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2026

MATTOX VEGAS TCCACS™

Continuing 59 Years of Educational Excellence

MEDICAL DISASTER RESPONSE IN TODAY'S WORLD

2026

April 26, 2026

Las Vegas

www.trauma-criticalcare.com

MATTOX VEGAS
MEDICAL DISASTER RESPONSE
2027

ISTCC-MCI

1967

2027

MATTOX VEGAS TCCACS™

March 14, 2027
Caesars Palace
Las Vegas

LAS VEGAS

MARK YOUR CALENDAR TODAY!

March 14, 2027

SUN	MON	TUE	WED	THUR	FRI	SAT
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30	31			

CAESARS PALACE

LAS VEGAS

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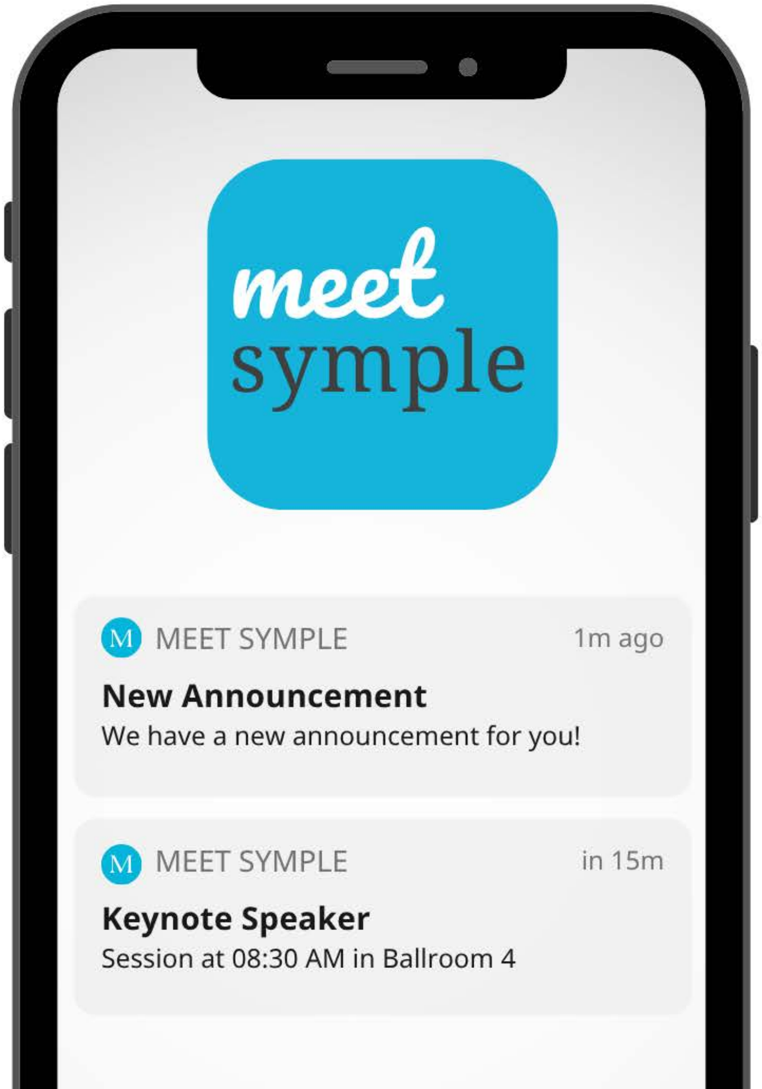
app name: MeetSymple

code/password: Tccacs!!

SCAN ME



- **Search by Daily Agenda:** Easily view daily agenda by date and time.
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SCAN QR CODES TO:

- **COMPLETE YOUR CME ACCREDITATION FORMS**
- **STAY UP TO DATE ON MEETING ANNOUNCEMENTS**
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CME FORMS:

Follow this convenient link to access the Trauma 2026 System, which allows you to sign and complete required CME FORMS, as well as download your CME Certificate.

Keep in touch with Trauma, Critical Care & Acute Care Surgery!

Tweet with us at:
@TCCACS

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Download the official conference app!

MeetCsymple

Code: Tccacs2026

SCAN ME

CONTINUING MEDICAL EDUCATION CREDIT INFORMATION

AMA PRA Category 1 Credits™
The American College of Surgeons designates this live activity for a maximum of 8.75 AMA PRA Category 1 Credits™. Physicians should claim only the credit commensurate with the extent of their participation in the activity.

Of the AMA PRA Category 1 Credits™ listed above, a maximum of 2.25 hours meet the requirements for Ethics*

Of the AMA PRA Category 1 Credits™ listed above, a maximum of 0.75 hours meet the requirements for Pediatric.Trauma*

Of the AMA PRA Category 1 Credits™ listed above, a maximum of 8.75 hours meet the requirements for Surgical.Critical.Care*

Of the AMA PRA Category 1 Credits™ listed above, a maximum of 8.75 hours meet the requirements for Trauma*

Of the AMA PRA Category 1 Credits™ listed above, a maximum of 8.75 hours meet the requirements for Emergency.General.Surgery*

The content of this activity may meet certain mandates of regulatory bodies. Please note that ACS has not and does not verify the content for such mandates with any regulatory body. Individual physicians are responsible for verifying the content satisfies such requirements.

ACS AMERICAN COLLEGE OF SURGEONS

ACCME ACCREDITED WITH COMMENDATION

CME
Successful completion of this CME activity, which includes participation in the evaluation component, enables the learner to earn credit toward the CME requirements of the American Board of Surgery's Continuous Certification program.

Diplomates of the American Board of Surgery
By participating in an ACS-accredited activity, you may choose to participate in the automatic transfer of your CME credits to the ABS via the ACCME if you are a Diplomate of the American Board of Surgery (ABS). This is a free service.

Opt in to Automatically Send your CME Data to the ABS
The direct automatic transfer applies to all learners who have an ACS profile, are Diplomates of the ABS, and have provided their ABS ID and date of birth in the ACS MyCME Portal on the Board Certification page.

Step-by-Step Instructions to Access MyCME and Opt in to Transmit Your CME Data

- Log in to your MyCME Portal
- Select the Board Certification tab
- Enter the American Board of Surgery
- Enter your ABS ID
- Enter your Day and Month of birth
- Next go to the Send CME Data tab
- Toggle to Opt In (green) "Yes! I choose to opt in and permit the ACS to automatically transfer all my ACS-accredited CME data to my chosen specialty board earned March 1, 2021, and forward."

Please note if you have previously successfully transmitted your ACS-accredited CME credits to the ABS via ACCME, then you can skip steps 2-6, and go directly to the Send CME Data tab, and Toggle to Opt In (green).

Once you have opted to automatically transfer your CME credits to the ABS, please allow 24 hours for the credit to appear in your ABS CME Repository.

You may opt out at any time.

For more information or to request assistance, contact mycme@facs.org

OBJECTIVES

1. Enhance disaster and trauma preparedness by applying evidence-based strategies for mass casualty incidents, natural disasters, emerging threats, and large-scale combat operations.
2. Optimize acute clinical management of trauma and critical illness in resource-rich and resource-limited.
3. Integrate new technologies such as artificial intelligence, drones, and advanced monitoring tools into disaster response, while recognizing limitations and ethical considerations.
4. Strengthen interagency collaboration among civilian, military, and emergency response systems.
5. Address the human dimensions of disaster medicine by recognizing and managing mental health impacts for patients, providers, and communities.
6. Improve systems resilience and response.

DISCLOSURE INFORMATION

In accordance with the ACCME Accreditation Criteria, the American College of Surgeons must ensure that anyone in a position to control the content of the educational activity (planners and speakers/authors/discussants/moderators) has disclosed all financial relationships with any commercial interest (termed by the ACCME as "ineligible companies", defined below) held in the last 24 months (see below for definitions). Please note that first authors were required to collect and submit disclosure information on behalf all other authors/contributors, if applicable.

Ineligible Company: The ACCME defines an "ineligible company" as any entity producing, marketing, re-selling, or distributing health care goods or services used on or consumed by patients. Providers of clinical services directly to patients are NOT included in this definition.
Financial Relationships: Relationships in which the individual benefits by receiving a salary, royalty, intellectual property rights, consulting fee, honoraria, ownership interest (e.g., stocks, stock options or other ownership interest, excluding diversified mutual funds), or other financial benefit. Financial benefits are usually associated with roles such as employment, management position, independent contractor (including contracted research), consulting, speaking and teaching, membership on advisory committees or review panels, board membership, and other activities from which remuneration is received, or expected.
Conflict of Interest: Circumstances create a conflict of interest when an individual has an opportunity to affect CME content about products or services of an ineligible company with which he/she has a financial relationship.

The ACCME also requires that ACS manage any reported conflict and eliminate the potential for bias during the educational activity. Any conflicts noted below have been managed to our satisfaction. The disclosure information is intended to identify any commercial relationships and allow learners to form their own judgments. However, if you perceive a bias during the educational activity, please report it on the evaluation.

Speakers / Moderators / Discussants / Authors	Nothing to Disclose	Disclosure		
		Company	Role	Received
Carlos Brown	No			
Jeremy Cannon	Yes	UpToDate	Author	Author royalties
		Flosonics	Consultant	Consulting fees
Bryan Cotton	Yes	Grifols	Consultant, Scientific Advisory Board	Research Funding
		Haemonetics	Consultant, Scientific Advisory Board	Research Funding
		Cerus	Consultant, Scientific Advisory Board	Research Funding
		Teleflex	Consultant, Scientific Advisory Board	Honoraria; consulting fee
Miguel Cubano	No			
Alexander Eastman	No			
Brian Eastridge	No			
Tanya Egodage	No			
Jeffrey Elder	No			
Mark Escott	No			
Joseph Fernandez-Moure		Becton Dickinson	Key opinion leader	
		Synthese	Key opinion leader	Honorarium, travel expenses
		JSFM Consulting Group	Founder/principal; ownership interest; consulting firm	May receive external consulting fees
		GuidSET Inc	Founder; equity holder; board/oversight role	Potential for financial benefit
		LockPoint	Founder; equity holder; board/oversight role;	Potential for financial benefit
Jennifer Gurney	No			
Jay Johannigman	No			
Bellal Joseph	No			
Natasha Keric	No			
Matthew Martin	No			
Kenneth Mattox	No			
Purvi Patel	No			
Martin Schreiber	No			
Jeffrey Skubic	No			
Sydney Vail	No			
Alison Wilson	No			

Mattox Vegas TCCACS 2026 wishes to recognize and thank the following company(ies) for their commercial promotion towards this activity.

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CONTENTS

SUNDAY MORNING
SESSION 1
Palace Ballroom 1-2
Palace Tower
Emperors Level

FROM CHAOS TO COORDINATION IN THE TRENCHES – BEEN THERE, DONE THAT

SUNDAY MORNING
SESSION 2

CASE MANAGEMENT SESSION
Case by Case: Expert Lessons in Disaster/MCI Response

SUNDAY AFTERNOON
SESSION 3

MEDICAL DISASTER RESPONSE KEYNOTE ADDRESS

SUNDAY AFTERNOON
SESSION 4

NEXT-GEN THREATS, REAL-WORLD TRAUMA

SUNDAY AFTERNOON
SESSION 5

BEYOND TRIAGE AND RESUSCITATION

MATTOX VEGAS TCCACS™ 2026
PROGRAM AT A GLANCE

SUNDAY, APRIL 26, 2026

Time	Activity	Location
6:30 – 8:30	Continental Breakfast Served in Exhibit Hall	Emperors Ballroom Palace Tower Emperors Level – 4th Floor
7:00	Registration Opens	Roman Ballroom Registration Desk Palace Tower Promenade Level – 3rd Floor
7:30	GENERAL SESSION OPENS	Palace Ballroom 1-2 Palace Tower Emperors Level – 4th Floor
8:00 – 10:00	SESSION 1 FROM CHAOS TO COORDINATION IN THE TRENCHES - BEEN THERE, DONE THAT Moderator: Jay A. Johannigman	Palace Ballroom 1-2 Palace Tower Emperors Level – 4th Floor
	TITLE	SPEAKER
8:00 – 8:10	Setting the Stage: Review/Preview 2026	Kenneth L. Mattox
8:10 – 8:30	New Year's Eve Tragedy on Bourbon Street	Jeffrey M. Elder
8:30 – 8:50	Brave New World: The Realities of Prolonged Casualty Care from the Battlefield to the Homefront	Jennifer M. Gurney
8:50 – 9:10	729 Active Shooter Incidents Later: Have We Learned Anything Since Sandy Hook?	Alexander L. Eastman
9:10 – 9:30	Artificial Intelligence on the Frontlines: Transforming Medical Disaster Response	Joseph Fernandez-Moure
9:30 – 10:00	PANEL DISCUSSION	
10:00 – 10:30	Break & Visit Exhibits	Emperors Ballroom Palace Tower Emperors Level – 4th Floor
	SESSION 2 CASE MANAGEMENT SESSION Case by Case: Expert Lessons in Disaster/MCI Response Co-Moderators: Matthew J. Martin and Purvi P. Patel	Palace Ballroom 1-2 Palace Tower Emperors Level – 4th Floor
10:30 – 12:00	Panelists: Carlos V.R. Brown · Jeffrey M. Elder Bryan A. Cotton · Jennifer M. Gurney Brian J. Eastridge · Jeffrey J. Skubic Alison Wilson	

	SESSION 3 **LUNCHEON KEYNOTE ADDRESS** **Moderator: Kenneth L. Mattox**	**Palace Ballroom 1-2** **Palace Tower** **Emperors Level – 4th Floor**
	TITLE	**SPEAKER**
12:00 – 1:30	**Large Scale Combat Operations' Impact on Civilian Trauma Systems**	**Jeremy W. Cannon**
1:30 – 3:00	**SESSION 4** **Next-Gen Threats, Real-World Trauma** **Moderator: Alexander L. Eastman**	**Palace Ballroom 1-2** **Palace Tower** **Emperors Level – 4th Floor**
	TITLE	**SPEAKER**
1:30 – 1:45	**Emerging Threats: Directed Energy Weapons, Biologic Agents, and Hospital Vulnerabilities**	**Jay A. Johannigman**
1:45 – 2:00	**When Heat Turns Fatal: Lessons from Maricopa County**	**Sydney J. Vail**
2:00 – 2:15	**Crossing the Blood-Brain Barrier: Neurotrauma in Disasters and Resource Limited Settings**	**Purvi P. Patel**
2:15 – 2:30	**After the Bang: Managing Blast Trauma**	**Jeremy W. Cannon**
2:30 – 3:00	**PANEL DISCUSSION**	
3:00 – 3:30	**Break & Visit Exhibits**	**Emperors Ballroom** **Palace Tower** **Emperors Level – 4th Floor**
3:30 – 6:00	**SESSION 5** **BEYOND TRIAGE AND RESUSCITATION** **Moderator: Jeffrey J. Skubic**	**Palace Ballroom 1-2** **Palace Tower** **Emperors Level – 4th Floor**
	TITLE	**SPEAKER**
3:30 – 3:45	**Five Pieces of Equipment You Should Never Touch During a Mass Casualty Incident**	**Bellal A. Joseph**
3:45 – 4:00	**After the Sirens - Mental Health For Responders and Survivors**	**Natasha Keric**
4:00 – 4:15	**Inside the Wire: When a Cyberattack Hits Your Trauma Center**	**Matthew J. Martin**
4:15 – 4:30	**Flying High: Drones for Good in Emergency Response Scenarios**	**Martin A. Screiber**
4:30 – 4:45	**Interagency Tango - Coordinating EMS, Hospital, and Military Assets Under Pressure: Lessons Learned from the July 4 Texas Flood**	**Mark E.A. Escott**
4:45 – 5:00	**Ethics Under Fire: Making Difficult Decisions and No-Win Scenarios in MASCAL and Disaster Events**	**Tanya Egodage**
5:00 – 5:15	**The Second Wave: Infections, Chronic Illness, Delayed Injuries**	**Miguel Cubano**
5:15 – 5:30	**When the Dust Settles: The Art of an Effective After Action Report**	**Mark E.A. Escott**
5:30 – 6:00	**PANEL DISCUSSION**	
6:00	**MEETING ADJOURNED**	

MEDICAL DISASTER RESPONSE IN TODAY'S WORLD

GENERAL COURSE INFORMATION

Medical Disaster Response 2026 is a one-day course focusing on clinical realities of medical disaster response, not logistics, organizational charts, and the like, while providing practical information that trauma care providers can take home and implement to improve institutional disaster response plans. Information presented is physician/nurse/hospital care oriented and emphasizes that the trauma center, whether a Level 1, 2, 3 or 4, is the foundation of the disaster medical response system.

CONFERENCE REGISTRATION

Registration opens on Sunday, April 26TH at 7:00 a.m. The Medical Disaster Response registration desk is in the Palace Tower, 3rd floor, Promenade Level, immediately outside the Roman Ballroom.

GENERAL SESSIONS

All general sessions are held in the **Palace Ballrooms 1-2 on the 4th floor of the Palace Tower**. You must have a *MEDICAL DISASTER RESPONSE* badge to enter the General Session. The General Session begins at 8:00 a.m.

CONTINENTAL BREAKFAST

Continental breakfast will be served in the **Exhibit Hall, the Emperors Ballroom, 4TH floor, Palace Tower**. Continental breakfast will be available from 7:00 - 8:30 a.m., Sunday, April 26th. Morning and afternoon breaks will also be held in the **Emperors Ballroom**.

LUNCH SESSION

The luncheon session will be held in Palace Ballroom 1-2, where the General Sessions are. The session is moderated by Doctor Kenneth Mattox, and Dr. Jeremy Cannon will present, "**Large Scale Combat Operations' Impact on Civilian Trauma Centers."**

BADGES

Your badge must be worn at all times to be admitted to all sessions. If your badge is lost, a replacement is required, and the fee is $20.00. Your badge serves as your "admission ticket" to the General Sessions, Exhibit Hall, and Luncheon Session. **YOUR BADGE HAS YOUR ID NUMBER ON THE BOTTOM RIGHT. YOU WILL NEED THIS NUMBER TO SUBMIT YOUR CME DOCUMENTATION and access your certificate.**

CLAIMING YOUR CME CREDITS

This is done online, optimally done during the conference. We have provided complimentary Wi-Fi in the convention general session and Exhibit Hall, as well as in your Caesars Palace hotel room. Your conference App has a link to the conference dashboard, where you can claim your CME. Alternately, instructions for accessing CME Claiming site while at the conference:

1. Go to Wi-Fi list on your phone, laptop, etc.
2. Click on our SSID (network name), which is **MattoxTCCACS2026**
3. Then, it will prompt you to put in the password, which is **Tccacs!!**
4. Then, it will take you to the internet
5. Next go to Conference URL to CLAIM CME: www.lvtraumacme.com
6. The conference dashboard offers you several options, including claiming your CME

ALL CME REQUIREMENTS MUST BE SUBMITTED NO LATER THAN JUNE 26, 2026 (60 DAYS POST CONFERENCE). NO CME CAN BE CLAIMED/AWARDED AFTER THAT TIME. You are urged to complete documents and request CME onsite while at the conference

ATTENDANCE VERIFICATION & CME CERTIFICATES
INNOVATION, SIMULATION, & TECHNOLOGY IN TRAUMA, CRITICAL CARE & MCI (ISTCC-MCI)
APRIL 26, 2026
LVtraumacme.com

MEDICAL DISASTER RESPONSE
TRAUMA, CRITICAL CARE & ACUTE CARE SURGERY

Log in to Verification of Attendance System

WHICH CONFERENCE DID YOU ATTEND?

- Medical Disaster Response
- Trauma & Critical Care

-Choose year-

Badge Number:

Last Name:

SUBMIT

Your USER ID is the ID NUMBER PRINTED ON THE LOWER CORNER OF YOUR BADGE, OPPOSITE THE BARCODE. TAKE A MOMENT NOW TO INPUT YOUR BADGE NUMBER IN THE BLANK ABOVE, AND/OR NOTE IT IN YOUR TELEPHONE OR OTHER ELECTRONIC DEVICE.

10

CME / MOC Instructions

The link to Step 2 will be available upon submitting Step 1. You can access any of the steps as many times as you wish.

Step #	Description	Completed?
1	**Complete Verification of Attendance Form (VOA)**	✖
2	Course Evaluation You may SUBMIT this form multiple times.	✖
3	**Download CME Certificate** (must complete VOA form and course evaluation first)	✖

LOG OUT

STEP 1: ACCESS CONFERENCE URL TO CLAIM CME

- Go to the Wi-Fi list on your phone, laptop, etc.
- Click on our SSID (network name), which is **MattoxTCCACS2026**
- Then it will prompt you to put in the password, which is **Tccacs!!**
- Then it will take you to the Internet.
- Next go to Confrenece URL to claim one: LVtraumacme.com

STEP 2: VERIFICATION OF ATTENDANCE

- FREE WI-FI provided in the General Session and your Caesars Palace hotel rooms to facilitate your completing your required forms immediately, during the conference
- You may save and submit this form multiple times
- Once you complete and submit your Verification of Attendance (VOA) Form, you may:
  - Complete the course evaluation (Step 3) REQUIRED

STEP 3: COURSE EVALUATION

- Course evaluation form must be completed for your certificate to be downloaded (Step 4).
- You may complete the forms in stages, following each session (advised), or at the completion of the course

STEP 4: DOWNLOAD CME CERTIFICATE

- PLEASE ENSURE YOU SAVE A COPY FOR YOUR RECORDS
- If you note any errors on your certificates, contact Mary Allen IMMEDIATELY at REDSTART@AOL.COM or Telephone: 713.798.4557

The Verification of Attendance system for submitting requests for CME credit is available via any device connected to the Internet. Should the Wi-Fi network in the meeting room seem slow because of high usage, you may use your data plan's wireless connection or access the system.

LVtraumacme.com

SCAN THE ABOVE QR CODE TO GO TO THE TCCAS 2026 DASHBOARD, WHICH ALLOWS YOU TO SIGN IN TO ACCESS REQUIRED CME FORMS, AS WELL AS DOWNLOAD YOUR CME CERTIFICATE.

ALSO, SUBMIT YOUR QUESTIONS TO THE SESSION MODERATORS VIA THIS SYSTEM

ALL CME REQUIREMENTS MUST BE SUBMITTED NO LATER THAN JUNE 26, 2026 (60 DAYS POST CONFERENCE). NO CME CAN BE CLAIMED/AWARDED AFTER THAT TIME. You are urged to complete documents and request CME onsite while at the conference

2026

PROGRAM COMMITTEE

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SESSION 1

FROM CHAOS TO COORDINATION
IN THE TRENCHES – BEEN THERE, DONE THAT

Moderator: Jay A. Johannigman

Sunday, April 26, 2026
8:00 – 10:00 AM
Palace Ballroom 1-2
Palace Tower
Emperors Level – 4th Floor

8:00 – 8:10	**Setting the Stage: Review/Preview 2026** **Kenneth L. Mattox, MD, FACS, MAMSE** **Program Director, Mattox Vegas TCCACS/MDR**
8:10 – 8:30	**New Year's Eve Tragedy on Bourbon Street** **Jeffrey M. Elder, MD**
8:30 – 8:50	**Brave New World: The Realities of Prolonged Casualty Care from the Battlefield to the Homefront** **Jennifer M. Gurney, MD, FACS**
8:50 – 9:10	**729 Active Shooter Incidents Later: Have We Learned Anything Since Sandy Hook?** **Alexander L. Eastman, MD, MPH, FACS, FAEMS**
9:10 – 9:30	**Artificial Intelligence on the Frontlines:** **Transforming Medical Disaster Response** **Joseph Fernandez-Moure, MD**
9:30 – 10:00	**Panel Discussion**
10:00 – 10:30	**Break & Visit Exhibits** **Emperors Ballroom** **Palace Tower** **Emperors Level – 4th Floor**

DISASTER MEDICAL RESPONSE – REVIEW/PREVIEW 2026

Kenneth L Mattox, MD, FACS, MAMSE

Course Director, TCC ACS / MDR
Distinguished Service Professor
Michael E. DeBakey Department of Surgery
Special Advisor to the President and CEO
Baylor College of Medicine
Houston, TX

This is the 18th year the Mattox Vegas Trauma Group (TCCACS) has offered this course on Medical Disaster Response in conjunction with Mattox Vegas Trauma, Critical Care, & Acute Care Surgery. Since most disasters involved the trauma team from the local trauma center, it was logical, in 2008, to develop this course. Many courses and books focus on regional and hospital disaster committees, their organization and administration, creating shelters, property recovery, various drills and communications, and obtaining certification by taking such courses. This conference exists because the clinical challenges we face during mass casualty incidents continue long after the sirens stop—and because those challenges increasingly land in our trauma bays, ICUs, and operating rooms.

Today's sessions are designed to move beyond the initial resuscitation. We will explore how trauma systems adapt under sustained load, how evolving threats—from blast injury to neurotrauma to biologic exposure—change clinical decision-making, and how emerging tools like artificial intelligence may support, or complicate, patient care during disasters. We also address the ethical dimensions of disaster medicine—allocation of limited resources, no-win clinical scenarios, and the long tail of injury that follows mass casualty events.

This is a forum for open discussion, critical appraisal, and shared learning. The goal is not just better individual care, but stronger systems that support clinicians when conditions are far from ideal. Your experience and voice matter, and many of today's sessions are built to reflect the realities you face —limited resources, evolving threats, and the need to adapt in real time.

There are some ESSENTIALS for you to navigate this course:

1. Your badge is your "ticket" to enter general sessions, the luncheon session, and the Exhibit Hall, where breakfast and all breaks take place. It is also essential to claim your CME certificate. So, RECORD YOUR BADGE NUMBER. Take a picture with your phone, whatever you need to do to be able to retrieve it.

2. Wi-Fi is complimentary in the General Session and your hotel room, allowing ready access to claiming your CME. See step-by-step instructions in your syllabus book, and a link to the CME claiming site is on your Conference App.

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3. You will access the **conference dashboard** via LVtraumacme.com to:
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Visit the exhibitors, who provide an additional, important dimension to the conference. Take full advantage of opportunities to interact with the other attendees and our faculty in person and using the conference app. Using the Evaluation Tool, please tell us what you hope to see addressed in next year's course, as well as firsthand experiences you might have encountered in dealing with a disaster in your hospital. Your interest, participation, and enthusiasm are the conference "energy" – one of the key elements to our success.

NEW YEAR'S EVE TRAGEDY ON BOURBON STREET

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Section of Emergency Medicine
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Co-Director of the Division of EMS and Disaster Medicine
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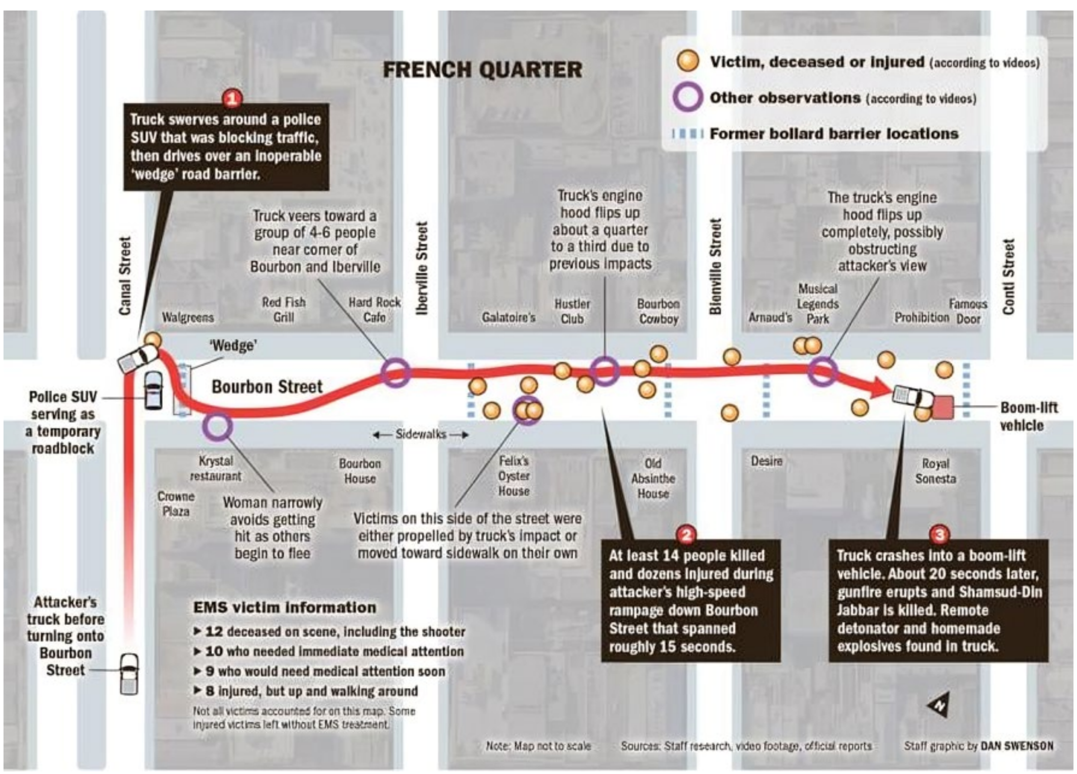
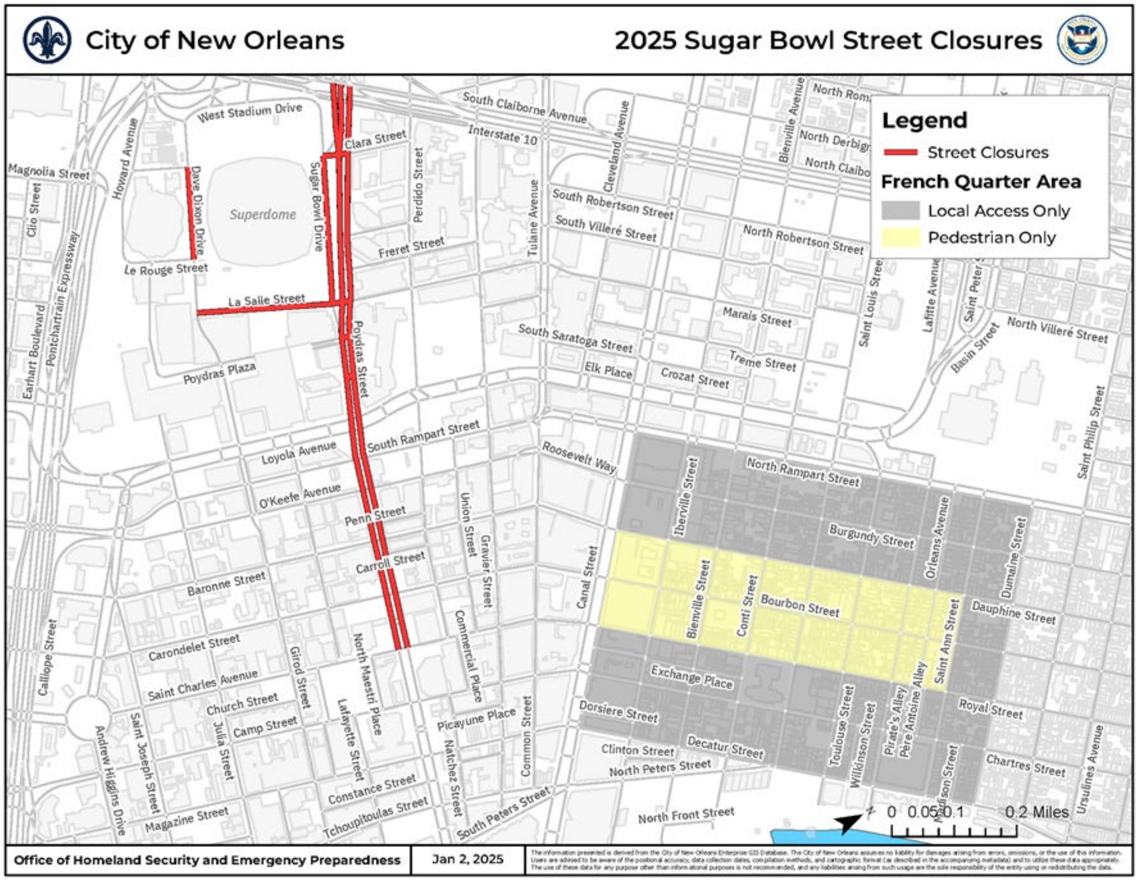
New Orleans, LA

KEY TAKEAWAYS:

- Prepare – The need for whole house education and training
- Relationships – Who can you count on?
- Communicate – internal and external communications plans
- Reunification – have an area set aside for families / friends
- Family Notifications – have a plan, even if they aren't your patients
- Family needs and Repatriation – long term needs outside of traditional inpatient care
- Responder / Staff Care – have a plan for staff needs and support



Source: NOLA.com

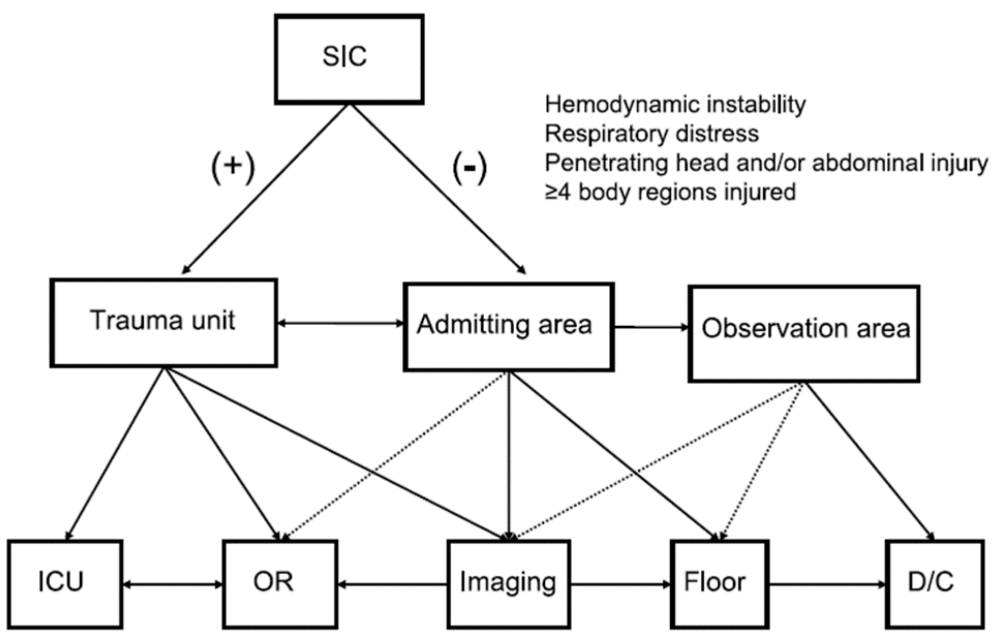


Hospital MCI Classifications

Scale Size	Number of Patients	Resources Required		MD Discretion	
LARGE SCALE Activated by House Supervisor/Administrator on Call (AOC), in consultation with Trauma/AR ED Physicians	>20 patients Based on event and ED present capacity.	AND / OR	Potential for hospital operations disrupted. Requires full participation from other hospital departments, surge all admitted and discharged patients from the ED and the opening and re-arrangement all additional resources in the hospital such as: • ED Triage performed on ED Ramp • 2nd floor clinic to evaluate to evaluate and treat patients classified as disaster tag color “green” (minor) • Labor pool opened • Family/Waiting Area opened	AND / OR	Decrease of a Large Scale can be made at the discretion of the ED MD Lead and/or Incident Commander.

