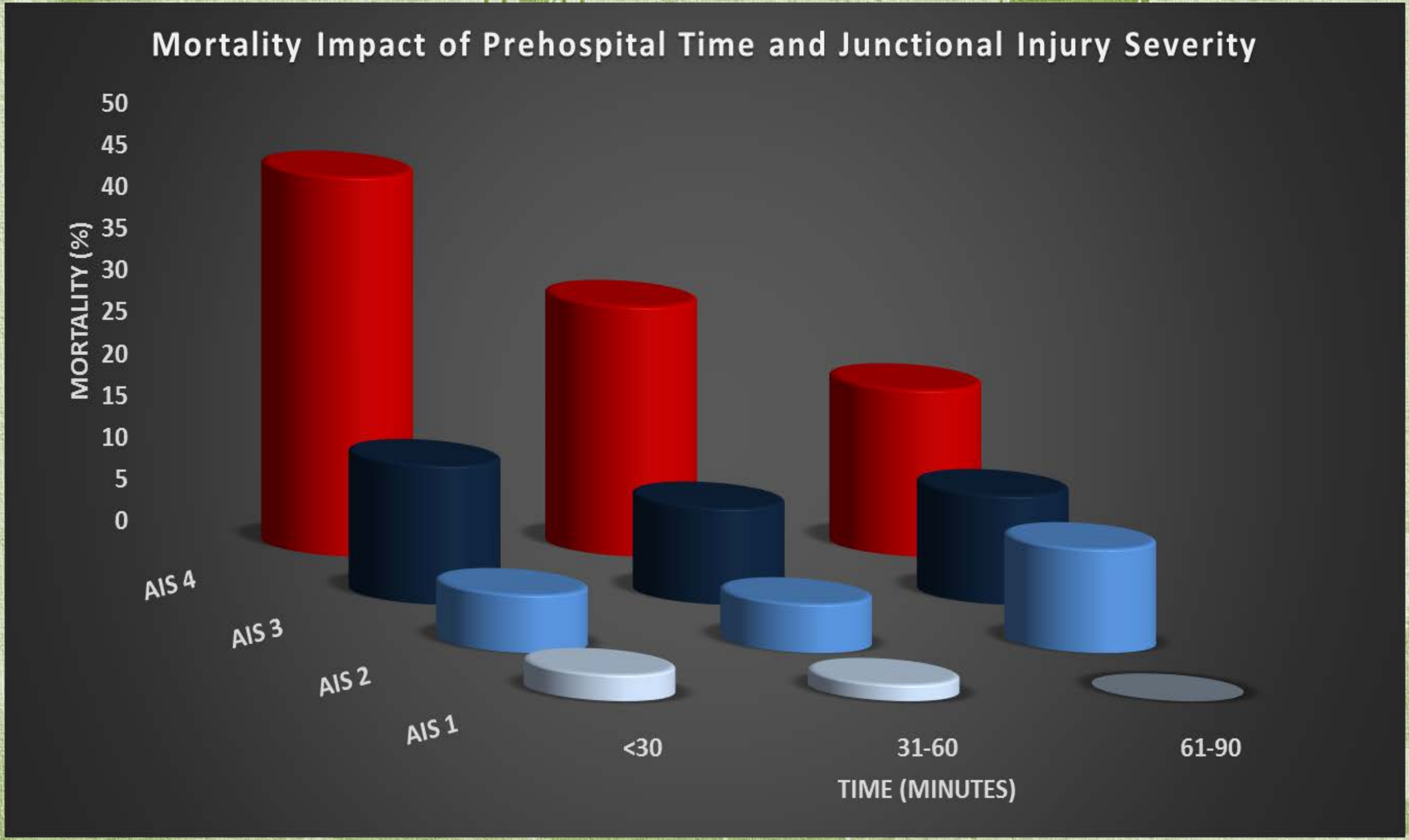
Prehospital Time in Noncompressible Torso Hemorrhage (GSW)



Alarhayem, Eastridge, et al: Mortality in Trauma Patients with Hemorrhage from Torso Injury Occurs Long Before the "Golden Hour" Am J Surg 2016

- High grade torso injury, AIS grades > 4, associated with significant hemorrhage.
- Rise in patient mortality was exhibited in high grade injury demonstrated at prehospital times < 30 minutes
- Highlights critical nature of prehospital time in patients with non-compressible torso hemorrhage.
- Evacuation times < 30 minutes not realistic, particularly in rural or austere environments,
- Future efforts should be directed toward the development of therapies to increase the window of survival in the prehospital environment.

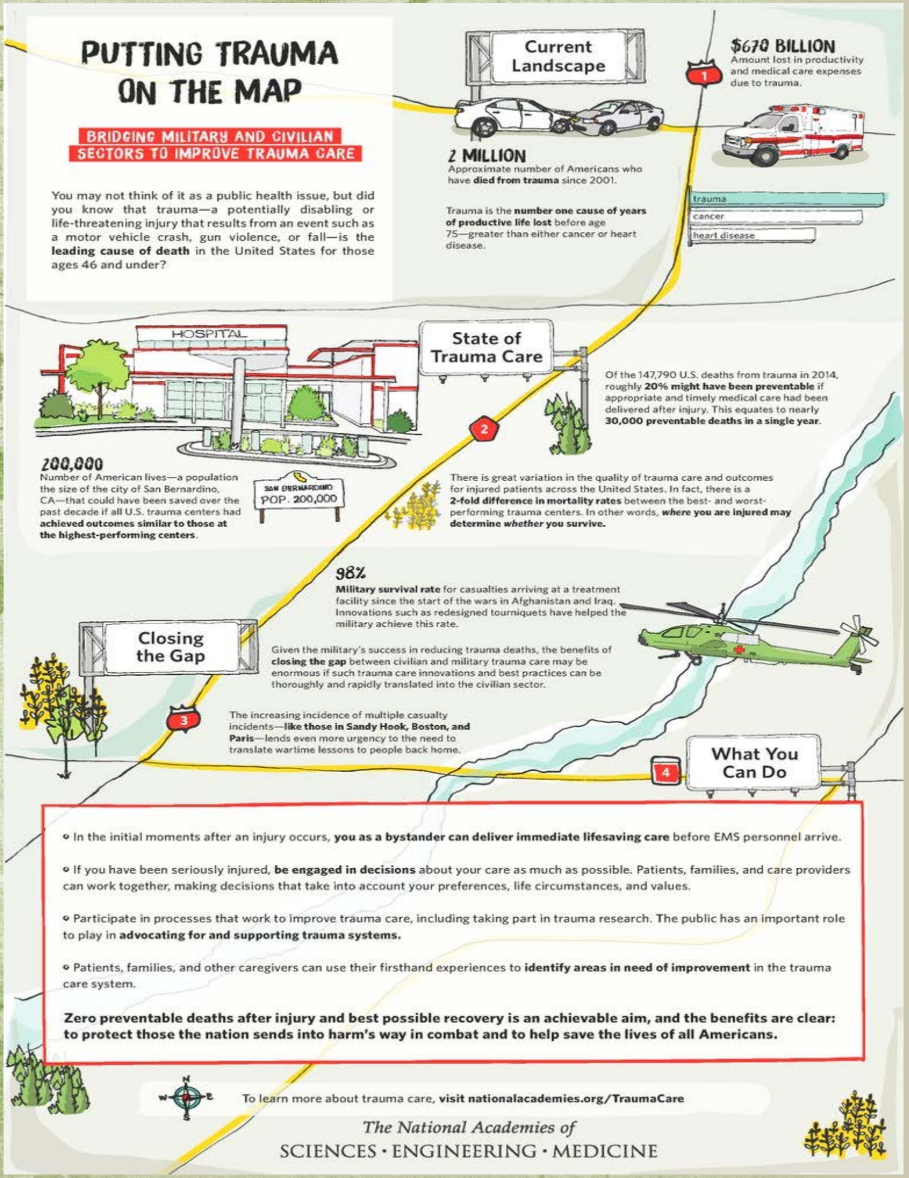
Junctional Hemorrhage and Prehospital Time Impact on Injury Mortality



Alarhayem, Eastridge: Highlighting the Need for Novel Strategies to Control Complex Sources of Hemorrhage and Temporize Survival to Definitive Care. Presented MHSRS 2016

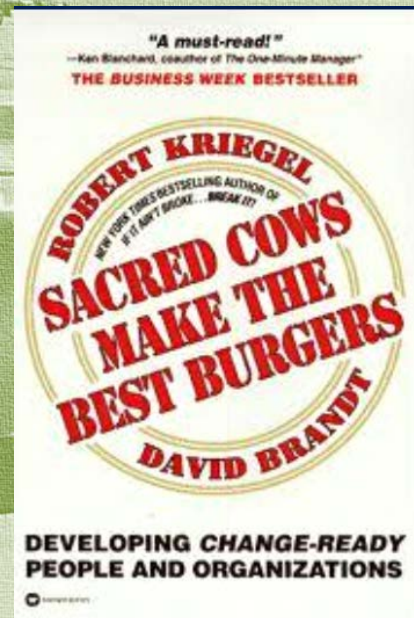
Getting Beyond Estimates

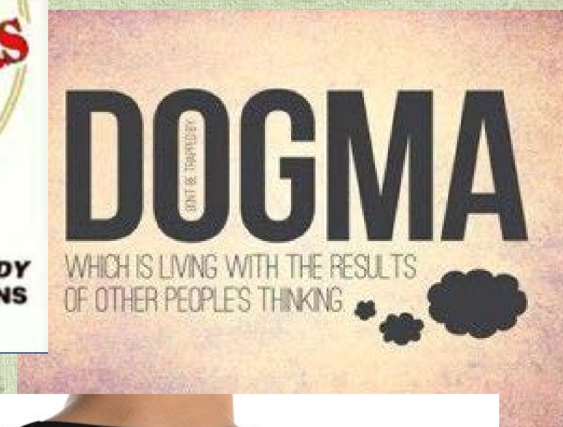
Objectively establishing the need to push care forward



Revisit the Sacred Cows

- **“Golden Hour”**
- **Hemorrhage control**
- **IV fluid resuscitation**





Multiinstitutional Multidisciplinary Injury Mortality Investigation in Civilian PreHospital Environment

PIs:Eastridge, Nolte, MacKenzie

Funded by USAMRMC
(Department of Defense)

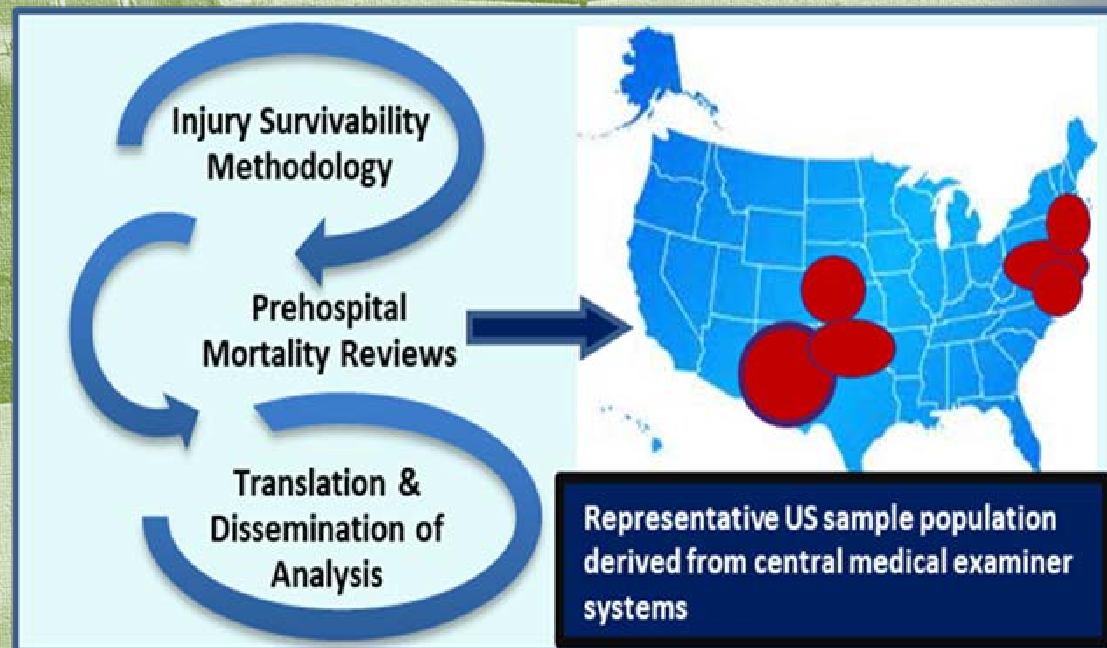
Purpose of this proposal is to develop a coordinated, multidisciplinary, multi-institutional effort within the civilian clinical sector to identify and characterize the causes of pre-mortality from trauma

Identify potential high yield areas for research and development in pre-hospital medical care, injury prevention, and trauma systems.

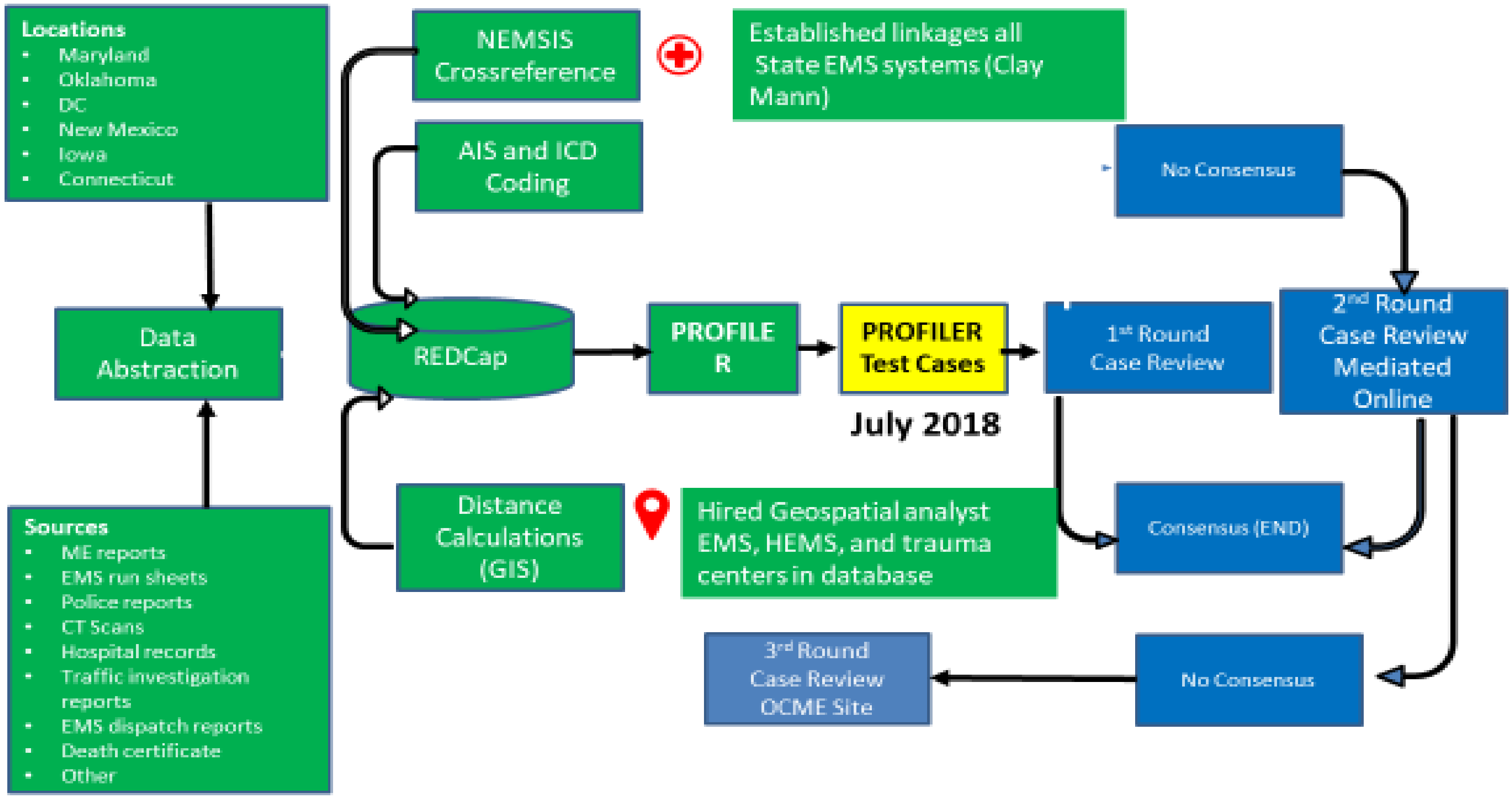
mimic

Multi-Disciplinary Multi-Institutional Mortality Investigation in the Civilian Prehospital Environment (MIMIC)

- Develop a framework for evaluating the causes and pathophysiology of pre-hospital deaths
- Network of experts identify the causes of 3,000 pre-hospital deaths due to trauma and estimate potential for survivability.
    - Trauma surgery
    - Neurosurgery
    - Orthopedic surgery
    - Forensic pathology
    - Emergency medicine
    - Emergency medical services

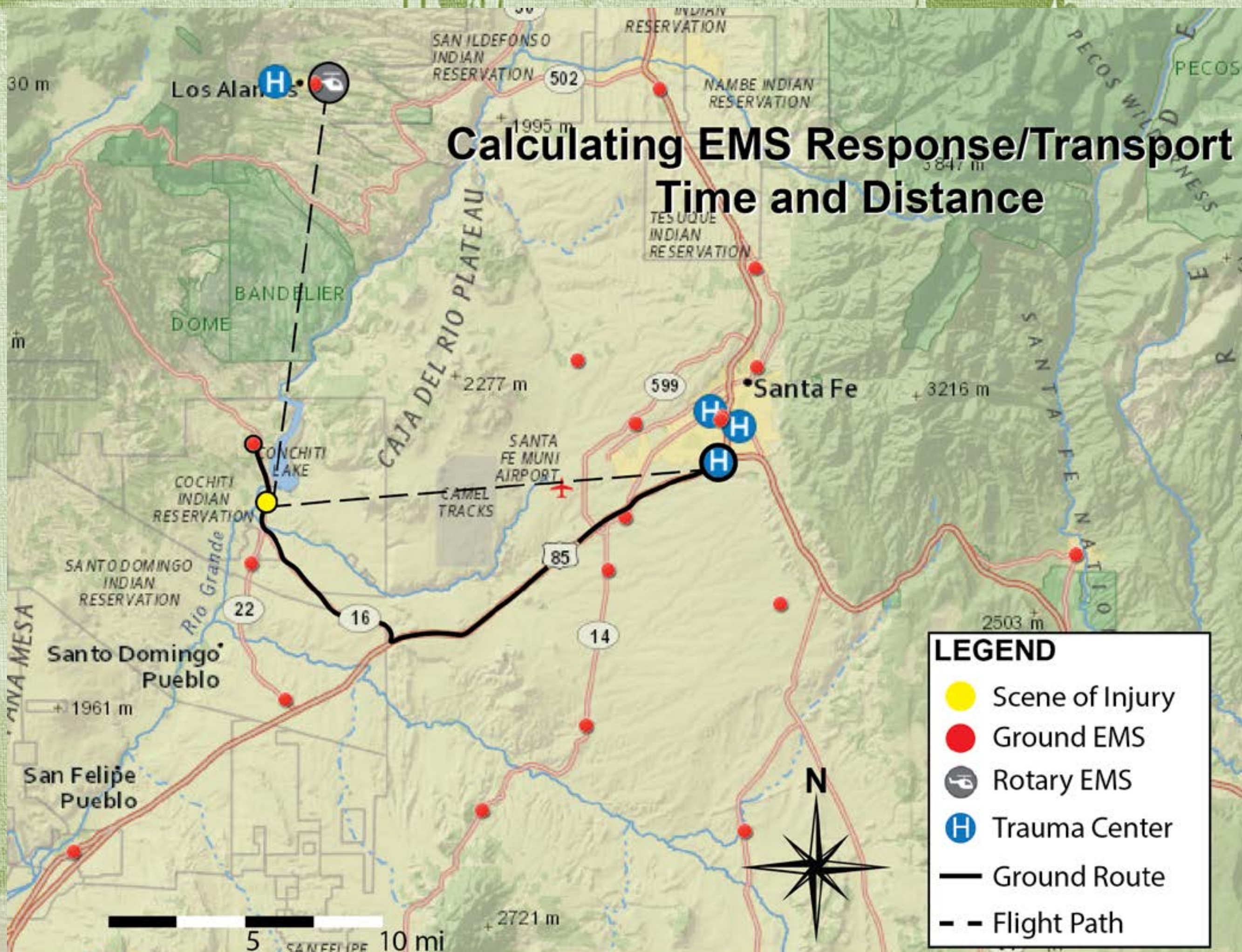


MIMIC



Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages all State EMS systems (Clay Mann)
AIS and ICD Coding
No Consensus
Data Abstraction
REDCap
PROFILE R
PROFILER Test Cases
July 2018
1st Round Case Review
2nd Round Case Review Mediated Online
Distance Calculations (GIS)
Hired Geospatial analyst EMS, HEMS, and trauma centers in database
Consensus (END)
Sources
ME reports
EMS run sheets
Police reports
CT Scans
Hospital records
Traffic investigation reports
EMS dispatch reports
Death certificate
Other
3rd Round Case Review OCME Site
No Consensus

Integrating Geospatial Modeling



Preliminary
Round 1 and Round 2 Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

	Frequency
	322 (78%)
	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

Note: Using 414 cases that have reached consensus on survivability assessments

Preliminary
Round 1 and Round 2 Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency
	389 (94%)
	24 (6%)
	1
Cannot Judge	0

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

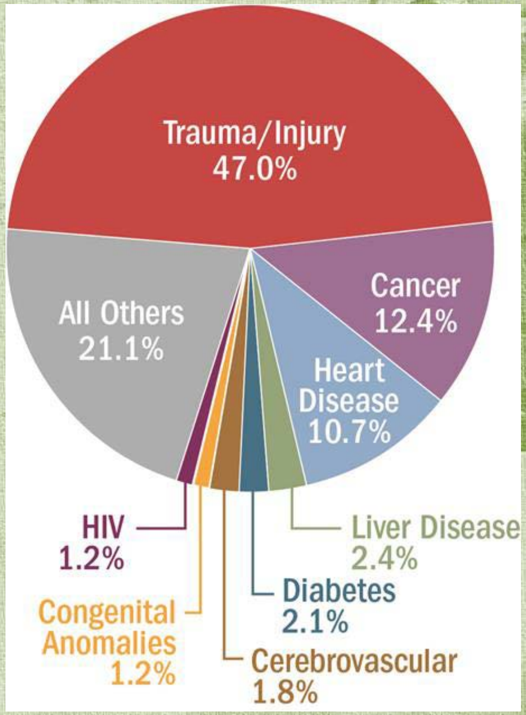
Note: Using 414 cases that have reached consensus on survivability assessments

Immediate Access Survivability	Frequency
Non-survivable	322 (78%)
Potentially Survivable	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

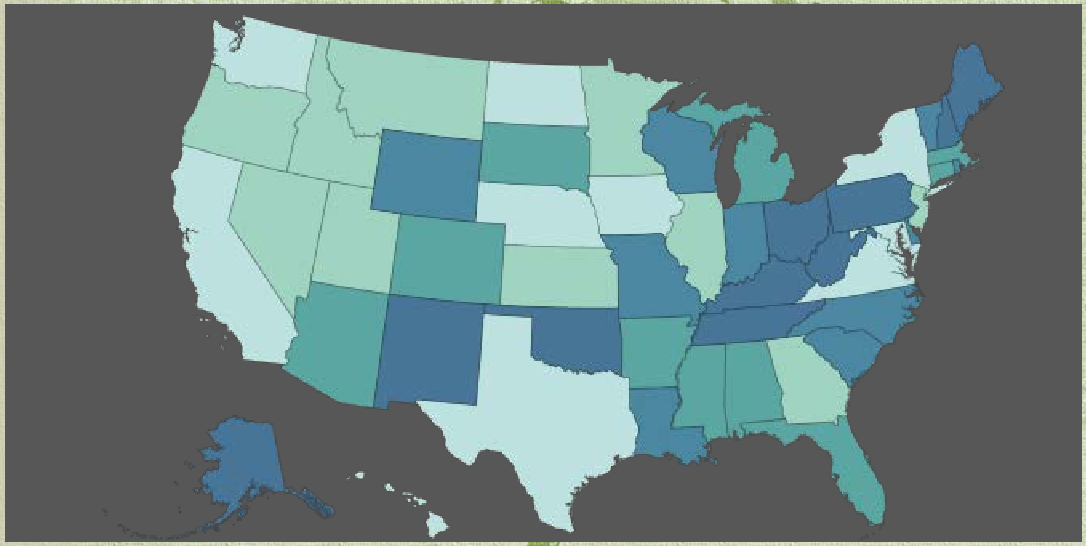
Actual Scenario Survivability	[illegible]equency
Non-survivable	[illegible]9 (94%)
Potentially Survivable	24 (6%)
Definitely Survivable	1
Cannot Judge	0

Trauma System Scope of the Problem



- **Potentially survivable injuries US military operations**
  - **1,273 / 4,574 (27.6%)**
- **Potentially survivable injuries US civilian population 2014**
  - **147,790 x 0.276 = 40,790**

Survivable Injury Louisiana



Potentially survivable injuries Louisiana civilian population 2017

- **4,431 x 0.276 = 1,223**

Lessons Learned for PreHospital Injury Management

- Death secondary to injury major problem for civilians and troops
- Majority of deaths in occur pre-hospital environment
  - CNS injury and hemorrhagic shock
  - Many hemorrhage deaths potentially survivable
  - Incremental benefit for outcome with interventions more proximate to time of injury

Bleeding Casualty is on the Clock

PREHOSPITAL BLOOD RESUSCITATION

Breaking the Bloody Vicious Cycle

Hemorrahge

Coagulopathy

Resuscitation

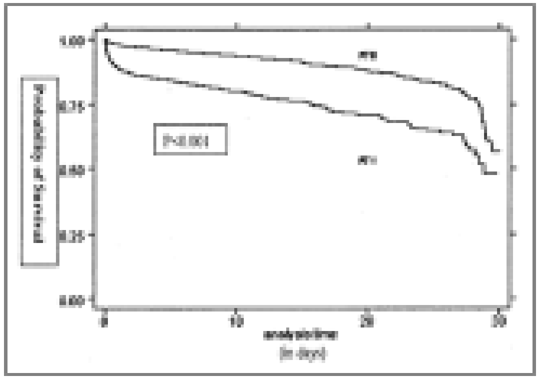
Hemodilution

&

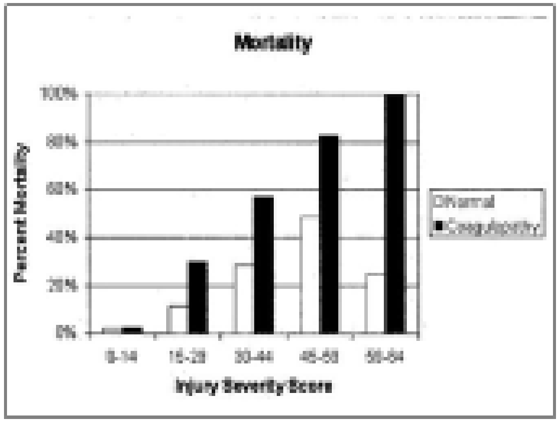
Hypothermia

- Control hemorrhage
- Use best possible resuscitation practice
- Prevent hypothermia
- Prevent hemodilution
- Treat coagulopathy

Background



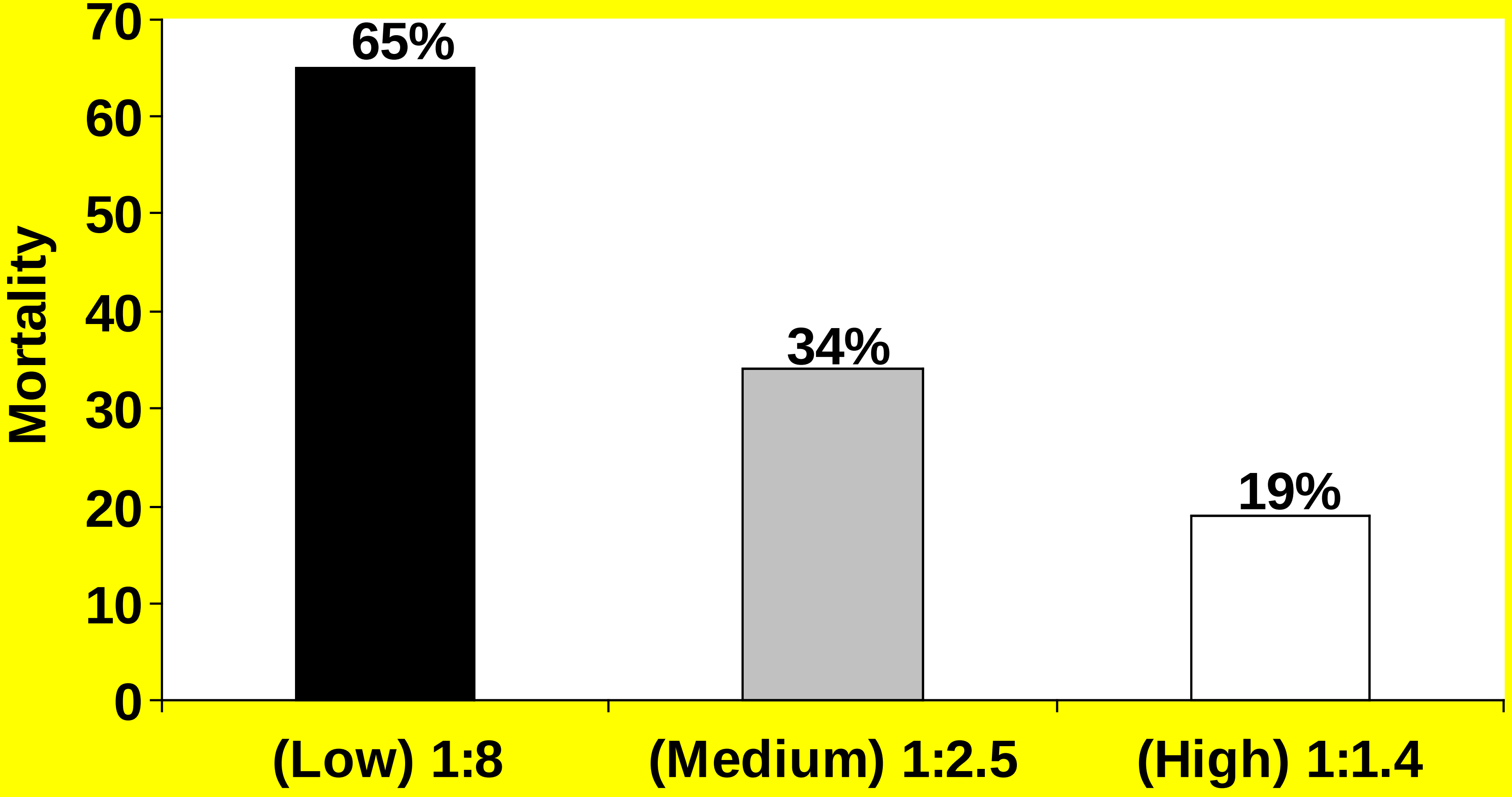
MacLeod JBA et al.
Early Coagulopathy Predicts Mortality in Trauma
J Trauma 2003



Brohi K et al.
Acute Traumatic Coagulopathy
J Trauma 2003

By the time of arrival at the ED, 28% (2,994 of 10,790) of trauma patients had a detectable coagulopathy that was associated with poor outcome

Mortality by Plasma : RBC Ratio



The ratio of blood products transfused affects mortality in patients receiving massive transfusions at a combat support hospital. Borgman MA, et. al.

Whole Blood in Combat

- US Vietnam > 230,000 units transfused (mostly cold stored)
- US OIF/OEF > 10,000 units transfused (almost all fresh): first transfusion October 2001

Remote Damage Control Resuscitation

- Austere/rural environment patients
  - Modified transfusion strategy
  - Different than those with scene/pre-hospital time < 30 minutes
  - Limited resources available
  - Lack of plasma availability
  - 40% of the population, 60% of the trauma mortality
- Current treatment options for uncontrolled hemorrhage in this environment are very limited
- >75% of combat fatalities occur in the field

Whole Blood in Combat

- US Vietnam > 230,000 units transfused (mostly cold stored)
- US OIF/OEF > 10,000 units transfused (almost all fresh): first transfusion October 2001

REVIEW ARTICLE

Whole blood for hemostatic resuscitation of major bleeding

Philip C. Spinella,[1,2] Heather F. Pidcoke,[2] Geir Strandenes,[3,4] Tor Hervig,[4] Andrew Fisher,[5] Donald Jenkins,[6] Mark Yazer,[7] James Stubbs,[8] Alan Murdock,[9] Anne Sailliol,[10] Paul M. Ness,[11] and Andrew P. Cap[2]

Trans 2016

- Logistical, economic and clinical benefits of cold stored low titer type O whole blood
- Cold stored for up to 21 days
  - Platelets OK
- Improved function compared to 1:1:1

Multi-disciplinary and Multi-National Review

SHOCK, Vol. 41, Supplement 1, pp. 70–75, 2014

LOW TITER GROUP O WHOLE BLOOD IN EMERGENCY SITUATIONS

Geir Strandenes,[*,†] Olle Berséus,[‡] Andrew P. Cap,[§] Tor Hervig,[*,||] Michael Reade,[¶] Nicolas Prat,[§,] Anne Sailliol,[††] Richard Gonzales,[‡‡] Clayton D. Simon,[§§] Paul Ness,[||||] Heidi A. Doughty,[¶¶] Philip C. Spinella,[§,***] and Einar K. Kristoffersen[*,||]**

[*]Department of Immunology and Transfusion Medicine, Haukeland University Hospital; and [†]Norwegian Naval Special Operation Commando, Bergen, Norway; [‡]Department of Transfusion Medicine, Örebro University Hospital, Örebro, Sweden; [§]US Army Institute of Surgical Research, FT Sam Houston, Texas; [||]Institute of Clinical Science, The University of Bergen, Norway; [¶]Australian Defense Force Joint Health Command, Canberra, Australian Capital Territory; [**]French Military Medical Service, Clamart, France; [††]Commander French Military Blood Transfusion Center, Clamart, France; [‡‡]Director, US Army Blood Program and [§§]US Army Transfusion Medicine Consultant to the Surgeon General San Antonio Military Medical Center, JBSA–Fort Sam Houston, Texas; [||||]Transfusion Medicine Division, Johns Hopkins Medical Institutions, Baltimore, Maryland; [¶¶]NHS Blood and Transplant, Birmingham, England, United Kingdom; and[***]Division of Pediatric Critical Care, Department of Pediatrics, Washington University in St Louis, St Louis, Missouri

Conclusion: Low titer Group O is preferred alternative for emergency transfusions where safe ABO identical transfusions cannot be ensured

American Association of Blood Bankers October 2017

- Board approves petition to allow low titer group O whole blood as standard product without need for waiver
- Low titer defined locally
- No limit on amount of whole blood when used
- Transformational paradigm shift

Experience and Extrapolation

- 1 January 2015 to 31 August 2017 (32 months) UHS evaluated 16,947 trauma patients.
- 715 of these patients (4.2%) received 1244 units of emergency release blood products (this is before whole blood was available)
- Red cells = 584
- Plasma = 364
- Platelets = 257
- Other = 39

Massive Transfusion in Trauma at UHS

- In a recent 30 month period
  - 124 MTP activations for trauma
  - 42 yo blunt injured (67%) male patients (79%)
  - SBP < 90 (died = 82, lived = 97 not significant)
  - 73% mortality, 84% due to hemorrhage
  - Majority died within 24 hours (>90%)
  - Only vital sign different in lived vs died was pulse pressure (46 vs 32 p = 0.03)
  - First hematocrit 35% (Hgb > 10 g/dl)

Experience and Extrapolation

- 289 of those patients died (40%) with an average Injury Severity Score (ISS which has a range of 0-75) of 22
- 124 (17% of emergency release blood product patients and 0.2% of the total) adults required a massive transfusion
  - The mortality in this group was 76%
  - DOA's were excluded (no Lazarus effect)

MTP Data

- Odds of MTP:
  - 1.6 x more likely in men vs women
  - 1.8 x more likely for penetrating injury vs other injuries
  - Risk increases with each year of age
  - 6 x more likely in patients in shock vs no shock
    - Shock = scene SBP ≤90, pulse ≥120, SI ≥0.9

Rh- Data

- 63% Hispanic and 7% African American
- Differences in Rh prevalence based upon ethnicity:
  - Rh- in Hispanic and African American populations = 7%
  - Rh- in Caucasian populations = 18%
- > 2/3 of our possible donors and potential recipients have Rh+ blood

Rh Isoimmunization

- Of the 124 patients receiving MTP
  - 26 were women (21%)
  - 18 were age 18-50 (14%)
  - 10 of those 18 died (55%)
  - 16 of the 18 had a type and screen/cross (89%)
  - 1 was Rh negative (6.3%) (she lived)
- Published rate of isoimmunization in Rh- woman 3-6%

Rh- Data

- Risk of isoimmunization of 0.012 and 0.12 patients/year
- Would take 3000 months (250 years) to have 100 Rh- women of childbearing age receive LTO+WB, and somewhere between 3 and 30 of them would develop isoimmunization without the administration of RhIg
- Without transfusion of LTO+WB in the pre-hospital setting over this time period, nearly 500 women of childbearing age would die of hemorrhage

Takeaways

- Data demonstrate a high mortality rate in trauma patients who require MTP
- Death from hemorrhage early
- Recommend pre-hospital whole blood transfusion based upon triggers to increase window of survival
- Study supports
  - Idetification prehospital tranafusion triggers
  - Development and implementation of a pre-hospital whole blood transfusion program

Hypothesis

- Lack of adequate blood resuscitation in remote regions of STRAC
- Very high mortality in current MTP environment
- No agreed upon transfusion triggers
- No standard hemostatic resuscitation
- No early hemostatic resuscitation

Answers

- Cold stored whole blood
- Prehospital transfusion protocols need to be written and implemented

MTP Patients by Ground

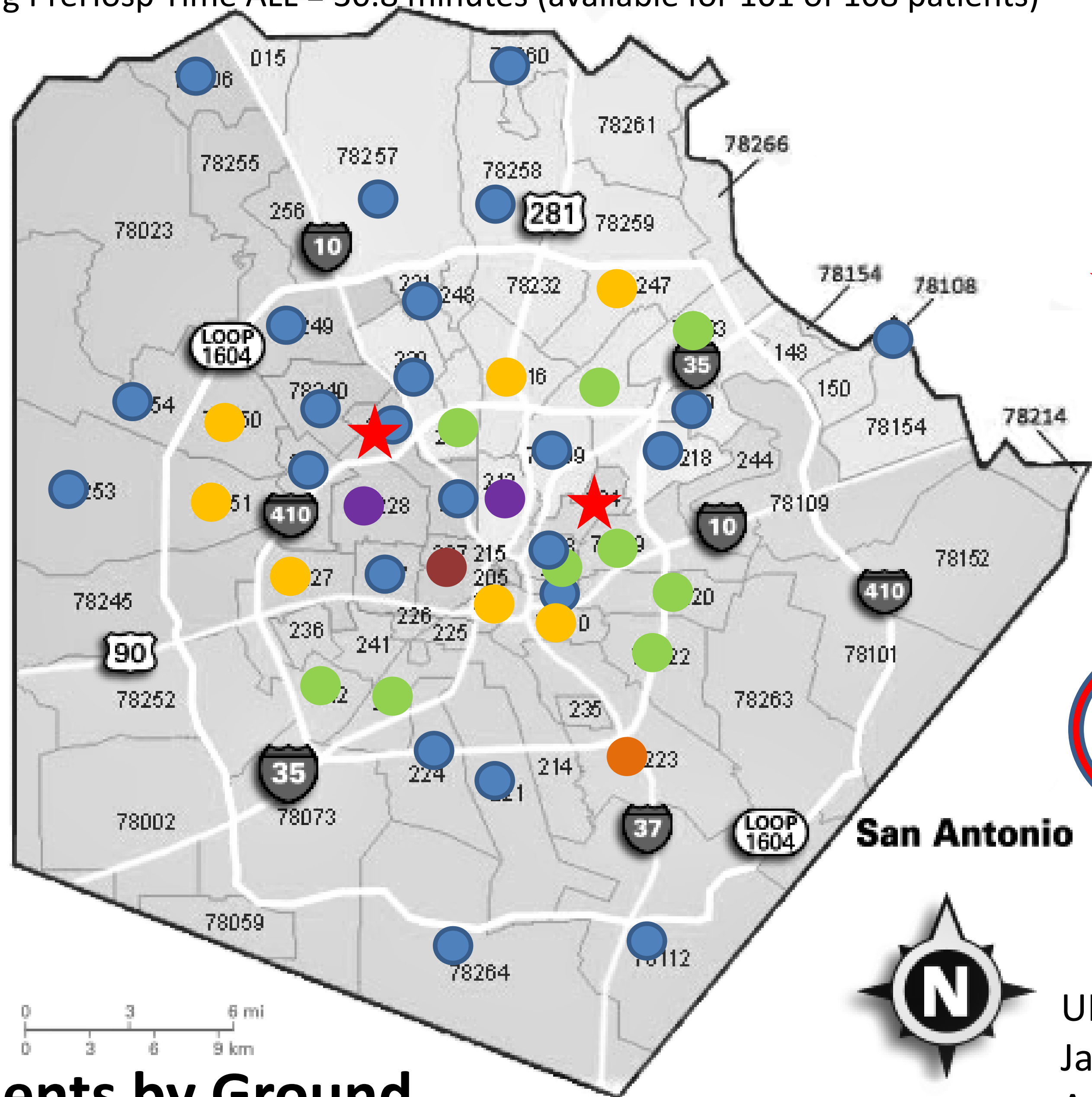
Dead/Total = 69/108 (64%);
Avg PreHosp Time ALL = 30.8 minutes (available for 101 of 108 patients)

Outside of Bexar County

- 77901-
- 78016-
- 78017-
- 78028-
- 78041-
- 78052-
- 78063-
- 78064-
- 78066-
- 78122-
- 78133-
- 78155-
- 78572-
- 78576-
- 78577-
- 78629-
- 78839-

Dead/Total = 14/23 (61%)

Avg PreHosp Time = 43.9 min (available for 17 of 23 patients)



Inside Bexar County

- 1 patient
- 2 patients
- 3 patients
- 4 patients
- 5 patients
- 7 patients
- Hospital

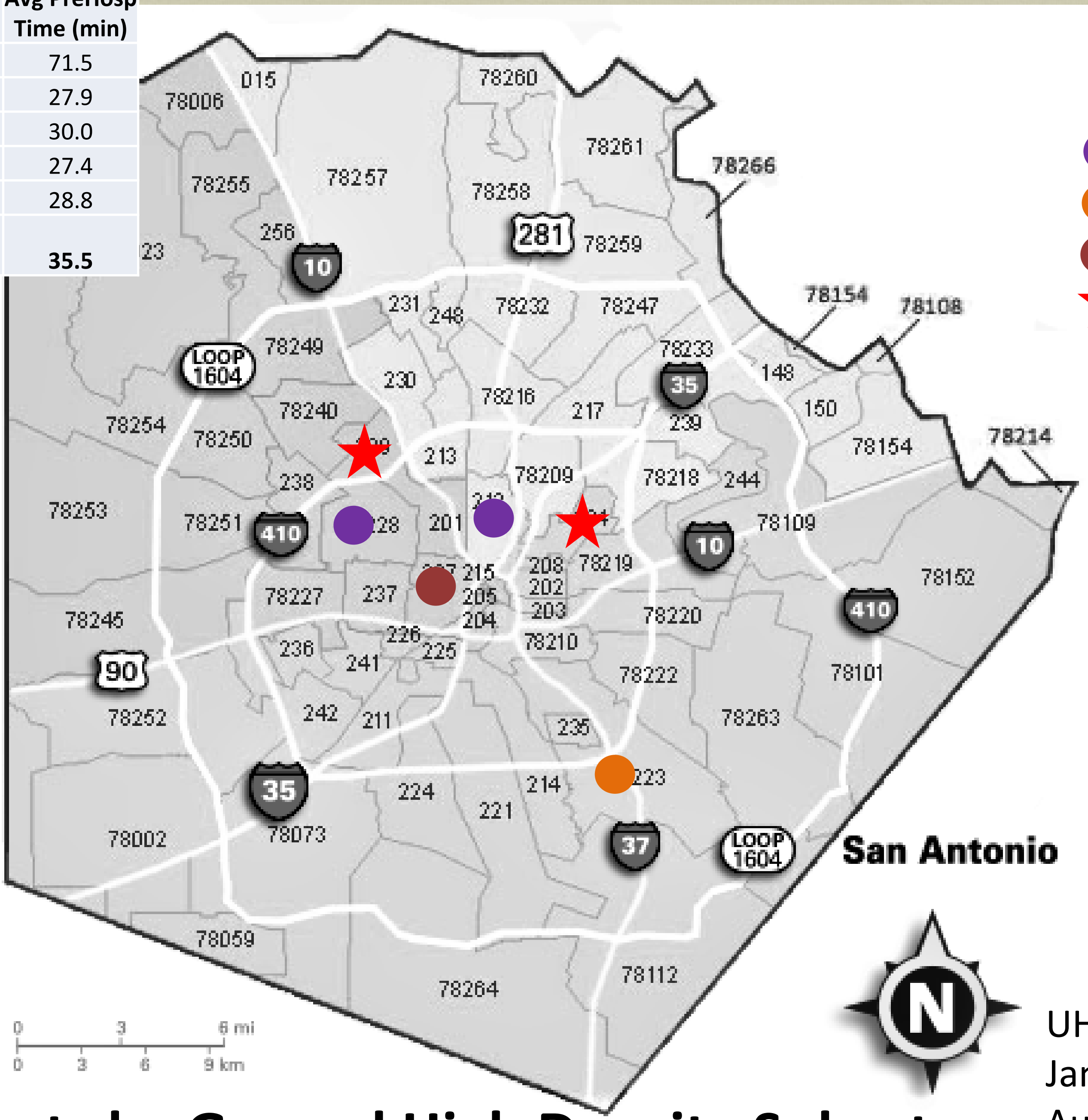
Dead/Total = 55/85 (65%)

Avg PreHosp Time = 28.8 min (Available for 85 of 86 patients)

1 pt unknown dead or alive

UHS + SAMMC
January 1, 2016 – August 31, 2018

Zipcode	Dead/Total	Avg PreHosp Time (min)
78155	2 of 4	71.5
78207	6 of 7	27.9
78212	4 of 4	30.0
78223	2 of 5	27.4
78228	1 of 4	28.8
Total	15 of 24 (63%)	35.5



4 patients
5 patients
7 patients
Hospital

Outside of Bexar County

78155-

MTP Patients by Ground High Density Subset

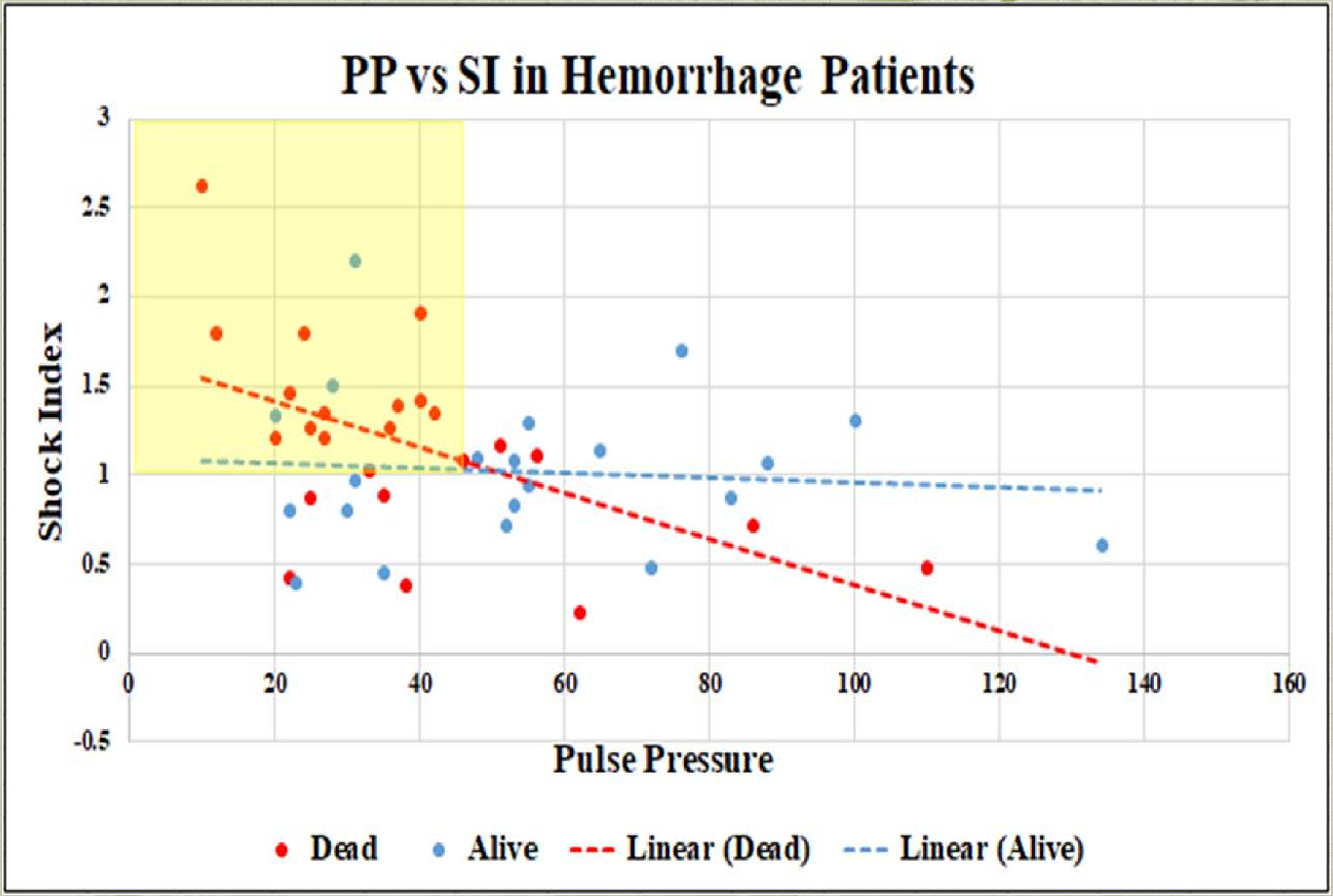
UHS + SAMMC
January 1, 2016 – August 31, 2018

Positive Predictive Values of Death

PP<45	**0.78**
SI>1	**0.71**
SBP ≤110	**0.73**
SBP ≤110 and SI>1	**0.73**
PP<45 and SI>1	**0.79**
SBP ≤110 and PP<45	**0.79**

PP<45 and SI>1:

- 0.81 for blunt injury
- 0.92 for elderly patients


PP vs SI in Hemorrhage Patients
Shock Index
3
2.5
2
1.5
1
0.5
0
-0.5
0
20
40
60
80
100
120
140
160
Pulse Pressure
Dead
Alive
Linear (Dead)
Linear (Alive)

Whole Blood Transfusion Criteria

Transfusion Criteria	
Penetrating Trauma (requires 1 physiologic parameter)	Blunt Trauma (requires 2 physiologic parameter)

<u>Physiologic Parameters</u>

Patient age ≥ 5

Single reading of systolic blood pressure (SBP) < 90 mm Hg

Single reading of heart rate (HR) > 120

Shock index > 1

Pulse Pressure < 45

Positive focused assessment with sonography in trauma (FAST)

Point of care lactate greater than 5.0 mg/dl

Known or presumed anticoagulant use; or dual anti-platelet therapy

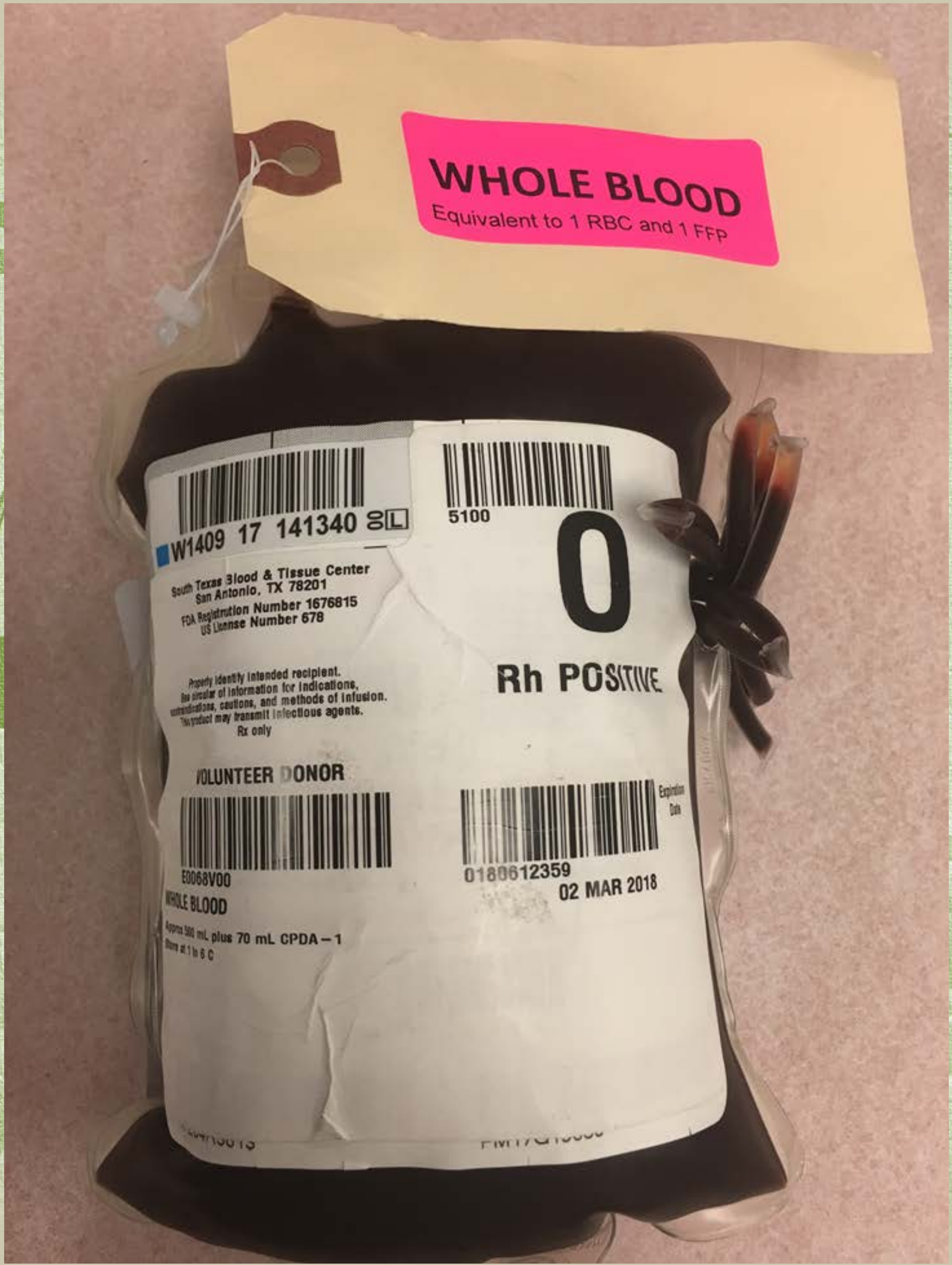
Signs of hemorrhage: (high index of suspicion of active internal bleeding or visual evidence of external bleeding)

Component Therapy vs. Whole Blood

<u>Component Therapy Gives You</u>

1U PRBC + 1U PLT + 1U FFP + 10 pk Cryo =

- 660 mL
- Hct 29%
- Coag activity 65%
- 750 mg fibrinogen

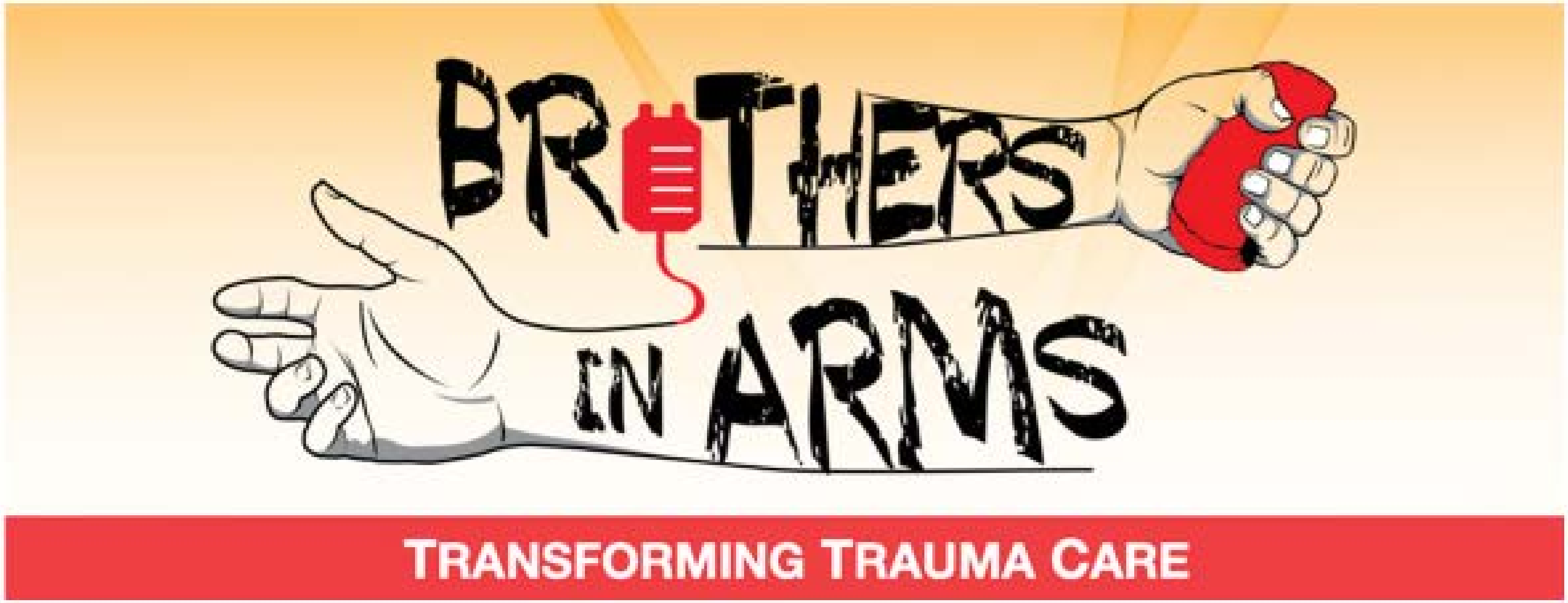

WHOLE BLOOD
Equivalent to 1 RBC and 1 FFP
W1409 17 141340
South Texas Blood & Tissue Center
San Antonio, TX 78201
FDA Registration Number 1676815
US License Number 678
Properly identify intended recipient.
Rx only
VOLUNTEER DONOR
E0068V00
WHOLE BLOOD
5100
0
Rh POSITIVE
Expiration Date
02 MAR 2018

RBC's vs Whole Blood


AB
Rh POSITIVE
CMV antibody negative

Advantages of Whole Blood
"It's What You Bleed"

- Natural
- Keto
- Organic
- Non-GMO
- Free range
- Gluten Free
- High in protein
- Low in carbs


BROTHERS IN ARMS
TRANSFORMING TRAUMA CARE

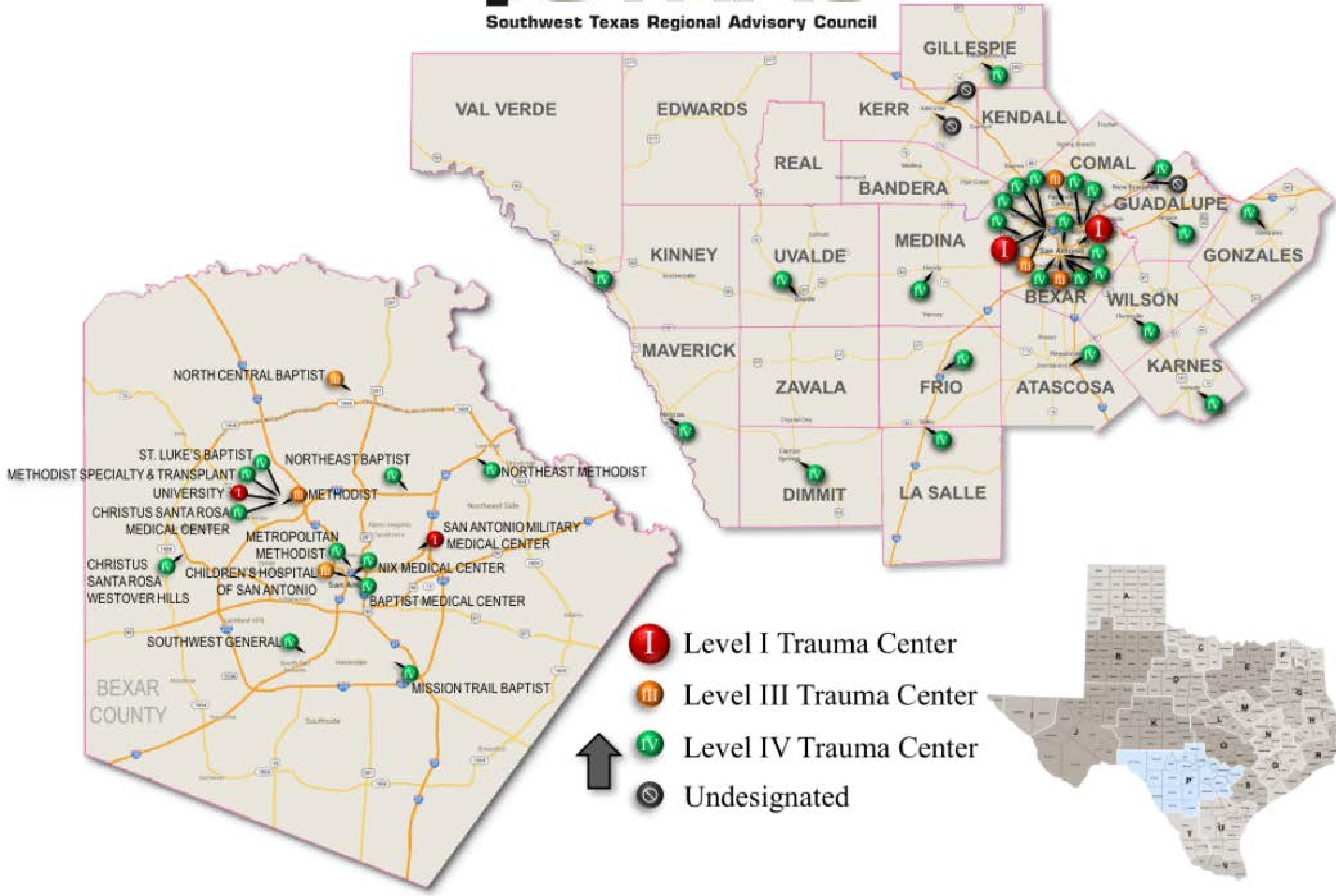
Prehospital Cold Stored O+ Whole Blood in San Antonio

- Kicked off January 29 2018
- 18 helicopters
- 2 units each
- Women of child bearing age not excluded
- Rh isoimmunization risk versus bleeding to death

REGIONAL TRAUMA & EMERGENCY HEALTHCARE SYSTEM

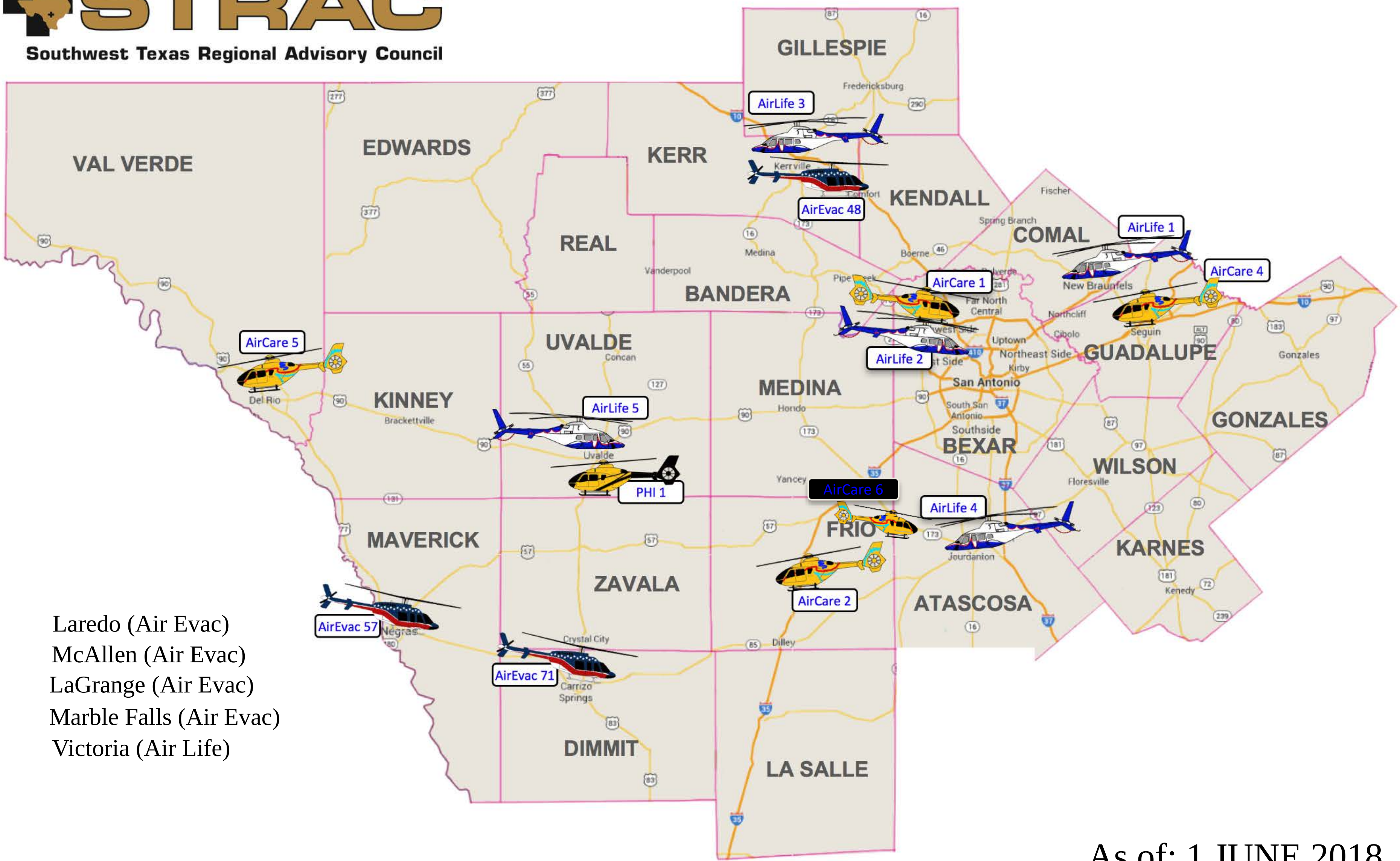
STRAC

Southwest Texas Regional Advisory Council



AIR MEDICAL BASES IN THE REGIONAL EMERGENCY HEALTHCARE SYSTEM

STRAC
Southwest Texas Regional Advisory Council

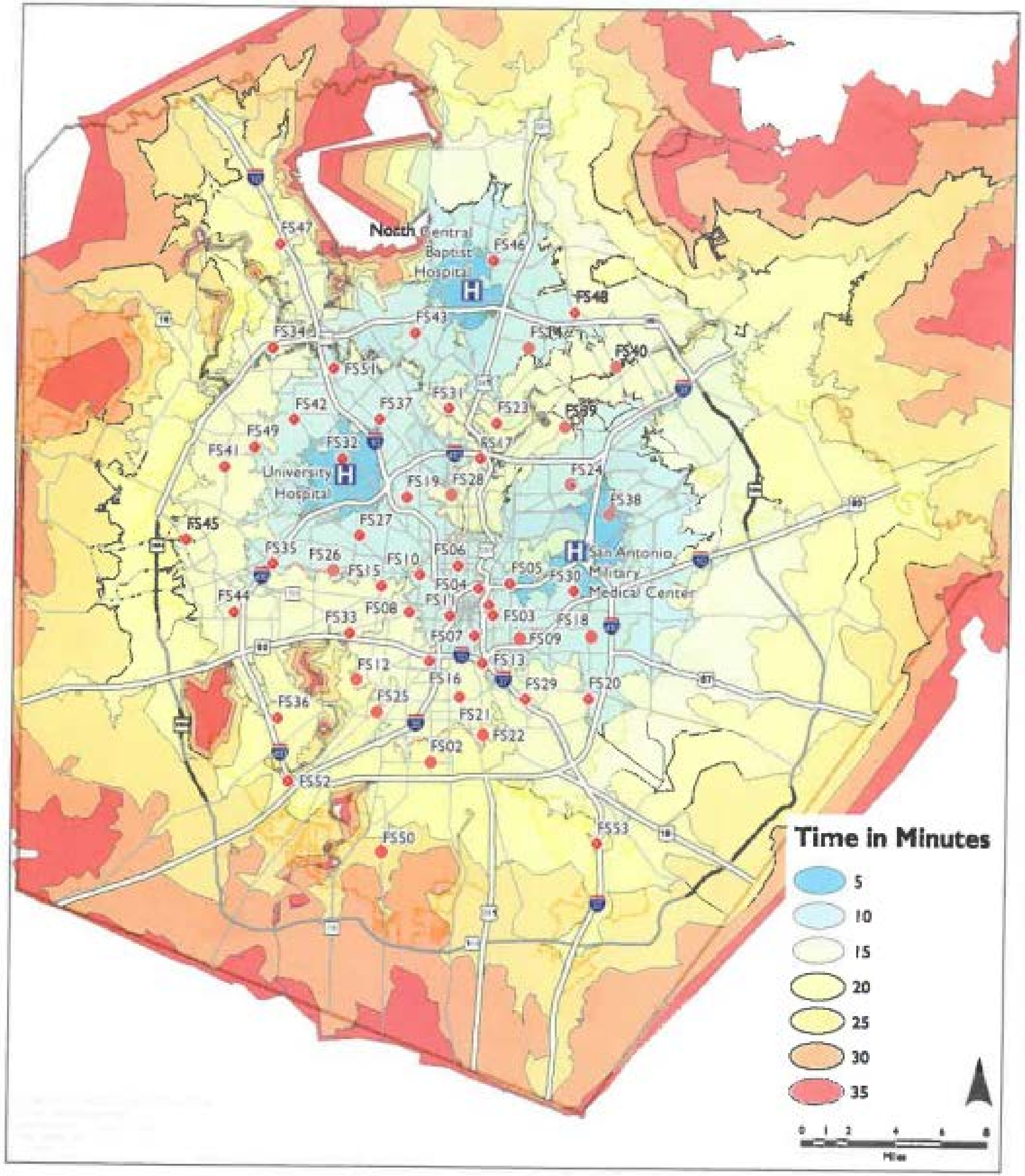


Laredo (Air Evac)
McAllen (Air Evac)
LaGrange (Air Evac)
Marble Falls (Air Evac)
Victoria (Air Life)