Scale Size	Number of Patients	Resources Required	MD Discretion
MODERATE SCALE Activated by House Supervisor/Administrator on call (AOC),in consultation with Trauma/AR ED Physicians	10-20 patients	Moderate resources required – call trees are initiated in specific areas, potential for hospital operations disruption. Requires greater participation of other hospital departments. ED patients will be surged out of the ED that are discharged or admitted will be surged out of the ED.	Decrease of a Moderate Scale can be made at the discretion of the ED MD Lead and/or Incident Commander/ To increase from a moderate to a large must have HICS approval.
SMALL SCALE Activated by Trauma/AR ED Physicians	5 to <10 patients	Minimal increase in resources; no disruption in hospital operations. Event contained in the ED. ED Patients will be shifted within the ED to provide best possible room assignments to critical patients.	Increase of a Small Scale to a moderate or large must have HICS approval.

Source: Hospital Triage Algorithm – *Almogy & Rivkind 2006*



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BRAVE NEW WORLD: THE REALITIES OF PROLONGED CASUALTY CARE FROM THE BATTLEFIELD TO THE HOMEFRONT

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Top 10 Realities - Prolonged Casualty Care & Large Scale Combat Operations

1. **Evacuation Is No Longer Assured** – In LSCO, medical evacuation is contested, delayed, fragmented, or absent. Air superiority cannot be assumed. Ground routes are interdicted. Casualty movement may take hours to days. Medical planning must assume prolonged holding at lower echelons.
2. **Prolonged Care Is the Norm, Not the Exception** – Prolonged casualty care is not a niche challenge confined to special operations. In LSCO, most casualties will experience delayed evacuation. Sustaining physiology - not speed of movement - becomes the dominant determinant of survival.
3. **The Burden of Care Shifts Forward** – Care once delivered at higher roles now occurs at the point of injury and forward medical nodes. Medics and small teams must provide ongoing resuscitation, ventilation, analgesia, infection prevention, and monitoring over extended periods.
4. **The Entire Trauma System Is Contested and Congested** – LSCO disrupts every node of the trauma system. Congestion propagates downstream: forward units hold longer, surgical teams fatigue, evacuation bottlenecks form, and civilian centers receive waves of complex casualties.
5. **Casualty Volume and Injury Severity Will Be Higher** – Future war will be high-energy and technology-driven. Artillery, drones, robotics, and long-range fires will produce polytrauma at scale. Injury patterns will differ from those seen in Iraq and Afghanistan.
6. **Medical Units Operate Under Persistent Threat** – Forward medical facilities may be targeted, displaced, or forced to operate in hardened or improvised environments with limited power, oxygen, blood, and supplies.
7. **Logistics, Not Knowledge, Become the Rate Limiter** – In prolonged care, outcomes are often constrained not by clinical knowledge but by blood availability, oxygen, antibiotics, and consumables. Logistics resilience becomes as critical as clinical expertise.
8. **Cognitive Load and Moral Injury Increase** – Providers face sustained cognitive burden, fatigue, and repeated triage decisions under uncertainty. The risk of burnout and post-traumatic stress rises significantly.
9. **Prolonged Care Extends to the Homefront** – Prolonged care does not end with evacuation from theater. Delays and complications propagate into the U.S. system. Civilian trauma centers will manage advanced infections, prolonged shock physiology, and complex rehabilitation.
10. **Civilian Trauma Systems Are Integral to LSCO Success** – In LSCO, civilian trauma systems are not peripheral - they are part of the operational medical system. Surge capacity, subspecialty expertise, and long-term recovery depend on seamless military-civilian integration.

INTRODUCTION: A NEW ERA OF WAR AND MEDICINE

The global security environment has entered a period of sustained instability characterized by great power competition, regional conflict, and the credible risk of large-scale combat operations (LSCO). Unlike the counterinsurgency campaigns that defined U.S. military operations for much of the early twenty-first century, future conflicts are expected to occur against technologically sophisticated adversaries capable of contesting every domain of warfare. These adversaries possess advanced surveillance, long-range fires, integrated air defense systems, cyber and space-enabled disruption, and the ability to target logistics and infrastructure at scale. These capabilities fundamentally challenge the assumptions that have underpinned modern combat casualty care for the past two decades.

For surgeons and medical professionals – both military and civilian – this shift represents more than a change in strategy. It alters the tempo, geography, and feasibility of casualty evacuation, reshaping how wounded patients are treated, how long they must be sustained before definitive care, and how they move through medical systems. The expectation that casualties can be evacuated rapidly to surgical care within a predictable time window can no longer be relied upon. Instead, future battlefields will be characterized by delayed evacuation, fragmented movement, and prolonged exposure of casualties to austere and dangerous environments.

The ongoing war in Ukraine offers the clearest modern illustration of these realities. High-intensity artillery fire, widespread use of drones, extensive minefields, and deliberate attacks on infrastructure have produced casualty patterns and evacuation challenges not seen since World War II. Medical evacuation is frequently delayed or impossible. Casualties often remain forward for extended periods, requiring sustained stabilization, monitoring, and intervention far beyond traditional doctrinal expectations.

These conditions are not unique to Ukraine. They are representative of the environments U.S. forces would face in a conflict in Eastern Europe, the Indo-Pacific, or other contested regions. Importantly, the implications extend well beyond the battlefield. This 'prolonged care' construct will stress the entire military trauma system and inevitably draw civilian trauma systems into the clinical care and management of large numbers of complex wartime casualties.

UNDERSTANDING THE PROLONGED CARE SPECTRUM – MILITARY DEFINITIONS

> LSCO will produce a casualty care environment that is congested, contested, and resource-constrained across the entire continuum of care – from point of injury through evacuation, theater hospitalization, and ultimately definitive care in the homeland. Although doctrine separates prolonged casualty care into distinct constructs, these phases represent different expressions of a single operational reality: evacuation delay in a disrupted medical system. The following definitions clarify the terms as currently used within the Defense Trauma Enterprise.

This section examines the realities of prolonged casualty care from the battlefield to the homefront. It explores how modern warfare disrupts evacuation, how PCC reshapes the roles of medics and clinicians, how LSCO congests and degrades trauma systems, and how military and civilian medical communities must integrate to meet these challenges. Finally, it outlines pragmatic solutions – training, education, data-driven systems, and military-civilian integration – that are essential to prepare for this brave new world.

Critically, PCC represents a shift from evacuation-centric to care-centric models. Success is measured not by speed of evacuation alone, but by the ability to maintain physiology, prevent secondary injury, and adapt care to prolonged timelines.

While the military often refers to the spectrum of 'proloned care' as doctrinal constructs (Prolonged Field Care, Prolonged Casualty Care, and Prolonged Care/Prolonged Hold – each scenario are in reality manifestations of one systemic problem → evacuation delays along the entire continuum of care.

Prolonged Field Care (PFC)

Prolonged Field Care (PFC) originated within the Special Operations Forces (SOF) community and was formally described in Joint Trauma System (JTS) and U.S. Special Operations Command (USSOCOM) doctrine. PFC refers to field medical care applied beyond doctrinal planning timelines when evacuation to a higher level of care is delayed or unavailable. It is delivered primarily by SOF medics who are trained and equipped to provide advanced resuscitative, monitoring, and critical care capabilities in austere, resource-limited environments.

PFC is defined by the requirement to manage a casualty for extended durations outside a medically regulated system, often in small teams operating independently and without immediate access to Role 2 or higher capabilities. It represents the earliest doctrinal recognition that evacuation superiority cannot be assumed in future conflicts. The goal of PFC is to 'get out of PFC'

Prolonged Casualty Care (PCC)

Prolonged Casualty Care (PCC), as defined in Joint Trauma System position statements and published guidance in the *Journal of Special Operations Medicine* (JSOM), expands the concept of prolonged care beyond SOF and applies it to the conventional force. PCC refers to the provision of medical care to casualties in the pre-hospital environment when evacuation to definitive care is delayed beyond established planning timelines.

Unlike PFC, PCC is not SOF-specific. It encompasses care delivered by both medical and non-medical personnel, including combat medics, corpsmen, and trained non-medical service members operating in contested environments. PCC remains limited to the pre-hospital phase of care – from point of injury through Role 1 and up to arrival at a medically regulated Role 2 forward surgical facility. Once the casualty enters a Role 2 Surgical Team or higher echelon within the formal medical system, the construct transitions away from PCC. Similar to PFC, the goal of PCC is 'to get out of PCC'

PCC reflects the operational reality that, in LSCO, evacuation delays will affect the conventional force at scale and that prolonged pre-hospital management will not be unique to SOF formations and will involve non-medical personnel caring for the injured.

Prolonged Care (PC) and Prolonged Hold

Prolonged Care (PC) and Prolonged Hold describe extended casualty management within the medically regulated system – specifically at Role 2 (Surgical Teams), Role 3 (Theater Hospitals), and potentially Role 4 facilities – when evacuation to the next echelon of care is delayed or denied.

In contrast to PFC and PCC, which apply to the pre-hospital environment, Prolonged Care occurs after a casualty has entered formal medical channels. It reflects the requirement for surgical teams and theater hospitals to provide extended critical care, ventilatory support, resuscitation, and inpatient management beyond doctrinal timelines due to evacuation constraints, limited strategic lift, contested airspace, or overwhelmed receiving facilities. It also needs to be considered that casualties entering in this medically regulated environment will be sicker and require more resources if they are leaving PCC. Tourniquets will be on for longer, hemorrhage control will have been delayed, and resuscitation might not have been fully optimized. So war casualties leaving the PCC environements arriving at foreward surgical teams of theater hospitals will likely have more ICU needs and be more physiologically deranged.

Prolonged Hold is often used to describe the operational condition in which casualties accumulate at a given role of care because forward movement through the system is interrupted. In LSCO, prolonged hold is not an anomaly but an anticipated operational challenge. It creates backpressure throughout the trauma system, from Role 2 forward surgical elements to Role 3 hospitals and ultimately to evacuation out of theater.

A Unified Perspective

While doctrine separates Prolonged Field Care, Prolonged Casualty Care, and Prolonged Care into discrete categories, these constructs represent different phases of a single systemic phenomenon: disruption of timely evacuation across the continuum of care. In future conflict against a peer adversary, congestion and contestation will not be confined to the point of injury. Delays will propagate through evacuation platforms, theater hospitals, strategic lift, and reception facilities in the homeland. Accordingly, prolonged care should be understood not as a niche capability but instead the lack of full capabilities and an overwhelmed trauma system.

GREAT POWER COMPETITION AND THE END OF ASSURED EVACUATION

Great power competition has reintroduced the possibility of sustained, high-intensity warfare between peer adversaries. Unlike recent conflicts in which U.S. forces enjoyed uncontested air superiority and robust logistical support, and rapid evacuation of causalities which allowed the military's trauma system to have an overall small footprint; future conflicts will feature contested airspace, degraded communications, and persistent threats to evacuation platforms. Rotary-wing and fixed-wing medical evacuation assets will be vulnerable to surface-to-air missiles, drone attacks, electronic warfare, and long-range fires. Ground evacuation will be constrained by damaged infrastructure, surveillance, interdiction and the threat of being amhilatied in a drone attack.

These realities fundamentally change the medical problem. Evacuation timelines will be unpredictable and often prolonged. Forward medical units will be required to hold casualties for hours to days rather than minutes to hours. Medical planning can no longer assume rapid throughput to higher levels of care; instead, it must prioritize the ability to sustain physiology over time. For trauma systems accustomed to predictable evacuation chains, this represents a paradigm shift. Survival will depend less on speed of movement and more on the quality and durability of care delivered at lower echelons.

THE WAR IN UKRAINE: A CONTEMPORARY CASE STUDY IN PROLONGED CASUALTY CARE

The conflict in Ukraine has provided an unprecedented window into modern high-intensity warfare and its medical consequences. Casualties are predominantly caused by artillery, rockets, mines, and drones, producing severe polytrauma, blast injuries, burns, amputations, and penetrating wounds. High-energy mechanisms generate extensive soft tissue destruction, massive hemorrhage, and a high risk of infection. There are more head and neck injuries from drone attacks given that they are 'bombs from above' instead of 'bombs from below', such as improvised explosive devices (IEDs) that were common in Afghanistan and Iraq.

Evacuation challenges are pervasive. Air evacuation is frequently precluded by air defense threats. Ground evacuation is slow, dangerous, and often staged through multiple intermediate points. Trains have been used in Ukraine, similar to how they were used in both WWI and WWII; however, they are easy to detect and predict, resulting in risks of 'casualty trains' being attacked by enemies that do not follow the Geneva Convention. Casualties may spend prolonged periods in improvised or hardened medical facilities with limited diagnostic capability, intermittent power, constrained oxygen supply, and shortages of blood and medications.

In Ukraine, medical facilities themselves are often targeted or disrupted. The ‘Red Cross’ has become the ‘Dread Cross’. The Geneva Convention is explicit in how medical facilities should not be attacked; however, not every nation follows the Geneva Convention. Hospitals have been targeted, damaged or destroyed, forcing relocation and improvisation. Supply chains for blood, antibiotics, analgesics, and surgical consumables are fragile. Clinicians must make difficult decisions about prioritization, resource allocation, and timing of interventions under constant threat.

The Ukrainian experience demonstrates that prolonged casualty care is not an exception reserved for special operations or isolated environments; it is the dominant mode of care in modern high-intensity conflict. These lessons are directly applicable to future U.S. military operations and must inform planning across the continuum of care.

THE BURDEN OF CARE SHIFTS FORWARD: THE MEDIC AND THE SMALL MEDICAL TEAM

In prolonged casualty care environments, the burden of care shifts decisively to the lowest echelons of medical support. Combat medics and small medical teams become responsible not only for initial lifesaving interventions, but for sustained critical care over extended periods.

This role expansion challenges traditional training paradigms. Medics must manage airway support, ventilation, hemorrhage control, analgesia, sedation, infection prevention, fluid and blood resuscitation, nutrition, temperature control, and psychological stress - often simultaneously. Decision-making becomes continuous rather than episodic, and cognitive fatigue poses a significant risk to patient safety.

PCC-oriented education emphasizes physiologic sustainment rather than isolated procedures. Anticipation of deterioration, repeated reassessment, and adaptation to changing conditions are core skills. Equipment and protocols must be designed for prolonged use, not just rapid handoff.

The psychological and moral burden on medics is substantial. Providing prolonged care under threat, with limited resources and uncertain outcomes, creates moral distress and risk of burnout. Addressing PCC therefore requires attention not only to clinical capability, but to human performance, leadership, and resilience.

A CONTESTED AND CONGESTED TRAUMA SYSTEM

In LSCO, the trauma system itself becomes contested. Casualty flow is disrupted at every node: point of injury, evacuation platforms, forward surgical teams, theater hospitals, strategic lift, and stateside receiving facilities. Evacuation assets are limited, surgical capacity is strained, and downstream facilities experience surges of critically injured patients.

Congestion propagates through the system. Forward units hold patients longer. Surgical teams operate continuously with limited rest. Theater hospitals become bottlenecks rather than throughput nodes. Strategic evacuation is delayed or fragmented. Ultimately, casualties arrive in the United States in waves, overwhelming select regions and specialties.

For civilian trauma systems, this means an influx of patients with injury patterns and care requirements that differ from peacetime trauma. Polytrauma, complex blast injuries, burns, traumatic brain injury, and infection require multidisciplinary care, prolonged ICU stays, and extensive rehabilitation. Civilian systems must be prepared not only for volume, but for complexity and duration.

THE NATIONAL DISASTER MEDICAL SYSTEM IN LSCO: STRUCTURAL LIMITS EXPOSED

LSCO will stress the National Disaster Medical System (NDMS) in ways for which it was not originally designed. NDMS was structured to respond to natural disasters, limited regional catastrophes, and episodic surge events. It was not engineered for sustained daily casualty flows, casualty volumes exceeding 10,000 in 60 days, simultaneous domestic infrastructure disruption, or strategic cyber and power grid degradation. In LSCO, NDMS may not simply augment the Military Health System, it may become the backbone of Role 4 casualty care. This represents a fundamental shift in scale, tempo, and duration from historical contingency planning assumptions. Compounding this scale mismatch is the illusion of available capacity.

While NDMS relies on commitments from more than 1,600 participating hospitals, the U.S. healthcare system routinely operates with less than 15 percent excess bed capacity. Many hospitals function at 85-95 percent occupancy, ICU beds are frequently constrained, trauma centers operate near saturation, and staffing shortages persist in the post-COVID environment. In LSCO, civilian trauma centers would not only receive evacuated military casualties but could simultaneously confront domestic mass casualty incidents, terrorism, cyberattacks, or infrastructure collapse. Blood supply chains may be disrupted, pharmaceutical supply chains strained, and critical infrastructure degraded. Under such conditions, NDMS bed commitments may exist on paper but not in functional reality.

Workforce depletion further intensifies this vulnerability. A substantial portion of military medical capability resides in the Reserve Component, embedded within civilian hospitals as surgeons, nurses, CRNAs, emergency physicians, and critical care providers. Mobilization of these personnel for overseas operations produces immediate loss of staffing in the very hospitals expected to absorb returning casualties. Operating rooms close, ICU staffing contracts, and trauma call coverage diminishes. This creates a paradox: mobilizing medical forces to sustain combat operations abroad weakens homeland hospital resilience at the precise moment it is most needed.

Finally, LSCO generates medical burdens that extend far beyond initial trauma resuscitation. Casualties will include polytrauma, amputations, severe burns, traumatic brain injury, behavioral health injuries, infectious disease outbreaks, and potential CBRN exposures. NDMS must therefore manage not only surgical stabilization but also rehabilitation, long-term ventilator care, chronic wound management, and enduring mental health sequelae. The burden shifts from episodic surge response to sustained national medical absorption. In LSCO, the challenge is not merely the first 72 hours – it is the months and years that follow.

The NDMS was established to augment national medical capacity during disasters and military contingencies. Its design reflects episodic surge events – hurricanes, regional catastrophes, limited overseas conflicts - not sustained, high-volume casualty flows generated by prolonged large-scale combat operations. In LSCO, NDMS would not simply augment the Military Health System; it would become a central pillar of Role 4 casualty absorption. Yet the scale envisioned in peer conflict exposes a structural mismatch between NDMS's historical design assumptions and the demands of sustained, contested warfare.

A second vulnerability lies in the illusion of available bed capacity. Although NDMS counts more than 1,600 participating hospitals, the U.S. healthcare system routinely operates with less than 15 percent excess capacity. Many trauma centers and ICUs function near saturation under normal conditions. Bed availability on paper does not equate to functional surge capacity when staffing shortages, supply chain fragility, and infrastructure disruptions are factored in. In LSCO, the same civilian trauma centers expected to receive military casualties may also be managing domestic mass casualty incidents, cyber disruptions, or infrastructure failures. Surge commitments cannot be divorced from operational reality.

Workforce depletion presents an even more complex paradox. A significant proportion of military medical capability resides in the Reserve Component, embedded within civilian hospitals. Mobilization of these physicians, nurses, and critical care providers for overseas operations simultaneously weakens the very civilian institutions expected to receive evacuated casualties. Operating rooms close, ICU staffing tightens, and trauma call coverage thins. In a peer conflict, medical mobilization is not simply additive to national capacity – it may be redistributive, shifting strain from the battlefield to the homeland.

Finally, LSCO generates long-term medical burdens that extend far beyond acute trauma resuscitation. Polytrauma, amputations, severe burns, traumatic brain injury, infectious disease exposure, and behavioral health sequelae create sustained rehabilitation demands. NDMS was not structured to serve as a long-duration convalescent and rehabilitation system at scale. Yet in LSCO, civilian hospitals, rehabilitation centers, and outpatient networks would inevitably absorb this longitudinal burden. The challenge is not merely initial surge, but enduring national medical absorption over months to years.

CIVILIAN HEALTHCARE AS AN OPERATIONAL DOMAIN OF WARFARE

Civilian trauma centers will become essential partners in managing this burden. Many wartime injuries require subspecialty expertise that exists predominantly in civilian institutions. Rehabilitation, mental health care, and long-term recovery will extend for years beyond the cessation of hostilities.

In large-scale combat operations, the U.S. healthcare system does not remain a passive recipient of military casualties; it becomes an operational domain of warfare. Casualty evacuation from theater terminates not in isolation, but within civilian trauma centers, community hospitals, rehabilitation facilities, and behavioral health systems. These institutions become extensions of the Defense Trauma Enterprise. Their capacity, resilience, cybersecurity, supply chains, blood availability, and workforce stability directly influence combat power restoration and national endurance.

Future conflicts will not produce discrete categories of “military” and “civilian” casualties. Trauma will move across borders and systems, and adversaries may deliberately target infrastructure – cyber networks, logistics hubs, energy grids - that underpin medical care delivery. In this environment, civilian healthcare infrastructure becomes strategically relevant terrain. Protecting hospital functionality, ensuring data interoperability, preserving workforce resilience, and integrating trauma system planning are not public health considerations alone – they are national security imperatives. In LSCO, the homeland healthcare system is not a backdrop to war; it is part of the battlespace.

RESEARCH PRIORITIES IN PROLONGED CASUALTY CARE

The Department of Defense has increasingly recognized prolonged casualty care as a critical research domain. Priority areas include physiologic monitoring technologies suitable for austere environments, durable ventilatory support options, blood and resuscitation products optimized for forward use, and infection prevention strategies for contaminated wounds.

Decision-support tools capable of functioning in degraded communications environments are also an area of active investigation. However, technological solutions alone are insufficient. Implementation science – understanding how innovations are adopted, sustained, and integrated into operational practice – is equally important. Research must be informed by real-world data from training, exercises, and conflict. Without robust data capture and feedback loops, advances risk remaining theoretical rather than operational.

SOLUTIONS: BUILDING A RESILIENT AND INTEGRATED TRAUMA SYSTEM

Training and Education

Training must prepare providers for prolonged care realities. Scenario-based training, simulation, and deliberate exposure to austere and prolonged care scenarios are essential. Civilian surgeons must be trained as well, especially in the management of complex wartime wounds.

Data-Driven Trauma Systems

A learning trauma system capable of capturing data across the continuum and rapidly feeding lessons back into practice is essential. Standardized data collection, shared registries, and real-time analytics can identify gaps, guide research, and improve outcomes.

Military-Civilian Integration

Military-civilian partnerships are critical enablers of resilience. Regional Medical Operations Coordination Centers (RMOCCs) and an expanded National Disaster Medical System (NDMS) provide mechanisms to distribute casualties, coordinate surge response, and integrate military and civilian expertise. These structures should be viewed as standing capabilities rather than ad hoc solutions, with regular exercises and shared governance. RMOCCs could and should be the unit of action for the NDMS.

CONCLUSION

Prolonged Care in a LSCO environment is no longer a contingency - it is a defining feature of future conflict. The realities observed in Ukraine provide a preview of the challenges ahead: delayed evacuation, contested systems, mass casualties, and prolonged physiologic stress. Addressing these challenges requires a shift in mindset from evacuation-centric to care-centric models, sustained investment in training and research, and deep integration between military and civilian trauma systems. A large-scale conflict will not only impact the battlefield trauma system, but the civilian trauma system as well. For surgeons and medical professionals, preparation for the consequences of LSCO and prolonged care along the contested and congested evacuation chain is not optional. In a large-scale conflict, military-civilian trauma system integration is essential to sustaining life, restoring function, and rebuilding systems strained by war. Preparing now is necessary to avoid increase morbidity and mortality in the event of large scale conflict.

729 ACTIVE SHOOTER INCIDENTS LATER: HAVE WE LEARNED ANYTHING SINCE SANDY HOOK?

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BLUF

Active shooter incidents represent a persistent and complex threat to public safety in the United States. Since the 2012 Sandy Hook Elementary School shooting, substantial efforts have been directed toward improving the law enforcement response, integrating medical care into high-threat environments, and enhancing healthcare system preparedness. However, despite evolving doctrine and improved technical capabilities, recent high-profile failures demonstrate enduring gaps among policy, training, leadership, intent and real-world execution. While the "field" has learned critical lessons – particularly regarding rapid threat suppression, hemorrhage control, and integrated response – implementation remains inconsistent, and outcomes remain highly dependent on leadership, interagency coordination, and systems-level preparedness and continue to be plagued by a lack of national standards guiding training and response.

ACTIVE SHOOTER EVENTS IN THE UNITED STATES

Definitional Challenges

Describing and quantifying trends in active shooter violence is complicated by inconsistent terminology across agencies and research organizations. The Federal Bureau of Investigation (FBI) defines an active shooter as "one or more individuals actively engaged in killing or attempting to kill people in a populated area." This definition differs substantially from the term "mass shooting," which is often based solely on the number of victims and may include incidents rooted in domestic violence, gang activity, or other criminal motives. As a result, databases and media outlets frequently use broader or narrower criteria, leading to significant discrepancies in incident counts and public reporting. This variability has contributed to confusion among policymakers, researchers, and the public regarding the true scope and nature of the threat. Nevertheless, there is broad consensus that active shooter incidents represent a recurrent, high-impact threat to public safety. These events occur in diverse environments, including schools, workplaces, houses of worship, and healthcare facilities, which further complicates prevention and response strategies.

Epidemiologic Trends

Analyses conducted by the FBI demonstrate an overall increase in active shooter incidents from 2000 through the late 2010s, with the early 2020s characterized by year-to-year variability. Some years have seen higher incident counts, while others have been lower, influenced by factors such as the COVID-19 pandemic and changes in public behavior. Although the number of incidents fluctuates annually, the severity and complexity of casualties remain consistent drivers of public safety burden. High-profile events often involve large numbers of victims and require complex law enforcement and medical responses. **Table I** lists notable active shooter events since Sandy Hook. Importantly, many active shooter incidents are terminated by law enforcement or civilian intervention before mass casualty thresholds are reached, and hence, often not counted in traditional studies. The speed and effectiveness of response are critical in limiting casualties, underscoring the importance of preparedness and rapid intervention rather than focusing solely on the number of events.

Table I. Notable Active Shooter Events in the United States Since Sandy Hook ES

Date	Location	Fatalities	Brief Description
Dec 14, 2012	Sandy Hook Elementary Newtown, CT	**26**	Shooter killed 20 children and 6 adults at an elementary school.
Jun 12, 2016	Pulse Nightclub Orlando, FL	**49**	Shooter targeted a nightclub, killing 49 and injuring 53.
Oct 1, 2017	Route 91 Harvest Festival Las Vegas, NV	**58**	Shooter fired from a hotel window into a music festival crowd.
Nov 5, 2017	First Baptist Church Sutherland Springs, TX	**26**	Shooter opened fire during a church service.
Feb 14, 2018	M.S. Douglas High Parkland, FL	**17**	Shooter attacked a high school, killing students and staff.
May 18, 2018	Santa Fe High School Santa Fe, TX	**10**	Shooter killed students and teachers at a high school.
Aug 3, 2019	Walmart El Paso, TX	**23**	Shooter targeted shoppers, motivated by anti-immigrant views.
Aug 4, 2019	Oregon District Dayton, OH	**9**	Shooter opened fire in a nightlife district; police responded within seconds.
May 14, 2022	Tops Friendly Market Buffalo, NY	**10**	Shooter targeted a supermarket, motivated by racial animus.
Jul 4, 2022	Highland Park Parade Highland Park, IL	**7**	Shooter fired from a rooftop into a parade crowd.
May 24, 2022	Robb Elementary School Uvalde, TX	**21**	Shooter killed 19 children and 2 teachers at an elementary school.
Oct 25, 2023	Lewiston, ME	**18**	Shooter attacked a bowling alley and restaurant.
Mar 17, 2024	Kansas City, MO	**8**	Shooter opened fire at a downtown event, causing multiple fatalities and injuries.
Jun 9, 2024	Seattle, WA	**6**	Shooter targeted a crowded public market, resulting in several deaths.
Sep 2, 2024	Miami, FL	**7**	Shooter attacked a workplace, leading to multiple casualties.

Date	Location	Fatalities	Brief Description
Feb 11, 2025	Houston, TX	**9**	Shooter opened fire at a large healthcare facility, resulting in numerous fatalities.
Apr 28, 2025	Philadelphia, PA	**10**	Shooter targeted a house of worship during a service, causing significant loss of life.

Sandy Hook as an Inflection Point

The Sandy Hook Elementary School shooting on December 14, 2012, marked a significant psychological and operational inflection point in the national consciousness regarding active shooter threats. The targeting of young children in an educational setting intensified public concern and created a sense of urgency for action. However, while Sandy Hook catalyzed a multidisciplinary reassessment of law enforcement tactics, emergency medical response, and public preparedness the Nation remains essentially paralyzed and ineffective in confronting the root causes of continued active violence. Initiatives such as the Hartford Consensus and Stop the Bleed emerged directly from lessons learned, emphasizing integrated response by law enforcement, fire/EMS, and civilian bystanders. Training programs and protocols for care under fire, hemorrhage control, and rapid casualty evacuation were widely adopted in the aftermath. The incident continues to shape policy, training, and public awareness efforts related to active shooter preparedness and response, but to date, whether in concert with recent events or as a standalone, remains insufficient to prompt frank national discourse on eliminating these from our current scope of public safety threats. By any measure, the answer to have we learned enough as a nation since this senseless tragedy must be a resounding “NO!”.

EVOLUTION OF THE LAW ENFORCEMENT RESPONSE: COLUMBINE TO THE PRESENT

While outside of the scope of the role of most surgeons and emergency physicians in responding to these incidents, understanding law enforcement response is critical to identify opportunities to improve the medical and surgical response to these incidents.

From Containment to Immediate Action

The 1999 Columbine High School shooting fundamentally altered the landscape of active shooter response in the United States. Prior to Columbine, law enforcement agencies typically relied on perimeter-and-containment strategies, in which officers would secure the area, wait for specialized tactical units (SWAT), and attempt to negotiate with the perpetrator. This approach proved tragically inadequate during the Columbine attack, as the shooters continued their assault inside the school while first responders remained outside, unable to intervene effectively. The resulting delay contributed to a higher number of casualties and exposed critical gaps in traditional response doctrine.

In the aftermath, U.S. law enforcement agencies recognized the need for a more dynamic and proactive approach. This led to the development and widespread adoption of Immediate Action Rapid Deployment (IARD) tactics. IARD prioritizes the rapid movement of solo officers or small teams directly toward the threat, with the primary objective of stopping the killing as quickly as possible. This doctrine emphasizes speed, decisive action, and the willingness of first-arriving officers to engage the shooter without waiting for backup or specialized units.

The shift to IARD became institutionalized in training curricula nationwide, supported by organizations such as the International Association of Chiefs of Police (IACP), the Police Executive Research Forum (PERF) and the Advanced Law Enforcement Rapid Response Training Center (ALERRT). Active shooter response training now routinely includes scenario-based exercises, stress inoculation, and integrated tactics for law enforcement personnel at all levels. The evolution from containment to immediate action has saved lives in subsequent incidents, as officers are better prepared to confront and neutralize active threats.

Integration, Unified Command, and NFPA 3000

As active shooter incidents grew in scale and complexity, it became clear that rapid law enforcement engagement alone was insufficient to address the full spectrum of challenges posed by these events. The need for a coordinated, multi-agency response encompassing law enforcement, fire, emergency medical services (EMS), and emergency management became increasingly apparent. In response, the National Fire Protection Association (NFPA) released NFPA 3000: Standard for an Active Shooter/Hostile Event Response (ASHER) Program, which formalized best practices for integrated response. Unfortunately, while most fire/rescue departments adhere to NFPA recommendations, they remain just that: recommendations. Uptake of NFPA 3000 by US law enforcement agencies has been slow to minimal.

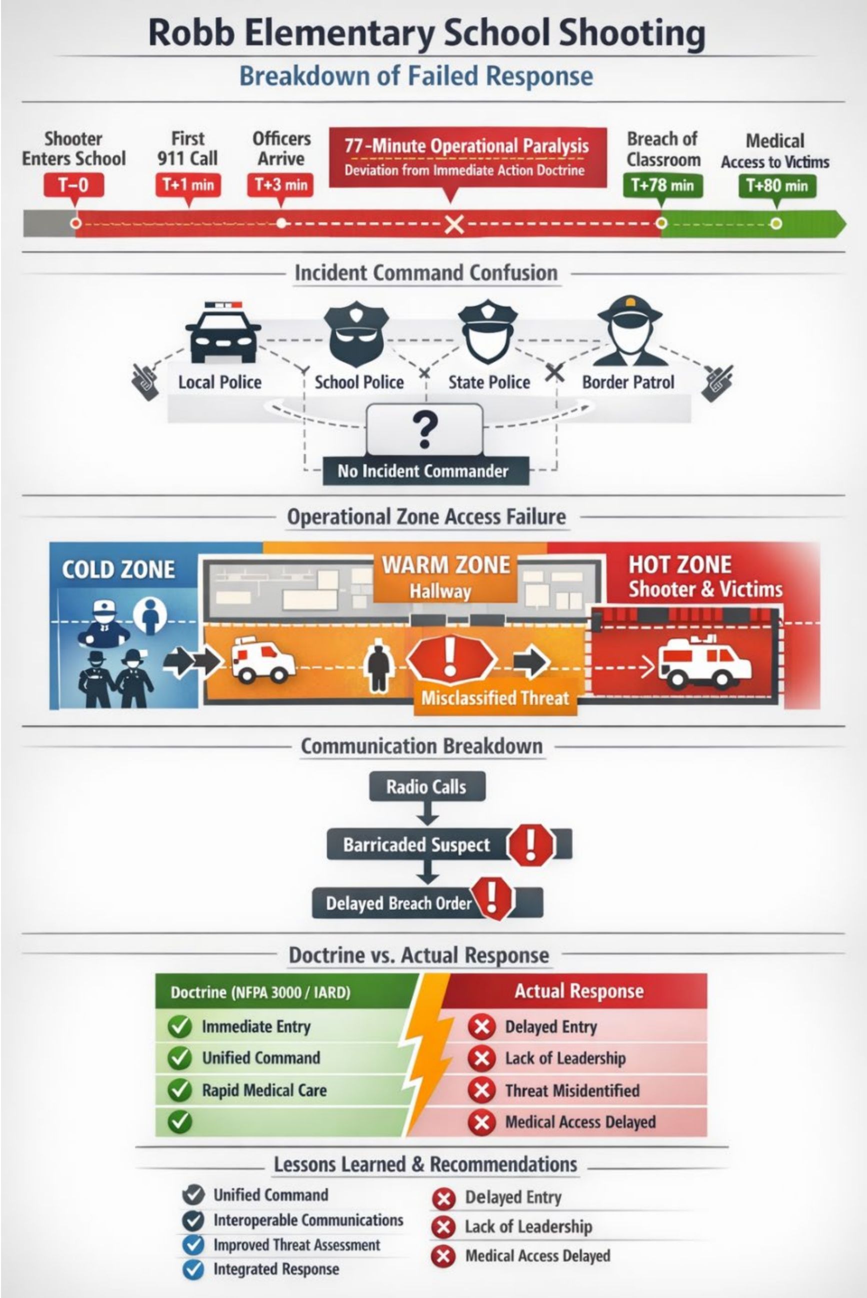
NFPA 3000 establishes clear expectations for agencies involved in active shooter and hostile event response. The standard emphasizes the early establishment of Unified Command, ensuring that leaders from all relevant agencies collaborate to direct operations from the outset. Interoperable communications are prioritized, enabling seamless information sharing and coordination across disciplines. The use of defined operational zones – hot, warm, and cold – provides a framework for managing safety, resource allocation, and tactical movement within the incident area. Yet in these dynamic law enforcement incidents, the definition of these zones is poorly understood by planners and policy makers as they are often defined well after the window for the provision of critical emergency hemorrhage control has closed. Nonetheless, better integrated operations between law enforcement, fire, EMS, and emergency management are essential for effective response, and recovery.

Persistent Failures: Uvalde as a Case Study

Despite the maturation of doctrine and the widespread adoption of best practices, persistent failures in execution continue to plague active shooter response. The 2022 Robb Elementary School shooting in Uvalde, Texas, stands as a stark example. Although law enforcement agencies on scene were familiar with IARD tactics and integrated response principles, breakdowns in leadership, communication, and threat assessment led to catastrophic delays. **Figure 1** represents graphically the complicated and connected failures at Robb Elementary.

Multiple critical incident reviews echoed similar themes. Command authority was unclear, resulting in confusion over who was responsible for directing the response. Officers misclassified the threat status, treating the situation as a barricaded subject rather than an ongoing active shooter event, which led to delayed entry into the classroom. Communication between agencies was fragmented, and medical personnel were unable to access victims in a timely manner due to lack of coordination and operational clarity.

Figure 1. Complex Failures at Robb Elementary School



These failures were not due to a lack of knowledge or resources, but rather a breakdown in execution under pressure. The Uvalde incident underscores the importance of leadership, training, and adherence to established protocols. It serves as a reminder that doctrine alone is insufficient – effective response requires disciplined implementation, clear command structure, and unwavering commitment to saving lives.

MEDICAL INTERVENTIONS IN ACTIVE SHOOTER RESPONSE

The Hartford Consensus and the THREAT Framework

In the wake of mass casualty incidents such as Sandy Hook, the Hartford Consensus was convened by leading trauma surgeons, law enforcement officials, and federal partners to address the critical gap between law enforcement response and lifesaving medical care during active shooter events. This multidisciplinary effort recognized that traditional approaches, which treated these incidents primarily as law enforcement problems, failed to address the urgent medical needs of victims who often suffered preventable deaths from uncontrolled bleeding.

The Hartford Consensus reframed active shooter response as a time-critical medical emergency, emphasizing that survival depends not only on neutralizing the threat but also on delivering immediate medical intervention. Central to this paradigm shift is the THREAT framework, which prioritizes five essential actions:

1. **Threat Suppression:** The principal priority is to stop the ongoing violence by neutralizing or containing the shooter, allowing medical responders to access victims safely.
2. **Hemorrhage Control:** Rapid control of life-threatening bleeding is crucial, as exsanguination can occur within minutes. The framework advocates for the use of tourniquets and hemostatic agents by both first responders AND trained civilians.
3. **Rapid Extrication:** Victims must be quickly removed from dangerous environments to facilitate further assessment and treatment.
4. **Assessment:** Systematic evaluation of casualties enables responders to identify those with the most urgent needs and allocate resources effectively.
5. **Transport to Definitive Care:** Prompt transfer to trauma centers or hospitals ensures that victims receive advanced surgical and critical care.

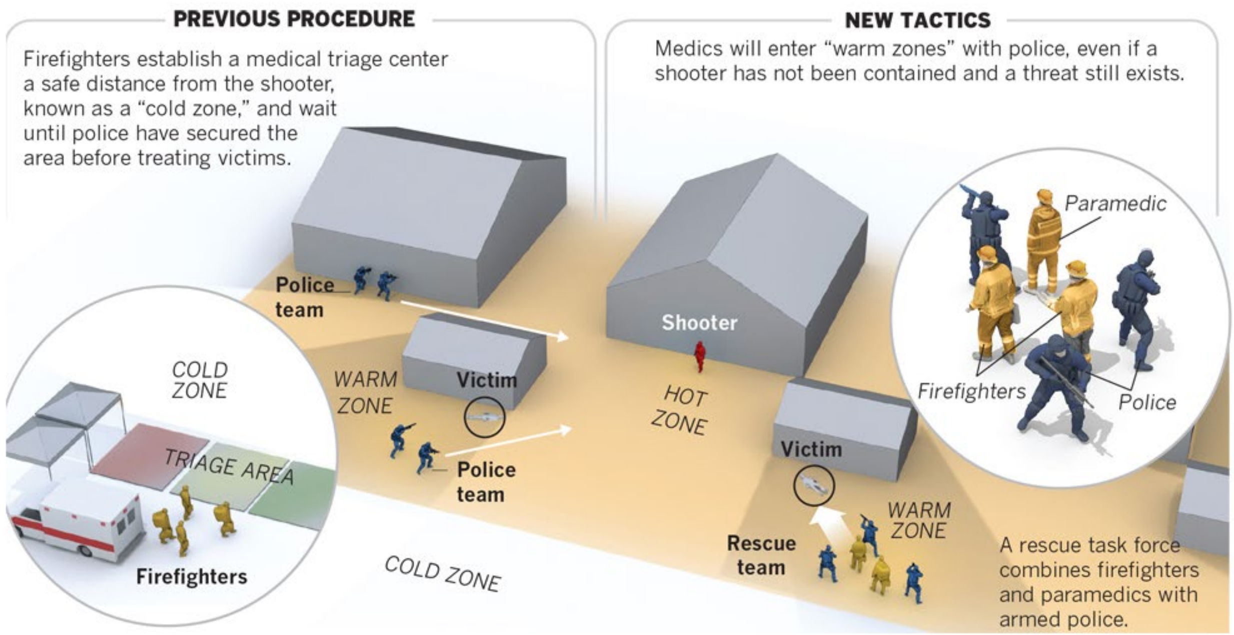
This approach fundamentally changed expectations regarding when and where medical care should occur. Rather than waiting for law enforcement to declare a scene "safe," the Hartford Consensus encourages medical intervention as soon as possible, even in areas that may still pose risk. The framework has been widely adopted in policy, training, and operational planning, influencing protocols for both professional responders and the public.

Rescue Task Force and Hemorrhage Control

The Rescue Task Force (RTF) concept has been lauded widely as a potential advance in the integration of medical and law enforcement operations during active shooter incidents. RTF teams, composed of EMS and fire personnel, enter "warm zones" – areas of potential but not immediate threat – under the protection of law enforcement to perform lifesaving interventions. The primary focus of RTF operations is hemorrhage control and rapid evacuation of victims to safer areas or directly to awaiting ambulances.

While well advocated and even funded in certain jurisdictions, the model remains poorly implemented and flawed in places. Despite reports of successfully implementation in numerous incidents, including the 2015 San Bernardino terrorist attack, where coordinated RTF teams provided immediate care to victims while law enforcement secured the scene, the RTF remains a slow, clunky solution to a vexing clinical problem: active hemorrhage in a non-permissive environment. The expansion of public hemorrhage-control training, most notably through the Stop the Bleed campaign inspired by Hartford Consensus principles, represents one of the most tangible medical advances since Sandy Hook. Millions of civilians have received training in tourniquet application and wound packing, empowering bystanders to act as immediate responders and dramatically improving survival rates in mass casualty events.

Figure 2. The Rescue Task Force



HEALTHCARE SYSTEM PREPAREDNESS

Hospitals located near active shooter incidents experience an immediate, no-notice surge of patients, frequently beginning within minutes of the first shots. This surge often includes a mix of critically injured victims transported by EMS and a substantial number of "walk-ins" or self-transported casualties arriving by private vehicle, law enforcement, rideshare, or on foot. During the 2017 Las Vegas Route 91 Harvest Festival shooting, for example, local hospitals received hundreds of patients in a very short time, many arriving without EMS triage or prior notification. Similar patterns were seen after the Pulse nightclub shooting in Orlando and the Boston Marathon bombing, where emergency departments had to simultaneously manage severely injured patients requiring emergent surgery, those with minor injuries, and uninjured but psychologically distressed individuals. Effective preparedness for these scenarios requires rapid activation of trauma teams, immediate reassessment of ED capacity, and dynamic patient flow management to avoid bottlenecks at triage and imaging. Despite learning the same lessons repeatedly, the US trauma community has yet to lead a reexamination of alternative care sites (urgent care, standalone emergency departments, etc.) that might be force multipliers during legitimate mass casualty incidents like these.

To sustain care during these surges, hospitals must have preplanned mechanisms for blood bank surge capacity, operating room and post-anesthesia care unit (PACU) flexibility, and close coordination with hospital security. Mass transfusion protocols must be rapidly activated, with sufficient type O blood and blood products immediately available and logistics in place for rapid resupply, as occurred at Orlando Regional Medical Center after the Pulse shooting. Operating rooms may need to be rapidly reprioritized, with elective cases canceled, additional rooms opened, and staffing reallocated to support multiple simultaneous damage-control surgeries. Security coordination is equally critical, both to protect staff and patients from a potentially evolving threat and to manage crowd control, media presence, and family reunification. The Hospital Incident Command System (HICS), reinforced by the Centers for Medicare & Medicaid Services (CMS) Emergency Preparedness Rule, provides a scalable framework for organizing these efforts. Through HICS, hospitals can rapidly stand-up incident command, assign clear roles (operations, logistics, planning, finance), integrate with community emergency management and law enforcement, and coordinate clinical, logistical, and security operations in a structured, repeatable manner.

UAS AND THE ACTIVE SHOOTER RESPONSE

Unmanned aircraft systems (UAS) have emerged as significant force multipliers in active shooter incidents, complementing traditional law enforcement tactics rather than replacing them. Many agencies now deploy drones as “first-on-scene” assets, launching them from patrol vehicles or central stations within minutes of the initial 911 call. From an overwatch position, UAS can provide live video of building exteriors, parking lots, and surrounding terrain, helping to identify points of entry, observe suspect movement, detect fleeing individuals, and distinguish victims from potential threats. In complex environments such as multi-building school campuses, shopping centers, or large entertainment venues, aerial views can assist Incident Command in confirming or refuting reports of multiple shooters, identifying potential ambush locations, and detecting secondary threats such as suspicious vehicles or improvised explosive devices. Real-time imagery can be streamed to command posts and mobile devices, allowing commanders to define earlier the hot, warm, and cold zones, direct contact teams, and coordinate perimeter assets with much greater precision than ground observations alone.

From a medical and rescue standpoint, UAS offer additional advantages. Aerial reconnaissance can assist in casualty location mapping by identifying where victims are sheltering, clustering, or attempting self-evacuation, which informs Rescue Task Force (RTF) routing and staging decisions. For example, UAS video can help determine the safest and most efficient paths for RTF teams to reach known casualty sites while minimizing exposure to residual threat areas. Situational triage can be supported indirectly by identifying areas of high victim density, visible signs of severe injury (e.g., large blood pools), or locations where bystanders are attempting improvised care, allowing EMS leaders to prioritize limited resources. Experimental and pilot programs have also explored the use of UAS to deliver lightweight medical supplies – such as tourniquets, hemostatic dressings, or small bleeding-control kits – to otherwise inaccessible or high-risk areas, although these concepts remain largely developmental. Regulatory requirements (including FAA rules and local airspace restrictions), ethical considerations (such as privacy and data retention), and operational constraints (training, deconfliction with crewed aircraft, and cyber security) all shape how far and how fast UAS capabilities can be expanded. Nonetheless, when integrated into unified command and aligned with NFPA 3000–consistent tactics, UAS support has the potential to enhance both tactical decision-making and time-critical medical care without delaying immediate threat suppression.

CONCLUSIONS

More than a decade after Sandy Hook, the professional consensus on active shooter response is clearer than ever. The frameworks exist. The standards exist. The medical and tactical tools exist. Yet outcomes remain uneven, determined less by doctrine than by leadership, training fidelity, and systems integration. The enduring lesson is sobering but actionable: preparedness is not a document – it is a practiced capability.

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ARTIFICIAL INTELLIGENCE ON THE FRONTLINES: TRANSFORMING MEDICAL DISASTER RESPONSE

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CONVERGING REALITIES IN DISASTER AND COMBAT MEDICINE

Medical disaster response – across both civilian and military domains – is undergoing a fundamental paradigm shift. Historically, civilian disaster medicine and combat casualty care were treated as distinct problem sets, governed by different operational assumptions and resource constraints. In the current era, that distinction is no longer valid.

Civilian disasters, including earthquakes, hurricanes, infrastructure collapse, and mass-casualty shootings, are increasingly characterized by delayed evacuation, overwhelmed transport capacity, disrupted communication, and prolonged on-site care.[1-3] Simultaneously, modern near-peer conflict has eroded the assumptions that defined the Global War on Terror, particularly the expectation of rapid aeromedical evacuation and downstream definitive care.[4-6] In both settings, injured patients must now be stabilized, treated, and monitored in place for extended periods under austere conditions.

This convergence represents a return to a care paradigm more closely resembling World War II and Korean War medicine: high-energy injury patterns, limited diagnostics, prolonged holding, and reliance on forward capability rather than transport.[6] Artificial intelligence (AI), when architected as an integrated clinical system rather than a standalone analytic tool, offers a mechanism to fundamentally transform how care is delivered under these constraints.

HISTORICAL CONTEXT: TRAUMA SURGERY HAS FACED THIS BEFORE

During World War II and the Korean War, casualty survival depended on early hemorrhage control, rapid clinical judgment, and prolonged stabilization close to the point of injury, often without advanced imaging or subspecialty support.[6] The late twentieth and early twenty-first centuries saw a temporary departure from this model. The Global War on Terror enabled unprecedented survival gains through rapid aeromedical evacuation, tiered trauma systems, and centralized expertise.[5]

That paradigm is now eroding. Peer and near-peer conflict environments are defined by contested airspace, distributed operations, and evacuation delays measured in hours to days.[4,5] Civilian disasters demonstrate parallel failures. Hurricane Katrina and the 2010 Haiti earthquake revealed that infrastructure damage and system overload can isolate hospitals and prevent evacuation for prolonged periods, leading to preventable morbidity and mortality driven by system failure rather than injury severity.[7,8]

Urban mass-casualty incidents similarly expose the fragility of transport-dependent care. Events such as large-scale shootings overwhelm EMS and hospital surge capacity, forcing prolonged front-end stabilization and rationing of operative and critical care resources.[9] Across these domains, the lesson is consistent: when transport fails, capability must move forward.

THE SHARED FAILURE MODE: TRANSPORT-DEPENDENT TRAUMA CARE

Modern trauma systems – both civilian and military – remain fundamentally transport-dependent. This dependence represents a critical vulnerability.

In earthquakes, structural collapse and road damage isolate casualties and hospitals, delaying definitive care.[7] Hurricanes flood trauma centers and sever evacuation routes, forcing care delivery in shelters or compromised facilities.[8] Mass-casualty shootings overwhelm regional trauma systems, requiring extended on-scene and emergency department stabilization.[9]

In each scenario, patients often die not because injuries are unsurvivable, but because diagnosis, localization, and intervention cannot occur rapidly enough at the point of care.[1,9] This mirrors historical patterns in trauma surgery, where delayed fixation, delayed hemorrhage control, or prolonged immobilization led to secondary complications and preventable mortality.

PROLONGED CARE AS THE NEW STANDARD, NOT THE EXCEPTION

Prolonged field care – defined as the provision of advanced medical treatment when evacuation is delayed or infeasible – has become an explicit doctrinal reality in modern combat medicine.[1-3] Increasingly, civilian disaster medicine faces the same requirement. Patients must be held, monitored, and treated over extended periods in environments characterized by fatigue, limited staffing, degraded diagnostics, and evolving physiology.

Human cognition degrades under these conditions. Vigilance declines, subtle deterioration is missed, and decision-making becomes reactive rather than anticipatory. Protocols and checklists, while necessary, are insufficient to manage continuously evolving physiology over prolonged time horizons.

This environment is uniquely suited to augmentation by AI systems that do not fatigue, can continuously integrate multivariate data streams, and can recognize deterioration trajectories before irreversible collapse occurs.[10,11]

REFRAMING THE ROLE OF ARTIFICIAL INTELLIGENCE IN DISASTER RESPONSE

Artificial intelligence in disaster medicine cannot be conceptualized as a passive decision-support overlay. Disaster response is not an analytics problem – it is an **execution problem under uncertainty**.[11] Effective systems must operate as closed-loop clinical architectures capable of sensing, reasoning, acting, and verifying outcomes in real time.

Sensing

In disaster and austere environments, no single diagnostic modality is reliable. Blood, debris, deformation, motion, and noise degrade traditional imaging and physiologic monitoring. Multimodal sensing – incorporating wearable physiologic sensors, point-of-care ultrasound, optical and near-infrared imaging, and motion-derived signals – is required to maintain situational awareness.[10-12]

Perception

AI-driven sensor fusion enables construction of a continuously updated physiologic "digital twin," integrating incomplete and noisy data into a coherent representation of hemorrhage, perfusion, and organ function.[11,13] These models allow early recognition of deterioration trends rather than reliance on threshold-based alarms.

Maneuver

In environments where expert hands are limited or inaccessible, robotic and semi-autonomous systems can assist with diagnostics, access, stabilization, and procedural guidance, enforcing safety constraints and reducing variability.[14,15]

Intervention and Verification

Prolonged care is inherently longitudinal. Hemorrhage control, resuscitation, and stabilization must be verified continuously, with detection of rebleeding, reperfusion injury, or evolving organ failure. Closed-loop AI systems are uniquely suited to this task.[1,11]

MAPPING AI ARCHITECTURES TO CIVILIAN DISASTER SCENARIOS

Earthquake

AI-enhanced ultrasound and multimodal sensing can identify internal hemorrhage and organ injury in trapped victims without reliance on expert operators.[16] Digital twin models enable continuous monitoring during prolonged extrication and delayed evacuation, identifying deterioration before overt clinical collapse.[11,13]

Hurricane

Wearable sensors combined with AI-based anomaly detection support monitoring of large patient populations in shelters or isolated hospitals, where clinician fatigue and staffing shortages limit continuous assessment.[10,12]

Mass-Casualty Shooting

AI-assisted imaging interpretation and explainable machine-learning triage systems support rapid prioritization of limited operative and critical care resources during surge conditions, reducing time to hemorrhage control and definitive intervention.[9,11]

AVAILABLE AND EMERGING AI, ML, AND ROBOTIC TECHNOLOGIES: CIVILIAN INNOVATION AS THE SUBSTRATE FOR DISASTER MEDICINE

A critical and often underappreciated feature of artificial intelligence in disaster medicine is that many of the most impactful capabilities are not being invented specifically for disaster response. Rather, they are emerging from civilian technologies already deployed at scale in consumer, industrial, and hospital environments. Disaster medicine therefore represents a **translation problem rather than a discovery problem**.

Perception at Scale: Lessons from Autonomous Vehicles

Modern self-driving vehicles operate in environments characterized by uncertainty, partial observability, sensor dropout, and dynamic obstacles – conditions strikingly analogous to disaster and combat medicine. Autonomous driving systems fuse inputs from cameras, radar, lidar, GPS, and inertial sensors into a continuously updated world model, allowing safe navigation despite incomplete or degraded data streams.

The relevance to disaster medicine is direct. The same multimodal sensor-fusion architectures that allow a vehicle to detect pedestrians in fog or rain can be repurposed to integrate physiologic waveforms, ultrasound images, optical signals, and environmental data into a coherent representation of patient state.[11,13] Importantly, autonomous vehicles rely not on perfect sensing, but on **probabilistic perception with confidence estimation**, a principle that is essential for safe AI deployment in clinical environments.

This paradigm underpins the concept of the physiologic digital twin in prolonged care: an evolving model that updates continuously, tolerates sensor failure, and supports anticipatory decision-making rather than reactive alarms.[11,13]

Foundation Models and Clinical Cognition: Large Language Models as Force Multipliers

Large language models (LLMs), exemplified by systems such as ChatGPT, have demonstrated an unprecedented ability to synthesize heterogeneous information, generate context-aware recommendations, and communicate uncertainty in natural language. In medicine, these models are increasingly being explored as **clinical copilots rather than autonomous decision-makers**.[11]

In disaster response, the relevance of LLMs lies not in diagnosis per se, but in **cognitive load reduction and knowledge projection**. LLM-based systems can synthesize evolving patient data streams into coherent clinical narratives, translate complex physiologic trends into actionable summaries, provide just-in-time procedural guidance when expertise is unavailable, and support triage decisions by contextualizing limited information against large knowledge priors. This mirrors how LLMs assist professionals in other high-cognitive-load domains by compressing information and reducing decision fatigue.[11]

Automated Image Interpretation: From Consumer Ultrasound to AI Echocardiography

Automated interpretation of medical imaging represents one of the most mature and clinically validated applications of AI. Point-of-care ultrasound (POCUS), long limited by operator skill variability, is increasingly augmented by AI systems that identify anatomy, optimize probe positioning, and interpret images in real time, dramatically reducing the expertise required to detect free fluid, cardiac activity, or gross organ injury.[16]

A parallel civilian example is AI-assisted echocardiography, in which commercial platforms provide automated chamber identification, ejection fraction estimation, and wall-motion analysis. These systems demonstrate that clinically meaningful physiologic inference can be extracted reliably from noisy, operator-dependent imaging modalities. In disaster settings, this capability allows non-expert providers to perform diagnostic imaging with confidence, extending advanced assessment into austere environments without requiring subspecialists on site.[16]

Quantitative Bedside Measurement: The Bladder Scanner as a Model System

Bladder scanners provide an instructive example of how AI-driven quantitative measurement can transform bedside care. These devices automatically acquire ultrasound data, segment anatomy, and calculate volume without requiring operator interpretation.

The broader implication is profound: AI can convert qualitative bedside assessments into objective, reproducible physiologic measurements, even in the hands of minimally trained users. In disaster and prolonged care settings, similar approaches can be applied to estimation of intraperitoneal fluid, assessment of cardiac filling, and quantification of pleural or pulmonary pathology, enabling closed-loop monitoring during prolonged holding.[16]

Predictive Physiology and Early Deterioration Detection

Predictive deterioration models trained on large physiologic datasets have demonstrated the ability to forecast shock, respiratory failure, and cardiac arrest minutes to hours before overt clinical signs appear.[10,13] In civilian hospitals, such systems already trigger rapid response activation and ICU escalation.

In disaster medicine, where evacuation is delayed and provider bandwidth is limited, early prediction may be the only opportunity for timely intervention. These models transform care from reactive rescue to anticipatory stabilization, aligning directly with damage-control principles familiar to trauma surgeons.

Robotics and Physical Augmentation: Extending Human Reach

Robotic systems represent the physical counterpart to AI perception and cognition. Tele-operated and semi-autonomous robots are already deployed in hazardous civilian environments, including disaster search-and-rescue, nuclear facilities, and infectious disease wards.[14,15]

In medical disaster response, robotics can stabilize access and visualization in confined or dangerous spaces, assist with diagnostics when human access is unsafe, maintain consistency in repetitive or fatigue-sensitive tasks, and deliver supplies when transport routes are compromised. Drone-based medical delivery systems, already used to deliver AEDs and blood products, demonstrate how autonomous logistics can extend care beyond traditional infrastructure.[17,18]

Crucially, these systems do not replace clinicians. They **amplify reach, precision, and endurance**, allowing limited human expertise to be projected across space and time.

EVIDENCE, VALIDATION, AND OPERATIONAL REALISM

As with damage-control surgery and massive transfusion protocols, traditional randomized controlled trials are often infeasible in disaster medicine.[1] Validation must instead emphasize operational realism.

Meaningful outcome measures include time to hemorrhage control, accuracy of injury localization, reduction in provider cognitive burden, and survival during prolonged holding.[1,11] Simulation, translational models, and field exercises currently provide the most relevant evidence base for system performance.

RISK, GOVERNANCE, AND TRUST

AI systems in disaster medicine fail most often due to overconfidence, poor integration, and lack of transparency rather than algorithmic weakness.[11] Safe deployment requires redundant sensing, confidence-gated autonomy, explainable outputs, and graceful degradation under uncertainty. These principles mirror those used in aviation safety and critical care monitoring.

IMPLICATIONS FOR TRAUMA SURGERY

Trauma surgeons uniquely bridge civilian disaster response and combat casualty care. The discipline is defined by management of physiology under stress, system failure, and time-critical decision-making. AI-enabled systems allow trauma principles to be extended forward into disaster environments when surgeons cannot physically be present.[1-6]

This represents not a departure from trauma surgery's mission, but a return to its historical roots – now augmented by sensing, computation, and robotics capable of sustaining life when time, transport, and certainty are limited.

CONCLUSION

Medical disaster response – civilian and military alike – is converging toward a common reality: delayed evacuation, prolonged care, and increasing system strain. History demonstrates that when transport fails, care must adapt.

Artificial intelligence, when integrated as a physiology-aware, closed-loop clinical system and governed with discipline, offers a mechanism to restore early intervention, vigilance, and precision where traditional systems break down. For trauma surgeons, this represents an opportunity to lead the next evolution of disaster medicine – grounded in history, driven by necessity, and enabled by technology.

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SESSION 2

CASE MANAGEMENT SESSION
Case by Case: Expert Lessons in Disaster/MCI Response

Co-Moderators: Matthew J. Martin and Purvi P. Patel

Sunday, April 26, 2026
10:30 – 12:00 NN
Palace Ballroom 1-2
Palace Tower
Emperors Level – 4th Floor

Panelists:
Carlos V.R. Brown
Bryan A. Cotton
Brian J. Eastridge
Jeffrey M. Elder
Jennifer M. Gurney
Jeffrey J. Skubic
Alison Wilson

SESSION 3

MEDICAL DISASTER RESPONSE KEYNOTE ADDRESS

Moderator: Kenneth L. Mattox

Sunday, April 26, 2026
12:00 – 1:30 PM
Palace Ballroom 1-2
Palace Tower
Emperors Level – 4th Floor

"Large Scale Combat Operations' Impact on Civilian Trauma Systems"

Jeremy W. Cannon, MD, SM, FACS COL, USAF (Ret)
Professor of Surgery at the
Hospital of Pennsylvania and the
Presbyterian Medical Center of Philadelphia
Philadelphia, PA

LARGE SCALE COMBAT OPERATIONS' IMPACT ON CIVILIAN TRAUMA SYSTEMS

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Large-Scale Combat Operations (LSCO) represent a return to casualty volumes, injury complexity, and system stress not seen since World War II. Unlike recent conflicts, future wars will be fought against peer or near-peer adversaries in **contested environments**, with medical units deliberately targeted, evacuation disrupted, and civilian infrastructure directly affected.

This keynote argues that **the greatest threat posed by LSCO is not tactical – it is medical unpreparedness**, and that failure to address this gap constitutes a national security vulnerability. Civilian trauma systems will be essential to sustaining military operations, absorbing casualties, and maintaining public trust.

THE HISTORICAL PATTERN: WHAT IS PAST IS PROLOGUE

Across a century of conflict, the United States has entered every major war **medically underprepared**, relearning the same lessons at the cost of preventable death:

- World War I: Rapid improvement only after catastrophic early losses
- World War II: Steep early learning curve despite prior experience
- Korea and Vietnam: Excellence achieved only after system maturation
- GWOT: Lowest case fatality rate in history – **but only after a decade**

This recurring phenomenon – the **"peacetime effect" or Walker Dip** – reflects the predictable degradation of readiness between conflicts, driven by low volume, loss of expertise, and institutional amnesia.

LSCO REALITIES: SCALE CHANGES EVERYTHING

Future LSCO scenarios differ fundamentally from GWOT:

- Casualty volumes: ~1,000 per day for 100+ days
- Injury patterns: Polytrauma, multi-cavity injury, burns, amputations
- Environment: Contested airspace, cyber disruption, targeted medical units
- Evacuation: Prolonged, unreliable, or unavailable

Modeling from the National Disaster Medical System (NDMS) pilot suggests **100,000 casualties**, with historic case fatality rates approaching 50% in the opening months of peer conflict – translating to tens of thousands of potentially preventable deaths.

THE CIVILIAN TRAUMA SYSTEM PROBLEM

The U.S. civilian healthcare system is already operating at or near capacity:

- High hospital and ICU occupancy
- Limited blood, imaging, and OR surge capacity
- Severe workforce shortages (nursing, surgeons, critical care)
- Fragmented regional coordination

Civilian trauma centers will be asked to:

- Receive large numbers of combat casualties
- Maintain ongoing civilian trauma and emergency care
- Support training and sustainment of military medical teams

Without prior integration and coordination, the system will fail and patients with preventable deaths will die.

MILITARY READINESS IS A MEDICAL PROBLEM

Medical readiness is not an adjunct to combat power – it is a **force multiplier** and a component of deterrence.

Key challenges today include:

- Inexperienced and understaffed trauma teams
- Critical wartime specialists unable to maintain skills
- Joint Trauma System constrained in maneuver space
- Military Health System incentives misaligned with readiness

As prior conflicts demonstrate, **experience saves lives**, and that experience cannot be generated "just in time" once war begins.

THE SOLUTION SET: ZONE OF THE INTERIOR 2.0

The United States has solved this problem before. During World War II, a coordinated **Zone of the Interior** mobilized civilian hospitals, trained military surgeons, expanded capacity, and absorbed casualties at scale.