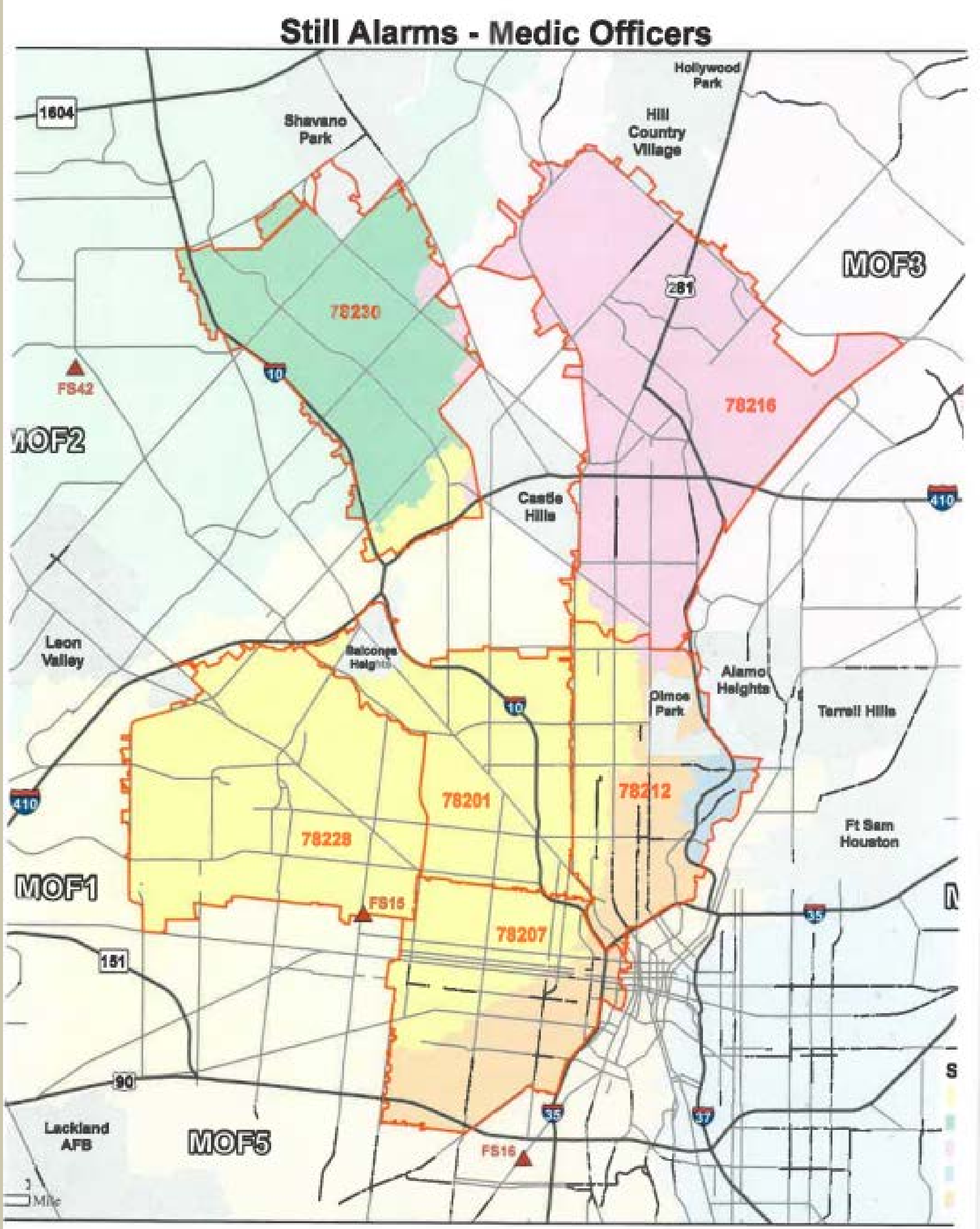
277 Miles

As of: 1 JUNE 2018

[redacted]

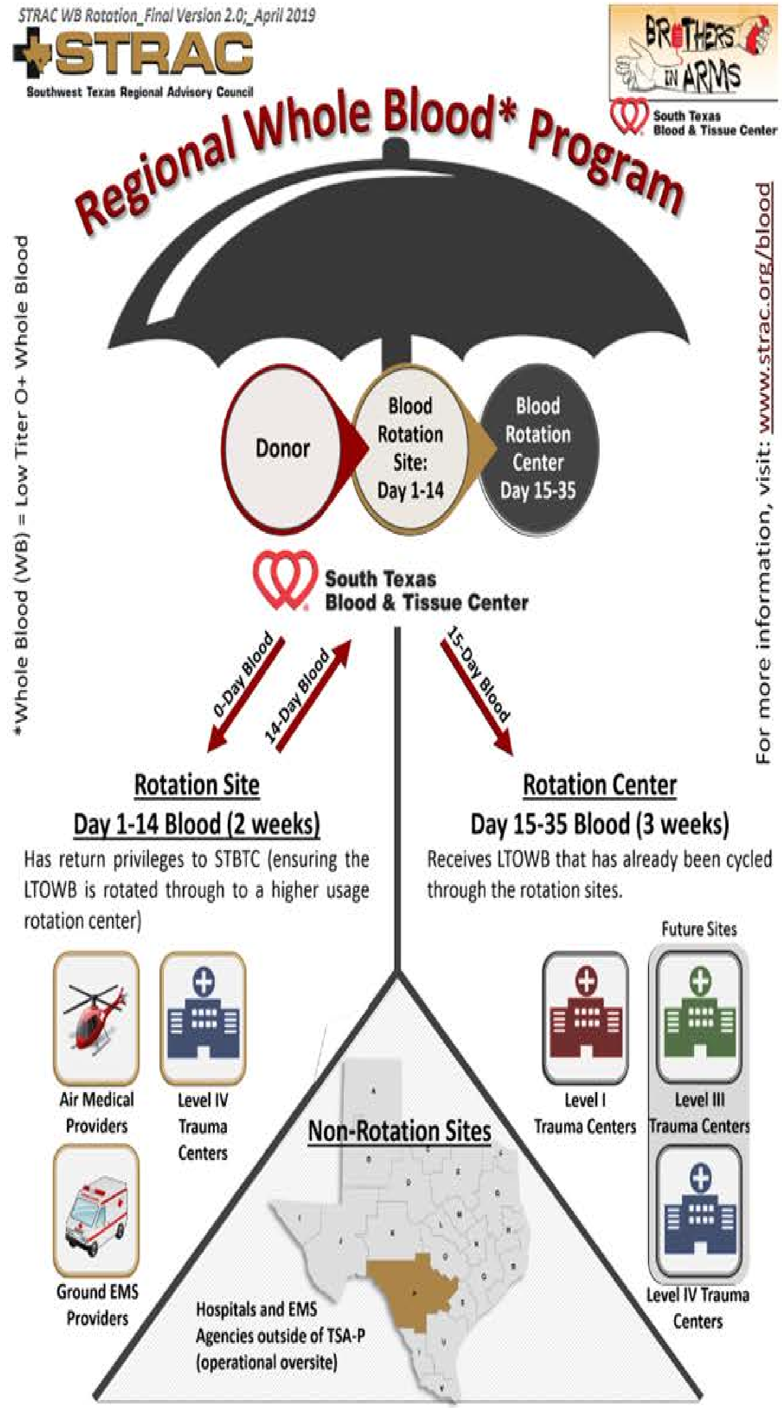


San Antonio Area Trauma Centers Estimated Drive Times



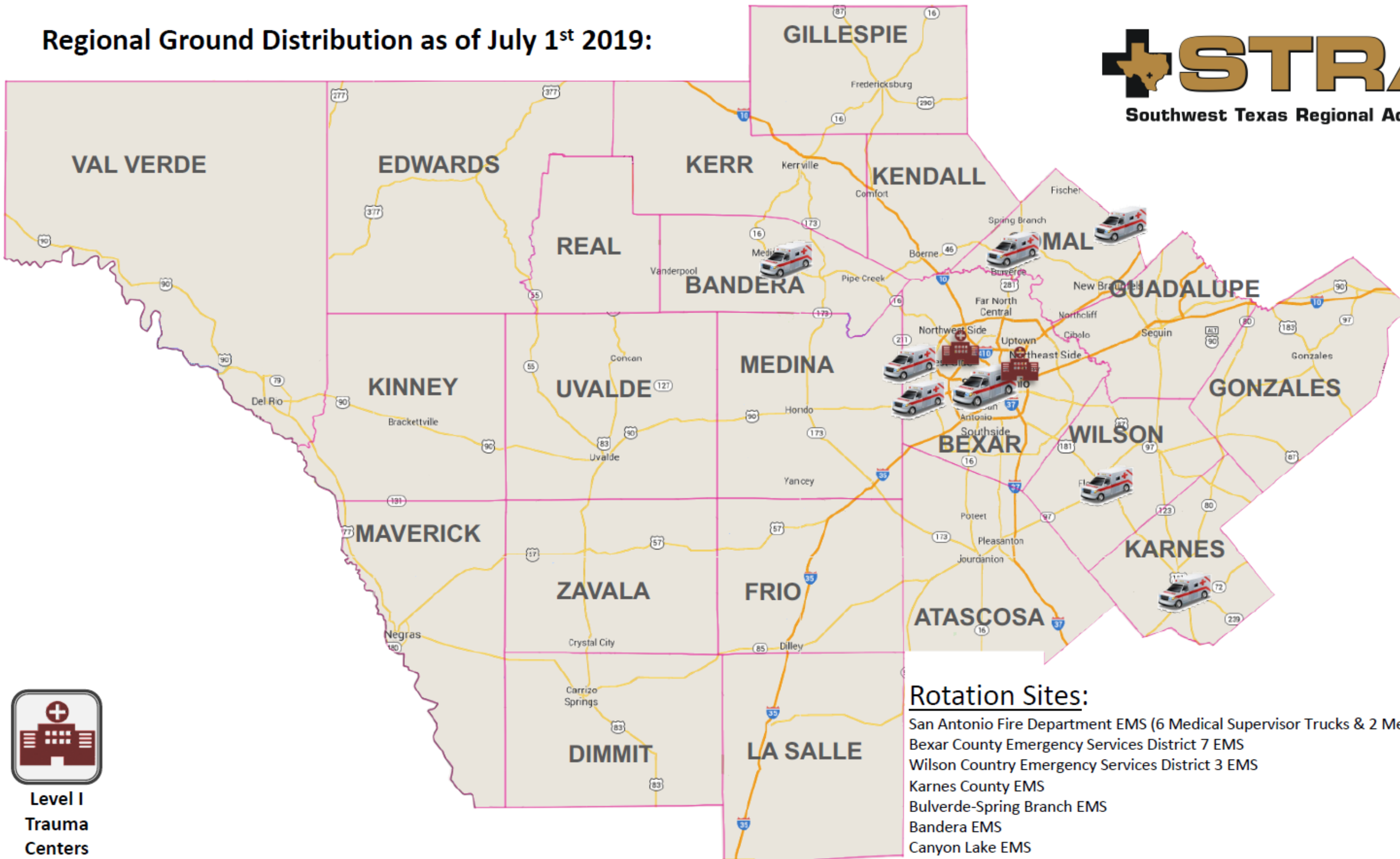
- Medic Officers (MOFs) are EMS Lieutenants who have primary responsibility of ~10 EMS units in their geographic sector.
- There are 5 MOFs. One in each of the 4 quadrants of the city with the fifth located within the downtown south central sector.

LTO+WB Program Overview



Regional Ground Distribution as of July 1st 2019:

Southwest Texas Regional Advisory Council



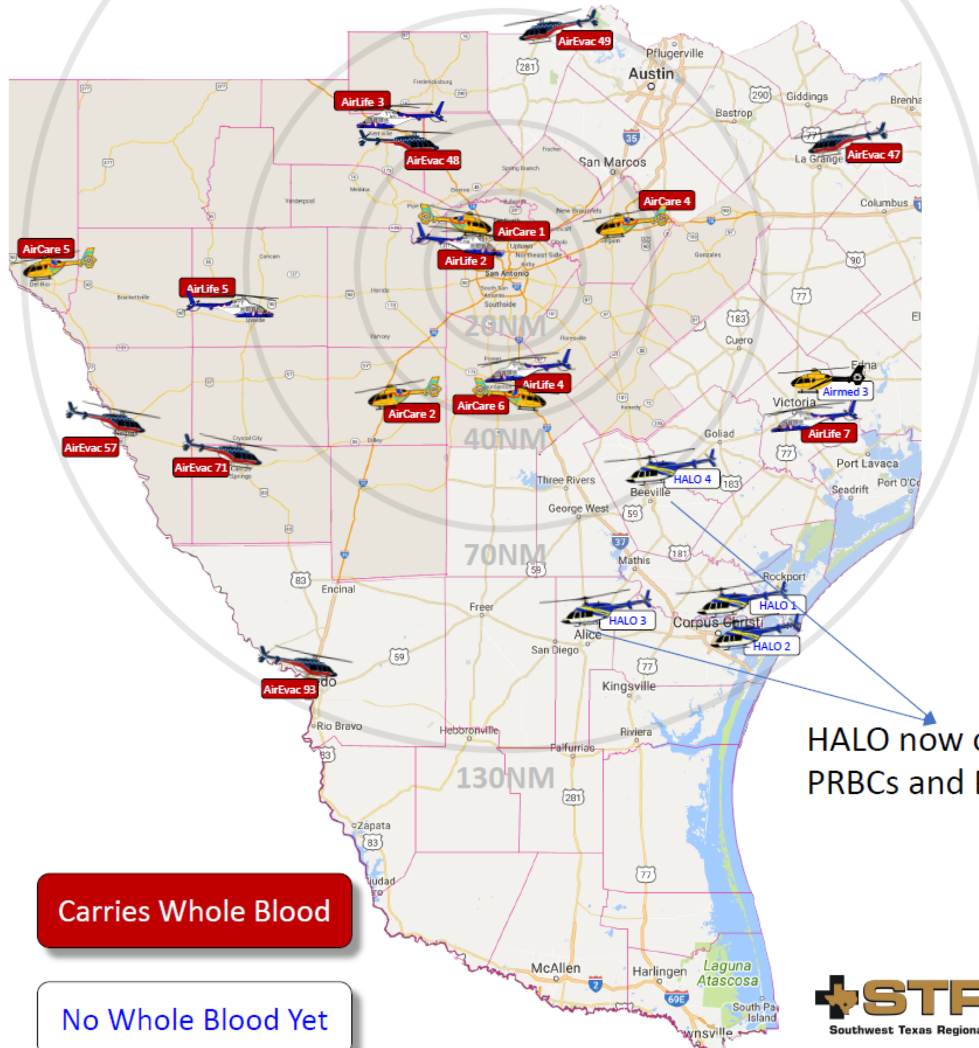
Level I Trauma Centers

Rotation Sites:

San Antonio Fire Department EMS (6 Medical Supervisor Trucks & 2 Medical Special Operations U
Bexar County Emergency Services District 7 EMS
Wilson Country Emergency Services District 3 EMS
Karnes County EMS
Bulverde-Spring Branch EMS
Bandera EMS
Canyon Lake EMS
Bexar County Emergency Services District 2 EMS

Helicopter Bases as of July 2019

Aircraft Callsign	Base Location (City)	County	NM From SA
Aircare-1	San Antonio	Bexar	7
AL-2	San Antonio	Bexar	7
Aircare-4	Seguin	Guadalupe	29
AL-4	Jourdanton	Atascosa	30
Aircare-6	Jourdanton	Atascosa	30
Aircare-2	Pearsall	Frio	45
AEL-48	Kerrville	Kerr	50
AL-3	Kerrville	Kerr	50
AL-5	Uvalde	Uvalde	69
AEL-49	Marble Falls	Burnet	70
HALO-4	Beeville	Bee	73
AL-7	Victoria	Victoria	86
Airmed-3	Victoria	Victoria	86
AEL-47	La Grange	Fayette	89
AEL-71	Carrizo Springs	Dimmit	90
HALO-3	Alice	Jim Wells	102
HALO-1	Corpus Christi	Nueces	113
HALO-2	Corpus Christi	Nueces	113
AEL-57	Eagle Pass	Maverick	115
Aircare-5	Del Rio	Val Verde	125
AEL-93	Laredo	Webb	128



HALO now carrying PRBCs and Plasma

STRAC
Southwest Texas Regional Advisory Council

egional WB Update July 2019.pdf - Adobe Acrobat Pro DC

Edit View Window Help

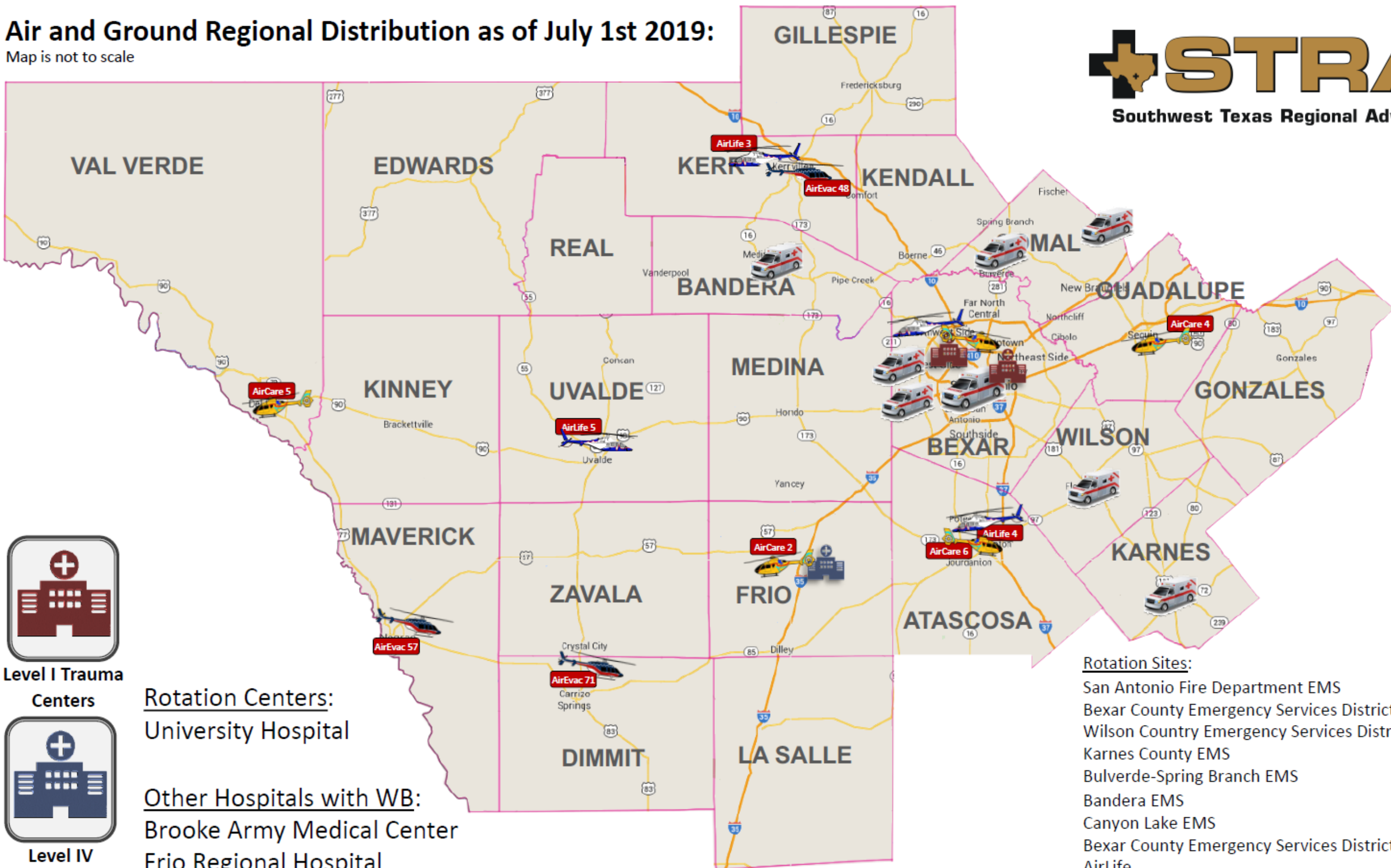
ome Tools Document 2 / 10

Air and Ground Regional Distribution as of July 1st 2019:

Map is not to scale

STRAC

Southwest Texas Regional Advisory Council



Level I Trauma Centers

Level IV Trauma Centers

Rotation Centers:
University Hospital

Other Hospitals with WB:
Brooke Army Medical Center
Frio Regional Hospital

Rotation Sites:
San Antonio Fire Department EMS
Bexar County Emergency Services District 7 EMS
Wilson Country Emergency Services District 3 EMS
Karnes County EMS
Bulverde-Spring Branch EMS
Bandera EMS
Canyon Lake EMS
Bexar County Emergency Services District 2 EMS
AirLife
AirCare

LTO+WB in South Texas Thus Far:

- February 2018 – June 2019

	Total	Adult	Pediatric
# Patients Transfused	287	268	19
# Total Units Transfused	774	719	55
# Units Transfused at UHS	706	656	50
# Units Transfused Prehospital	68	63	5

Contemporary Work by Pokorny First Year in Whole Blood Era

- Component therapy emergency transfusion
  - Death rate in trauma room = 24%
  - Time to death = 1 ½ hours
  - Overall mortality 34%
- Whole blood as emergency transfusion
  - Death rate in trauma room = 11%
  - Time to death = 5 ½ hours
  - Overall mortality 27%

Current State

- SAFDEMS = 203 patients
- UHS = over 315 patients in the trauma registry but does not account for any patients in October yet
- Rural EMS = 12 patients*
- Critical Access Hospitals = 2 patients
- Helicopter EMS = 125 patients

“Time is Life”

and

PreHospital Whole Blood Promising

AABB SAN ANTONIO OCTOBER 19-22

Potentially Survivable Injury and Potentially Preventable Deaths from Traumatic Injuries

Brian Eastridge, MD, FACS

Professor, Department of Surgery

Division Chief, Trauma and Emergency General Surgery

Jocelyn and Joe Straus Endowed Chair in Trauma Research

UT Health San Antonio

Disclosures

DoD Broad Agency Announcement (BAA) Grant

Disclaimer

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

Objectives

- Establish the epidemiology of potentially survivable injury and preventable deaths after injury in adults and children
- Foster professional collaborations between transfusion and injury care experts
  - Stimulate scientific research
  - Enhance and improve the quality of clinical practice in order to improve outcomes for patients with hemorrhagic shock
- Advance innovation in transfusion medicine

AABB-THOR Joint Working Group
18 OCT 2019
San Antonio, Texas
Register at www.aabb.org/annualmeeting

SESSION 1 — TRAUMA BY THE NUMBERS

08:00 - 08:25 **Preventable Deaths from Traumatic Injuries**
Brian J. Eastridge, MD FACS
UT Health San Antonio
San Antonio, Texas USA

08:25 - 08:50 **Pediatric Outcomes In 500 Children With Severe Bleeding**
Phil Spinella, MD FCCM
Washington University School of Medicine
St. Louis, Missouri USA

08:50 - 09:10 **2° Analyses of the PAMPER RCT of prehospital plasma**
Mark Yazer, MD
University of Pittsburgh
Pittsburgh, Pennsylvania USA

09:10 - 09:25 **Panel Discussion**

09:25 - 09:40 **BREAK**

SESSION 2 — DO WE STILL NEED PLASMA?

09:40 -10:00 **Hemostatic Effects Of Cryo Vs. Fibrinogen In Microfluidic Models**
Susan Shea, PhD
Washington University School of Medicine
St. Louis, Missouri USA

10:00 - 10:20 **Dried Plasma: Who Should Get It?**
COL Jennifer M. Gurney, MD FACS
US Army Joint Trauma System
USA

10:20 - 10:40 **What's New In Trauma-Induced Endotheliopathy**
Shibani Pati, MD PhD
University of California, San Francisco
San Francisco, California USA

10:40 - 10:50 **Panel Discussion**

10:50 - 11:05 **BREAK**

SESSION 3 — WHAT'S NEW IN BLOOD PRODUCTS?

11:05 - 11:25 **New Blood Product Update**
Andrew P. Cap, MD, PhD, FACS
U.S. Army Institute of Surgical Research
San Antonio, Texas USA

rdcr.org

rev. 7/18/19 v3 yazer

10

people in United States
who will bleed to death
with
potentially survivable injury
during this session

Bleeding Casualty is "On the Clock"

All Cause Death

10 Leading Causes of Death, United States
2017, All Races, Both Sexes

	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	All Ages
1	Congenital Anomalies 4,580	Unintentional Injury 1,267	Unintentional Injury 718	Unintentional Injury 860	Unintentional Injury 13,441	Unintentional Injury 25,669	Unintentional Injury 22,828	Malignant Neoplasms 39,266	Malignant Neoplasms 114,810	Heart Disease 519,052	Heart Disease 647,457
2	Short Gestation 3,749	Congenital Anomalies 424	Malignant Neoplasms 418	Suicide 517	Suicide 6,252	Suicide 7,948	Malignant Neoplasms 10,900	Heart Disease 32,658	Heart Disease 80,102	Malignant Neoplasms 427,896	Malignant Neoplasms 599,108
3	Maternal Pregnancy Comp. 1,432	Malignant Neoplasms 325	Congenital Anomalies 188	Malignant Neoplasms 437	Homicide 4,905	Homicide 5,488	Heart Disease 10,401	Unintentional Injury 24,461	Unintentional Injury 23,408	Chronic Low. Respiratory Disease 136,139	Unintentional Injury 169,936
4	SIDS 1,363	Homicide 303	Homicide 154	Congenital Anomalies 191	Malignant Neoplasms 1,374	Heart Disease 3,681	Suicide 7,335	Suicide 8,561	Chronic Low. Respiratory Disease 18,667	Cerebro-vascular 125,653	Chronic Low. Respiratory Disease 160,201
5	Unintentional Injury 1,317	Heart Disease 127	Heart Disease 75	Homicide 178	Heart Disease 913	Malignant Neoplasms 3,616	Homicide 3,351	Liver Disease 8,312	Diabetes Mellitus 14,904	Alzheimer's Disease 120,107	Cerebro-vascular 146,383
6	Placenta Cord Membranes 843	Influenza & Pneumonia 104	Influenza & Pneumonia 62	Heart Disease 104	Congenital Anomalies 355	Liver Disease 918	Liver Disease 3,000	Diabetes Mellitus 6,409	Liver Disease 13,737	Diabetes Mellitus 59,020	Alzheimer's Disease 121,404
7	Bacterial Sepsis 592	Cerebro-vascular 66	Chronic Low. Respiratory Disease 59	Chronic Low. Respiratory Disease 75	Diabetes Mellitus 248	Diabetes Mellitus 823	Diabetes Mellitus 2,118	Cerebro-vascular 5,198	Cerebro-vascular 12,708	Unintentional Injury 55,951	Diabetes Mellitus 83,564
8	Circulatory System Disease 449	Septicemia 48	Cerebro-vascular 41	Cerebro-vascular 56	Influenza & Pneumonia 190	Cerebro-vascular 593	Cerebro-vascular 1,811	Chronic Low. Respiratory Disease 3,975	Suicide 7,982	Influenza & Pneumonia 46,862	Influenza & Pneumonia 55,672
9	Respiratory Distress 440	Benign Neoplasms 44	Septicemia 33	Influenza & Pneumonia 51	Chronic Low. Respiratory Disease 188	HIV 513	Septicemia 854	Septicemia 2,441	Septicemia 5,838	Nephritis 41,670	Nephritis 50,633
10	Neonatal Hemorrhage [illegible]	Perinatal Period [illegible]	Benign Neoplasms [illegible]	Benign Neoplasms [illegible]	Complicated Pregnancy [illegible]	Complicated Pregnancy [illegible]	HIV [illegible]	Homicide [illegible]	Nephritis [illegible]	Parkinson's Disease [illegible]	Suicide [illegible]173

WISQARS™ Produced By: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System

Access to Trauma Center Care (Level I / II)

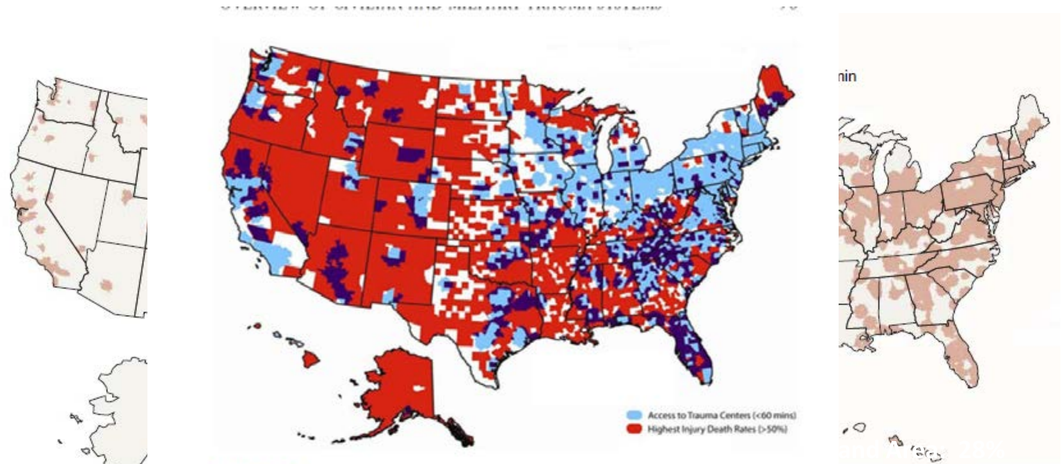
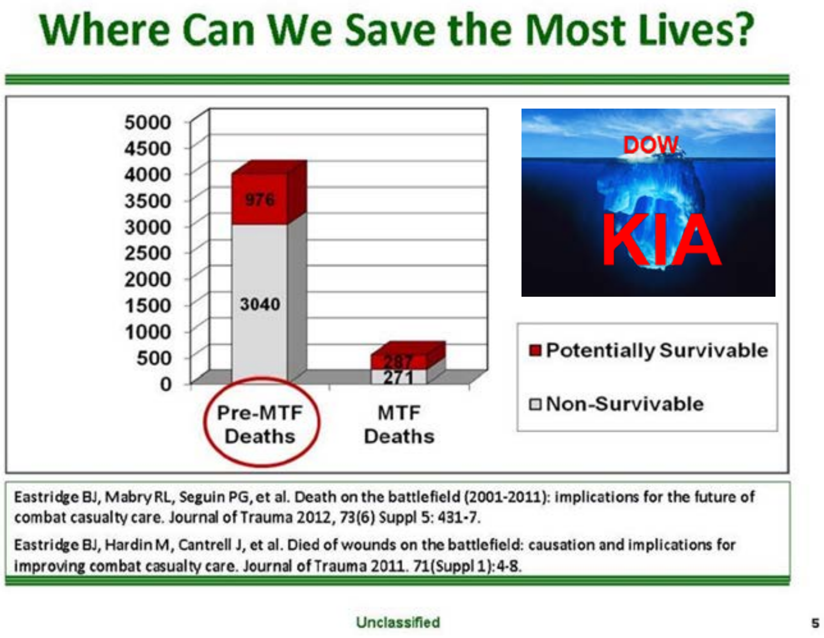
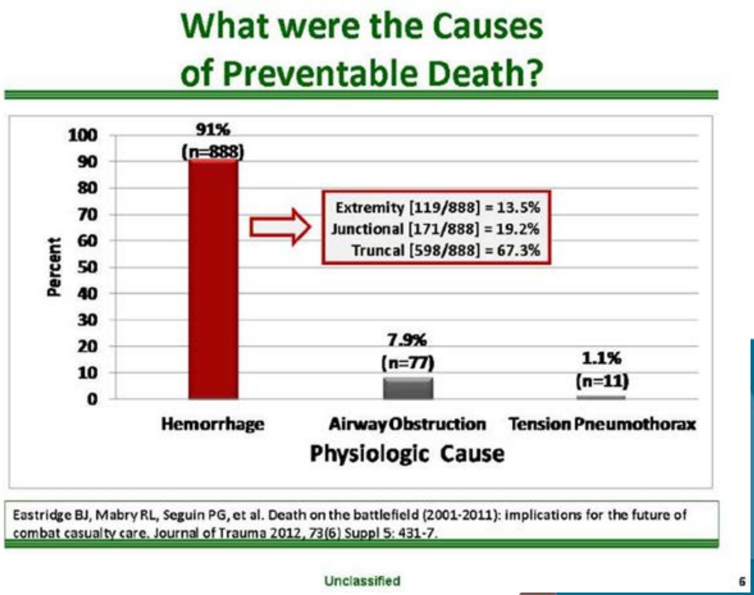


FIGURE 2-3 Lack of access to an appropriate level of trauma care is associated with higher trauma patient mortality.

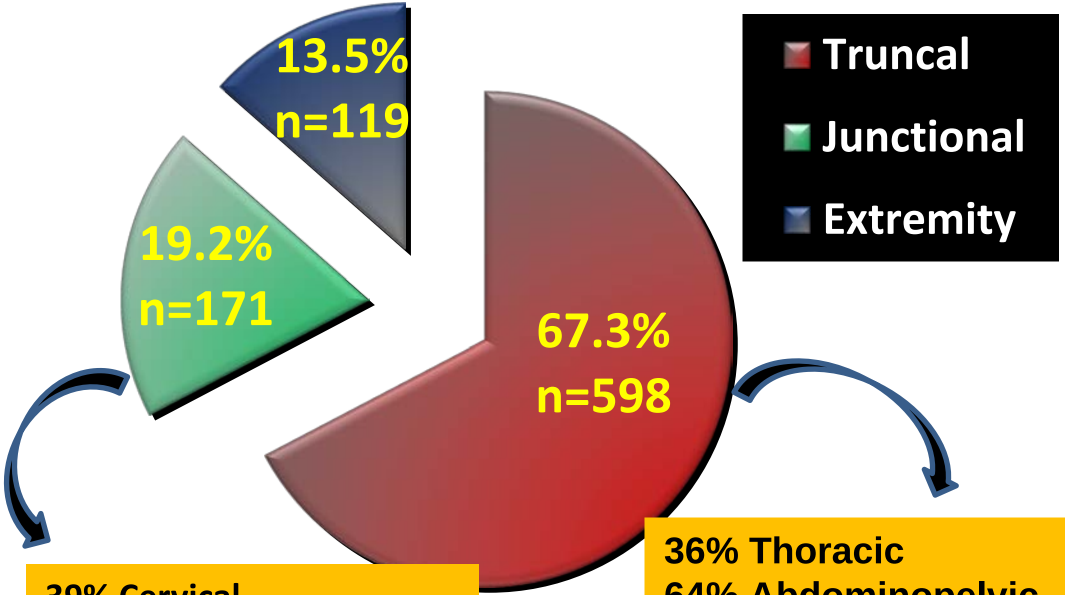
SOURCE: Map provided by Charles Branas, Ph.D., Professor of Epidemiology, University of Pennsylvania, 2016.

Background/Scientific Rationale
PreHospital Battlefield Mortality





Anatomic / Physiologic Mechanism of Death



39% Cervical
61% Axilla and Groin

36% Thoracic
64% Abdominopelvic

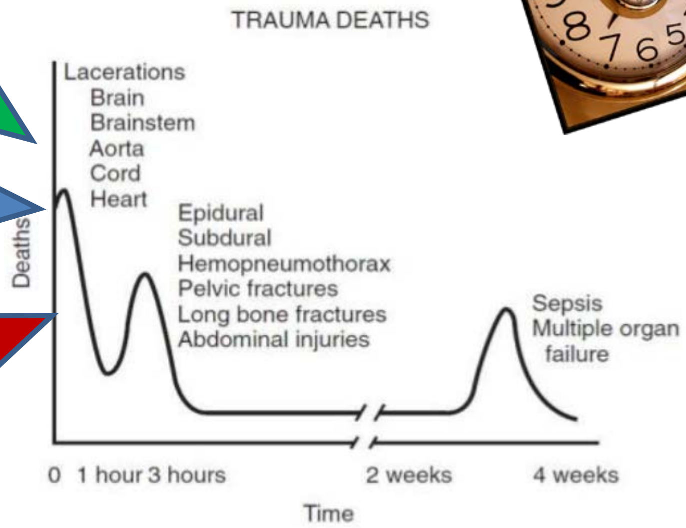
Eastridge BJ, Mabry RL, Seguin PG, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. Journal of Trauma, 2012.

Background/Scientific Rationale
Pre-Hospital Civilian Mortality

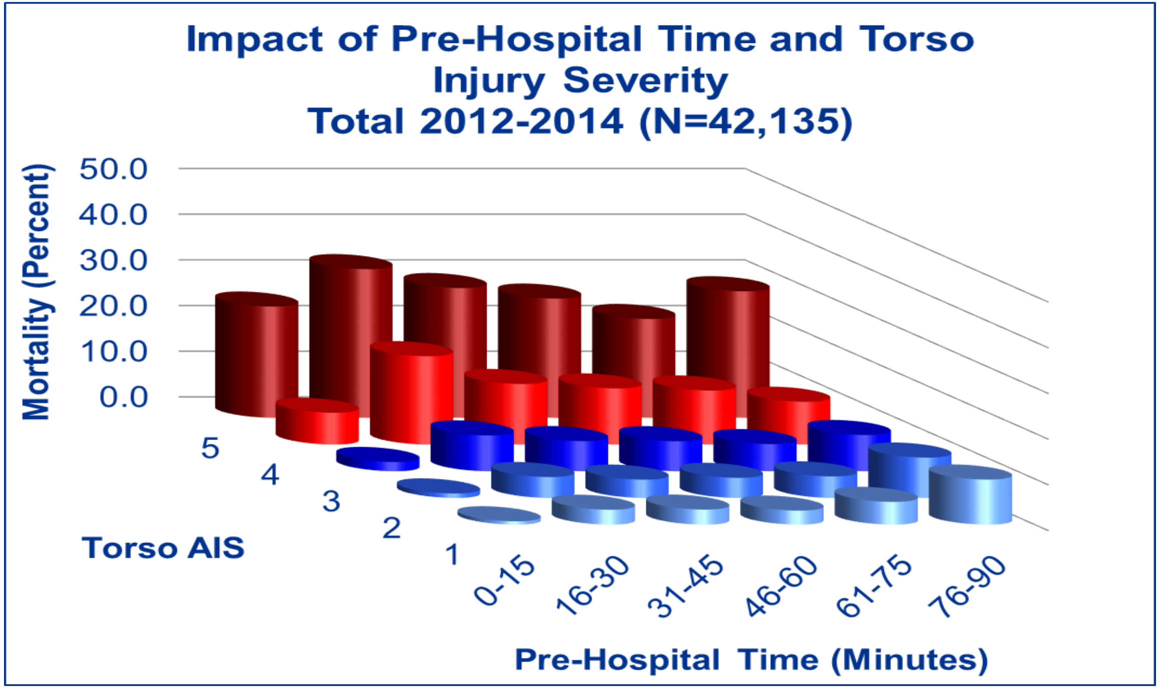
Impact Not Well Quantitated

Potential Survivability Poorly Defined

NASEM Report Emphasis

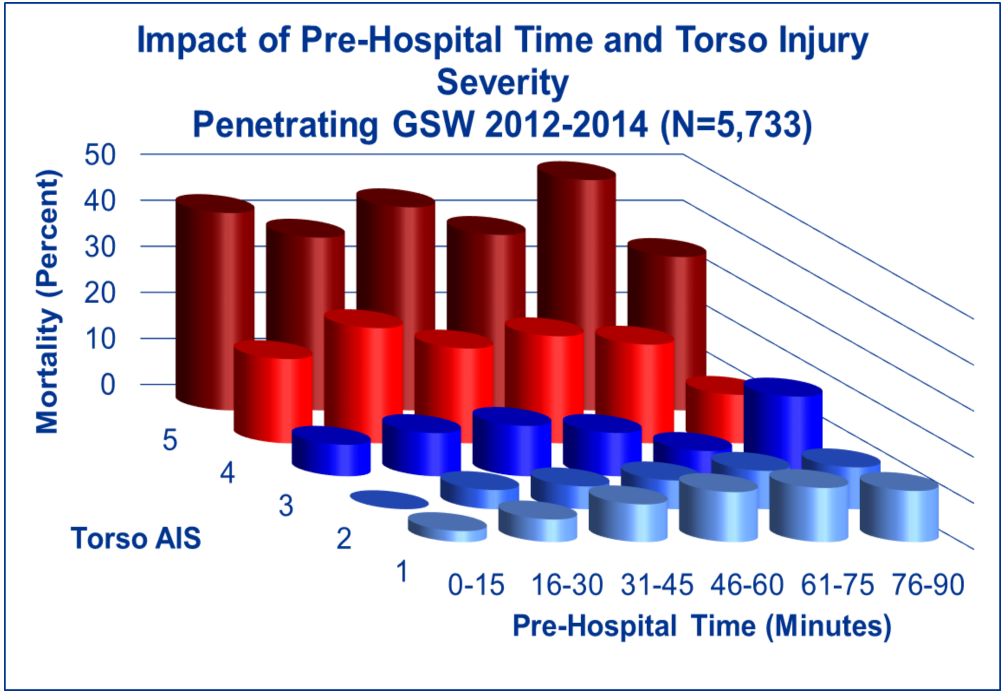


Prehospital Time
Noncompressible Torso Hemorrhage (All)



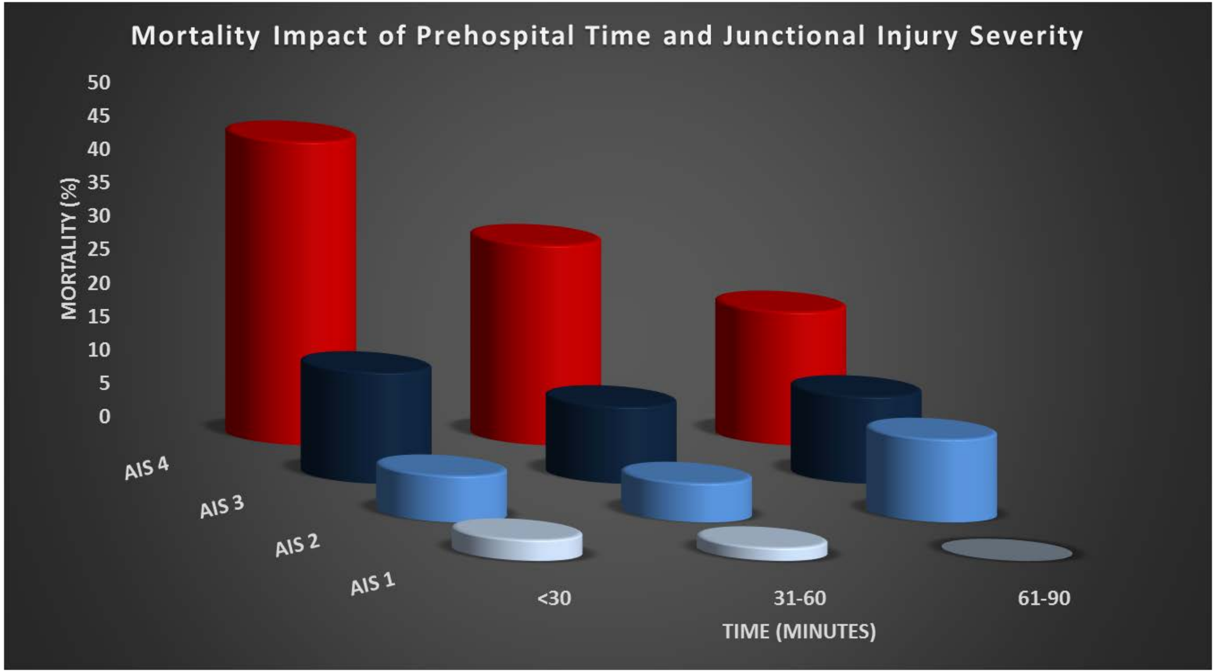
Alarhayem, Eastridge, et al: Mortality in Trauma Patients with Hemorrhage from Torso Injury Occurs Long Before the "Golden Hour" Presented at Southwestern Surgical Congress April 2016

Prehospital Time
Noncompressible Torso Hemorrhage (GSW)



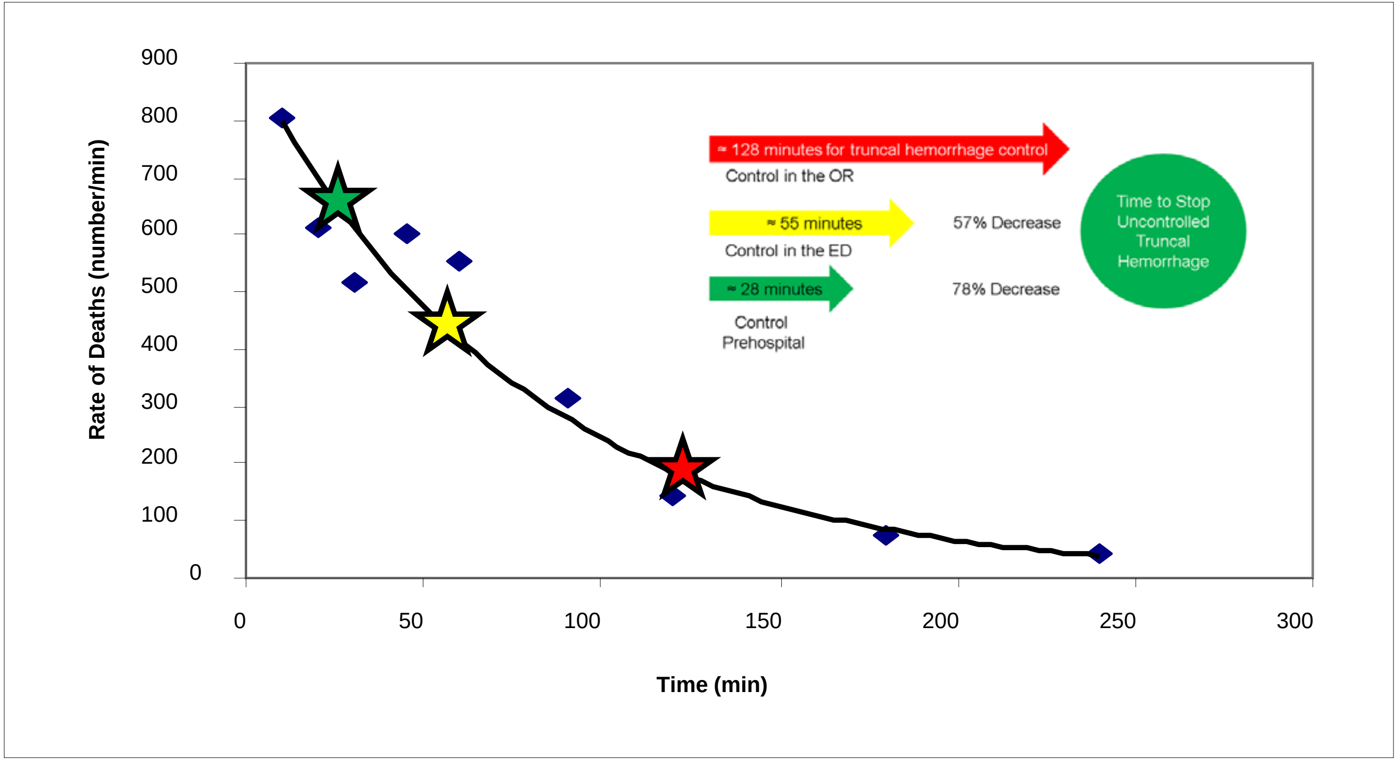
Alarhayem, Eastridge, et al: Mortality in Trauma Patients with Hemorrhage from Torso Injury Occurs Long Before the "Golden Hour" Presented at Southwestern Surgical Congress April 2016

Prehospital Time
Junctional Hemorrhage



Alarhayem, Eastridge: Highlighting the Need for Novel Strategies to Control Complex Sources of Hemorrhage and Temporize Survival to Definitive Care. Presented MHSRS 2016

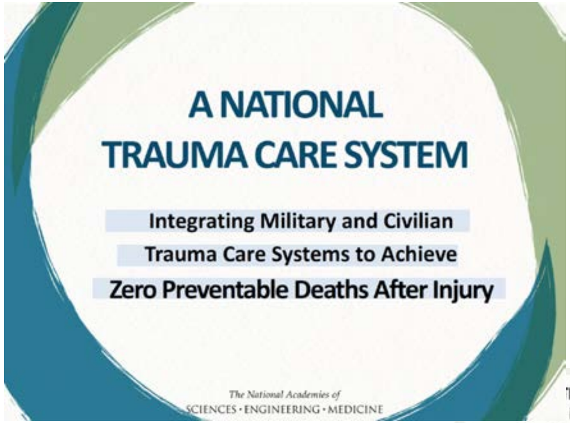
Time to Hemorrhage Control

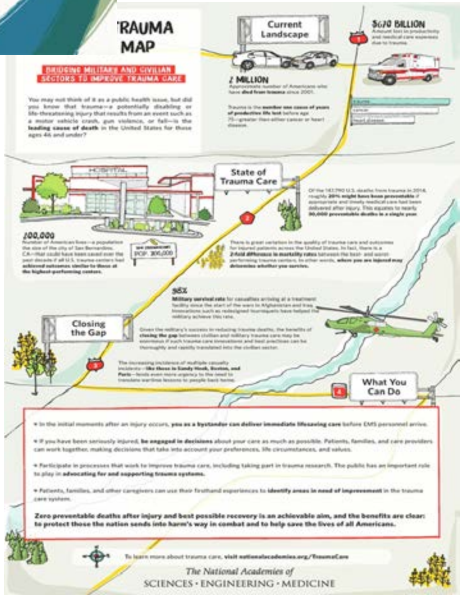


Transport Time and Preoperating Room Hemostatic Interventions Are Important: Improving Outcomes After Severe Truncal Injury

John B. Holcomb, MD, FACS

CCM 2018





Potentially survivable injuries US civilian population

147,790 x 0.276 = 40,790

Getting Beyond Estimates

Objective establishment of the impact on society

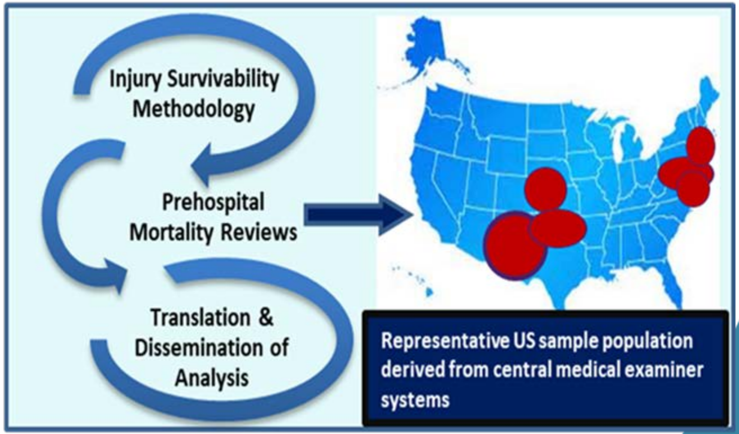
Multiinstitutional Multidisciplinary Injury Mortality Investigation in Civilian PreHospital Environment

PI:Eastridge
Co-I: Nolte, MacKenzie

Funded by USAMRMC (Department of Defense)

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 pre-mortality from trauma

Identify potential high yield areas for research and development in pre-hospital medical care, injury prevention, and trauma systems.



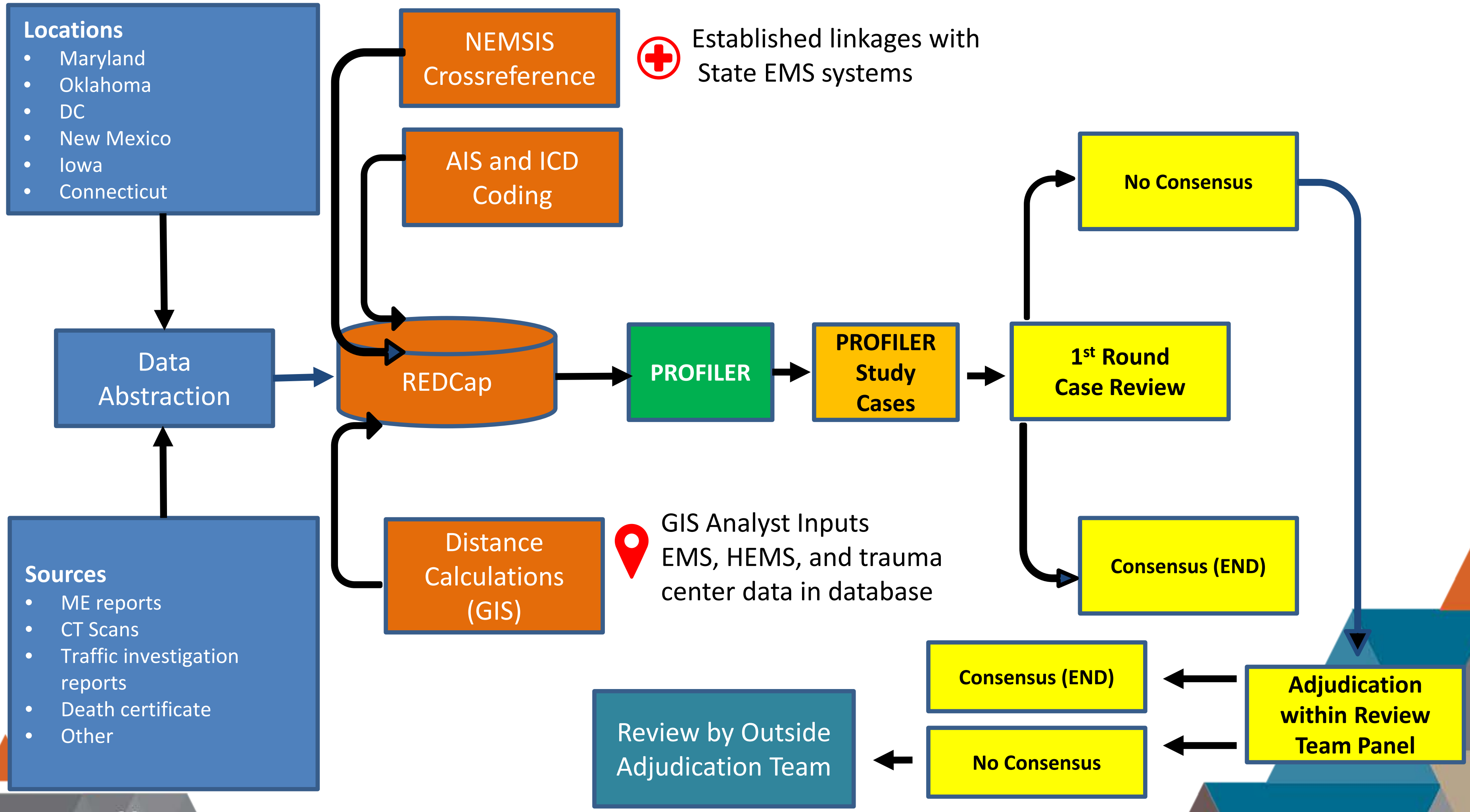
MIMIC Objectives

Completed

- **Objective #1:** ***Develop a framework and methodology*** for evaluating pre-hospital deaths
- **Objective #2:** Organize and standardize a ***multidisciplinary, multi-institutional network of experts*** to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.

In Progress

- **Objective #3:** ***Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths***, and estimate the potential for survivability
- **Objective #4:** ***Describe the epidemiology of pre-hospital mortality*** in the context of trauma system development and estimate its impact on society.
- **Objective #5:** ***Develop a blueprint for a sustained effort*** identifying high priority areas for injury prevention, trauma systems performance improvement and research and development.


Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages with State EMS systems
AIS and ICD Coding
Data Abstraction
REDCap
PROFILER
PROFILER Study Cases
1st Round Case Review
No Consensus
Consensus (END)
Distance Calculations (GIS)
GIS Analyst Inputs EMS, HEMS, and trauma center data in database
Sources
ME reports
CT Scans
Traffic investigation reports
Death certificate
Other
Adjudication within Review Team Panel
Consensus (END)
No Consensus
Review by Outside Adjudication Team

Survivability Definitions

- **Non-Survivable-** Death as a result of catastrophic anatomic injuries
- **Possibly Survivable -** Anatomic injuries that were severe but medically survivable
- **Definitely Survivable-** Minimal anatomic injuries with a high likelihood of survival
- **Cannot Judge-** information insufficient to make a determination

Anatomic Survivability

Medically Non-Survivable (MNS)

- Dismemberment / decapitation
- Traumatic Brain evisceration
- Cervical cord transection (above C3)
- Airway transection within thorax
- Cardiac injury > 2cm
- Uncontained hemorrhage, thoracic aorta
- Uncontained hemorrhage, pulmonary artery
- Hepatic avulsion
- Junctional lower extremity amputations with open pelvis
- Injuries to the deep CNS nuclei, brainstem, or massive brain tissue injury
- Massive Pulmonary Tissue Disruption

Medically Potentially Survivable / Definitely Survivable

- All other

Project Update

Data Abstraction

- 2,539 of 3,000 cases have been abstracted

Coding

- AIS/ICD – 860 cases completed
- GIS – 2,587 cases completed

Case Reviews

- Created 13 review team panels each consisting of 4 surgeons, 1 EM/EMS reviewer, and 1 Forensic Reviewer. All panels have a reviewer with past military experience, and a minimum of 1 female reviewer on each panel.
- Case reviews were launched to the first review team panel in January 2019.
- To date, 775 cases have been released to panels.
- 585 cases have been completed.

Case Reviews

Study Round	Number of Cases Released	Case Completion	Comments
Round 1 Status *Began 1-16-2019*	260 Cases Released	240 Cases Completed	1 panel pending to close out Round 1
Round 2 Status *Began 3-25-2019*	240 Cases Released	220 Cases Completed	1 panel pending to close out Round 2
Round 3 Status *Began 6-13-2019*	300 Cases Released	125 Cases Completed	-1 panel pending cases to be released -other panels are completing reviews

- 13 review team panels
- Study will consist of 10 rounds
- Reviewers are reporting being able to complete each case review in about 10-15 minutes

Case Adjudication

Study Round	Number of Cases That Did Not Reach Initial Consensus	Cases Resolved During Team Adjudication	Cases Still In Team Adjudication	Could Not Reach Consensus, Pushed for Outside Adjudication
Round 1 Status	**61 cases**	**44 cases**	**3 cases**	**14 cases**
Round 2 Status	**49 cases**	**21 cases**	**20 cases**	**8 cases**
Round 3 Status	**36 cases**	**9 cases**	**24 cases**	**3 cases**

- Look for adjudication email
- Provide a comment in the discussion bar
- If you are changing your response, be sure to change and then click Submit, to resubmit your case

Preliminary Round 1 and Round 2 Data

Q1: Based on your judgment, what was the principal mechanism(s) of death?