A modern equivalent must include:

A. Building Strategic Depth: National Trauma and Emergency Preparedness System (NTEPS)

- A true national trauma system
- Built on daily coordination, not episodic activation
- Designed for both civilian disasters and LSCO

B. The NTEPS Building Block: Regional Medical Operations Coordinating Centers (RMOCCs)

- The operational "unit of action"
- Real-time visibility of beds, blood, ORs, and expertise

- Mechanism for patient distribution, quality monitoring, and learning

C. Domestic Military–Civilian Partnerships (MCPs)

- Embedded military trauma teams in high-volume civilian centers
- Sustained clinical exposure for wartime specialists
- Bidirectional benefit for readiness and disaster response

D. Defending Forward with International Engagement

- Historic example of the American Hospital in Paris, World War I
- Glean important lessons from contemporary conflicts
- Support allies with medical expertise and assets
- Apply experience to ensure our own medical readiness

WHY THIS MATTERS: DETERRENCE AND TRUST

The American public expects that wounded service members will receive **optimal care**, regardless of scale or circumstance. Failure to meet that expectation erodes:

- θέμις (*themis*)
- Military morale
- Public trust
- Strategic deterrence

Medical readiness signals national resolve. **Medical supremacy on day one** is as consequential as air or maritime superiority.

FINAL THOUGHTS AND TAKE-HOME POINTS

- LSCO will stress civilian trauma systems at WWII scale
- The peacetime effect is predictable – and preventable
- Medical readiness is a national security imperative
- Civilian and military trauma systems must be optimized together, or not at all
- The time to build the system is **before** the first casualty arrives

"In war, you win or lose, live or die – and the difference is just an eyelash."
In medicine, that eyelash is preparation.

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SESSION 4

NEXT-GEN THREATS, REAL-WORLD TRAUMA

Moderator: Alexander L. Eastman

Sunday, April 26, 2026

1:30 – 3:00 PM
Palace Ballroom 1-2
Palace Tower
Emperors Level – 4th Floor

1:30 – 1:45	**Emerging Threats: Directed Energy Weapons, Biologic Agents, and Hospital Vulnerabilities** **Jay A. Johannigman, MD, FACS**
1:45 – 2:00	**When Heat Turns Fatal: Lessons from Maricopa County** **Sydney J. Vail, MD, FACS**
2:00 – 2:15	**Crossing the Blood-Brain Barrier: Neurotrauma in Disasters and Resource Limited Settings** **Purvi P. Patel, MD, FACS**
2:15 – 2:30	**After the Bang: Managing Blast Trauma** **Jeremy W. Cannon, MD, SM, FACS, COL USAF**
2:30 – 3:00	**Panel Discussion**
3:00 – 3:30	**Break & Visit Exhibits** **Emperors Ballroom** **Palace Tower** **Emperors Level – 4th Floor**

EMERGING THREATS: DIRECTED ENERGY WEAPONS, BIOLOGIC AGENTS, AND HOSPITAL VULNERABILITIES

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Globally, disasters are increasing with more devastating consequences than before. Disasters are categorized into two types: man-made and natural. While literature on natural disasters is abundant, this review will focus on man-made disasters. Directed Energy weapons and chemical, biological, radiological, or nuclear and explosive (CBRNE) threats represent man-made incidents, accounting for an average of 35% of all community disasters. Although CBRNE disasters have been reported for many years in emergency event databases, they receive less attention from the scientific community. Whether deliberate or accidental, these disasters can have harmful effects on communities. One only needs to open the drawer of PTSD regarding COVID and the worldwide impact on our lives to understand that the next threat is a breath away.

Throughout history, many CBRNE disasters, both deliberate and accidental, have killed numerous people and posed global threats. Examples include the Fukushima and Chernobyl radiological incidents, the Seveso chemical incident, the planned release of sarin gas in Japan, and biological events such as the 2001 anthrax attacks in the United States. The number of casualties from CBRNE disasters can range from a few individuals to entire populations. The harm inflicted on casualties can be complex and multifaceted, including etiological, chemical, mechanical, thermal, or radioactive effects.

If the reader is willing to suspend political affiliation and bias aside for just a moment – one needs only to review the devastating impact of COVID on the global community. Whether COVID was an intentional, man-manipulated virus or not, the more important issue is that viruses and other biologic agents CAN BE INTENTIONALLY CREATED and wreak similar havoc. Whether intentional or not, the lessons learned from the incapacitation of the global community must not be forgotten.

Directed Energy Weapons, Biologic Agents and Hospital Vulnerabilities are the assignments for this brief discussion. After more than four decades of military service, I am able to practically recite the standard dictums regarding nuclear radiation, chemical nerve gas agents, time of radiation exposure to lethality, etc. As I sit in my office preparing, I would like to engage in a conversation regarding TTP. TTP is the military term for Tactics, Technique, and Procedures. The near-peer threats to our country have been, and will remain for the foreseeable future, The Soviet Union and the People's Republic of China. Let's take a moment and think tactically and put ourselves in their shoes regarding the employment of directed energy weapons, biologic agents and the CBRNE weaponry menu.

DIRECTED ENERGY WEAPONS (DEWS)

Directed energy weapons use focused electromagnetic energy, such as high-energy lasers (HEL) and high-power microwaves (HPM), to damage or disable combatants, vehicles, and electronics. These systems provide low-cost-per-shot, deep-magazine defense against drones and threats, with capabilities ranging from non-lethal crowd control to lethal, long-range destruction.

High-Energy Lasers (HEL): These weapons use intense light to physically destroy, melt, or ignite targets, such as missiles, drones, and boats.

High-Power Microwaves (HPM): These systems, including the Active Denial System, emit radiofrequency energy to disrupt electronics or cause intense heat sensations on skin to deter personnel.

Operational Use & Benefits: DEWs offer instantaneous engagement and can be used for base defense, counter-drone operations, and stopping vehicles. They are considered highly efficient, with some systems able to disable systems without causing, in some cases, lasting injury.

Medical & Ethical Concerns: While often touted as non-lethal, DEWs can cause skin burns, blisters, and eye injuries. There are concerns regarding their long-term health effects and potential to cause unnecessary suffering, raising questions under international humanitarian law. As of today, the majority use of DEW appears to be in countering airborne missile and drone threats.

CBRNE

Tactically, utilizing CBRNE weapons gives advantage over the adversary which will allow you to advance your battle campaign. From this perspective, the lethality of a weapon is an important consideration. From a brutally pragmatic perspective, a weapon with high lethality may not accomplish a tactical or strategic advantage. US Forces have long been recognized to care for their wounded casualties, while Russian and Chinese forces have traditionally moved forward into the battle spaces leaving wounded to fend for themselves. The Japanese commanders on Iwo Jima emphasized wounding US Marines by striking them in the legs or arms; realizing that a casualty would take three to five US Marines out of battle (the casualty and two to four litter bearers to carry the soldier to the rear). In today's discussion, this also implies a logistical burden on civilian hospital resources, as dramatically demonstrated across our nation during the first 12-18 months of SARS-Covid.

With this preface completed, let us examine each class of weaponry and the threat posed in today's complex world and battle space.

C- CHEMICAL

1. **Nerve Agents**

   Nerve agents form part of a group of environmentally persistent and highly toxic organo-phosphorous (OP) compounds that block the transmission of nerve impulses in the human nervous system.

   Their primary means of absorption is via the skin and lungs. Nerve agents are divided into two groups - G-series (or "German - series") agents and V-series (or "Venomous-series") agents.

2. **Blister Agents**

   Blister agents (also known as vesicants) are one of the most common chemical weapon agents, typically dispersed via liquid, vapor, aerosol, or dust.

The chemical compounds in blister agents cause severe irritation to multiple organ systems, including the eyes, skin, mucous membranes and respiratory tract, as a result of inhalation or direct contact.

Examples of blister agents include sulfur mustard (H,HD), nitrogen mustard (HN), lewisite (L), and phosgene oxime (CX).

Blister agents have less toxicity than nerve agents; however, they are known to cause prolonged morbidity and degradation of health. The percentage of deaths from exposure to blister agents is quite small - estimated to be around 2-3%.

3. **Choking Agents**

   Choking agents (or pulmonary agents) are so named due to their effect on the human respiratory tract, which can result in severe swelling or irritation of the lining of the nose, throat and lungs.

   When choking agents are inhaled, they cause air sacs (or alveoli) in the lungs to secrete fluid which impedes the ability to breathe thereby drowning or choking the victim.

   Common examples of choking agents are chlorine (Cl), phosgene (PS), diphosgene (DP) and chloropicrin (CG).

4. **Blood Agents**

   Blood agents form part of a cyanide or arsenic-based group of chemicals that inhibit the ability of blood cells in the human body to use and transfer oxygen.

   They are fast-acting and highly toxic poisons that are typically disseminated as aerosols and that take effect through inhalation.

   The symptoms of blood agent poisoning vary depending on the concentration and duration of exposure. At sufficient concentrations; they can quickly saturate the blood causing respiratory failure.

   Examples of blood agents include arsine (SA), cyanogen chloride (CK), and hydrogen cyanide (AC).

B-BIOLOGIC

1. **Bacillus anthracis (Anthrax):** Anthrax spores are hardy, can be produced relatively easily, and can be widely dispersed as an aerosol in powders, or in water/food supplies. The 2001 anthrax letter attacks in the U.S. demonstrated its use in a real-world bioterrorism event. It was also a principal weapon in former state-run programs, including the Soviet Union's.

2. **Yersinia pestis (Plague):** Plague has a long history of use, including catapulting plague-infected bodies during medieval sieges. In modern times, the bacterium was weaponized for aerosol delivery by several countries, and the pneumonic form is highly contagious and spreads person-to-person.

3. **Variola major (Smallpox):** This highly contagious and lethal virus was eradicated in 1980, but due to a cessation of worldwide vaccination, most of the global population is now susceptible. Its person-to-person transmissibility and high fatality rate make it an ideal and potent theoretical weapon, and it was produced in large quantities by the Soviet Union.

4. **Francisella tularensis (Tularemia):** This agent is extremely infectious and was developed into an aerosol weapon by several countries in the past, including the U.S. and the former Soviet Union. It causes a serious, though generally less lethal than anthrax or plague, illness and can incapacitate a large number of people.

5. **Botulinum Neurotoxin:** One of the most potent and lethal toxins known, it can be dispersed via aerosol or by contaminating food/water supplies. The toxin causes flaccid paralysis and respiratory failure requiring intensive medical care. It was a principal weapon in the former Soviet arsenal.

The agents listed above are the traditional biologic agents. They have the potential for great lethality but are generally hard to handle, difficult to appropriately distribute, and their effect is highly lethal – thereby eliminating the need for hospital logistical support.

I will return to the biological agents at the end of this discussion for one final important update.

R- RADIOLOGIC

Radiological weapons, often called "dirty bombs," use conventional explosives to spread radioactive material, causing contamination and panic rather than massive blast destruction like nuclear weapons. They are considered "weapons of mass disruption" designed to create fear, economic damage, and widespread cleanup issues, not mass casualties from radiation itself. While nuclear weapons are a form of radiological weapon, the term generally refers to devices like dirty bombs (Radiological Dispersal Devices - RDDs) that spread radioactive dust and debris, contaminating an area and posing health risks from ingestion, inhalation, or skin contact. While radiological weapons were researched and, in some cases, tested during the Cold War, there is no evidence that any military has ever deployed operational radiological weapons, although they have been used for assassination.

N- NUCLEAR

Nuclear weapons have been used in war only twice, both times by the United States against Japan during the final stages of World War II in August 1945. These bombings of Hiroshima and Nagasaki remain the only instances of nuclear weapons being used in armed conflict. A nuclear weapon is a binary weapon in that it either immediately kills or creates a radiation or thermal injury that results in a slow delayed death. If our world comes to nuclear weapons, we all lose- enough said.

E- EXPLOSIVE

In the acronym CBRNE, the "E" stands for Explosives, representing threats from high-yield explosives, including Improvised Explosive Devices (IEDs) and conventional bombs, often used to deliver or disperse chemical, biological, radiological, or nuclear (CBRN) agents, highlighting the combined dangers in emergency response and national security. Over the past twenty-five years of the GWOT and the TCCACS and MDR conferences, this topic has been extensively reviewed and examined

For final consideration, I wish to return to what I believe is the most concerning and credible CBRNE threat in our future, namely **biological viral agents**. From a military perspective, the appropriate weaponization of a biologic virus may be the potential "perfect weapons". I was privileged to be the last senior medical commander in the Afghan theater. This also placed me in theater during the COVID epidemic, where I witnessed not only the medical but the military consequences of this biologic agent, which resulted in one of the largest medical pandemics in the history of our country. The consequences of this agent not only on the civilian community but the concomitant impact on battle readiness was not lost on either US Forces or the Russian and Chinese military leadership. At the height of the epidemic, the fighting forces of NATO and US were seriously degraded. Whether loss of infantry, air crew chiefs, or combat information center personnel, daily readiness was threatened, and fighting capability diminished.

In reflection, a COVID like virus is the perfect biologic. As opposed to the other agents, which are "one and done," the virus persisted and was potentiated by spreading throughout the entire population. The diabolic advantage of COVID is that it did not rapidly kill the host, rather it lingered and silently travelled throughout the entire theater. Attempts to isolate the virus in seemingly healthy troops were only partially effective, while simultaneously degrading readiness and diverting logistical support to non-combat tasks and hospitals quarantined away from combat medical preparation.

For those who want to pursue this issue a bit further, I would recommend a very well written and thoughtful article from a military website entitled WAR ON THE ROCKS (https://warontherocks.com/). The article itself is entitled Will China Force a Rethink of Biological Warfare? (June 10, 2025).

Little reliable open-source information exists about an offensive Chinese biological warfare program. Beijing has never admitted to possessing a biological warfare program, although the U.S. government assesses that China had an active offensive biological warfare program from the 1960s to, at least, the late 1980s. Beijing's historical biological warfare program reportedly developed and weaponized ricin; botulinum toxins; and the causative agents of anthrax, cholera, plague, and tularemia. The U.S. government consistently has highlighted concerns – in both the annual State Department arms control compliance reports as well as the annual Department of Defense reports to Congress on Chinese military power – about studies at Chinese military medical institutions that include researchers identifying, testing, and characterizing diverse families of potent toxins with dual-use applications.

As China's biotechnology and biopharmaceutical sectors mature and become more innovative, China is also developing a dual-use production capability and scientific know-how relevant to sophisticated offensive biological warfare research. Yet the U.S. government has stopped short of claims that China possesses an offensive biological warfare program. Clearly, China has the capability to research, develop, produce, and weaponize sophisticated biological weapons, should the national leadership decide to do so. On very short notice, China can also produce a wide range of biological threat agents and sophisticated delivery systems (i.e., a mobilization capability converting civilian infrastructure to military use).

It is always a pleasure to participate in this great conference, and the task of preparing this syllabus is always a learning journey. This time, not only did I greatly update my own personal knowledge, but I walked away more than a bit apprehensive about the lack of significant concern about what may be the greatest threat facing our nation in the upcoming decades of AI, genetic manipulation, and bioweaponization. Now is the time for our nation to face and prepare for the grim reality of the new world.

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WHEN HEAT TURNS FATAL: LESSONS FROM MARICOPA COUNTY

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Living in an extremely hot environment is a study in resilience, adaptability, and common sense. When we speak about survival of the fittest, it has real meaning living in temperatures that sustain above 100 degrees; **AN OVEN** is an appropriate term used to describe summer living in Maricopa County.

"Phoenix Summer Hiking: A Deadly Gamble You Can't Afford to Take"

Maricopa County is home to the nation's 4th largest county in terms of population. It covers 9,224 square miles, larger than four U.S. states and includes 24 cities and towns and several unincorporated communities. Of this, 53% is federal land, 29% private land, 13% state land and nearly 5% is tribal land, including Fort McDowell Yavapai, Gila River, Salt River Pima-Maricopa, and Tohono O'odham. It has one of the largest regional parks systems in the United States with more than 120,000 acres of open space.[1]

In 2021, the Parks and Recreation Board established the Trail Heat Safety Program, a proactive measure to help bikers, hikers, and outdoor enthusiasts navigate the beautiful Phoenix trail system while minimizing the risks of extreme heat to both trail users and first responders.[2]

The county hospital system, serving all residents (and visitors) of Maricopa County, recognized the need to deal with extreme heat injuries and burns secondary to living in or visiting the hot desert environment. The Arizona Burn Center, now the Diane & Bruce Halle Arizona Burn Center at Valleywise Health, opened in 1965 in the Maricopa County General Hospital.[3] Today, what began as a five-bed unit has expanded to a 50-bed, state-of-the-art facility recognized nationally for its excellence in adult and pediatric burn treatment. Each year, the Burn Center admits more than 1,600 pediatric and adult patients, treats 12,000 outpatients, and serves as the primary referral center for Arizona and much of the Southwestern U.S. ***The Burn Center's survival rate is 98 percent***.[4]

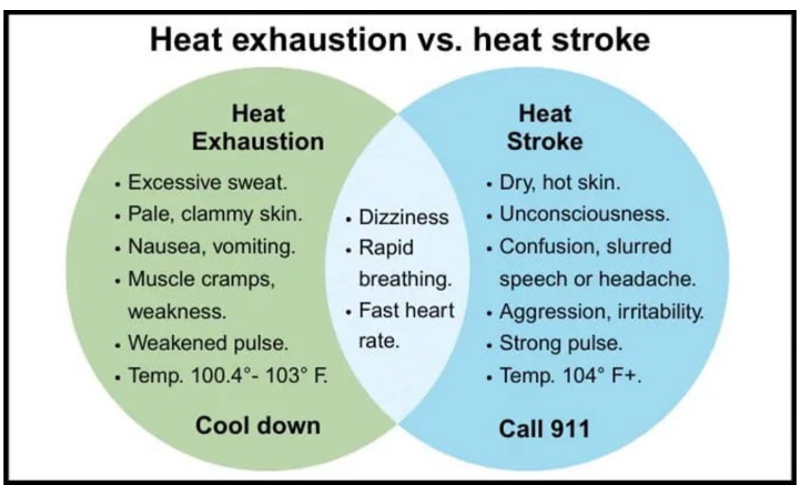
Warm/hot weather anywhere in the U.S. attracts people looking for adventure and outdoor activities. It is not until the ambient temperatures exceed body temperature that safety issues increase significantly. Phoenix, in Maricopa County, is typically one of the hottest major cities each year.

City	Mean °F	Mean °C
Phoenix, Arizona	94	34
Las Vegas, Nevada	91	33
Dallas, Texas	86	30
Austin, Texas	85	30
San Antonio, Texas	84	29
Houston, Texas	84	29
Miami, Florida	84	29

US cities with the highest normal daily mean temperatures in June, July and August [5]

Human nature always makes for interesting traumatic/burn injuries, despite what common sense *should* dictate. We expect people with diabetic neuropathy, reduced or lack of plantar foot sensation to wear shoes to walk on hot/overheated pavement or road surfaces, but that is not always the case. Intoxication with drugs and/or alcohol, as well as some medical conditions, muscular weakness, dehydration, assaults, etc., can lead to balance instability. Any of these can result in falls onto hot/overheated pavement or road surfaces, which can lead to burns ranging from 1st degree to 3rd degree, as well as other associated conditions, i.e., rhabdomyolysis, heat exhaustion or heat stroke.

Heat Exhaustion symptoms include heavy sweating, weakness, cold, pale, and clammy skin, fast or weak pulse, nausea, and fainting. **Heat Stroke** is a more severe condition that can occur if heat exhaustion is not treated. Symptoms include high body temperature (above 103°F), altered mental state, and hot, dry skin.



Activities performed in the heat: working, hiking, running, playing sports, or any other exertional activity can lead to **heat stroke** = elevated body temperature and central nervous system dysfunction, which can be fatal. Excessive metabolic heat from skeletal muscle activity combined with inadequate heat dissipation leads to internal heat accumulation in the body. The course of heat stroke is highly time sensitive; without rapid intervention, it can quickly progress to multiple organ failure, with a mortality rate of up to 26.5%. [6]

In the recently published, May 2025 report by Maricopa County Public Health Dept. Division of Epidemiology and Informatics: **2024 Heat-Related Deaths Report**[7], statistics and other information related to heat injuries, including heat related deaths are available to the public for review and education.

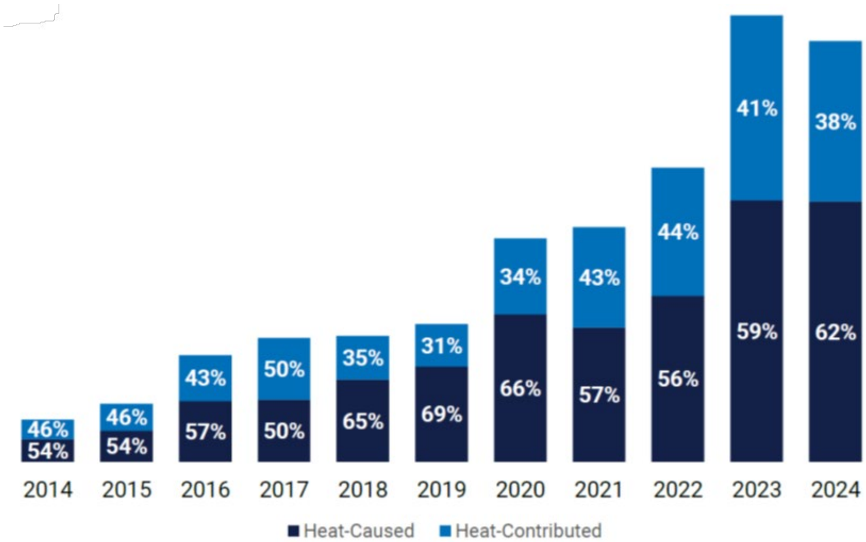
2022: 425 heat related deaths

2023: 645 heat related deaths

2024: 608 heat related deaths

1. Approximately 60% of heat-related deaths were among those age 50 or older
2. More than 3 out of 4 heat-related deaths had an injury location outside
3. Fifty-seven percent of heat-related deaths involved substances (overdose/alcohol poisoning) in 2024
4. 45% of heat-related deaths had a medical history of cardiovascular disease
5. 49% of heat-related deaths were among people experiencing homelessness

In 2024, 62% of all heat-related deaths were heat-caused. This means environmental heat was directly involved in the cause of death in these cases, rather than only a contributing factor.



The majority of heat-related deaths in Maricopa County were among Maricopa County residents. 76.3% Maricopa County Residents, 9.9% In-State Residents Includes residents of nine other Arizona counties, 5.9% Out-of-State Residents includes residents of 23 other states, 7.9% residency unknown.

The weather Heat Risk Categories are set to allow for public warnings related to the relative risks associated with the expected outside temperatures.

2024 Heat-Related Deaths by National Weather Service Heat Risk Category			
Heat Risk	**Description**	**Days**	**Deaths**
None	No risk	128	1
Minor	Risk to those extremely sensitive to heat	103	23
Moderate	Risk to those sensitive to heat	82	309
Major	Risk to most people	34	148
Extreme	Risk to everyone	19	127

Summer heat with constant sun exposure, when temperatures exceed 105, can cause blacktop, dark concrete, tarred surfaces, etc. to reach temperatures around 180 degrees. At these temperatures, it only takes a few seconds of contact to cause second degree burns and 1 minute to cause a third-degree contact burn. The elderly, intoxicated (alcohol and or drugs), unconscious with ground or higher-level falls, can all potentially exceed the 1-minute threshold and have extensive 3rd degree burns that require medical and or surgical burn care. Extended down times can lead to rhabdomyolysis, shock, and metabolic derangements that can lead to organ dysfunction and or failure; increased morbidity and mortality are then potential consequences of these heat related injuries. Burn size varies depending on direct skin contact with the hot ground; degree/lack of clothing, footwear, etc. all contribute to the burn total surface area as well as body part burned.

The Arizona Burn Center stays busy in the summer months but as the Maricopa County numbers demonstrate a decrease in heat related deaths for the last 2 years due in part to emergency response initiatives, such as the expansion of cooling centers and outreach teams, which appear to be instrumental in reducing these numbers.[8]

As of mid-August 2025, there have been 35 confirmed heat-related deaths in Maricopa County, with an additional 369 deaths under investigation.[9]

Confirmed Deaths: As of August 2025, 35 heat-related deaths have been confirmed in Maricopa County, which includes Phoenix. Out of these, 17 deaths were directly attributed to heat, while 18 were cases where heat exacerbated existing health issues.

Investigations: There are 369 additional deaths currently under investigation for potential heat-related causes.

At the Arizona Burn Center, they are publishing findings for summer pavement contact burns and methamphetamine use. Surprisingly, no deaths for patients brought alive to the Burn Center were reported.[10]

> *A total of 23 patients were admitted who suffered contact burns and tested positive for methamphetamine. Ten of those patients had core body temperatures greater than 38.8 C upon initial evaluation. The mean age was 36.6 years (24- 62) with an average body temperature of 42.3C/108.1F (40.5/104.9 – 43.1C/109.5F). All ten were found down in the community with altered mental status. The average Glasgow Coma Scale was 5, 12 CT scans were done on nine patients, which were all negative for acute intracranial abnormalities. Ten of these patients were concurrently positive for fentanyl. The mean total burn surface area was 9.6% (4- 17.5%). Of the eight patients discharged, the average length of stay was 30 days (10- 61). At the time of analysis, two patients remained hospitalized in the ICU with lengths of stay from 61 -71 days.*

Aggressive burn injury resuscitation/critical care remains the cornerstone of treatment after "stopping the burn." Rapid scene responses, immediate cooling both external and internal may be necessary to treat hyperthermia. Body temperatures above normal are considered hyperthermia, but a consistent core body temperature above 104°F (40ºC) is severe hyperthermia. Accurate assessment of core body temperature is necessary. Instituting cooling measures, such as shade/removing from hot environment, evaporation using a spray bottle and fan, conduction from a cooler surface, po or IV fluids (*if ice cold is used be prepared for potential vagal response*), cool/cold towels in groins/axilla/neck/scalp, ice sheets wrapping or immersion, or core cooling with NG/foley/rectal tubes, peritoneal lavage, intrathoracic lavage, and esophageal cooling devices are all tools in the tool box to thermoregulate a hyperthermic patient. In the above Arizona Burn Center data, the maximum surviving temperature was 109.5F, but the patient had significant CNS impairments.

Public education/signage, public announcements via media, providing public access cooling stations, increasing water availability, heat safety training are all parts of a city-wide planning: **City of Phoenix 2025 Heat Response Plan**[11]

The plan details the programs and services that Phoenix delivers to residents and visitors to prevent illness, death, and other serious and immediate adverse health outcomes associated with indoor and outdoor heat exposure.

The 2025 Heat Response Plan contains 30 specific heat response actions for which the City holds a leadership role, organized into eight broad strategies:

1. *Equip first responders for effective heat response.*
2. *Provide publicly accessible cool space.*
3. *Increase access to drinking water.*
4. *Support cool and safe home environments.*
5. *Support cool and safe mobility and recreation.*
6. *Implement heat safety measures for workers.*
7. *Engage with the community to build heat readiness.*
8. *Collaboratively work across department and agency boundaries.*

The 2025 plan draws from 2024's lessons learned, with expanded services, data-driven adjustments, and stronger partnerships, ensuring enhanced coordination, accessibility, and outreach to protect residents during extreme heat events.

Despite best case scenarios, people find ways to increase their risks during extreme heat despite warning and education. Burn Centers and Trauma Centers remain open and available for those people that do not practice safety -we call that job security in our field of Medicine! Typical news release in Phoenix:[12]

Camelback Mountain sees 44 rescues in 2025 as temperatures soar to 117 degrees

Two critical heat-related hiking rescues occurred within days of each other, despite trail closures

As I stated-- job security.

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CROSSING THE BLOOD-BRAIN BARRIER: NEUROTRAUMA IN DISASTERS AND RESOURCE LIMITED SETTINGS

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Care of the patient with traumatic brain injury (TBI) is well established when provided at specialized centers. Patients are often jointly managed by trauma surgeons, neurosurgeons, and intensivists. Interventions include invasive intracranial pressure (ICP) monitoring, applications of advanced management algorithms, craniotomy for evacuation of hematomas, and decompressive hemicraniectomy for refractory cerebral edema with elevated ICP. Many of these techniques and practices are not possible in austere or resource limited settings.

The United Nations approximates 144 million people are directly impacted by trauma through conflict or environmental disasters with neurotrauma representing one of the most lethal and resource-intense injury patterns.[1] Rapid-onset natural disasters, armed conflicts, and humanitarian crises generate large numbers of patients with TBI, often overwhelming local health care systems. In these settings, mortality from severe TBI can be substantially higher than in high-resource areas, largely due to delayed presentation, limited access to imaging and neurosurgical expertise, and constrained critical care and rehabilitation resources.

For trauma surgeons operating in disaster and austere environments, neurotrauma care requires a pivot from technology-dependent algorithms towards physiology-driven, pragmatic decision-making. Traditional neurocritical care strategies with frequent re-imaging, continuous ICP monitoring, and subspecialty multidisciplinary teams are often unavailable. Military and global medicine groups have therefore emphasized simplified triage, damage-control neurosurgery, and minimizing secondary brain injury using readily available tools. This review synthesizes civilian disaster experience, global health organization guidelines, and lessons from military medicine to outline practical approaches to neurotrauma management in resource-limited settings.

EPIDEMIOLOGY AND PATTERNS OF NEUROTRAUMA IN DISASTERS

The epidemiology of neurotrauma varies by disaster type but is consistently characterized by high injury severity and delayed access to care. Earthquakes and building collapses commonly produce blunt and crush injuries, with high rates of skull fractures, intracranial hemorrhage, and polytrauma. In contrast, armed conflict and terrorist attacks are associated with penetrating brain injuries, blast-related TBI, and combined blunt–penetrating mechanisms. While road traffic accidents including pedestrians struck and ejections from motor vehicles remain one of the leading causes of all TBI in low-resource countries in Africa.[3]

Military data provides additional insights into injury patterns under austere conditions. During recent conflicts in Iraq and Afghanistan, blast-related TBI from improvised explosive devices emerged as a dominant mechanism resulting in a combination of barotrauma, penetrating injury from device fragments, and blunt injury from being thrown.[4] This pattern was often accompanied by thermal injury, hypoxemia, polytrauma and hemorrhagic shock. These injuries were first managed at forward operating bases great distances away from definitive care reinforcing the importance of early airway control, hypotension avoidance, and rapid evacuation. Early access to the "NeuroTeam," which included a neurosurgeon and neurointensivists, deployed to forward operating facilities in the most recent wars has demonstrated the impact of rapid specialty care with neurosurgical expertise on improving outcomes.[4]

PRE-HOSPITAL SECONDARY BRAIN INJURY IN RESOURCE-LIMITED SETTINGS

Secondary brain injury is amplified in disaster settings due to prolonged exposure to hypoxia, hypotension, hyperthermia, and untreated intracranial hypertension in the pre-hospital setting. Even brief episodes of systolic blood pressure below 90 mmHg or oxygen saturation below 90% are independently associated with increased mortality in severe TBI with adjusted odds of mortality two times greater when both are present.[4] In resource-limited environments, these insults are common during prolonged extrication, transport without advanced airway support, and overcrowded emergency facilities.

Secondary injury prevention focuses on limiting systemic contributors to secondary injury. Key measures include prioritizing airway protection, oxygen delivery, and hemorrhage control. This approach reflects the reality that cerebral ischemia from systemic failure often precedes intracranial hypertension as the proximate cause of death in austere environments.

INITIAL TRIAGE AND ASSESSMENT

In mass-casualty situations, neurological triage must be rapid, reproducible by team members, and feasible without advanced diagnostics. The Glasgow Coma Scale (GCS), pupillary examination, and gross motor assessment remain the key aspects of the neurological exam. GCS can be used to grade TBI into three categories. Mild TBI is defined as a GCS 13 – 15, moderate TBI is GCS 9 – 12, and severe TBI is GCS 3 – 8. Stratifying patients based on exam only can identify those with mild injury requiring only a brief period of observation and discharge to improve allocation of the limited resources.[3] Alternatively, a declining GCS, new pupillary asymmetry, or progressive motor deficits should prompt escalation of care or surgical intervention if feasible.

Additional information from the history and physical examination may provide guidance on the patient's injury. Two or more episodes of vomiting and post-traumatic seizures has been associated with the presence of intracranial injury.[7] Head exam may reveal an open or depressed skull fracture, postauricular or periorbital ecchymosis raising suspicion for a basilar skull fracture, hemotympanum, or otorrhea. These features confer a positive predictive value of 19% to 82% for an intracranial injury.[7] A quick assessment based on these criteria can help determine the urgency of transport to a higher level of care.[5]

Computed tomography is the diagnostic standard for neurotrauma but is frequently unavailable or intermittently accessible during disasters and in low-resource areas. Utilizing a stepwise approach to imaging and including x-ray and ultrasound as alternative to CT will allow for better allocation of care.[8] CT imaging should be prioritized for patients with severe TBI, focal deficits, or deteriorating neurological status when resources permit.[3] In the absence of imaging, decisions regarding management and operative intervention may rely entirely on clinical findings.

NEUROCRITICAL CARE WITHOUT INVASIVE MONITORING

Consensus guidelines have been created based on expert opinion for the care of severe TBI patients in settings without advanced monitoring where intracranial hypertension is suspected. The CREVICE (Consensus REVised ICE) protocol provides algorithms for clinicians to escalate and wean therapies based on clinical exam and imaging. These protocols were first informed from the non-invasive arm of the

BEST:TRIP trial identifying and treating suspected intracranial hypertension based on Imaging and Clinical Examination (ICE).[9]

In the absence of ICP monitoring, clinicians must infer intracranial hypertension from clinical and radiographic surrogates. Once suspected, patients should have their airway secured and placed on mechanical ventilation, sedated and have a mean arterial pressure goal ≥ 90mmHg. Worsening mental status, pupillary changes, focal neurologic deficits and Cushing's response remain key indicators of increased ICP. Hyperosmolar therapy with mannitol or hypertonic saline is given based on clinical deterioration rather than numeric thresholds. Low-cost, high yield therapies include head of bed elevation, avoidance of hypercapnia, and judicious sedation use. Tiered approach is employed with increasing escalation of care.

Where available, non-invasive tools such as transcranial Doppler (TCD) ultrasound can provide insight into cerebral blood flow and autoregulation. As seen in the IMPRESSIT trial, TCD has a high negative predictive value making it a great tool to exclude intracranial hypertension.[10] Dedicated neuromonitoring can be helpful, but serial blood pressure recordings, oxygen saturation, and end-tidal CO_2 monitoring remain the most universally applicable physiologic tools in austere settings.

Across civilian, military, and humanitarian contexts, prevention of hypotension and hypoxia consistently emerges as the most effective neuroprotective strategy. Targeting systolic blood pressure ≥100–110 mmHg and oxygen saturation >94% is achievable even in low-resource environments and has been associated with meaningful reductions in mortality. Temperature control, glucose management, and early seizure prophylaxis are additional interventions that can optimize outcomes in severely injured patients.

SURGICAL MANAGEMENT OF NEUROTRAUMA

The fundamental indications for neurosurgical intervention – epidural hematoma, acute subdural hematoma with mass effect, depressed skull fracture, and penetrating injury with contamination – remain unchanged in disaster settings. However, thresholds for intervention may be modified based on resource availability and evacuation timelines. The International Committee of the Red Cross War Surgery publications emphasize early evacuation for patients requiring neurosurgical care but acknowledges that local intervention may be lifesaving when transfer is impossible.[11]

DAMAGE-CONTROL NEUROSURGERY

Damage-control neurosurgery (DCNS) is a central concept in austere neurotrauma care. This approach prioritizes rapid decompression and hemorrhage control over definitive reconstruction. The three key tenets include:

1. Immediate control of intracranial bleeding
2. Evacuation of intracranial hematoma
3. Early debridement of cranial wounds to minimize contamination[12]

While these principles were first pushed during Operation Iraqi Freedom, they have been adopted by surgeons in low-resource settings to improve patient survival.[13]

The Joint Trauma System has put forth a Clinical Practical Guideline for Emergency Life-Saving Cranial Procedures by Non-Neurosurgeons in Deployed Settings.[14] Key indications to escalate to surgical intervention include > 5 hours transport time to a neurosurgeon, severe supratentorial injury with a GCS ≤ 8, lateralizing signs, hemodynamic instability that persists despite critical care measures. They also list contraindications of a GCS equaling 3, catastrophic injury in CT or inadequate resources. Teleconsultation with a neurosurgeon is the first step. For penetrating injuries, the surgery is limited to bone removal, opening of the dura, bleeding control and rapid closure. If the wound has herniating brain matter, do not close the wound and place moist dressings. With closed head injuries, perform exploratory burr holes over the frontal, temporal and parietal convexities while avoiding midline and then connect these points for a decompression area measuring 15 x 12cm.

Time to procedure and earlier intervention is critical in patients with severe TBI and suspected uncontrolled intracranial hypertension. In a cohort of 486 patients, no mortality difference was seen between those that underwent surgery at a resource limited role 2 facility without neurosurgical expertise versus a role 3 facility where the procedure was completed by a neurosurgeon.[15] These findings emphasize it is time to craniotomy that is the key factor, less so who performs the procedure.

Emergency decompressive neurosurgical procedures can also be performed by non-neurosurgeons in low resource environments after sufficient training. A group in Cambodia trained general surgeons to perform emergency burr hole trephination and craniotomy. They were able to expand capacity to care for TBI patients with overall 90% favorable outcomes in those undergoing intervention.[16] These experiences underscore the feasibility of lifesaving neurosurgical interventions outside traditional tertiary centers when guided by sound principles.

ETHICAL CONSIDERATIONS AND TRIAGE

Disaster neurotrauma care is inherently constrained by ethical challenges related to resource allocation. Aggressive neurosurgical intervention in patients with devastating injuries may consume disproportionate resources with limited likelihood of survival. Rationing care based on likelihood of recovery with treatment has been the existing model for triage. Military medicine similarly acknowledges the necessity of prioritizing salvageable patients during mass-casualty events. Newer frameworks emphasize transparency and consistency based on accurate prognostication. Including families in the process can be pivotal. It empowers them to make informed decisions while taking into consideration the personal impact of high out of pocket costs balanced by the probability of meaningful recovery.

FUTURE DIRECTIONS

Improving neurotrauma outcomes in disasters require investment in training and systems. Task-sharing models, in which general surgeons are trained to perform basic neurosurgical procedures have demonstrated success in low-resource and military settings. Telemedicine support from neurosurgical specialists and pre-deployment training in neurotrauma principles can further enhance capacity and maximize the impact of a limited number of neurosurgeons.[4] From a global surgery perspective, strengthening trauma systems and surgical workforce readiness are as critical as procuring advanced monitoring equipment.

Advances in low-cost neuromonitoring, portable imaging, and point-of-care ultrasound hold promise for enhancing neurotrauma care in resource-limited settings. Research priorities include validating simplified monitoring strategies, defining context-appropriate surgical triggers, integrating disaster medicine into trauma training curricula, and creating population and resource specific outcome studies. Collaboration between civilian trauma systems, military medicine, and global health organizations will be essential to advancing the field.

Neurotrauma in disasters and resource-limited settings demands adaptable, physiology-driven care grounded in fundamental trauma principles. While advanced neuromonitoring may be unavailable, meaningful improvements in survival can be achieved through early resuscitation, vigilant clinical assessment and timely surgical intervention. Protocols adapted to these settings reinforce that effective neurotrauma care is possible when systems, training, and decision-making are aligned with available resources.

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AFTER THE BANG: MANAGING BLAST TRAUMA

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Blast injury represents one of the most complex and resource-intensive forms of trauma encountered in both military and civilian settings. While traditionally associated with warfare, modern civilian disasters – including terrorism, industrial explosions, and infrastructure failures – are increasingly producing injury patterns indistinguishable from those seen in combat.

Successful management of blast injury requires a disciplined application of damage control principles, realistic appreciation of system capabilities, and correct prioritization of life-threatening injuries. This syllabus provides a practical framework for managing blast casualties across the continuum of care, emphasizing decision-making under resource constraint rather than definitive reconstruction.

CONCEPTUAL FRAMEWORK: SEVERE BLAST INJURY

Severe blast injury is best understood as a polytrauma complex analogous to an extreme form of **crush injury.** Important features include:

- Traumatic amputation(s)
- Extensive soft-tissue contamination
- Evolving zones of ischemia
- Profound inflammatory response
- High risk for malnutrition

Ensuring survival requires an understanding of the extreme physiologic insult with an emphasis on staged care while deliberately avoiding early definitive repair that will result in burned bridges. The evolution of tissue injury over time mandates repeated reassessment and serial intervention.

INJURY PATTERNS AND EPIDEMIOLOGY

Blast injury patterns vary with energy transfer and proximity, but high-energy blast events frequently produce:

- Traumatic amputations of one or more extremities
- Open pelvic fractures
- Perineal, genitourinary, and colorectal injuries
- Burn injuries (in the case of thermobaric weapons)
- Massive hemorrhage requiring large-volume transfusion
- High rates of infection, including invasive fungal infection

Modern battlefield weaponry includes high-energy thermobaric weapons that combine extreme cavitation effects with burn injuries.

TRIAGE AND EARLY DECISION-MAKING

A. Resource-Dependent Strategy

Early decisions in blast injury must be consider a realistic assessment of institutional capability, including:

- Availability of blood products and massive transfusion protocols
- Ability to perform damage control surgery
- Access to orthopedic, vascular, and critical care support
- Availability of CT imaging

The same patient may be salvageable in one system and non-survivable in another. Triage decisions must reflect this reality.

B. Imaging Considerations

FAST exam can help guide early operative decision-making (OR Now?)

Start with "cavitary triage" using plain films: ("Big Head" courtesy of John Pryor, AP Chest, AP Abdomen, AP Pelvis)

CT imaging is often invaluable (if available and the patient's physiology allows):

- Full Body Scout (additional fragment hunt)
- CT Head (non-con)
- CT Neck (non-con vs neck angio if fragments are present in proximity)
- CT Chest/Abd/Pelvis with IV contrast

However, CT imaging must never delay hemorrhage control. In unstable patients, management should proceed based on mechanism, physiology, plain film cavitary triage and FAST.

OPERATIVE PRIORITIES: LIFE, THEN LIMB

The foundational principle of blast injury management is Life first, limb second—>>cavitary injuries first, then extremities.

This hierarchy is physiologic, not anatomic, and remains valid across military and civilian settings.

A. Cavitary Injuries

Life-threatening injuries to the:

- Thorax
- Abdomen
- Pelvis
- Retroperitoneum

These must be identified and addressed before attention is directed toward limb salvage.

Blast injuries are particularly deceptive, as visually dramatic extremity wounds may distract from occult cavitary hemorrhage. Cavitary bleeding kills first, and failure to control it early is uniformly fatal.

B. Extremities

Traumatic amputations and mangled extremities:

- Are often survivable with temporization
- Can be initially managed with tourniquets, proximal vascular control, and damage-control amputations
- Should not divert attention from physiologic rescue

Definitive limb reconstruction has no role during the index operation.

MANAGEMENT OF SPECIFIC INJURY DOMAINS

A. Hemorrhage and Vascular Control

- Early tourniquet application is essential
- Proximal vascular ligation is acceptable and often lifesaving
- Temporary vascular shunts and endovascular options may play a role but must not delay control

B. Orthopedic Injuries

- Prioritize length preservation when feasible
- External fixation for pelvic and long-bone fractures
- Expect serial debridement and revision amputations as tissue declares itself

C. Genitourinary Injuries

- Early exploration for bladder and urethral injury
- Pragmatic repair strategies
- Testicular salvage when possible; close dartos when indicated

D. Anorectal and Perineal Injuries

- Aggressive debridement
- Early fecal diversion
- Drainage and staged wound management

Historical paradigms of repair-in-place should be abandoned in favor of contamination control.

E. Soft Tissue Management

- Wide debridement back to viable tissue (a balance between too much vs too little)
  - Be careful to not sacrifice function early unless absolutely necessary
  - Take special care with hand/upper extremity debridement, ano-rectal debridement
- Anticipate of wound evolution
- Liberal use of negative-pressure wound therapy

- Frequent returns to the OR (q12 or 24 hours initially)
- Acceptance of staged reconstruction as the norm

COMPLICATIONS AND LONGITUDINAL CARE

Common complications include:

- Invasive fungal infection
- Heterotopic ossification
- Venous thromboembolism
- Chronic wound failure

Blast casualties require longitudinal, multidisciplinary care, and early decisions strongly influence long-term functional outcomes.

PRACTICAL ALGORITHM

1. Identify blast mechanism and likelihood of cavitary injury
2. Assess system capability for DCR and DCS
3. Control cavitary hemorrhage and contamination first
4. Temporize extremity injuries
5. Defer limb salvage decisions until physiology is restored.

FINAL THOUGHTS AND TAKE-HOME POINTS

- Blast injuries are survivable with disciplined systems-based care
- Think life before limb – cavitary first, then extremities
- Extremity injuries distract; cavitary hemorrhage kills
- Damage control principles save lives across all settings
- Favorable outcomes require system-level readiness and physician and provider-level excellence

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SESSION 5

BEYOND TRIAGE AND RESUSCITATION

Moderator: Jeffrey J. Skubic

Sunday, April 26, 2026
3:30 – 6:00 PM
Palace Ballroom 1-2
Palace Tower
Emperors Level – 4th Floor

3:30 – 3:45	**Five Pieces of Equipment You Should Never Touch During a Mass Casualty Incident** **Bellal A. Joseph, MD, FACS**
3:45 – 4;00	**After the Sirens - Mental Health For Responders and Survivors** **Natasha Keric, MD, FACS**
4:00 – 4:15	**Inside the Wire: When a Cyberattack Hits Your Trauma Center** **Matthew J. Martin, MD, FACS, FASMBS**
4:15 – 4:30	**Flying High: Drones for Good in Emergency Response Scenarios** **Martin A. Schreiber, MD, FACS, FCCM COL, MC, USAR**
4:30 – 4:45	**Interagency Tango - Coordinating EMS, Hospital, and Military Assets Under Pressure: Lessons Learned from the July 4 Texas Flood** **Mark Escott, MD, MPH, FACEP**
4:45 – 5:00	**Ethics Under Fire: Making Difficult Decisions and No-Win Scenarios in MASCAL and Disaster Events** **Tanya Egodage, MD, FACS**
5:00 – 5:15	**The Second Wave: Infections, Chronic Illness, Delayed Injuries** **Miguel A. Cubano, MD, MBA, FACS**
5:15 – 5:30	**When the Dust Settles: The Art of an Effective After Action Report** **Mark Escott, MD, MPH, FACEP**
5:30 – 6:00	**Panel Discussion**
6:00	**Meeting Adjourned**

FIVE PIECES OF EQUIPMENT YOU SHOULD NEVER TOUCH DURING A MASS CASUALTY INCIDENT

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A mass casualty incident (MCI) is any event in which the volume, severity, or type of casualties exceeds the immediate capabilities of the receiving medical system. MCIs force a fundamental shift in trauma care. Under routine conditions, clinicians aim to deliver optimal care to each individual patient. During an MCI, the priority becomes saving the greatest number of lives with limited personnel, supplies, and time.[1,2] Crisis standards of care and the Incident Command System (ICS) guide this transition and ensure that decisions protect overall system function rather than individual optimization (**Figure 1**).[3,4]

In these events, certain categories of equipment can rapidly consume resources or obstruct throughput when used without command authorization. These systems require staffing, oxygen, electricity, transport, or communication bandwidth at the exact moment the hospital must maintain mobility and situational awareness. After action reports from incidents including the Boston Marathon bombing, Las Vegas, Beirut, and multiple active shooter events consistently identify the following equipment groups as high risk when applied too early or too liberally during an MCI:[3-6]

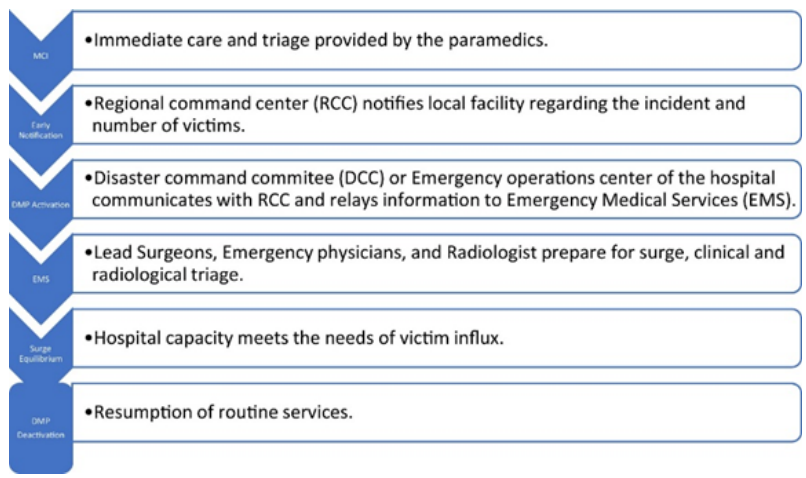

Figure 1. Schematic diagram of the sequence of events in MCI
Source: https://ars.els-cdn.com/content/image/1-s2.0-S0363018820301481-gr2_lrg.jpg

- **Tactical radios and communication consoles**
- **Ventilators and advanced airway devices**
- **Diagnostic imaging equipment, particularly CT scanners**
- **Spinal immobilization devices including cervical collars and long boards**
- **Electronic monitors and infusion pumps**

Each of these categories has the potential to slow triage, divert personnel, create chokepoints, or undermine command coordination. Uncontrolled radio traffic, unnecessary early intubation, premature imaging, excessive immobilization, and overuse of electronic monitoring have all been associated with reduced throughput and delayed lifesaving interventions during real world MCIs.[2-6]

Tactical Radios and Communication Consoles

Communication is both the lifeline and the primary failure point of mass casualty incident operations. The ICS is designed to maintain clear communication hierarchies and prevent information saturation that can impair decision making. Unregulated use of tactical radios or command consoles by responders who are not authorized to transmit often leads to frequency congestion, duplicated or conflicting requests, and misallocation of personnel and supplies.[1-3]

The FEMA Hospital Emergency Response Training Manual emphasizes that radio discipline is as critical as medical triage. Only designated personnel within the operations and logistics branches should communicate on tactical channels, and all others should relay information through their immediate supervisors.[3] Barbera and colleagues similarly identified communication overload as one of the most frequent operational failures during real world surge events, including hospital based responses to mass shootings.[4]

Inappropriate access to radios can delay casualty distribution, impair situational awareness, and result in inconsistent or contradictory task assignments. The American College of Surgeons Committee on Trauma advises hospitals to establish redundant but controlled communication pathways and to designate specific liaisons for internal and external coordination to preserve the integrity of the command structure.[1] When responders resist the instinct to grab the radio and instead follow defined communication channels, the system can maintain clarity, tempo, and operational control.

VENTILATORS AND ADVANCED AIRWAY DEVICES

Airway control is often viewed as the first priority in trauma care, yet during a mass casualty incident aggressive airway intervention can consume more lives than it saves. The guiding principle in an MCI is to provide the greatest benefit to the greatest number of patients, rather than the most definitive care to a small group of critically injured individuals.[1,5] Endotracheal intubation and mechanical ventilation require personnel, oxygen, electrical power, monitoring capability, and time. These resources cannot be diverted to a single patient when many others are competing for immediate care.[5,6]

Expert guidance emphasizes that only patients with an immediate and reversible airway threat who also have a realistic chance of survival should receive advanced airway intervention during surge conditions.[5,6] Talmor's review of airway management in MCIs highlights the logistic burden of mechanical ventilation in disaster environments and supports the use of simple airway adjuncts such as nasopharyngeal or oropharyngeal devices, bag valve mask ventilation, and frequent reassessment as safer and more scalable strategies.[5] White and Lo similarly note that ventilator allocation during crisis conditions must follow triage frameworks that preserve limited resources and maintain equity across the affected population (**Figure 2**).[6]

Both the ACS Resources for Optimal Care of the Injured Patient and international emergency medical team standards reinforce that early airway decisions must account for system capacity. Manual or improvised methods are acceptable when they achieve population level benefit and preserve critical supplies for patients most likely to survive.[1,3] In this context, the ventilator becomes a symbol of restraint. It should be used only when it will not compromise care for others. The most effective airway provider during an MCI is the one who knows when not to intubate.

Incident demand/resource imbalance increases →

Risk of morbidity/mortality to patient increases ← **Recovery**

	Conventional	**Contingency**	**Crisis**
Space	Usual patient care space fully utilized	Patient care areas re-purposed (PACU, monitored units for ICU-level care)	Facility damaged/unsafe or non-patient care areas (classrooms, etc.) used for patient care
Staff	Usual staff called in and utilized	Staff extension (brief deferrals of non-emergent service, supervision of broader group of patients, change in responsibilities, documentation, etc.	Trained staff unavailable or unable to adequately care for volume of patients even with extension techniques
Supplies	Cached and usual supplies used	Conservation, adaptation, and substitution of supplies with occasional re-use of select supplies	Critical supplies lacking, possible re-allocation of life-sustaining resources
Standard of Care	Usual care	Functionally equivalent care	Crisis standards of care

Normal operating conditions **Extreme operating conditions**

Figure 2. Continuum from Conventional to Crisis Standards of Care
Source: https://www.annemergmed.com/cms/10.1016/j.annemergmed.2011.06.012/asset/d317a12b-c348-4fc2-b1ec-995c7fe391e0/main.assets/gr1_lrg.jpg

Diagnostic Imaging Equipment, Particularly CT Scanners

Computed tomography and other diagnostic imaging modalities are essential components of routine trauma evaluation. During a mass casualty incident, however, these modalities become dangerous bottlenecks. Every patient transported to imaging removes staff, transport capability, and resuscitation resources from the triage area. This disrupts patient flow and delays time sensitive interventions that should occur early in surge operations.[1,3,7]

Radiology suites are fixed locations that depend on electrical power, technicians, coordination, and controlled patient movement. These requirements cannot be scaled rapidly during an MCI. After action reports from events such as the Beirut explosion and mass shooting incidents consistently note that unnecessary early imaging contributed to throughput collapse and avoidable delays in operative or procedural care.[3,7]

Nasir and colleagues emphasize that radiology teams must shift from diagnostic precision to operational triage during an MCI. The priorities become rapid patient identification, situational awareness, and clear communication with command rather than confirmatory imaging.[7] The ACS Resources for Optimal Care of the Injured Patient similarly advises that advanced imaging should be deferred until lifesaving procedures are completed and only when a scan will directly change immediate management.[1]

When imaging is unavoidable during surge operations, the FEMA Hospital Emergency Response Training Manual recommends designating a radiology control officer to coordinate scanner use and prevent unregulated access. This approach reflects the broader principles of crisis standards of care illustrated in (**Figure 3**).[3] The CT scanner should be regarded as a limited strategic asset rather than a default diagnostic step. Avoiding premature use preserves surge capacity, reduces staff movement, and keeps attention focused on interventions that change survival.

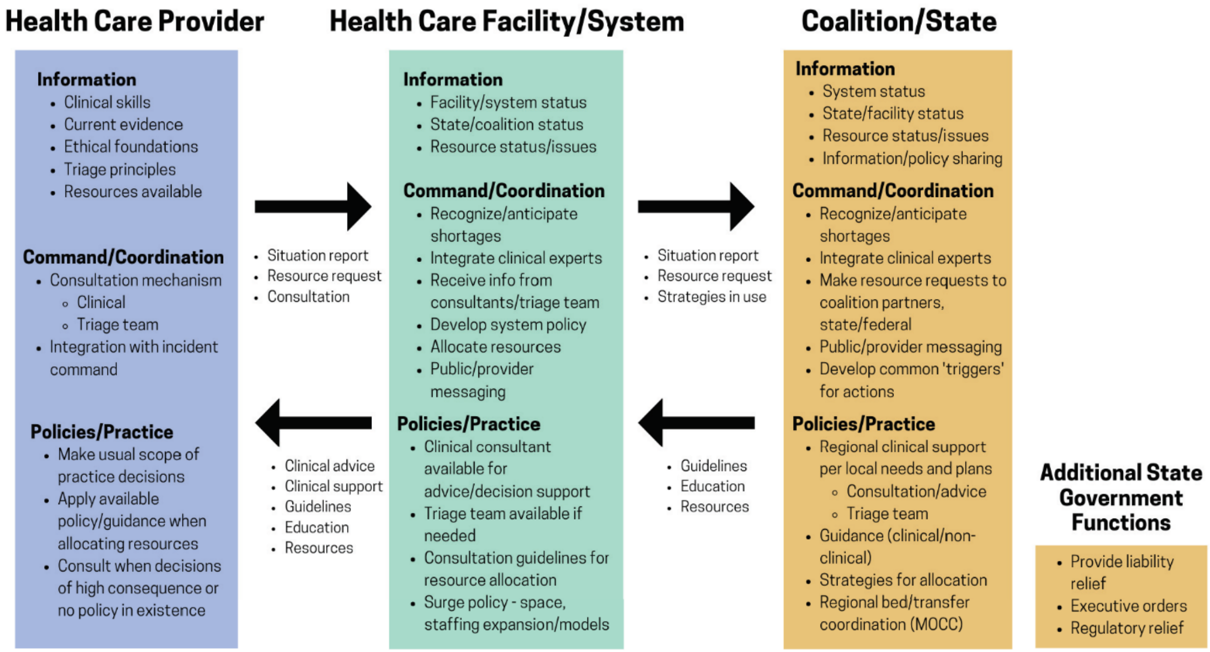

Figure 3. Key Domains and Requirements in Crisis Standards of Care
Source: https://pmc.ncbi.nlm.nih.gov/articles/PMC8486425/figure/pz9-2/

Spinal Immobilization Devices Including Cervical Collars and Long Boards

Spinal immobilization is a routine component of prehospital trauma care, but during a mass casualty incident its indiscriminate use can significantly impair patient flow. Cervical collars and long boards require time, personnel, and patient handling that cannot be sustained when large numbers of casualties arrive simultaneously. Immobilization also delays triage by limiting patient movement and slowing the rapid assessments that guide surge operations.[1,2]

During an MCI, the priority is to preserve throughput and identify patients with immediate life threats. Most casualties do not require routine immobilization unless they have a clear mechanism, neurologic deficit, or airway compromise. Established prehospital and disaster guidelines support minimizing immobilization during surge conditions to reduce bottlenecks and conserve personnel for higher priority interventions.[8] Excessive use of collars and boards has been associated with delayed triage, reduced mobility within treatment areas, and increased resource consumption in real world disaster responses.[1,3,8]

The ACS Resources for Optimal Care of the Injured Patient advises that early immobilization decisions must consider system capacity and the operational environment. Providers should prioritize airway protection and hemodynamic stabilization over strict spinal precautions when resources are strained and casualty volume is high.[1] In this context spinal immobilization should be selective and based on clear clinical indicators. Avoiding unnecessary collars and boards helps maintain triage tempo, improves patient distribution, and preserves critical staff availability.

Electronic Monitors and Infusion Pumps

During a mass casualty incident, advanced monitoring equipment and infusion pumps can become obstacles rather than assets. In a controlled trauma environment these devices guide precise and individualized care. During an MCI, however, monitors, syringe pumps, and other electronic equipment restrict mobility, consume electrical power, and divert staff attention toward a small number of critically ill patients while many others wait for basic interventions.[1,3]

Every monitor requires continuous oversight. A nurse or technician must interpret waveforms, alarms, and numeric trends, none of which are practical when casualty volume exceeds available staff. When dozens of monitors alarm simultaneously, responders experience alarm fatigue, and important visual cues may be missed. The ACS Resources for Optimal Care of the Injured Patient and the FEMA Hospital Emergency Response Training Manual both advise shifting from continuous physiologic monitoring to intermittent clinical reassessment performed by trained personnel during an MCI.[1,3] This approach preserves staff capacity and aligns with crisis standards of care, which prioritize population level benefit over individual optimization.[5,6]

Infusion pumps create similar challenges. These devices require setup time, electrical outlets, tubing, programming, and troubleshooting. In surge conditions, they slow throughput and consume staff time that could be spent performing higher impact tasks. Joint guidance on emergency operations during surge conditions recommends removing nonessential electronic equipment from triage and resuscitation zones to conserve space, reduce electrical load, and maintain operational flexibility.[9] International emergency medical team standards also support the use of gravity fed infusions or oral or intramuscular alternatives when feasible, reserving pumps for medications that have no safe manual substitute.[3]

Reducing or eliminating unnecessary monitors and pumps increases mobility, decreases setup time, and allows responders to concentrate on interventions that affect survival across the entire casualty population.

CONCLUSION

Mass casualty incidents demand disciplined decision making that protects system function rather than individual optimization. The misuse of key equipment can rapidly exhaust limited resources, disrupt triage flow, and reduce the number of survivors the system can support. Prioritizing simple, scalable interventions and restricting access to resource intensive devices preserves throughput and maintains operational control. Effective performance in an MCI depends on restraint, clarity of roles, and adherence to established protocols so that the greatest number of patients can receive timely, lifesaving care.

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AFTER THE SIRENS - MENTAL HEALTH FOR RESPONDERS AND SURVIVORS

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LEARNING OBJECTIVES

1. **Define moral injury** and distinguish it from burnout, compassion fatigue, and PTSD within high-stakes healthcare environments.
2. **Examine the impact** of moral injury on provider and survivor mental health, professional identity, and healthcare system performance.
3. **Describe unique stressors** that contribute to moral injury during high acuity clinical environments, MASCAL events, and crisis standards of care.
4. **Discuss mitigation strategies** that address moral injury through pre-disaster preparedness, intra-disaster support, and post-disaster recovery.
5. **Summarize best practices** for ethical transparency, leadership accountability, and sustainable moral repair in healthcare institutions.

DEFINING MORAL INJURY

Healthcare professionals who respond to disasters, mass casualty incidents (MASCAL), pandemics, and sustained high-acuity clinical environments are routinely exposed to extraordinary ethical, emotional, and operational stressors. While burnout and post-traumatic stress disorder (PTSD) have traditionally been used to describe distress in these settings, there is growing recognition that these frameworks are insufficient to capture the lived experience of many providers and survivors.

Moral injury has emerged as a distinct and critically important construct that more accurately reflects the psychological and professional harm sustained when providers are forced to act in ways that conflict with deeply held moral and ethical values.[1,2]

Moral injury is not currently defined as a psychiatric diagnosis and is not codified within the Diagnostic and Statistical Manual of Mental Disorders (DSM). Rather, it represents a form of **profound moral and existential distress** that arises from perceived violations of one's ethical code, particularly in complex, high-stakes, and resource-constrained environments.[1]

In healthcare, moral injury most often occurs not because of malicious intent or poor professionalism, but because providers are placed in systems that **constrain ethical action**, forcing tradeoffs that are incompatible with professional identity and moral expectations.[3]

WHY MORAL INJURY MATTERS IN DISASTER AND CRISIS CARE

In routine clinical practice, medical decision-making is anchored in the ethical principle of patient autonomy. In disaster scenarios, however, the ethical landscape shifts dramatically. During MASCAL events, pandemics, or Crisis Standards of Care activation, the principles of beneficence and justice supersede autonomy, requiring clinicians to prioritize population-level outcomes over individual patient preferences.[4,5] These ethically necessary shifts place clinicians in morally precarious positions that may result in lasting psychological harm, particularly when decisions are driven by command structures, scarcity, or opaque institutional processes.[4,6]

Moral injury is frequently mischaracterized as burnout. Burnout frames distress as an individual failure of resilience, implicitly suggesting that clinicians are not coping adequately with stress or workload. Moral injury, in contrast, correctly identifies the problem as systemic, rooted in broken processes, inadequate resources, and ethically incongruent rules of engagement.[3,4] When moral injury is mislabeled as burnout, proposed solutions tend to focus on self-care or resilience training, which may inadvertently worsen distress by failing to address the underlying cause.[7]

PREVALENCE AND IMPACT ON HEALTHCARE PROFESSIONALS

Available data suggest that moral injury affects approximately 30–50% of healthcare workers in high-stress environments, with even higher prevalence during disaster response and pandemic conditions.[8,9] Studies demonstrate strong associations between moral injury and depression, PTSD, emotional exhaustion, and suicidal ideation.[9] Severe moral injury has been linked to increased thoughts of self-harm, underscoring its importance as a clinician safety and public health issue.[1,2]

Beyond individual mental health consequences, moral injury erodes professional identity and engagement. Clinicians experiencing moral injury frequently report decreased job satisfaction, impaired clinical judgment, diminished teamwork, and loss of belonging.[10,11] At the organizational level, these outcomes contribute to workforce attrition, loss of institutional knowledge, increased error rates, and destabilization of care delivery systems – risks that are magnified during disasters and sustained crises.[12]

UNIQUE RISK FACTORS FOR MORAL INJURY

Risk factors for moral injury operate across individual, organizational, and situational domains.

Individual risk factors include younger age, female gender, and pre-existing mental health conditions.[9] These associations likely reflect differential exposure, role expectations, and cumulative moral burden rather than intrinsic vulnerability.

Organizational contributors are among the most potent drivers of moral injury. These include inadequate staffing, insufficient resources, excessive workload, lack of leadership visibility, and institutional cultures that discourage ethical dialogue or dissent.[7,12] When clinicians perceive that leadership decisions prioritize operational metrics over ethical integrity or clinician well-being, moral injury is intensified.

Situational risk factors include direct involvement in disaster response, repeated exposure to patient death, ethical dilemmas surrounding triage and resource allocation, and command-driven medical rules of engagement.[13] The cumulative burden of repeated crises – even outside formal MASCAL activation – leads to re-traumatization and a cyclical pattern of moral distress that compounds over time.[11]

MEASUREMENT CHALLENGES AND RESEARCH GAPS

Most existing instruments measure moral distress, not moral injury. Tools such as the Measure of Moral Distress for Healthcare Professionals (MMD-HP) demonstrate good reliability and validity for adult healthcare professionals[14], but they do not fully capture the depth, persistence, and identity-level impact of moral injury, particularly in disaster-specific populations.

Emerging research highlights significant gaps, including the absence of validated tools designed for disaster responders and command-driven healthcare environments.[14,15] Data suggest that women, nursing professionals, and community-based providers may experience higher levels of moral injury, reinforcing the need for inclusive, interdisciplinary approaches to assessment and mitigation.[9]

MITIGATION AND RECOVERY: A MULTI-LEVEL APPROACH

Addressing moral injury requires explicit acknowledgment that this is a system-level problem, not an individual failure. Effective mitigation must occur across the disaster continuum.

Pre-disaster preparedness includes establishing ethical frameworks, clear triage protocols, and transparent decision-making structures before crises occur.[5,6] Building trust and psychological safety within teams allows clinicians to contextualize ethically difficult decisions when they arise.

During disaster response, mitigation strategies should include structured team debriefs, “moral check-ins,” rotation strategies to limit cumulative exposure, and transparent leadership communication regarding constraints and decision rationale.[4] These interventions help clinicians process ethical tension within a shared moral framework.

Post-disaster recovery and healing require more than symbolic wellness initiatives. Institutions must provide structured debriefing focused on ethical processing rather than performance evaluation, access to mental health and peer support resources, and longitudinal monitoring with institutional follow-through.[7,10]

TOWARD SUSTAINABLE SOLUTIONS

Long-term solutions to moral injury require changes in the operational and business frameworks of healthcare. Clinician well-being must be recognized as a core component of quality, safety, and financial sustainability.[12,16] Open communication between frontline clinicians and leaders empowered to enact system-level change is essential.