Principal Mechanism(s) of Death	Frequency
Neurological – Traumatic Brain Injury	1342
Hemorrhage – Truncal: Thorax	354
Neurological – Spinal Cord	256
Hemorrhage – Truncal: Abdomen / Pelvis	136
Burn	133
Airway	79
Massive tissue disruption: CNS	67
Asphyxia	65
Massive tissue disruption: Whole Body	59
Massive tissue disruption: Thorax	41
Tension Pneumothorax	32
Hemorrhage – Junctional: Cervical	29
Massive tissue disruption: abdomen	28
hemorrhage - peripheral: upper extremity	21

Note: Cases with multiple causes are counted multiple times. (Round 1 and 2)

Preliminary Round 1 and Round 2 Data

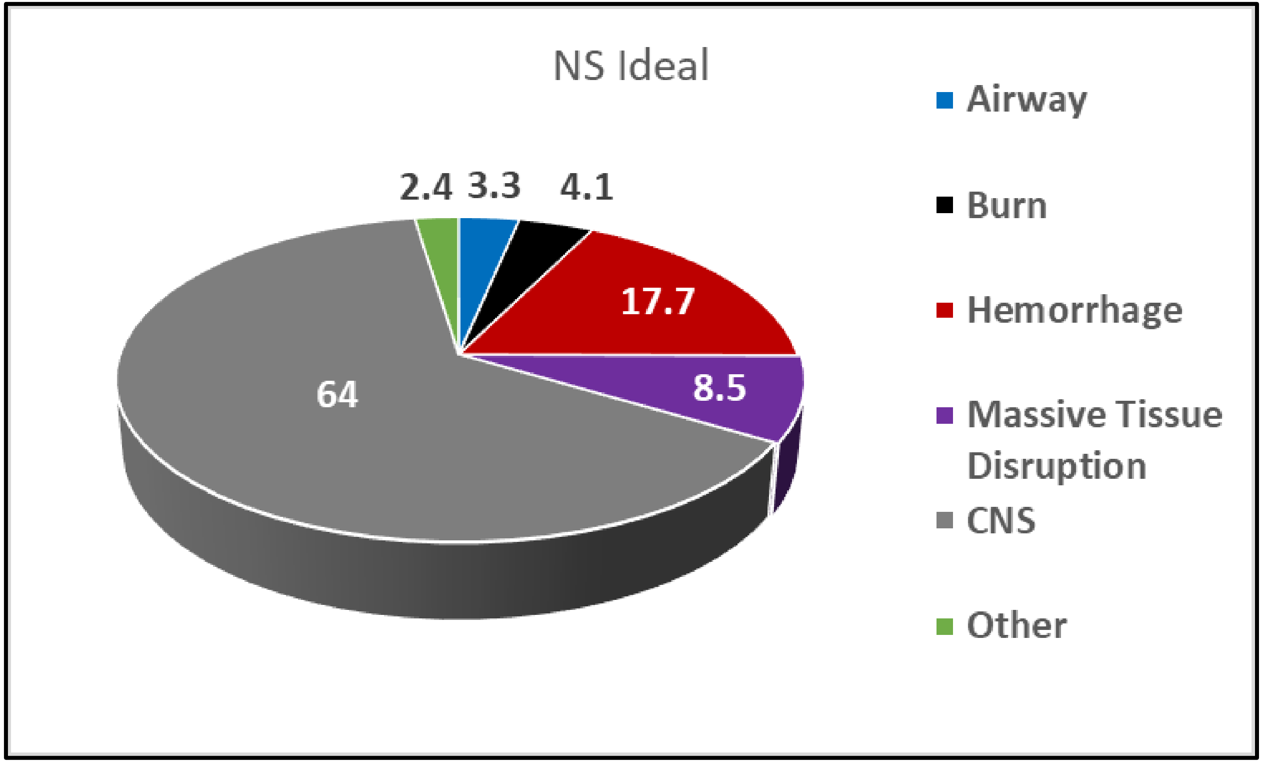
Q2: Assume survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

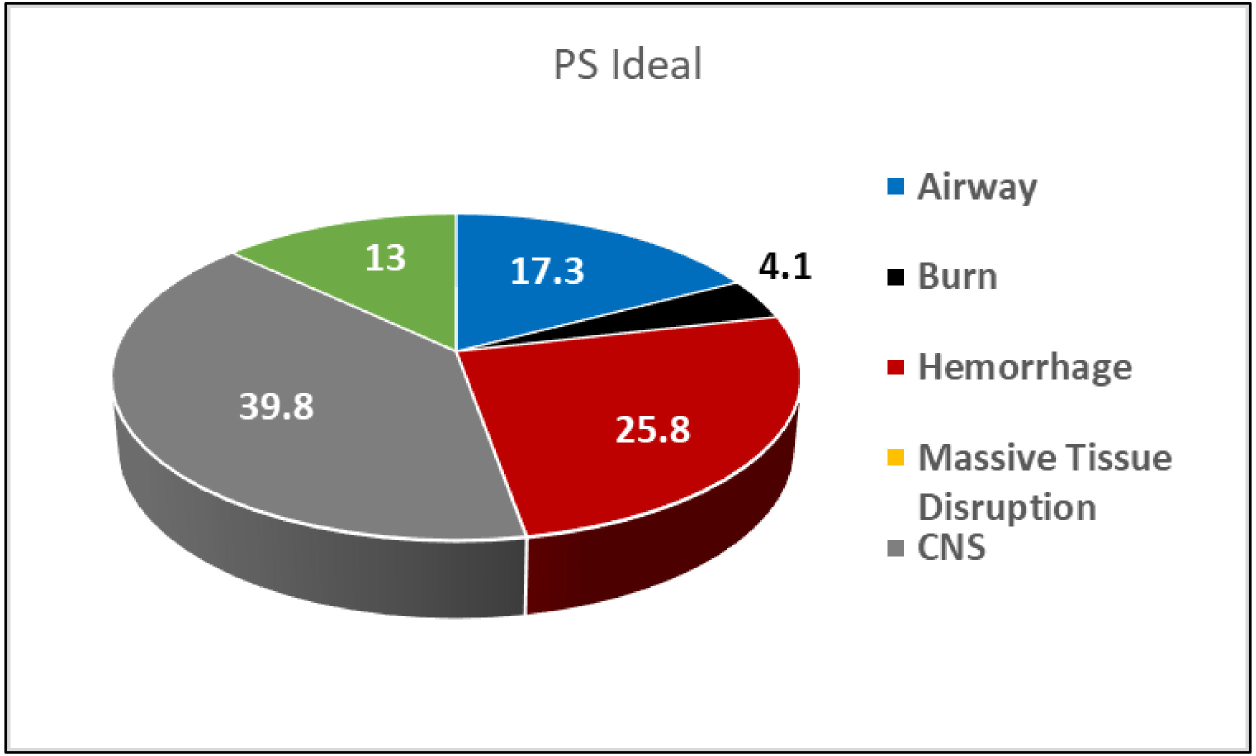
...ss	Frequency for reviewers reaching consensus	Frequency for medical examiners
[illegible]	262 (77%)	269 (79%)
...vable	75 (22%)	46 (14%)
...able	2 (1%)	5 (1%)
Cannot Judge	0	19 (6%)

Note: Using 339 cases that have reached consensus on survivability assessments for Q2

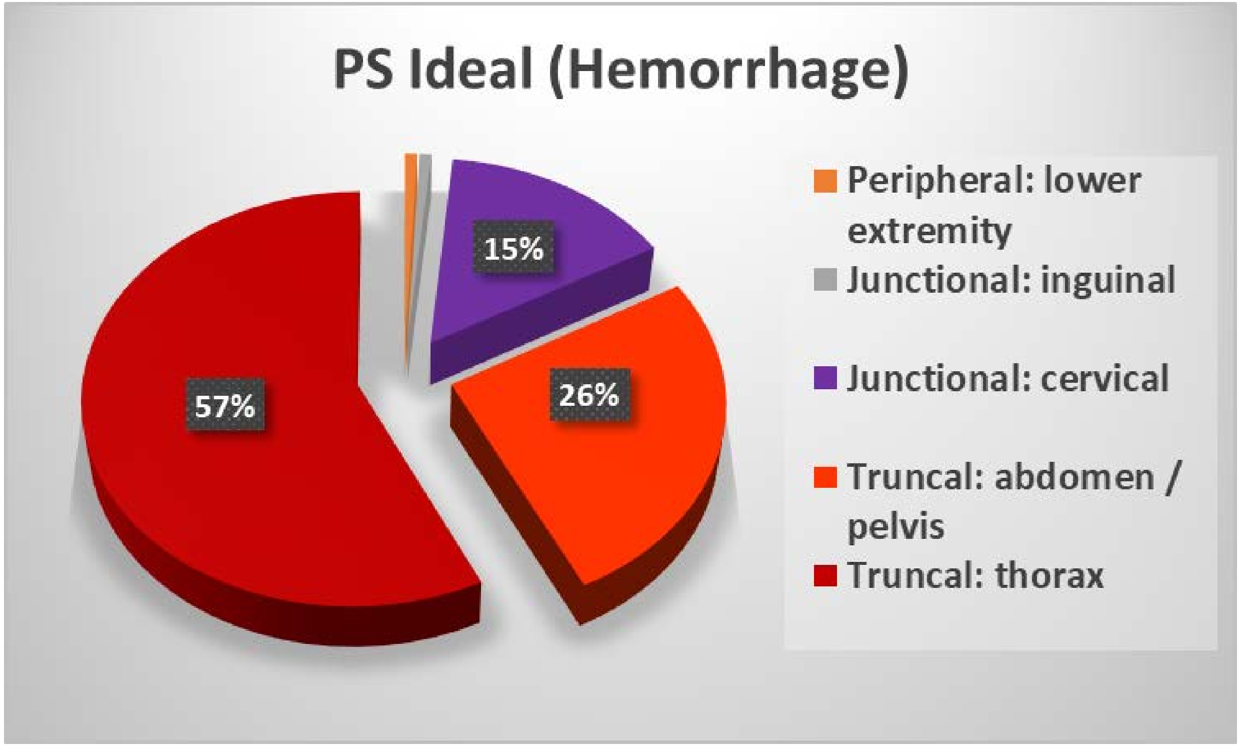
Nonsurvivable (Ideal)



Potentially Survivable (Ideal)



Potentially Survivable Ideal (Hemorrhage)



Preliminary Round 1 and Round 2 Data

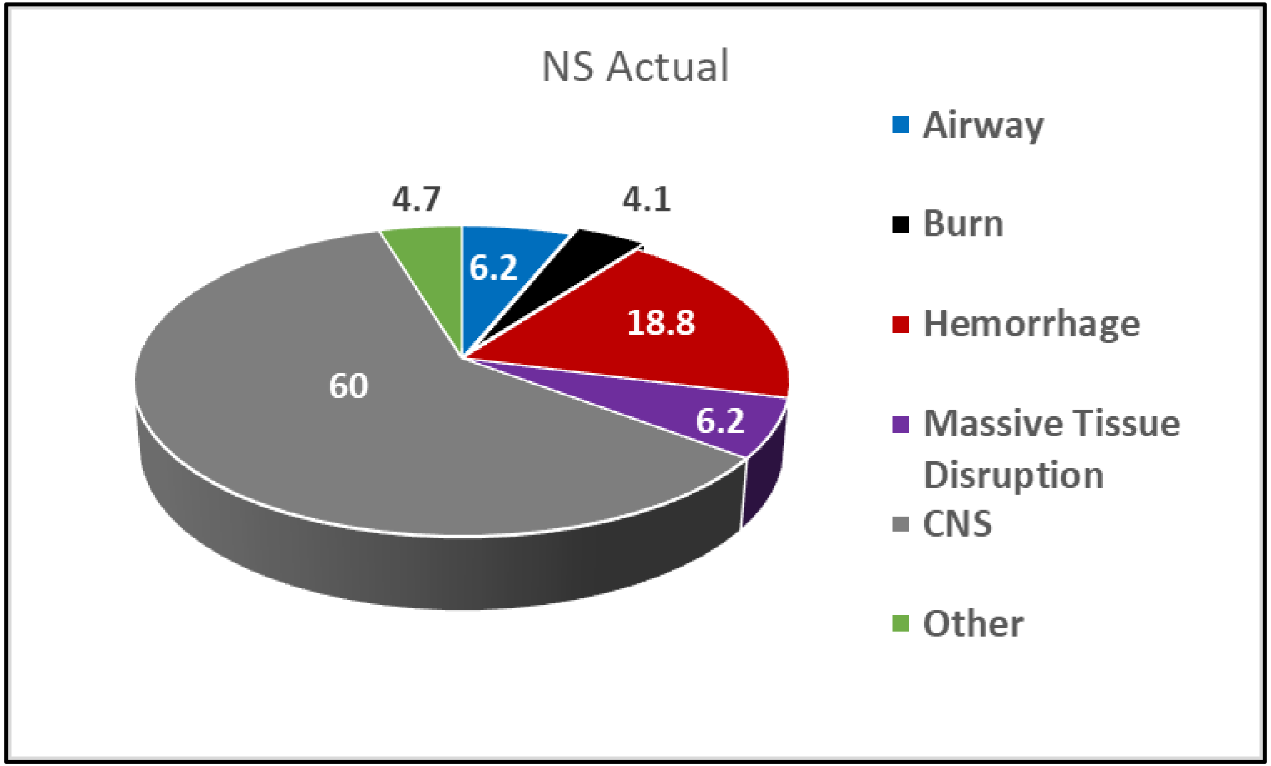
Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
	341 (93%)	325 (89%)
	26 (7%)	22 (6%)
	0	0
Cannot Judge	0	20 (5%)

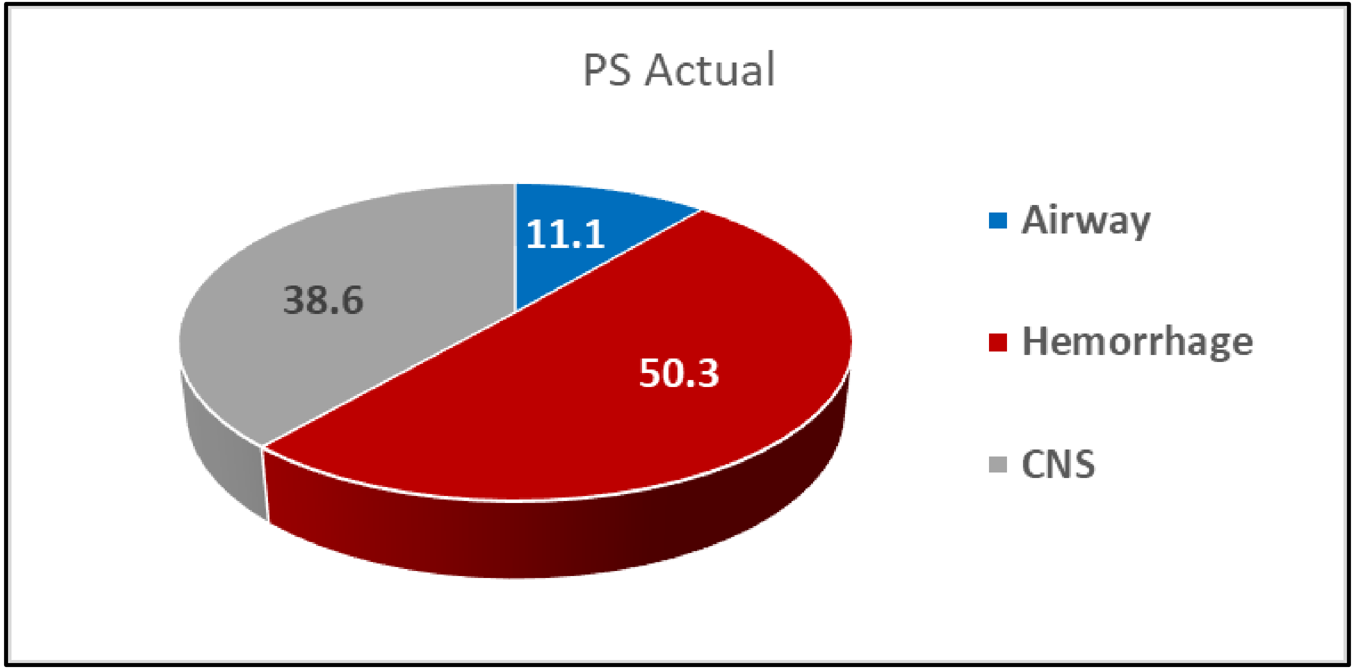
OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using 367 cases that have reached consensus on survivability assessments

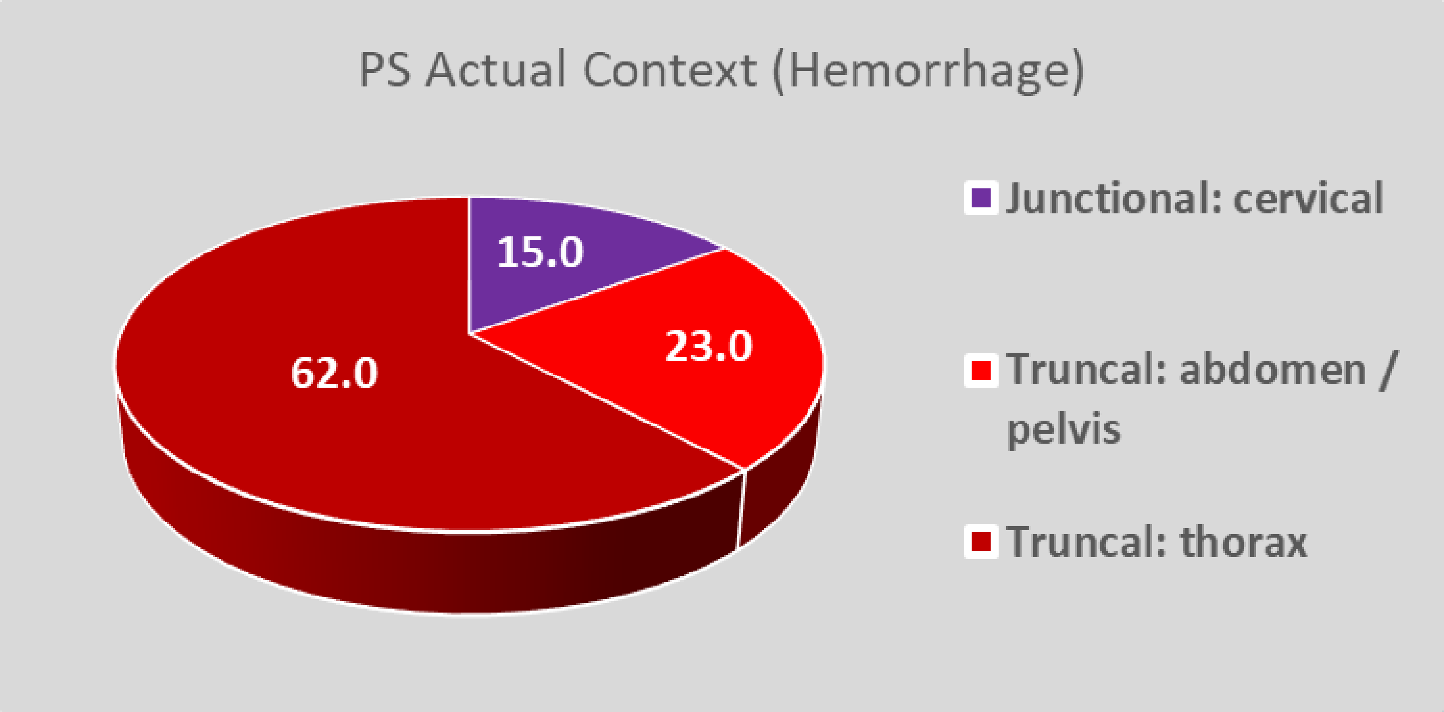
Nonsurvivable (Actual Context)



Potentially Survivable (Actual Context)



Potentially Survivable Actual Context (Hemorrhage)

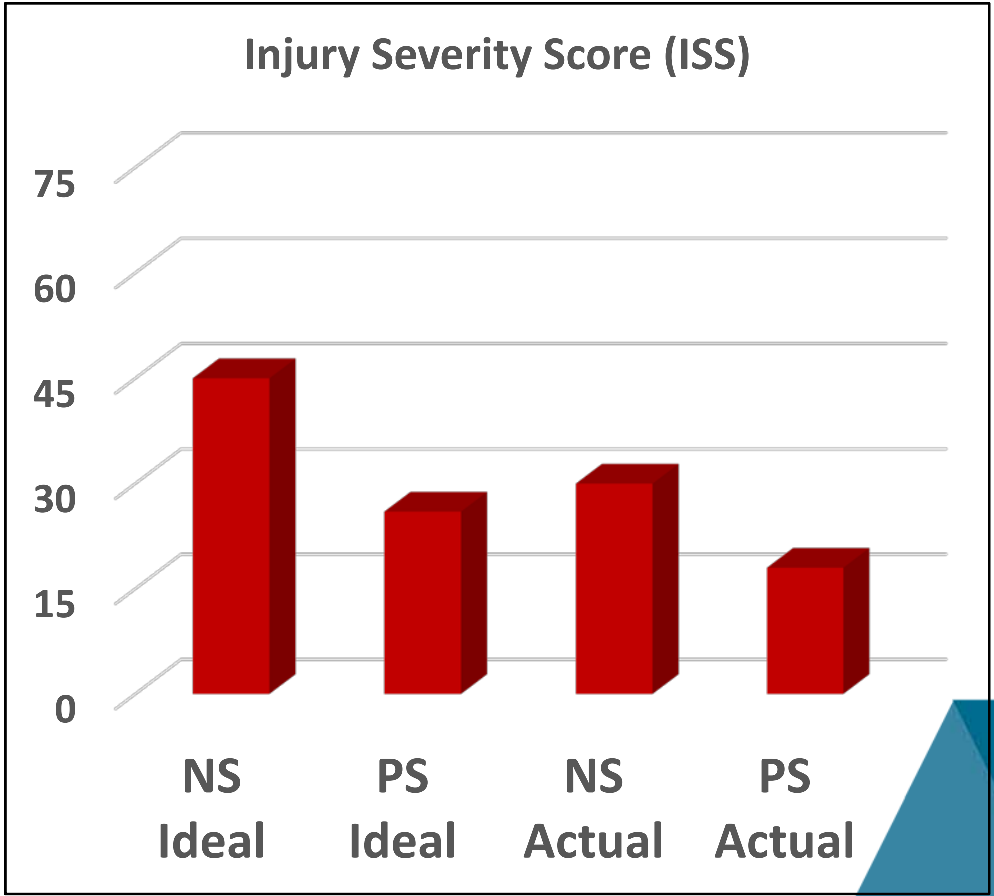


Immediate Access Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
Non-survivable	262 (77%)	269 (79%)
Potentially Survivable	75 (22%)	46 (14%)
Definitely Survivable	2 [illegible]	5 (1%)
Cannot Judge	[illegible]	19 (6%)

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	[illegible]r reviewers [illegible]g consensus	Frequency for medical examiners
Non-survivable	[illegible] (93%)	325 (89%)
Potentially Survivable	26 (7%)	22 (6%)
Definitely Survivable	0	0
Cannot Judge	0	20 (5%)

Potential Survivability vs ISS



Importance of Context

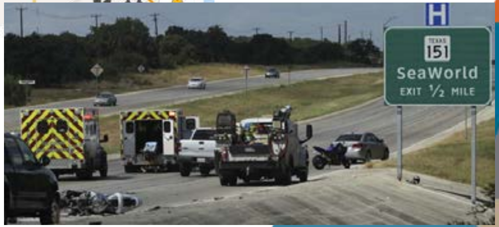
Does Where You Live Determine Whether You Live?

Del Rio to University Hospital = 152mi

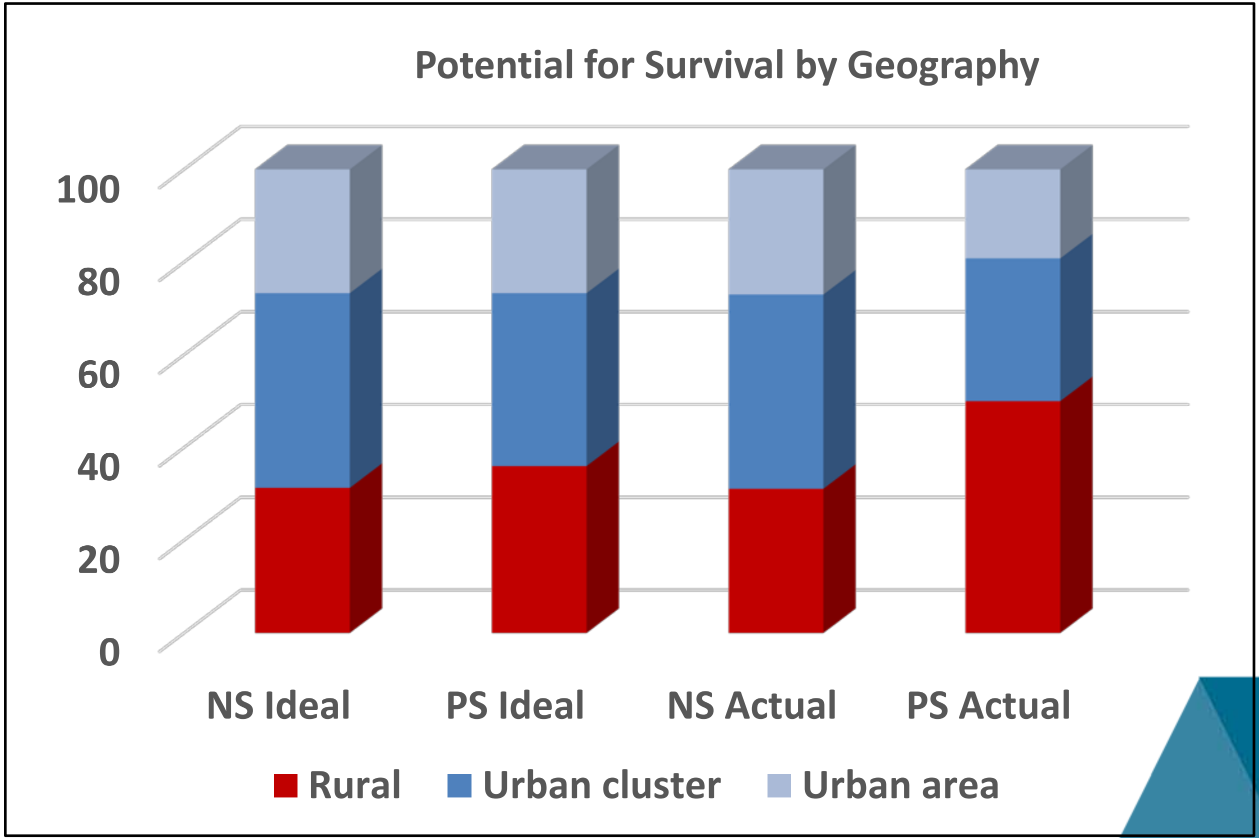
Ground Transport ≈ 2hr 33min | Air Transport ≈ 54min

Del Rio to SAMMC = 160mi

Ground Transport ≈ 2hr 40min | Air Transport ≈ 57min



Potential for Survival by Location



Pediatric

- 153 pediatric cases abstracted
- Gender, 61% male, 39% female.
- Injury Type (some cases associated with more than one injury type)
  - Penetrating 39% ,
  - Blunt 59%
  - Thermal 6%
  - Unknown 2%;.
- Manner of death
  - Unintentional 56%
  - Homicide 32%,
  - Suicide 12%.

Preliminary Round 1 and Round 2 Data

Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

***Note:** Using records from all reviewers in Round 1 and Round 2.*

Timeline

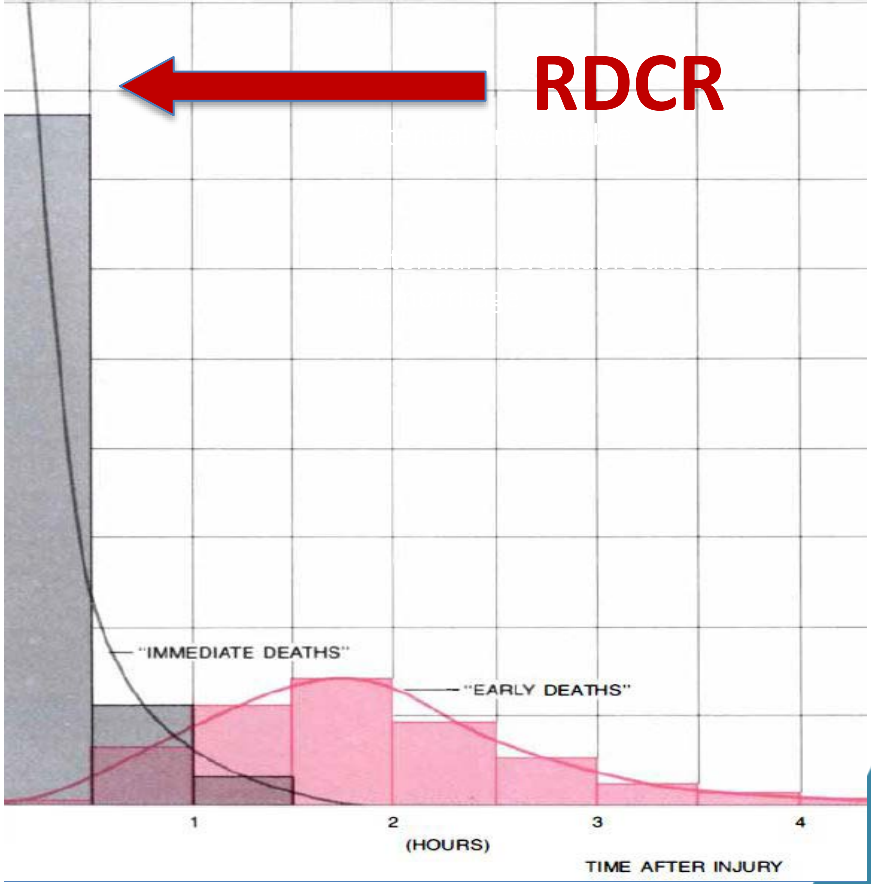
	First Panel Release	Last Panel Release	Reviews Completed
Round 4	9/27/2019	11/29/2019	12/27/2019
Round 5	12/6/2019	2/7/2020	3/6/2020
Round 6	2/14/2020	4/17/2020	5/15/2020
Round 7	4/24/2020	6/26/2020	7/24/2019
Round 8	7/3/2020	9/4/2020	10/2/2020
Round 9	9/11/2020	11/13/2020	12/11/2020
Round 10	11/20/2021	1/15/2021	2/12/2021

- ***Reviewers are given 3 weeks to complete case reviews.***
- ***Once adjudication is released, reviewers are given 1 week to complete.***

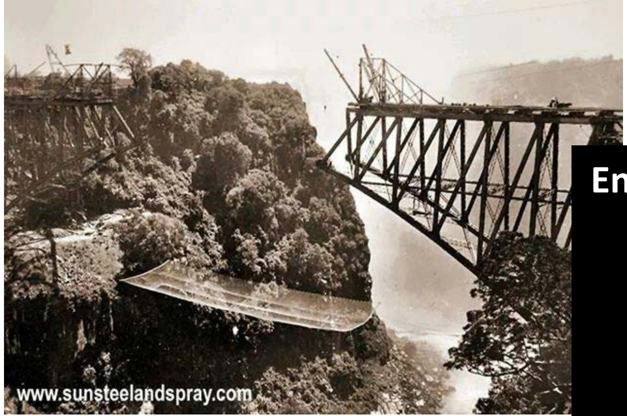
Epidemiology of prehospital injury mortality suggests

RDCR

shifting survival curve to the left will improve outcomes



Bridging the Chasm
Epidemiology to Inform Remote Damage Control R&D Agenda



Engagement
- Professional expertise
  - Transfusion
  - Trauma
- Academia
- US Military
- Healthcare Systems
- Industry
- Local Government

MIMIC Abstractor Recap

NAME Meeting

October 19, 2019

Introductions

- Lizette Villareal, MA: Program Manager
- Nick Medrano, MS: GIS/Data Analyst
- Michelle Price, PhD: Deputy Director/ Director of Research

Today's Goals

1. Review abstraction progress and preliminary results
2. Compare study site systems to identify opportunities for improvement
3. Ensure abstraction process is optimized for PEDS-MIMIC follow on study

DoD Broad Agency Announcement (BAA) Grant

- Department of Defense (BAA $3,979,380)
- PI: **Brian Eastridge, MD**

  Professor, Department of Surgery

  Division Chief, Trauma and Emergency General Surgery

  Jocelyn and Joe Straus Endowed Chair in Trauma Research

  University of Texas Health Science Center at San Antonio
- Co-I: **Kurt Nolte, MD**

  Professor of Pathology

  University of New Mexico

  Director of Radiology-Pathology Center for Forensic Imaging

  Chief Medical Investigator, Office of the Medical Investigator

  Ellen MacKenzie, PhD

  Dean, Johns Hopkins Bloomberg School of Public Health

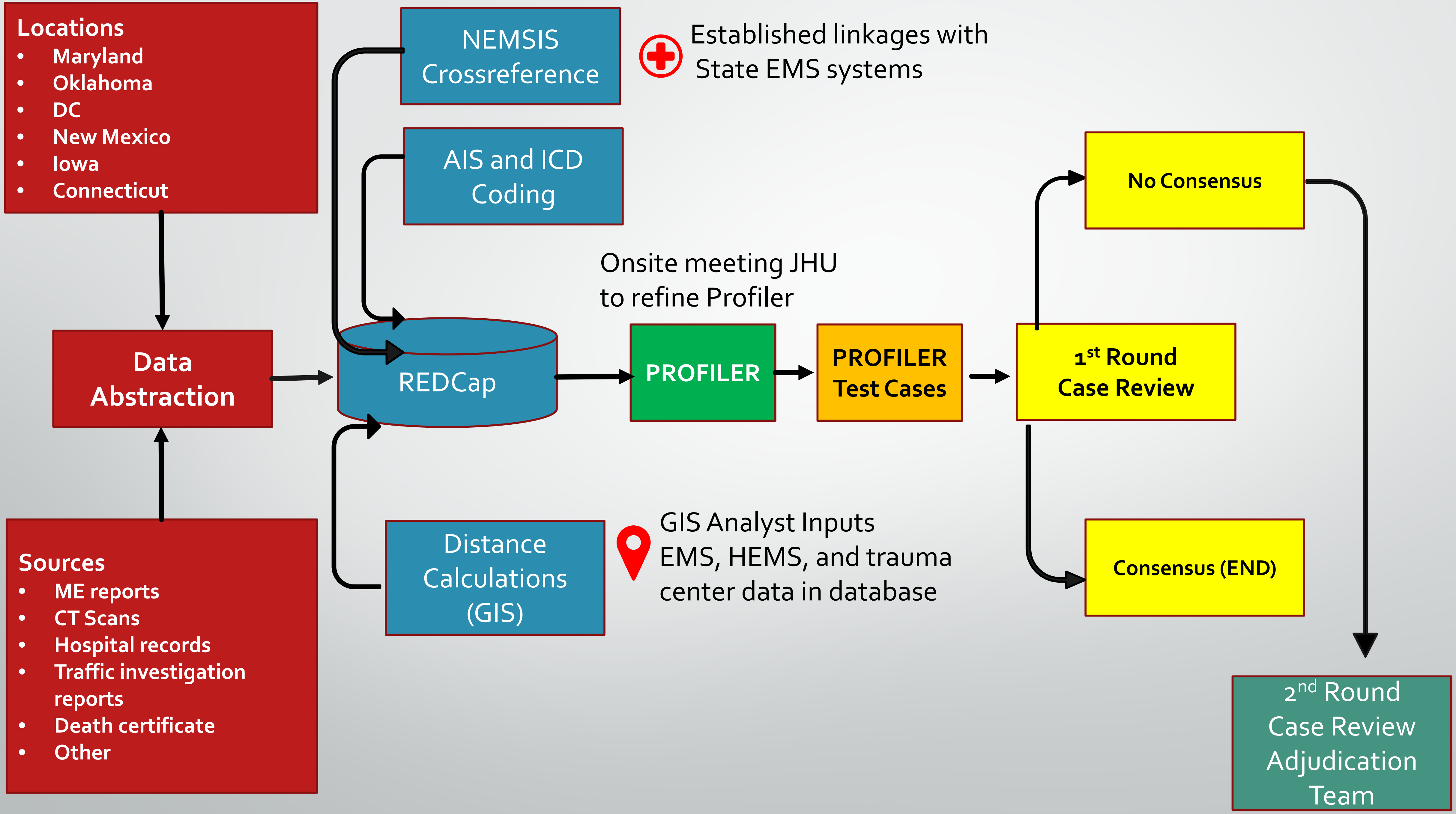
  Bloomberg Distinguished Professor

MIMIC Objectives

- Objective #1**:** Develop a framework and methodology for evaluating pre-hospital deaths
- Objective #2: Organize and standardize a multidisciplinary, multi-institutional network of experts to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.
- **Objective #3:** ***Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths, and estimate the potential for survivability***
- **Objective #4:** ***Describe the epidemiology of pre-hospital mortality in the context of trauma system development and estimate its impact on society.***
- Objective #5**:** Develop a blueprint for a sustained effort identifying high priority areas for injury prevention, trauma systems performance improvement and research and development.

Study Hypotheses

- Substantial opportunity to further reduce deaths in 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.


Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages with State EMS systems
AIS and ICD Coding
No Consensus
Onsite meeting JHU to refine Profiler
Data Abstraction
REDCap
PROFILER
PROFILER Test Cases
1st Round Case Review
Sources
ME reports
CT Scans
Hospital records
Traffic investigation reports
Death certificate
Other
Distance Calculations (GIS)
GIS Analyst Inputs EMS, HEMS, and trauma center data in database
Consensus (END)
2nd Round Case Review Adjudication Team

Abstraction Progress

Site	Number of Cases	Cases Completed	Percent Completed
Connecticut	422	315	75%
Iowa	41	41	100%
Maryland	845	655	78%
New Mexico	1194	1079	90%
Oklahoma	335	335	100%
Washington DC	142	142	100%
Total	**2979**	**2567**	**86%**

Project Progress

Data Abstraction

- 2,567 of 2,979* cases have been abstracted

Coding

- AIS/ICD – 890 cases completed
- GIS – 2,587 cases completed

Case Reviews

- Created 13 review team panels each consisting of 4 surgeons, 1 EM/EMS reviewer, and 1 Forensic Reviewer.
- 875 cases released to panels
- 585 cases completed.

*Cases may be added in order to reach 3,000

Questions Used to Determine Consensus

- **Consensus must be reached on both Survivability Questions:**
  - Assume the survival status of this patient is unknown, ***with immediate access to care at a level I trauma center***, assess the survival potential of this patient.
  - Assume the survival status of this patient is unknown, ***given the conditions of the actual scenario*** in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient.

Case Consensus Definition

- 5 reviewers are used to determine consensus. The ME/Forensic reviewer is not calculated in consensus as this analysis is kept separate.
- Each variable is independent. So it must be 3 or more reviewers answering the same on one specific category. (For example: 3 agree the case is Potentially Survivable)
  - If one reviewer selects non-survivable and the other 4 select either potentially, definitely survivable, or cannot judge, that case goes to adjudication
  - If two reviewers select cannot judge, but the other three are able to make a determination, the case goes to adjudication

Case Adjudication

Study Round	Number of Cases That Did Not Reach Initial Consensus	Cases Resolved During Team Adjudication	Cases Still In Team Adjudication	Could Not Reach Consensus, Pushed for Outside Adjudication
Round 1 Status	61 cases	44 cases	3 cases	14 cases
Round 2 Status	49 cases	21 cases	20 cases	8 cases
Round 3 Status	36 cases	9 cases	24 cases	3 cases

Preliminary Round 1 and Round 2 Data

- Q1: Based on your judgment, what was the principal mechanism(s) of death?

Principal Mechanism(s) of Death	Frequency
Neurological – Traumatic Brain Injury	1342
Hemorrhage – Truncal: Thorax	354
Neurological – Spinal Cord	256
Hemorrhage – Truncal: Abdomen / Pelvis	136
Burn	133
Airway	79
Massive tissue disruption: CNS	67
Asphyxia	65
Massive tissue disruption: Whole Body	59
Massive tissue disruption: Thorax	41
Tension Pneumothorax	32
Hemorrhage – Junctional: Cervical	29
Massive tissue disruption: abdomen	28
hemorrhage - peripheral: upper extremity	21

Note: Cases with multiple causes are counted multiple times. (Round 1 and 2)

Preliminary Round 1 and Round 2 Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

Immediate Access Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
[illegible]	262 (77%)	269 (79%)
[illegible]	75 (22%)	46 (14%)
[illegible]	2 (1%)	5 (1%)
[illegible]	0	19 (6%)

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

Note: Using 339 cases that have reached consensus on survivability assessments for Q2

Preliminary Round 1 and Round 2 Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
	341 (93%)	325 (89%)
	26 (7%)	22 (6%)
	0	0
Cannot Judge	0	20 (5%)

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using 367 cases that have reached consensus on survivability assessments

Immediate Access Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
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RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	[illegible] reviewers [illegible] consensus	Frequency for medical examiners
Non-survivable	3[illegible] (93%)	325 (89%)
Potentially Survivable	26 (7%)	22 (6%)
Definitely Survivable	0	0
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Preliminary Round 1 and Round 2 Data

- Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

Note: *Using records from all reviewers in Round 1 and Round 2.*

Questions

IF YOU HAVE ANY PROJECT RELATED QUESTIONS, PLEASE DO NOT HESITATE TO REACH OUT

LIZETTE VILLARREAL, MA

LIZETTE@NATTRAUMA.ORG

NICK MEDRANO, MS

NICK@NATTRAUMA.ORG

MIMIC

MIMIC Site Recap

A Data Abstractor's Perspective

NAME Meeting

October 19, 2019

Abstractor Training

- What should we include in a presentation?
- What could we have covered better prior to start of project?
- How could REDCap be improved?

Abstraction Quality Assurance

1. Ensure death occurred in pre-hospital environment/meets inclusion criteria
   - Cases where decedent arrived at ED with vital signs
   - Hospice case where injury occurred days prior to death
   - Decomposed Remains
2. Ensure injury location is as precise as possible given source document information
   - Writing in a description when no exact location is available
   - If no specific location is given in the primary location of source documents, read narrative
   - Putting street number in correct data field

Cases Removed from Study

- Decedent Arrived at ED with Vitals
  - "…arrived to the hospital in an agitated state."
  - "…was initially alert, but confused and agitated, at the scene of the crash and at the hospital…"
  - "…became hemodynamically unstable upon return from imaging and emergency thoracotomy was performed, but…died from injuries."
  - "She was responsive and alert en-route to the hospital but lost consciousness going into surgery…"

Ensure Precise Location Information

Abstracted Location	Source Documents
"Route 15 Southbound"	"…dispatched to the area of Route 15 SB and the Motter Ave overpass…"
"Whitehaven Ferry Road"	…southbound on Whitehaven Ferry Road near Nebo, Road…"
"I-95 Northbound"	"…vehicle was rear ended and pushed into another vehicle traveling northbound on I-95 just past exit 70."

Street Number in Correct Field

Date and Location of Injury

Is any information on 'Location of Injury' available?	(•) Yes ( ) No reset
1. Is exact date of injury known? * must provide value	(•) Yes ( ) No reset
Date of Injury * must provide value	05-15-2015 Today M-D-Y Use date control OR enter date in MM-DD-YYYY format (hyphens only, no slashes)
2. Time of injury known? * must provide value	(•) Yes ( ) No reset
Time of injury (military time) * must provide value	05:15 Now H:M Type in time (HH:MM) or use time control above
3. Location of Injury	
Street Number	1950
Street Name	M St, SE
City	Washington
State	Washington D.C.
Zipcode	20003

Working on Securing EMS Data

-Oklahoma NEMSIS data was received on **17-Jun-2019**

-Maryland NEMSIS is currently working on data matching

-Washington, DC is currently working on data matching

-Connecticut data agreement is under review

-New Mexico data agreement is under review

-Iowa review was denied, and asked to resubmit in the Spring of 2020

CT capabilities

- How many sites have CT capabilities?
- Which sites are unable to due to funding?

Publication

- Serve as a Co-author

Future Funding Opportunities

- PEDS-MIMIC
  - Replication of MIMIC study with solely pediatric patients
  - Application submitted this week
  - Study would begin July 2020
- NHTSA
- DOJ

Any additional comments or ideas!

Thank you for all you hard work!

Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): Concept of Utilizing Medical Examiner Data to Determine Prehospital Injury Survivability

NAME Annual Meeting

October 2019

Brian Eastridge, MD

Disclosures

- Nothing to Disclose

Overview

- MIMIC Project Overview
- Survivability Definitions
- Profiler
- Preliminary Data

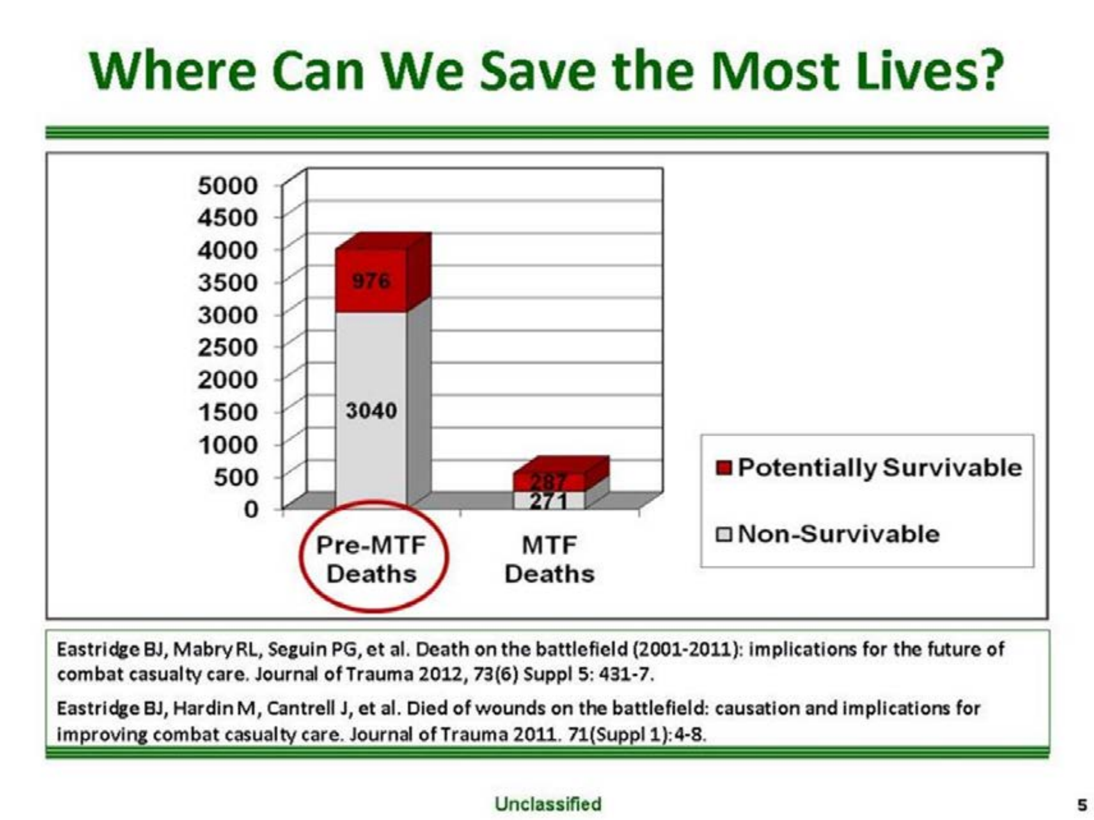
MIMIC Project Overview

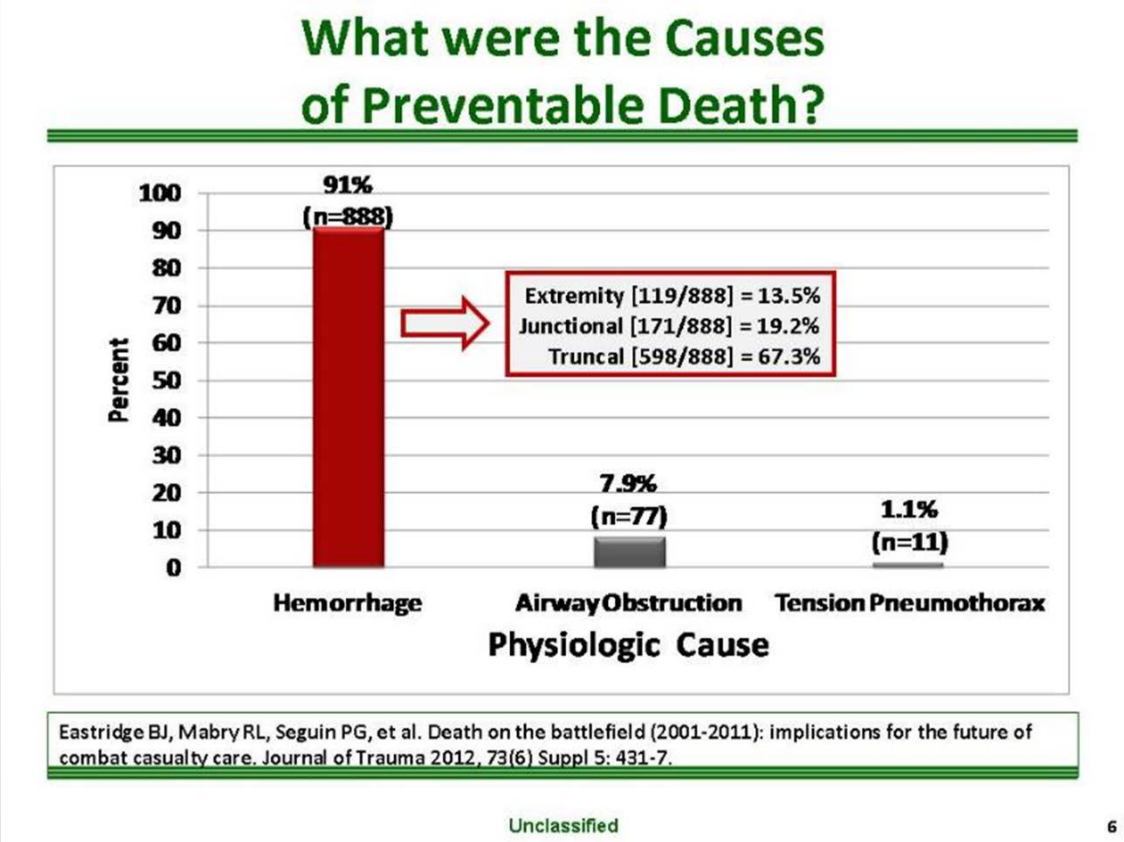
DoD Broad Agency Announcement (BAA) Grant

- Department of Defense (BAA $3,979,380)
- PI: Brian Eastridge, MD
  - Professor, Department of Surgery
  - Division Chief, Trauma and Emergency General Surgery
  - Jocelyn and Joe Straus Endowed Chair in Trauma Research
  - University of Texas Health Science Center at San Antonio
- Co-PIs: Kurt Nolte, MD
  - Professor of Pathology
  - University of New Mexico
  - Director of Radiology-Pathology Center for Forensic Imaging
  - Chief Medical Investigator, Office of the Medical Investigator

  Ellen MacKenzie, PhD
  - Dean, Johns Hopkins Bloomberg School of Public Health
  - Bloomberg Distinguished Professor

Background/Scientific Rationale Pre-Hospital Mortality Combat

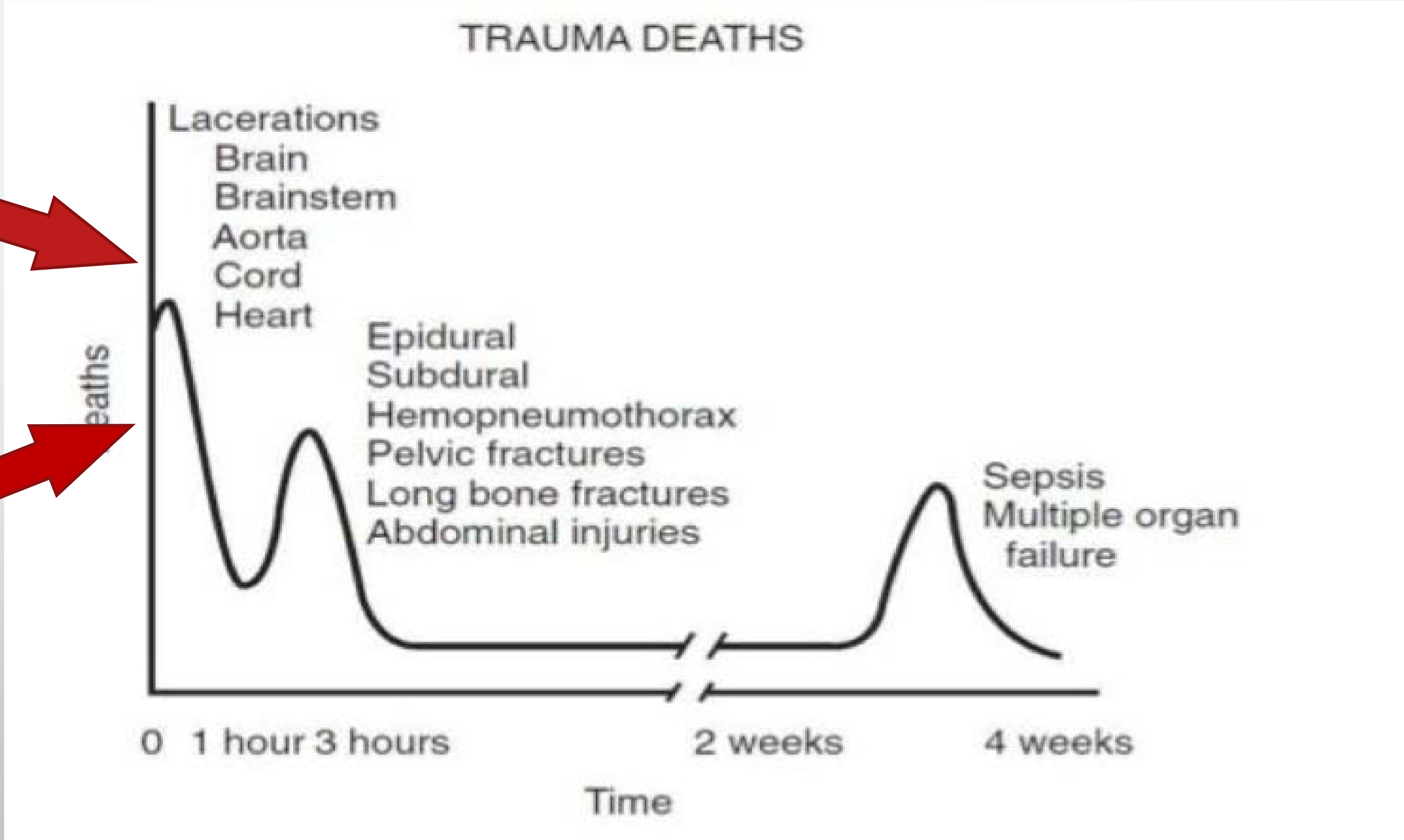




Background/Scientific Rationale
Pre-Hospital Mortality Civilian

Poorly defined

NASEM Report Emphasis



Why is the MIMIC study unique?

- It replicates what other small studies have done.
- Provides a multi-disciplinary review team with granular injury details to determine survivability.
- Allows reviewers to determine survivability.
- Utilizes death data from autopsy reports to determine survivability.
- The MIMIC study is the only study that has examined pre-hospital trauma deaths to determine ways to improve outcomes.

Medrano NW, Villarreal CL, Price MA, et al. Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-hospital Environment (MIMIC). Trauma Surgery and Acute Care Open. 2019.

Study Hypotheses

- Substantial opportunity to further reduce deaths in 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.

MIMIC Objectives

- **Objective #1:** ***Develop a framework and methodology*** for evaluating pre-hospital deaths
- **Objective #2:** Organize and standardize a ***multidisciplinary, multi-institutional network of experts*** to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.
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- **Objective #4:** ***Describe the epidemiology of pre-hospital mortality*** in the context of trauma system development and estimate its impact on society.
- **Objective #5:** ***Develop a blueprint for a sustained effort*** identifying high priority areas for injury prevention, trauma systems performance improvement and research and development.

System Benefits

Trauma

- Performance improvement
  - Engineering
  - Medical devices / procedures
  - EMS value validation
  - Injury Prevention
  - Collaboration between trauma and ME communities

Medical Examiner

- Funding for advanced radiological imaging
- Improve mechanistic information
- Interaction between trauma and ME communities
- Bridge the gap between ME and TS data sets

Study Population

- **Inclusion Criteria:**
  1. Pre-hospital deaths (at scene, en route to hospital or DOA defined as no vitals upon arrival at hospital)
  2. Blunt, Penetrating, Thermal, and Suicides are included

- **Exclusion Criteria:**
  1. Non-mechanical causes of death – poisoning, drug overdoses, hangings, drowning (unless associated with trauma)
  2. Decomposed remains only (not fully fleshed with distinguishable organs)

Forensic Record

Medical Examiner cases may involve any of the following:

- External examination
- Internal examination
- Investigator reports
- Toxicology Report
- Radiographs- CT Reports will be uploaded. Actual images will be uploaded if available and when a case requires adjudication.

Study Setting
Six Regions in the Country

(Centralized ME systems and utilizing electronic case management system to collect uniform data on all deaths)

1. **State of Connecticut**. Serves a population of 3.6 million. They perform approximately 2,200 autopsy examinations at a single, centralized facility annually.
2. **Johnson County, Iowa.** Serves a population of 142,000. In 2014 JCME accepted jurisdiction of 380 deaths and performed 118 autopsies.
3. **State of Maryland.** Serves a population of approximately 6.0 million residents . They perform 4,220 autopsies at the single, centralized facility annually.
4. **State of New Mexico.** Serves a population of 2.0 million. They perform approximately 2,100 full autopsy examinations annually
5. **State of Oklahoma.** Serves a population of 3.8 million and conducts investigation of roughly 4,000 deaths annually.
6. **The District of Columbia.** Serves a population of 659,000. They perform approximately 1,110 examinations annually.

Estimates of Number of Injury Deaths

(Blunt, Firearm and Other Sharp Forces)

OCME	**2012**	**2013**	**2014**	**Total**
Connecticut	684	621	692	1997
Johnson Co, Iowa	133	128	110	371
Maryland	1509	1200*	1200*	3909
Oklahoma	1044	1153	1007	3204
New Mexico	823	778	906	2507
Washington, DC	232	267	254	753
Total	**4,425**	**4,147**	**4,169**	**12,741**

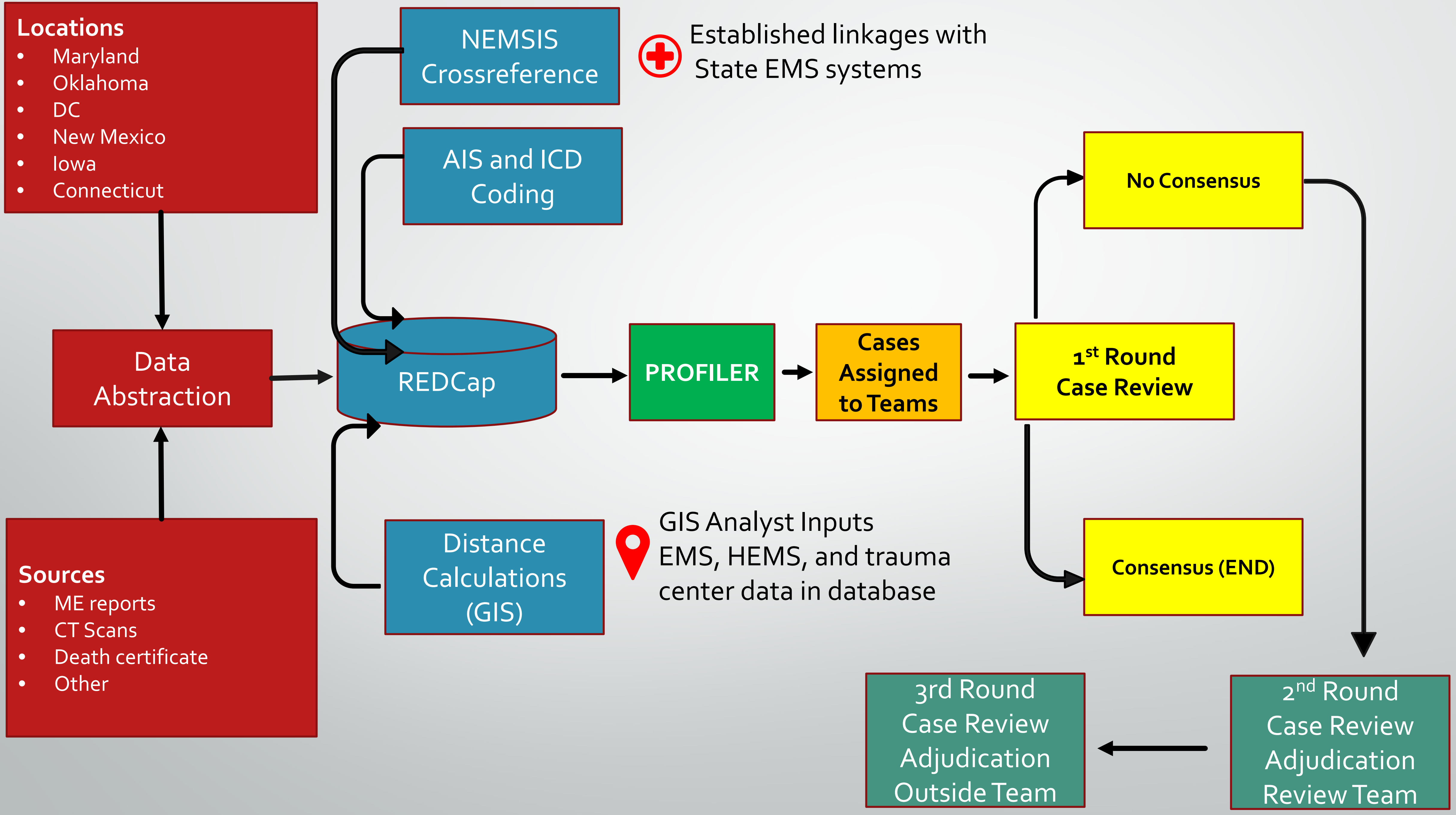
* Estimates

MIMIC Final Subject Selection

ME Site	Number of Cases
Connecticut	427
Johnson Co, Iowa	47
Maryland	848
Oklahoma	341
New Mexico	1,243
Washington, DC	152
Total	**3,058**

Case Review Methods

- Steering Committee (Military and Civilian) defined definitions and process
- Expert review panels (~ 80 Military and Civilian reviewers) (6 individuals are on each panel)
  - 4 Surgeons
  - 1 Emergency Medicine/EMS
  - 1 Forensic Reviewer
- Panels will each review a certain number of cases using the **PROFILER** and assign a determination of survivability to each case
- Reviewers will review cases independently. Throughout the course of the study approximately **250 cases** will be reviewed by each team panel.
- Discrepancies in determination of survivability will be identified and non-consensus will be reviewed by an adjudication team


Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
Data Abstraction
Sources
ME reports
CT Scans
Death certificate
Other
NEMSIS Crossreference
Established linkages with State EMS systems
AIS and ICD Coding
REDCap
Distance Calculations (GIS)
GIS Analyst Inputs EMS, HEMS, and trauma center data in database
PROFILER
Cases Assigned to Teams
1st Round Case Review
No Consensus
Consensus (END)
2nd Round Case Review Adjudication Review Team
3rd Round Case Review Adjudication Outside Team

Survivability Definitions

Survivability Definitions

- **Non-Survivable-** Death as a result of catastrophic anatomic injuries
- **Potentially Survivable -** Anatomic injuries that were severe but medically survivable
- **Definitely Survivable-** Minimal anatomic injuries with a high likelihood of survival
- **Cannot Judge-** information insufficient to make a determination

Anatomic Survivability

Medically Non-Survivable (MNS)

- Dismemberment / decapitation
- Traumatic Brain evisceration
- Cervical cord transection (above C3)
- Airway transection within thorax
- Cardiac injury > 2cm
- Uncontained hemorrhage, thoracic aorta
- Uncontained hemorrhage, pulmonary artery
- Hepatic avulsion
- Junctional lower extremity amputations with open pelvis
- Injuries to the deep CNS nuclei, brainstem, or massive brain tissue injury
- Massive Pulmonary Tissue Disruption

Medically Potentially Survivable / Definitely Survivable

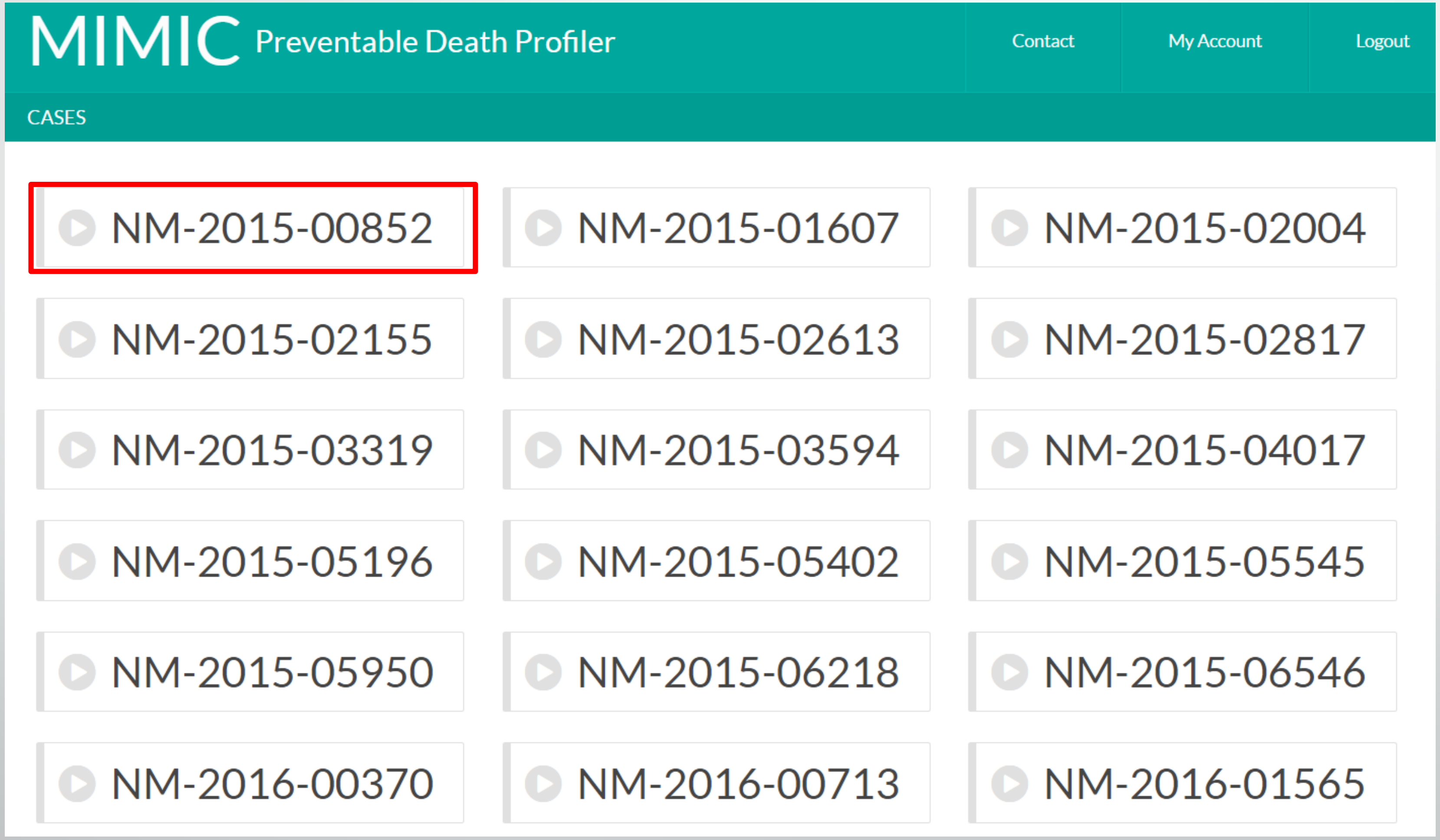
- All other

Profiler

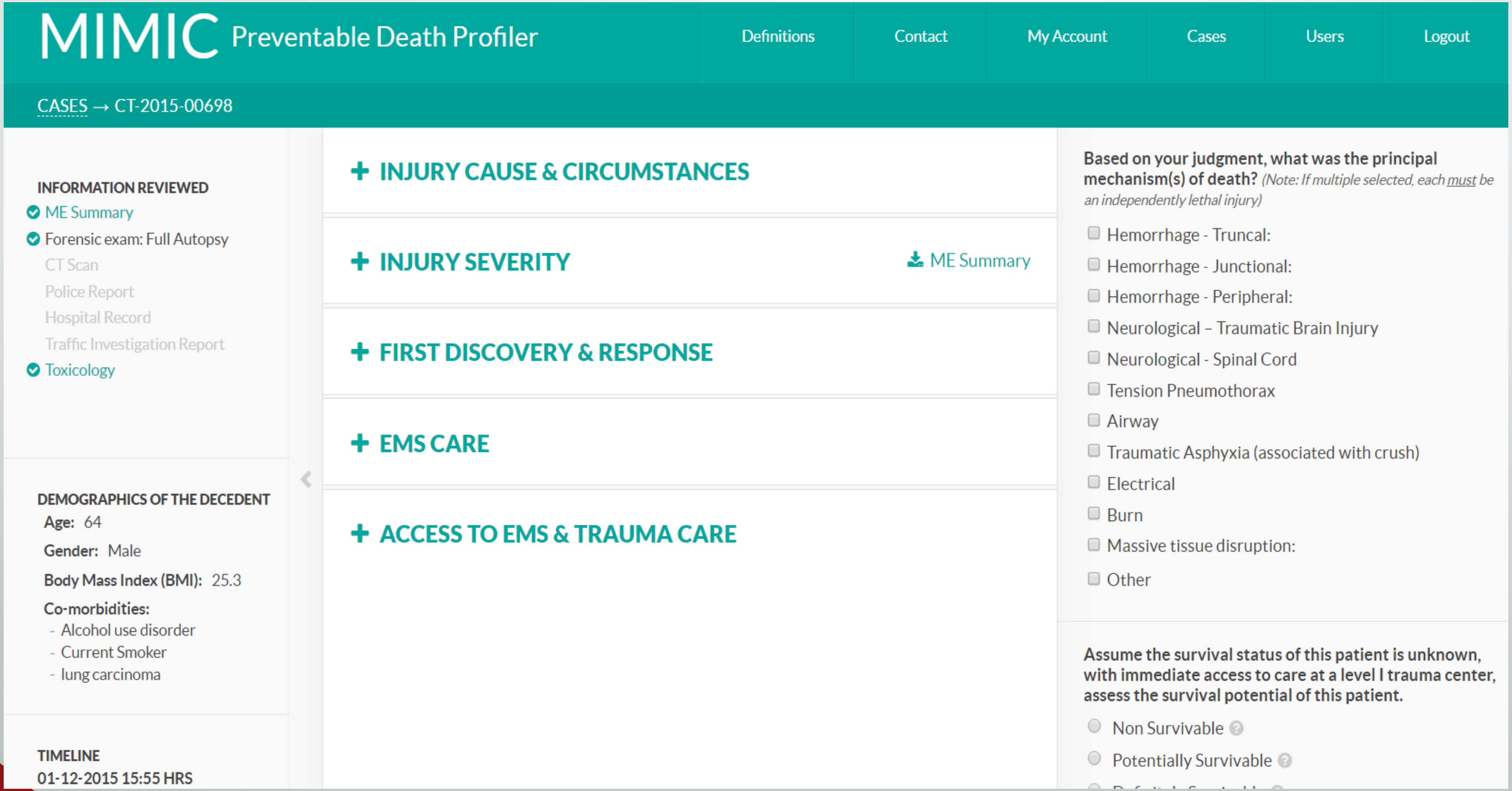
Profiler

1) **Open medical examiner case in Profiler**
2) **Review case**
   - Medical examiner data (left side of page)
   - Injury cause / circumstance
   - Injury severity
   - First Discovery & Response
   - EMS Care
   - Access to EMS and Trauma Center
3) **Causation and survival determination**
   - Primary cause of death (may choose multiple but must be associated with severe injury)
   - Assuming immediate access to trauma care
   - Actual conditions
   - Opportunities for improvement (free text)

Open Medical Examiner Case in Profiler

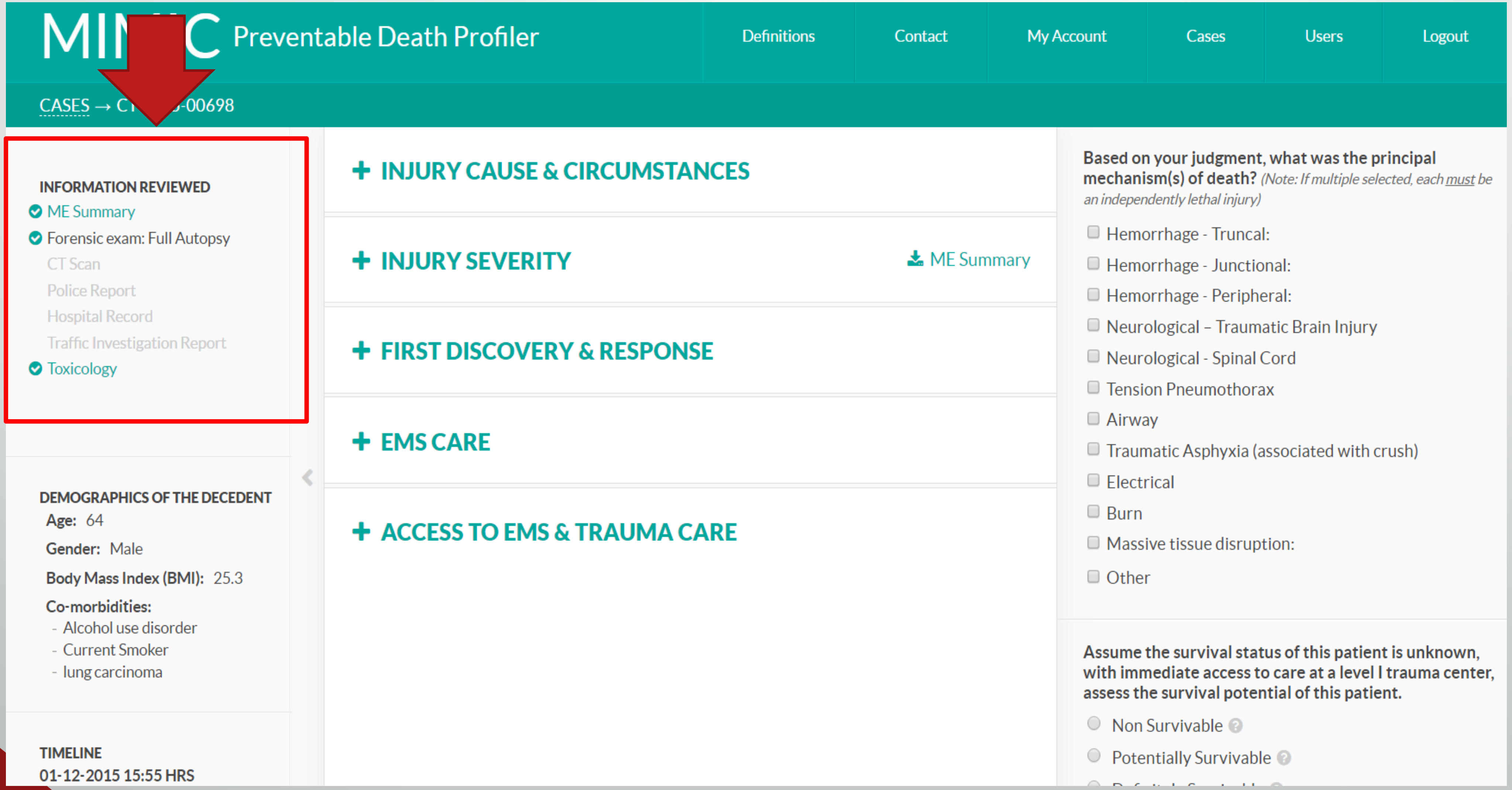


Open Medical Examiner Case in Profiler

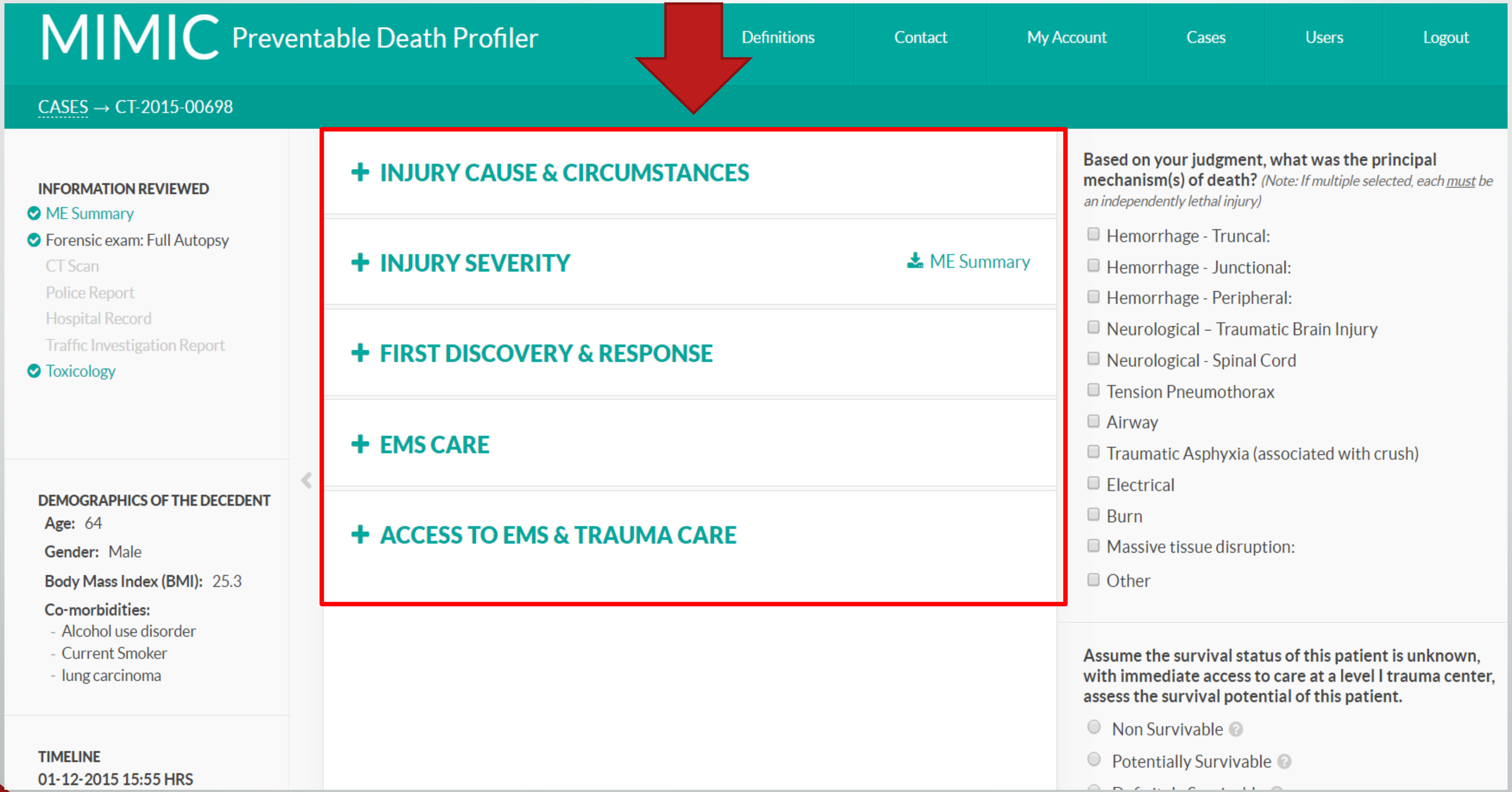


Review Case

Medical Examiner Data



Review Case



MIMIC Preventable Death Profiler
Definitions
Contact
My Account
Cases
Users
Logout
CASES → CT-2015-00698
INFORMATION REVIEWED
ME Summary
Forensic exam: Full Autopsy
CT Scan
Police Report
Hospital Record
Traffic Investigation Report
Toxicology
DEMOGRAPHICS OF THE DECEDENT
Age: 64
Gender: Male
Body Mass Index (BMI): 25.3
Co-morbidities:
- Alcohol use disorder
- Current Smoker
- lung carcinoma
TIMELINE
01-12-2015 15:55 HRS
+ INJURY CAUSE & CIRCUMSTANCES
+ INJURY SEVERITY
ME Summary
+ FIRST DISCOVERY & RESPONSE
+ EMS CARE
+ ACCESS TO EMS & TRAUMA CARE
Based on your judgment, what was the principal mechanism(s) of death? (Note: If multiple selected, each must be an independently lethal injury)
Hemorrhage - Truncal:
Hemorrhage - Junctional:
Hemorrhage - Peripheral:
Neurological – Traumatic Brain Injury
Neurological - Spinal Cord
Tension Pneumothorax
Airway
Traumatic Asphyxia (associated with crush)
Electrical
Burn
Massive tissue disruption:
Other
Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.
Non Survivable
Potentially Survivable

Review Case

MIMIC Preventable Death Profiler

Definitions | Contact | My Account | Cases | Users | Logout

CASES → CT-2015-00698

INFORMATION REVIEWED
- ME Summary
- Forensic exam: Full Autopsy
- CT Scan
- Police Report
- Hospital Record
- Traffic Investigation Report
- Toxicology

DEMOGRAPHICS OF THE DECEDENT

Age: 64

Gender: Male

Body Mass Index (BMI): 25.3

Co-morbidities:
- Alcohol use disorder
- Current Smoker
- lung carcinoma

TIMELINE

01-12-2015 15:55 HRS

Event Occurred

– INJURY CAUSE & CIRCUMSTANCES

Injury Type:
- Thermal (including electrocution)

Agent of Wounding:
- Other: House Fire

Use of Protective Equipment:
- No protective equipment utilized

Manner of Death: Accident

Blood Alcohol Level: A blood alcohol test was not performed

Toxicology Screen: No drugs detected

Weather conditions: Unknown

Place of Event: Home

Place of Event Description:

Deceased's residence seated on couch

...