Reestablishing a sense of professional community, particularly after disasters – is central to moral repair. Ethical transparency, leadership accountability, and shared ownership of complex decisions help restore meaning, trust, and professional identity.[1,2,17]

CONCLUSION

Moral injury is a predictable and consequential outcome of disaster response and sustained crisis care. It is distinct from burnout, multifactorial in origin, and deeply rooted in ethical conflict and systemic constraints. Disasters and MASCAL events amplify moral and operational challenges, but early preparation, transparent leadership, and system-level mitigation strategies can meaningfully reduce harm. Addressing moral injury is not only an ethical imperative but a strategic necessity for healthcare institutions committed to sustaining their workforce and delivering high-quality care long after the sirens fade.

FINAL THOUGHTS & TAKE-HOME POINTS

- Moral injury is **distinct from burnout** and rooted in ethical conflict, not individual weakness
- Disaster and MASCAL environments **intensify moral strain** through command-driven decision-making
- Early identification and preparation are critical to mitigation
- Moral injury requires **system-level solutions**, not resilience training alone
- Sustainable recovery depends on ethical transparency, leadership accountability, and rebuilding the professional community

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INSIDE THE WIRE: WHEN A CYBERATTACK HITS YOUR TRAUMA CENTER

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"If you spend more on coffee than on IT security, you will be hacked. What's more, you deserve to be hacked"

- *Richard Clarke*

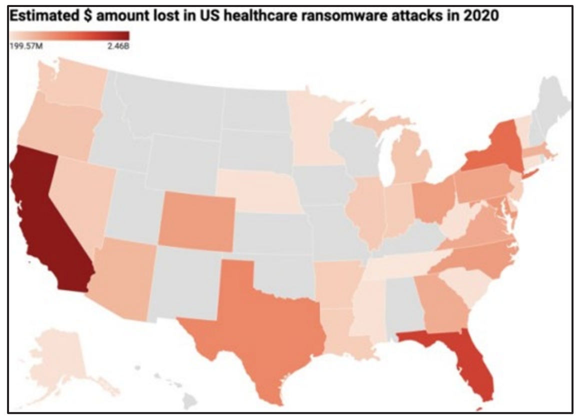
BLUF (BOTTOM LINE UP FRONT)

1. All healthcare facilities and systems are at high risk of cyberattacks and compromised information security. They are now among the most common sector targeted in these events.
2. Assume that it is not a matter of "if" I will be hacked/attached, it is simply a matter of "when".
3. Modern hospitals are frequently a giant conglomeration of various IT systems that include modern components but also much older "legacy" systems that can be easily exploited as points of access.
4. Common points of entry are through individual users responding to phishing emails or links/downloads, networked devices with outdated software or security patches, or vendor systems that access the healthcare facility.
5. Cybersecurity and information/systems protection needs to be a priority focus of every hospital or healthcare system C-suite, and not treated as an afterthought or a delegated responsibility.
6. Cybersecurity and IT protection training should be mandatory for every employee or affiliate, and should be focused, robust, and responsive to the latest changes and techniques being employed to compromise your systems.
7. EQUALLY IMPORTANT, and consistent with item #2 above, there must be robust preparation and training for a successful cyberattack that takes down all critical hospital information and communication systems simultaneously.
8. In addition to the hospital IT systems and data, assume that any personal/professional data on your individual work computer or other devices will be lost. Have a robust backup/duplication system to protect against this event.
9. A successful attack can take down ALL of your systems and access, not just the EMR. You may lose access to medication dispensing, blood product dispensing/tracking, telemetry, pager systems, radiology systems, wired or wireless internet, and even the ability to log on to any hospital computer.

10. Preparation must include maintaining a large supply of paper charts, order sets, backup access to medication and blood product dispensers, and billing/coding sheets. Do not count on having these stored on a computer to be printed when needed as you may lose the ability to log on or connect to any networked printer.

The healthcare industry is at a particularly high risk

- The mandate to move to electronic records
- The sensitive nature of health care data
- The immaturity of the information security practices that exist in the health care industry today
- The cost of compromise could range from an inconvenience to loss of life



<u>Follow the Money $$$</u>

Medical Records are the crown jewel for hackers

Stolen Electronic Healthcare Records (EHR) can be sold on the darknet <u>for up to $1,000</u>. By comparison, social security numbers and credit card information usually sell for $1 and up to $110, respectively [6]. EHRs contain information that is harder to cancel/recover once stolen (PII, insurance, policy numbers, medical diagnoses, billing information). This information is often used by fraudsters to create fake IDs, to purchase medical equipment or drugs, or to file a false insurance claim.

WHAT IS RANSOMWARE?

Ransomware is a specific form of malware that can assume control of an individual computer, computer network, and/or various peripherally networked devices and encrypt some or all personal information, documents, applications, and other items. Once successfully deployed, the users will no longer be able to access or unencrypt any of the affected folders, files, programs, or other involved items. In some cases, they may even lose the ability to log on to the affected device.

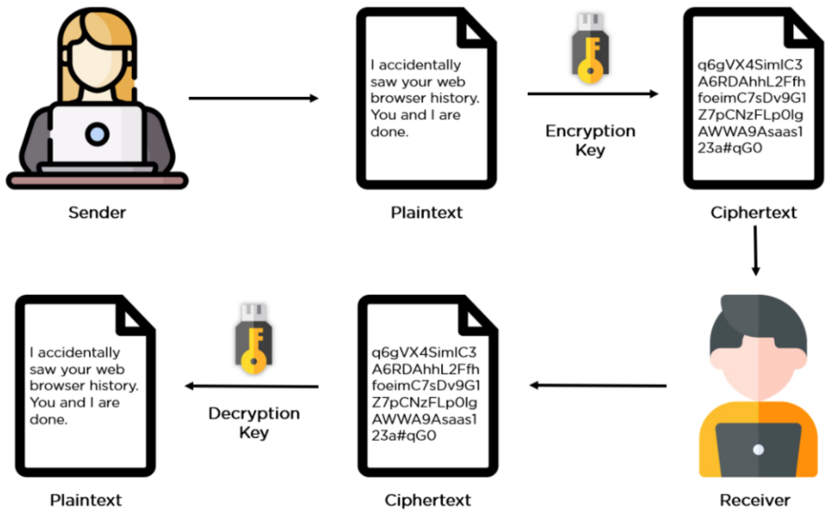
With the efficacy of modern ransomware encryption that is utilized, there is little to no chance of breaking the encryption or restoring the affected files, even by professional or government cybersecurity personnel. The only way to re-establish access and restore all affected files is to obtain the appropriate decryption key or program from the persons responsible for deploying the ransomware. The initial ransomware attack typically includes a file or a popup message that contains the "ransom note" including a demand for payment in exchange for the encryption key. It is important to note that there is no guarantee that the hackers will provide the encryption key even after payment of the demanded ransom.

Common ransomware demands are for payment of a specified sum to the responsible party or a third-party middleman, usually in the form of a secure cryptocurrency such as bitcoin (Figure below shows the NoCry ransomware demand). Common threats include permanent inability to access the data, deletion of the data, or public disclosure or posting of highly sensitive patient or corporate data.

ANATOMY OF A RANSOMWARE ATTACK

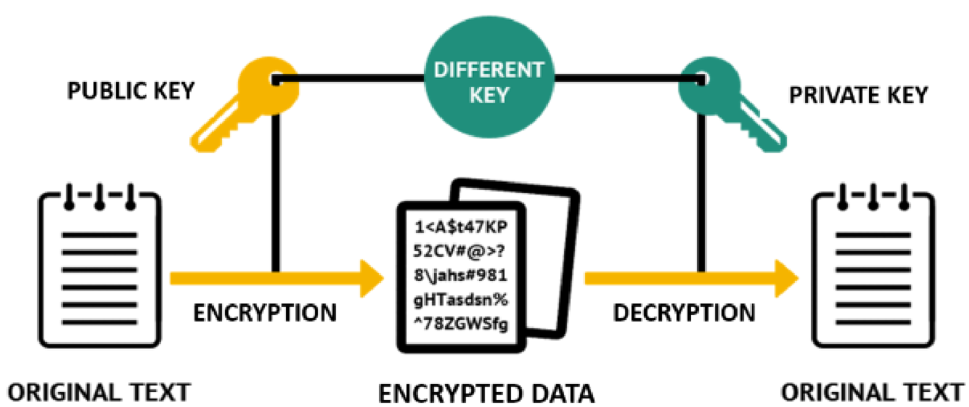
There are a number of ways the ransomware code can gain initial entry to an individual device or a large network. The most common of these is via various types of phishing attacks involving infected emails, text messages, hyperlinks, malicious websites, or download files. These are often made to look like official messages, links, or files from well-known companies or websites, or even disguised as internal work-related business from executive leadership or Information Technology personnel. This has been a prime focus of awareness and prevention training. Alternate methods that may also be utilized, particularly when accessing large healthcare or other corporate systems involve exploiting weaknesses in existing systems or software to gain access to one node on the network. This may often be easiest via older or "legacy" systems that do not have the most up to date firewall and protections installed or that may not have maintained updated hardware or software patches. Files with ransomware or other malware may also be introduced via an infected device such as a USB flash drive, CD or DVD, or other data storage device. Thus, even a device that is not networked or even connected to an intranet or the internet can be infected with ransomware via this method. It can also be spread via a compromised Ethernet or Wi-Fi system to any device that connects to that network.

At some point after gaining access to the targeted system(s), the ransomware will encrypt all targeted information, data, and files. This essentially converts them to unreadable code or text which cannot be opened, or which appear to be gibberish when opened. As shown in the figure below, the encryption process requires an encryption key, and the only reliable method to restore affected files is via the specific decryption key that is known only to the attackers.



Encryption is defined as “the conversion of data from a readable format into an encoded format that can only be read or processed after it's been decrypted.” Encryption is a key component of data protection and security that is widely used throughout the world by both individuals and business entities. However, the positive security features that make encryption a key component of data security can similarly be utilized by hackers to capture and control the victim’s data.

The majority of ransomware utilizes asymmetric encryption methods. As shown in the figure below, this method utilizes both a public key and a private key that are mathematically related, and that are used to encrypt and then decrypt the data respectively. This has several security advantages over the symmetric encryption method in which the sender and receiver both have to have the same private key, and thus data security is dependent on the ability to securely store or send the decryption key.



One of the most important aspects of a ransomware cyberattack against a medical facility or healthcare system to understand is that the malware typically does not immediately activate and start to encrypt files. This would often result in it being quickly recognized and contained, thus limiting the scope and impact of the attack. The malware will take an inventory of the local files and folders to be attacked, but also will begin mapping the network and spreading to connected devices, servers, and peripherals. This can occur over weeks to months. It maximizes the effect and impact of the ransomware once it is deployed, ensures complete or near-complete control of the targeted network, and minimizes opportunities for the targeted center or system to make an effective early response or regain control of the network and critical data.

In addition to the above, there will be a critically important search to identify, access, and compromise any on-site or off-site backup servers. If the targeted center or system maintains a backup copy of its computer systems and critical data, then they could potentially avoid paying the ransomware and simply wipe and restore the affected systems. If the attackers are able to control and encrypt or delete these critical backup servers, then the victim will often have little option other than paying to retrieve their data and access to their information systems.

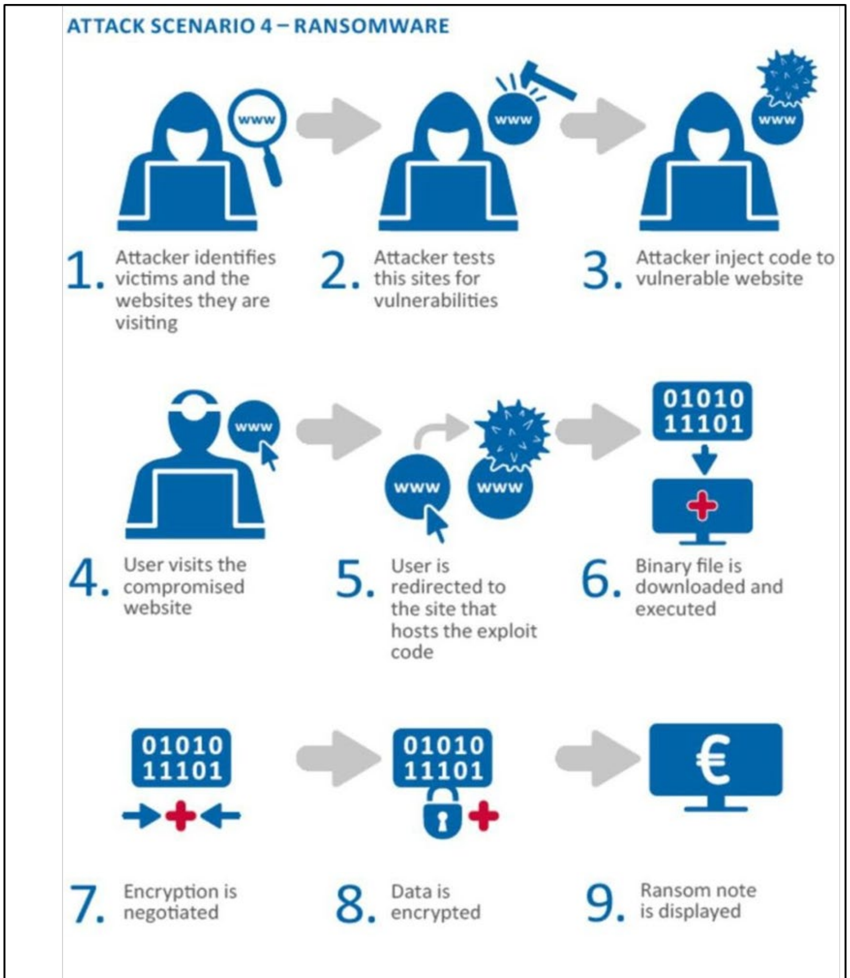
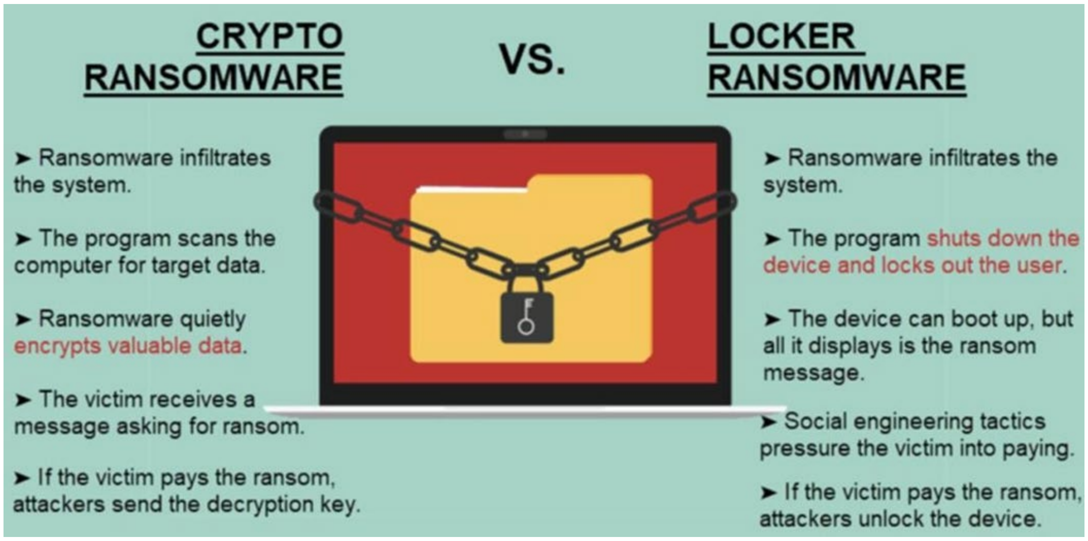


Figure 13 Ransomware attack on hospital information system

TYPES OF CYBERSECURITY AND RANSOMWARE ATTACKS

As shown in the figure above, ransomware is just one of the many types of cybersecurity attacks or threats that all healthcare organizations face in the modern era of information systems and connectivity. It is also important to note that these threats are often related and combined to achieve the desired effect. For ransomware, the point of entry is often obtained via other methods on the list including phishing, spam email, malware, or identity theft. Phishing attacks and information leakage (or identify theft) are the two most methods employed to initiate a ransomware attack.

Ransomware can be broadly grouped into two categories as shown below with their definitions. The non-encrypting or "locker" version is more commonly seen with attacks on individuals, and the encrypting or "crypto" type is by far the more common method utilized when attacking hospitals, healthcare systems, and any corporate or industry target. In an estimate from 2018 there were 350 different variants of ransomware described, representing a 150% increase from the year prior. These numbers have only continued to increase at a significant rate, and the variants continue to become more technically sophisticated over time. Another recent trend in the types of cybersecurity and ransomware attacks is the move to cloud-based solutions for data storage and backup by many healthcare organizations. This has predictably resulted in an increase in ransomware designed to exploit these cloud-based platforms in addition to in-house information systems and data backup/storage devices. Of great concern, 25% of healthcare institutions are not encrypting their data during transfer to the cloud, and 36% with data in a multi-cloud environment are not using encrypted technology.



HOW TO PREVENT SUCCESSFUL RANSOMWARE ATTACKS

Protection of IT systems and prevention of the deployment of ransomware or other malware is obviously far preferable to responding to a successful attack that has stolen and/or encrypted critical data and data systems. Although there are numerous specific technological practices and programs that should be implemented to prevent access to a center's IT systems by malicious actors or organizations, the most important preventive measures are arguably related to the institutional leadership and culture. The healthcare industry has been identified as one of the common sectors that continues to have lax or inadequate cybersecurity awareness, policies, training, and leadership. Even the most secure firewall and other technologic factors cannot overcome the "human-factor" of lax or non-existent security practices or even willful misconduct of employees that compromise the IT security.

Adoption of a universal posture of cybersecurity diligence from the top leadership through all levels of the organization and any affiliated personnel, vendors, and collaborative partners is the first and most important step to preventing successful cyberattacks and to limiting the damage or extent of any executed incursions. The majority of successful cyberattacks arise from compromise of security by an employee or affiliate, either unintentionally (via malware, identity theft) or intentional.

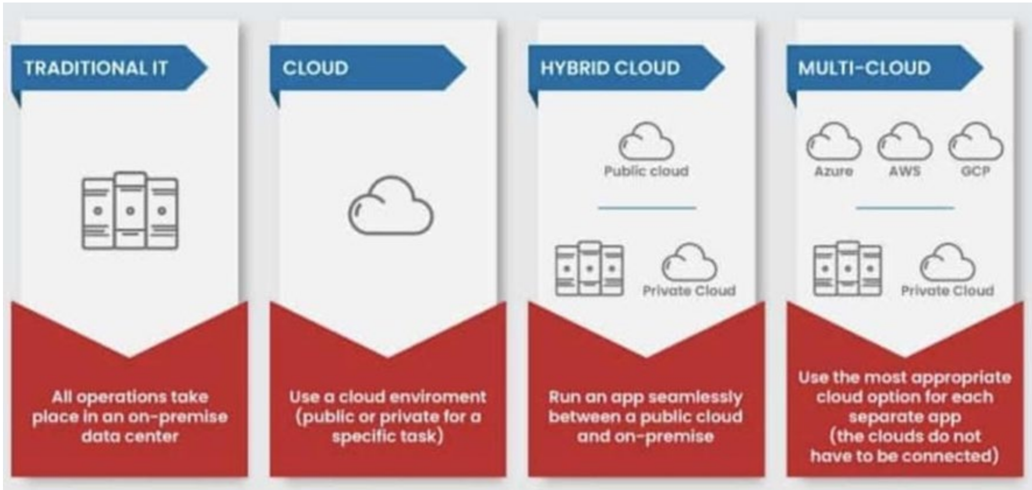
Some sobering statistics related to healthcare IT and cybersecurity:

- 42% leave cybersecurity in the hands of a vice president or C-level official
- 39% report biggest challenge is the lack of qualified IT employees
- 40% of small and medium organizations do not have dedicated staff to deal with cloud-based issues
- 61% cited senior-level executives as a high security threat due to their level of access privileges and lack of stringent cybersecurity practices and knowledge

11 Steps to Defend Against the Top Healthcare Cyberthreats

(from Dobran B, https://phoenixnap.com/blog/healthcare-cybersecurity-threats)

1. Consider threat entry points and vulnerabilities
2. Learn about ransomware attacks and likely targets
3. Create a ransomware policy and train for immediate response
4. Focus on employee cybersecurity and best practices training
5. Create or expand security measure risk levels and restrict access as appropriate
6. Go beyond employee access and factor in patient concerns and data access issues
7. Protect health data on ALL "smart" equipment and not just computers
8. Consider cloud migration for data storage and backup, transition to multi-cloud approach (Figure below) as appropriate
9. Ensure vendors are compliant with access, updated security, and threat detection
10. Educate employees on HIPAA regulations and compliance for data protection
11. Push a top-down security program and conduct regular risk-assessments



Zero Trust Security Approach

With the recognition that the majority of cyberattacks involve compromise of employee credentials, logon information, malware introduction, or purposeful sabotage, the Zero Trust Security approach has been developed. This involves a posture of never assuming that persons or devices attempting to access protected information are legitimate and implementing numerous checks and balances to confirm all identities, partitioning data and data-access, and continuously monitoring the network for any atypical or suspicious activity. This "default deny" posture results in systems that are hardened and isolated until a verified level of trust is established.

The Figure below shows the seven principles of implementation of a zero-trust model. This includes zero assumed trust in five areas: 1) employees or other people accessing the system, 2) devices and 3) networks that access or interact with the system, 4) data and data sharing, and 5) workloads (particularly running in the public cloud). The final two principles are visibility and analytics to continuously monitor and analyze every activity on the network, and automation and orchestration to enable automatic and coordinated incident response and task delegations during any cyberattack attempt or successful infiltration of the protected network.

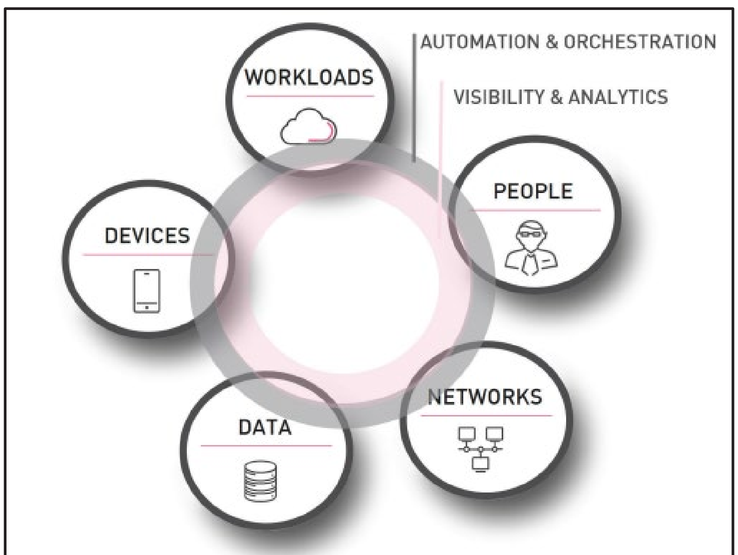


Figure 1: The Forrester Zero Trust Extended Security Model

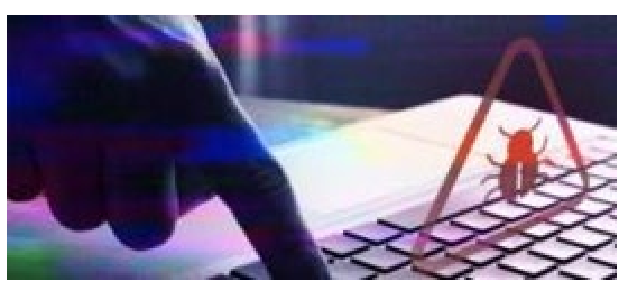
IMMEDIATE AND DELAYED RESPONSE TO RANSOMWARE

The immediate and delayed responses to ransomware are critical to preserve as much data and system operability as possible in the face of the cyberattack. The two immediate and simultaneous priorities should be disconnection of the device from the network and notification of the appropriate IT or cybersecurity personnel. The figure and expanded explanation table below highlights eight immediate and delayed actions that should be undertaken upon identification of an impending or executed cyberattack.

- **Isolation:** Isolate the infected system from the rest of the network. Shut down the device, pull out the network cable, and turn off the Wi-Fi to localize the problem.
- **Malware identification:** Next, determine what type of malware has infected the system. Either the IT team or an outside consultant should analyze and identify the threat.
- **Report the breach:** Even if some regulation does not oblige you to report an attack, authorities can offer expertise and insights the in-house team perhaps lacks.
- **Remove the malware:** Remove the malware by uninstalling everything on the infected device and reinstalling the operating system.
- **Analyze data loss:** Identify which data the attacker managed to encrypt. Also, search for signs of data exfiltration.
- **Recover data:** Once you contain the attack, restore data from the most recent backup available.
- **IT forensics:** Most hackers try to leave a back door in each system they infect. Ensure the team scans all IT environments for potential entry points.
- **Improve the system:** Determine how the intruder breached the system and make improvements to ensure the same attack does not happen again.

ARTIFICIAL INTELLIGENCE AND CYBERSECURITY

Artificial intelligence (AI) is transforming the cybersecurity landscape, acting as a **"double-edged sword"** that enhances both attacker capabilities for more sophisticated **ransomware attacks** and defender tools for more effective detection and response.



How AI Powers Ransomware Attacks: AI makes ransomware faster, more autonomous, and more effective at evading traditional, signature-based defenses. Key enhancements include:

- Smarter Reconnaissance
- Automated Exploitation & Speed
- Evasion of Security Controls
- Advanced Social Engineering
- AI-Powered Negotiation Bots
- Adaptive Behavior

How AI Enhances Cybersecurity Defenses: Organizations are leveraging AI to fight back and level the playing field. AI-driven defense mechanisms offer crucial advantages:

- Behavioral Analysis
- Automated Response & Recovery
- Faster Threat Detection
- Enhanced Threat Intelligence

The 3 AI defense pillars every organization needs

A comprehensive approach to combating AI-enabled threats consists of three types of defense, all of which are essential:

1 **Automated security hygiene**, such as self-healing software code, self-patching systems, continuous attack surface management, zero-trust-based architecture, and self-driving trustworthy networks. Automating these routine tasks reduces manual workloads while strengthening protection against attacks that target core system vulnerabilities.

2 **Autonomous and deceptive defense systems**, which use analytics, machine learning, and real-time data collection to learn from, identify, and counteract threats. Examples include simultaneously automated moving-target defense, and deceptive tactics and information. Both types of systems enable teams to take a proactive approach to defense, rather than getting stuck in reactive mode.

3 **Augmented oversight and reporting**, which give executives real-time data-driven insights. For example, automated risk analysis uses AI to spot emerging threats and predict how they might impact an organization.

MIT MANAGEMENT SLOAN SCHOOL by Zach Church | Sep 8, 2025

RANSOMWARE

What It Is & What To Do About It

What is Ransomware?

Ransomware is a type of malicious software, or malware, that encrypts data on a computer making it unusable. A malicious cyber criminal holds the data hostage until the ransom is paid. If the ransom is not paid, the victim's data remains unavailable. Cyber criminals may also pressure victims to pay the ransom by threatening to destroy the victim's data or to release it to the public.

Government Efforts to Combat Ransomware

While ransomware attacks impact all sectors, the federal government is particularly concerned about the impact of ransomware on the networks of state, local, tribal, and territorial governments, municipalities, police and fire departments, hospitals, and other critical infrastructure. These types of attacks can delay a police or fire department's response to an emergency or prevent a hospital from accessing lifesaving equipment. To combat this threat, the NCIJTF has convened an interagency group of subject matter experts to educate the public on ways to prevent ransomware attacks, to improve law enforcement coordination and response, and to enable and sequence whole-of-government actions that impose consequences against the criminals engaged in this malicious activity. The Cybersecurity and Infrastructure Security Agency (CISA) leads a number of efforts including —CISA Cyber Essentials—and—CISA Insights— to assist entities in protecting themselves from cyber incidents like ransomware. More about these efforts and the tools CISA offers can be found at https://www.cisa.gov/ransomware. The FBI's IC3.gov website has additional ransomware focused resources that can be found at https://ic3.gov/Home/Ransomware.

Common Infection Vectors

Although cyber criminals use a variety of techniques to infect victims with ransomware, the most common means of infection are:

- Email phishing campaigns: The cyber criminal sends an email containing a malicious file or link, which deploys malware when clicked by a recipient. Cyber criminals historically have used generic, broad-based spamming strategies to deploy their malware, though recent ransomware campaigns have been more targeted and sophisticated. Criminals may also compromise a victim's email account by using precursor malware, which enables the cyber criminal to use a victim's email account to further spread the infection.

- Remote Desktop Protocol (RDP) vulnerabilities: RDP is a proprietary network protocol that allows individuals to control the resources and data of a computer over the internet. Cyber criminals have used both brute-force methods, a technique using trial-and-error to obtain user credentials, and credentials purchased on dark web market - places to gain unauthorized RDP access to victim systems. Once they have RDP access, criminals can deploy a range of malware—including ransomware—to victim systems.

- Software vulnerabilities: Cyber criminals can take advantage of security weaknesses in widely used software programs to gain control of victim systems and deploy ransomware.

RANSOMWARE

What It Is & What To Do About It

Best Practices To Minimize Ransomware Risks

1. Backup your data, system images, and configurations, test your backups, and keep the backups offline
2. Utilize multi-factor authentication
3. Update and patch systems
4. Make sure your security solutions are up to date
5. Review and exercise your incident response plan

How Ransomware Has Impacted The Public Sector

The examples below may show the impacts in terms of ransom paid or service restoration cost, but it is difficult to calculate the total impact/costs of a ransomware infection. In addition, paying a ransom does not guarantee that stolen sensitive data will not be sold on the dark web.

- A U.S. county was infected by Ryuk, taking almost all of the county's systems offline. The county had backup servers, but they were not isolated from the network, allowing them to be infected as well. The county paid a $132,000 ransom.

- A U.S. city's systems were infected by Robbinhood with a ransom demand of 13 Bitcoins ($76,000). The attackers entered the network through old, out-of-date hardware and software. The ransom was not paid, but service restoration was estimated to cost over $9 million.

- A U.S. county's computer systems were infected by Ryuk. The attackers demanded over $1.2 million in Bitcoin for a decryption key. Officials decided to rebuild their systems rather than pay the ransom and spent $1 million in new equipment and technical assistance. A user allegedly opened a malicious link or attachment which caused the infection.

Reporting Information

- The FBI does not encourage paying a ransom to criminal actors. Paying a ransom may embolden adversaries to target additional organizations, encourage other criminal actors to engage in the distribution of ransomware, and/or fund illicit activities. Paying the ransom also does not guarantee that a victim's files will be recovered. Regardless of whether you or your organization have decided to pay the ransom, the FBI urges you to report ransomware incidents to your local field office or the FBI's Internet Crime Complaint Center (IC3). Doing so provides investigators with the critical information they need to track ransomware attackers, hold them accountable under U.S. law, and prevent future attacks.

Victims of ransomware can file a complaint with law enforcement or report incidents by:

- **Contacting your local federal law enforcement field office**
- **Filing a complaint with the Internet Crime Complaint Center (IC3)** https://ic3.gov/Home/Ransomware
- **Contacting NCIJTF CyWatch 24/7 support at 1-855-292-3937**
- **Reporting incidents, phishing, malware or vulnerabilities with CISA** https://us-cert.cisa.gov/report

FLYING HIGH: DRONES FOR GOOD IN EMERGENCY RESPONSE SCENARIOS

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Drones have become the signature weapon of the war between Russia and Ukraine and likely future wars between modernized nations. They have the capacity to cause mass destruction, terror, and chaos on the battlefield and have been used since WWI. Civilian infrastructure is frequently targeted with tremendous damage. (**Figure 1**) The devastation due to drones is only limited by the number of drones that can be created, their payload, and their ability to penetrate defenses.

Figure 1. Damage to civilian infrastructure in Ukraine due to Russian Drones

Figure 2 shows the number of Russian drone attacks on Ukraine per week and the number that are intercepted from January 2024 through September 2025. During that period, drone attacks exponentially increased exceeding 2000 per week with hundreds reaching their targets.

Drones come in many sizes and shapes. The smallest are insect sized and are used for surveillance. Slightly larger drones can carry grenades and improvised explosive devices while others are jet sized with the capability of carrying missiles and other devastating explosive devices like thermobaric weapons.