Further information relevant to the cause or circumstances of the event:

[redacted]

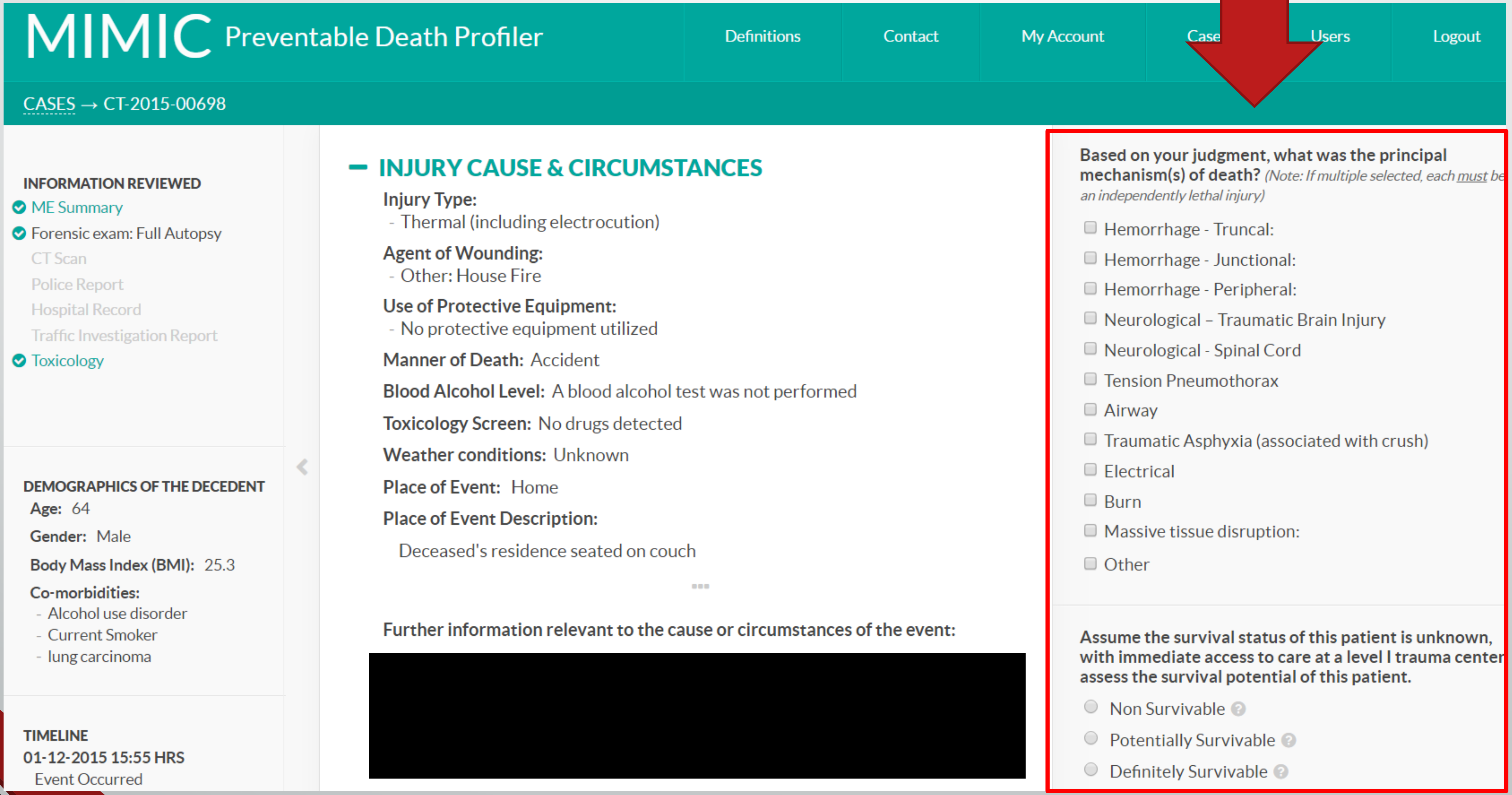
Based on your judgment, what was the principal mechanism(s) of death? *(Note: If multiple selected, each must be an independently lethal injury)*

- ☐ Hemorrhage - Truncal:
- ☐ Hemorrhage - Junctional:
- ☐ Hemorrhage - Peripheral:
- ☐ Neurological – Traumatic Brain Injury
- ☐ Neurological - Spinal Cord
- ☐ Tension Pneumothorax
- ☐ Airway
- ☐ Traumatic Asphyxia (associated with crush)
- ☐ Electrical
- ☐ Burn
- ☐ Massive tissue disruption:
- ☐ Other

Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

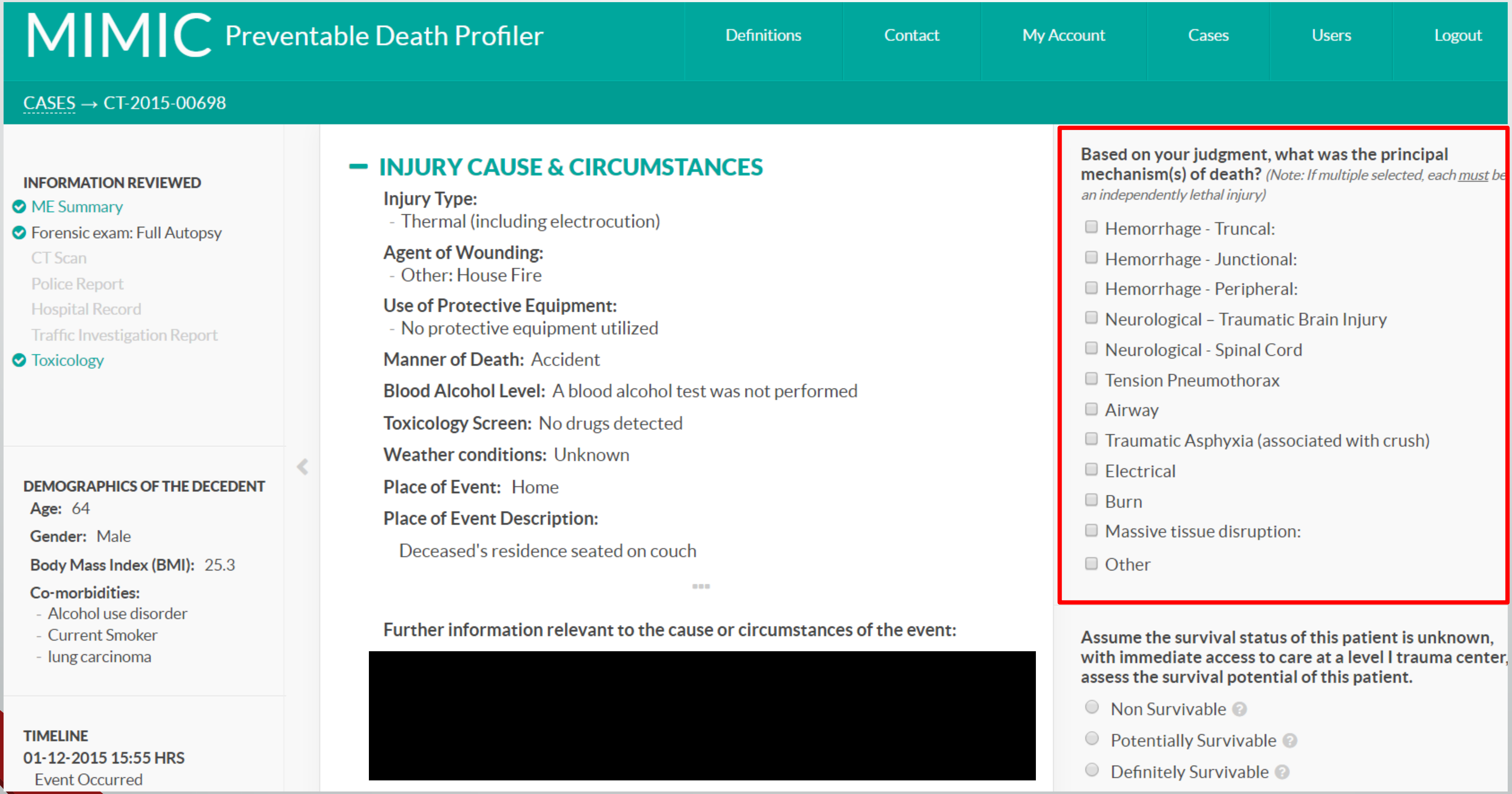
- ○ Non Survivable
- ○ Potentially Survivable
- ○ Definitely Survivable

Causation and Survival Determination



Causation and Survival Determination

Principal mechanism of death



Causation and Survival Determination

Assuming immediate access to care…rate the likelihood of survival

DEMOGRAPHICS OF THE DECEDENT

Age: 64

Gender: Male

Body Mass Index (BMI): 25.3

Co-morbidities:

- Alcohol use disorder
- Current Smoker
- lung carcinoma

TIMELINE

01-12-2015 15:55 HRS
Event Occurred

01-12-2015 16:05 HRS
Death Pronounced

Toxicology Screen: No drugs detected

Weather conditions: Unknown

Place of Event: Home

Place of Event Description:

Deceased's residence seated on couch

Further information relevant to the cause or circumstances of the event:

[redacted]

+ INJURY SEVERITY ME Summary

+ FIRST DISCOVERY & RESPONSE

- ☐ Traumatic Asphyxia (associated with crush)
- ☐ Electrical
- ☐ Burn
- ☐ Massive tissue disruption:
- ☐ Other

Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

- ○ Non Survivable
- ◉ Potentially Survivable
- ○ Definitely Survivable
- ○ Cannot Judge

Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, rate the likelihood of survival of this patient on the scale below from 0 to 100%

0% — 100%

0 20 40 60 80 100

Causation and Survival Determination

If Non Survivable…what led to your assessment?

- Current Smoker
- lung carcinoma

TIMELINE

01-12-2015 15:55 HRS
Event Occurred

01-12-2015 16:05 HRS
Death Pronounced

Further information relevant to the cause or circumstances of the event:

[redacted]

INJURY SEVERITY

ME Summary

BODY REGION	AIS INJURY DESCRIPTION	AIS	MISS
THORAX	Smoke inhalation with large amounts of soot in upper and lower airways	5	5
EXTERNAL AND OTHER	1st - 3rd degree burns over 70 % BSA	5	5

OVERALL INJURY SEVERITY:

ISS:	50
NISS:	50
MISS:	50

FIRST DISCOVERY & RESPONSE

Event Witnessed? No

Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

- (●) Non Survivable
- ( ) Potentially Survivable
- ( ) Definitely Survivable
- ( ) Cannot Judge

IF NOT survivable assuming immediate access to definitive trauma care, what was the nature of the injury that led to your assessment?

IMMEDIATE / ACUTE

- [ ] Dismemberment
- [ ] Decapitation
- [ ] Traumatic brain evisceration
- [ ] Injuries to deep CNS nuclei, brainstem, or massive brain tissue injury
- [ ] Avulsive injury thorax (loss of portion chest wall in combination with avulsive destructive injury to thoracic organs
- [ ] Airway transection within thorax
- [ ] Massive pulmonary parenchymal destruction
- [ ] Cardiac Perforation (> 2 cm)
- [ ] Cardiac rupture / destruction
- [ ] Uncontained hemorrhage, thoracic aorta
- [ ] Uncontained hemorrhage, pulmonary artery
- [ ] Cardiac Injury (> 2 cm)

Causation and Survival Determination

Given the condition of the actual scenario…rate the likelihood of survival

− FIRST DISCOVERY & RESPONSE

Event Witnessed? No

RESPONSE	ARRIVAL	INTERVENTIONS	EXTRICATION
POLICE	Unknown	Unknown	No
FIRE	Unknown	Unknown	No

Transport from Scene:
- Mode of Transport: Trade Service
- Destination from Scene: OCME (Office of the Chief Medical Examiner)

− EMS CARE

EMS was not involved in this case.

+ ACCESS TO EMS & TRAUMA CARE

0 20 40 60 80 100

Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

- ( ) Non Survivable
- (•) Potentially Survivable
- ( ) Definitely Survivable
- ( ) Cannot Judge

Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), rate the likelihood of survival of this patient on the scale below from 0 to 100%

0% 100%

0 20 40 60 80 100

Causation and Survival Determination

What contributed to the death?

- Destination from Scene: OCME (Office of the Chief Medical Examiner)

EMS CARE

EMS was not involved in this case.

ACCESS TO EMS & TRAUMA CARE

Despite what actually occurred in this case, this table shows the estimated time and distance from the closest EMS facility to the location of the patient.

EMS GROUND DISTANCE (miles)	EMS GROUND TIME (minutes)	EMS AIR DISTANCE (miles)	EMS AIR TIME (minutes)
4	12	9	7

Despite what actually occurred in this case, this table shows estimated time and distance to the closest trauma center from the time EMS dispatch receives the call to the patient's arrival at the trauma center. These distances and times were calculated based on the location of this patient.

CLOSEST TRAUMA CENTER	EMS GROUND DISTANCE (miles)	EMS GROUND TIME (minutes)	EMS AIR DISTANCE (miles)	EMS AIR TIME (minutes)
LEVEL I	22	56	22	34
LEVEL II	19	51	19	33
LEVEL III	62	86	52	47
LEVEL IV OR NON-DESIGNATED	0	0	0	0

<u>Given the conditions of the actual scenario in which the injury occurred</u>, what contributed to the death (and how much did each contribute: very little, some, a lot)?

TRAUMA SYSTEM

- ☐ Lack of field intervention by law enforcement
- ☐ Lack of field intervention by bystander
- ☐ Access to regional trauma center > 30 minute transport
- ☐ Timeliness of discovery
- ☐ Delay secondary to tactical response
- ☐ Lack of specialized responders (high angle, swift water, etc)
- ☐ Lack of resources
- ☐ Failure of preparedness
- ☐ Other

AGENT / ENVIRONMENT

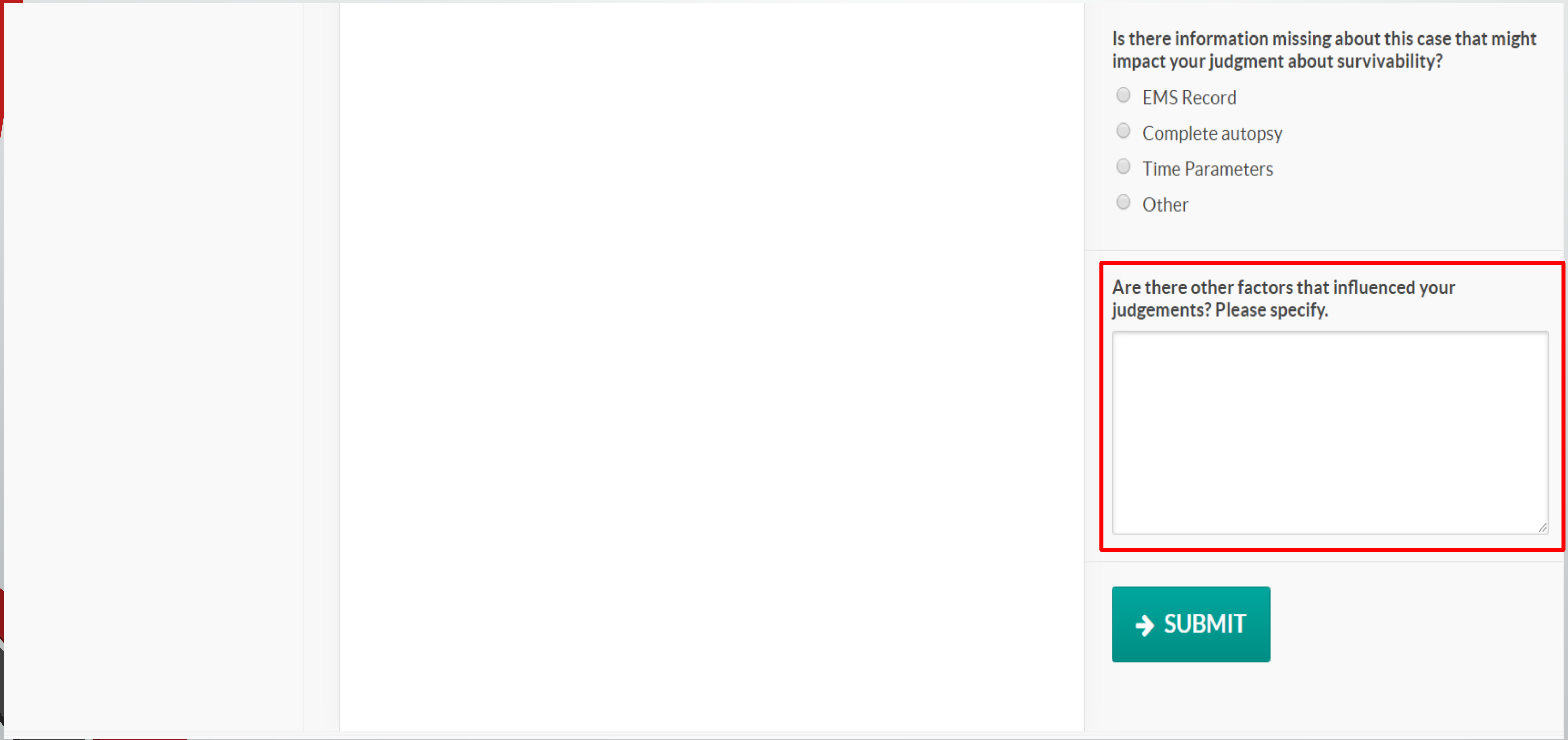
- ☐ Mechanical failure
- ☐ Safety device failure
- ☐ Safety device not used
- ☐ Automatic crash identification systems
- ☐ Other

PATIENT

- ☐ Comorbid physical conditions
- ☐ Comorbid behavioral health conditions
- ☐ Intoxication - Alcohol
- ☐ Intoxication - Drugs

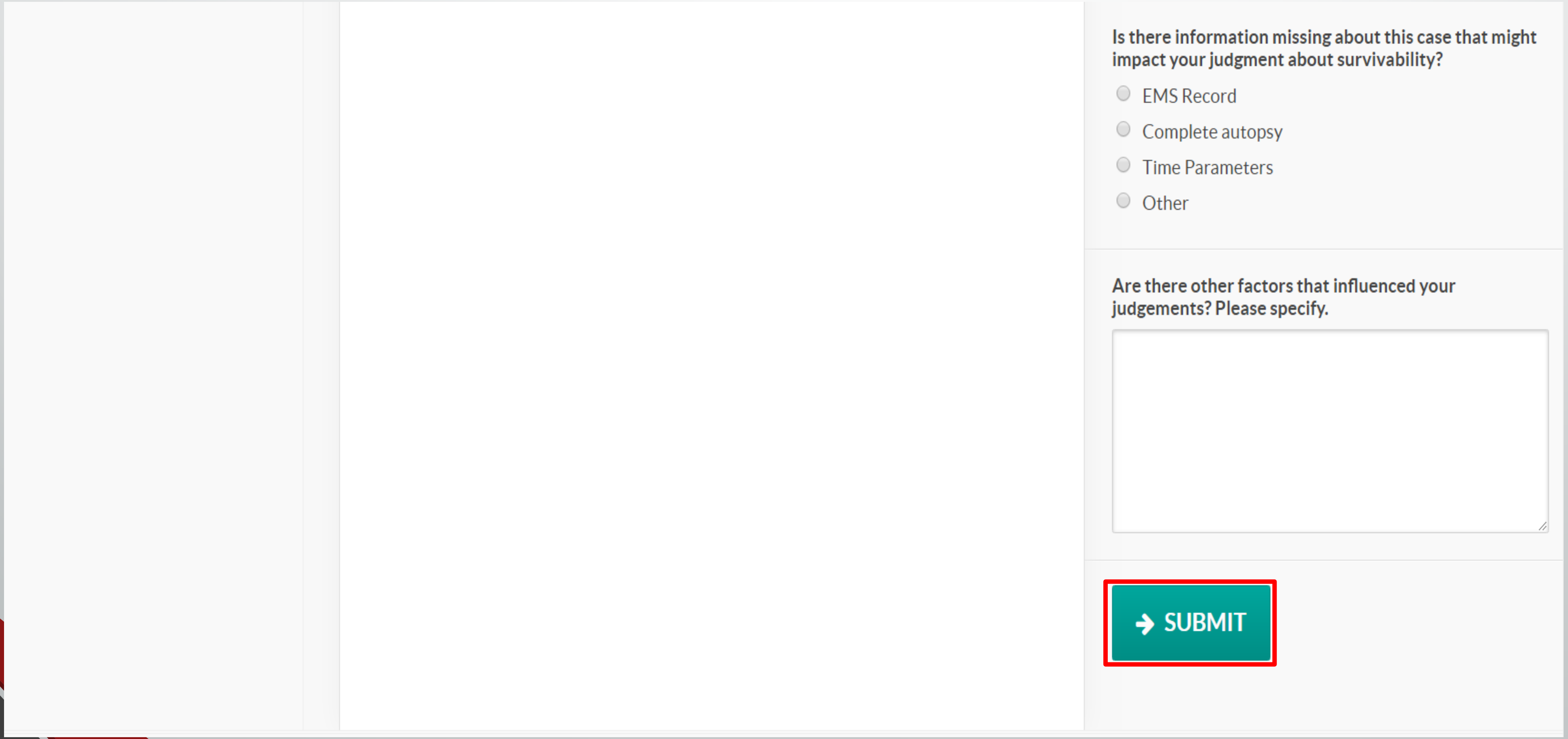
Causation and Survival Determination

- Rationale for how you made your determination; may help if adjudication is needed



Causation and Survival Determination

- Submission is final, unless adjudication is needed



Preliminary Data

Case Reviews

Study Round	Number of Cases Released	Case Completion
Round 1 Status *Began 1-16-2019*	260 Cases Released	240 Cases Completed
Round 2 Status *Began 3-25-2019*	240 Cases Released	240 Cases Completed
Round 3 Status *Began 6-13-2019*	300 Cases Released	150 Cases Completed

- 13 review team panels
- Study will consist of 10 rounds
- Reviewers are reporting being able to complete each case review in about 10-15 minutes

Questions Used to Determine Consensus

- **Consensus must be reached on both Survivability Questions:**
  - Assume the survival status of this patient is unknown, ***with immediate access to care at a level I trauma center***, assess the survival potential of this patient.
  - Assume the survival status of this patient is unknown, ***given the conditions of the actual scenario*** in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient.

Case Consensus Definition

- 5 reviewers are used to determine consensus. The ME/Forensic reviewer is not calculated in consensus as this analysis is kept separate.
- Each variable is independent. So it must be 3 or more reviewers answering the same on one specific category. (For example: 3 agree the case is Potentially Survivable)
  - If one reviewer selects non-survivable and the other 4 select either potentially, definitely survivable, or cannot judge, that case goes to adjudication
  - If two reviewers select cannot judge, but the other three are able to make a determination, the case goes to adjudication

Case Adjudication

Study Round	Number of Cases That Did Not Reach Initial Consensus	Cases Resolved During Team Adjudication	Cases Still In Team Adjudication	Could Not Reach Consensus, Pushed for Outside Adjudication
Round 1 Status	61 cases	44 cases	3 cases	14 cases
Round 2 Status	49 cases	21 cases	20 cases	8 cases
Round 3 Status	36 cases	9 cases	24 cases	3 cases

Preliminary Round 1 and Round 2 Data

- Q1: Based on your judgment, what was the principal mechanism(s) of death?

Principal Mechanism(s) of Death	Frequency
Neurological – Traumatic Brain Injury	1342
Hemorrhage – Truncal: Thorax	354
Neurological – Spinal Cord	256
Hemorrhage – Truncal: Abdomen / Pelvis	136
Burn	133
Airway	79
Massive tissue disruption: CNS	67
Asphyxia	65
Massive tissue disruption: Whole Body	59
Massive tissue disruption: Thorax	41
Tension Pneumothorax	32
Hemorrhage – Junctional: Cervical	29
Massive tissue disruption: abdomen	28
hemorrhage - peripheral: upper extremity	21

Note: Cases with multiple causes are counted multiple times. (Round 1 and 2)

Preliminary Round 1 and Round 2 Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

Immediate Access Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
	262 (77%)	269 (79%)
	75 (22%)	46 (14%)
	2 (1%)	5 (1%)
	0	19 (6%)

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

Note: Using 339 cases that have reached consensus on survivability assessments for Q2

Preliminary Round 1 and Round 2 Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
	341 (93%)	325 (89%)
	26 (7%)	22 (6%)
	0	0
Cannot Judge	0	20 (5%)

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using 367 cases that have reached consensus on survivability assessments

Immediate Access Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
Non-survivable	262 (77%)	269 (79%)
Potentially Survivable	75 (22%)	46 (14%)
Definitely Survivable	2 (1[illegible]	5 (1%)
Cannot Judge	0[illegible]	19 (6%)

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	[illegible] reviewers [illegible] consensus	Frequency for medical examiners
Non-survivable	3[illegible]	325 (89%)
Potentially Survivable	26 (7%)	22 (6%)
Definitely Survivable	0	0
Cannot Judge	0	20 (5%)

Preliminary Round 1 and Round 2 Data

- Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

***Note:** Using records from all reviewers in Round 1 and Round 2.*

Questions

Summary

The goal of the research is 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. The research intends to identify ways that the ME and trauma communities can improve linkages to foster in-depth reviews of trauma mortality.

Future Directions

- Submission of an NIH R-24 award to fund a PEDS-MIMIC project
- Looking for funding opportunities aimed at building the ME system
- Exploring funding opportunities that focus on suicides

Team Acknowledgment

- Authors: Villarreal CL, Medrano NW, MacKenzie E, Nolte KB, Phillips MJ, Price MA, Eastridge BJ
- MIMIC Steering Committee
- MIMIC Forensic Reviewers
  - Kurt Nolte, Edward Mazuchowski, Roger Mitchell, Stacy Drake, Marcus Nashelsky, David Fowler, Greg Davis, James Gill, Joseph Hunt

Team Acknowledgment

Study Sites	Medical Examiner	Data Abstractors
New Mexico	Kurt Nolte	Garon Bodor Victoria Chavez Kayla Moorman Susan Catlett Yvette Gonzalez
Maryland	David Fowler	Ling Li Haitaio Bi
Washington, DC	Roger Mitchell	Chikarlo Leak Ameerah Battle
Oklahoma	Eric Pfeifer	Lynda Goldberg-Baedke
Connecticut	James Gill	Michelle Clark Jessica Crowson
Iowa	Marcus Nashelsky	Heather Sanderson

Questions

IF YOU HAVE ANY PROJECT RELATED QUESTIONS, PLEASE DO NOT HESITATE TO REACH OUT

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MIMIC Reviewer Update

NAME Meeting
October 20, 2019

Project Progress

Data Abstraction

- 2,567 of 2,979* cases have been abstracted

Coding

- AIS/ICD – 890 cases completed
- GIS – 2,587 cases completed

Case Reviews

- Created 13 review team panels each consisting of 4 surgeons, 1 EM/EMS reviewer, and 1 Forensic Reviewer.
- 875 cases released to panels
- 585 cases completed.

*Cases may be added in order to reach 3,000

Abstraction Progress

Site	Number of Cases	Cases Completed	Percent Completed
Connecticut	422	315	75%
Iowa	41	41	100%
Maryland	845	655	78%
New Mexico	1194	1079	90%
Oklahoma	335	335	100%
Washington DC	142	142	100%
Total	**2979**	**2567**	**86%**

Case Adjudication

Study Round	Number of Cases That Did Not Reach Initial Consensus	Cases Resolved During Team Adjudication	Cases Still In Team Adjudication	Could Not Reach Consensus, Pushed for Outside Adjudication
Round 1 Status	61 cases	44 cases	3 cases	14 cases
Round 2 Status	49 cases	21 cases	20 cases	8 cases
Round 3 Status	36 cases	9 cases	24 cases	3 cases

On Site Adjudication

- For cases that could not reach consensus within the team panel
- Set up on site visits once all site cases have been reviewed
- Preparing for on site visits

Preliminary Round 1 and Round 2 Data

Q1: Based on your judgment, what was the principal mechanism(s) of death?

Principal Mechanism(s) of Death	Frequency
Neurological – Traumatic Brain Injury	**1342**
Hemorrhage – Truncal: Thorax	**354**
Neurological – Spinal Cord	**256**
Hemorrhage – Truncal: Abdomen / Pelvis	**136**
Burn	**133**
Airway	**79**
Massive tissue disruption: CNS	**67**
Asphyxia	**65**
Massive tissue disruption: Whole Body	**59**
Massive tissue disruption: Thorax	**41**
Tension Pneumothorax	**32**
Hemorrhage – Junctional: Cervical	**29**
Massive tissue disruption: abdomen	**28**
hemorrhage - peripheral: upper extremity	**21**

Note: Cases with multiple causes are counted multiple times. (Round 1 and 2)

Preliminary Round 1 and Round 2 Data

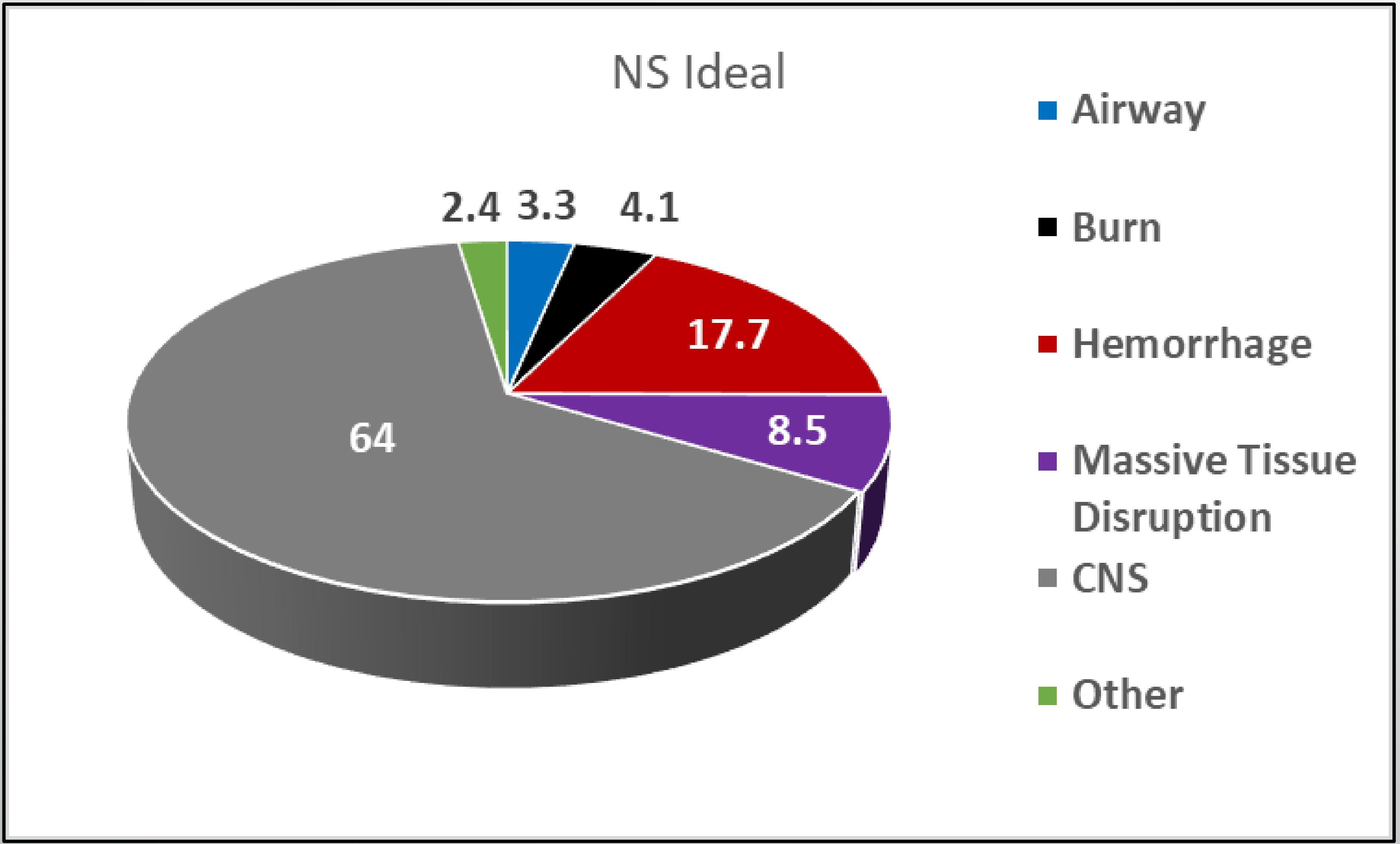
Q2: Assume survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

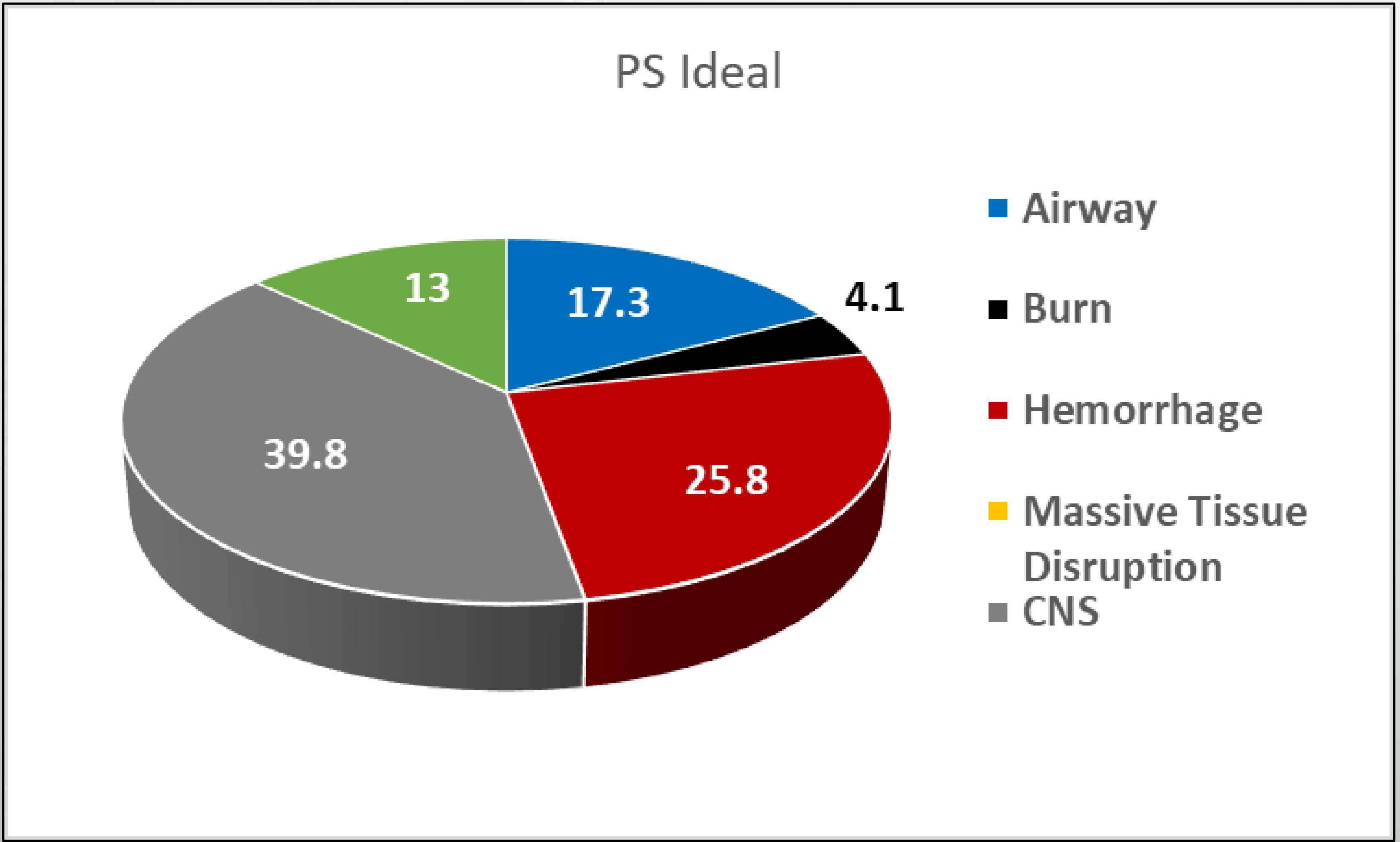
[illegible]ess	Frequency for reviewers reaching consensus	Frequency for medical examiners
[illegible]	262 (77%)	269 (79%)
[illegible]vable	75 (22%)	46 (14%)
[illegible]able	2 (1%)	5 (1%)
Cannot Judge	0	19 (6%)

Note: Using cases that have reached consensus on survivability assessments for Q2

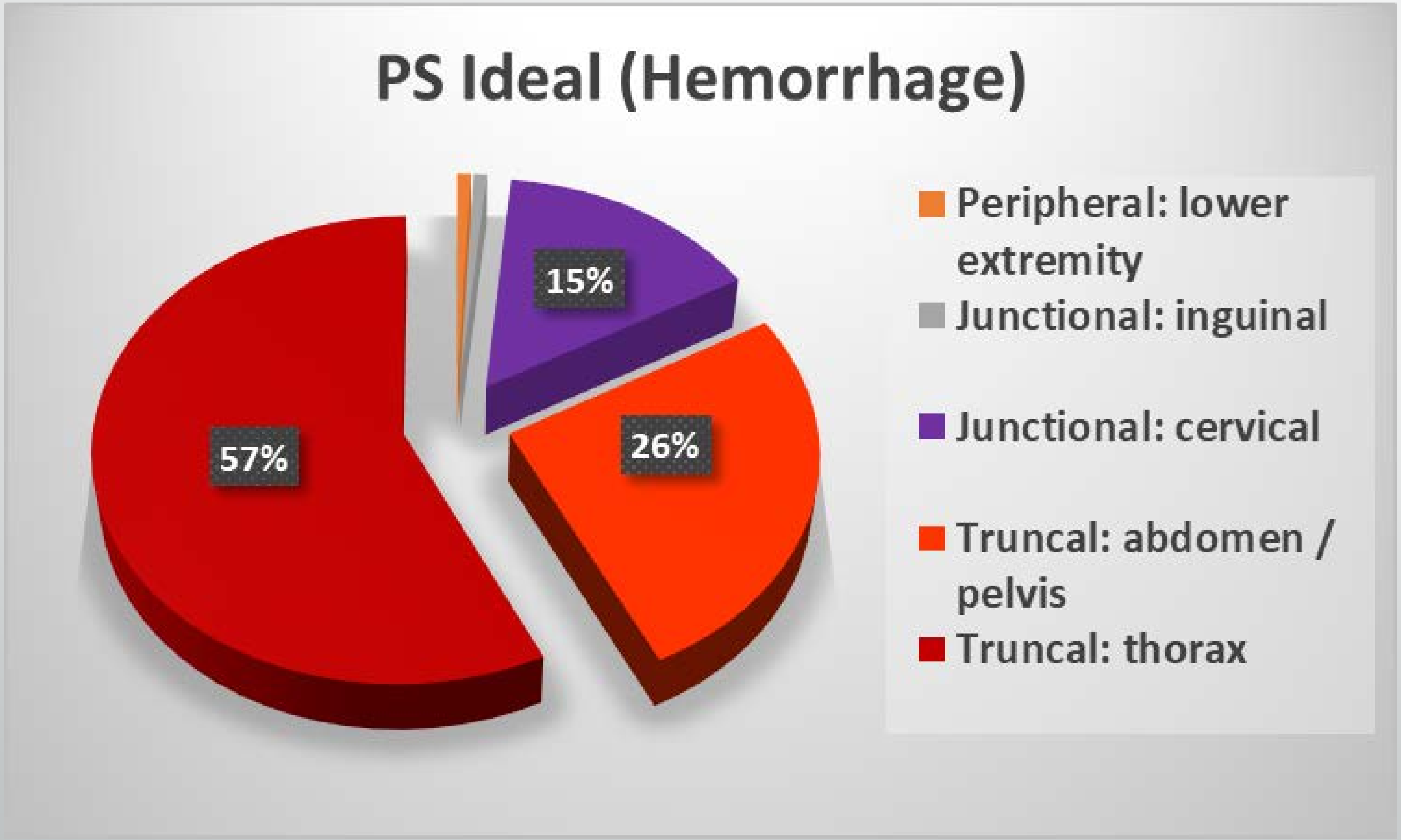
Nonsurvivable (Ideal)



Potentially Survivable (Ideal)



Potentially Survivable Ideal (Hemorrhage)



Preliminary Round 1 and Round 2 Data

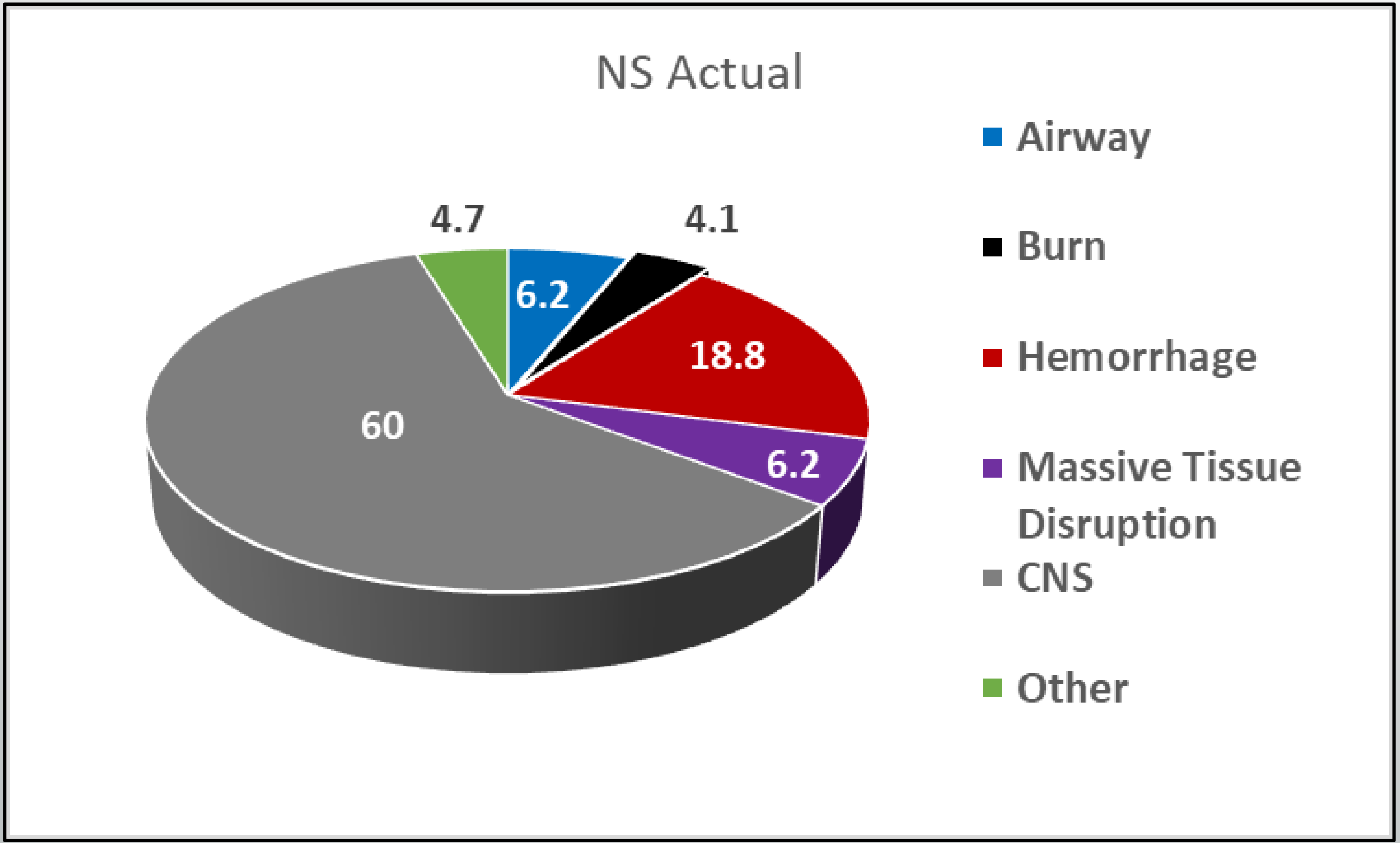
Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
	341 (93%)	325 (89%)
	26 (7%)	22 (6%)
e	0	0
Cannot Judge	0	20 (5%)

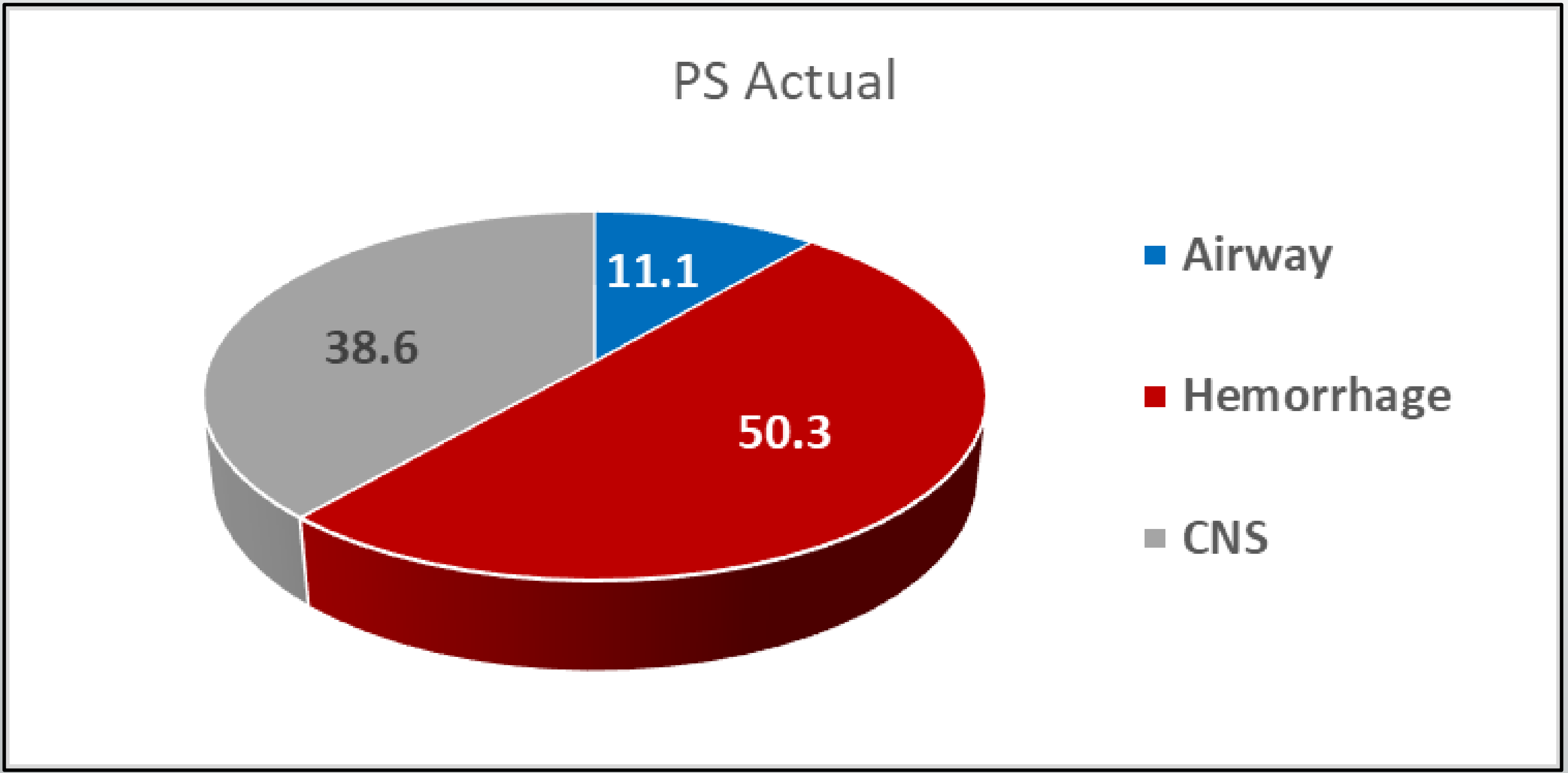
OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using cases that have reached consensus on survivability assessments

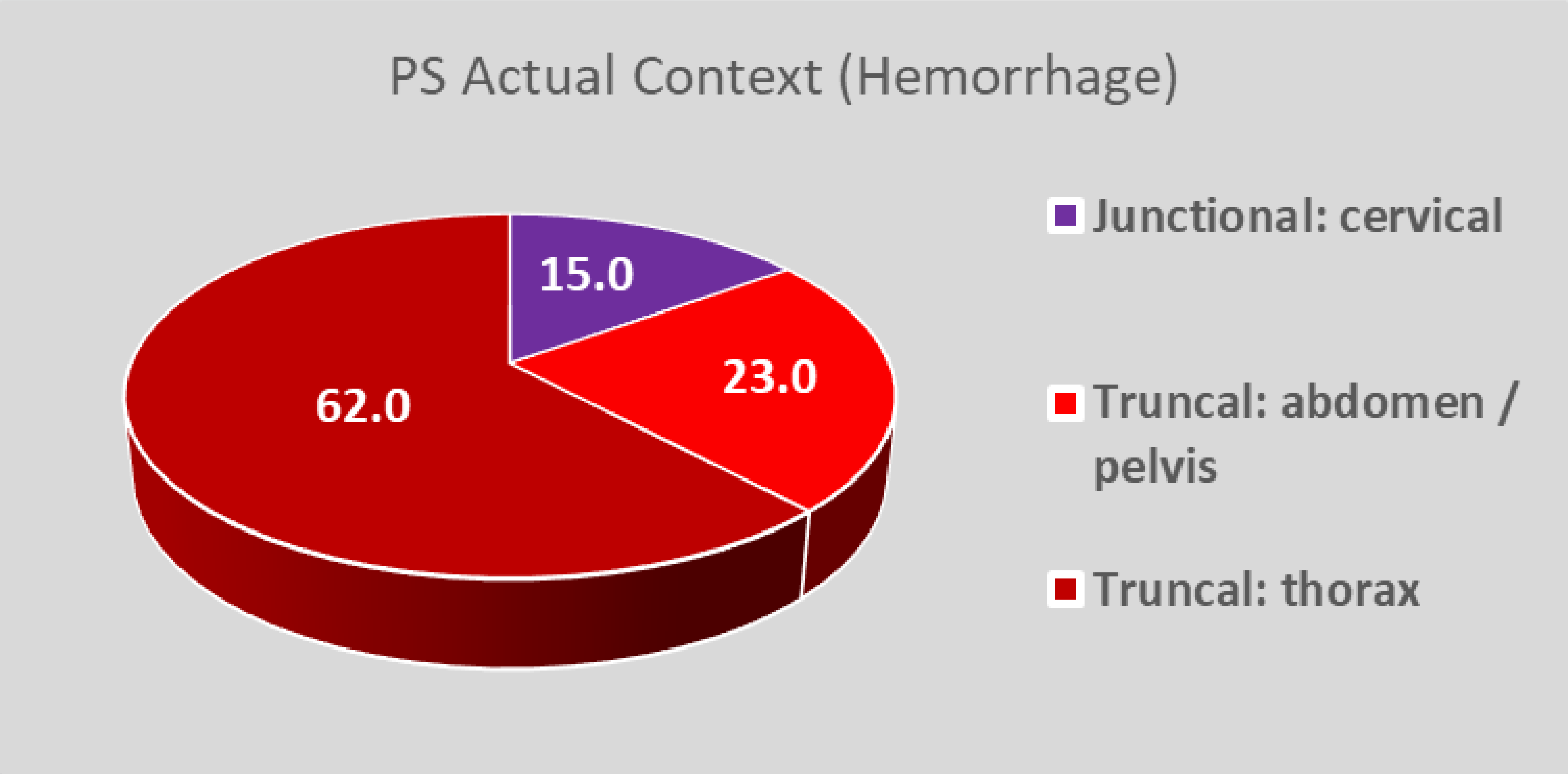
Nonsurvivable (Actual Context)



Potentially Survivable (Actual Context)



Potentially Survivable Actual Context (Hemorrhage)

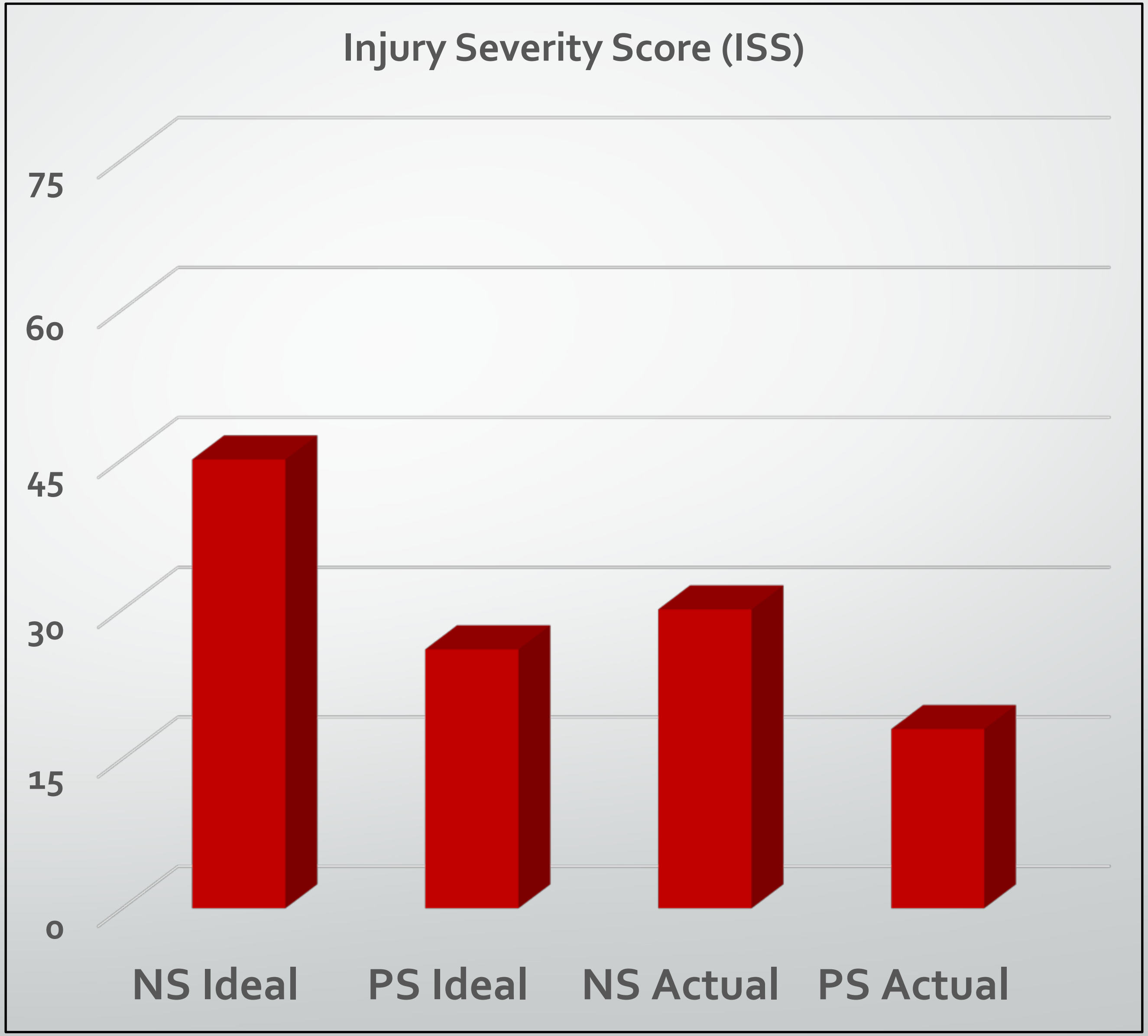


Immediate Access Survivability	Frequency for reviewers reaching consensus	Frequency for medical examiners
Non-survivable	262 (77%)	269 (79%)
Potentially Survivable	75 (22%)	46 (14%)
Definitely Survivable	2 [illegible]	5 (1%)
Cannot Judge	[illegible]	19 (6%)

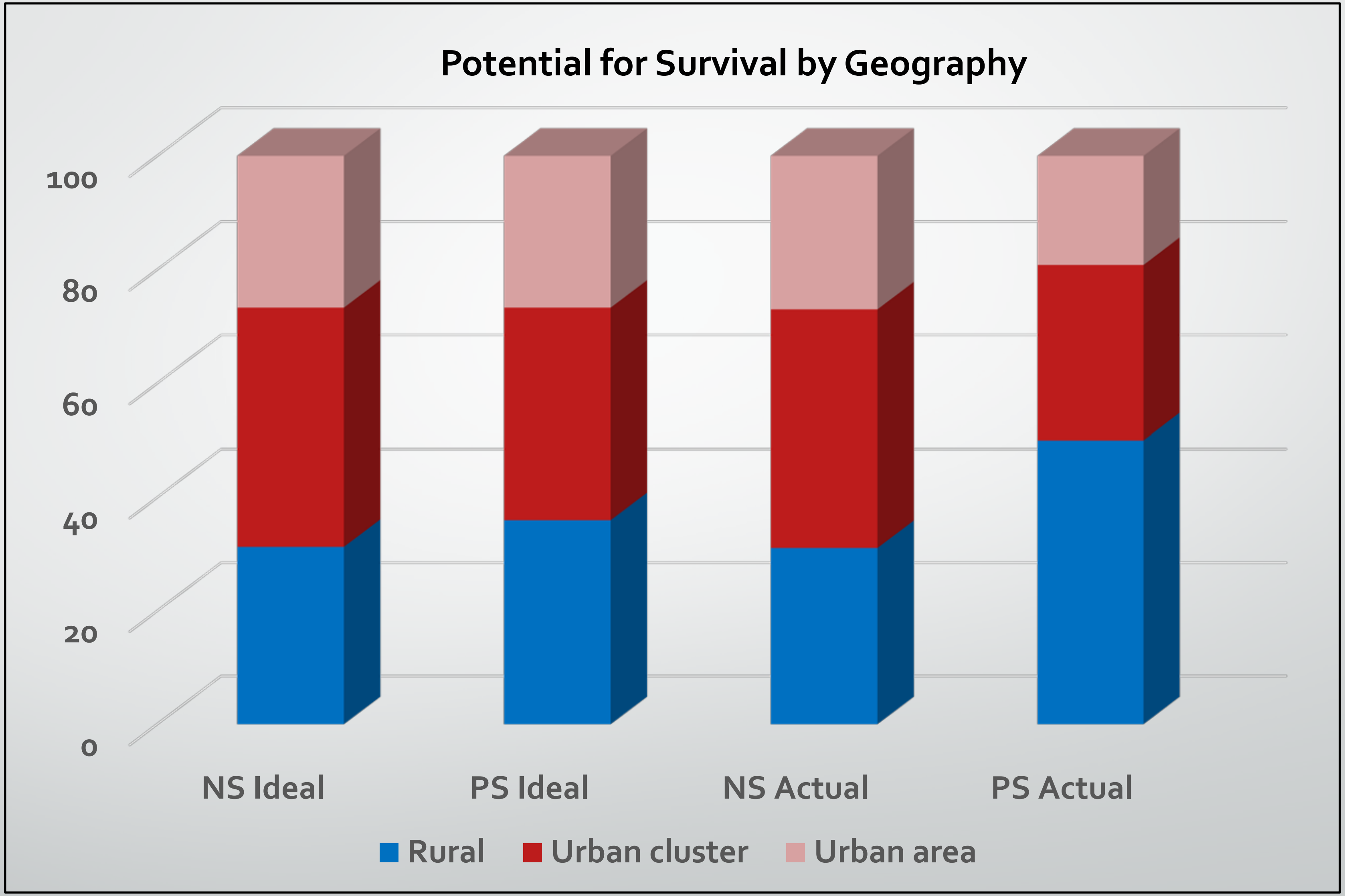
RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	[illegible]or reviewers [illegible]g consensus	Frequency for medical examiners
Non-survivable	[illegible] (93%)	325 (89%)
Potentially Survivable	26 (7%)	22 (6%)
Definitely Survivable	0	0
Cannot Judge	0	20 (5%)

Potential Survivability vs ISS



Potential for Survival by Location



Preliminary Pediatric Data from MIMIC Project

MIMIC Pediatric Population (n=158)	
Sex	61% Male 39% Female
Latino or Hispanic	29% Yes 48% No 23% Unknown
Race	8% American Indian or Alaska Native 1% Asian 18% Black or African-American 0% Native Hawaiian or Other Pacific Islander 67% White 3% Unknown 3% Not Reported
Injury Type *May select more than one	39% Penetrating 59% Blunt 6% Thermal 2% Unknown
Manner of Death	12% Suicide 32% Homicide 56% Accident
Event Witnessed	42% Yes 20% No 38% Unknown
Was EMS Involved	61% Yes 39% No

Preliminary Round 1 and Round 2 Data

Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

***Note:** Using records from all reviewers in Round 1 and Round 2.*

NEMSIS Data Linkage Update

- Contact has been made with states from all 6 MIMIC sites
  - Oklahoma – EMS data was received, will see data in Round 4
  - Washington DC - Currently working on data matching
  - Maryland - Currently working on data matching
  - New Mexico - Currently working on finalizing agreement
  - Iowa – Initial request was denied, will resubmit in Spring 2020.
  - Connecticut - Working internally to determine how to handle Non-Human Research project within the state requirements.

Timeline

	First Panel Release	Last Panel Release	Reviews Completed
Round 4	9/27/2019	11/29/2019	12/27/2019
Round 5	12/6/2019	2/7/2020	3/6/2020
Round 6	2/14/2020	4/17/2020	5/15/2020
Round 7	4/24/2020	6/26/2020	7/24/2019
Round 8	7/3/2020	9/4/2020	10/2/2020
Round 9	9/11/2020	11/13/2020	12/11/2020
Round 10	11/20/2020	1/15/2021	2/12/2021

- ***Reviewers are given 3 weeks to complete case reviews.***
- ***Once adjudication is released, reviewers are given 1 week to complete.***

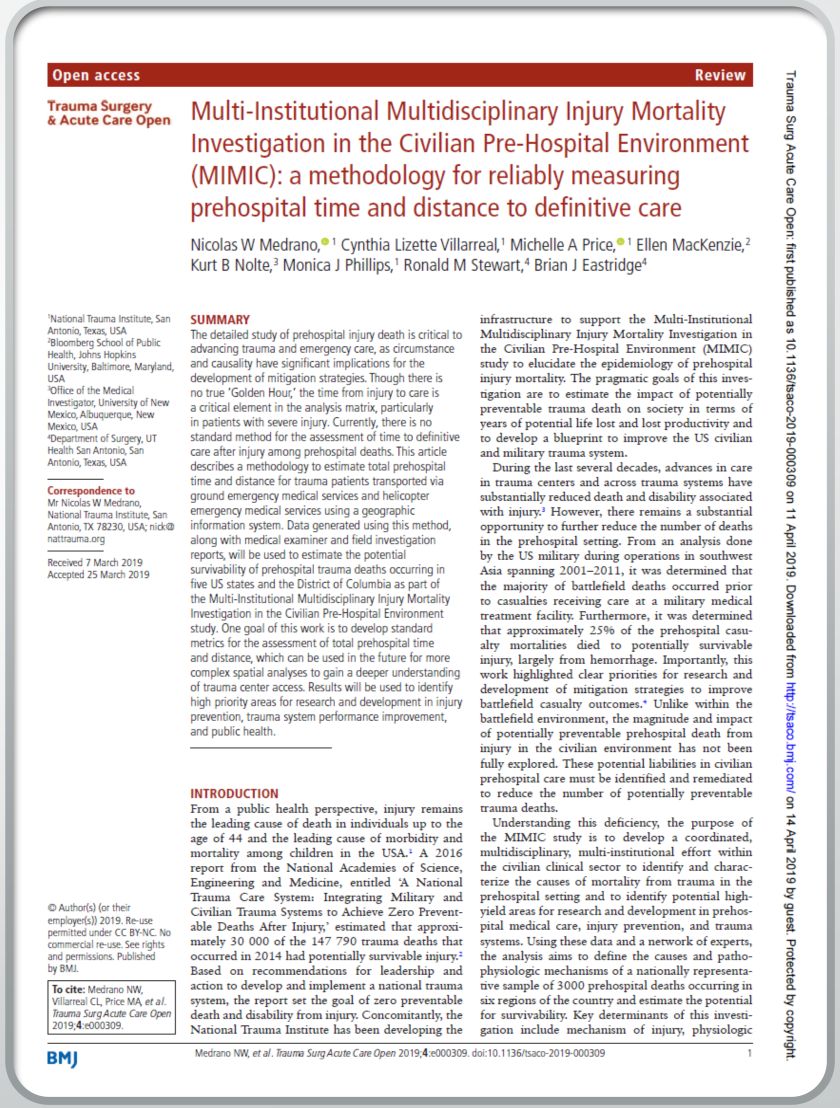
Data Challenges

- EMS data agreements to match individual patient level data have to be executed with each state since data cannot be matched with the national data set.

- Under Oklahoma statute they are not allowed to provide information beyond the ME autopsy report for research purposes. Other states are able to provide field investigator reports, and additional case details.

Publication

- Medrano NW, Villarreal CL, Price MA, MacKenzie E, 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. *2019; 4:e000309. doi:10.1136/tsaco-2019-000309.*



Open access Review

Trauma Surgery & Acute Care Open

Multi-Institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC): a methodology for reliably measuring prehospital time and distance to definitive care

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Received 7 March 2019
Accepted 25 March 2019

SUMMARY
The detailed study of prehospital injury death is critical to advancing trauma and emergency care, as circumstance and causality have significant implications for the development of mitigation strategies. Though there is no true 'Golden Hour,' the time from injury to care is a critical element in the analysis matrix, particularly in patients with severe injury. Currently, there is no standard method for the assessment of time to definitive care after injury among prehospital deaths. This article describes a methodology to estimate total prehospital time and distance for trauma patients transported via ground emergency medical services and helicopter emergency medical services using a geographic information system. Data generated using this method, along with medical examiner and field investigation reports, will be used to estimate the potential survivability of prehospital trauma deaths occurring in five US states and the District of Columbia as part of the Multi-Institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment study. One goal of this work is to develop standard metrics for the assessment of total prehospital time and distance, which can be used in the future for more complex spatial analyses to gain a deeper understanding of trauma center access. Results will be used to identify high priority areas for research and development in injury prevention, trauma system performance improvement, and public health.

INTRODUCTION
From a public health perspective, 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 USA.[1] A 2016 report from the National Academies of Science, Engineering and Medicine, 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 trauma deaths that occurred in 2014 had potentially survivable injury.[2] Based on recommendations for leadership and action to develop and implement a national trauma system, the report set the goal of zero preventable death and disability from injury. Concomitantly, the National Trauma Institute has been developing the infrastructure to support the Multi-Institutional Multidisciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC) study to elucidate the epidemiology of prehospital injury mortality. The pragmatic goals of this investigation are to estimate the impact of potentially preventable trauma death on society in terms of years of potential life lost and lost productivity and to develop a blueprint to improve the US civilian and military trauma system.

During the last several decades, advances in care in trauma centers and across trauma systems have substantially reduced death and disability associated with injury.[3] However, there remains a substantial opportunity to further reduce the number of deaths in the prehospital setting. From an analysis done by the US military during operations in southwest Asia spanning 2001–2011, it was determined that the majority of battlefield deaths occurred prior to casualties receiving care at a military medical treatment facility. Furthermore, it was determined that approximately 25% of the prehospital casualty mortalities died to potentially survivable injury, largely from hemorrhage. Importantly, this work highlighted clear priorities for research and development of mitigation strategies to improve battlefield casualty outcomes.[4] Unlike within the battlefield environment, the magnitude and impact of potentially preventable prehospital death from injury in the civilian environment has not been fully explored. These potential liabilities in civilian prehospital care must be identified and remediated to reduce the number of potentially preventable trauma deaths.

Understanding this deficiency, the purpose of the MIMIC study 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 prehospital setting and to identify potential high-yield areas for research and development in prehospital medical care, injury prevention, and trauma systems. Using these data and a network of experts, the analysis aims to define the causes and pathophysiologic mechanisms of a nationally representative sample of 3000 prehospital deaths occurring in six regions of the country and estimate the potential for survivability. Key determinants of this investigation include mechanism of injury, physiologic

To cite: Medrano NW, Villarreal CL, Price MA, *et al. Trauma Surg Acute Care Open* 2019;**4**:e000309.

Presentations

- MHSRS Conference Poster Presented; August 2019
- Pre-hospital Blood McSwain Conference; October 2019
- AABB THOR MIMIC presentation; October 2019
- NAME presentation; October 2019
- Western Trauma Association; Abstract submitted for 2020 conference

Future Funding Opportunities

- PEDS-MIMIC
  - Replication of MIMIC study with solely pediatric patients
  - Application submitted this week
  - Study would begin July 2020
- NHTSA
- DOJ

Other Research Ideas???

Questions

IF YOU HAVE ANY PROJECT RELATED QUESTIONS, PLEASE DO NOT HESITATE TO REACH OUT

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Prehospital Mortality, The Missing Dead:

Implications for the Trauma System Development

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Division of Trauma and Emergency Surgery
University of Texas Health Science Center at San Antonio

THE COMMITTEE ON TRAUMA

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Disclosure / Disclaimer

Nothing to disclose

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

Public Health Crisis
Injury and Access to Care

Injury and Violence Facts

Injury is a MAJOR global public health problem

- Leading cause of death for ages 15 – 29, worldwide
  - Leading cause of death Ages 1-44 US
  - More deaths in children than all other causes combined
- About 6 million deaths, worldwide
- Leading cause of lost years of productive life
  - More than either cancer, stroke or heart disease combined
- Enormous economic burden
  - Medical treatment and loss of work productivity costs

Despite the obvious magnitude, there is little public focus

All Cause Death

10 Leading Causes of Death, United States
2017, All Races, Both Sexes

	Age Groups										
Rank	<1	1-4	5-9	10-14	15-24	25-34	35-44	45-54	55-64	65+	All Ages
1	Congenital Anomalies 4,580	Unintentional Injury 1,267	Unintentional Injury 718	Unintentional Injury 860	Unintentional Injury 13,441	Unintentional Injury 25,669	Unintentional Injury 22,828	Malignant Neoplasms 39,266	Malignant Neoplasms 114,810	Heart Disease 519,052	Heart Disease 647,457
2	Short Gestation 3,749	Congenital Anomalies 424	Malignant Neoplasms 418	Suicide 517	Suicide 6,252	Suicide 7,948	Malignant Neoplasms 10,900	Heart Disease 32,658	Heart Disease 80,102	Malignant Neoplasms 427,896	Malignant Neoplasms 599,108
3	Maternal Pregnancy Comp. 1,432	Malignant Neoplasms 325	Congenital Anomalies 188	Malignant Neoplasms 437	Homicide 4,905	Homicide 5,488	Heart Disease 10,401	Unintentional Injury 24,461	Unintentional Injury 23,408	Chronic Low. Respiratory Disease 136,139	Unintentional Injury 169,936
4	SIDS 1,363	Homicide 303	Homicide 154	Congenital Anomalies 191	Malignant Neoplasms 1,374	Heart Disease 3,681	Suicide 7,335	Suicide 8,561	Chronic Low. Respiratory Disease 18,667	Cerebro-vascular 125,653	Chronic Low. Respiratory Disease 160,201
5	Unintentional Injury 1,317	Heart Disease 127	Heart Disease 75	Homicide 178	Heart Disease 913	Malignant Neoplasms 3,616	Homicide 3,351	Liver Disease 8,312	Diabetes Mellitus 14,904	Alzheimer's Disease 120,107	Cerebro-vascular 146,383
6	Placenta Cord Membranes 843	Influenza & Pneumonia 104	Influenza & Pneumonia 62	Heart Disease 104	Congenital Anomalies 355	Liver Disease 918	Liver Disease 3,000	Diabetes Mellitus 6,409	Liver Disease 13,737	Diabetes Mellitus 59,020	Alzheimer's Disease 121,404
7	Bacterial Sepsis 592	Cerebro-vascular 66	Chronic Low. Respiratory Disease 59	Chronic Low. Respiratory Disease 75	Diabetes Mellitus 248	Diabetes Mellitus 823	Diabetes Mellitus 2,118	Cerebro-vascular 5,198	Cerebro-vascular 12,708	Unintentional Injury 55,951	Diabetes Mellitus 83,564
8	Circulatory System Disease 449	Septicemia 48	Cerebro-vascular 41	Cerebro-vascular 56	Influenza & Pneumonia 190	Cerebro-vascular 593	Cerebro-vascular 1,811	Chronic Low. Respiratory Disease 3,975	Suicide 7,982	Influenza & Pneumonia 46,862	Influenza & Pneumonia 55,672
9	Respiratory Distress 440	Benign Neoplasms 44	Septicemia 33	Influenza & Pneumonia 51	Chronic Low. Respiratory Disease 188	HIV 513	Septicemia 854	Septicemia 2,441	Septicemia 5,838	Nephritis 41,670	Nephritis 50,633
10	Neonatal Hemorrhage 379	Perinatal Period 42	Benign Neoplasms 31	Benign Neoplasms 31	Complicated Pregnancy 168	Complicated Pregnancy 512	HIV 831	Homicide 2,275	Nephritis 5,671	Parkinson's Disease 31,177	Suicide 47,173

WISQARS™ Produced By: National Center for Injury Prevention and Control, Centers for Disease Control and Prevention

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System

Violent Injury Death

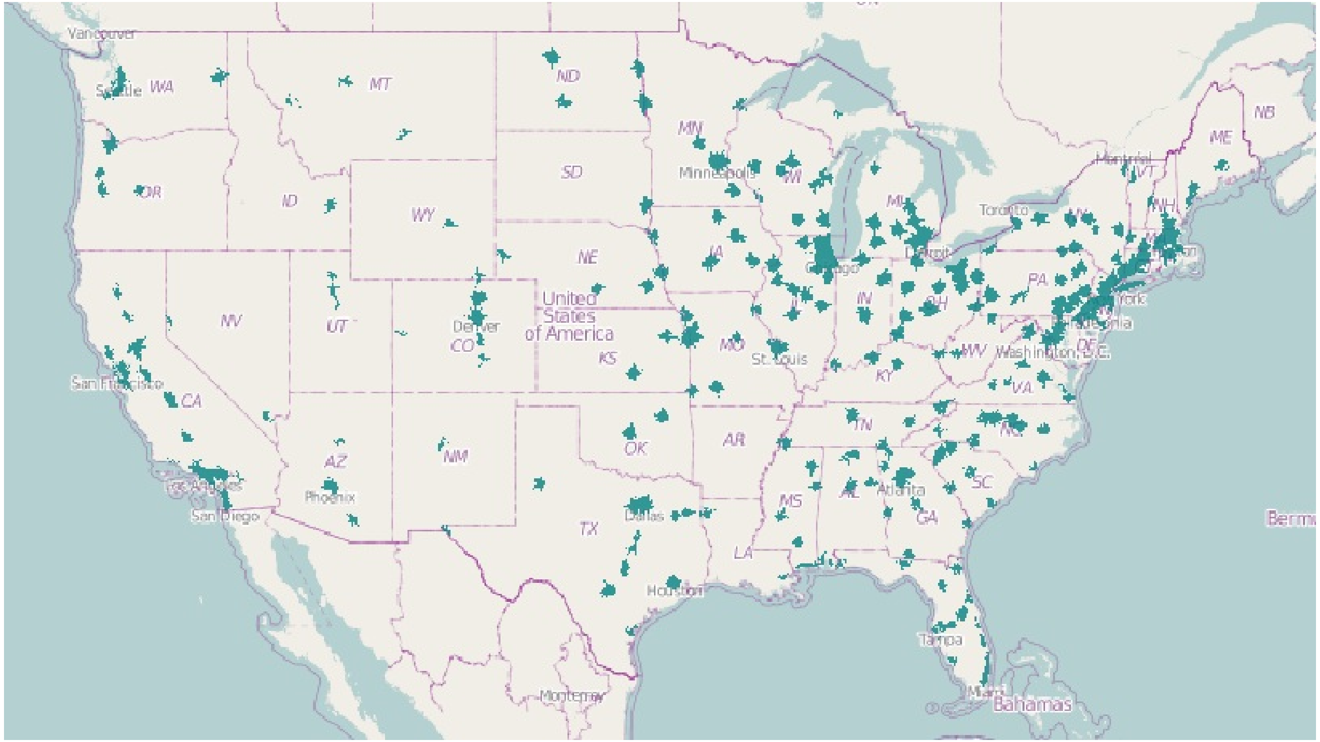
10 Leading Causes of Injury Deaths by Age Group Highlighting Violence-Related Injury Deaths, United States – 2017

	Age Groups										
Rank	**<1**	**1-4**	**5-9**	**10-14**	**15-24**	**25-34**	**35-44**	**45-54**	**55-64**	**65+**	**Total**
1	Unintentional Suffocation 1,106	Unintentional Drowning 424	Unintentional MV Traffic 327	Unintentional MV Traffic 428	Unintentional MV Traffic 6,697	Unintentional Poisoning 16,478	Unintentional Poisoning 15,032	Unintentional Poisoning 14,707	Unintentional Poisoning 10,581	Unintentional Fall 31,190	Unintentional Poisoning 64,795
2	Homicide Unspecified 139	Unintentional MV Traffic 362	Unintentional Drowning 125	Suicide Suffocation 280	Unintentional Poisoning 5,030	Unintentional MV Traffic 6,871	Unintentional MV Traffic 5,162	Unintentional MV Traffic 5,471	Unintentional MV Traffic 5,584	Unintentional MV Traffic 7,667	Unintentional MV Traffic 38,659
3	Unintentional MV Traffic 90	Homicide Unspecified 129	Unintentional Fire/Burn 94	Suicide Firearm 185	Homicide Firearm 4,391	Homicide Firearm 4,594	Suicide Firearm 3,098	Suicide Firearm 3,937	Suicide Firearm 4,219	Suicide Firearm 5,996	Unintentional Fall 36,338
4	Homicide Other Spec., Classifiable 76	Unintentional Suffocation 110	Homicide Firearm 78	Homicide Firearm 126	Suicide Firearm 2,959	Suicide Firearm 3,458	Suicide Suffocation 2,562	Suicide Suffocation 2,294	Unintentional Fall 2,760	Unintentional Unspecified 5,125	Suicide Firearm 23,854
5	Undetermined Suffocation 56	Unintentional Fire/Burn 95	Unintentional Suffocation 36	Unintentional Drowning 110	Suicide Suffocation 2,321	Suicide Suffocation 3,063	Homicide Firearm 2,561	Suicide Poisoning 1,604	Suicide Suffocation 1,631	Unintentional Suffocation 3,920	Homicide Firearm 14,542
6	Unintentional Drowning 43	Unintentional Pedestrian, Other 88	Unintentional Other Land Transport 25	Unintentional Other Land Transport 66	Unintentional Drowning 469	Undetermined Poisoning 887	Suicide Poisoning 1,089	Homicide Firearm 1,447	Suicide Poisoning 1,459	Adverse Effects 2,902	Suicide Suffocation 13,075
7	Undetermined Unspecified 37	Homicide Other Spec., Classifiable 49	Homicide Suffocation 15	Unintentional Fire/Burn 56	Suicide Poisoning 463	Suicide Poisoning 788	Undetermined Poisoning 792	Unintentional Fall 1,248	Homicide Firearm 824	Unintentional Poisoning 2,871	Unintentional Suffocation 6,946
8	Homicide Suffocation 26	Homicide Firearm 44	Homicide Cut/pierce 14	Suicide Poisoning 39	Undetermined Poisoning 280	Unintentional Drowning 479	Unintentional Fall 522	Undetermined Poisoning 887	Unintentional Suffocation 811	Unintentional Fire/Burn 1,278	Unintentional Unspecified 6,606
9	Unintentional Natural/ Environment 18	Unintentional Natural/ Environment 34	Unintentional Firearm 14	Unintentional Poisoning 39	Homicide Cut/pierce 266	Homicide Cut/pierce 404	Unintentional Drowning 397	Unintentional Drowning 451	Adverse Effects 773	Suicide Poisoning 1,111	Suicide Poisoning 6,554
10	Three Tied 16	Unintentional Firearm 31	Two Tied 13	Unintentional Suffocation 35	Unintentional Fall 212	Unintentional Fall 351	Homicide Cut/pierce 337	Unintentional Suffocation 441	Undetermined Poisoning 732	Suicide Suffocation 919	Adverse Effects 4,459

Data Source: National Center for Health Statistics (NCHS), National Vital Statistics System.
Produced by: National Center for Injury Prevention and Control, CDC using WISQARS™.

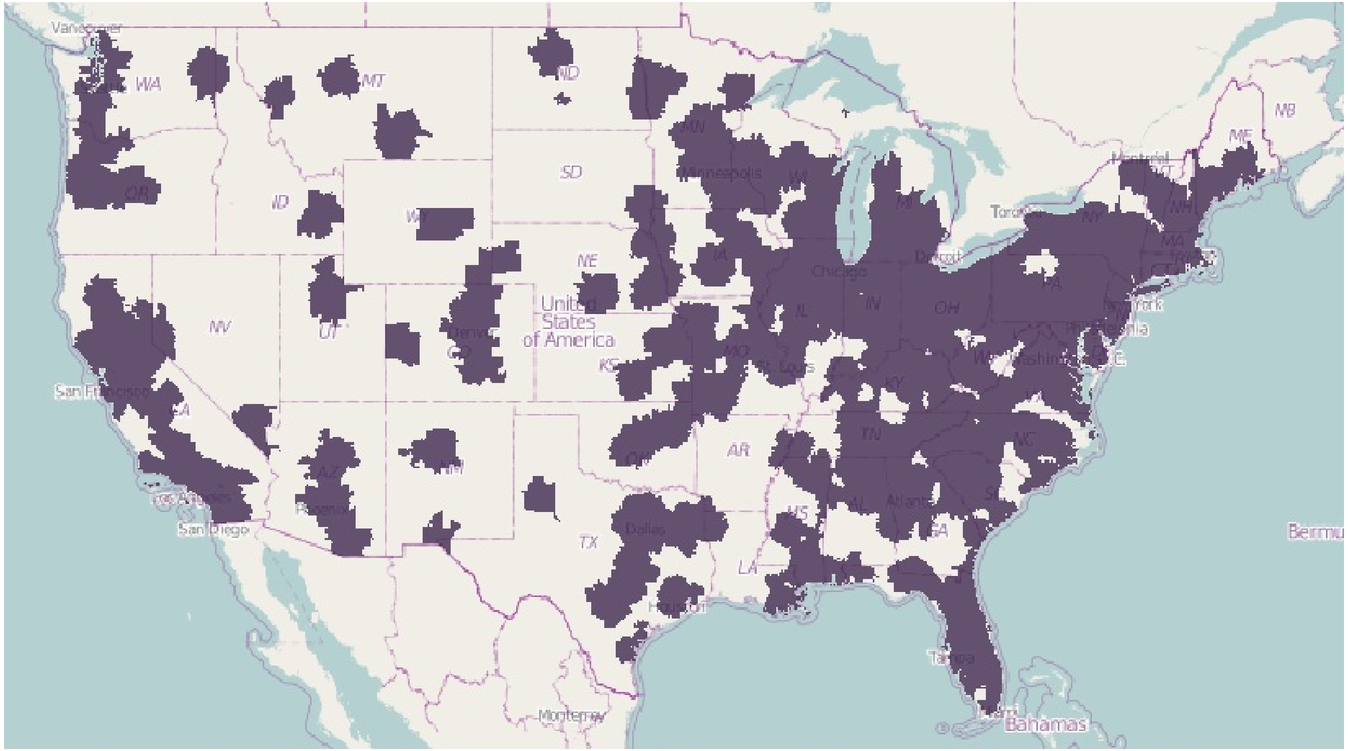
Centers for Disease Control and Prevention
National Center for Injury Prevention and Control

Access to Level I and II Trauma Centers (60 Minutes) Ground EMS (5% land area, 60 % population)



Branas, MacKenzie, E, et al: Access to Trauma Centers in the United States. JAMA. 2005; 293:2626-2633.

Access to Level I and II Trauma Centers (60 minutes)
Ground + Air Medical EMS (35% land area, 90% population)



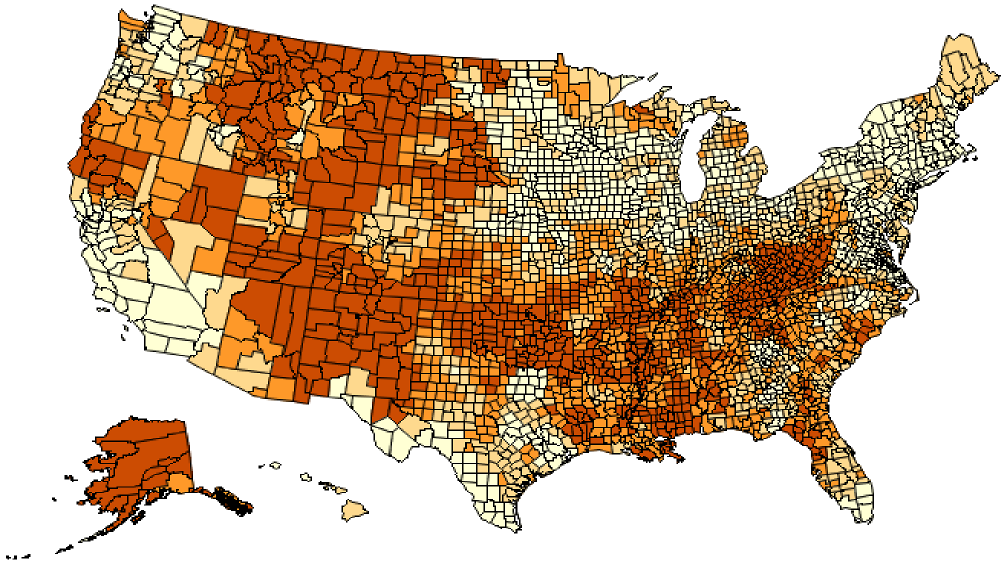
Branas, MacKenzie, E, et al: Access to Trauma Centers in the United States. JAMA. 2005; 293:2626-2633

2008-2014, United States

Smoothed Age-adjusted Death Rates per 100,000 Population

All Injury, All Intents, All Races, All Ethnicities, Both Sexes, All Ages

Annualized Age-adjusted Rate for United States: 58.16



Suppressed/Unstable/Undefined
29.95-58.52
58.53-68.03
68.04-79.08
79.09-207.82

Reports for All Ages include those of unknown age.

* Rates based on 20 or fewer deaths may be unstable. These rates are suppressed for counties (see legend above); such rates in the title have an asterisk.

The standard population for age-adjustment represents the year 2000, all races, both sexes.

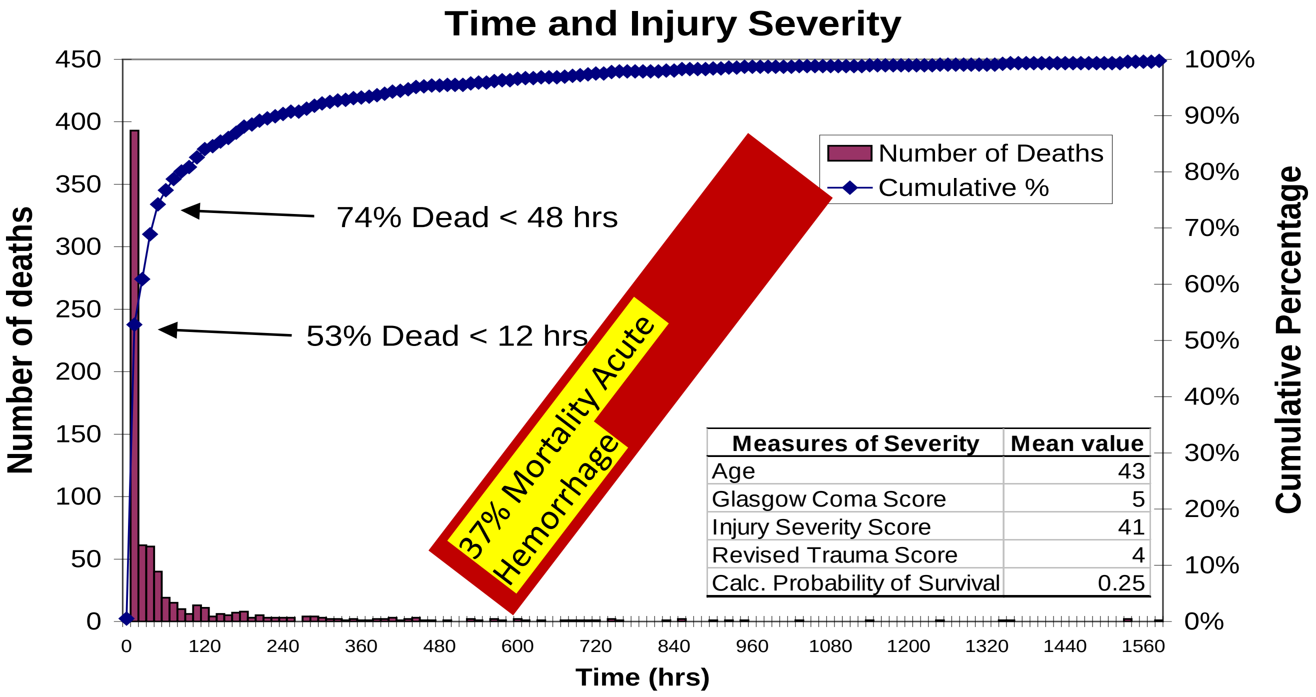
Rates appearing in this map have been geospatially smoothed.

Produced by: the Statistics, Programming & Economics Branch, National Center for Injury Prevention & Control, CDC

Data Sources: NCHS National Vital Statistics System for numbers of deaths; US Census Bureau for population estimates.

Trauma Center Mortality
and
Opportunities for Improvement

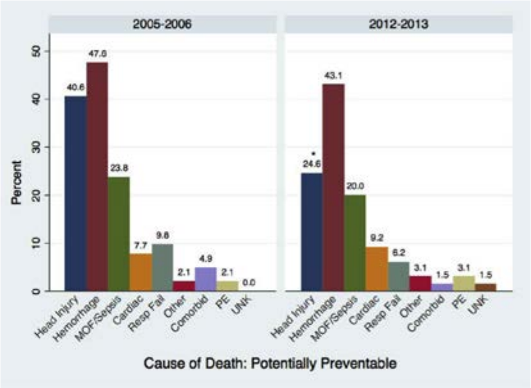
Trauma Center Mortality

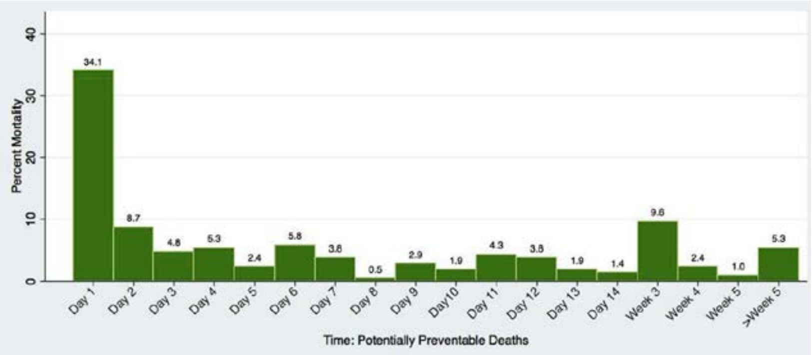


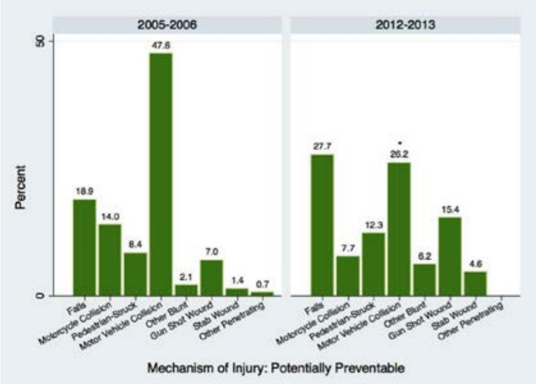
Measures of Severity	Mean value
Age	43
Glasgow Coma Score	5
Injury Severity Score	41
Revised Trauma Score	4
Calc. Probability of Survival	0.25

Stewart: Analysis of 753 deaths in a Level I Trauma Center. J Trauma 2003.

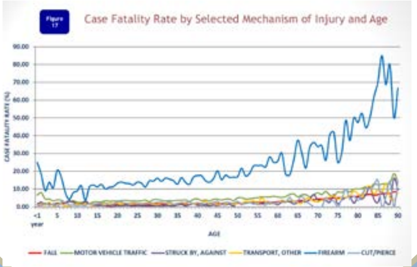
Trauma Center Potentially Preventable Death

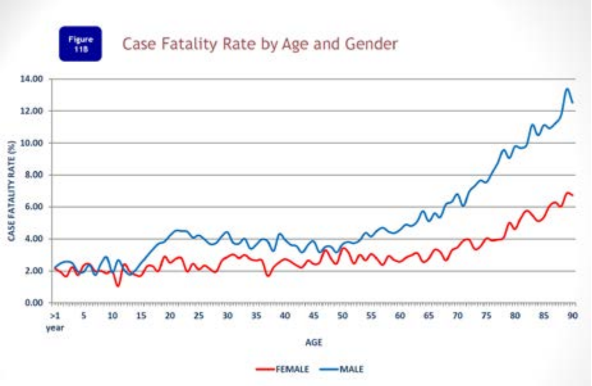






Koh, Holcomb et al: Trends in potentially preventable trauma deaths between 2005-2006 and 2012-2013. Am J Surg 2018





"Therapeutic Turnip"
Trauma Case Fatality Rate

Statement of the Problem

Missing dead are a blind spot for trauma systems

Fundamental Gap

Blind Spot

- 1. portion of a field that cannot be seen or inspected with available equipment
- 2. failure to exercise judgment or discrimination
- 3. lack of understanding or impartiality

If we do not recognize it, we will not develop strategies to remediate

Early Hospital Injury Mortality
Military

History of Battlefield Medical Innovation

World War I
- IV fluids
- Blood transfusions
- Motorized ambulances
- Topical antisepsis

World War II
- Whole blood/plasma
- Specialty-specific surg
- Antibiotics
- Fixed wing aero-medical evacuation

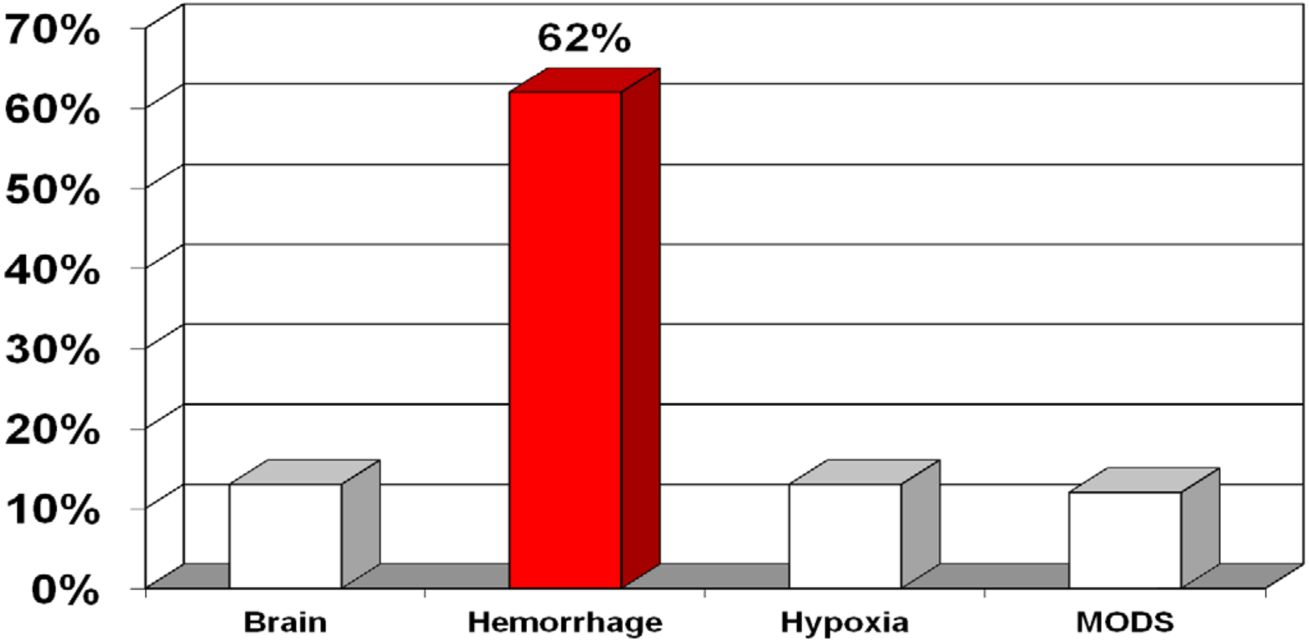
Korean Conflict
- Improved fluid resuscitation
- Forward availability of definitive surgery
- Helicopters for patient evac/transport
- Primary repair/grafts for vascular injury

Vietnam
- Improved use of helicopter
- Improved laboratory support
- Portable radiology equipment
- Mechanical ventilators in theater

Desert Shield/Storm
- Burn team augmentation of evacuation hospitals to provide theater-wide burn care
- Intercontinental aeromedical transport of burn patients

OEF / OIF
- Military trauma system (JTS / DoDTR)
- Damage control resuscitation
- Tactical Combat Casualty Care
- Tourniquet
- Combat casualty care research
- Analysis of preventable death

Combat Hospital Death



Martin, M et al., J Trauma 2009

DOW Analysis

- Review died of wounds (DOW)deaths n=558
- Data sources
  - DoD Trauma Registry
  - Armed Forces Medical Examiner System (AFMES)
- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity
- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

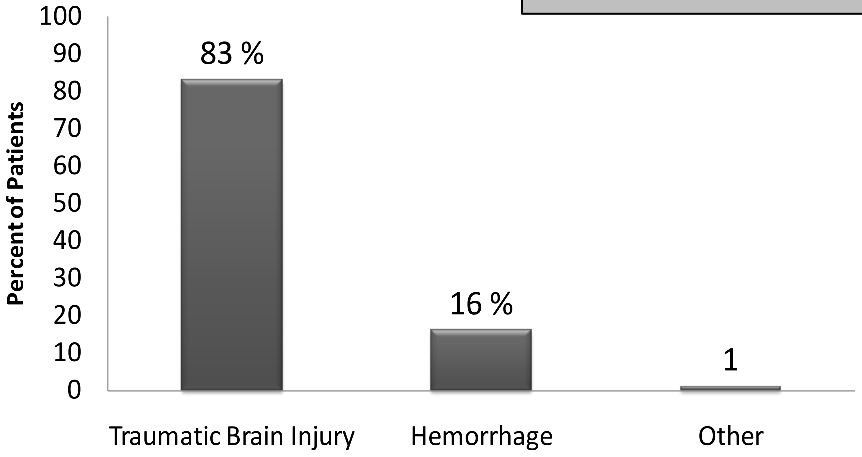
- Goal: Identify areas for improved training, medical care, material, research and development

DOW
Potentially Survivability

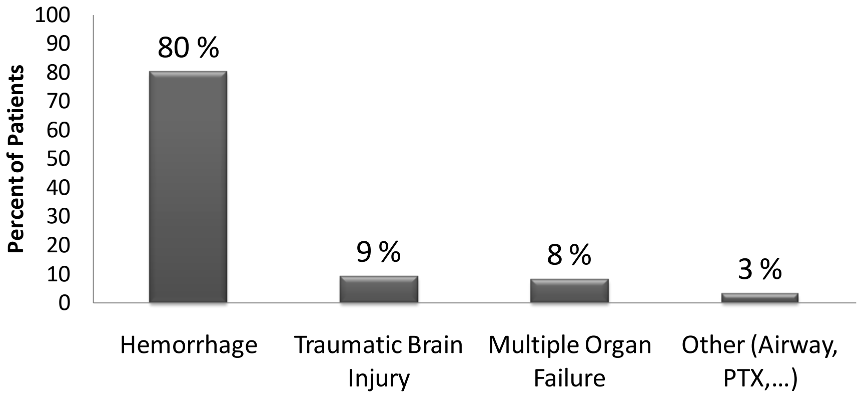
Eastridge et al: Died of Wounds on the Battlefield. J Trauma 2011

- DOW rate 4.6%
- NS in 271 (48.6%) and PS in 287 (51.4%)

Non Survivable

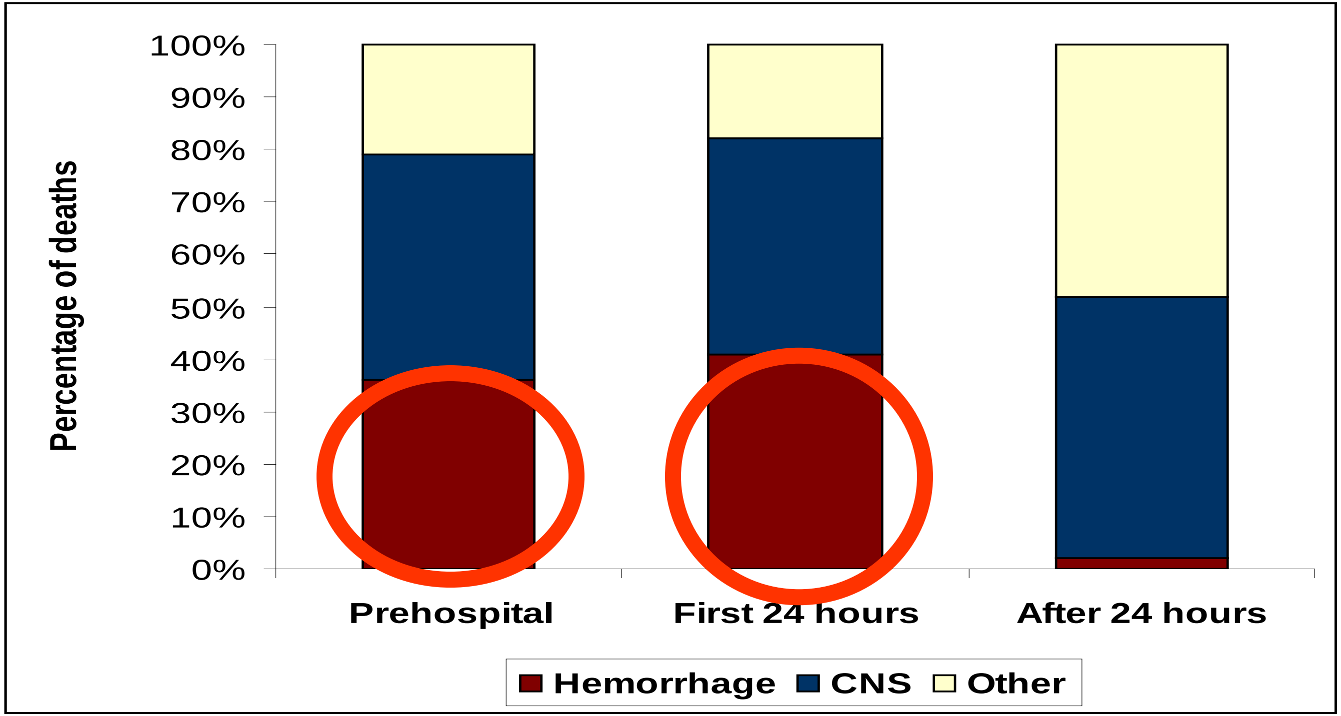


Potentially Survivable



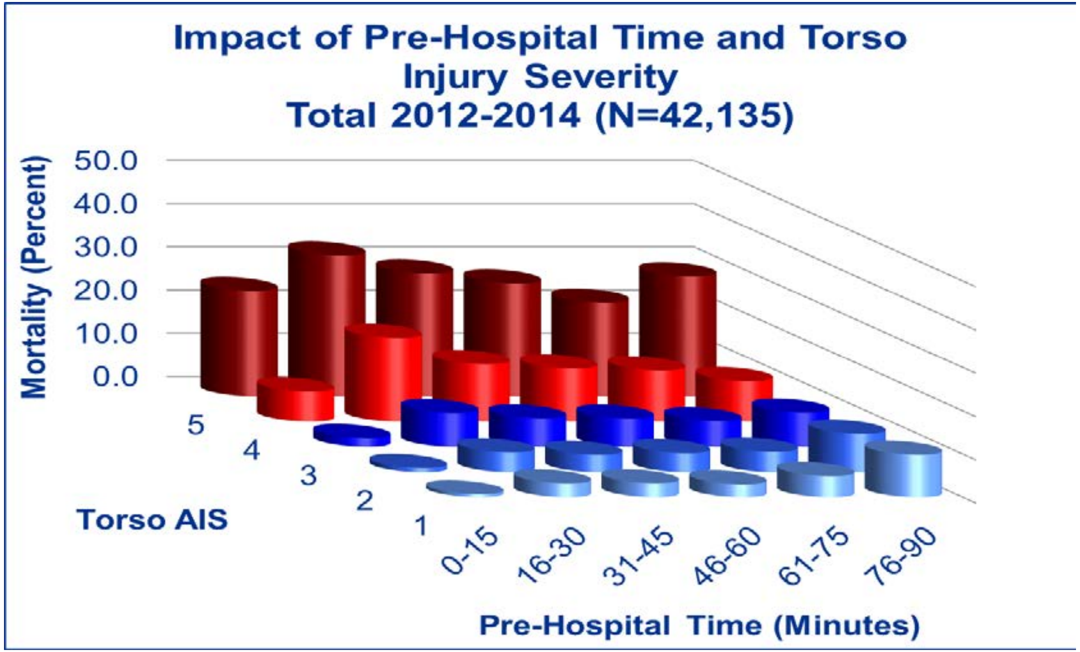
Early Hospital Injury Mortality
Civilian

Civilian Injury Hemorrhage Mortality



Data adapted from: Acosta, et al. *J Am Coll Surg* 1998
& Sauaia, et al. *J Trauma* 1995

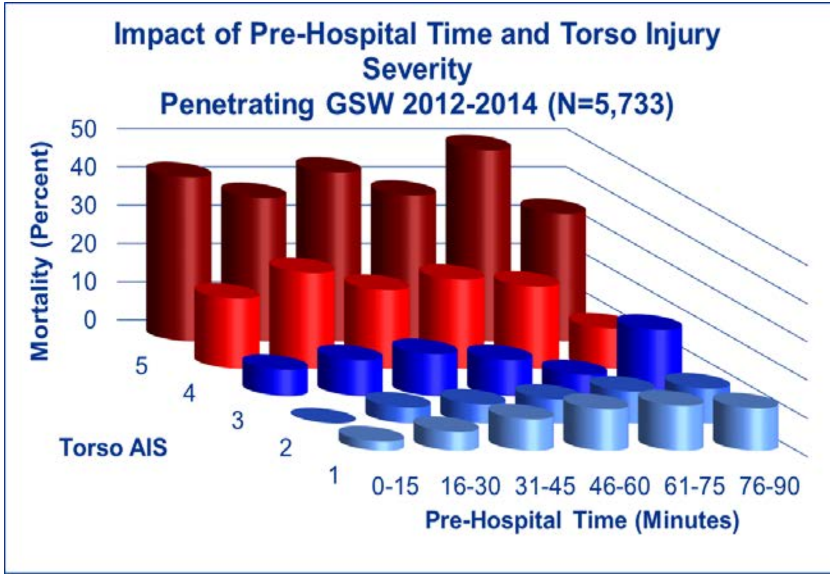
Prehospital Time
Noncompressible Torso Hemorrhage (All)



Alarhayem, Eastridge, et al: Mortality in Trauma Patients with Hemorrhage from Torso Injury Occurs Long Before the "Golden Hour" Am J Surg 2016

Time is the Enemy

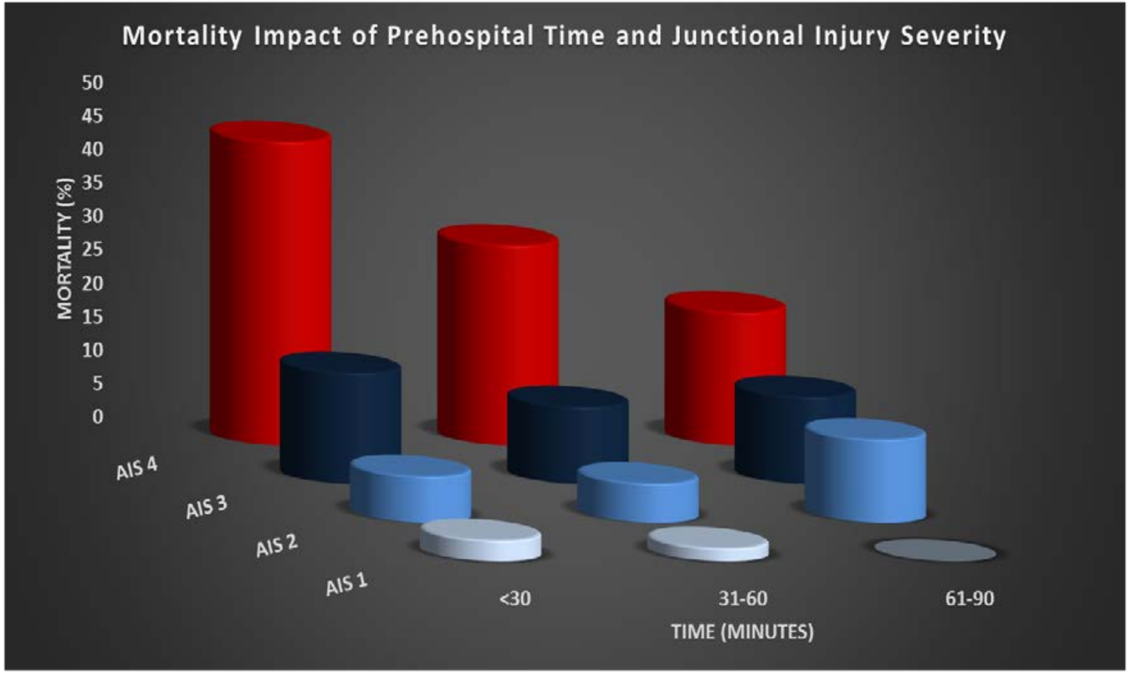
Prehospital Time in Noncompressible Torso Hemorrhage (GSW)



Alarhayem, Eastridge, et al: Mortality in Trauma Patients with Hemorrhage from Torso Injury Occurs Long Before the "Golden Hour" Am J Surg 2016

- **High grade torso injury, AIS grades $\geq$ 4, associated with significant hemorrhage.**
- **Rise in patient mortality was exhibited in high grade injury demonstrated at prehospital times < 30 minutes**
- **Highlights critical nature of prehospital time in patients with non-compressible torso hemorrhage.**
- **Evacuation times < 30 minutes not realistic, particularly in rural or austere environments,**
- **Future efforts should be directed toward the development of therapies to increase the window of survival in the prehospital environment.**

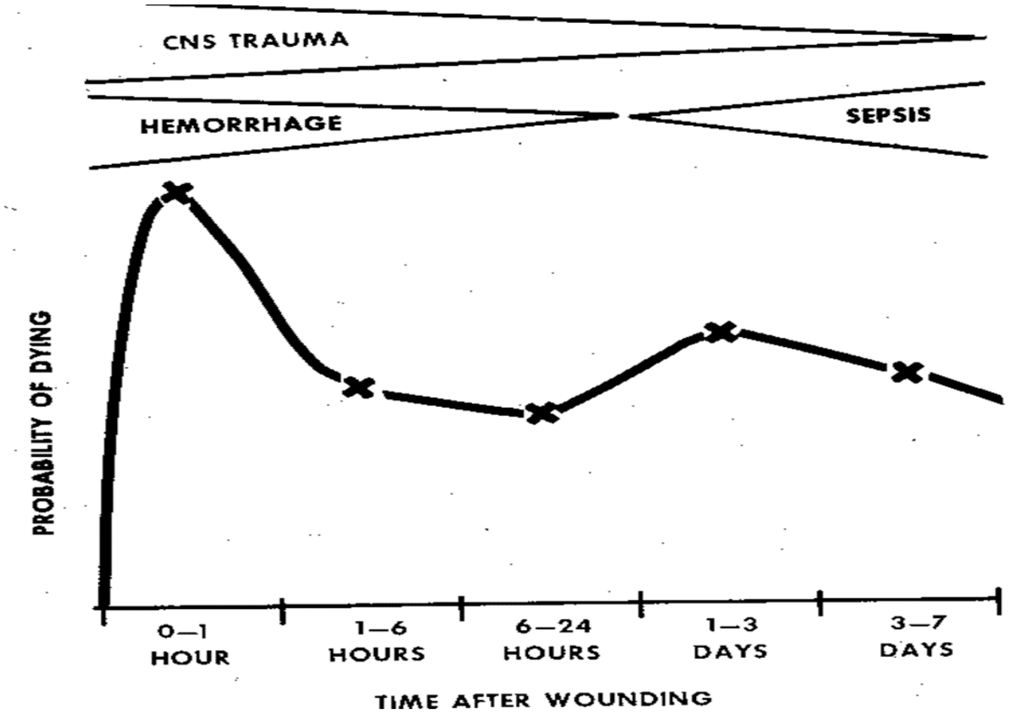
Junctional Hemorrhage and Prehospital Time Impact on Injury Mortality



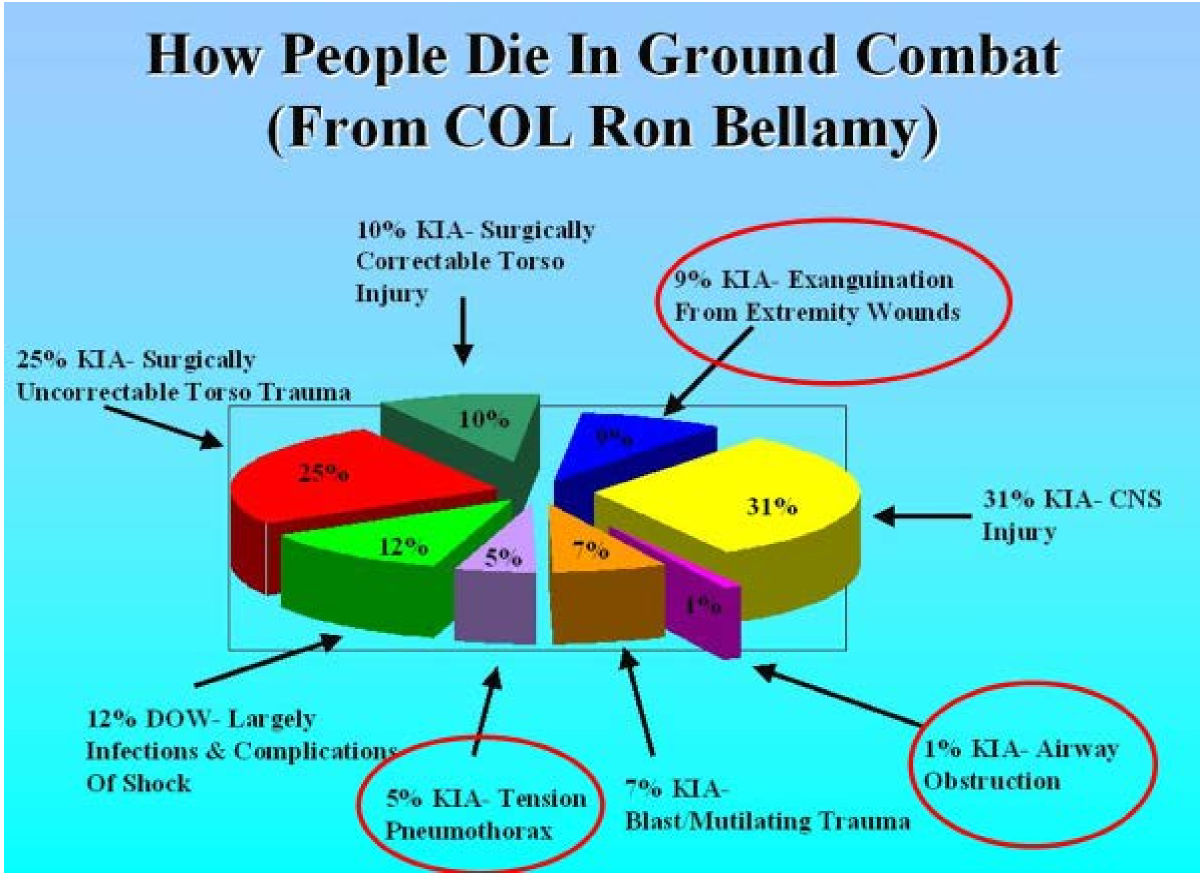
Alarhayem, Eastridge: Highlighting the Need for Novel Strategies to Control Complex Sources of Hemorrhage and Temporize Survival to Definitive Care. Presented MHSRS 2016

Prehospital Injury Mortality
Military

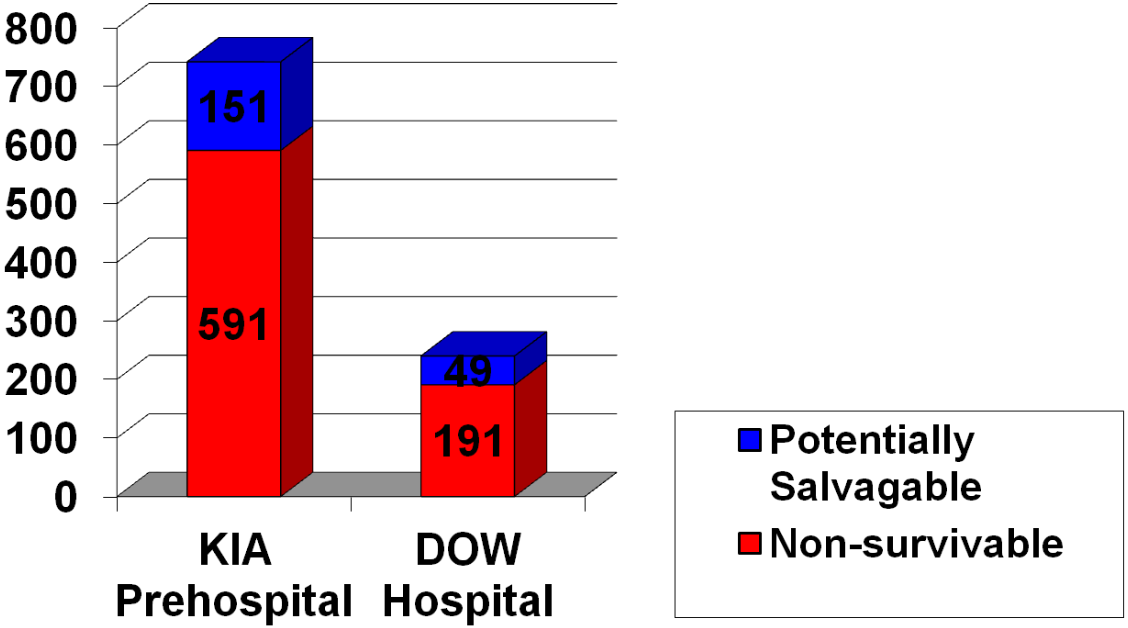
Empiric Probability Combat Death



Bellamy, J Trauma, 1984


How People Die In Ground Combat
(From COL Ron Bellamy)
10% KIA- Surgically Correctable Torso Injury
9% KIA- Exanguination From Extremity Wounds
25% KIA- Surgically Uncorrectable Torso Trauma
10%
9%
25%
31%
12%
5%
7%
1%
31% KIA- CNS Injury
12% DOW- Largely Infections & Complications Of Shock
5% KIA- Tension Pneumothorax
7% KIA- Blast/Mutilating Trauma
1% KIA- Airway Obstruction

Combat Mortality
Early OIF and OEF



Kelly JF, et.al. Injury severity and causes of death from Operation Iraqi Freedom and Operation Enduring Freedom: 2003-2004 versus 2006. J Trauma

Killed in Action Analysis

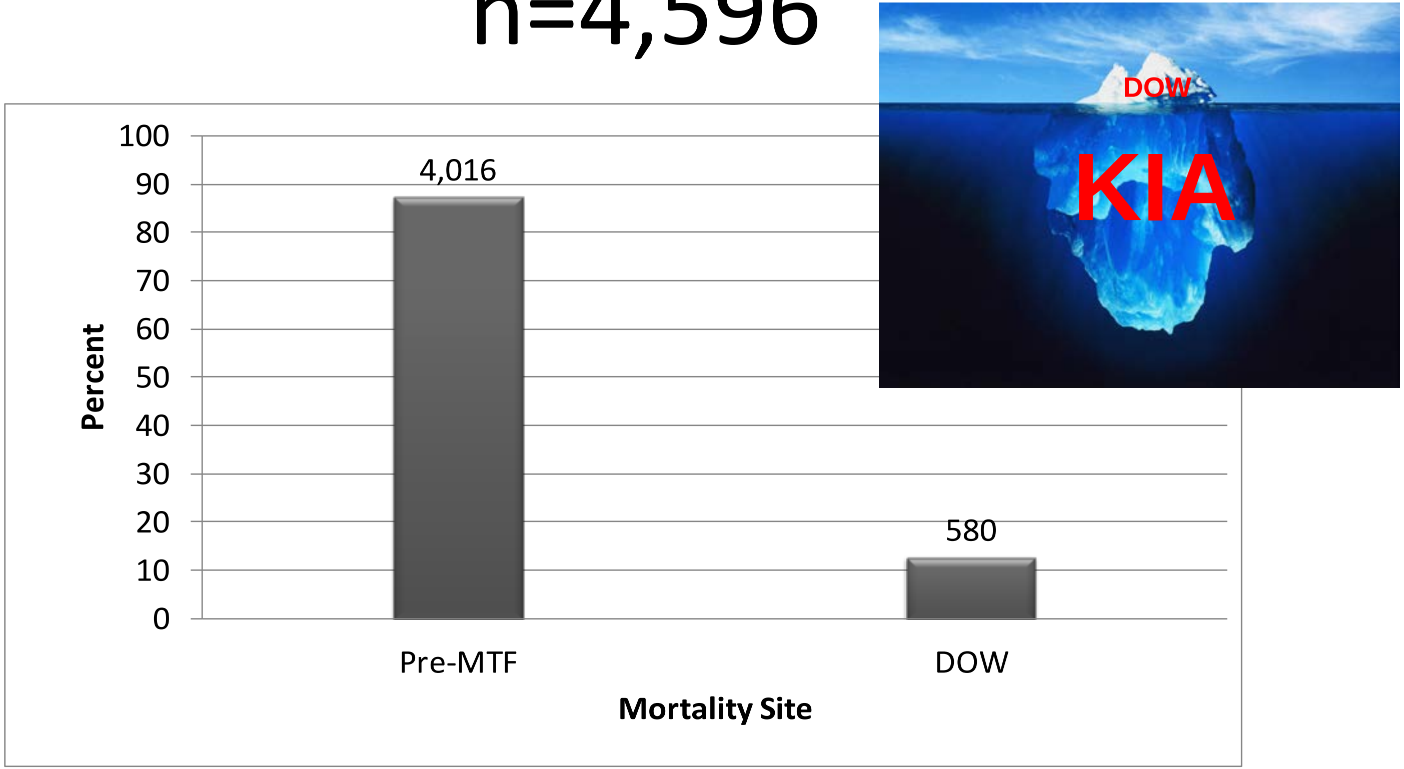
KIA Analysis

- Review battlefield deaths (n=4,596)
- Data sources
  - DoD Trauma Registry
  - Armed Forces Medical Examiner System (AFMES)
- Variables
  - – Demographics
  - – Mechanism and cause
  - – Injury severity
- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

- Goal: Identify areas for improved training, medical care, material, research and development

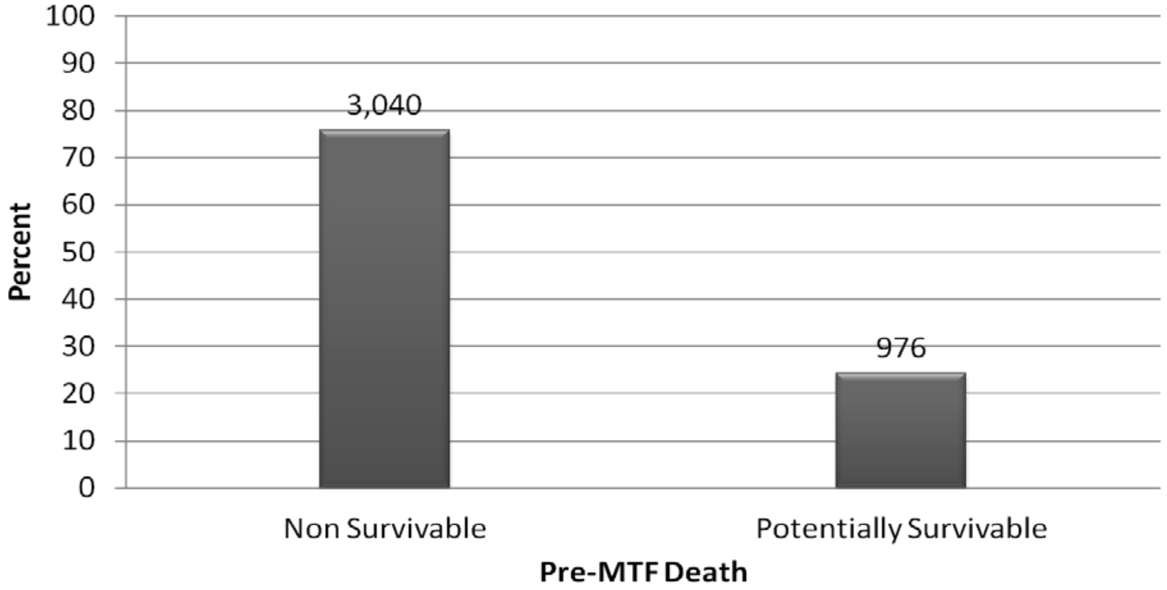
Where Battlefield Casualties Die

n=4,596



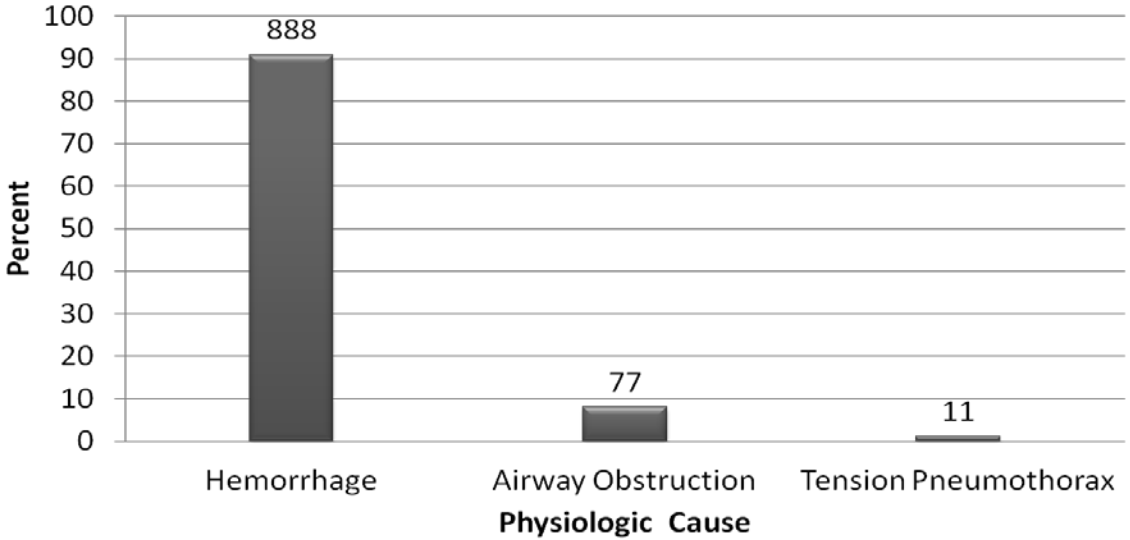
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield Pre-Hospital Death Analysis n=4,016 (DOW excluded)



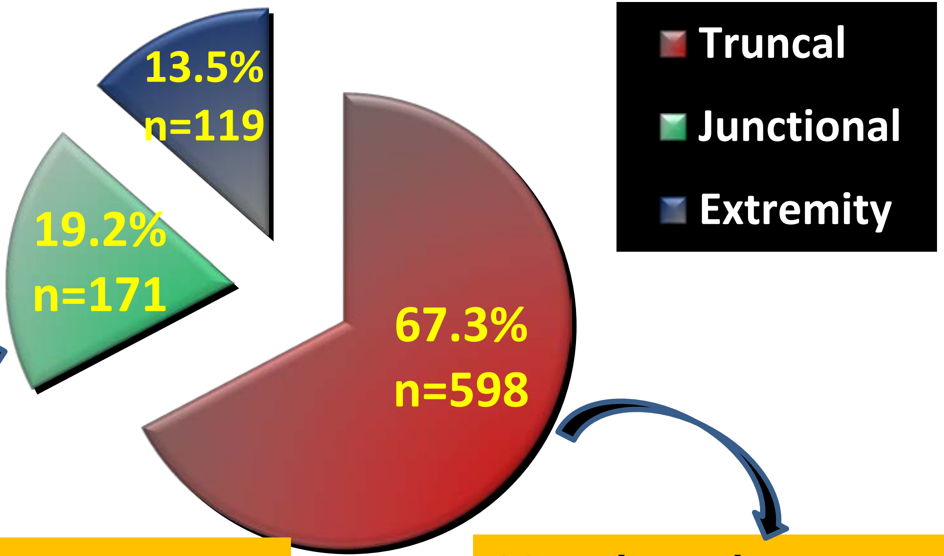
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield Acute Lethality Potentially Survivable n=976



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Anatomic / Physiologic Cause of Death

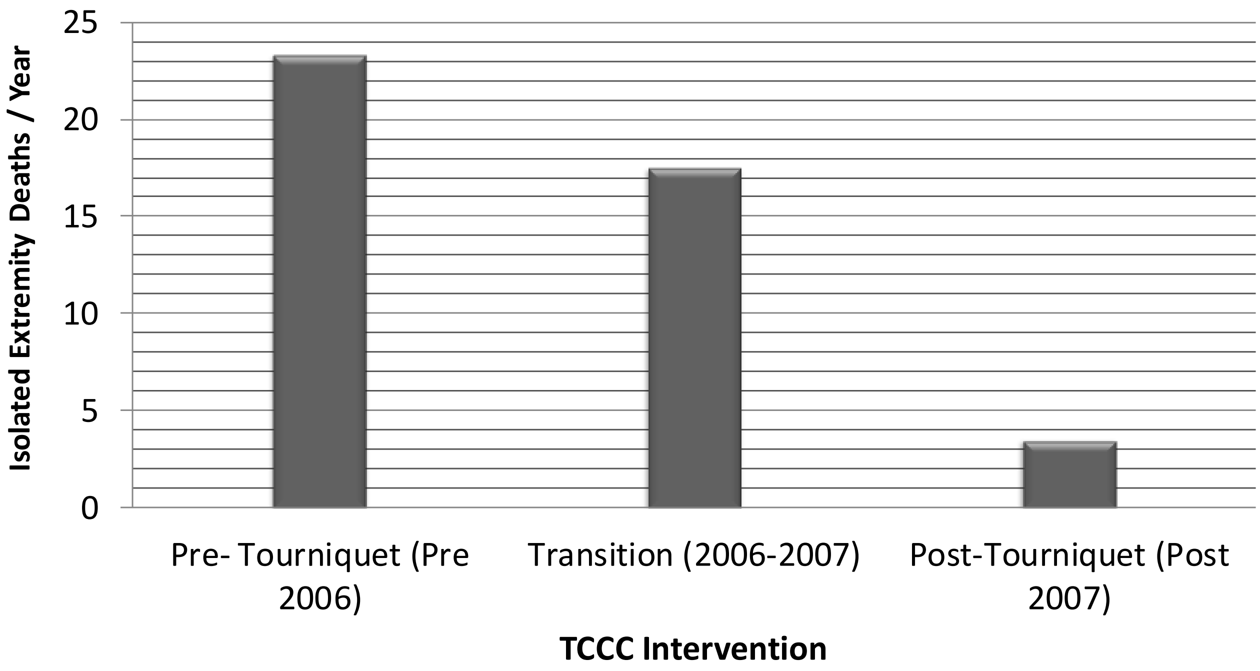


39% Cervical
61% Axilla and Groin

36% Thoracic
64% Abdominopelvic

Eastridge BJ, Mabry RL, Seguin PG, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. Journal of Trauma, 2012. In press.