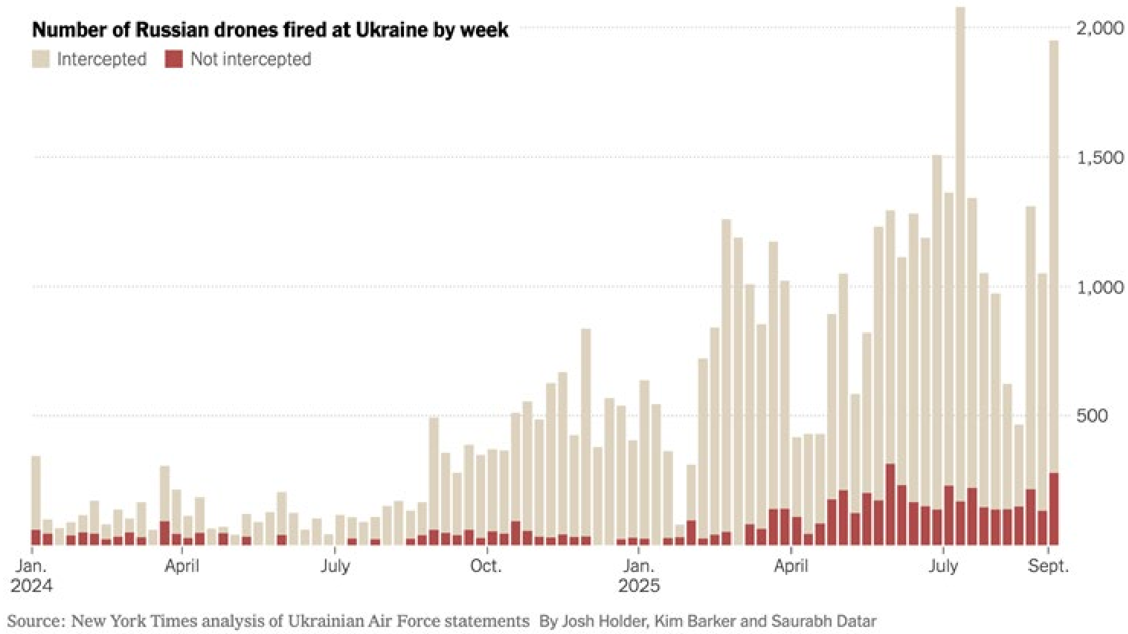

Figure 2. Russian attacks on Ukraine per week showing numbers intercepted (yellow) and not intercepted (red).

Any type of drone may be radio frequency operated, operated by GPS or have a pre-determined path. Drones used for warfare may be controlled by a connected fiberoptic cable that can be up to 100km long with new technology. Fiberoptic technology is utilized because it is jam proof and the drone cannot be taken over, diverted, or blown up by the enemy. Counter scissor drones are actually designed to cut these fiberoptic cables rendering the drone useless. Much of the Ukrainian war effort has been geared toward attaching IEDs to drones in makeshift housing near the front, while those making and deploying the drones attempt to hide from their Russian counterparts.

The use of drones for medical purposes has been documented since 2015 in multiple settings around the world.[1] (**Table I**) Emergency drugs, automatic external defibrillators, medical supplies, blood samples, vaccines, chemotherapy, and transplant organs have all been successfully delivered by drone. The maximum distances reported are around 80 km at a speed of 100 km/hr. Drones have also been used to survey disaster zones and epidemic areas without danger to their human operators.[2]

TABLE 1 | Key global medical drone delivery projects (2015–2024).

Year	Country	Company/Initiative	Payload type	Reported distance	Payload capacity	Max drone speed	Approx. flight duration	Notes/Highlights
2015	USA (Virginia)	Flirtey [10]	Emergency drugs	0.8 km	4.5 kg	Not specified	3 min	First FAA-approved drone delivery in the US. Delivered medical supplies to a rural health clinic.
2016	Rwanda	Zipline [11]	Blood products	50km	Up to 1.8 kg	~100 km/h	~14 min	First national drone delivery service, significantly cut blood delivery time.
2017	Sweden	Karolinska Institute [12]	AEDs	~10 km	Not specified	Not specified	~5 min	Drones delivered AEDs faster than ambulances.
2017	Switzerland	Swiss Post + Matternet [13]	Blood, lab samples	20 km	2 kg	Not specified	17 min	Routine transport between hospitals and labs in Lugano.
2018	Vanuatu	UNICEF [14]	Vaccines	Up to 47 km	Not specified	Not specified	Not specified	Delivered vaccines to remote islands, improved access.
2019	Ghana	Zipline	Vaccines, blood, meds	Up to 80 km	Up to 1.8 kg	~100 km/h	~45 min	Expanded Zipline's success in Rwanda to broader operations.
2020	USA (North Carolina)	Zipline/Novant Health	PPE, medical supplies	Up to 80 km	Up to 1.8 kg	~100 km/h	~45 min	FAA-approved long-range COVID-19 drone delivery.
2021	Botswana	Avy [15]	Medical supplies	Up to 60 km	Up to 1.5 kg	~74 km/h	~55 min	Reduced transport time by 65% vs. road.
2022	Nigeria	Zipline	Vaccines, medical supplies	Up to 80 km	Up to 1.8 kg	~100 km/h	~45 min	Expanding reliable medical delivery network.
2022	UK (Isle of Wight)	NHS/Apian [16]	Chemotherapy drugs	47 km	Not specified	Not specified	30 min	Saved hours by replacing car/ferry transport.
2023	UK (Scotland)	Project CAELUS	Medical supplies	~50 km	Not specified	Not specified	35 min	Among the first UK trials to demonstrate BVLOS operations transitioning between controlled and uncontrolled airspace.
2024	UK (London)	NHS/Apian	Blood samples	~2 km	Not specified	~100 km/h	<2 min	Slashed delivery time from 30+ minutes to under 2.

Note: Compiled from sources including peer-reviewed literature, government reports, NGO publications, and reputable media sources. Full references are listed at the end of the manuscript.

Table I. Examples of medical drone delivery projects around the world.

The greatest experience with using drones for medical purposes is in Rwanda. Rwanda developed a system for delivering blood throughout the nation in 2016.[3] (**Figure 3**) Blood is stored at 2 hubs, and each hub is equipped with 20 drones that have an 80 km radius. Utilizing this method, both hubs cover 90% of the country outside of the capitol.

Figure 3. Drone delivering blood in Rwanda by parachute.

During the period from March of 2017 to December of 2019, 12,733 blood product orders were delivered by drone, with 43% of these for emergency delivery. The mean drone delivery time was 50 minutes, which was 79 – 98 minutes faster than estimated driving times for these deliveries depending on the source of the estimate. The maximum reduction in delivery time was 211 minutes for distant sites with bad roads. The start of the drone program was also associated with a 7.1 unit/month reduction in blood expiring, which translated to a 67% reduction at 12 months.

Investigators in Montreal studied drone transport of simulated blood product components in the city.[4] They found that each components could be maintained at the required regulatory temperature and that drone transport was significantly faster than ground delivery. All flights were conducted safely without adverse events. The maximum payload was 6.4 kg, and the drone speed was 10 m/s. The group from Fort Sam Houston studied the effects of drone flight and delivery on the hemostatic qualities of low titer type

O whole blood to ensure there was no negative impact.[5] Flight duration was 3 to 7 minutes, and units of blood were dropped by parachute from an altitude as high as 100 meters. RapidTEGs, iSTAT chemistries, and free hemoglobin measurements were obtained before and after flight. This study showed no change in coagulation capacity, lactates, or evidence of hemolysis as a result of drone flight and delivery. Massive transfusions supported by autonomous drones have also been reported in the combat settings where casualties were injured in remote inaccessible locations.[6]

An interesting area where drone technology may be especially helpful is organ transplantation. Cold ischemia time remains one of the greatest barriers to successful transplantation, and enormous resources are required to get donated organs to recipients. Distances organs are being sent are increasing as attempts are being made to shorten the waiting list which remains at around 100,000 patients in the US alone. A scoping review was performed to assess the current status of organ delivery by drone in the world.[1] This review revealed 5 successful organ deliveries by drone to date to include 3 kidneys, a lung, and a pancreas. (**Table II**) There was no evidence of a negative impact of drone delivery on the quality of the organs, and a study comparing drone delivery of organs versus standard techniques is planned.

TABLE 2 | Selected UAV organ-delivery demonstrations (2019–2024).

Year	Location	Organ(s)	Study type	Distance (km)	Flight time (min)	Outcome
2019	Baltimore, USA	Kidney	Clinical transplant	4.3	~10	Delivered; transplanted; stable telemetry
2021	Toronto, CAN	Lung	Clinical transplant	1.5	6	Delivered; transplanted; uneventful recovery
2021	Minneapolis, USA	Pancreas	Research payload	16	~20 loop	Biopsy unchanged pre/post
2020	Las Vegas, USA	Kidney	Research payload	16.6	~20	Viability confirmed
2024	Turin, ITA	Kidney (sim)	Simulated payload	0.5	~2	Autonomy + smart capsule validated

Table II. Examples of transplant organs being delivered by drone

CONCLUSIONS

The advantages of drone technology in human medicine are essentially unlimited and have just begun to be elucidated. Drones provide rapid access to inaccessible areas without danger to their human operators. This has incredible advantages from a surveillance standpoint for disaster scenarios and epidemics. In addition to surveillance, critical resources such as blood products, medical equipment, medicines, first aid supplies, laboratory studies, and AEDs can be provided rapidly and dependably and in large quantities. Drones for good will continue to play an increasing role in our medical future.

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INTERAGENCY TANGO - COORDINATING EMS, HOSPITAL, AND MILITARY ASSETS UNDER PRESSURE: LESSONS LEARNED FROM THE JULY 4 TEXAS FLOOD

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INCIDENT OVERVIEW

- Timeline of the July 4, 2025 flooding event
- Geographic and population impact in Kerrville and surrounding areas
- Scope of medical emergencies and casualty profile
- Initial activation of emergency response systems

ROLE OF EMERGENCY MEDICAL SERVICES AND LAW ENFORCEMENT

- Field triage and patient stabilization
- Rescue operations in flood-affected zones
- EMS surge capacity and mutual aid activation
- Communication pathways with hospitals and command centers
- Body recovery and medical examiner coordination

HOSPITAL SYSTEM RESPONSE

- Emergency department surge management
- Hospital evacuation and shelter-in-place decisions
- Patient tracking and regional patient distribution
- Integration with regional trauma and specialty care networks

MILITARY ASSET INTEGRATION

- Texas National Guard and federal military medical support roles
- Aeromedical evacuation capabilities
- Logistics support including transport, communications, and field medical assets
- Coordination with civilian incident command structures

INTERAGENCY COORDINATION FRAMEWORK

- Incident Command System (ICS) and Unified Command application
- Multi-Agency Coordination Centers (MACC)
- Information sharing platforms and communication interoperability
- Resource request and deployment processes

LESSONS LEARNED & FUTURE PREPAREDNESS

- Successful coordination strategies
- Identified gaps in communication, resource allocation, or training
- Recommendations for strengthening joint disaster medical operations

CLOSING & KEY TAKEAWAYS

- Importance of pre-established relationships and joint planning
- Value of unified operational objectives
- Commitment to continuous improvement in disaster medical response

ETHICS UNDER FIRE: MAKING DIFFICULT DECISIONS AND NO-WIN SCENARIOS IN MASCAL AND DISASTER EVENTS

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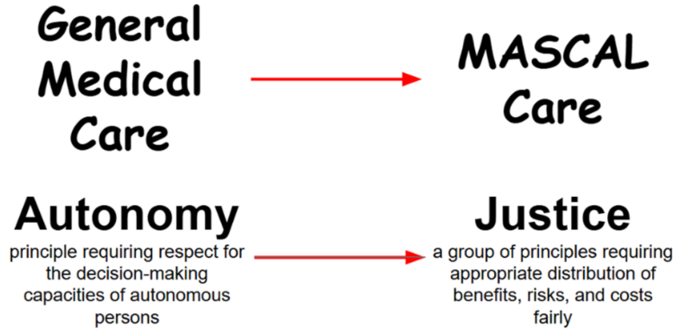
TAKEAWAY POINTS:

1. System-wide preparation is required to optimize success in mass casualty (MASCAL) incidents
2. A priori discussion of ethical dilemmas may abate some of the moral injury associated with decisions during MASCAL
3. Despite resource scarcity, ethical norms must be upheld
4. Consider adoption of the "secure, preserve, fight" model for active shooter scenarios in healthcare settings
5. Moral injury may be unavoidable in MASCAL incidents, but a mechanism for psychological first aid should be employed

Medical ethics in clinical care are traditionally grounded in the four principles articulated by Beauchamp and Childress: **autonomy**, **beneficence**, **non-maleficence**, and **justice**. In routine trauma practice, respect for patient autonomy often serves as the dominant ethical driver, guiding informed consent, shared decision-making, and individualized care. While ethical challenges arise daily in trauma/acute care surgery and surgical critical care, they are typically navigated with time for deliberation, multidisciplinary input, and alignment with established standards of care.

Mass casualty incidents (MASCALs) fundamentally disrupt this ethical equilibrium. Decisions must be made under extreme time pressure, incomplete information, and resource scarcity, often with irreversible consequences. In this setting, the ethical focus shifts from individual autonomy to **justice**, emphasizing fair and consistent allocation of limited resources to achieve the greatest overall benefit. Although frameworks and operational guidelines exist for MASCAL management, they cannot fully resolve the ethical complexity inherent in these scenarios, particularly when real-time clinical demands outpace formal institutional declarations of crisis standards of care.



As a result, trauma surgeons are frequently confronted with profound ethical dilemmas, including triage prioritization, the transition from patient-centered to population-based decision-making, equity during resource scarcity, modified informed consent practices, and conflicts between professional obligation and personal risk. Additional challenges arise in the care of vulnerable populations, the influence of social and cultural factors, divergent perceptions of professional duty, and the moral injury that may follow participation in no-win decisions, especially when operating under de facto crisis conditions without formal designation. In this review, we examine these ethical tensions that trauma surgeons may confront, and discuss specific scenarios resulting in difficult decision-making, and unavoidable trade-offs that are characteristic of a MASCAL response.

SCENARIO 1: HOSPITAL MASCAL/ACTIVE SHOOTER SCENARIO

One underrecognized yet ethically and operationally complex scenario for surgeons arises when a MASCAL or active shooter event occurs while a patient is on the operating room table. Active shooter incidents within healthcare facilities are increasingly reported, underscoring that this is not a theoretical concern. For the operating surgeon, these events immediately collapse the distinction between personal safety, team safety, and professional duty to a vulnerable, anesthetized patient. Unlike many disaster scenarios, there is no opportunity to pause, transfer responsibility, or safely disengage from care without foreseeable harm.

Consider the case of a surgeon performing an emergent operation for perforated diverticulitis in a patient in septic shock, complicated by the fact that the patient has dense intra-abdominal adhesions. Mid-procedure, a hospital-wide active shooter alert is announced, and the threat has not yet been secured. Standard institutional guidance for active shooter events, typically framed around the run, hide, fight paradigm, offers little practical direction for an active operating room, where the patient is physiologically unstable and incapable of self-preservation. Recognizing this gap, Dr. Mattox and others have proposed a "secure, preserve, fight" framework tailored to surgical and acute care environments. Securing the scene, preservation of life, and fighting only as required. In the above scenario, a "secure, preserve, fight" mechanism would entail immediate containment of the operative space, preservation of life including that of both the surgeon, staff, and patient, and preparation to defend the team only if necessary.

During an active shooter, the surgeon would be confronted with multiple ethically-fraught options immediately, none of which are without risk: abort the operation and leave the patient with an unaddressed septic source; continue the procedure by performing an abbreviated source control or damage-control surgery with temporary abdominal closure; continue the operation as planned behind locked doors. Each choice forces a recalibration of the duty to treat against the duty to protect staff and oneself from imminent harm. Following containment of the active shooter, the surgeon and the system must decide upon next steps. It is unlikely that standard operating procedure can be carried on via standard operating procedures following an active shooter or MASCAL, but this should be reassessed. Considerations should include whether casualties exist, the nature of those, and whether those within the system require psychological first aid. These scenarios highlight the need for explicit inclusion of intraoperative active shooter contingencies in MASCAL planning, with clear institutional guidance that supports surgeons in securing the operating room as rapidly as possible while minimizing both patient harm and moral injury to the care team.

SCENARIO 2: CONFLICT BETWEEN CHAIN OF COMMAND VS ETHICAL CARE OF PATIENT

During an ongoing MASCAL, let's take the case of a patient who presents with devastating polytrauma, including a grade V hepatic injury with active hemorrhage, mesenteric small bowel injury, splenic injury, and a partial traumatic lower extremity amputation following a blast mechanism. The trauma surgeon performs rapid damage-control surgery, including splenectomy, small bowel resection, control of hepatic and mesenteric bleeding, and a guillotine amputation. While all injuries are surgically hemostatic at the conclusion of the operation, the patient remains profoundly coagulopathic and hypotensive, with a systolic blood pressure of 70 mmHg. In accordance with an institutional directive issued during the MASCAL, transfusion has been capped at four units of packed red blood cells and four units of plasma per patient.

At this juncture, the ethical conflict becomes explicit. From a clinical standpoint, continued balanced blood component therapy represents the standard of care for hemorrhagic shock and trauma-induced coagulopathy, whereas crystalloid-heavy resuscitation risks dilutional coagulopathy, acidosis, and further physiologic deterioration. The surgeon is aware that the blood bank maintains an adequate reserve at this specific time, approximately 50 units of packed red blood cells, with most currently available. Nevertheless, hospital administration has issued a strict mandate prohibiting additional transfusion to preserve resources for other casualties. The surgeon must now weigh adherence to the chain of command and population-level resource stewardship against a fiduciary obligation to a young, potentially salvageable patient whose injuries have been surgically controlled.

The available alternatives including vasoactive agents, crystalloid, or albumin, may temporarily augment blood pressure but fail to address the underlying oxygen debt and coagulopathy driving the patient's shock. Administering additional blood products would likely improve survival but directly contradicts administrative orders. This scenario exemplifies a core ethical tension during mass casualty response: when leadership-driven directives impose population-based constraints that conflict with bedside clinical judgment, trauma surgeons are left to bear the moral risk of choosing between obedience to command and ethical commitment to beneficence and nonmaleficence toward the individual patient.

SCENARIO 3: TRIAGE OF VULNERABLE POPULATIONS - THE AGE GAP

Several algorithms exist to guide triage during mass casualty incidents, with SALT triage remaining among the most widely accepted frameworks. Notably, SALT does not explicitly incorporate age as a decision-making variable, reflecting a deliberate effort to avoid discriminatory practices. In practice, however, age may enter the ethical calculus when scarce, life-saving resources must be allocated. When clinicians are confronted with choices such as providing a limited intervention to five older adults versus five younger patients, or even ten older adults versus five adolescents, these decisions become ethically fraught and emotionally charged. Many clinicians, consciously or subconsciously, gravitate toward prioritizing younger patients, reflecting deeply ingrained societal values about life-years saved rather than explicit triage doctrine.

Importantly, chronologic age alone should not serve as a determinant of resource allocation, as doing so risks unjust and ethically indefensible discrimination. Instead, ethical frameworks increasingly emphasize vulnerability to disease and likelihood of benefit, often conceptualized as biological risk rather than age per se. Prognosis has therefore emerged as a more ethically defensible criterion, with many disaster ethics models converging on an estimated one-year survival threshold to guide access to scarce resources. While this cutoff remains inherently arbitrary, it attempts to balance fairness, transparency, and utility by focusing on near-term survival rather than social worth or age alone. Interestingly, for some disease processes (Covid, for example), age has been independently established as a predictor of worsened outcomes, and insofar as that is true, can be utilized as a discerning tool for triage and use of scarce resources.

Nevertheless, age cannot be entirely divorced from outcomes in certain disease processes, as advanced age may independently predict worse prognosis even after adjusting for comorbidities and injury severity for specific conditions. Scoring systems such as the Sequential Organ Failure Assessment (SOFA) score have been used to operationalize prognostic triage in some disaster settings, although these tools are better validated for non-traumatic, medical crises than for acute traumatic injury. Ultimately, while age itself cannot ethically function as a triage tool, the related concepts of frailty, physiologic reserve, and likelihood of recovery offer a more nuanced and defensible approach to guiding difficult allocation decisions during mass casualty events.

SCENARIO 4: PERSONAL BIAS VS RESOURCE OPTIMIZATION IN MASCAL

During a mass casualty incident, an on-call trauma surgeon may be confronted with two patients arriving simultaneously with comparable life-threatening injuries and only one can be treated immediately. In this scenario, one patient is a professional colleague, while the other is identified as the perpetrator of the event. Although both patients meet criteria for emergent intervention, personal relationships, emotional responses, and moral intuitions inevitably intrude upon what is ideally an objective triage process. The conflict is further complicated if the colleague is older but has a clearly survivable injury, whereas the perpetrator is younger with a similar injury burden. The surgeon must act swiftly, without the benefit of time, consultation, or emotional distance, while remaining committed to ethical standards that reject retribution and personal bias as legitimate triage criteria.

Ethically, triage decisions must rest on clinical factors such as injury severity, physiologic reserve, and likelihood of survival, rather than social identity, perceived moral worth, or professional role. While one might argue that treating a healthcare provider first could yield broader societal benefit through future service to others, this reasoning risks sliding toward utilitarian assessments of social value, which are widely regarded as ethically impermissible in disaster triage. Justice demands that perpetrators are entitled to the same standard of care as any other patient, regardless of the harm they have caused. This scenario starkly illustrates the moral dilemma inherent in mass casualty triage: even when decisions are ethically justified by prognosis and survivability alone, they may conflict profoundly with personal values, professional loyalty, and emotional instinct, leaving lasting moral distress for the clinician involved.

SCENARIO 5: ADDITIONAL VULNERABLE POPULATIONS AND DECISIONS RESULTING IN MORAL INJURY

During a MASCAL following an explosion at a local sports arena, a 31-year-old woman at 29 weeks gestation presents in profound hemorrhagic shock with vaginal bleeding. She is rapidly taken to the operating room, where exploratory laparotomy reveals multiple intra-abdominal injuries requiring urgent surgical control. Given concern for placental abruption and maternal instability, an emergent cesarean delivery is performed as part of maternal resuscitation. The neonate is delivered without spontaneous respirations, with an initial Apgar score of 2, and continued APGAR score of 2 at 5 and 10 minutes. The operating team remains actively engaged in controlling maternal hemorrhage with multiple additional critical patients amid ongoing resource strain from the mass casualty event. It is understood that a low APGAR score, which remains critical, is associated with a poor outcome. However, decisions involving neonates are often emotionally charged situations.

At this moment, the trauma surgeon faces a stark ethical dilemma: whether to continue full neonatal resuscitation, or to limit intervention, understanding the grave prognosis associated with this patient's low APGAR scores. At 29 weeks' gestation, survival is possible with aggressive neonatal care, but outcomes are highly variable and resource intensive, often requiring prolonged ventilatory support, neonatal ICU admission, and specialized staffing. In the setting of an active MASCAL, where critical care resources are constrained and other salvageable patients may require immediate attention, initiating neonatal resuscitation raises questions of justice, proportionality, and opportunity cost. At the same time, the absence of prenatal counseling, parental input, or advance directives eliminates the possibility of shared decision-making, forcing clinicians to act on presumed best interests under extreme uncertainty.

This scenario underscores the ethical tension between beneficence toward a potentially viable neonate and justice-driven stewardship of scarce resources during disaster response. While standard neonatal practice would favor attempted resuscitation at this gestational age, mass casualty conditions may necessitate consideration of prognosis, available resources, and the likelihood that meaningful survival can be achieved without compromising care for others. The decision, whether to proceed with intubation and resuscitation or to provide comfort-focused care, illustrates the moral weight borne by trauma and acute care teams when disaster circumstances compress time, information, and ethical clarity, often leaving no choice untouched by moral dilemma.

SCENARIO 6: IMPACT OF DIFFICULT ETHICAL DECISIONS: MORAL INJURY AND PSYCHOLOGICAL FIRST AID

Moral injury is an unavoidable yet frequently overlooked consequence of practicing in high-acuity, high-intensity clinical environments where clinicians are required to make rapid, ethically complex decisions. In MASCAL and disaster settings, moral injury arises when providers carry the burden of actions taken, actions witnessed, or actions they were powerless to prevent that conflict with deeply held moral commitments. Examples of moral beliefs often held by trauma providers include honesty, compassion, respect for autonomy, justice, and professional excellence, although innumerable core values exist. When these core values are violated, clinicians may experience moral injury, often expressed through guilt, shame, anger, or moral disgust. Addressing this phenomenon begins with explicit recognition that moral injury is distinct from burnout and requires intentional strategies, including protected time for rest and recovery, even when clinicians feel compelled to continue working.

At the individual and team level, awareness and early identification of moral injury are essential. Creating trusted spaces where clinicians can openly share and process ethically distressing experiences with peers or leaders who share similar values is a critical first step. Practical approaches include identifying colleagues and institutional leaders aligned in values, engaging in reflective dialogue, and seeking opportunities to contribute to organizational change. Empowering clinicians to participate meaningfully in discussions that shape policies and operational decisions – rather than relegating ethical concerns to the margins – helps restore agency and reinforces professional integrity.

Understand Values	Identify	Treat
- Honesty - Compassion - Autonomy - Justice - Excellence	- Guilt - Shame - Disgust - Anger - Helplessness	- Discuss with those with shared values - Share your experience - Identify system values - Create relevant system changes

Institutional commitment is equally necessary to address moral injury in a sustainable way. Organizations should implement anonymous mechanisms for reporting morally injurious experiences and ensure that these reports prompt accountability and action rather than silence. Transparency around institutional values, active efforts to measure how well those values are upheld, and visible leadership engagement in creating equitable, safe, and supportive work environments are essential. By recognizing and addressing moral injury before it becomes entrenched as burnout or disengagement, healthcare systems can better support their workforce and preserve ethical practice in both everyday care and extraordinary crisis situations.

A psychological first-aid approach to this methodology should be utilized, in which safety, comfort, stabilization of the provider are paramount, and all appropriate information is gathered.

CONCLUSIONS

The scenarios discussed in this paper highlight the unique and often underappreciated ethical conflicts that arise during MASCAL incidents, particularly for trauma surgeons practicing at the intersection of individual patient care and population-level responsibility. Whether confronting resource rationing imposed without formal crisis standards of care, navigating conflicts between chain of command and bedside clinical judgment, managing intraoperative threats during active shooter events, triaging patients entangled with personal relationships or moral culpability, or making time-critical decisions for vulnerable populations such as pregnant patients and neonates, these situations share a common feature: they demand immediate, irrevocable decisions in the absence of ideal information, guidance, or consensus. In each case, traditional patient-centered ethical frameworks are strained, requiring clinicians to reconcile beneficence and nonmaleficence toward the individual with justice-driven stewardship of scarce resources.

Collectively, these vignettes underscore the moral burden borne by trauma surgeons during disaster response and the inadequacy of relying solely on abstract ethical principles or generic MASCAL algorithms to guide real-time decision-making. Ethical preparedness must extend beyond triage protocols to include explicit institutional policies, leadership accountability, and anticipatory guidance for scenarios that place clinicians in no-win positions. By acknowledging these conflicts and incorporating them into disaster planning, training, and debriefing, trauma systems can better support surgeons tasked with making ethically defensible decisions under extreme conditions – while mitigating moral injury and preserving trust in both the profession and the systems within which it operates.

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THE SECOND WAVE: INFECTIONS, CHRONIC ILLNESS, DELAYED INJURIES

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I have had the privilege of presenting at the Disaster and Trauma Critical Care and Acute Care Surgery (TCCACS) conferences for many years. However, this subject carries a level of relevance and social consequence that extends far beyond this conference forum – it has the potential to transform the lives of millions.

In the immediate aftermath of mass shootings, terrorist attacks, and natural disasters, support is abundant. Federal agencies such as FEMA, the Red Cross, state and local governments, faith-based organizations, community volunteers, media outlets, and private donors mobilize rapidly. Neighbors help neighbors. In large-scale catastrophes, entire nations respond. Yet this collective response is short-lived, even in disasters here in the mainland.

The global response to the 2010 Haiti earthquake illustrates this reality. The 7.0-magnitude earthquake killed approximately 220,000 people, injured more than 300,000, and displaced 1.5 million. International aid poured in, and media coverage was intense – but brief. Within weeks, global attention shifted elsewhere. Fifteen years later, Haiti continues to struggle with the long-term consequences of that disaster.

The uncomfortable questions remain: What happened to the injured? How many received appropriate long-term medical care? Where did the donated funds ultimately go? Where is the media now?

Multiple studies demonstrate that public attention – and even institutional support – often fades within days to weeks after a catastrophic event. For survivors, however, the consequences do not fade. They evolve to chronic illnesses and sequalae that interfere with their daily life.

I will focus on what I define as **"The Second Wave"** – the delayed, chronic, and frequently invisible consequences of disasters, terrorism, and mass violence. These include long-term physical injuries, chronic infections, mental health disorders, delayed disability, and progressive illness that emerge months or years after the initial event.

Survivors often face fragmented care, insurance denials, escalating out-of-pocket costs, and the loss of coverage entirely due to high utilization or repeated hospitalizations. Even in the United States – despite its vast resources – long-term survivor care remains inconsistent and inadequate.

The October 1, 2017, the Las Vegas mass shooting underscores this failure. In ten minutes, a lone gunman fired over 1,000 rounds into a crowd attending the Route 91 Harvest Festival, killing 60 people, and injuring 867 others. Five years later, many survivors continue to suffer from chronic physical injuries, post-traumatic stress disorder (PTSD), major depression, and financial hardship – despite having done nothing wrong. Mental health care remains profoundly underutilized and underfunded. PTSD and depression are the most common long-term conditions among survivors and their families. A 2021 JAMA study found that more than half of surveyed Las Vegas concertgoers experienced a major depressive episode within the previous year, and over 60% met criteria for PTSD.

While legislation such as the Stafford Act provides critical short-term disaster assistance, it was never designed to address long-term survivor needs. The Post-Disaster Mental Health Response Act, signed into law in 2022, represents meaningful progress – but it still falls short of addressing chronic, lifelong consequences. I would argue that long-term survivor care must be treated as a matter of public responsibility, not temporary charity. History provides us with a model. The structured, decades-long care provided to atomic bomb survivors in Hiroshima and Nagasaki demonstrates that sustained medical, psychological, and social support are both possible and effective.

The question is no longer whether we can do better – but whether we choose to have the courage and determination to work with our government representatives and pass legislation that correct the gaps in our current laws.

HISTORICAL PERSPECTIVE

Hiroshima and Nagasaki Atomic Bombs

On August 6, 1945, a uranium atomic bomb named "Little Boy" was detonated over the Hirushima killing 80,000 people instantly and injuring 60,000 within minutes. Thousands more later die from radiation sickness. By the end of 1945 is estimated that around 140,000 Japanese citizens, the majority civilians, had died.

Figure 1. Photograph of the Atomic Cloud Rising Over Nagasaki, Japan, August 9, 1945.
Source: National Archives, Records of the Office of War Information.

On August 9, 1945, at 11:02 am Nagasaki time, a B29 bomber called "Bockscar" dropped a plutonium implosion-type based bomb- "Fat Man"- over Nagasaki killing 40,000 instantly and injuring 35,000. Thousands later died from radiation sickness. By December 1945, total deaths in Nagasaki were estimated at approximately 80,000 Japanese citizens, predominantly civilians.

The temperature at the hypocenter reached and estimated 5400 to 7200 degrees Fahrenheit. To put it in perspective, steel melts at 2700 degrees Fahrenheit.

On August 10, 1945, Japan offered to surrender to the Allies, with sole condition that Emperor Hirohito remain the nominal head of state. The formal surrender ceremony took place aboard the USS Missouri on September 2, 1945.

By late 1945, more than 200,000 people had died because of the atomic bombings. Many additional survivors later succumbed to radiation-related injuries and illnesses.

ATOMIC BOMB CASUALTY COMMISSION (ABCC)

In 1946, under a presidential directive from Harry S. Truman, the U.S. National Academy of Sciences–National Research Council was tasked with conducting long-term investigations into the medical and biological effects of radiation among survivors of the Hiroshima and Nagasaki bombings. This directive led to the establishment of the Atomic Bomb Casualty Commission (ABCC). Initial funding came from the U.S. Atomic Energy Commission and was later supplemented by the U.S. Public Health Service, the National

Heart and Lung Institute, and the National Cancer Institute. Japanese participation began in 1948 under the auspices of the Japanese National Institute of Health and the Ministry of Health and Welfare.

DEFINITION AND RECOGNITION OF HIBAKUSHA (HIBAKUSHA MEANS ATOMIC BOMB SURVIVORS)

Immediate Postwar Period (1945–1956)

- No national legislation defined Hibakusha or provided government-sponsored medical care
- Early use of the term Hibakusha appeared in Japanese media in 1946
- During the U.S. occupation (until 1952), ABCC research focused on radiation effects but did not include compensation or medical treatment

First Legal Definition and Medical Support (1957)

In March 1957, the Japanese government enacted the **Atomic Bomb Medical Care Law**, legally defining Hibakusha and establishing government-funded medical care.

Key Eligibility Criteria

1. **Exposure Type**
    - Direct exposure within Hiroshima or Nagasaki
    - Fallout exposure, including radioactive "black rain" (with evidence of illness)
    - In utero exposure if the mother met eligibility criteria
    - Early entrants who entered within two weeks of the bombing within a 2-km radius
    - Relief workers physically affected while assisting survivors.

2. **Medical Condition**

    Diagnosis or treatment for radiation-associated illnesses, including cancers, cataracts, liver disease, cardiovascular disease, diabetes, and hypertension

Certification and Benefits

- A Hibakusha Certificate issued by the Ministry of Health, Labor and Welfare confirms bomb-related illness.
- Benefits include free medical care, periodic health examinations, welfare services, monthly allowances, nursing support, and funeral benefits.
- Overseas Hibakusha may apply for certification and medical expense support if eligibility criteria are met.