Can We Have An Impact?



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

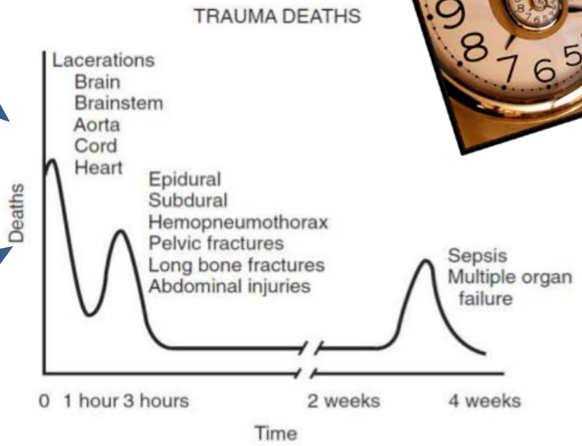
Civilian Prehospital Injury Mortality

Background/Scientific Rationale
Pre-Hospital Mortality Civilian

Impact Not Well Quantitated

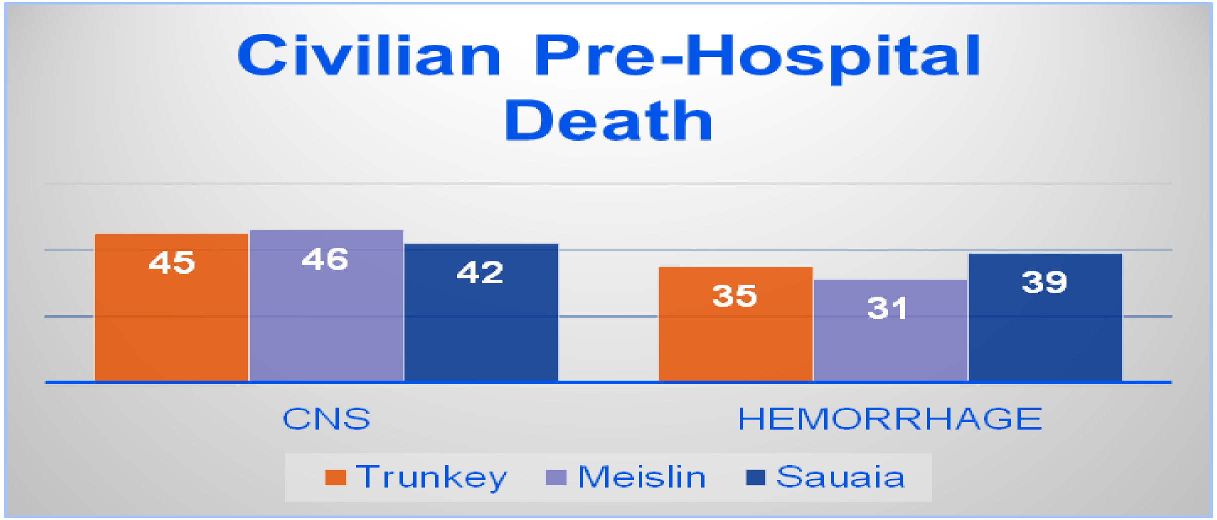
Potential Survivability Poorly Defined

NASEM Report Emphasis



Case Fatality Rate (CFR) ~ 4.1% /
2-5 % Hospital Mortality Potentially Preventable

Civilian Injury Death Pre-Hospital

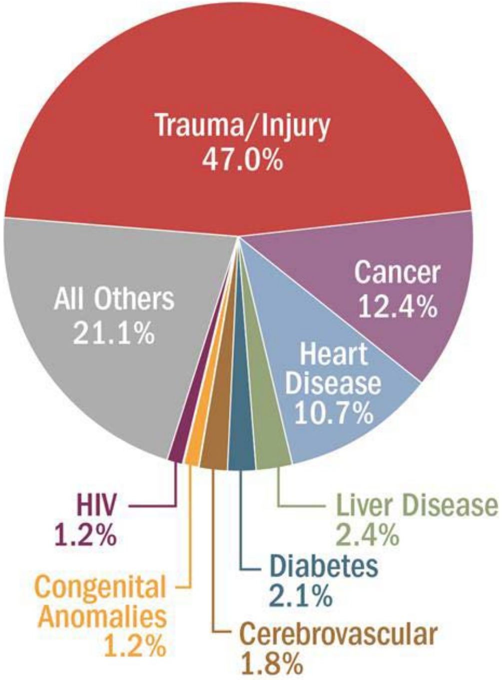


Sauaia A, Moore FA, Moore EE, Moser KS, Brennan R, Read RA, Pons PT. Epidemiology of trauma deaths: a reassessment. *J Trauma*1995;38(2):185–193.

Meislin H, Criss EA, Judkins D, Berger R, Conroy C, Parks B, Spaite DW, Valenzuela TD. Fatal trauma: the modal distribution of time to death is a function of patient demographics and regional resources. *J Trauma* 1997;43(3):433–440.

Trunkey DD, Lim RC. Analysis of 425 consecutive trauma fatalities: anautopsy study. *J Am Coll Emerg Phys* 1974;3(6):368–371.

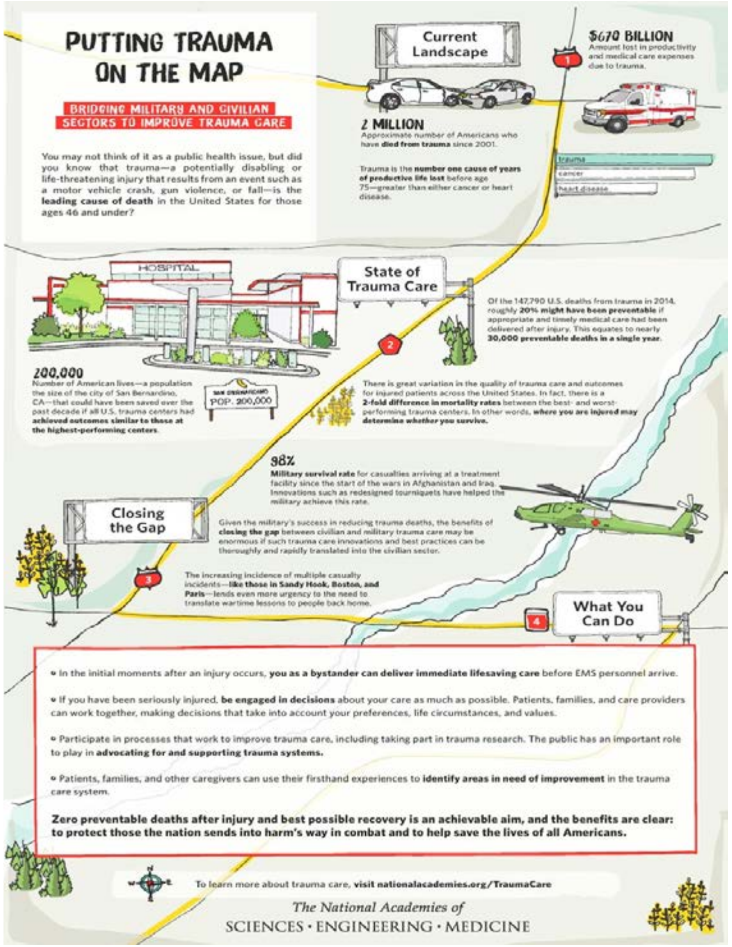
Trauma System
Scope of the Problem



- **Potentially survivable injuries US military operations**
  - **1,273 / 4,574 (27.6%)**
- **Potentially survivable injuries US civilian population 2014**
  - **147,790 x 0.276 = 40,790**

Getting Beyond Estimates

Objectively establishing the need to push care forward



Multiinstitutional Multidisciplinary Injury Mortality Investigation in Civilian PreHospital Environment

PIs:Eastridge, Nolte, MacKenzie

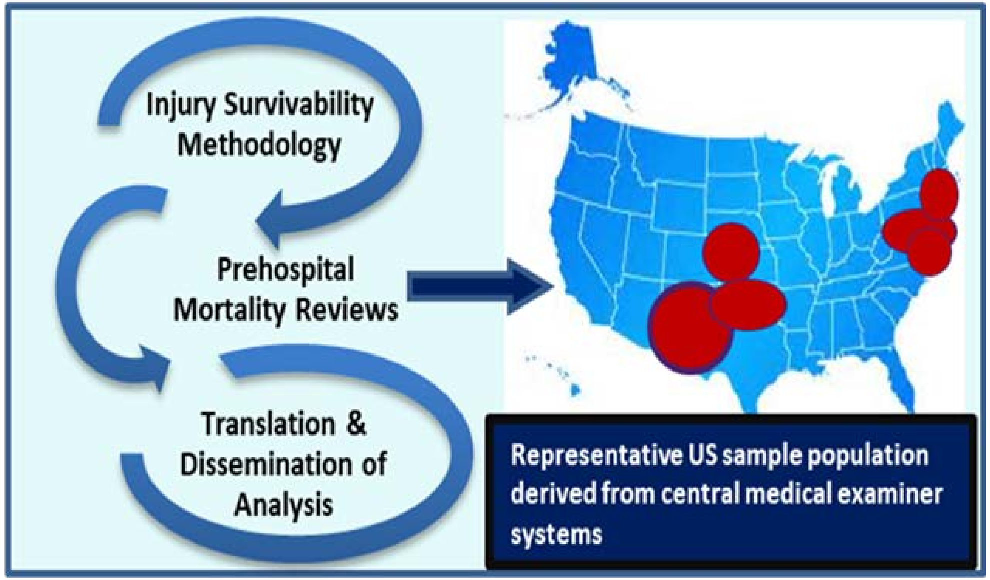
Funded by USAMRMC
(Department of Defense)

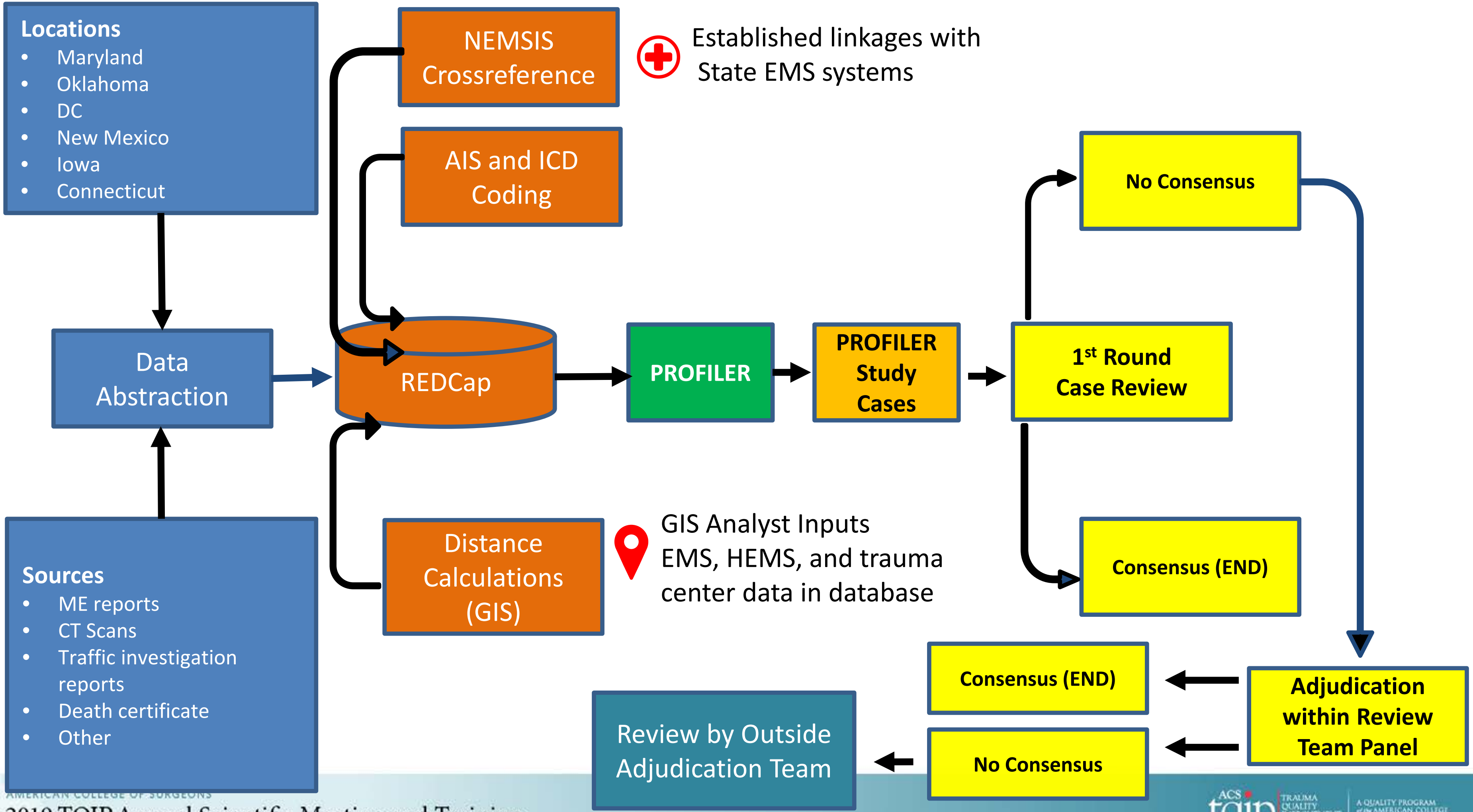
Purpose of this proposal is to develop a coordinated, multidisciplinary, multi-institutional effort within the civilian clinical sector to identify and characterize the causes of pre-mortality from trauma

Identify potential high yield areas for research and development in pre-hospital medical care, injury prevention, and trauma systems.

Multi-Disciplinary Multi-Institutional Mortality Investigation in the Civilian Prehospital Environment (MIMIC)

- **Develop a framework for evaluating the causes and pathophysiology of pre-hospital deaths**
- **Network of experts identify the causes of 3,000 pre-hospital deaths due to trauma and estimate potential for survivability.**
  - **Trauma surgery**
  - **Neurosurgery**
  - **Orthopedic surgery**
  - **Forensic pathology**
  - **Emergency medicine**
  - **Emergency medical services**





Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages with State EMS systems
AIS and ICD Coding
Data Abstraction
REDCap
PROFILER
PROFILER Study Cases
1st Round Case Review
No Consensus
Consensus (END)
Distance Calculations (GIS)
GIS Analyst Inputs EMS, HEMS, and trauma center data in database
Sources
ME reports
CT Scans
Traffic investigation reports
Death certificate
Other
Adjudication within Review Team Panel
Consensus (END)
No Consensus
Review by Outside Adjudication Team

Preliminary Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

	Frequency
	322 (78%)
	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

Note: Using 414 cases that have reached consensus on survivability assessments

Preliminary Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency
	389 (94%)
	24 (6%)
	1
Cannot Judge	0

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using 414 cases that have reached consensus on survivability assessments

Immediate Access Survivability	Frequency
Non-survivable	322 (78%)
Potentially Survivable	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	[illegible]equency
Non-survivable	[illegible]9 (94%)
Potentially Survivable	24 (6%)
Definitely Survivable	1
Cannot Judge	0

Translating Injury Mortality Data into Trauma System Development

Interventions with potential to impact injury mortality

- Pre-injury prevention
  - oz prevention = lb cure (therapeutic revolution)
- Trauma system development
  - EMS (pre-hospital intervention high yield)
  - Acute care
  - Regional networks
- Novel interventions for hemorrhagic shock
  - NTI – Increased funding for trauma research
- Performance Improvement
  - Preventable death registry

Lessons Learned from the "UnMissing" Dead

- Death secondary to injury major problem for civilians and military
- Majority of deaths in occur pre-hospital environment
  - CNS injury and hemorrhagic shock
  - Many hemorrhage deaths potentially survivable
  - Incremental benefit for outcome with interventions more proximate to time of injury

Potential System Benefits of Developing a Comprehensive Perspective of ALL Injury Mortality

Trauma

- Military / civilian trauma system evolution
- Performance improvement
  - Engineering
  - Medical devices / procedures
  - EMS value validation
  - Injury Prevention
- Integration of ME and injury data sources
- Collaboration between trauma and ME communities

Medical Examiner

- Support for enhanced ME systems / resources
- Funding for radiological imaging / advanced technology
- Bridge the gap between ME and trauma care providers

COMBAT CASUALTY MORTALITY:

Survivability of Injury, Preventability of Death and their Implications to the Joint Trauma System and the Warfighter

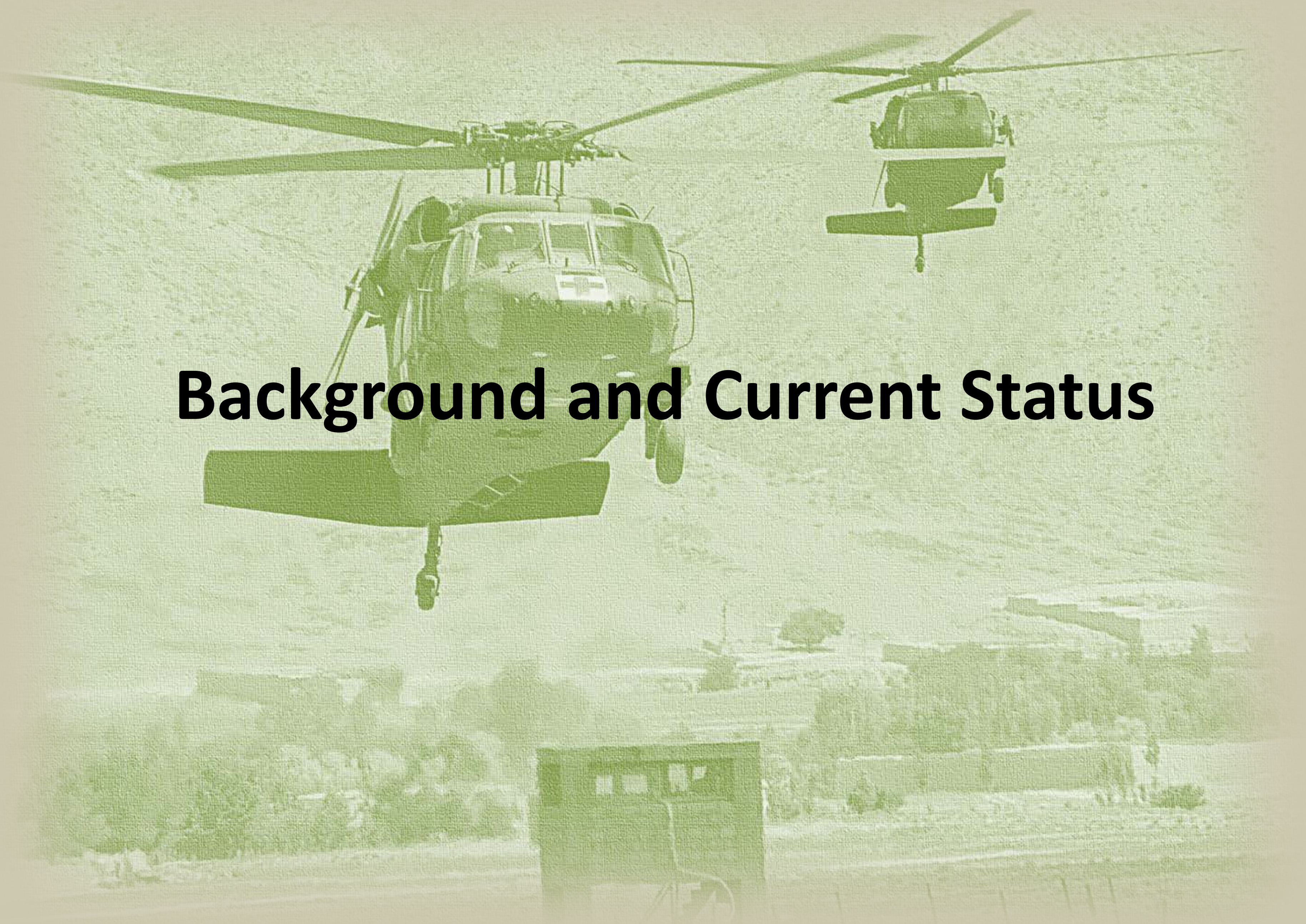
Combat Trauma Care Workshop
18 November 2019

Brian Eastridge, MD, FACS
COL, MC, USAR
Professor, Department of Surgery
Division of Trauma and Emergency Surgery
University of Texas Health Science Center at San Antonio

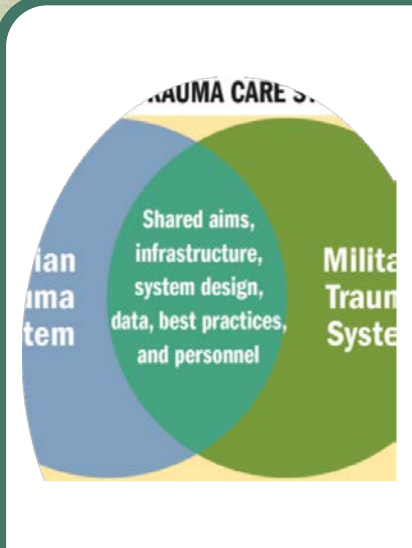
Disclosure / Disclaimer

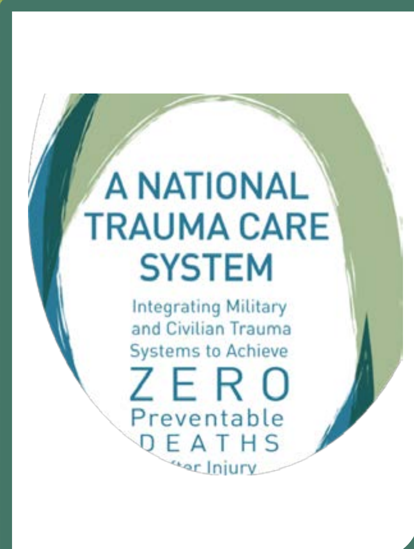
Nothing to disclose

The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.



Background and Current Status





National Trauma System Vision

A unified effort is needed to ensure the delivery of optimal trauma care to save the lives of Americans injured within the United States and on the *battlefield.*

NASEM 2016

FINDINGS & RECOMMENDATIONS

- The Aim (Rec 1)
- Role of Leadership
  - National-Level Leadership (Rec 2)
  - Military Leadership (Rec 3)
  - Civilian Sector Leadership (Rec 4)
- Integrated Military–Civilian Framework for Learning to Advance Trauma Care
  - Improving the Collection, Integration, and Use of Data (Recs 5 and 9)
  - Collaborative Research Infrastructure in a Supportive Regulatory Environment (Recs 7 and 8)
- Systems and Incentives for Improving Prehospital Trauma Care
  - Quality (Rec 10)
  - Developing Expertise (Recs 6 and 11)

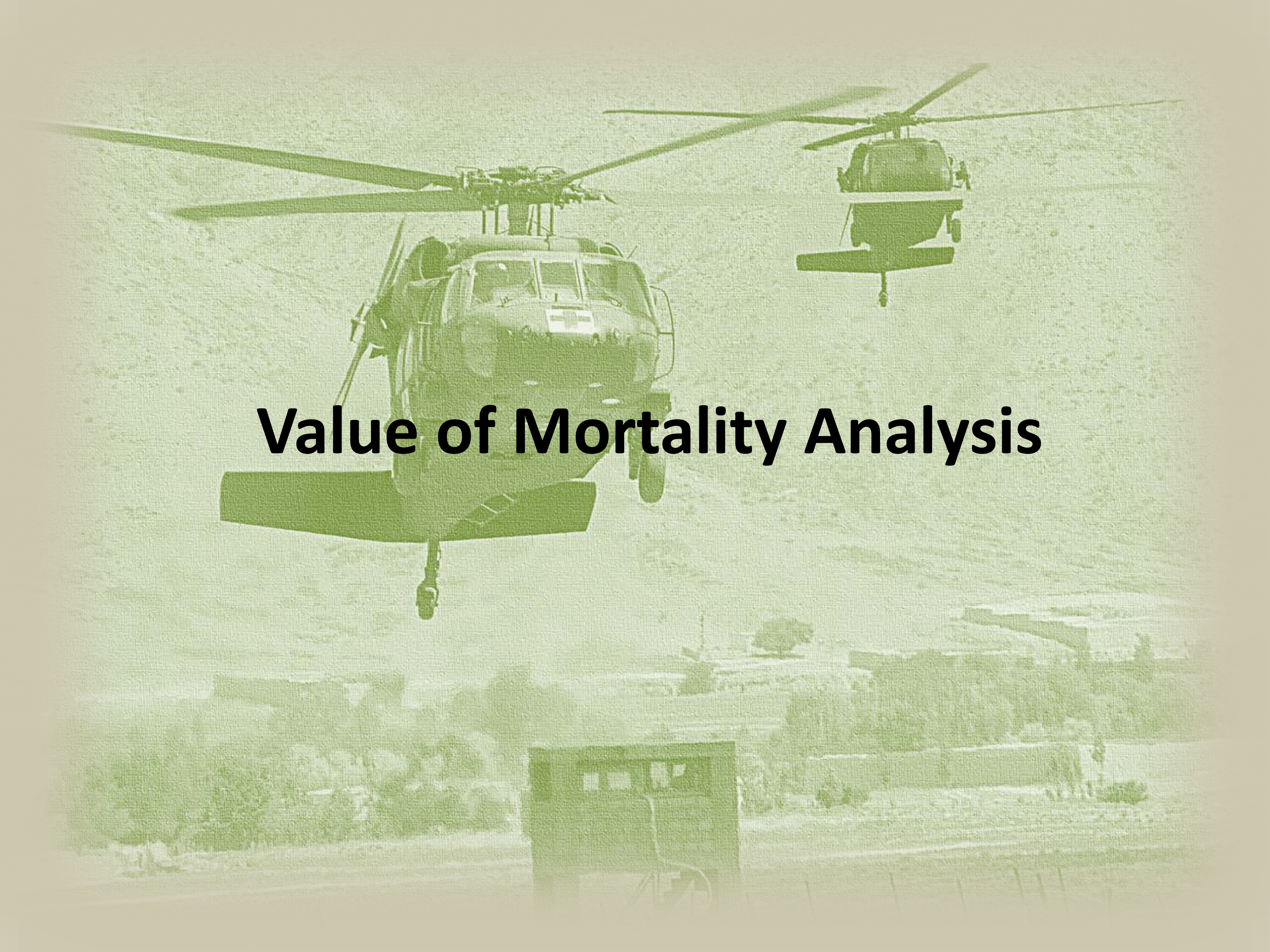
Fundamental Gap

Missing Dead:
Trauma System Blind Spot

- 1. portion of a field that cannot be seen or inspected with available equipment
- 2. failure to exercise judgment or discrimination
- 3. lack of understanding or impartiality

If we do not recognize it, we will not develop strategies to remediate

Value of Mortality Analysis



IOM Report 1966

"If this opportunity to ascertain the specific cause of death is to be grasped, complete autopsies must be performed routinely on those who have died as the result of injury. Furthermore, the findings in large numbers of autopsies must be critically analyzed in order to point the way to necessary changes in treatment."

ACCIDENTAL DEATH AND DISABILITY:
THE NEGLECTED DISEASE
OF MODERN SOCIETY

Prepared by the

COMMITTEE ON TRAUMA AND COMMITTEE ON SHOCK
DIVISION OF MEDICAL SCIENCES
NATIONAL ACADEMY OF SCIENCES
NATIONAL RESEARCH COUNCIL

NATIONAL ACADEMY OF SCIENCES — NATIONAL RESEARCH COUNCIL
Washington, D. C., September, 1966

NASEM Findings
Medical Examiner Systems 2003

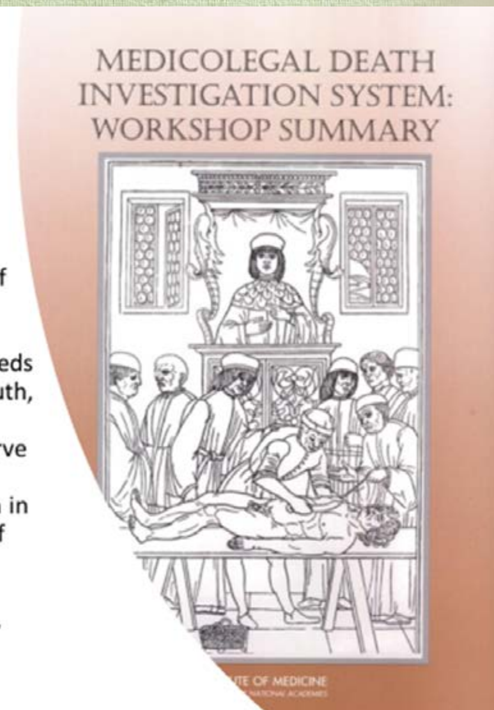
“The current practices of medicolegal death investigation in this country are in substantial need of improvement.

Need accurate data on the circumstances and causes of death

Valuable to public health which accrues to the benefit of the nation as a whole.”

Value of a Functional Medical Examiner System

“On first glance, official identification of human remains and certification of the cause of death appear to be mundane endeavors that serve mainly private needs of families, insurers, and litigants. In truth, however, valid and reliable data on the circumstances and causes of deaths serve a variety of important public needs, including fair and accurate adjudication in criminal and civil cases, maintenance of accurate vital statistics, effective public health surveillance and response, advances in health and safety research, and improvement in quality of heath care.”



NASEM Zero Preventable Death

Specific Recommendations for Mortality Analysis and ME System Integration

Gap:

Linkages are incomplete or entirely missing among prehospital care; hospital-based acute care; rehabilitation; and medical examiner data.

“A critical but often neglected source of data—particularly in civilian systems—is autopsy reports on trauma deaths, which could be used to determine the preventability of fatalities based on a common, accepted lexicon.”

Recommendation 5:

The Secretary of Health and Human Services and the Secretary of Defense, together with their governmental, private, and academic partners, should work jointly to ensure that military and civilian trauma systems collect and share common data spanning the entire continuum of care

Understanding Combat Casualty Mortality: Developing Targets for Mitigation Strategies

- **Advances in care in both trauma centers and trauma systems have substantially reduced death and disability associated with injury**
- **Substantial opportunity to further reduce deaths in pre-hospital setting.**
  - **Opportunities for trauma system improvement in pre-hospital environment must be identified and remediated in order to reduce the number of potentially preventable deaths.**

Relationship Impacts
Pillars of a Modern Trauma System

- Prevention
- Acute Care
  - Data integration
  - Communications systems
  - EMS
  - Trauma Centers
- Rehabilitation
- Framework for Disaster Preparedness

Mortality Analysis Points of Impact

Joint Trauma System

Learning Healthcare System

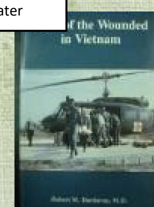
History of Battlefield Medical Innovation

World War I
- IV fluids
- Blood transfusions
- Motorized ambulances
- Topical antisepsis

World War II
- Whole blood/plasma a
- Specialty-specific surgical groups
- Antibiotics
- Fixed wing aero-medical evacuation

Korean Conflict
- Improved fluid resuscitation
- Forward availability of definitive surgery
- Helicopters for patient evac/transport
- Primary repair/grafts for vascular injury

Vietnam
- Improved use of helicopters
- Improved laboratory support
- Portable radiology equipment
- Mechanical ventilators in theater

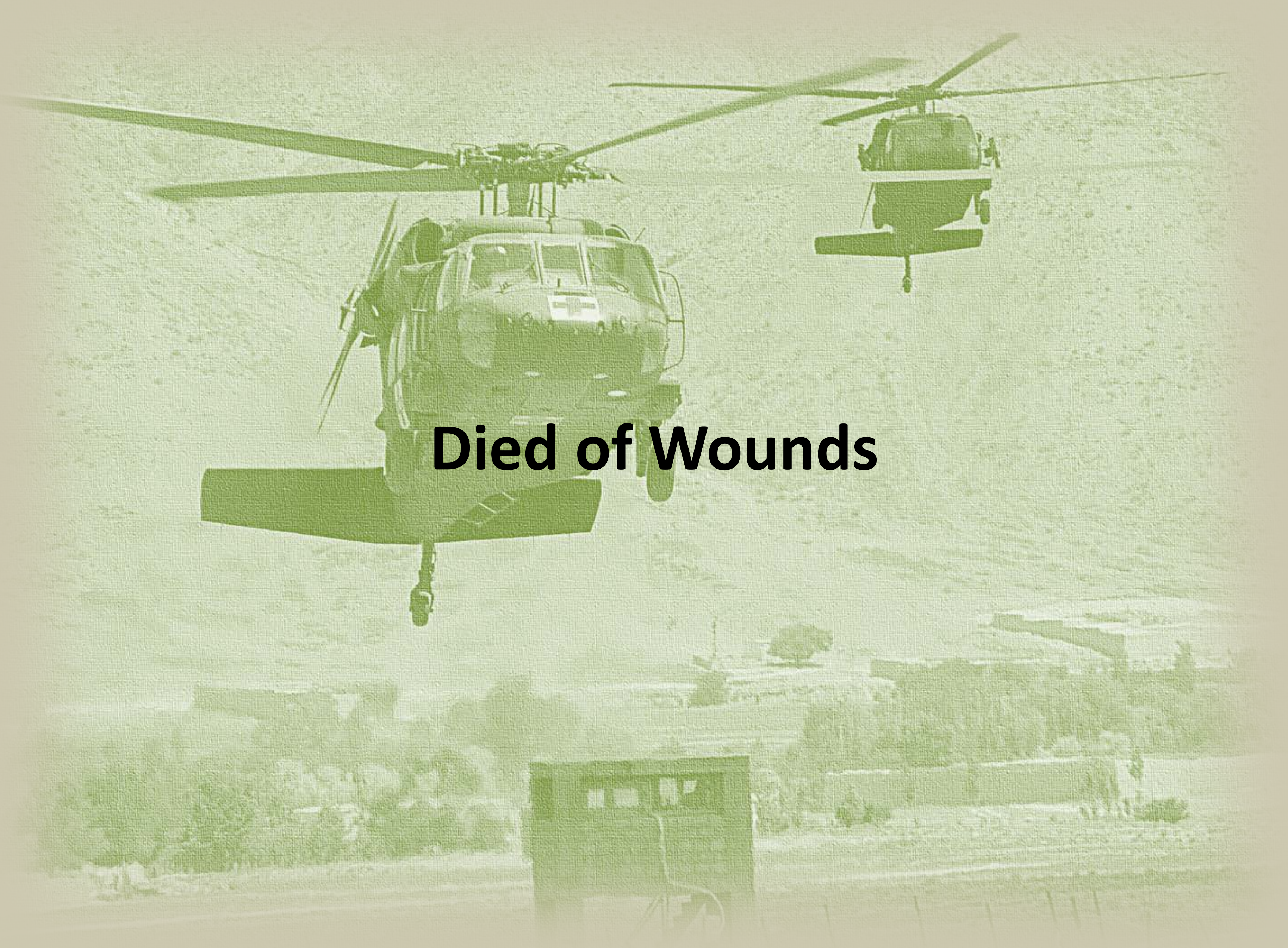


Desert Shield/Storm
- Burn team augmentation of evacuation hospitals to provide theater-wide burn care
- Intercontinental aeromedical transport of burn patients

OEF / OIF
- Military trauma system (JTS / DoDTR)
- Damage control resuscitation
- Tactical Combat Casualty Care
- Tourniquet
- Understanding of preventable death
- Combat casualty care research

Battlefield Mortality Mechanism and Causation

Died of Wounds

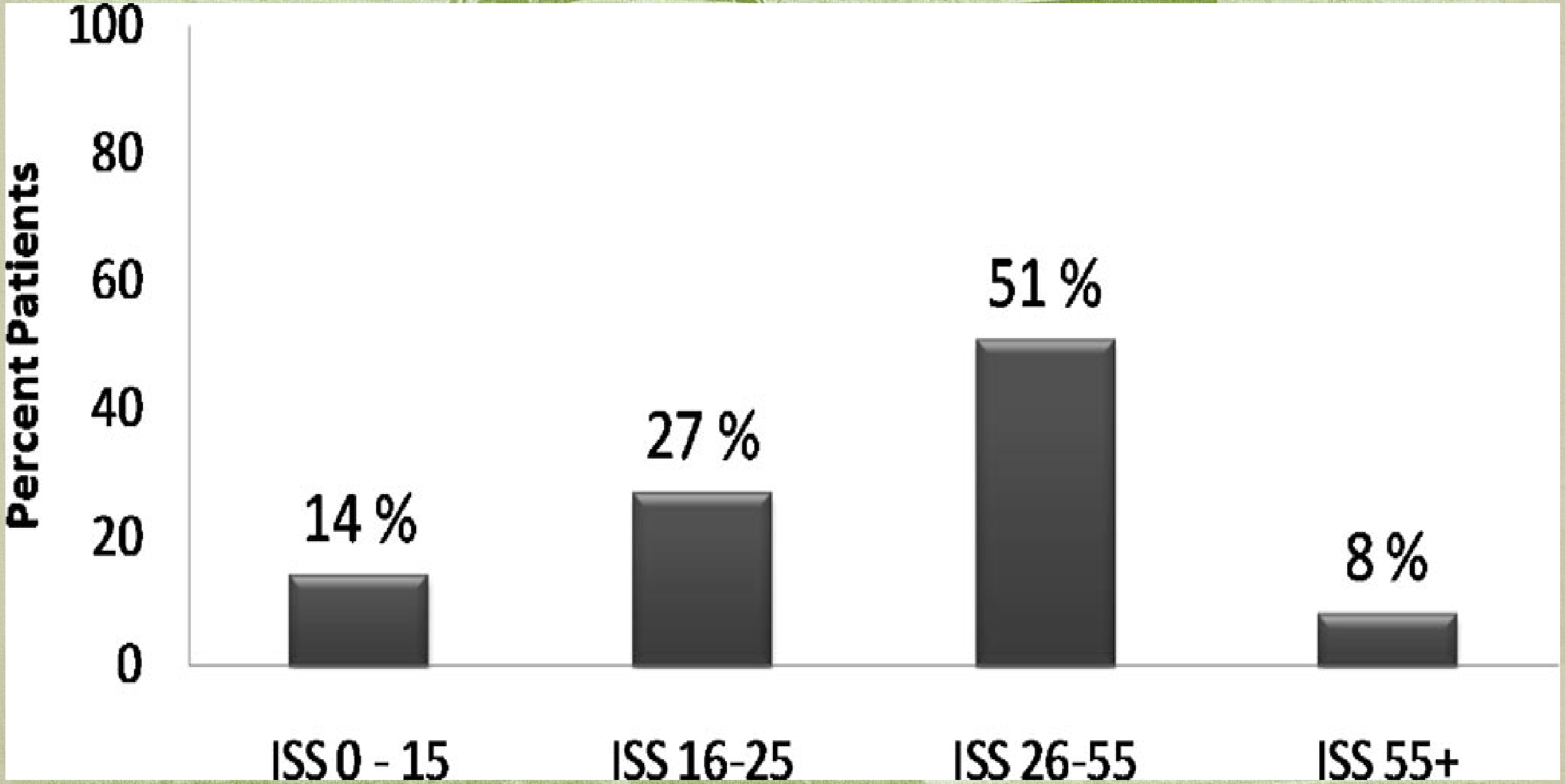


DOW Analysis

- Review died of wounds (DOW)deaths n=558
- Data sources
  - DoD Trauma Registry
  - Armed Forces Medical Examiner System (AFMES)
- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity
- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

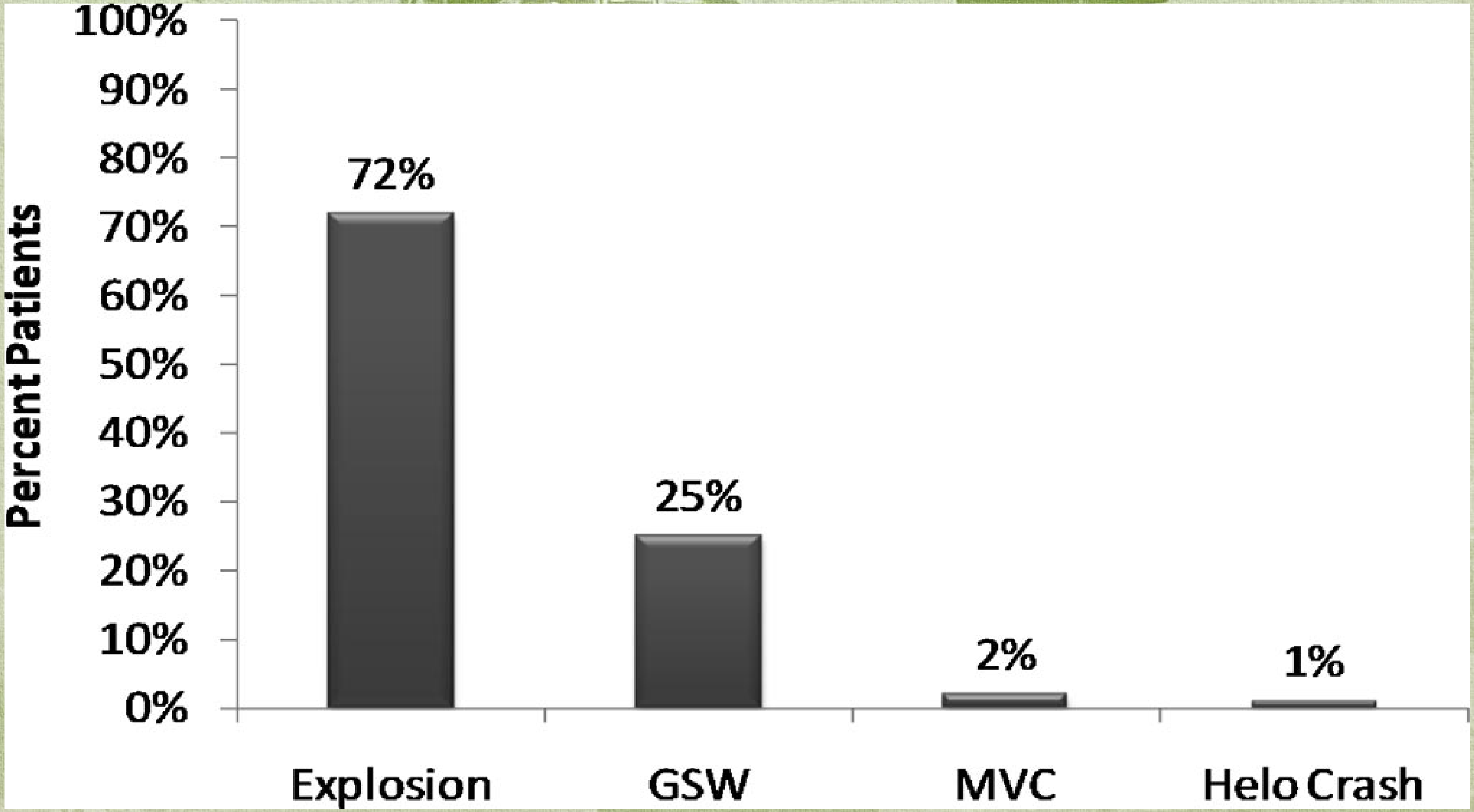
- Goal: Identify areas for improved training, medical care, material, research and development

DOW ISS



Eastridge et al: Died of Wounds on the Battlefield. J Trauma 2011

DOW Cause



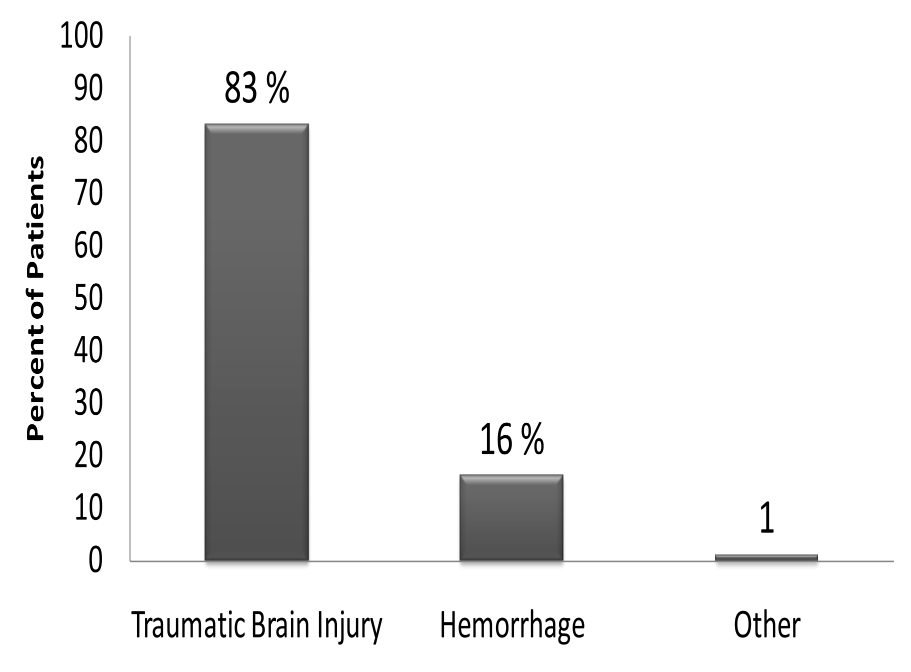
Eastridge et al: Died of Wounds on the Battlefield. J Trauma 2011

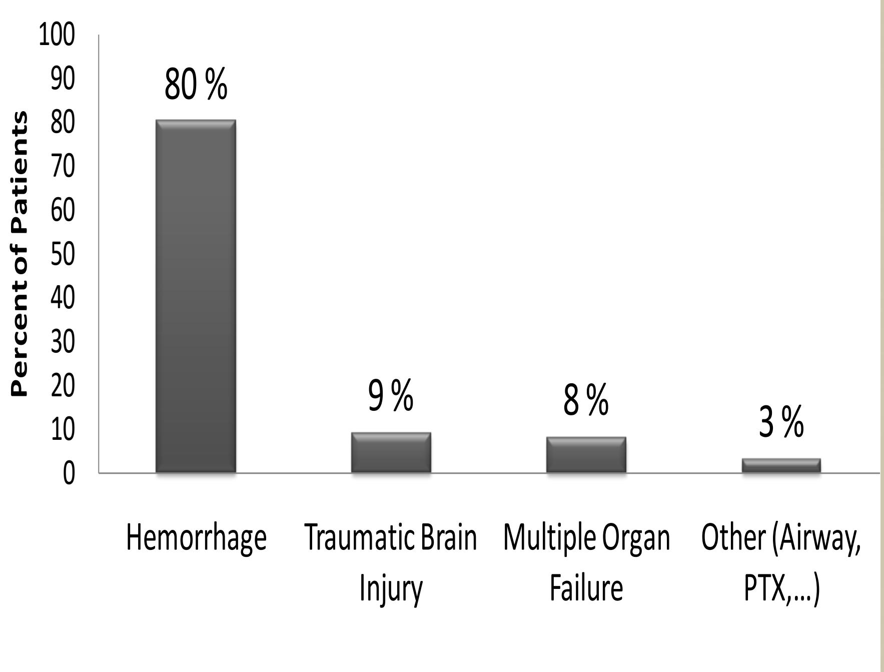
DOW Survivability

Non-Survivable

- DOW rate 4.6%
- NS in 271 (48.6%) and PS in 287 (51.4%)

Potentially Survivable





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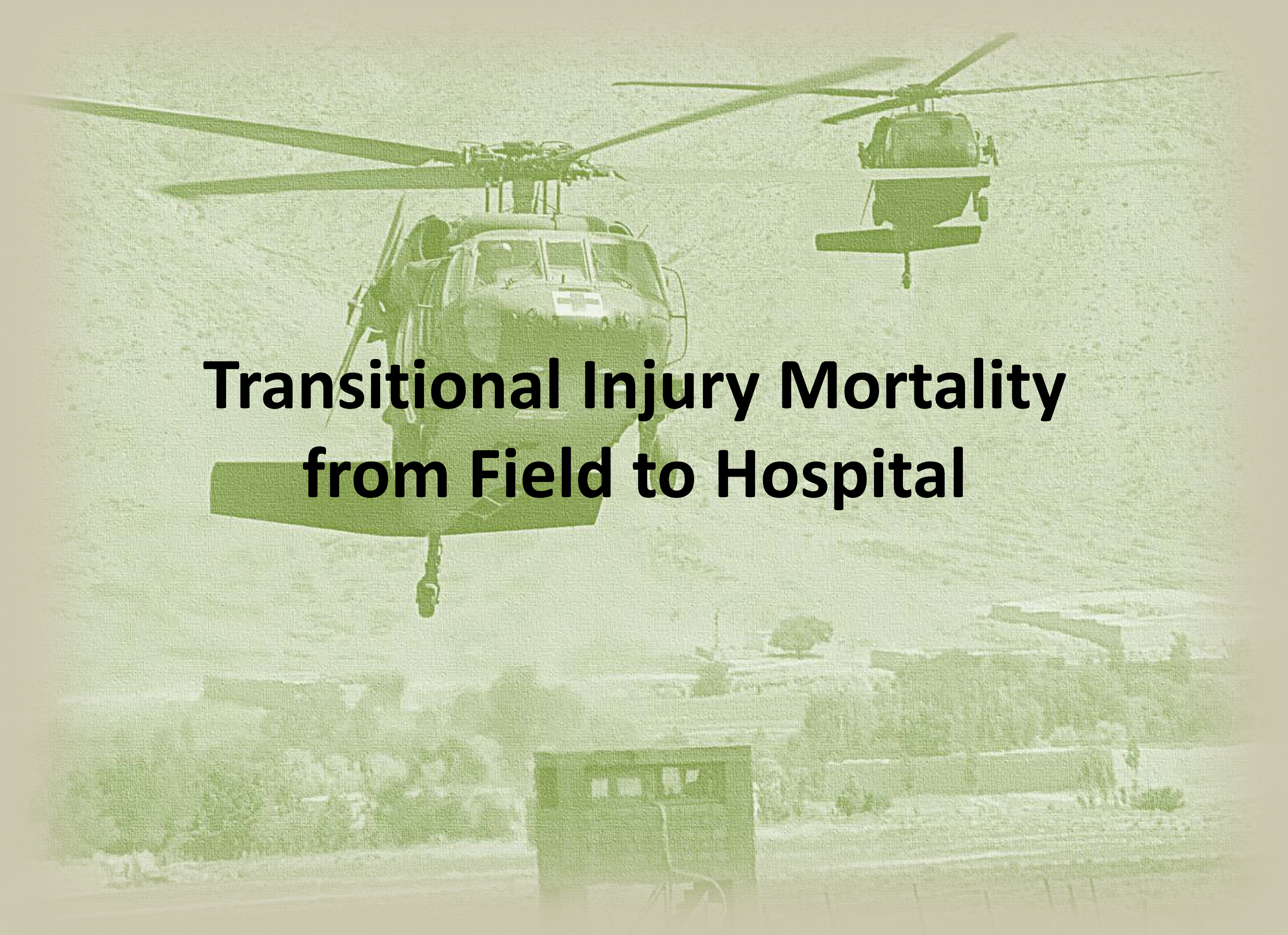
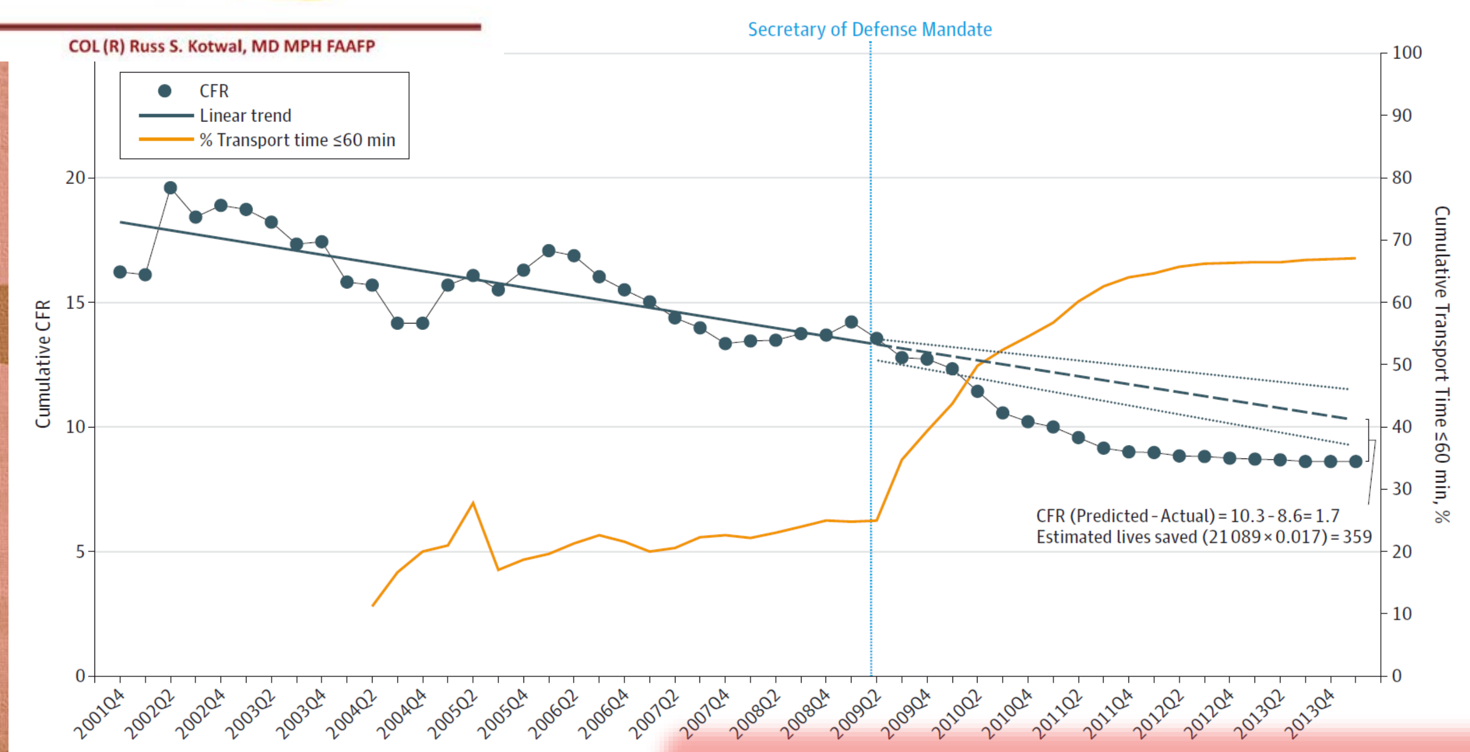


Transitional Injury Mortality from Field to Hospital

Gates Effect

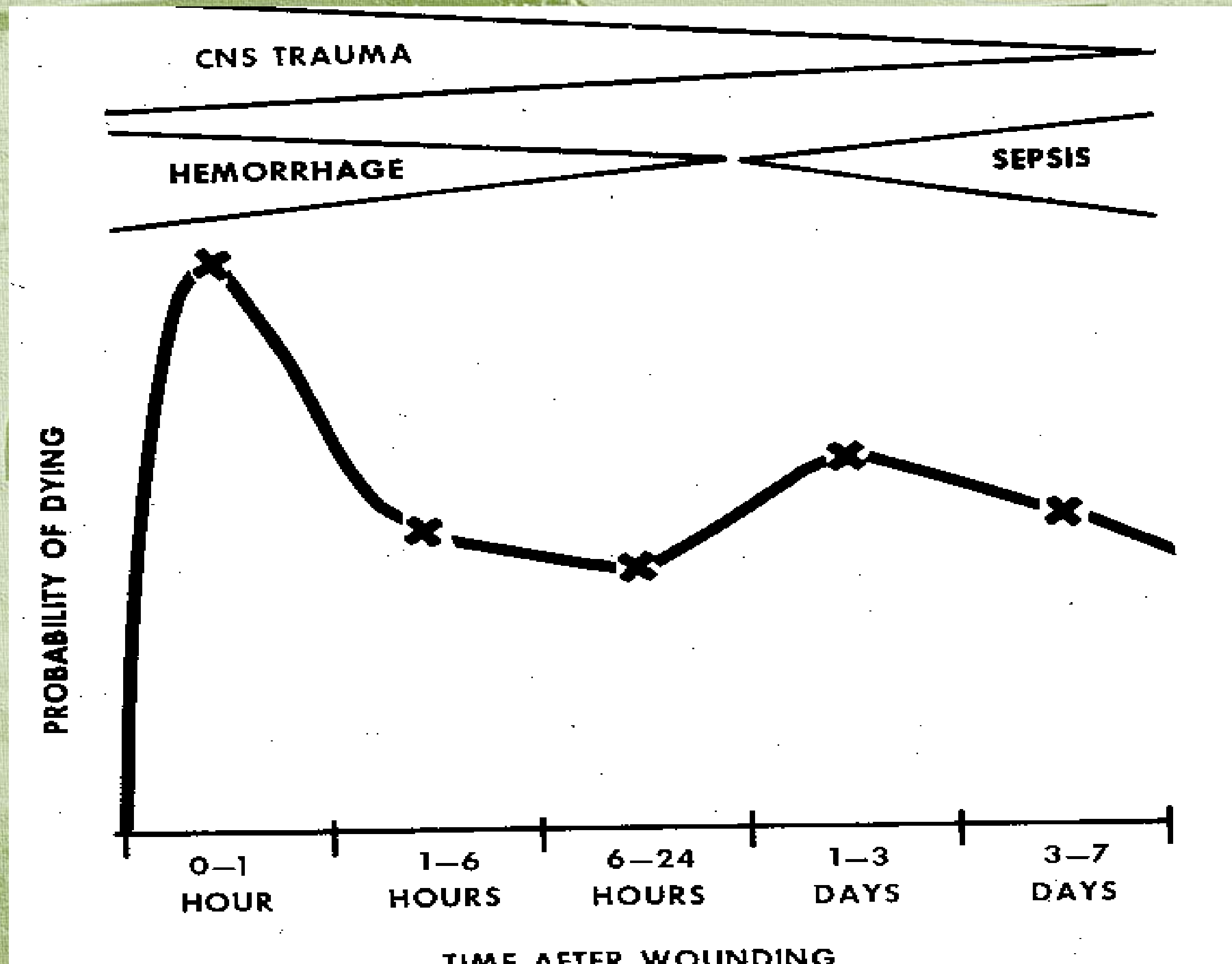


Conclusions

A 2009 mandate by Secretary of Defense Gates reduced the time between critical injury and definitive care for combat casualties in Afghanistan. Despite evidence of increased severity and complexity of wounds from explosive devices, the combination of reduced prehospital transport time and increased treatment capability are likely contributors of casualty survival.

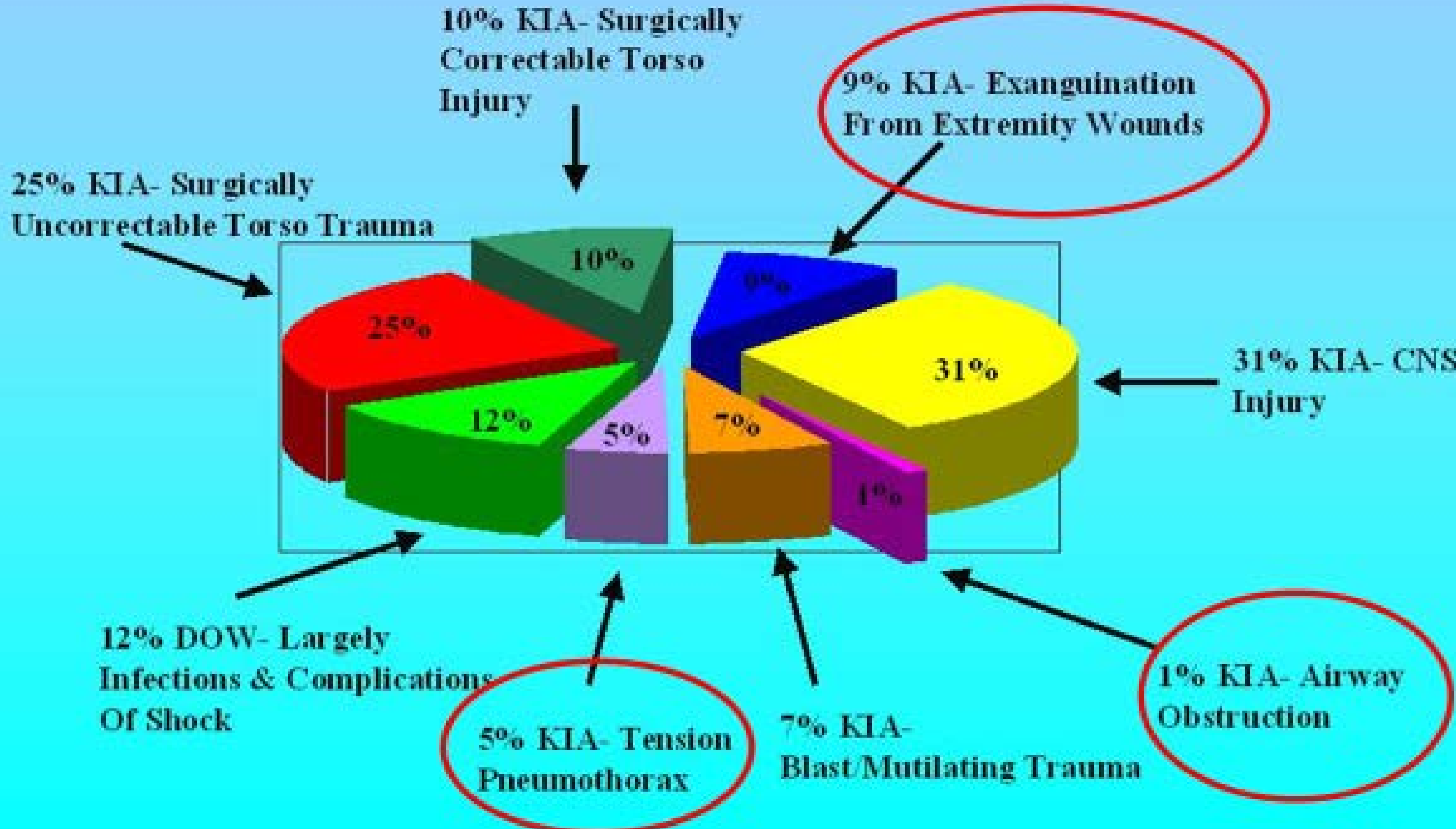
Killed in Action

Empiric Probability of Combat Death



Bellamy, J Trauma, 1984

How People Die In Ground Combat (From COL Ron Bellamy)



KIA Analysis

- Review battlefield deaths (n=4,596)
- Data sources
  - DoD Trauma Registry
  - Armed Forces Medical Examiner System (AFMES)
- Variables
  - Demographics
  - Mechanism and cause
  - Injury severity
- Expert panel trauma surgeons, emergency physician, neurosurgeon, and forensic pathologist graded deaths as non survivable or potentially survivable.

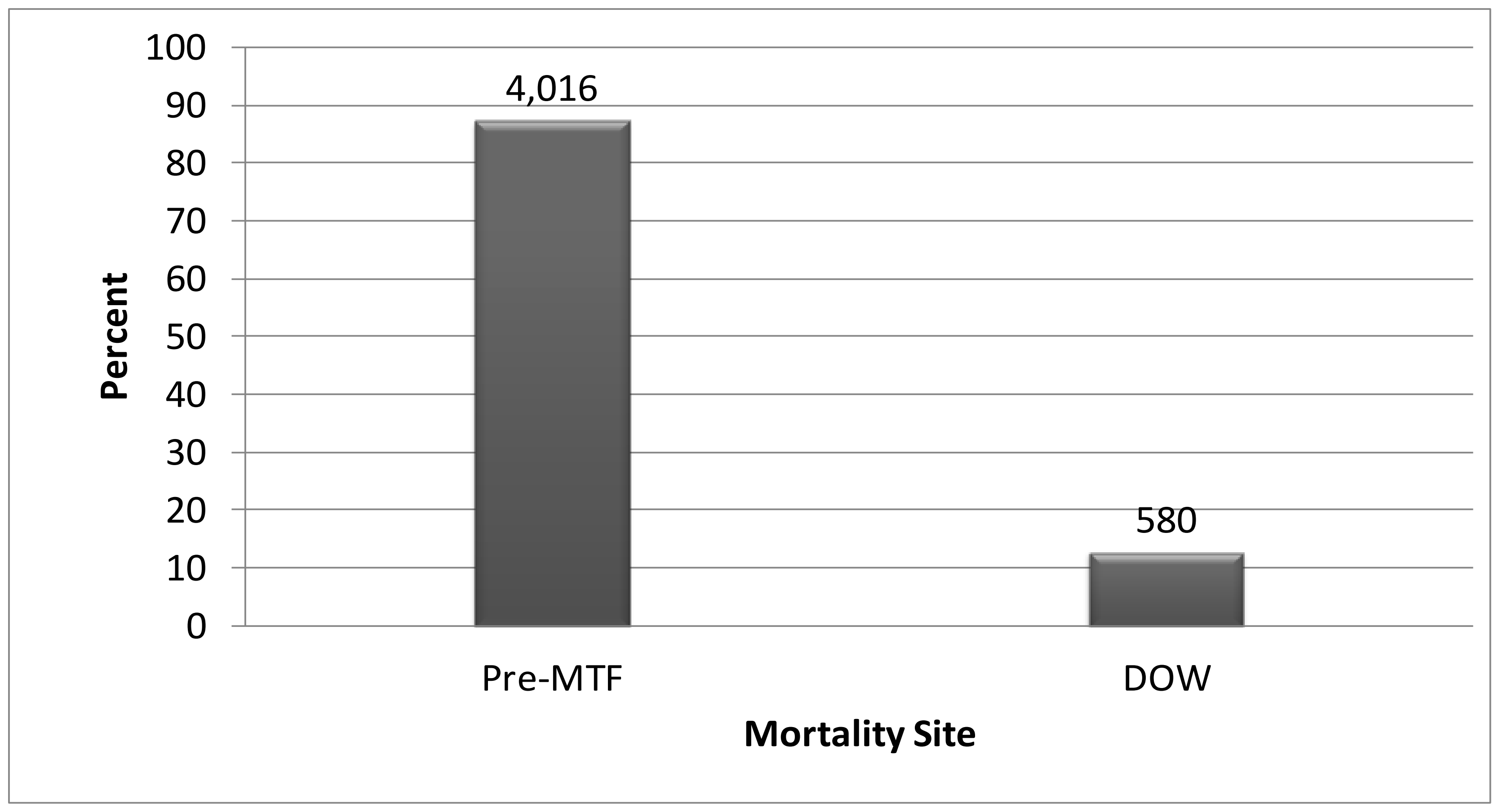
- Goal: Identify areas for improved training, medical care, material, research and development

KIA Analysis

- **Nonsurvivable**
  - **Dismemberment**
  - **Traumatic brain injury**
  - **Cervical cord transection (above C3)**
  - **Airway transection within thorax**
  - **Cardiac injury (>1/2”), thoracic aorta injury, pulmonary artery**
  - **Hepatic avulsion**
  - **Junctional lower extremity amputations with open pelvis with soft tissue loss**

- **Potentially Survivable**
  - **All other**

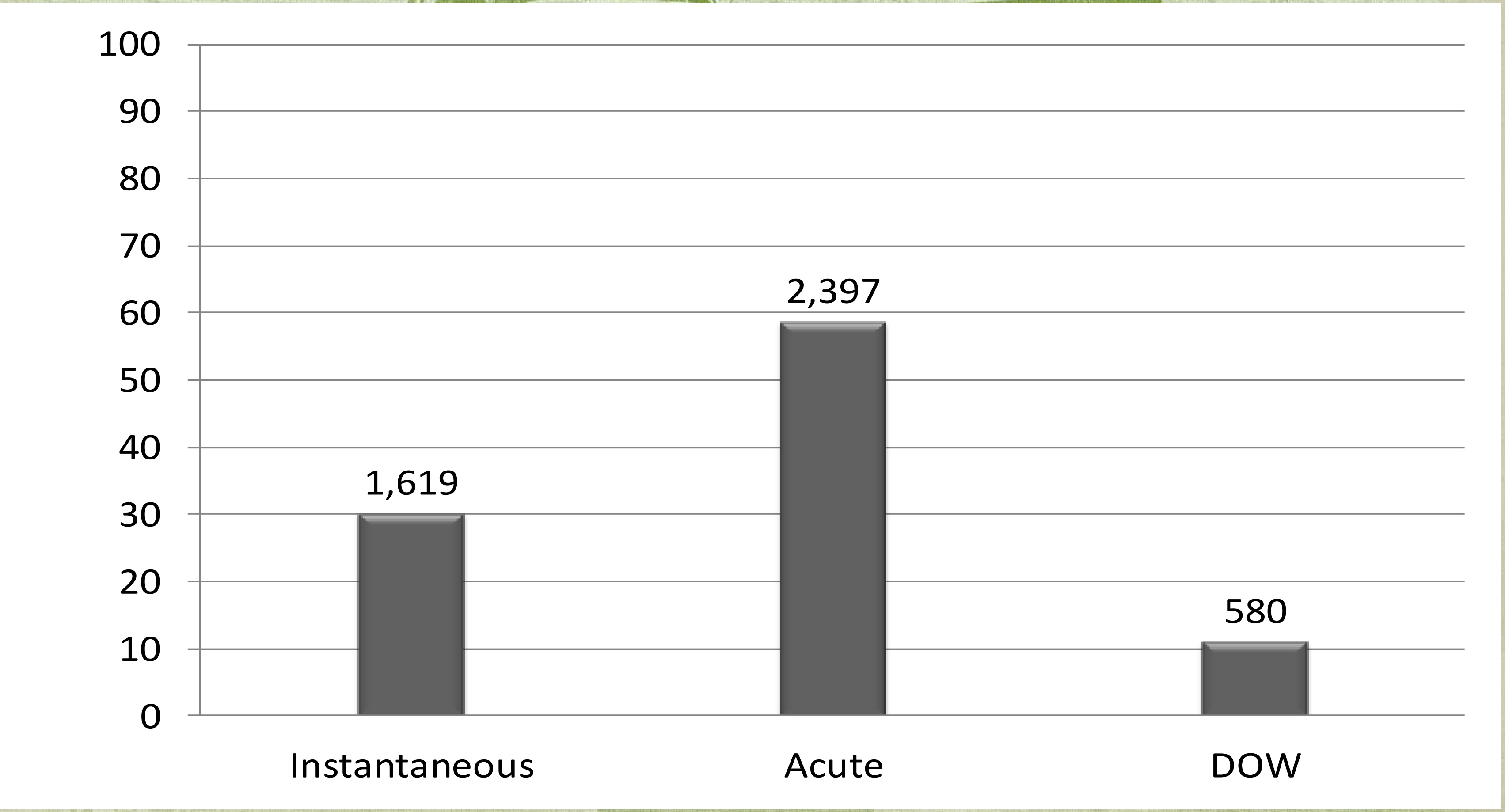
Where Battlefield Casualties Die
n=4,596



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Putting it in Perspective

Distribution of Battlefield Death n=4,596



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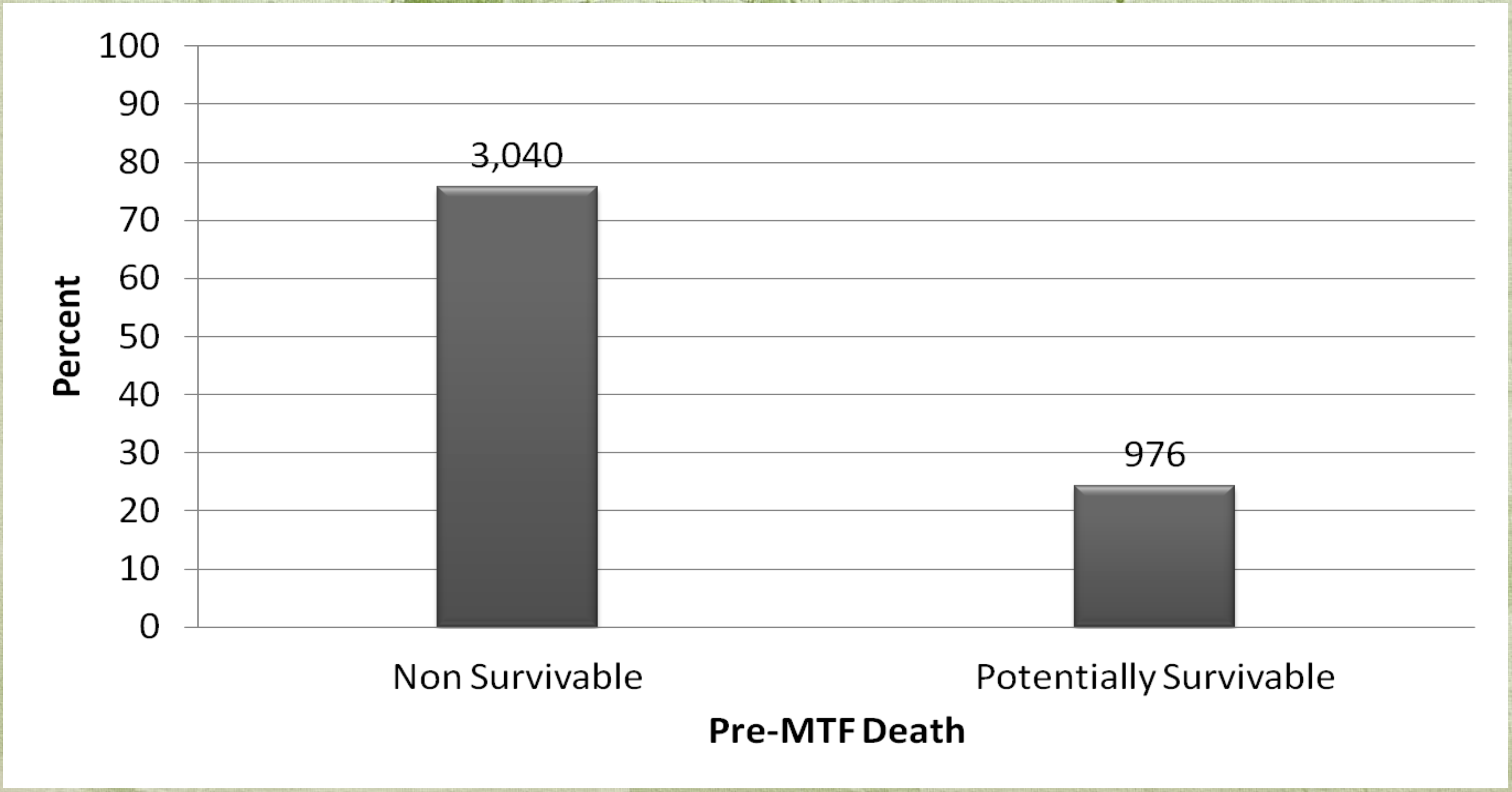
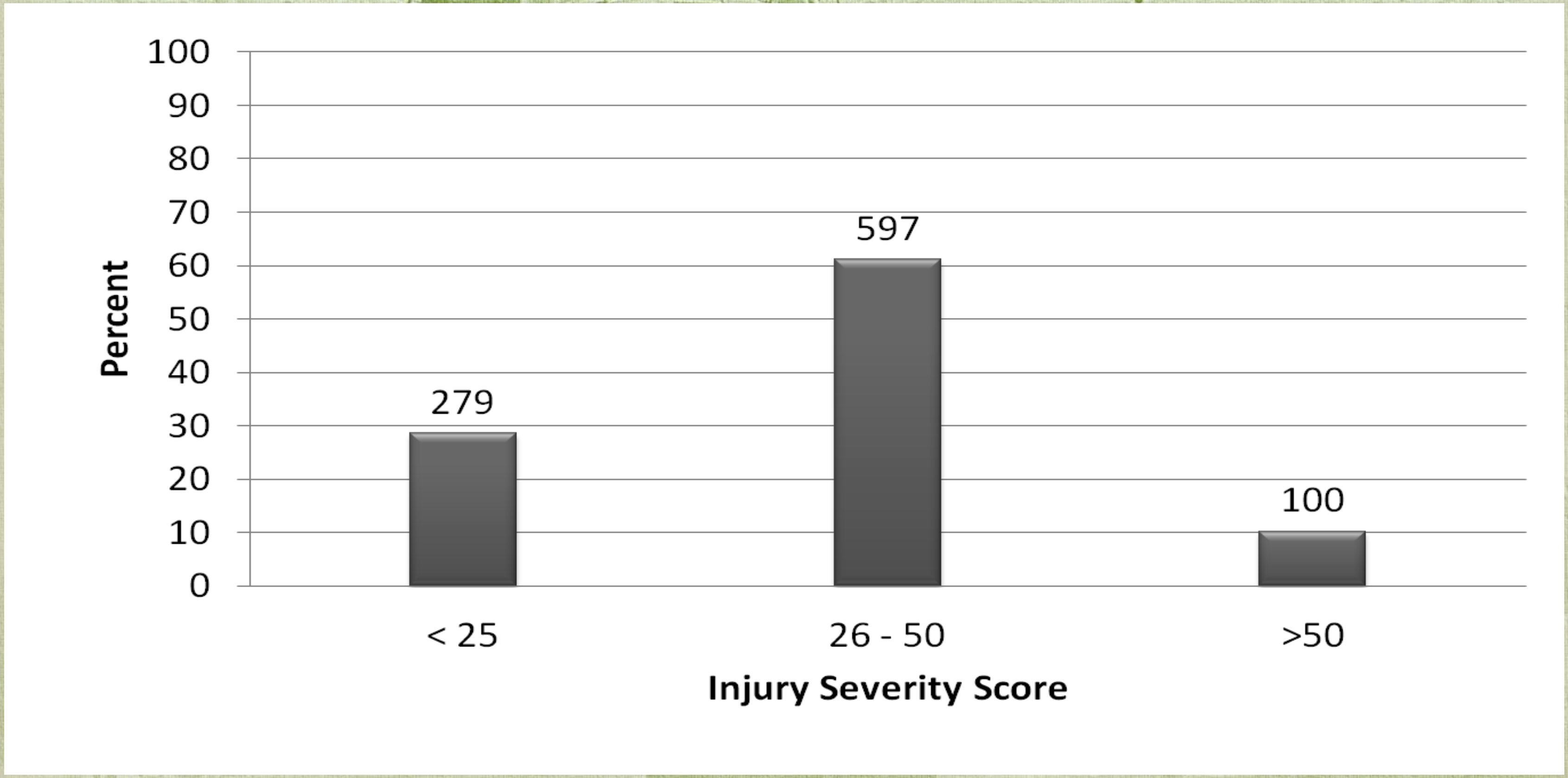
Battlefield Pre-Hospital Death Analysis n=4,016 (DOW excluded)



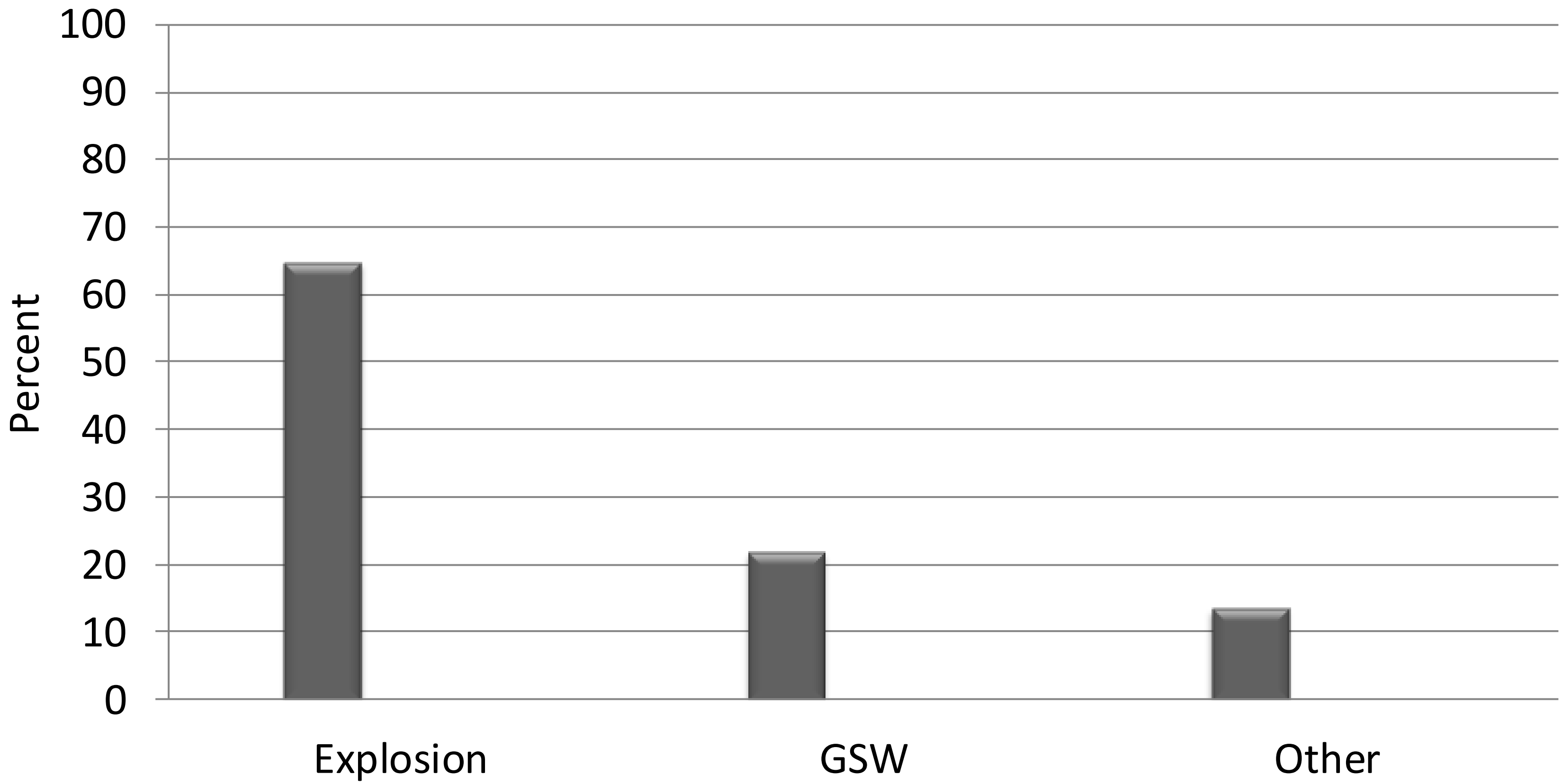
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Potentially Survivable Pre-MTF Death Analysis (n=976)



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield Pre-MTF Mortality Cause
n=4,016



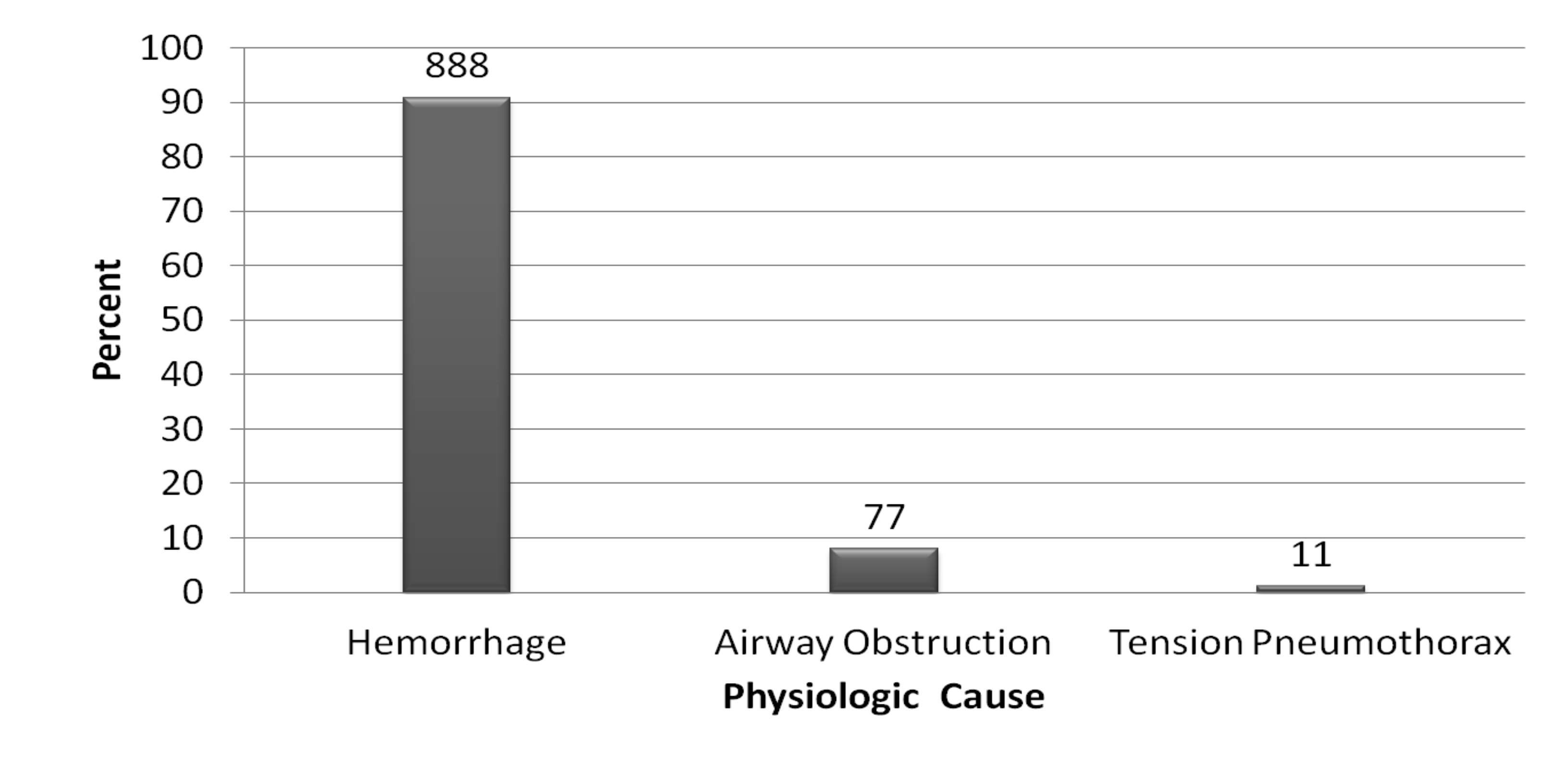
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield NS Lethality

Cause of Death	Instantaneous (n=1,619)	Acute (n=1,421)
Brain Injury	38.3% (620)	53.0% (753)
High Spinal Cord Injury	---	9.2% (131)
Dismemberment	31.6% (512)	---
Heart/ Thoracic Injury	23.6% (383)	21.8% (310)
Open Pelvic Injury	---	6.5% (93)
Other	6.5% (104)	9.5% (134)

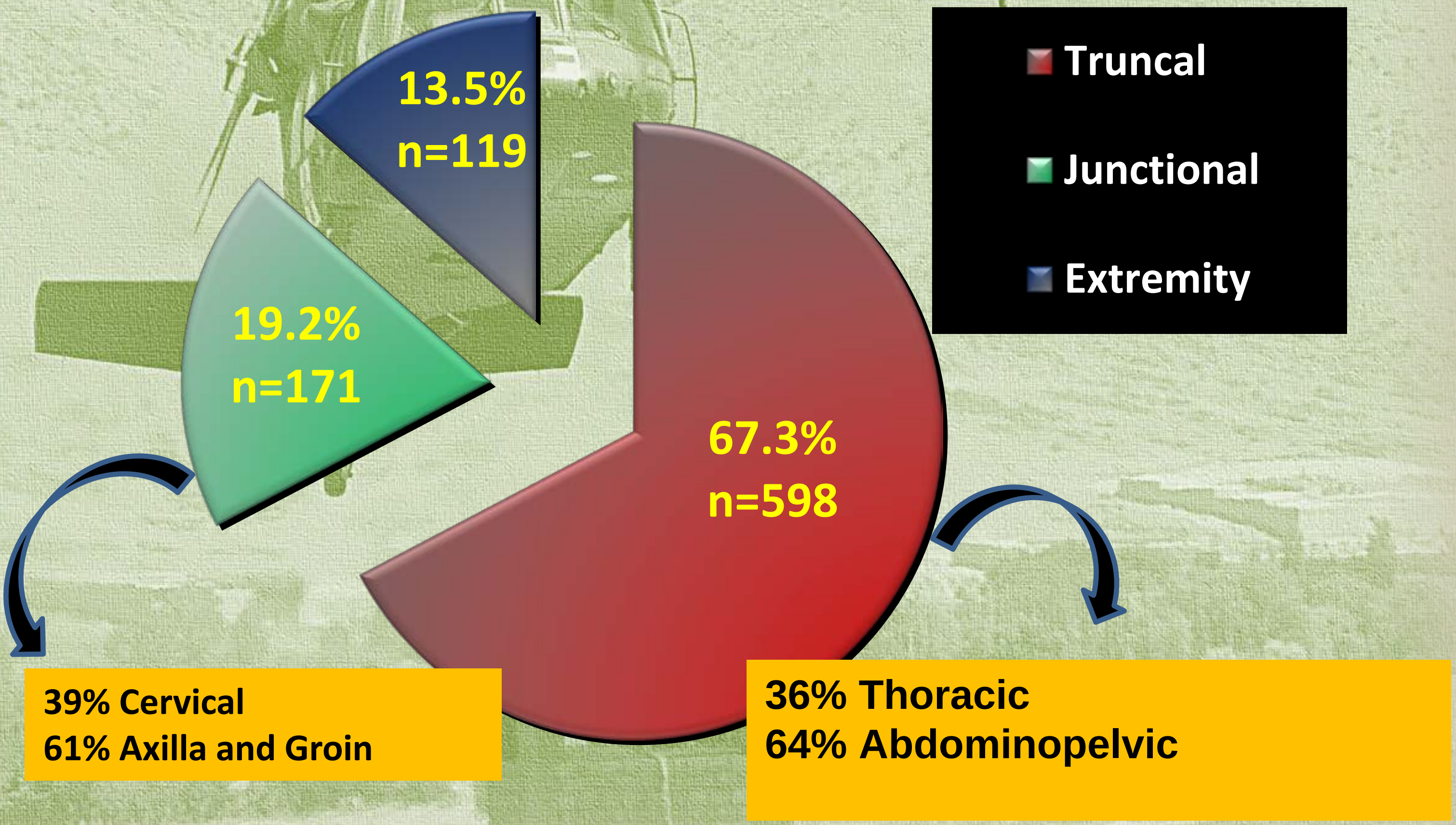
Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Battlefield Acute Lethality Potentially Survivable n=976



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Anatomic Locus of Hemorrhagic Death



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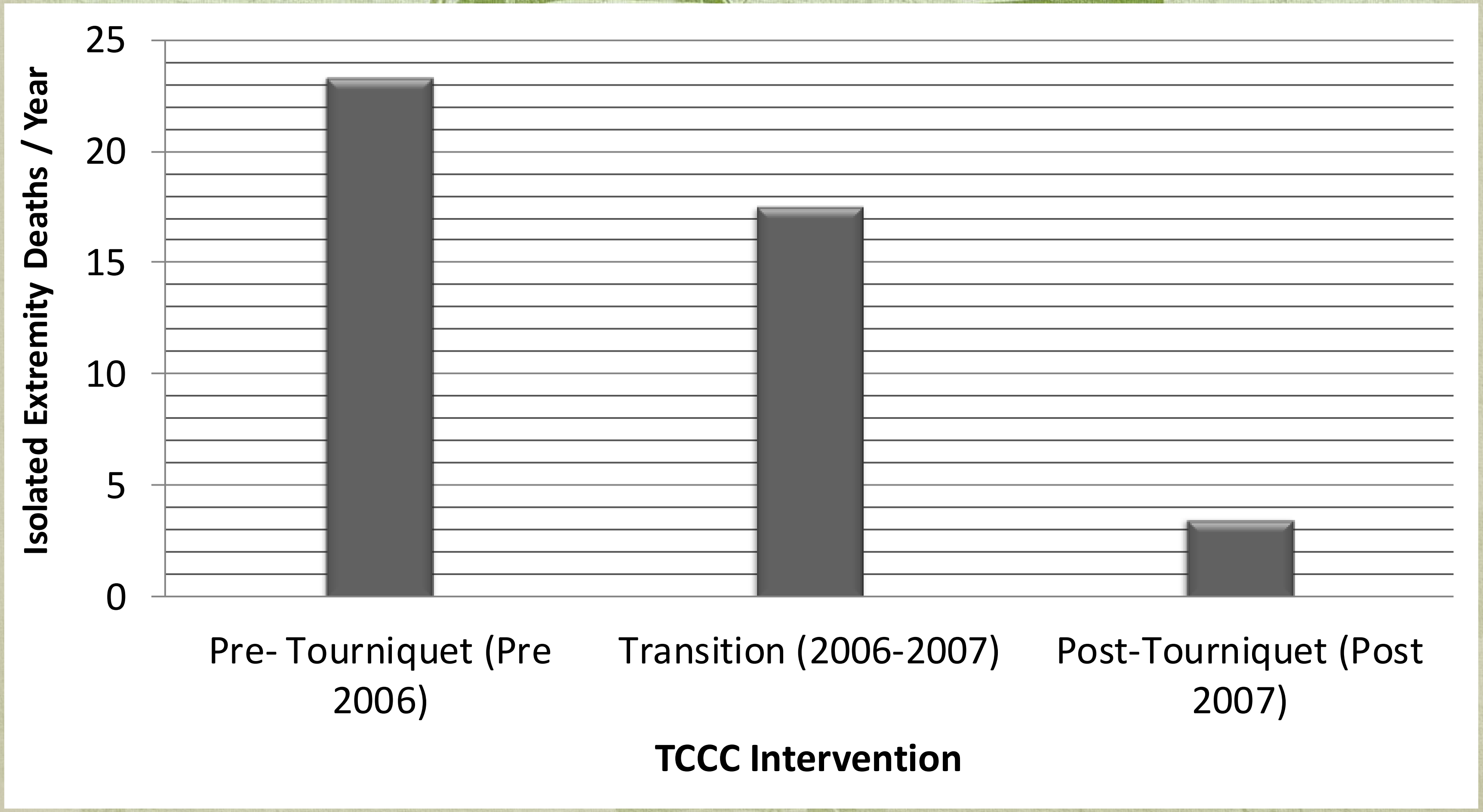
Can We Have An Impact?



Eastridge et al: Death on the Battlefield: Implications for the Future of Combat Casualty Care. J Trauma 2012

Summary

- Most battlefield casualties (87.3 %) die on the battlefield
- Majority of battlefield deaths (75.7%) are non-survivable
  - Mitigation strategy: prevention
- Hemorrhage is the major mechanism of death in (90.9 %) of PS combat injuries .
  - Mitigation strategy: hemorrhage control
    - Tourniquets
    - Junctional hemorrhage control
    - Intracorporeal hemostasis
      - Freeze dried plasma
      - TXA
      - Novel therapeutics
    - Extending the survival time window from POI to MTF

U.S. military
potentially survivable injury:
<u>24%</u>

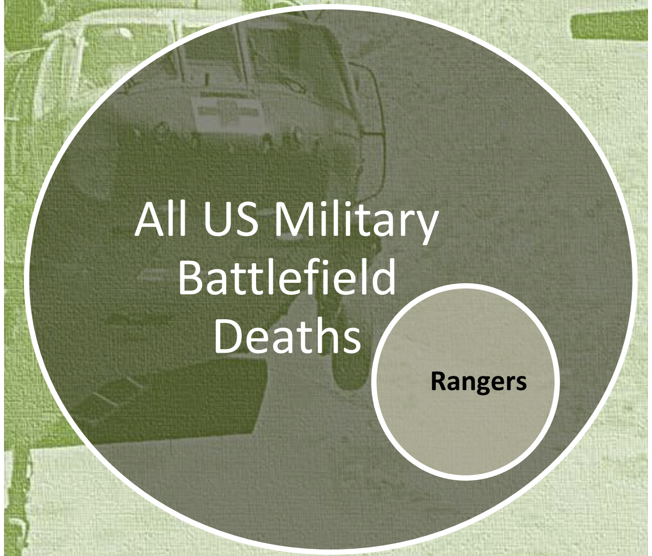
Ranger
Potentially preventable death incidence:
<u>3%</u>

ORIGINAL ARTICLE

Death on the battlefield (2001–2011): Implications for the future of combat casualty care

Brian J. Eastridge, MD, Robert L. Mabry, MD, Peter Seguin, MD, Joyce Cantrell, MD, Terrill Tops, MD, Paul Uribe, MD, Olga Mallett, Tamara Zubko, Lynne Oetjen-Gerdes, Todd E. Rasmussen, MD, Frank K. Butler, MD, Russell S. Kotwal, MD, John B. Holcomb, MD, Charles Wade, PhD, Howard Champion, MD, Mimi Lawnick, Leon Moores, MD, *and* Lorne H. Blackbourne, MD

J Trauma Acute Care Surg
Volume 73, Number 6, Supplement 5 S431



ORIGINAL ARTICLE

ONLINE FIRST

Eliminating Preventable Death on the Battlefield

Russ S. Kotwal, MD, MPH; Harold R. Montgomery, NREMT; Bari M. Kotwal, MS; Howard R. Champion, FRCS; Frank K. Butler Jr, MD; Robert L. Mabry, MD; Jeffrey S. Cain, MD; Lorne H. Blackbourne, MD; Kathy K. Mechler, MS, RN; John B. Holcomb, MD

Arch Surg. 2011;146(12):1350-1358. Published online August 15, 2011. doi:10.1001/archsurg.2011.213

Injury survivability

Injury death preventability

DoD Lexicon

Combat Casualty Mortality Assessment Definitions

Defense Health Agency
PROCEDURAL INSTRUCTION

NUMBER 6040.03
August 21, 2018

Assistant Director, Combat Support Agency (CSA)

SUBJECT: Joint Trauma Lexicon

References: See Enclosure 1.

1. PURPOSE. This Defense Health Agency-Procedural Instruction (DHA-PI), based on the authority of References (a) and (b), and in accordance with the guidance of References (c) through (m), establishes the Defense Health Agency's (DHA) procedures to develop a universally accepted, standardized Joint Trauma Lexicon.

2. APPLICABILITY. This DHA-PI applies to OSD, the Military Departments (MILDEPs), the Office of the Chairman of the Joint Chiefs of Staff (CJCS) and the Joint Staff, the Combatant Commands, the Office of the Inspector General of the DoD, the Defense Agencies, the DoD Field Activities, and all other organizational entities within the DoD (referred to collectively in this DHA-PI as the "DoD Components").

3. POLICY IMPLEMENTATION. It is DHA's instruction, pursuant to References (e) and (f), that the Joint Trauma Lexicon establishes and defines key common trauma terms used in support of trauma care, operational medical planning, performance improvement, and research across the full range of military operations. The DHA serves as the Military Health System's authoritative source for Joint Trauma Lexicon; therefore, this DHA-PI will be used to update DoD Issuances, Joint Publications (JPs), DHA Publications, and Service-level regulations. The DoD will use these terms where applicable and, if not used, the author of the alternative term and/or definition will disclose the reason.

4. RESPONSIBILITIES. See Enclosure 2.

5. PROCEDURES. See Enclosure 3.

12 non-survivable injury	An injury so severe the casualty would not have survived even if all required medical resources were available and appropriate medical care was optimally administered initially and throughout the continuum of care.			X
13 potentially preventable death	A death that occurred from a survivable or potentially survivable injury when the tactical situation limited prompt and/or optimal medical care.			X
14 potentially survivable injury	An injury that the casualty might have survived if all required medical resources were available and appropriate medical care was optimally administered initially and throughout the continuum of care.			X
15 preventable death	A death that occurred from a survivable injury when the tactical situation did not limit prompt or optimal medical care.		X	
[redacted]				
21 survivable injury	An injury that the casualty should have survived if all required medical resources were available and appropriate medical care was optimally administered initially and throughout the continuum of care.			X

Multiinstitutional Multidisciplinary Injury Mortality Investigation in Civilian PreHospital Environment

PIs:Eastridge, Nolte, MacKenzie

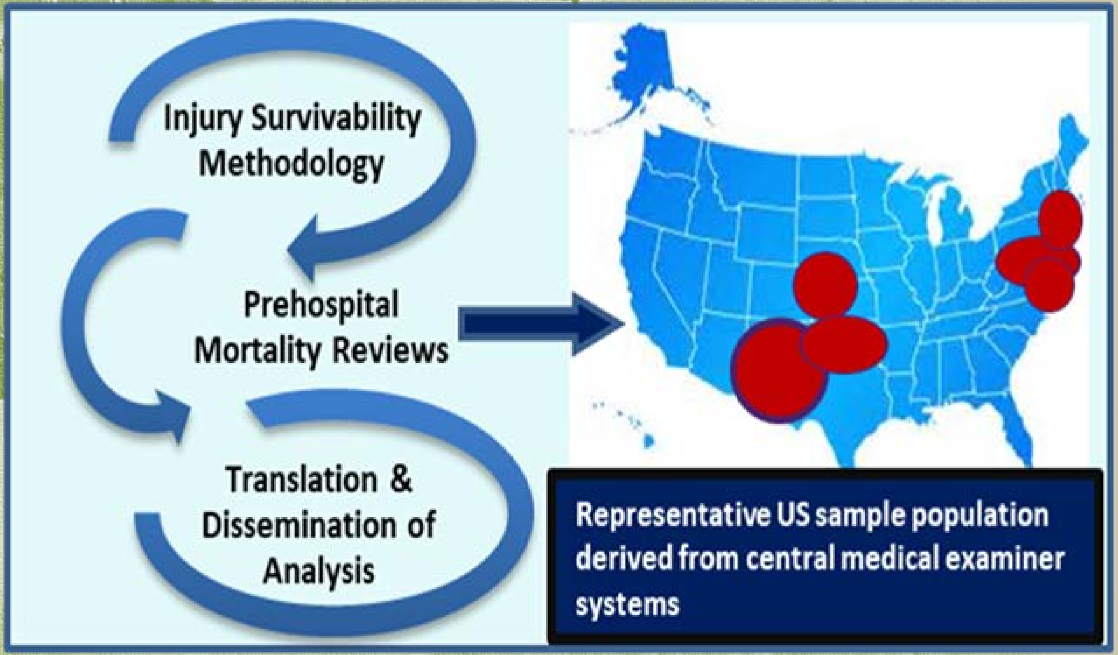
Funded by USAMRMC
(Department of Defense)

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 pre-mortality from trauma

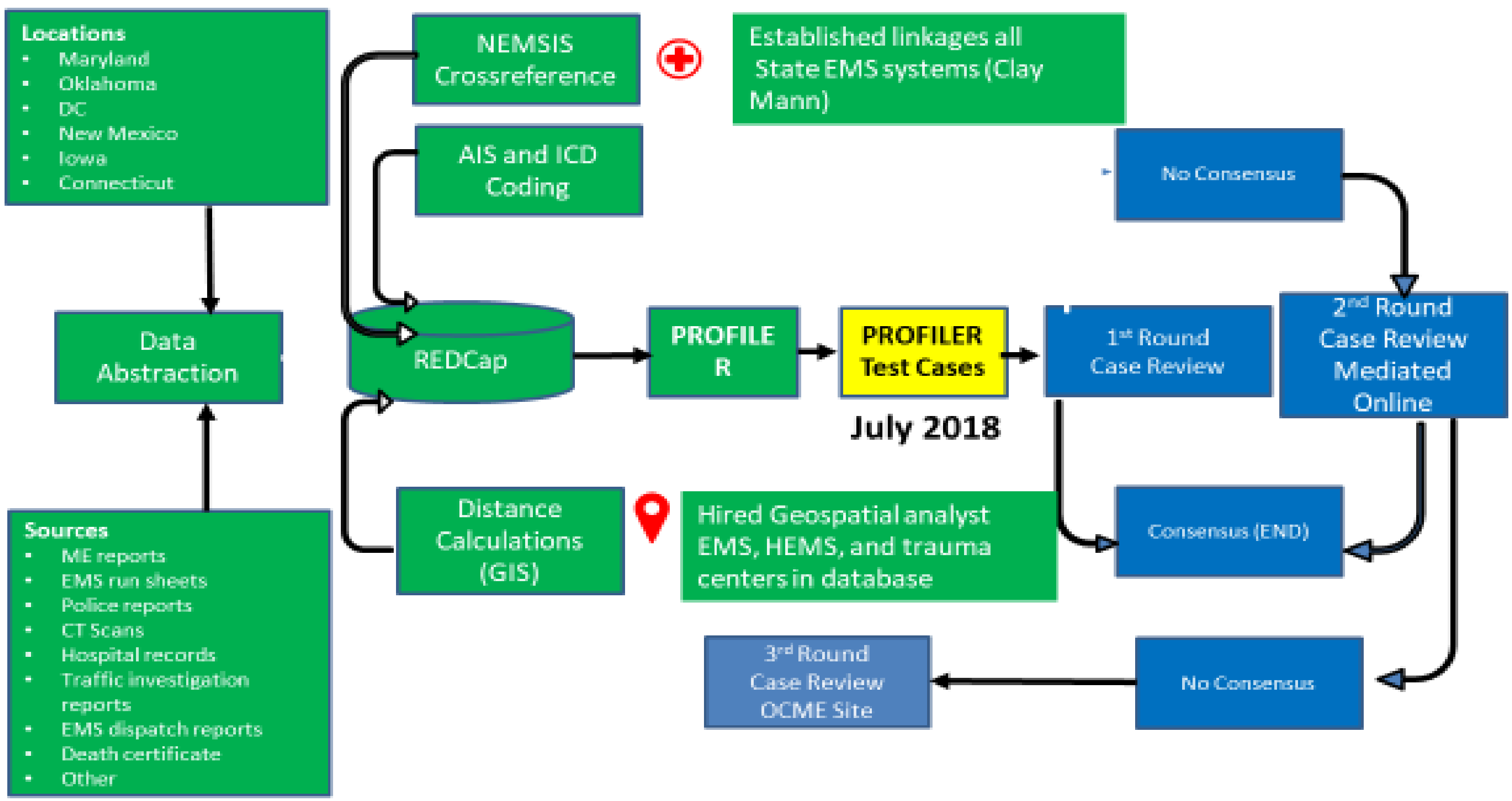
Identify potential high yield areas for research and development in pre-hospital medical care, injury prevention, and trauma systems.

Multi-Disciplinary Multi-Institutional Mortality Investigation in the Civilian Prehospital Environment (MIMIC)

- Develop a framework for evaluating the causes and pathophysiology of pre-hospital deaths
- Network of experts identify the causes of 3,000 pre-hospital deaths due to trauma and estimate potential for survivability.
    - Trauma surgery
    - Neurosurgery
    - Orthopedic surgery
    - Forensic pathology
    - Emergency medicine
    - Emergency medical services

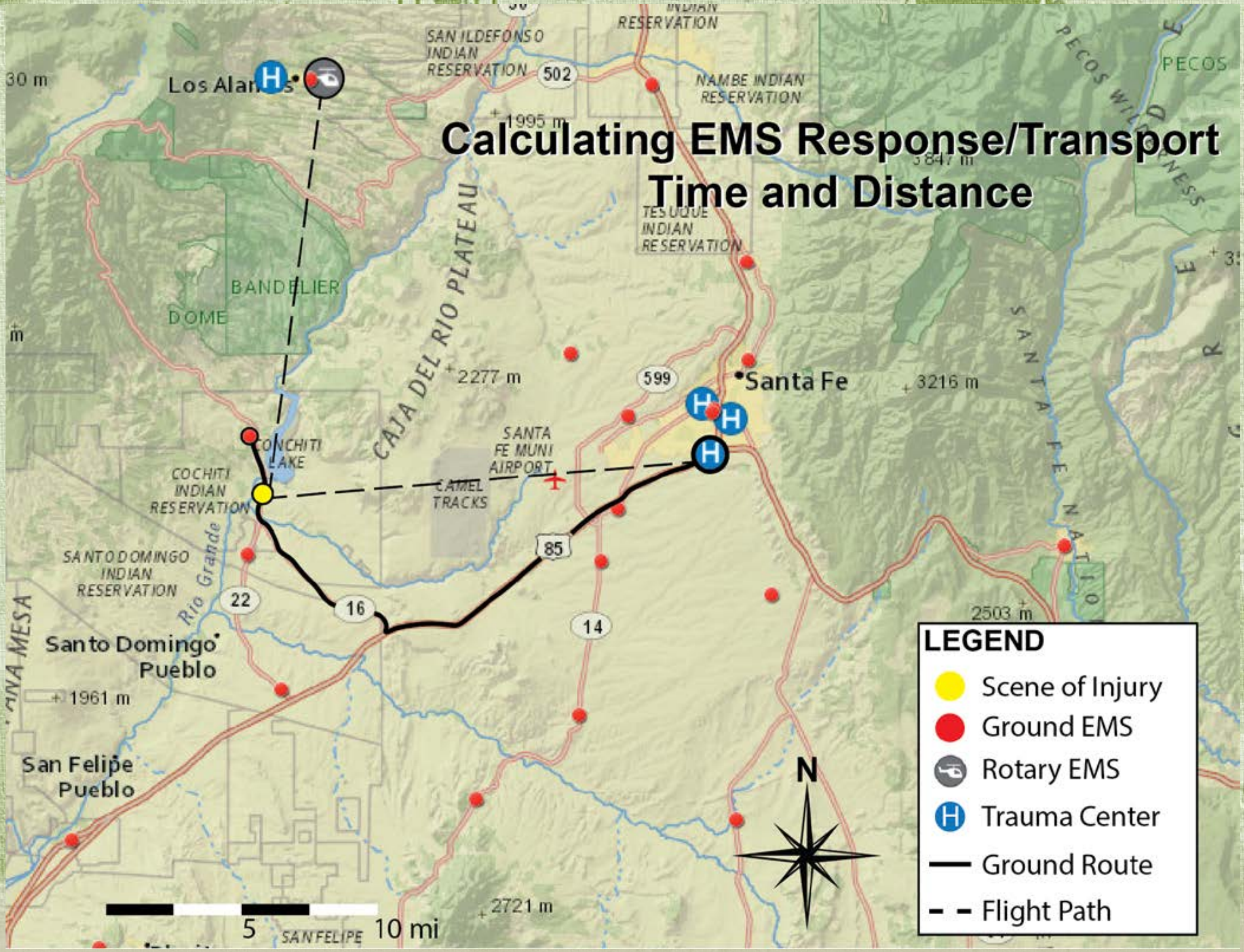


MIMIC



Locations
Maryland
Oklahoma
DC
New Mexico
Iowa
Connecticut
NEMSIS Crossreference
Established linkages all State EMS systems (Clay Mann)
AIS and ICD Coding
No Consensus
Data Abstraction
REDCap
PROFILER
PROFILER Test Cases
July 2018
1st Round Case Review
2nd Round Case Review Mediated Online
Distance Calculations (GIS)
Hired Geospatial analyst EMS, HEMS, and trauma centers in database
Consensus (END)
Sources
ME reports
EMS run sheets
Police reports
CT Scans
Hospital records
Traffic investigation reports
EMS dispatch reports
Death certificate
Other
3rd Round Case Review OCME Site
No Consensus

Integrating Geospatial Modeling



Project Update

Data Abstraction

- 2,539 of 3,000 cases have been abstracted

Coding

- AIS/ICD – 860 cases completed
- GIS – 2,587 cases completed

Case Reviews

- Created 13 review team panels each consisting of 4 surgeons, 1 EM/EMS reviewer, and 1 Forensic Reviewer. All panels have a reviewer with past military experience, and a minimum of 1 female reviewer on each panel.
- Case reviews were launched to the first review team panel in January 2019.
- To date, 775 cases have been released to panels.
- 585 cases have been completed.

Preliminary
Round 1 and Round 2 Data

- Q2: Assume the survival status of this patient is unknown, with immediate access to care at a level I trauma center, assess the survival potential of this patient.

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

	Frequency
	322 (78%)
	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

Note: Using 414 cases that have reached consensus on survivability assessments

Preliminary
Round 1 and Round 2 Data

- Q3: Assume the survival status of this patient is unknown, given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather etc.), assess the survival potential of this patient

Actual Scenario Survivability	Frequency
	389 (94%)
	24 (6%)
	1
Cannot Judge	0

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

Note: Using 414 cases that have reached consensus on survivability assessments

Immediate Access Survivability	Frequency
Non-survivable	322 (78%)
Potentially Survivable	87 (21%)
Definitely Survivable	5 (1%)
Cannot Judge	0

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Actual Scenario Survivability	equency
Non-survivable	9 (94%)
Potentially Survivable	24 (6%)
Definitely Survivable	1
Cannot Judge	0

Preliminary
Round 1 and Round 2 Data

- Q4: Which injury prevention programs/devices or interventions might have improved the chances of survival for this individual?

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

Note: Using records from all reviewers in Round 1 and Round 2.

Current State

Gaps and Vulnerabilities

Opportunities

Combat Casualty Death Review

Does the DoD have at present reliable methodology for reviewing all combat fatalities and identifying those deaths that might have been prevented if optimal care had been provided?

DoD CCC Mortality Analysis
Current State

- Interval process based upon established DoD CCC mortality review process
- Ability of JTS subject matter experts to perform comprehensive reviews of battlefield deaths proximate to date of death
- Ability of Armed Forces Medical Examiner System (AFMES) to perform full autopsy analysis of combat casualty deaths supported by low operational tempo
- Limited prehospital Tactical Combat Casualty Care data
- Mortality review focuses determinations based upon most severe injuries

DoD CCC Mortality Analysis Gaps and Vulnerabilities

- **Lack of prehospital data limits ability of JTS / AFMES review team to examine salient factors necessary to render decision**
- **Review and cataloging of combat mortality injury survivability data is not codified by “requirement”**
- **Sensitivity and operational security issues may limit open discussion and review of cases**

DoD CCC Mortality Analysis
Gaps and Vulnerabilities

- Complete autopsy, including imaging may be constrained / delayed by high operational tempo scenarios
- Review process based upon single system injury severity likely underestimates the complex interactions of multiple injuries

DoD CCC Mortality Analysis Opportunities for Improvement

- Develop requirement for mortality review process and support with commensurate policy (mandate) and resources (monies, manpower) (Near/Immediate)
- Codify mortality review construct (policy, mandate, enforcement) to ensure standardized care, documentation, and data collection practices are performed and transferred to the AFMES and JTS (Near/Immediate)
- Mandate prehospital care documentation (Near/Immediate)

DoD CCC Mortality Analysis Opportunities for Improvement

- Augmented ME workforce / contingency plan for mass casualty producing events (Peer / Near Peer / High Volume Casualty Producing Event)
- Consider specialty of Forensic Pathology critical wartime specialty (5 Year)
- Develop interactional review / assessment algorithms for injury mortality outcome determination (5 year)
  - Artificial intelligence solution based upon data (15 year)

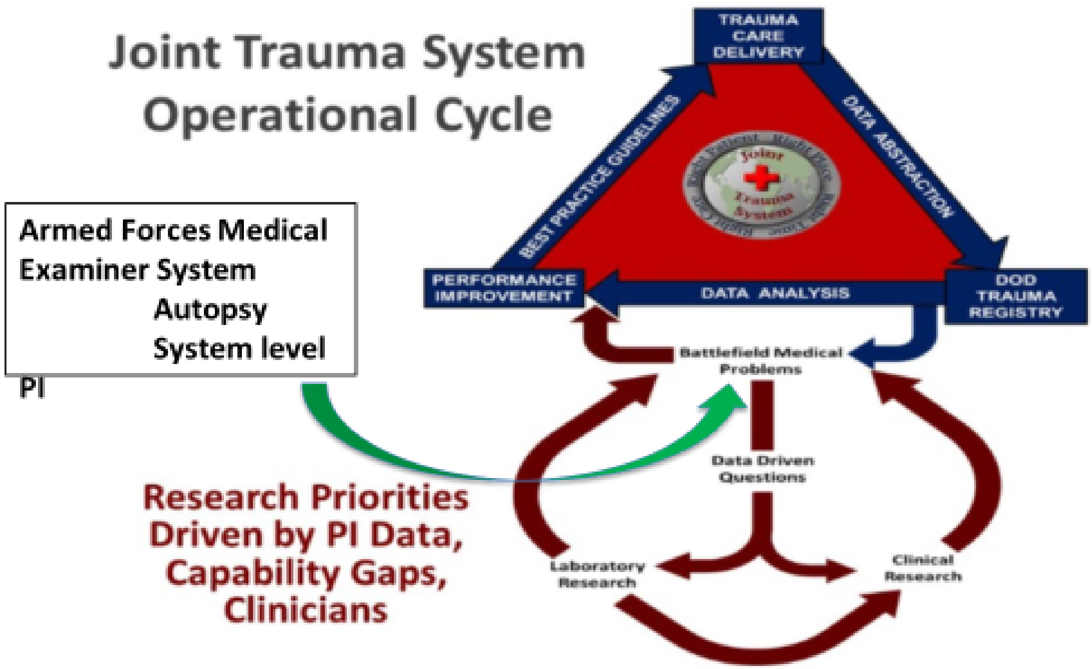
Performance Improvement and Loop Closure

For all fatalities identified as preventable or potentially preventable, is there reliable methodology for determining what could have been done differently that might have prevented the casualty's death?

Is there reliable methodology for ensuring that the needed improvements have been made?

PI / Loop Closure
Current State

Operationalizing Mortality PI Process



PI / Loop Closure
Current State

- JTS / TCCC integrate mortality review assessments into system performance improvement activities
- AFMES liaison to the JTS charged with review of battlefield deaths for system PI codified in DHA-AI 107.

PI / Loop Closure
Gaps and Vulnerabilities

- **Fundamental challenges related to the perception of performance improvement activities**
  - **Perception as punitive process limits stakeholder engagement**
- **Current military investigative processes**
  - **Perception of wrongdoing**
  - **UCMJ implication**

PI / Loop Closure Opportunities

- **Formal integration of performance improvement process in relevant doctrine (5 year)**
- **Further develop "learning healthcare system" perspective of the JTS (Near/Immediate)**

Informing End User(s)

Are these Opportunities for Improvement reliably and effectively communicated to the units and organization that could effect these changes?

Informing End User(s)
Current State

- No process exists to effectively communicate mortality review lessons learned to the units and organizations
- No clear pathway exists to disseminate mortality review assessments to leadership
  - Medical
  - Line
- Leadership does not understand the implications and value of combat casuaty mortality review information

Informing End User(s) Gaps and Vulnerabilities

Unrealized Potential Value

Medical

- Performance Improvement
- Emerging injury hazards / threats
- Training

Line

- TCCC improvements
- Operational risk assessment
- Training

Informing End User(s) Opportunities

- **Develop and implement a formal process to inform commanders about the care and outcomes of their troops (Near/Immediate)**
  - **Communication "pipeline" directly to commanders (medical and non-medical) for their visibility in order to inform decision-making and action**
    - **Medical**
    - **Operational (Near/Immediate)**

Summary

- Battlefield death secondary to injury is a significant operational mission capability issue
  - Majority of deaths in occur pre-hospital environment
  - 24% combat casualty deaths potentially survivable of which most are hemorrhage related
  - Mortality review data informs
    - Training
    - Clincal care
    - Research
    - Operational considerations

Summary

- DoD must develop an organizational commitment to understanding combat casualty mortality and eliminating potentially preventable death.
- Insightful analysis of combat casulty deaths valuable for informing battlefield care, training, the combat casualty research and development agenda, as well as supporting operational risk assessment.

Summary
Highest Value Opportunities

- **Develop requirement for mortality review process and support with commensurate policy (mandate) and resources (monies, manpower) (Near/Immediate)**
- **Develop interactional review / assessment algorithms for injury mortality outcome determination (5 year)**
  - **Artificial intelligence solution based upon data (15 year)**
- **Communication “pipeline” directly to commanders (medical and non-medical) for their visibility in order to inform decision-making and action (Near/Immediate)**

Conclusion

- **Understanding battlefield mortality is a vital component of the trauma system**
  - Trauma system optimization
  - TCCC improvements
  - Data driven research and development focus
  - Command emphasis
  - Training & tactical perspective
  - Equipment and materiel

"People are always the #1 priority and are our greatest strength and our most important weapon system."

General James C. McConville

40th Chief of Staff, US Army

2019

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

BJ Eastridge, K Nolte, E MacKenzie, R Stewart, JB Holcomb, CL Villarreal, N Medrano, M Price, G Davis, RT Maxson, E Mazuchowski and the MIMIC Investigator Group

Introduction: Advances in trauma centers and systems have substantially reduced death associated with injury. However, there are substantial opportunity to further reduce deaths in the prehospital setting. The goal of this research was to characterize survival potential of prehospital injury deaths in order to develop mitigation strategies and improve trauma systems.

Methods: A steering committee developed prehospital injury survivability definitions and study process. Balanced expert review panels were established from 80 military and civilian reviewers specializing in trauma surgery, orthopedics, neurosurgery, emergency medicine, EMS, and forensic pathology. Panels reviewed injury mortalities from comprehensive medical examiner systems and assigned a determination of survivability to each case based upon principal mechanism of death. Survivability determinations were made based upon the assumption of immediate access to care and in the context of the actual injury scenario. Non-consensus in determination of survivability was remediated though an online adjudication process. Data were entered into an electronic review and response tool (Profiler) for collation and analysis.

Results: 436 prehospital mortality cases were assessed by the reviewer panel. Panel consensus of survivability was reached in 414/436 cases (94.9%) (Table 1). Assuming immediate access to care, potentially / definitely survivable mortality was 22.2% .

Conclusions: This preliminary analysis of prehospital injury mortality develops a perspective of relative importance of injury mortality causation in the prehospital environment. This assessment may provide objective evidence to support the development of mitigation strategies for therapy and injury prevention to improve trauma systems.

Survivability Determination	Immediate Access	Actual Scenario
Non-Survivable	322 (77.8%)	389 (94.0%)
Potentially Survivable	87 (21.0%)	24 (5.8%)
Definitely Survivable	5 (1.2%)	1 (0.2%)
Cannot Determine	0 (0%)	0 (0%)

Table 1. Prehospital Injury Survivability

STATEWIDE SYSTEM-BASED GEOGRAPHIC APPROACH TO TRAUMA CARE ACCESS

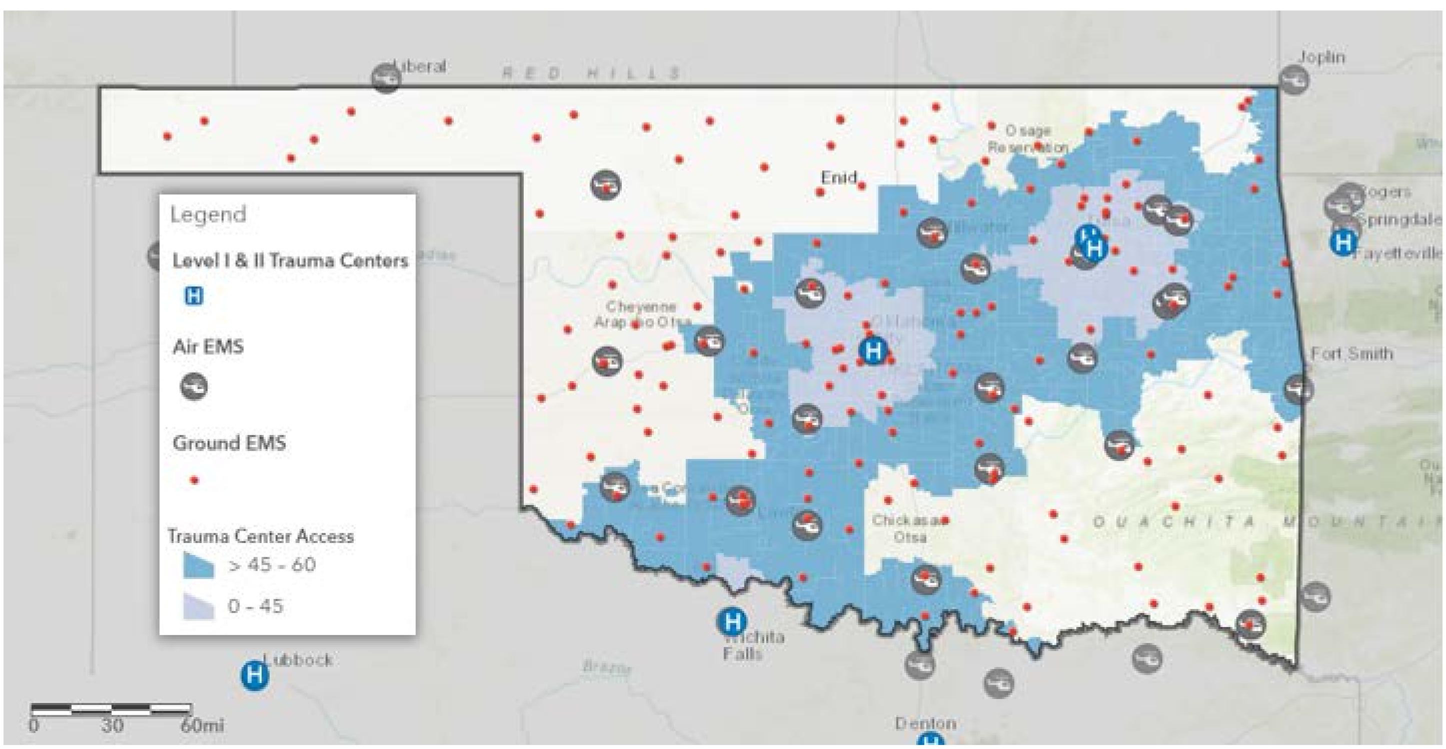
Nicolas W. Medrano MS, Cynthia L. Villareal MA, Michelle A. Price PhD., Brian J. Eastridge MD, MIMIC Study Group

Introduction: The Multi-Institutional Multi-Disciplinary Injury Mortality Investigation in the Civilian Pre-Hospital Environment (MIMIC) study developed a novel geographic information system (GIS) model to estimate the total pre-hospital time for emergency medical services (EMS) based upon a specified injury location from the EMS or forensic records. Our aim was to apply the MIMIC model to state-wide populations to estimate trauma center access using the composite pre-hospital interval, from the time the 9-1-1 call was received until arrival at the nearest trauma center. This includes time taken for the EMS unit to dispatch, response time to the scene, time spent on the scene, and time taken to transport the patient to the nearest trauma center.

Methods: GIS-based models were built using ArcGIS 10.6 for four states (CT, MD, NM, OK) participating in the MIMIC study. These models include ground EMS, air EMS and designated level I, II, and III trauma center locations. Ground EMS locations within the state were collected from the respective state Departments of Health. Air EMS base locations were obtained from the Atlas and Database of Air Medical Services (ADAMS) for locations within the state and in neighboring states response jurisdiction. Designated trauma center locations within and in immediately adjacent regions of neighboring states were collected from the American Trauma Society Information Exchange Program. This trauma system infrastructure was connected to a street network with traffic data to estimate the total prehospital interval. A previous meta-analysis of pre-hospital care times was added to account for dispatch and on-scene times. Finally, the model used US Census block group population weighted centroids to determine the population with access within 45- and 60-minute intervals.

Results: Engaging ground EMS, the model predicted 45 and 60-minute access to level I and II trauma centers as follows: CT (71.4%, 97.3%), MD (57.2%, 77.8%), NM (25.9%,40.6%), and OK (29.9%, 49.3%). When air EMS was integrated into the model, all sites demonstrated enhanced access for both 45 and 60-minute intervals: CT (98.1%, 100%), MD (88.9%, 96.9%), NM (43.6%, 64.1%), OK (56.1%, 82.6%). When level III trauma centers are included in analysis, increases in access were seen for all sites.

Conclusion: This GIS model is the first to analyze trauma center access incorporating the entire pre-hospital interval, utilizing street network traffic data, and the complete trauma system. This approach can be replicated with other states and provides a means to more realistically assess the current state of trauma systems and may aid in future trauma system development.



Title: Instituting a Multi-disciplinary Review Team to Determine Pre-Hospital Injury Survivability After Traumatic Injury

Authors: Cynthia L. Villareal MA, Nicolas W. Medrano MS, Craig Remenapp MS, Kurt B. Nolte MD, Ellen MacKenzie PhD, Michelle A. Price PhD., Brian J. Eastridge MD, and the MIMIC Investigator Group

Introduction: The Multi-Institutional Multi-Disciplinary Injury Mortality investigation in the Civilian Pre-Hospital Environment (MIMIC) study developed a multidisciplinary review team to provide subject matter expertise-based survivability determinations on 3,000 civilian pre-hospital trauma death cases in the United States.

Methods: A 15 question survey was distributed via SurveyMonkey to MIMIC reviewers. The survey collected demographic and professional information on expertise and clinical background. Survey data were used to create thirteen review teams to determine potential survivability.

Results: The MIMIC Investigator Group consists of 74 reviewers. 70% are surgeons, 18% are emergency medicine or EMS providers, and 12% are forensic pathologists including one forensic nurse. Of these, 77% are male, and 23% are female with an average age of 54 years-of-age. Race breakdown indicated a team composition of 88% White, 4% Asian, 3% Black or African American, 1% American Indian or Alaska Native, and 4% did not report. 36% percent of review team members have military experience, and of these over 92% of them were part of a medical unit while in the military. 77% have played a role in their state or local trauma/EMS system. The areas of expertise for reviewers varies, 53% consider prehospital/EMS systems, 61% trauma systems, and 74% hospital-based practice.

Conclusion: A uniform structured injury mortality review process is vital to understanding patterns of prehospital trauma mortality in order to identify opportunities to improve trauma systems. Creating a diverse team of professionals allows for a broader discussion on potentially survivable deaths.

Summary
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 pre-hospital care must be identified and remediated in order to reduce the number of potentially preventable deaths on in the civilian environment.

Several gaps exist in understanding the epidemiology of prehospital trauma deaths. This study aims to connect medical examiner data including autopsy reports, emergency medical service data, injury severity codes, ICD codes, and GIS trauma center access by location of trauma centers and EMS ground and air in each study area. The data is summarized and displayed in an online review system known as “Profiler” where each review team is assigned a set of cases to determine potential for survivability and identify liabilities in trauma systems and identify injury prevention strategies that could have been effective.

A multi-disciplinary, multi-institutional network of subject matter experts in the disciplines of trauma surgery, neurosurgery, orthopedic surgery, emergency medicine, radiology, forensic pathology, forensic nursing, trauma systems, and emergency medical services collaborated upon the development of a consensus taxonomy relative to determination of injury survivability. This framework and methodology were developed for evaluating the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths; the appropriateness of EMS response and care delivered; and the potential for survivability under both optimal clinical circumstances and within the context of each individual injury event.

We aim to educate the public health community:

- Composition of review team panels and the process for reviewing cases.
- Explore the components and utilization of the Profiler system. Profiler is an electronic data tool that displays all relevant information that was specifically developed for reviewers in order to make informed survivability judgements and record their determinations.
- Review survivability determinations that were used to identify strategies to mitigate prehospital injury mortality in the future.

Your Abstract Submission Has Been Received

Instituting a multi-disciplinary review team to determine pre-hospital injury survivability after traumatic injury

C. Lizette Villarreal, MA[1], Nicolas W. Medrano, MS[1], Craig Remenapp, MS[2], Ellen MacKenzie, PhD[2], Kurt B. Nolte, MD[3], Michelle A. Price, PhD[1] and **Brian J. Eastridge, MD**[4], (1)National Trauma Institute, San Antonio, TX, (2)Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, (3)Office of the Medical Investigator, Albuquerque, NM, (4)University of Texas Health Science Center San Antonio, San Antonio, TX

Abstract:

Introduction: The Multi-Institutional Multi-Disciplinary Injury Mortality investigation in the Civilian Pre-Hospital Environment (MIMIC) study developed a multi-disciplinary review team process to provide subject matter expertise-based survivability determinations on 3,000 civilian pre-hospital trauma death cases in the United States.
Methods: A 15 question survey was distributed via SurveyMonkey to MIMIC reviewers. The survey collected demographic and professional information on expertise and clinical background. Survey data were used to create thirteen review teams to determine potential survivability.
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Conclusion: A uniform structured injury mortality review process is vital to understanding patterns of prehospital trauma mortality in order to identify opportunities to improve trauma systems. Creating a diverse team of professionals allows for a broader discussion on potentially survivable deaths.

Extended Abstract:
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Several gaps exist in understanding the epidemiology of prehospital trauma deaths. This study aims to connect medical examiner data including autopsy reports, emergency medical service data, injury severity codes, ICD codes, and GIS trauma center access by location of trauma centers and EMS ground and air in each study area. The data is summarized and displayed in an online review system known as “Profiler” where each review team is assigned a set of cases to determine potential for survivability and identify liabilities in trauma systems and identify injury prevention strategies that could have been effective.

A multi-disciplinary, multi-institutional network of subject matter experts in the disciplines of trauma surgery, neurosurgery, orthopedic surgery, emergency medicine, radiology, forensic pathology, forensic nursing, trauma systems, and emergency medical services collaborated upon the development of a consensus taxonomy relative to determination of injury survivability. This framework and methodology were developed for evaluating the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths; the appropriateness of EMS response and care delivered; and the potential for survivability under both optimal clinical circumstances and within the context of each individual injury event.

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• Review survivability determinations that were used to identify strategies to mitigate prehospital injury mortality in the future.

Title:
Instituting a multi-disciplinary review team to determine pre-hospital injury survivability after traumatic injury

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Preferred Presentation Format:
Oral Preferred

Related Web Page:
https://www.nattrauma.org/research/ (copy&paste to your browser)

Learning Outcome(s):

Define the composition of MIMIC review team panels and the process for reviewing cases.
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Define survivability determinations that were used to identify strategies to mitigate prehospital injury mortality in the future.

Consider for award:
N

Keyword(s):
Methodology, Epidemiology

Learning Areas:
Clinical medicine applied in public health
Epidemiology
Public health or related education
Systems thinking models (conceptual and theoretical models), applications related to public health

Health Indicator(s):
Access to Care and Place matters/geographic location (e.g. Exposure to crime, violence, social disorder, zip code counts, infrastructure (physical), broadband)

External Funding:
Project funded by the Department of Defense

First-time presenter at APHA

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University of Texas Health Science Center San Antonio
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Qualified on the content I am responsible for because: As a Professor of Surgery and Chief in Trauma Surgery, I have an extensive background in trauma, with specific training and expertise in pre-hospital injury care, damage control resuscitation and surgery, and trauma systems. My research includes investigation into the causes of pre-hospital injury mortality, remote pre-hospital injury outcomes, and non-compressible torso hemorrhage. As PI on several federally funded grants, I successfully administered projects, collaborated with other researchers, and produced peer-reviewed publications.
Any relevant financial relationships? No
Signed on 02/27/2020 by *Brian Eastridge*

Student? No

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

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Professor, Department of Surgery

Division Chief, Trauma and Emergency General Surgery

Jocelyn and Joe Straus Endowed Chair in Trauma Research

UT Health San Antonio

Disclosures

DoD Broad Agency Announcement (BAA) Grant

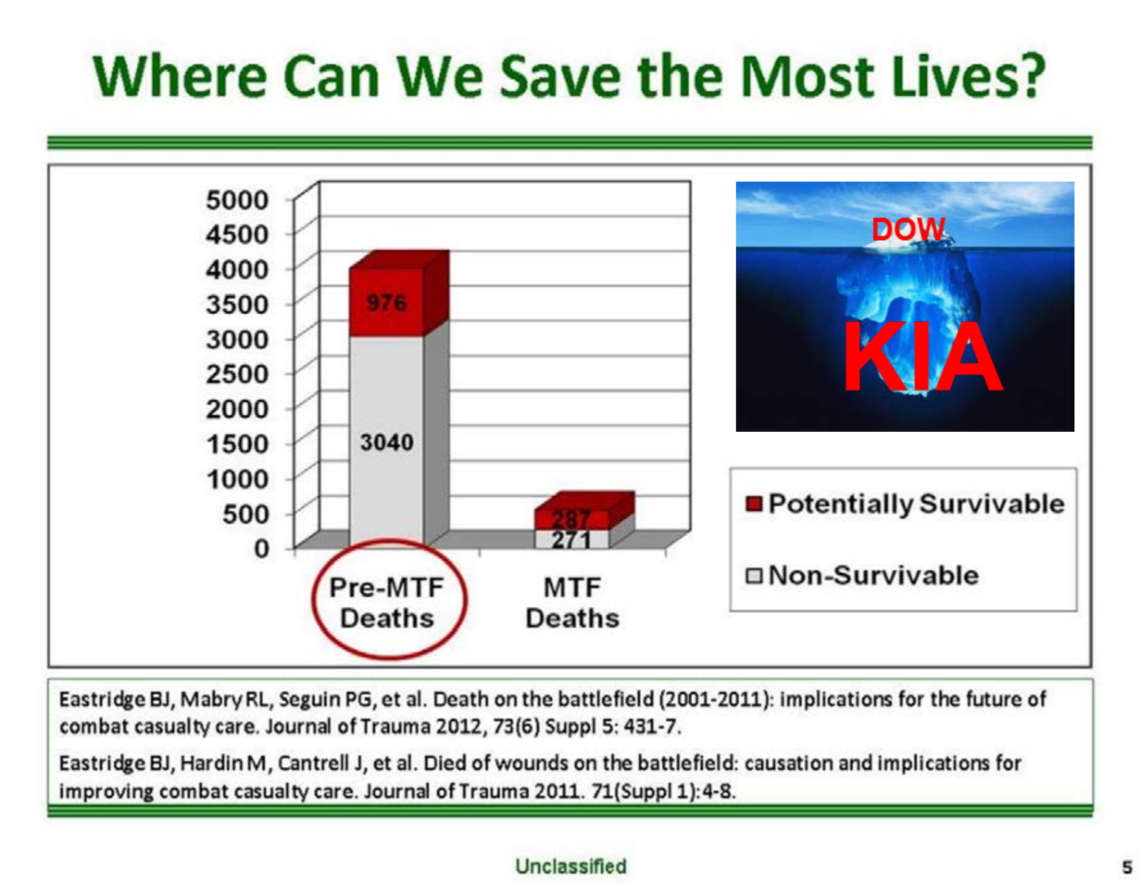
Disclaimer

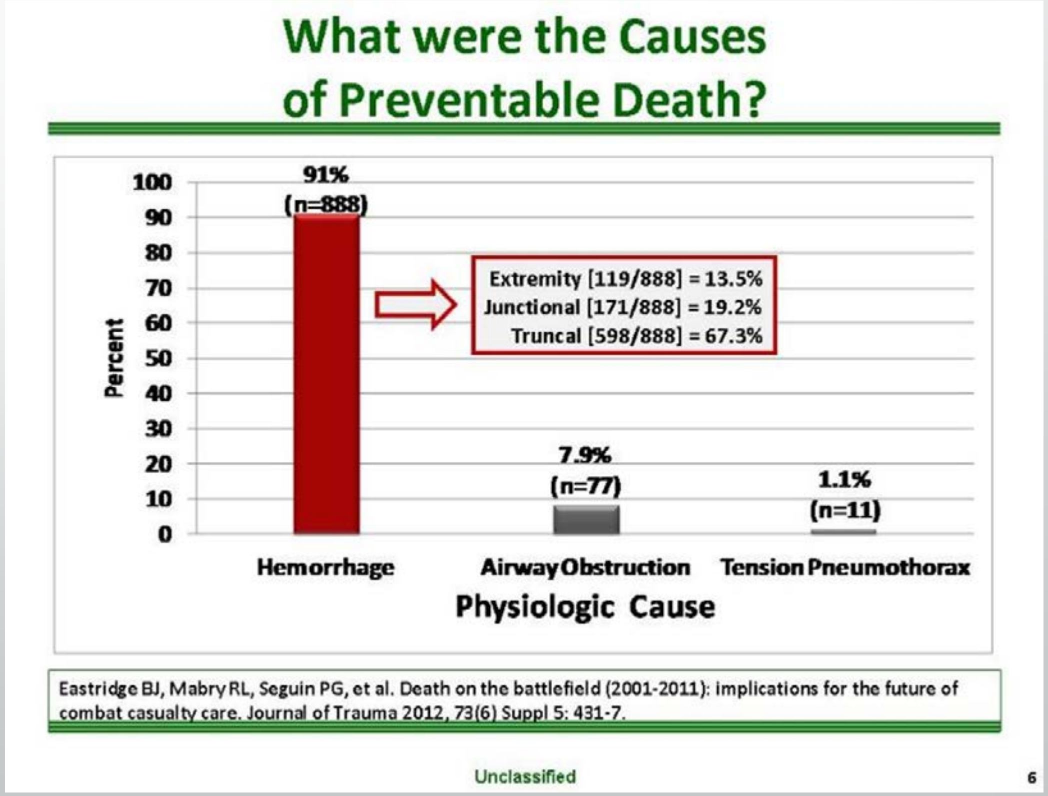
The opinions or assertions contained herein are the private views of the author and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

CNTR
COALITION for NATIONAL TRAUMA RESEARCH

Background

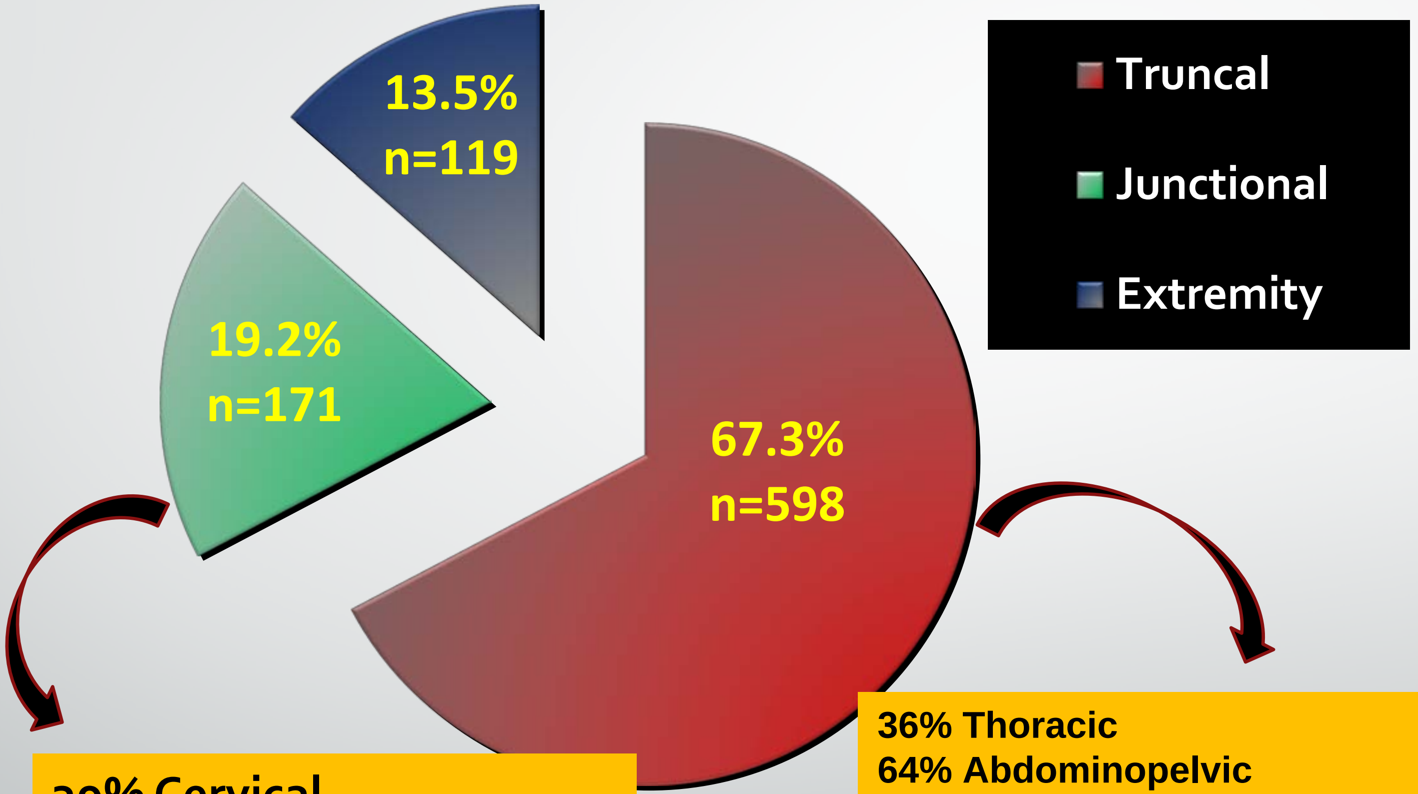
Background/Scientific Rationale
PreHospital Battlefield Mortality





CNTR
COALITION for NATIONAL TRAUMA RESEARCH

Anatomic / Physiologic Mechanism of Death



39% Cervical
61% Axilla and Groin

36% Thoracic
64% Abdominopelvic

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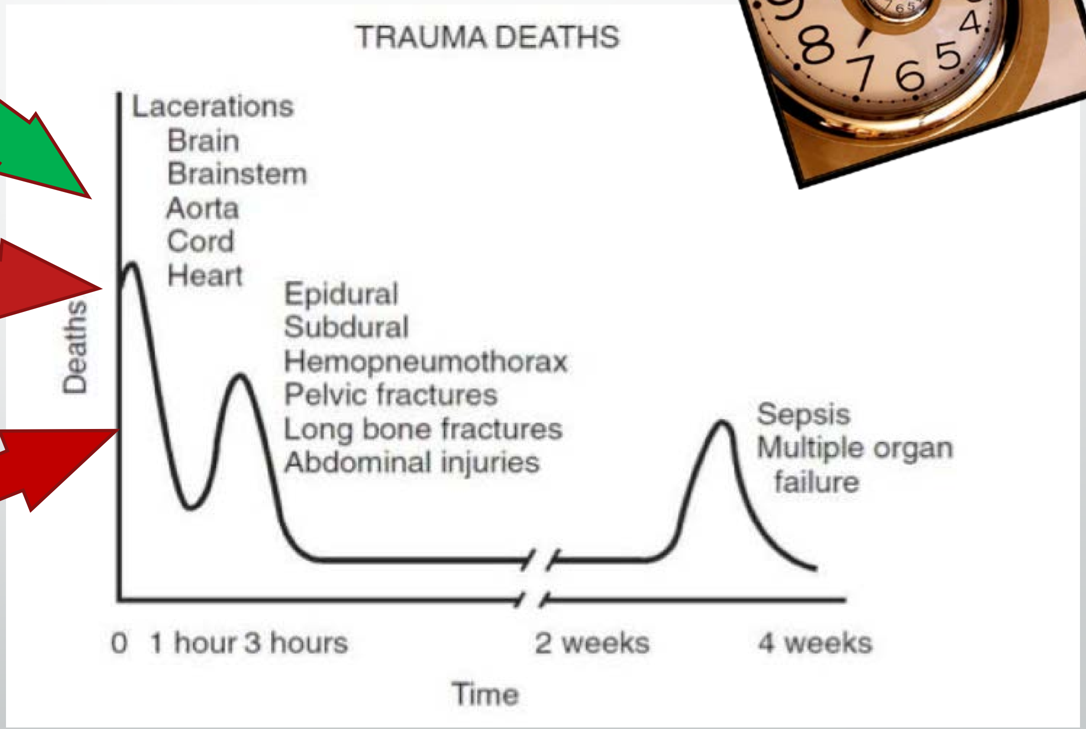
Eastridge BJ, Mabry RL, Seguin PG, et al. Death on the battlefield (2001-2011): implications for the future of combat casualty care. Journal of Trauma, 2012.

Background/Scientific Rationale
Pre-Hospital Civilian Mortality

Impact Not Well Quantitated

Potential Survivability Poorly Defined

NASEM Report Emphasis



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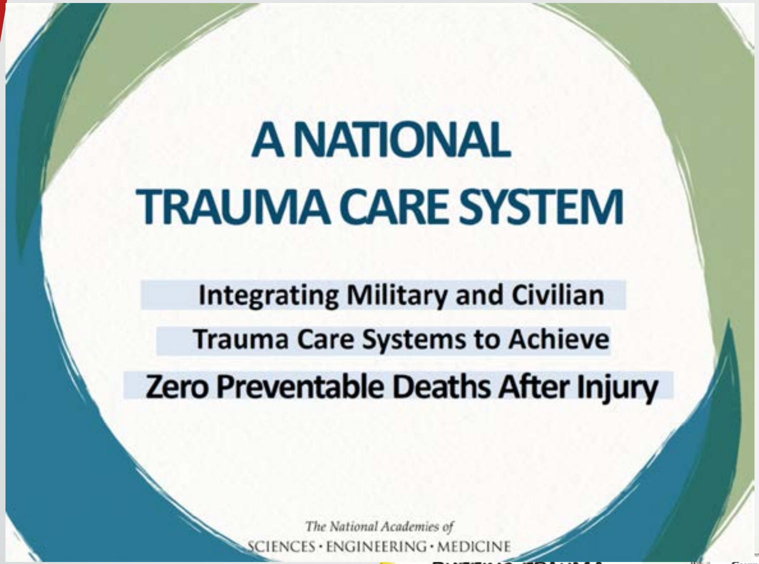

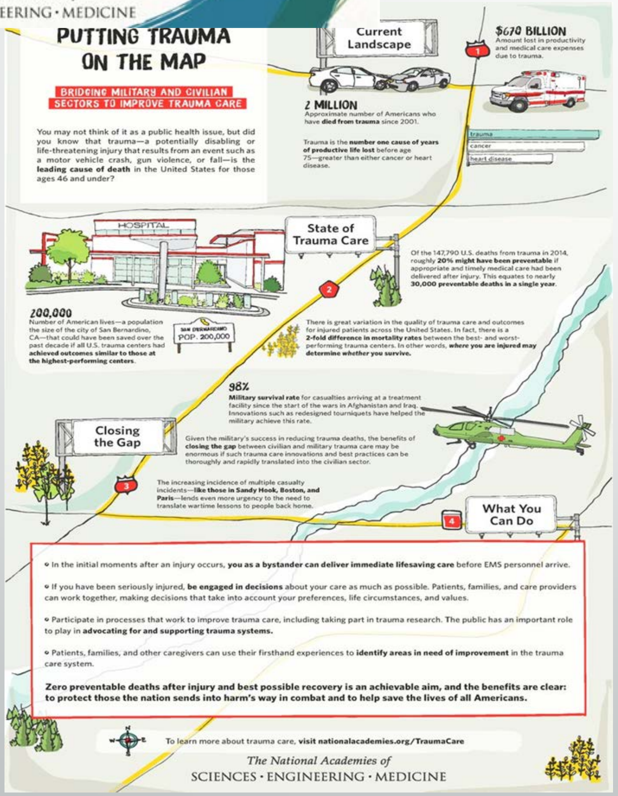

Potentially survivable injuries US civilian population

147,790 x 0.276 = 40,790

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Getting Beyond Estimates

Objective establishment of the impact on society

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Methods

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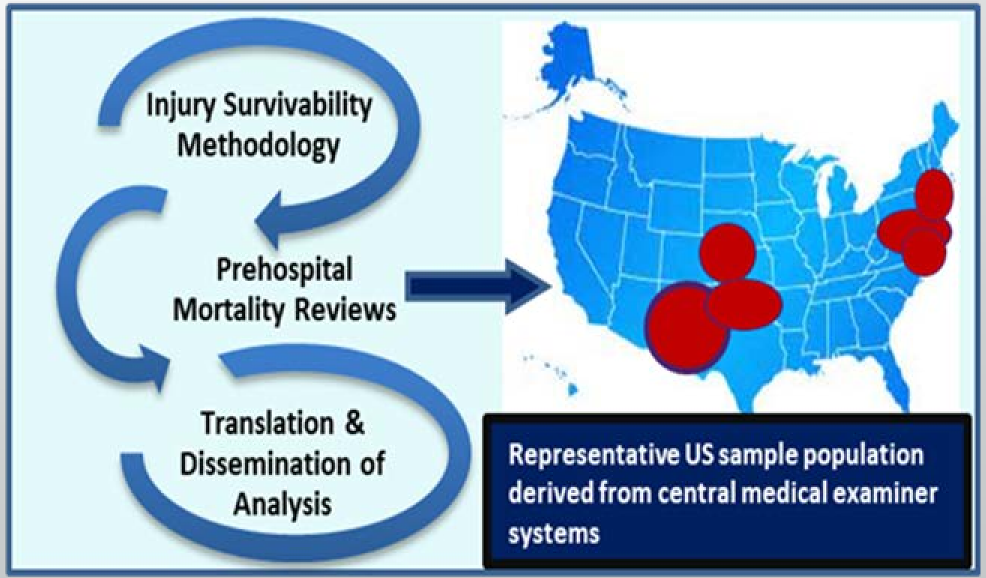
Multiinstitutional Multidisciplinary Injury Mortality Investigation in Civilian PreHospital Environment

PI:Eastridge
Co-I: Nolte, MacKenzie

Funded by USAMRMC
(Department of Defense)

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 pre-mortality from trauma

Identify potential high yield areas for research and development in pre-hospital medical care, injury prevention, and trauma systems.



MIMIC

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MIMIC Objectives

- **Objective #1:** ***Develop a framework and methodology*** for evaluating pre-hospital deaths
- **Objective #2:** Organize and standardize a ***multidisciplinary, multi-institutional network of experts*** to identify the causes of pre-hospital deaths due to trauma and estimate the potential for survivability.
- **Objective #3:** ***Define the causes and pathophysiologic mechanisms of 3,000 pre-hospital deaths***, and estimate the potential for survivability
- **Objective #4:** ***Describe the epidemiology of pre-hospital mortality*** in the context of trauma system development and estimate its impact on society.
- **Objective #5:** ***Develop a blueprint for a sustained effort*** identifying high priority areas for injury prevention, trauma systems performance improvement and research and development.

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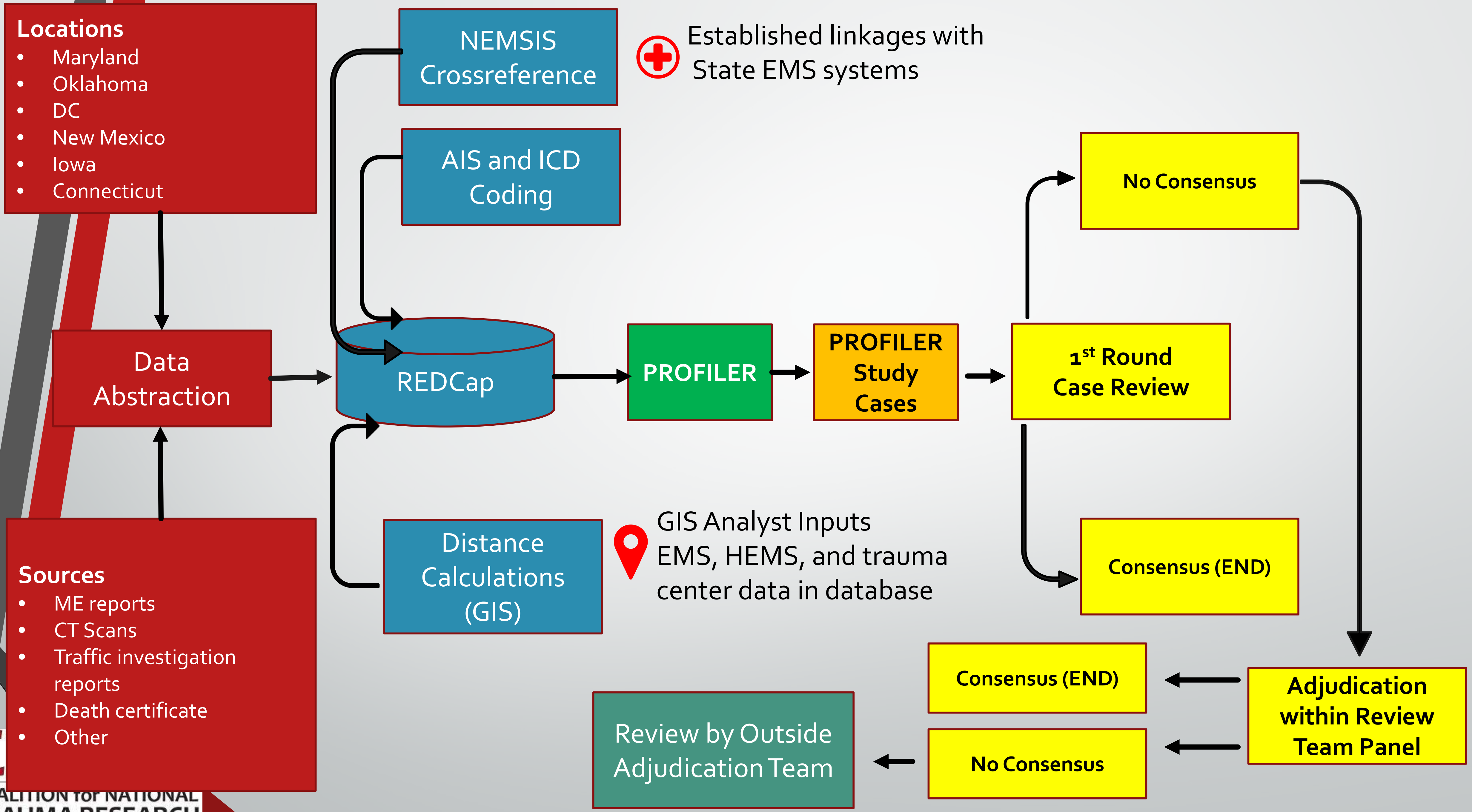

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Survivability Definitions

- **Non-Survivable-** Death as a result of catastrophic anatomic injuries
- **Possibly Survivable -** Anatomic injuries that were severe but medically survivable
- **Definitely Survivable-** Minimal anatomic injuries with a high likelihood of survival
- **Cannot Judge-** information insufficient to make a determination

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Anatomic Survivability

Medically Non-Survivable (MNS)

- Dismemberment / decapitation
- Traumatic Brain evisceration
- Cervical cord transection (above C3)
- Airway transection within thorax
- Cardiac injury > 2cm
- Uncontained hemorrhage, thoracic aorta
- Uncontained hemorrhage, pulmonary artery
- Hepatic avulsion
- Junctional lower extremity amputations with open pelvis
- Injuries to the deep CNS nuclei, brainstem, or massive brain tissue injury
- Massive Pulmonary Tissue Disruption

Medically Potentially Survivable / Definitely Survivable

- All other

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Results

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Preliminary Round 1 and Round 2 Data

Principal Mechanism(s) of Death	Frequency
Massive tissue disruption	146
Neurological – Traumatic Brain Injury	1342
Neurological - Spinal Cord	246
Hemorrhage - Truncal	393
Hemorrhage - Junctional	44
Hemorrhage - Peripheral	38
Airway	79
Traumatic Asphyxia	59
Tension Pneumothorax	32
Burn	133
Electrical	1
Other	84
Unknown	51

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Preliminary Round 1 and Round 2 Data (All Patients)

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO INFORM INJURY PREVENTION

Immediate Access	Immediate Access (All)	Actual Scenario (All)
	318 (79.5%)	380 (95.0%)
Survivable	78 (19.5%)	20 (5.0%)
Definitely Survivable	4 (1.0%)	0 (0.0%)
Cannot Judge	0 (0.0%)	0 (0.0%)

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Preliminary Round 1 and Round 2 Data (All Patients)

Immediate Access Survivability	Immediate Access (All)	Actual Scenario (All)
Non-survivable	318 (79.5%)	380 (95.0%)
	78 (19.5%)	20 (5.0%)
Survivable	4 (1.0%)	0 (0.0%)
Cannot Judge	0 (0.0%)	0 (0.0%)

OPPORTUNITIES TO IMPROVE CURRENT TRAUMA SYSTEM

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Preliminary Round ... a
(All Pa...

RESEARCH AND DEVELOPMENT OPPORTUNITIES TO IMPROVE FUTURE TRAUMA SYSTEMS

Immediate Access Survivability	Immediate Access (All)	Actual Scenario (All)
Non-survivable	**318 (79.5%)**	**380 (95.0%)**
Potentially Survivable	**78 (19.5%)**	**20 (5.0%)**
Definitely Survivable	**4 (1.0%)**	**0 (0.0%)**
Cannot Judge	**0 (0.0%)**	**0 (0.0%)**

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Preliminary Round 1 and Round 2 Data (Excluding Suicide)

Immediate Access Survivability	Immediate Access (Excluding Suicide)	Actual Scenario (Excluding Suicide)
Non-survivable	150 (67.9%)	202 (91.4%)
Potentially Survivable	68 (30.8%)	19 (8.6%)
Definitely Survivable	3 (1.4%)	0 (0.0%)
Cannot Judge	0 (0.0%)	0 (0.0%)

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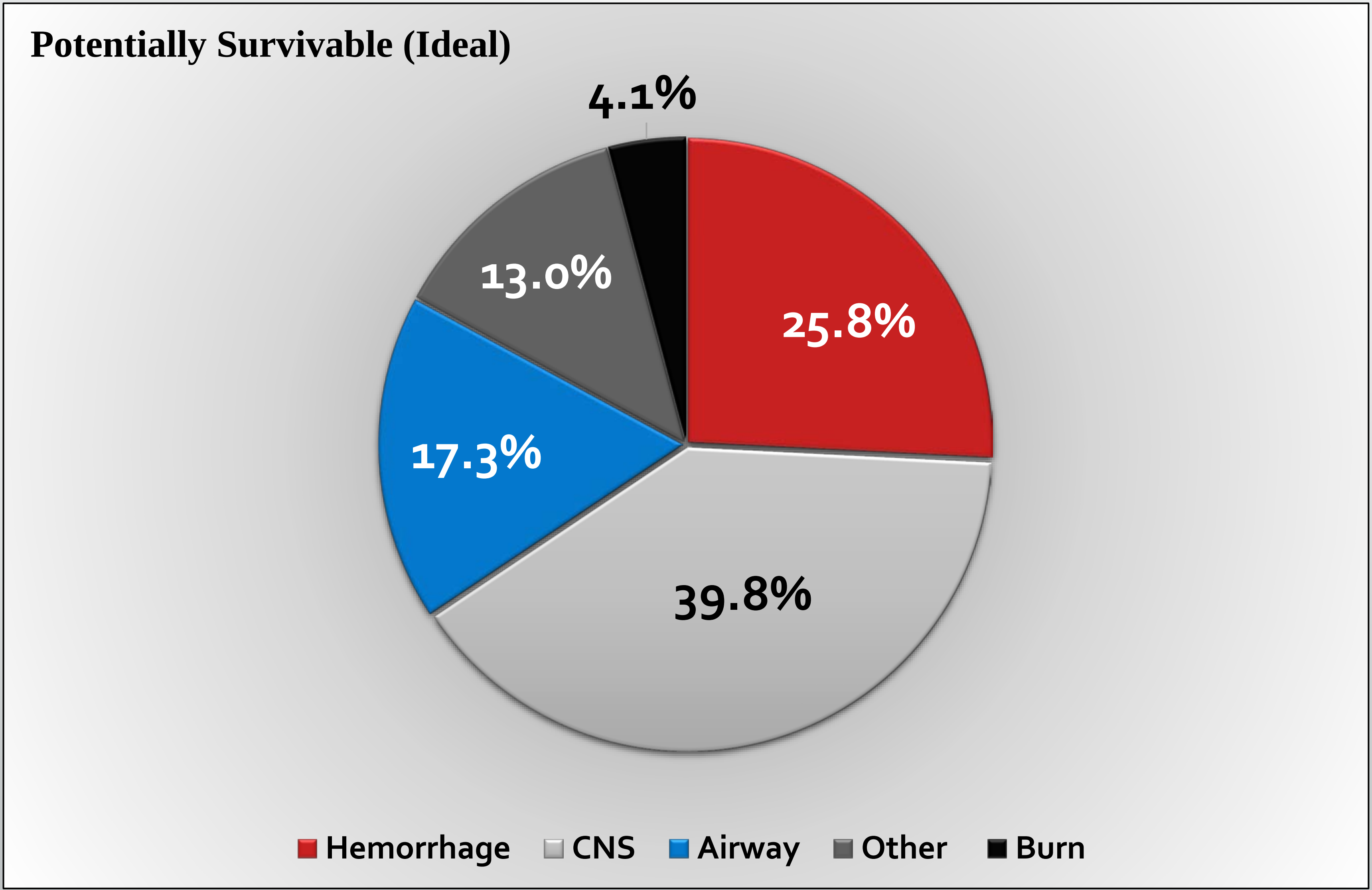
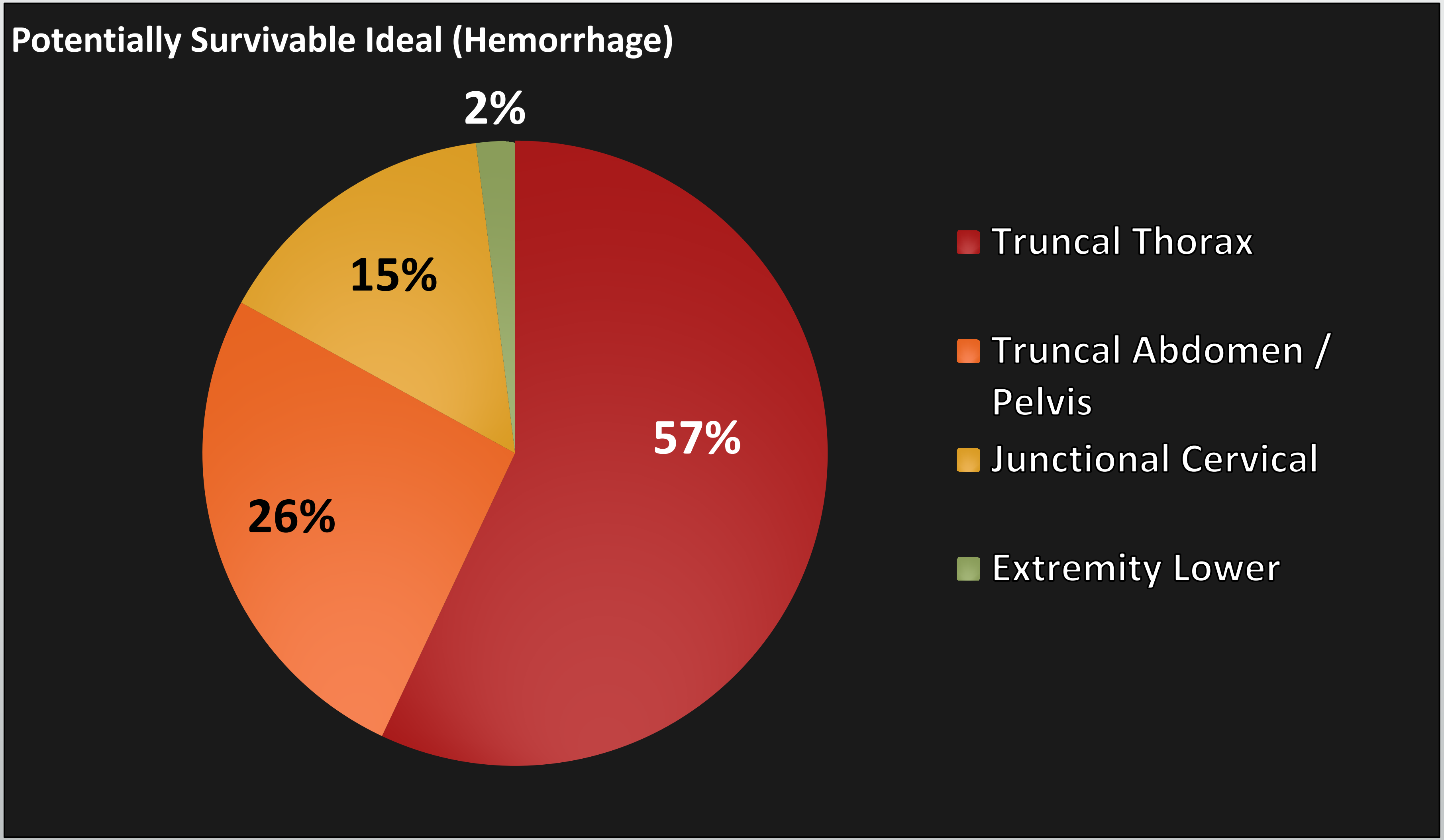
Mechanism of Death (All)
Ideal Circumstance



Potentially Survivable (Hemorrhage Focus) Ideal Circumstance



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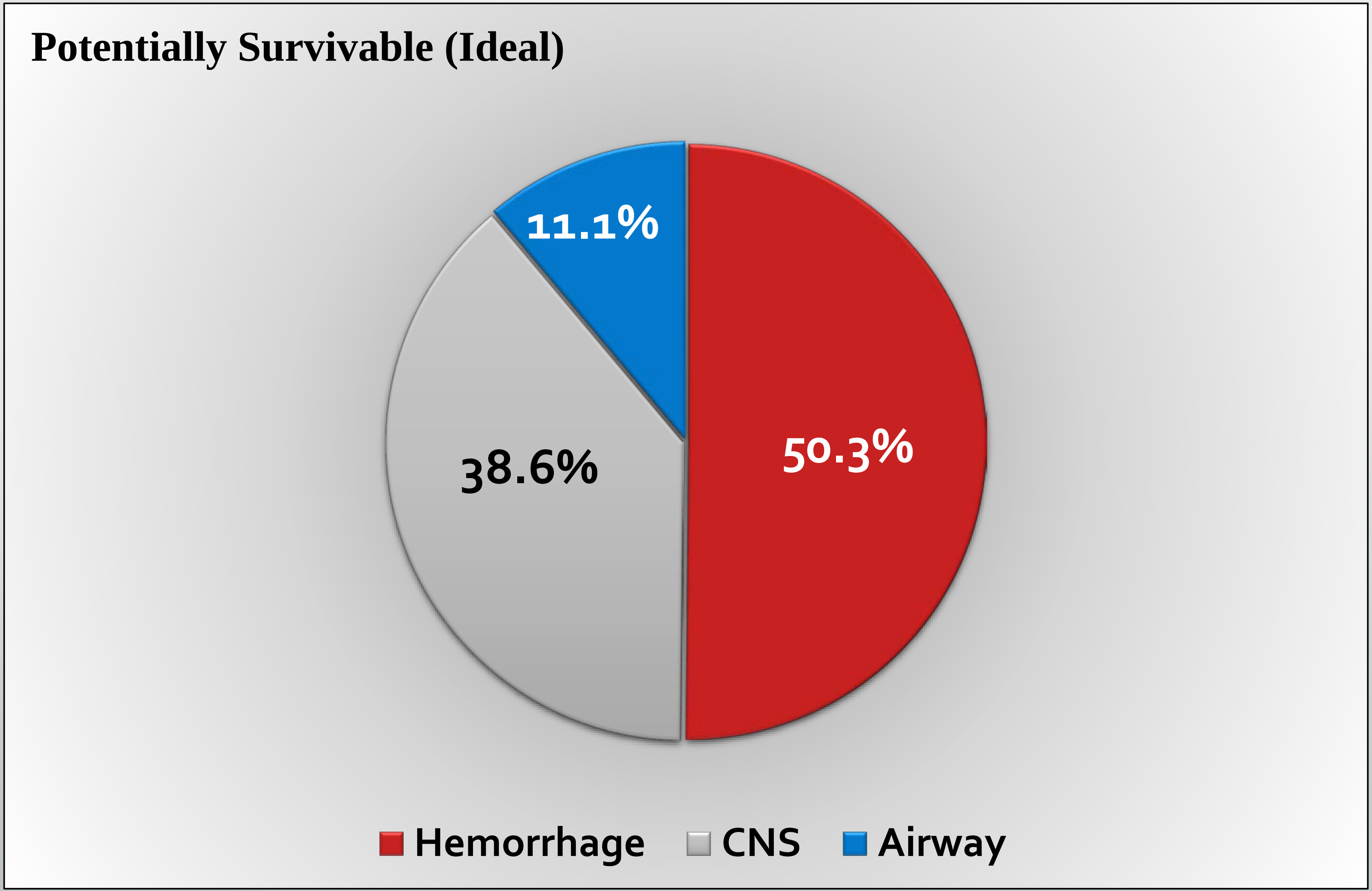
Mechanism of Death (All)
Actual Circumstance



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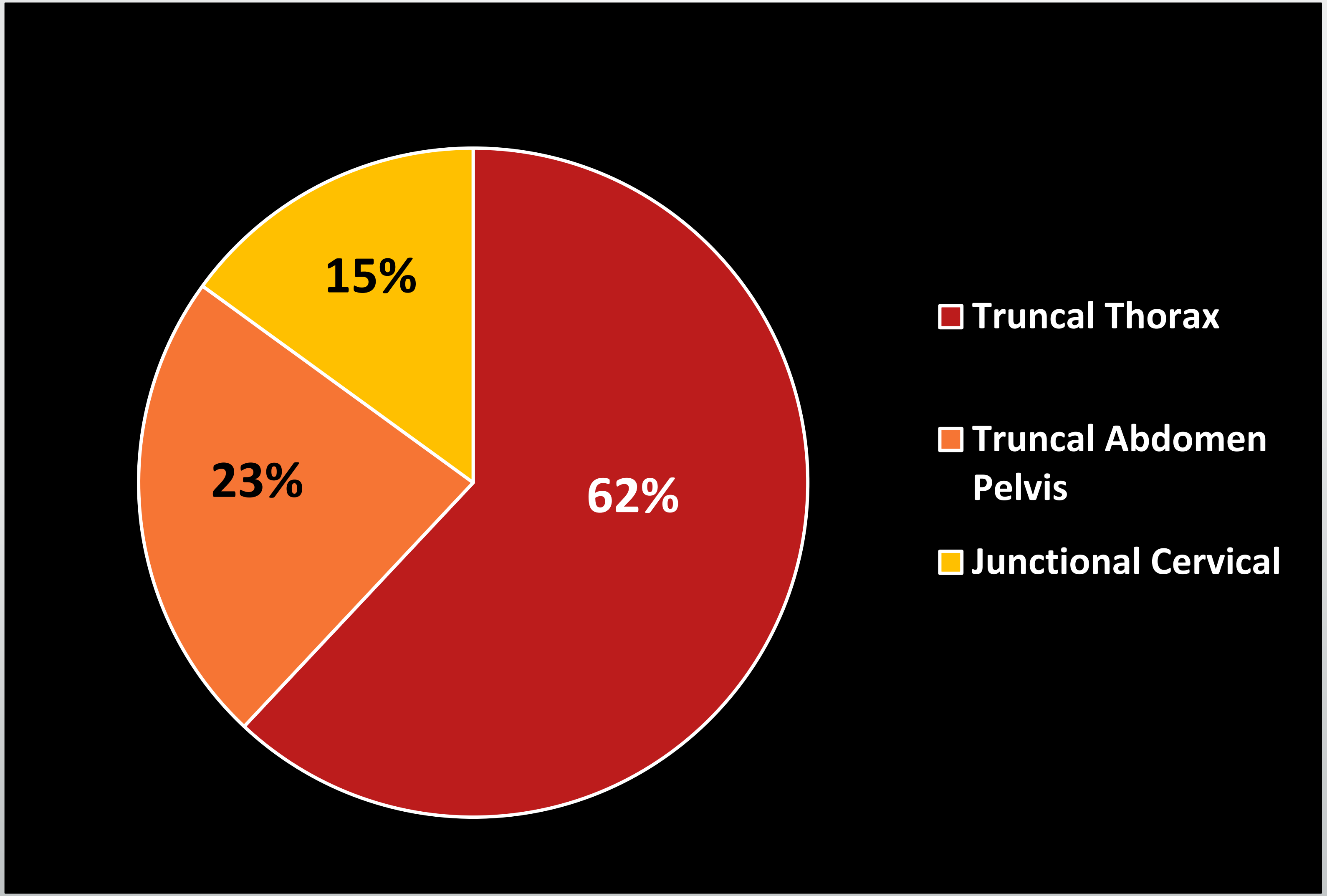
Potentially Survivable (Hemorrhage Focus) Actual Circumstance



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Preliminary Round 1 and Round 2 Data

Injury prevention programs/devices or interventions might have improved the chances of survival

Prevention Program(s)	Frequency
Behavioral health	777
Alcohol / drug	469
Seat belt	149
Airbag	55
Helmet	34
Child Restraint	5
Protective Clothing	5
Personal Flotation Device	4

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Limitations

- Potential sources of bias
  - Observer bias
  - Misclassification bias
  - Bias relative to consensus rule amongst expert panels
- Heterogeneity medical examiner system processes
- Survivability determinations based upon anatomic injury metrics
  - No consideration additive effects of multiple injuries, age, comorbidities
- Generalizability

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Conclusions

- Current assessment provides objective evidence to support a more comprehensive understanding of pre-hospital injury mortality
- Focus research and development response dedicated to improve the pre-hospital management and outcomes of the injured patient
- May be useful in the development and implementation of mitigation strategies for therapy and injury prevention to improve trauma systems

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PRELIMINARY ANALYSIS OF THE MULTI-INSTITUTIONAL MULTIDISCIPLINARY INJURY MORTALITY INVESTIGATION IN THE CIVILIAN PRE-HOSPITAL ENVIRONMENT (MIMIC)

Short Title:

Preliminary Civilian Pre-Hospital Injury Mortality Analysis

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FUNDING

This work was supported by the Office of the Assistant Secretary of Defense for Health Affairs, through the Defense Medical Research and Development Program under award number W81XWH-17-2-0010.

CONFLICT OF INTEREST

The authors and investigator group declare no conflicts of interest.

DISCLAIMER

Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense.

ABSTRACT

BACKGROUND: Advances in trauma centers and systems have substantially reduced death associated with injury. However, there are substantial opportunity to further reduce deaths in the prehospital setting. The goal of this research was to characterize survival potential of prehospital injury deaths in order to develop mitigation strategies and improve trauma systems.

METHODS: A steering committee developed prehospital injury survivability definitions and study process. Balanced expert review panels were established from 80 military and civilian reviewers specializing in trauma surgery, orthopedics, neurosurgery, emergency medicine, EMS, and forensic pathology. Panels reviewed injury mortalities from comprehensive medical examiner systems and assigned a determination of survivability to each case based upon principal mechanism of death. Survivability determinations were made based upon the assumption of immediate access to care and in the context of the actual injury scenario. Non-consensus in determination of survivability was remediated though an online adjudication process. Data were entered into an electronic review and response tool (Profiler) for collation and analysis.

RESULTS: 436 prehospital mortality cases were assessed by the reviewer panel. Panel consensus of survivability was reached in 400/436 cases (91.7%). Assuming immediate access to care, potentially / definitely survivable mortality was assessed to be 20.5%. Utilizing the context of the actual injury scenario, potentially / definitely survivable mortality decreased to 5.0%.

CONCLUSIONS: This preliminary analysis of prehospital injury mortality develops a perspective of relative importance of injury mortality causation in the prehospital environment.

This assessment may provide objective evidence to support the development of mitigation strategies for therapy and injury prevention to improve trauma systems.

KEY WORDS

Survivability, Preventable Death, Prehospital, Injury, Trauma System

INTRODUCTION

Death from injury was described as the neglected epidemic of modern medicine by the Institutes of Medicine in 1966 [1]. Despite dramatic advances in acute trauma care over the last several decades, including resuscitation of massive hemorrhage, damage control surgery, and technological advances in critical care, the health burden of injury on our society remains substantial. From a public health perspective, injury remains the leading cause of death in individuals up to the age of 45 and is responsible for a domestic cost of billions of dollars in medical care and lost productivity each year [2]. Though incremental improvements in care in both trauma centers and trauma systems have substantially reduced death and disability associated with injury over the past several decades [3]. However, there remains a substantial opportunity to further reduce deaths in the pre-hospital setting. The majority of injury mortality occurs in the field without access to hospital care or prior to hospital admission [4-7]. According to a Centers for Disease Control and Prevention report in 2008, 62% of all people who died from injuries and 75% of people who died from gunshot wounds were pronounced dead outside of a hospital [8]. Potential opportunities for improvement in 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 concept of the distribution of mortality along the axis of time and the associated prominence of immediate death and death within minutes of injury was initially characterized by Trunkey based upon his experience and research in his seminal work describing the trimodal distribution of trauma death [9]. The modal peaks represented immediate death in the pre-hospital environment, which was by far the largest population (~50%), followed by early death within hours and a subsequent late peak at days to weeks which corresponded to the patients who died secondary to sepsis and multiple organ failure. From this early work, the importance of injury prevention, evacuation, and acute healthcare delivery, formed the nascent concepts of regionalized injury care which evolved into trauma systems across the U.S. Recent review of the literature suggests a change in the mortality distribution within this paradigm, but the clear constant which remains is the predominance of immediate pre-hospital injury deaths with a diminution in the number of late deaths [10-12]. The decreased number of late deaths is likely largely a consequence of the evolution of medical technologies in resuscitation and critical care medicine which have markedly improved outcomes for this later population of injured patients. More contemporary analyses have similarly noted a reduction in the number of early deaths. This reduction has been advocated to be associated with expeditious evacuation, improvements in acute resuscitation and massive transfusion practice, and the evolution of regional trauma systems [13-14]. In contrast to the well-characterized outcome of injury mortality after reaching the hospital, there is a paucity of evidence that substantively defines injury-associated death in the pre-hospital environment. The purpose of this proposal was 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 into pre-hospital medical care, injury prevention, and trauma systems.

METHODS

The MIMIC Steering Committee of military and civilian experts in injury mortality defined definitions and process for the conduct of the study. Subsequently, expert review panels were developed utilizing 80 military and civilian medical professionals in the fields of trauma surgery, emergency medicine, neurosurgery, orthopedic surgery, forensic pathology, emergency medical systems (EMS), and trauma systems. Mortality review teams were formed consisting of 5 individuals each, inclusive of at least one trauma surgeon, one emergency medicine physician, and one forensic pathologist. All reviewers were formally trained with study definitions and process to determine prehospital injury potential for survival.

The study was developed on the pretext of a nationally representative sample of prehospital deaths occurring in six regions of the country (Connecticut, Maryland, District of Columbia, Oklahoma, New Mexico, and a region of Iowa). The six regions were chosen based upon the presence of a centralized medical examiner system utilizing an electronic case management system to collect uniform high fidelity data on all injury deaths. The study population was based upon inclusion criteria including all pre-hospital injury deaths from scene, en route to hospital or dead on arrival (DOA – defined as no vitals upon arrival at hospital). Exclusion Criteria were defined as non-mechanical causes of injury (poisoning, drug overdoses, asphyxia, and drowning) as well as those decedents whose decomposed remains were not fully fleshed with distinguishable tissues and organs.

A sample of 3,000 cases that meet inclusion criteria were developed to be representative of the epidemiology of all pre-hospital injury deaths for defined populations including age, type (blunt, penetrating, burn, etc.), manner (“accident”, homicide, suicide), geography (urban, suburban, rural), and major focus of pathophysiology associated with death.

Research coordinators at each medical examiner system abstracted defined comprehensive set of data on each case and enter these data into REDCap. All decedent’s records were reviewed by a professional abbreviated injury scale (AIS) coder and assigned AIS injury codes for all injuries. From this data, the injury severity score (ISS) and new injury severity score (NISS) were calculated. Likewise, all injuries were coded by the international classification of disease (ICD) 10. Geographic information systems (GIS) mapping was performed at point of injury death to determine the time and distance from EMS as well as trauma centers. NEMSIS data was cross-referenced with state EMS data mangers in order to integrate EMS data if there was an EMS encounter. These specific data elements were then utilized to populate an online electronic review tool “PROFILER” with a summary of the pertinent information about each case and provide electronic access to specific documents including autopsy, scene, investigator reports, ME summary, and forensic imaging for electronic case review.

Members of the mortality review panels independently reviewed 25 injury mortality cases per round using the PROFILER system and assigned a cause of injury death to each case. Reviewers were given the opportunity to choose multiple causes of death if each were independently potentially lethal. Subsequently, the determination of potential survivability was designated for each case based upon two conditions: assumption of immediate access to care at a level I trauma center and then given the conditions of the actual scenario in which the injury occurred (i.e. discovery, EMS response, access to trauma center, weather, etc.), Discrepancies in determination of survivability were identified by data coordinating center and the review panels subsequently discussed these cases online in order to attempt to reach consensus, at which time the consensus results were recorded.

The Institutional Review Board at UT Health San Antonio and the Human Research Protection Office at the Department of Defense as well as all medical examiner offices deemed this research as non-human subject research.

RESULTS

Through three rounds of panel reviews, 14 review panels reviewed 436 prehospital mortality cases. Panel consensus on the potential for survivability was reached in 400/436 cases (91.7%). Assuming immediate access to care, potentially / definitely survivable mortality was assessed to be 20.5%. Utilizing the context of the actual injury scenario, potentially / definitely survivable mortality decreased to 5.0% (Table 1). Performing the same analysis after excluding the population of suicides demonstrated an increase in the rate of potential survivability to 30.8% in the immediate access situation and 18.6% in the context if the actual scenario (Table 2). Mechanism of injury mortality was assessed by individual reviewer (Table 3). For the study sample to date, including all mechanisms of injury and manners, neurological causes were responsible for the majority of prehospital injury death with the principal mechanism of death being traumatic brain injury 1342 / 2648 (50.7%) determinations.

Including all manner of death, neurologic injury was the most substantial cause of nonsurvivable injury death in both the ideal and actual circumstances at 64% and 60% respectively. Similarly neurological injury was also responsible for 39.8% of the potentially survivable injury death in the ideal setting and 38.6% in the actual scenario. Hemorrhage was noted to be a more prominent cause of potentially preventable injury mortality under the actual circumstances of the traumatic event (50.3%) compared to the ideal circumstance (25.8%). (Figures 1 & 2). Under both idealized and actual circumstances, the majority of hemorrhage associated mortality was truncal in origin, ideal 83% (57% thorax, 26 % abdomen / pelvis) and actual 85% (62% thorax, 23% abdomen / pelvis) (Figures 3 & 4). Interestingly, when the manner of suicide was excluded from the analysis, the proportion of the potentially survivable mortality attributable to hemorrhage dramatically increased such that the majority of injury mortality in both ideal and actual groups was attributable to hemorrhage.

DISCUSSION

As the U.S. military combat operations of the last two decades evolved, a tremendous amount of evidence was amassed validating improvements in combat casualty care once a casualty had reached a military medical treatment facility (MTF) [15-17]. Likewise, concomitant Department of Defense investment in combat casualty care and research since 2001 produced promising returns resulting in the lowest case fatality rate recorded in the history of warfare which was in turn translated into life-saving interventions in civilian trauma care [18]. Complementary advances in civilian trauma care likewise informed military trauma care, as has been true in the history of modern conflict [19]. Not to rest on the laurels of these successes, military surgeons noted that a discrete "blind spot" in the perception of combat casualty outcomes was that no studies comprehensively evaluated the specific causes of death in combat casualties who succumbed to their injuries before reaching an MTF.

Conceptualizing the importance of the population of casualties who died on the battlefield helped investigators formulate a novel research strategy in collaboration with the Armed Forces Medical Examiner System to identify the most significant causes of lethal pathophysiology in the pre-MTF subset of fatalities and to determine which lethal injuries may have been potentially survivable. As a result, a mutidisciplinary military review group was formed that produced the most comprehensive analysis of pre-hospital injury death to date. This autopsy review of all 4,596 battlefield deaths from 2001-2011 demonstrated that 4,016 (87%) of the battlefield mortality occurred in the field before the casualty reached an MTF. Of particular note, 976 (24%) of pre-hospital battlefield deaths were deemed to be potentially survivable under optimal medical circumstances as qualified by the analysis. Furthermore, 90% (888 /976 casualties) of potentially survivable mortality was associated with hemorrhage. When this hemorrhagic mortality component was stratified into anatomic zones based upon potential for intervention, it was demonstrated that non-compressible torso hemorrhage was associated with the greatest proportion (67.3%) of potentially survivable combat injury deaths [20-21]. This military medical research provided a vital insight that hemorrhage was the most substantive mechanism of death from potentially survivable injury in the pre-hospital setting. This analysis fostered combat casualty care research and development initiatives to generate processes, systems, and materiel solutions to improve survival in the pre-hospital setting.

With the potential implication translated from the military mortality studies that a fraction of these deaths are potentially preventable, this situation has substantial potential impact on public health. Predicated upon the assumption of similar levels of potentially survivable injury in the civilian pre-hospital environment, the public health implications are staggering. However, no studies have comprehensively evaluated the potential survivability of civilian deaths due to several factors including inconsistent and ineffective integration of existing mortality data sources into the trauma registry. Prior domestic studies of pre-hospital injury mortality have been limited by small patient numbers, samples not representative of the population, lack of multidisciplinary review, inconsistent methodology, and limited scope / distribution of casualty characteristics leading to poor generalizability of these prior analyses. Few of the studies detail of injury to the level of organ system with concomitant organ injury scaling and associated pathophysiology with which to make a representative cause of death determination [22-28]. The judicious assessment of all aspects of injury care, including mortality, is essential to identifying gaps in knowledge and conceptualizing mitigation strategies to improve outcomes. Similar to US military studies of pre-hospital death, this research makes the assumption that the potential for survivability in civilian pre-hospital mortality can be modeled based upon clinical assumptions in conjunction with injury severity as defined by standard trauma scoring methodology (Abbreviated Injury Scale (AIS)) and discrete data derived from autopsy and scene investigation. In the civilian setting, a review of pre-hospital trauma deaths is essential to identifying areas of improvement and further study, including emergency medical services and trauma systems [29-31]. In the current study, for those casualties who had emergency medical service response to the scene of injury, available documentation of the interaction and response to attempted interventions may further highlight therapeutic vulnerabilities or injury pattern variation and their attributable impact upon casualty survivability. The impetus for the current study and methodology chosen were to "mimic" successes derived from contemporary military studies on potential survivability of combat injury.

Preliminary analysis of the results of the current study to date are striking. Given the presumption of immediate access to care at a level I trauma center, the analysis derived the rate of potential / definite survivability of the decedent group to be 20.5%. This result compares favorably to previous military analyses and appears to substantiate the consistency of the mortality review methodology. Of note, the rate of non-survivability in this analysis is similarly a potentially valuable data point. The data derived from this population has the potential to inform research and development opportunities and activities in the realm of injury prevention and injury risk mitigation. Unlike prior military prehospital injury mortality analyses, the current study also sought to assess the potential for injury survivability given the conditions of the actual scenario in which the injury occurred, included time of discovery, EMS response, access to trauma center, weather conditions, etc. The analysis of survivability under these realistic parameters yielded substantially different results. The rate of potential / definite survivability dropped to 5.0%. These results attest to the effectiveness of regional trauma system within the areas of study. Further developing these analyses may identify opportunities for improvements in current trauma system. Conceptually, understanding the factors which contribute to the survivability gap between idealized circumstances (20.5%) and actual circumstances (5.0%) may provide insight into research and development, training, workforce, process, and health policy opportunities to enhance future trauma systems.

Unlike many previous studies of pre-hospital injury mortality, the current study included all mechanism and manner of deaths, including suicide. In our composite decedent population, it is notable that neurologic injury, particularly traumatic brain injury is responsible causative factor for the majority of pre-hospital injury mortality. The aforementioned military pre-hospital injury mortality studies as well as most civilian investigations have specifically excluded the suicidal manner of death from their analyses. When the data from our study were analyzed excluding the subpopulation of suicides, injury mortality causation skewed strongly to be associated with hemorrhage. For all scenarios, those decedents with potentially survivable mortality due to hemorrhage, greater than 80% of the hemorrhagic foci were truncal. This correlates with prior military research previously noted. The most valid explanation for this finding is that unlike extremity hemorrhage which is amenable to tourniquet application and junctional injuries which are compressible, there is currently no effective therapy for truncal hemorrhage control in the pre-hospital environment.

As with previous studies on prehospital injury mortality survivability, the study has limitations inherent to retrospective nature of the analysis and the limitations imposed by large administrative data repositories such as the medical examiner systems. Potential sources of bias include observer bias, misclassification bias and sources of bias relative to consensus rule amongst expert panels. Likewise, as medical examiner system processes are largely heterogeneous, data recording and detail are not uniformly expressed and as such may represent a source of potential bias. Importantly, amongst the limitations of this study were that survivability determinations were based upon clinical metrics focused upon sources of potential injury lethality. However, fundamentally, injury survivability is multifactorial based upon the additive effects of multiple injuries, age, comorbidities, etc. Similar to other studies in the literature, one component of this analysis was predicated upon an idealized injury care scenario potentially affected by many sources of bias, including reviewer perception. In our second analysis of the potential for injury survivability in the actual circumstance of the injury event, we hoped to circumvent the limitations noted of prior studies which failed to take into account confounding elements such as discovery, prolonged recovery, tactical delay, evacuation limitations and delays, and environment. Finally, as this data set was a preliminary sample of the composite data set, the data may not be generalizable.

CONCLUSION

This preliminary analysis of prehospital injury mortality develops a perspective of relative importance of injury mortality causation in the prehospital environment. This current assessment provides objective evidence to support a more comprehensive understanding of pre-hospital injury mortality and may be useful in the development and implementation of mitigation strategies for therapy and injury prevention to improve trauma systems. It is expected our findings in the civilian environment will elicit a similar focused research and development response, the product of which could improve the pre-hospital management and outcomes of the injured patient and ultimately be translated back into military medicine. Supporting the evolution of trauma systems will imminently improve public health.

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TABLES AND FIGURES

Survivability Determination	Immediate Access	Actual Scenario
Non-Survivable	318 (79.5%)	380 (95.0%)
Potentially Survivable	78 (19.5%)	20 (5.0%)
Definitely Survivable	4 (1.0%)	0 (0.0%)
Cannot Determine	0 (0.0%)	0 (0.0%)

Table 1. Prehospital injury survivability

Survivability Determination	Immediate Access	Actual Scenario
Non-Survivable	150 (67.9%)	202 (91.4%)
Potentially Survivable	68 (30.8%)	19 (8.6%)
Definitely Survivable	3 (1.4%)	0 (0.0%)
Cannot Determine	0 (0.0%)	0 (0.0%)

Table 2. Prehospital injury survivability
(Suicide excluded)

Principal Mechanism(s) of Death	Frequency
Massive tissue disruption	**146**
Neurological – Traumatic Brain Injury	**1342**
Neurological - Spinal Cord	**246**
Hemorrhage - Truncal	**393**
Hemorrhage - Junctional	**44**
Hemorrhage - Peripheral	**38**
Airway	**79**
Traumatic Asphyxia	**59**
Tension Pneumothorax	**32**
Burn	**133**
Electrical	**1**
Other	**84**
Unknown	**51**

Table 3. Principal mechanism of death

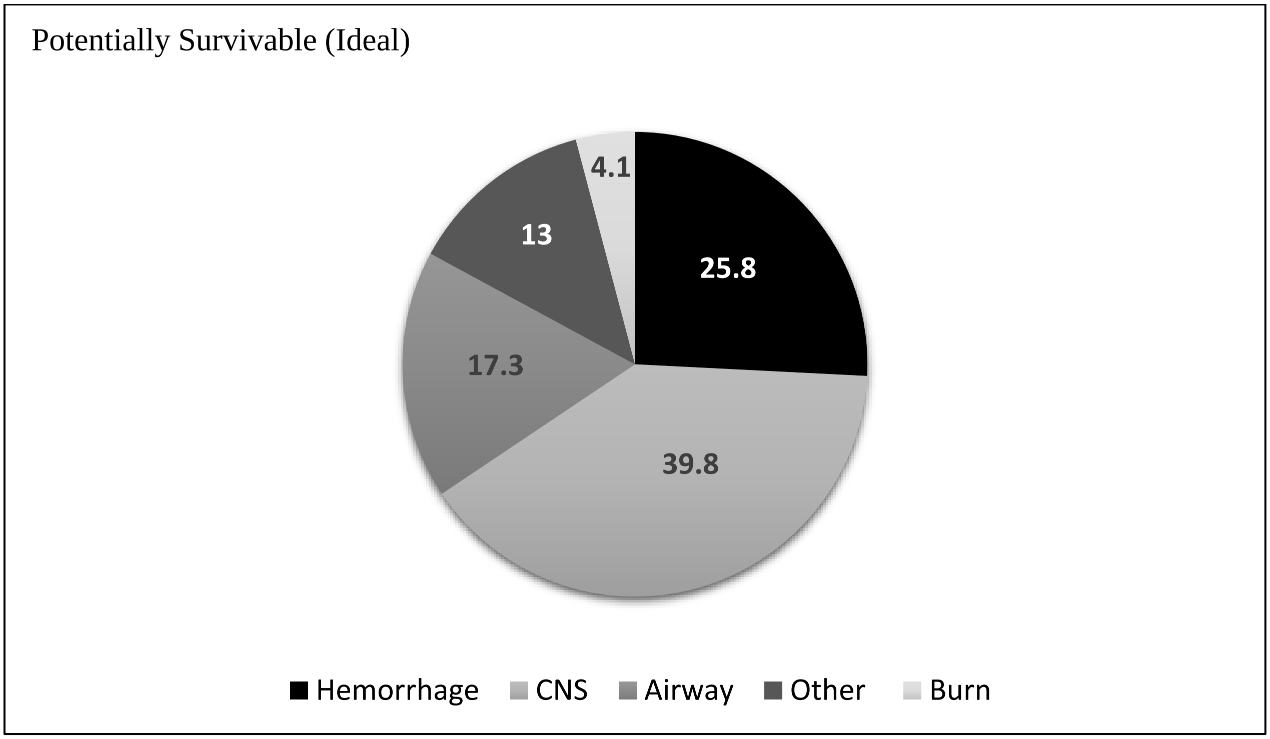

Figure 1. Potentially survivable ideal circumstance

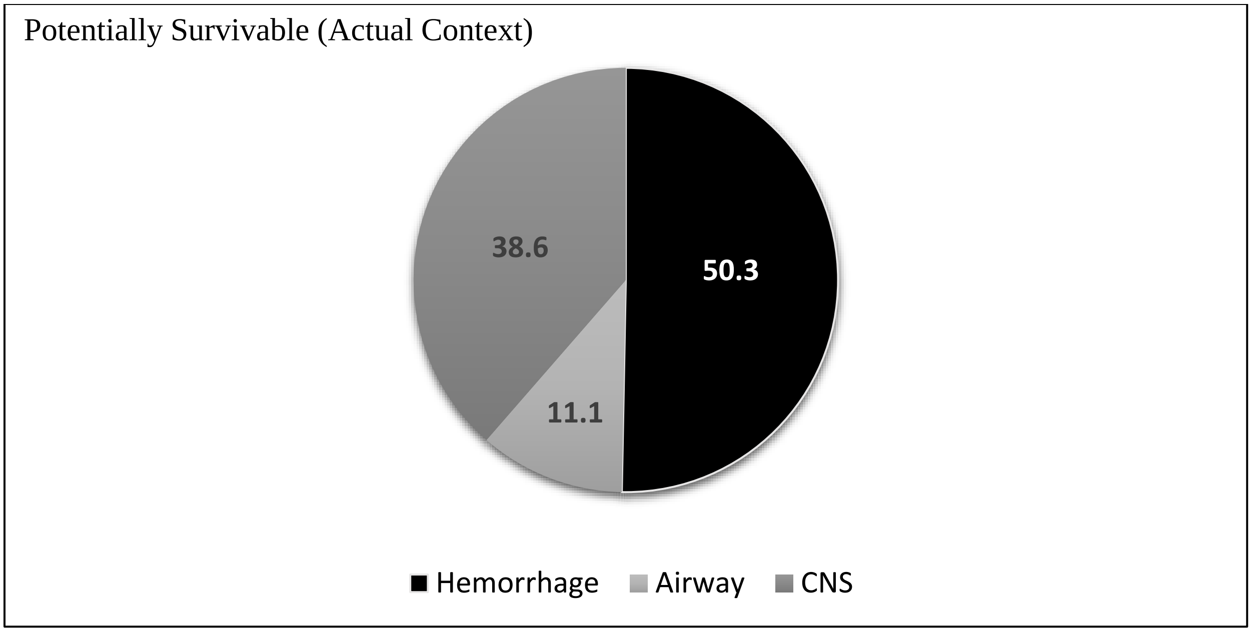

Figure 2. Potentially survivable actual context

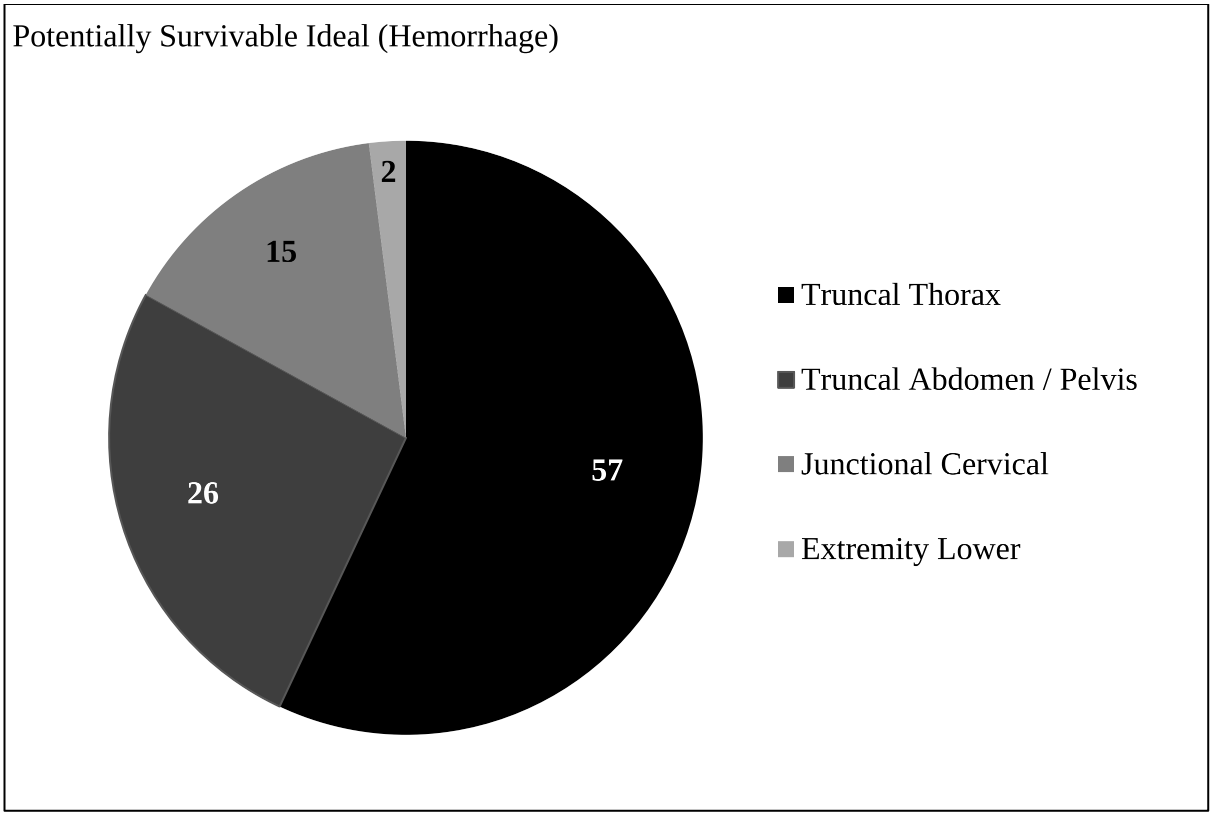

Figure 3. Potentially survivable ideal circumstance (hemorrhage)

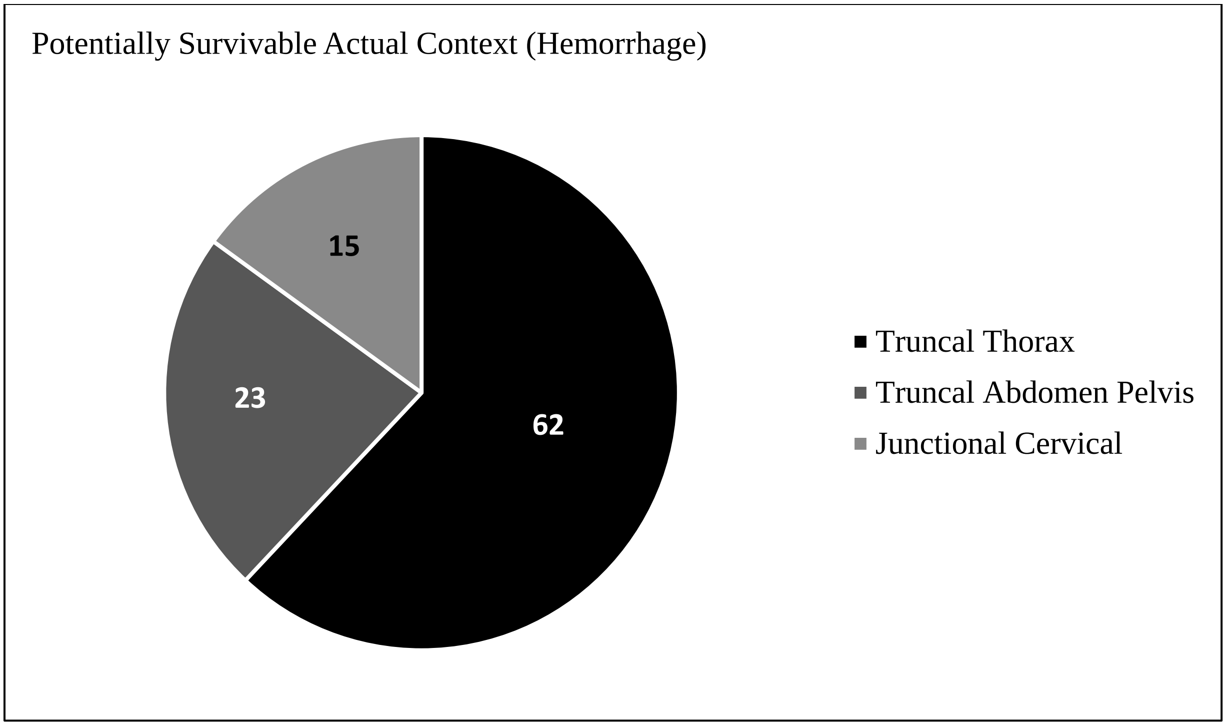

Figure 4. Potentially survivable actual circumstance (hemorrhage)