EXPANSION AND REFORM OF SURVIVOR SUPPORT

Expanding Criteria (1960–1970)

- Eligibility radius expanded to 3 km from the hypocenter
- Special Measures Laws broadened welfare, leave benefits, and financial support

Comprehensive Reform (1995)

The Atomic Bomb Survivor Support Law unified and expanded prior legislation, formalizing eligibility categories and enhancing medical, welfare, and financial support. In utero survivors retained full eligibility.

Case Law and Ongoing Policy Debates

- In 2005, Japan's Supreme Court ruled that overseas residence alone could not disqualify Hibakusha from benefits.
- "Black rain" exposure criteria were expanded through litigation.
- Second-generation children remain ineligible for benefits unless exposed in utero, despite ongoing concerns regarding potential genetic effects.

A major criticism has been that eligibility zones were initially defined by administrative boundaries rather than radiation distribution, which was uneven and influenced by geography and weather. Monthly stipends range from approximately $236 to $986. Since 1957, as many as 372,000 individuals have been registered as Hibakusha. As the 80th anniversary approaches, fewer than 100,000 remain alive, with an average age of 86. Thirteen survivors are designated double Hibakusha, having been exposed in both cities.

Challenges & Updates

- **"**Black Rain" cases pose a challenge because establishing eligibility for those patients in fallout zones is difficult. "Black rain" inclusion criteria have expanded if illnesses are confirmed.
- Legal Battles have expanded recognition of survivors that were outside of the initial strict zone.

Hibakusha Provided Benefits

- Twice a year examination
- Health handbook certified Hibakusha eligibility
- Medical care and expense support for recognize atomic-bomb related diagnosis.

Created the Atomic Bomb Survivor Support Law

- Formalized eligibility categories of the Hibakusha, while expanding welfare, support mechanism and comprehensive medical care
- Provided funeral allowances, standardized medical treatments, structure the regular examinations, and tailored the welfare payments based on eligibility and atomic bomb related illnesses
- Utero Hibakusha continued to be eligible for full benefits.

Case Law and Expanded Recognition (1990-Present)

- Japan highest court finally ruled, in 2005, that Hibakusha living overseas must not be denied benefits on that basis alone.
- "Black Rain" exposed individuals outside of the original designated zones should be eligible for benefits and designation as Hibakusha.

Ongoing Disputes and Contemporary Policy (2000-2020s)

- Second Generation children of Hibakusha do not have medical benefits unless they were in utero at the time of the bombing. The argument in court is that they may have potential genetic abnormalities not yet manifested.

One of the biggest criticisms of those who survived the atomic bombs is that the Hibakusha zone was defined by existing local government boundaries (not radius) dictated by bureaucrats and not by the physical damage or measure of contamination. The distribution of fallout was uneven and dependent on various factors, including geography and weather – the notorious radioactive "black rain" fell on outlying regions, where the bomb had hardly been felt.

As the 80th anniversary of the bombings approaches, just under 100,000 registered Hibakusha remain alive, with an average age of 86.

The Atomic Bomb Casualty Commission was the predecessor of the Radiation Effects Research Foundation (RERF), which was established on 1 April 1975.

Radiation Effects Research Foundation (RERF)

The Radiation Effects Research Foundation was the logical evolution of the Atomic Bomb Casualty Commission. The focus of the RERF research program is to study the radiation effects in the survivors of the atomic bombing of Nagasaki and Hiroshima. Several fixed cohorts and sub-cohorts have been set up to provide epidemiological and clinical data on health status and mortality of survivors and their children. Laboratory-based research in the fields of immunology, genetics, molecular epidemiology, and radiobiology is conducted to interpret numerous findings and contribute to understanding of the disease – induction mechanism.

Past Results and Future Studies

1. Cancers of specific organs have increased among A-bomb survivors.
2. Non-cancer diseases (cataract, heart disease, stroke, benign thyroid tumor) have also increased among survivors exposed to high doses of radiation.
3. Survivors exposed to high doses of radiation tend to show deterioration of the immune system like that seen with aging.
4. Research, thus, far has not shown any genetic effects in A-bomb survivors' children.
5. Many survivors exposed to high doses of radiation exhibit minor inflammatory reaction.
6. Observations made to date have not confirmed increased mortality or cancer incidence among A-bomb survivors' children.

Cancers with Increased Incidence Among A-bomb Survivors

The number one type of cancer seen in citizens exposed to the A-bomb is **leukemia.** Deaths from breast, lung, colon, thyroid, and stomach cancer are known to have increased. Some cancers, such as prostate, uterus, pancreas, and others have not increased.

As early as 1947, Dr. Takuso Yamawaki began noticing higher than normal levels of Leukemia in exposed survivors. At that time, there was little research regarding the relationship of radiation and human health. Nowadays, the RERF's own research has concluded that Leukemia is the disease most susceptible to radiation. Hibakusha began to develop leukemia two years after radiation exposure, and peaked at about 6 to 8 years after exposure. The RERF compared the rates of normal unexposed Japanese population to those of the Hibakusha at various levels of exposure and found there was an increase of risk from 7 in

1000, to 10 in 1000. It may not seem to be much different, but we must remember that the increased risk will also be accompanied by an increase in mortality. For example, for those exposed within one Kilometer from the hypocenter (about I Gy of radiation), RERF research confirmed that "death by leukemia increased by 310%". Their risk of death overall increased by 47%. Solid cancer starts appearing around 10 years after exposure and continues to increase through today. The leukemia cases start to disappear at around eight years, and the RERF have none reported today.

There are many projected surveillances in place to identify trends of illnesses, both physical and psychological, in the Hibakusha population beyond the next 20 years.

Site	Relative risk
Leukemia	5.6
All cancers (excluding leukemia)	1.5
Esophageal cancer	2.2
Stomach cancer	1.4
Colon cancer	1.5
Lung cancer	1.8
Breast cancer	1.8
Urinary bladder cancer	2.2

Note: Average relative risk for survivors exposed at age 30, both sexes combined. Risk for leukemia based on data collected between 1950 and 1990.

Table I. Relative risk of death due to cancer at 1 Sv of radiation exposure (1957-1997)
A Sievert (Sv) measures the biological impact of radiation, standing for 1 Joule of energy absorbed per kilogram of tissue. 1 Sv=100 rem indicating significant risk.

Psychological Effects

The psychological effects of the atomic bomb survivors were not immediately study or identified as a potential, long-term sequela that needed care like the burns and other visible injuries. Death of family members and the inability to assist those around them provided a lifelong guilt and stigma that took years to be properly addressed by the Japanese government. The increased incidence of cancer as a late effect of radiation exposure, heightened survivors' anxiety, and fears. It was unclear in the 1940s to what extent symptoms reported by survivors where psychological or radiation induced.

It was not until the 1950s that psychiatrist in Hiroshima and Nagasaki reported increased complaints among A- bomb survivors of neurotic symptoms, including general fatigue, lack of concentration, and amnesia, as well as other symptoms commonly associated with autonomic nerve imbalance, such as palpitations, or a sense of chill or burning.

In 1962 Dr. Robert Lifton, an American psychiatrist who interviewed atomic bomb survivors in Hiroshima, observed, *"From the otherworldly grotesqueness of the scene and the image of neither-dead-nor-alive human figures, many victims had a sense that life and death were out of phase with one another and no longer properly distinguishable. Victims tried to protect themselves by psychological closing-off while* *suffering from shame and guilt over survival in the phase of others' death. These psychiatric effects became permanent and plagued them from then on."*

The women and men that had to deal with the stigma of not only their fertility but more importantly the potential deformities of their offspring due to the uncertainty of genetic damage by the radiation exposure. Questionnaires provided to A-bomb survivors by the RERF, and other research groups revealed many of the symptoms now described in post-traumatic stress disorder (PTSD), which are common in population exposed to disasters, terrorist acts, mass shooting, earthquakes, floods, and volcanic eruptions.

Survivors guilt, nightmares of the blast and fires, flashbacks triggered by loud sounds or bright flashes, severe anxiety during anniversaries or news about nuclear threats, depression, social withdrawal, emotional numbness, dizziness, headaches, and nausea are all part of what we know as PTSD. Added to the list is the effect of radiation on their DNA and the fear that mutation induced to living cells by the exposure, even 80 years ago. Mutations can be caused spontaneously over the years due to environmental mutagens, including radiation.

Political constraints during the Cold War and the desire to promote the peaceful application of atomic energy discouraged close examination of the psychological suffering of the victims of the atomic bombs. In 1956 a survey noted neurosis in 7.3% of survivors, higher in women and those with acute radiation sickness. During WW1, Dr. Sigmund Freud and his followers linked "shell shock" (now PTSD) to traumatic neurosis. The term interchanged with war neurosis and was later called combat stress reaction and now PTSD. In WW1 and WWII, 10% of soldiers became unfit for duty due to psychological breakdown caused by combat, a condition known as "shell shock".

The characteristics, then and now, of individuals exposed to traumatic events are the same. Hibakusha had flashback of the explosion and nightmares reliving the same events, irritability, emotional numbness, anxiety with sweating, and increased heart rate. People with this kind of trauma tend to stay away from places, persons, or activities that trigger memories. Loss of interest in previously enjoyable activities, insomnia, irritability and anger, and, difficulty concentrating.

Birth Defects among the Children of Atomic Bomb Survivors (1948-54)

No major birth defects or other untoward pregnancy outcomes of statistical significance has been seen among children of survivors. Nearly all pregnancies in Nagasaki and Hiroshima were monitored between 1948 and 1954. During that period, 76,626 newborn infants were examined by the ABCC physicians. The newborns were monitored for two weeks after birth, providing important information related to the birth weight, sex ratio, neonatal death, prematurity, and major birth defects. The most common defects seen at birth were cleft palate, cleft lip with or without cleft palate, clubfoot, anencephaly, polydactyly, and syntactically. These abnormalities accounted for 445 of the 594 (75%) malformations in infants. The incident of major birth defects was 0.91% among the 65,431 registered pregnancy terminations. In a large series of contemporary Japanese birth at Tokyo Red Cross Maternity Hospital, where radiation exposure was not involved, an overall malformation frequency was 0.92%. No untoward outcome showed any relation to parental radiation dose or exposure.

In Utero Babies During Explosion and Disabilities

The most vulnerable time for in utero babies was between 8 to 15 weeks after conception. Severe mental disability (brain damage, microcephaly, mental retardation, and seizures) has been diagnosed in 4.4% (21 of 476) in utero survivors where the doses were 0.005 Gy or greater, compared to 0.8% (9 of 1,086) where doses were below 0.005 Gy. These population had an increased risk of miscarriage, stillbirth, infant death, and later cancers. The initial studies show fewer major malformations than expected.

Infection Outbreaks Following Natural Disasters

To design a disaster risk reduction strategy, we need to understand the relationship between a natural disaster and infectious disease outbreaks. Most events associated with epidemics are FLOODS. Epidemics occurs when there is an increased incidence of the infections among the population over a period in a specific geographical area. Population displacement and crowded shelters result in an increased risk of exposure to pathogens and disease transmission. Poor sanitation, malnutrition, and overcrowding make populations at risk more vulnerable to communicable diseases.

Contamination of the water systems is a main reason for disease spread. The usual scenario is when the sewage networks mixing with water supply systems and with water bodies that people have contact with. Untreated water was the cause of many reported outbreaks like diarrhea, gastrointestinal diseases, and cholera. The risk arising from water contamination includes respiratory diseases as well.

Having an adequate water, sanitation, and hygiene (WASH) system during natural disasters, especially in developing countries, is crucial to prevent epidemics after natural disasters. The proper excreta disposal and solid waste management system, in conjunction with clean water supplies, hygiene products, and water sanitizers in cases where there are no potable water sources is vital to prevent long term consequences of infectious diseases. Vector surveillance and prevention of ideal breeding grounds will reduce the chances of outbreaks after a disaster. Socioeconomic factors play a role in the emergence of an epidemics, in general. In the 2012 floods in Fiji, Leptospirosis diseases were associated with twice the incidence rate than people in other communities with higher socio-economic status. To prevent the spread of infection during displacement situation, consideration must be given to the size and characteristics of the population displaced to include vaccination and immune status. Rapid response with vaccination campaigns, specially, for children may contribute significantly to preventing the spread of infection.

Leptospirosis

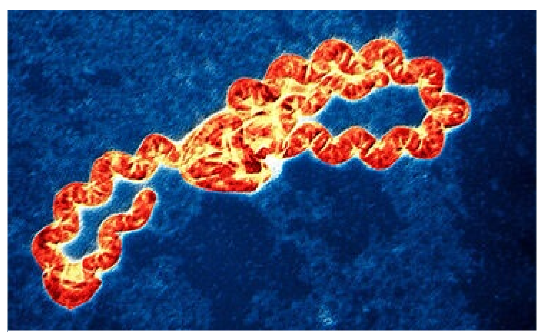

Figure 2. Leptospirosis

Bacterial disease from Leptospira bacteria spread through animal urine contaminated water or soil. Symptoms usually appear 5 to 14 days after exposures and are flu like initially with fever, chills, headache, and muscle ache. The patient also has nausea, vomiting, conjunctival suffusion, cough, hemoptysis, and chest pain. This initial phase can last 4-9 days. The immune phase is the 6^{th} to 12^{th} day, and it is the antibody response, the presence of bacteria in urine (especially kidneys), headaches, muscle pain, recurrence of fever, sometimes developing into severe complications, like meningitis or Weil's disease (jaundice, kidney failure). Another potential complication is pulmonary hemorrhage in the lungs, which is a major cause of death in these patients. The treatment of severe leptospirosis in hospital is IV antibiotics. Penicillin G is the golf standard, and ceftriazone is a suitable alternative. Only 10% develop Weil's disease, a severe form of Leptospirosis.

Unfortunately, chronic leptospirosis is seen in 30% to 45% of those infected. Lingering symptoms like fatigue, headaches, malaise, and muscle pain, continuing for months or even years after the acute infection. Persistent flu-like symptoms, eye pain (uveitis), chronic fatigue, depression, migraines, and significant kidney damage or fibrosis, as the bacteria lingers, causing inflammation and organ damage on a long-term basis. In the chronic phase, Leptospira bacteria evades the immune system and survives in the kidneys. The treatment is long term antibiotics.

Long Term Effects of COVID-19 (Post COVID Syndrome)

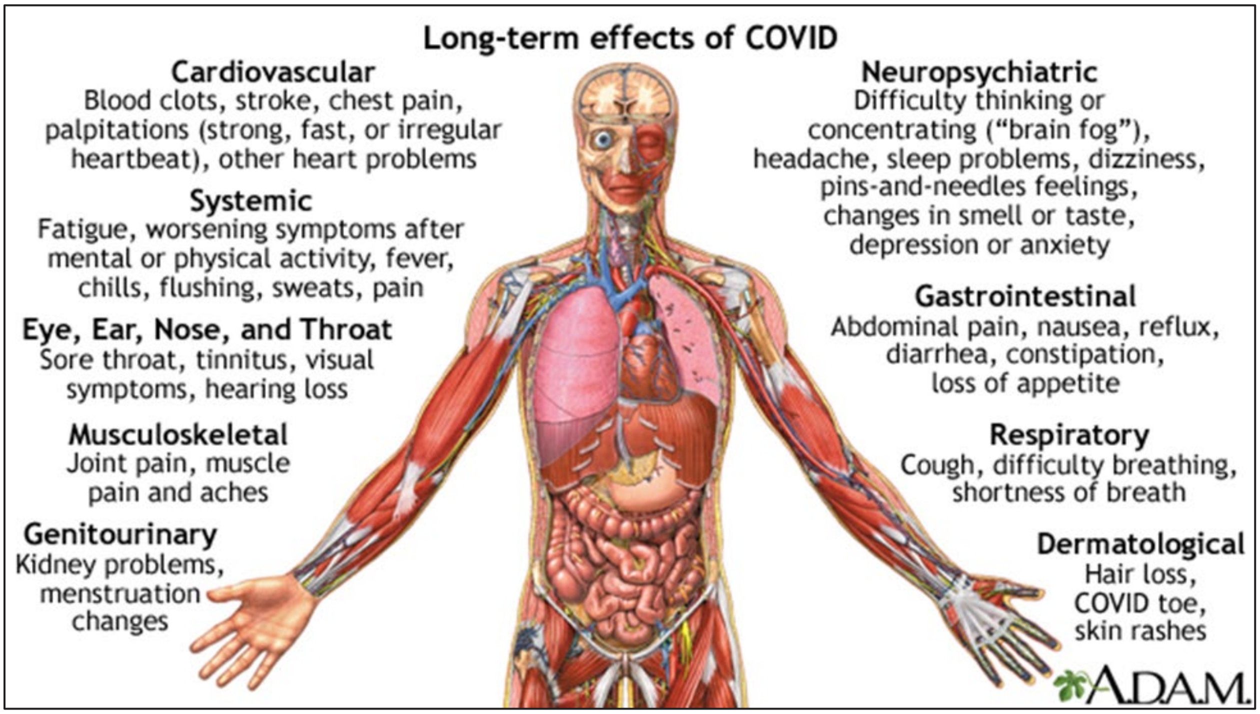

Figure 3. Long-term effects of COVID: MedlinePlus Medical Encyclopedia Image

Mild or moderate COVID-19 lasts about 2 weeks for most people, but for others, even when testing negative for the virus, the lingering health problem will come and go, affecting everyday functioning. There's no link between risk factors like smoking, diabetes, high blood pressure, obesity, and long-term problems in post-COVID-19. Patients with those risk factors are more likely to have a serious bout of COVID-19. Long term COVID-19 can happen to people with mild symptoms, but those with severe COVID-19 illness seem to be more likely to have long-term impairment. SARS-CoV-2 can attack the body in different ways, causing damage to the kidneys, liver, nervous system, heart, (arrhythmia, heart attacks, heart failure, myocarditis, blood clots, pericarditis), and lungs, as well as other organs. There is a mental health component arising from the grief and loss, as well as the long term symptoms. If you're vaccinated, you reduce the risk of long-term COVID-19 illnesses.

A severe case of COVID-19 can produce permanent damage in the lungs due to scarring. It can take months for a person's lung function to return to pre-COVID-19 levels. Respiratory therapy and breathing exercises can help expedite that process. Kidneys can potentially be damaged by COVID-19, sometime resulting in long-term kidney disease that may require dialysis.

Long-term loss of taste and smell can affect 25% of those infected with COVID-19. Some studies suggest that there's a 60 to 80% chance of improvement in sense of smell within a year.

Neurologic problems in long COVID-19 infection include fatigue, headaches, brain fog, and dizziness. This is an area of active research.

Post intensive care syndrome can occur in any patient spending extended time in the ICU and are at higher risk for problems with mental health, physical recovery, and cognition. Patient isolation, loss of control, mind altering medications, and strange surroundings, can leave patients with lasting and recurrence sensation of dread or terror, including PTSD.

Postural orthostatic tachycardia syndrome or POTS is a condition that affects blood circulation, and people that survive COVID-19 may be more vulnerable to it. Persistent post COVID-19 insomnia, or “COVID-somnia,” can be a typical symptom of POTS.

Treatment for Long-Haul COVID-19

By definition, long-haul COVID-19 is the patient with a wide range of symptoms that persist or start at least 3 months after the initial infection and linger without another clear differential diagnosis. Many trials are looking into immune modulating drugs for patient who developed POTS as a post-COVID-19 syndrome.

Phantom Limb Pain (PLP)

The feeling of pain or discomfort from an extremity that is no longer there is PLP, and it tends to present as a sequela of amputation. Patient that suffered traumatic amputation are more prone to develop PLP than elective amputations. The pathophysiology of PLP is poorly understood.

It is important to make the distinction between residual limp pain (stump pain), and phantom limp pain. Residual limb pain originates from an actual site in the stump due to a neuroma, infection, prosthetic fit issues, or wound healing post operatively. All issues in residual limb pain tend to resolve once the wound healing is completed. More than half of patients with PLP have residual limb pain.

Every year, an average of 30 to 40,000 amputations are performed in the United States. Eighty percent will experience some degree of phantom limb pain soon after surgery. PLP varies from person to person, but it can last seconds to minutes or hours or days. In most patients, PLP diminishes, both in duration and frequency during the first six months. Unfortunately many patients may suffer from this debilitating illness for years. Patients are reluctant to mention their pain to doctors or family members for fear that they will be considered crazy.

Etiology of PLP

There is still not a clear picture of the etiology of PLP, but researchers now believe that there is more definite central nervous system involvement. Utilizing pet scans and MRIs researchers have shown activity in the areas of the brain associated with the amputated limb during the episodes of PLP. The most recent theory is that the central nervous system and peripheral systems are involved. The spinal cord becomes more sensitive to pain signals, and even a mild signal can be interpreted as severe pain. Emotional factors, such as depression, grief, and stress do not cause the pain but intensifies and triggers the episodes.

Pathophysiology

One of the most promising research projects has been the recognition that cortical reorganization is one of the culprits for PLP. The areas of cortex that used to control the amputated part of the body are taken over by adjacent sections of the brain in both the primary somatosensory and motor cortex. There is a direct correlation between the amount of pain the patient may feel and the extent of cortical reorganization. Strong psychological components are involved in patients with chronic pain. We know that PLP can often develop into a chronic pain syndrome that will require patient’s pain behavior and pain processing to be addressed. The development and treatment of phantom limb pain is clearly multi factorial. The pain in PLP is generated by the brains interpretation of information that never comes, the absence of information becomes very real pain.

History and Physical

The patient with phantom limb pain usually complains of tingling, sharp, throbbing, pins/needles in the limb that no longer there. Make sure the skin has no infection or open wound. Test sensation of the stump looking for hyperalgesia and allodynia. Check the joint above the amputation for signs of dysfunction. The diagnosis of PLP is a diagnosis of exclusion and dependent on the history the patient provides. For unknown reasons, upper extremity amputations tend to be associated more often with PLP. A psychological evaluation is also indicated to identify other triggers.

Treatment of PLP

Unfortunately, there is not a single treatment 100% successful for patients that suffer PLP. PLP is focuses on systematic control. Tylenol and other NSAIDs are the most used treatment for PLP. Antidepressants are also used to treat PLP. Most patients get treated with Amitriptyline. In a six week randomize trial between placebo and Amitriptyline involving 39 patients, there was no significant difference between the two arms. Anticonvulsants (Pregabalin, Gabapentin) have shown mixed results. Cochrane review showed a slight benefit with Gabapentin. Opioids, in combination with antidepressants or neural modulating agents like gabapentin, have demonstrated effectiveness of opioids like tapentadol for neuropathic pain.

N-methyl-d-aspartate (NMDA) receptor antagonist mechanism to help with pain is not clear. Ketamine with dextromethorphan have shown benefit treating pain syndromes. In the Cochrane review of 6 studies looking at Memantine vs placebo, there was NO statistically significant improvement in pain between the groups. There is level 2 evidence to support the use of Ketamine to treat PLP.

The use of botulinum toxin type B injections is currently used to treat hyperhidrosis in the post amputation patient. Increased sweating hinders the use of the prosthetic limbs, but it can adversely affect the course of RLP and PLP. In small studies, botulinum toxin type B reduces sweating, RLP and PLP.

Figure 4. Mirror Therapy for Stroke Hemiplegia and Phantom Limb Pain

Mirror therapy in a small, randomized study showed significant benefit to patients with PLP. It takes consistency, but a 5-to-10-minute session every day for 4 to 6 weeks has provided superior results for some patients. You are retraining your brain to not feel the pain by moving the foot and extremity in the mirror. The mirror image becomes your missing limb.

Virtual and augmented reality is an advanced form of mirror therapy that mimics the movement of the missing extremity with the use of a headset. Repetition and a positive attitude have shown good results reducing PLP. Available studies have been conducted with smallpatient samples.

Surgery for Phantom Limb

Surgery should be the absolute last resort in treating PLP. The most common approach is Targeted Muscle Reinnervation (TMR) surgery. The procedure splits the ends of nerves and place them into new muscles. The surgical procedure allows robotic limbs to read signals for the muscles and prevent or decrease pain.

COMMON CHALLENGES WITH INSURANCE COVERAGE

- Coverage Limitations
- Pre-Authorization Requirements
- Experimental or Not Medically Necessary Denials
- "Fail First" Policies (Step Therapy)
- Lack of Specific Policies
- Out of Pocket Cost

PLP is best managed by a multidisciplinary team with an emphasis on starting treatment with a non-pharmacological, conservative approach. A mental health nurse and psychotherapist should be involved from the beginning to deal with anxiety and depression. A pain specialist should provide the pharmacological regimen if needed. A transparent multidisciplinary team will avoid the unfortunate reality of patients with PLP "doctor shopping" and try many non-conventional and conventional therapies. The issues with the medical insurance companies are added stress that patients must endure unless legislation is passed protecting their rights to receive support for chronic pain management, including PLP.

Disasters, Terrorism and Mass Shooting

Natural disasters, mass shooting, and acts of terrorism kill hundreds of thousands of people every year around the world. Tornadoes, wildfires, extreme temperatures, hurricanes, and earthquakes, just to name a few are occurring more frequently and with greater intensity. The US alone experiences an average of 18-billion-dollar climate disasters every year. Severe storms have caused the highest number of billion-dollar disasters (99) in the last decade, followed by tropical cyclones (24), flooding (17), droughts (10), and wildfires (9).

Figure 5. A fiery blast rocks the World Trade Center after being hit by two planes September 11, 2001, in New York City. Spencer Platt/Getti Images

Floods will affect you at some point as 90% of natural disasters in the U.S. involve flooding. Nearly all 99% of U.S. counties were affected by flooding between 1996 and 2019. **The National Flood Insurance Program payout average was $52,000 per claim. In 2022, Washington State had the highest number of flood insurance claims.** Due to the risk and cost for reconstruction of the damaged properties, certain areas of the country have no way to get insured. The frequency and intensity of disasters have prompted insurance companies to increase policy rates.

The Long-Term Health Consequences of Disasters, Mass Shooting, and Terrorism

The physical and mental health consequences of disasters and mass traumas are well documented in high profile disasters, including the March 11, 2004, train bombing in Madrid, hurricane Katrina on the US Gulf Coast, and the terrorist attack on September 11, 2001, in New York City. These events are associated with psychological illnesses, not only on the people directly affected by the event, but also among special groups, including rescue workers. There is evidence that considerable physical illness occurs after these events, over and above initial trauma related injury, and psychological illnesses occur not only in the short term, but also persist long after the event.

Morren's and colleagues studied the Enschede firework explosion disaster in the Netherlands in May 2000 that killed 23 people, including 4 firefighters, and injured 950 others. The exuding fire destroyed 400 homes and damaged 1500 buildings. Rescue workers who were healthier and younger than the general population were part of the group studied. Physical health in this group was a persistent concern long after a disaster, highlighting the impact that mass trauma and disasters have on our well-being. As expected, the most common psychological consequences are Post Traumatic Stress Disorder (PTSD), depression and generalized anxiety disorder. Populations involved in this kind of disaster tend to increase substance use.

The pathologies in descending order of burden are:

1. People directly injured during the disaster, terrorist attack, or mass shooting
2. Rescue workers
3. People who lost property belongings and their homes
4. The families of those injured
5. The general population

Physical pathology and psychopathology co-occur after disaster and mass trauma.

- Patients with physical injuries or illness are more likely to experience psychological problems
- Patients with psychopathology are more likely to become physically ill

The fact that there is a chance that physical and psychological symptoms will persist for several years after exposure to a mass casualty, terrorism, or disaster has implications for clinicians, regional health systems, and the medical insurance industry. Morten and colleagues found evidence of delayed increases in symptoms years after the disaster event or mass trauma. We need more studies that can elucidate the trajectory of physical symptoms caused by a disaster or mass trauma, and the mechanism that links trauma with physical and psychological symptoms that become chronic or manifest months or years later.

Las Vegas Mass Shooting

On October 1, 2017, over 22,000 people attended the yearly held Route 91 Harvest Festival in Las Vegas, Nevada. On the final night, a lone shooter opened fire from the 32nd floor of the Mandalay Bay Resort and Casino. For 10 minutes 1000 bullets rained down on the open space where the concert was held. At the end of those 10 long minutes, 58 people were dead and 867 injured. Two more later died from their injuries, making the tally to 60 deaths. The 867 injured included gunshot wounds (GSW), falls, trampling and psychological injuries. From the 867 injured, 413 were wounded by GSW or fragments of bullets after ricochet on the ground or other structures.

According to a study published by Johns Hopkins School of Medicine, US Firearm related injuries total about $2.8 billion annually in initial emergency department and inpatient charges alone. If you add physical therapy, medications, trauma counseling, loss of income, and legal claims you are talking about $45.6 billion annually. The fact that the worst mass shooting was never considered an act of terrorism is the main reason it did not receive the support of the federal government under Staffort Act and FEMA.

In Las Vegas, medical charges for approximately 500 injured or killed range from 2.6 million to 48 million. A lead expert on injury and violence at the Pacific Institute of Research estimated that the massacre will cost around $600 million, when you add medical bills, loss of productivity, mental health therapy, rehabilitation, and legal claims. Two thirds of the injured survivors had no medical insurance. Even patients with good insurance due to high deductibles, denied claims, out of network bills, and copayments. The majority of the uninsured were covered by Medicaid and Medicare. A GoFundMe account by Clark County commissioner raised a total of 20 million dollars to help the shooting victims. Sunrise Hospital and Medical Center, as well as Valley Hospital Medical Center, were sensitive and considered each patient's financial situation before billing the out-of-pocket portions. In Nevada, there is a program called Nevada Victims of Violent Crime, which also paid survivors bills.

As the spotlight shifted to a new disaster or world event, the survivors are left with long term consequences and complications of that horrific event. A recent study published by JAMA Network Open revealed that even 4 years after the tragic event, a considerable number of survivors and witnesses continued to suffer from severe mental health issues. More than 50% of concertgoers reported experiencing major depressive episodes in the past year, while more than 63% describe symptoms of PTSD. Many of the individuals surveyed continue to receive care at the Las Vegas Strong Resiliency Center, which is supported by the US Department of Justice Office for Victims of Crime. A survey performed in 2021 of 177 participants revealed the same findings reported by the JAMA group. Participants who were physically injured were 36% more likely to have experienced a major depressive episode, and 32% more likely to suffer from PTSD, compared to people who were not injured. Another critical factor identified in the study is that those patients with low social support are 50% more prone to have issues with PTSD and depression. All the studies pointed to the need for immediate and sustained (long-term) mental health care for survivors and their families after disasters, acts of terrorism and mass shooting.

Mental Health Access, Shortage of Mental Health Providers and Red Tape

The problem is accessibility to mental health providers and the fact that insurance companies usually had a limit of 20 visits (hard caps) per patient a year for mental health care. In 2008, congress passed the Mental Health Parity and Addiction Equity Act (MHPAEA), requiring health insurance plans to cover substance use disorder and mental health treatments as favorably as surgical/medical care, meaning visit limits, copays, and medical necessity rules could not be stricter for behavioral health than physical health. Insurance companies circumvent that law by requesting re-assessment of "medical necessity" every 10 visits. Medicaid benefits can differ by state on this rule. Part of the problem found, even as early as 1918 after the Spanish Flu, is the notion that mental health impacts of a disaster hit around 18 months later, which is what the Substance Abuse and Mental Health Services Administration (SAMHSA) has categorized as the "psychological recovery phase." FEMA provides short-term mental health care initially for 60 days under the Crisis Counseling Assistance and Training Program (CCP) and Immediate Service Program (ISP). If the disaster or terrorist act had a presidential major disaster declaration, the mental health can be extended to 9 months under the Regular Service Program (RSP). In exceedingly rare instances, FEMA can extend the RSP up to another 9 months (total 18 months) if the state can prove ongoing disaster-related mental health needs. The duration of the program is set by regulation. In the past, the mental health care of survivors, once FEMA left, was up to the state. Some funds come from federal grants administered by the Substance Abuse and Mental Health Administration (SAMHSA). There are various resources, available year-round, regardless of FEMA's, presence like local and state health departments, non-profit organizations, disaster distress helpline, disaster case management, and national resources (CDC, National Alliance on Mental Illness (NAMI)).

On December 23, 2022, the Post-Disaster Mental Health Response Act was signed into law in a response to the Boston marathon survivors. It advocated expansion of mental health services for emergency declarations, in their case secondary to terrorism. Now, this law expands eligibility for FEMA's Crisis Counseling Assistance and Training Program (CCP), which provides short term mental health resources for survivors of "Major Disaster Declarations" but NOT for "Emergency Declarations." In the last decade alone, there have been more than 4,000 Emergency Declarations in 37 states and 72% of all congressional districts. None of those patients received FEMA mental health support, but from now on, they will. **The bill DOES NOT cover long term mental health care,** which is the **elephant in the room**. It is a good start, but it does not cover that second wave of mental health issues described in every retrospective and prospective mental health analysis.

In the case of the Las Vegas shooting, FEMA just drafted an after-action report. It did not take part in any way, since Las Vegas shooting was not declared a terrorist act.

The shortage of behavioral health professionals and the bureaucratic red tape the mental health providers must endure to get paid has forced many to not accept insurance plans and serve only patients that pay out of pocket. Right now, 1/3 of the mental health providers stopped accepting insurance entirely, opting for only private pay models to avoid insurance denials, low reimbursement, and audits, even years after the service was provided. By 2037 the Health Resources and Services Administration projects shortages of nearly 88,000 mental health counselors and 114,00 addiction counselors.

The solution is policy change to remove insurance challenges, and bureaucratic inefficiencies designed to stall payments. The federal Mental Health Parity and Addiction Equity Act (MHPAEA) has been a step forward. The Act has provisions to cut down on red tape. It is important that patients and providers report any issues to their state insurance board or the Department of Labor.

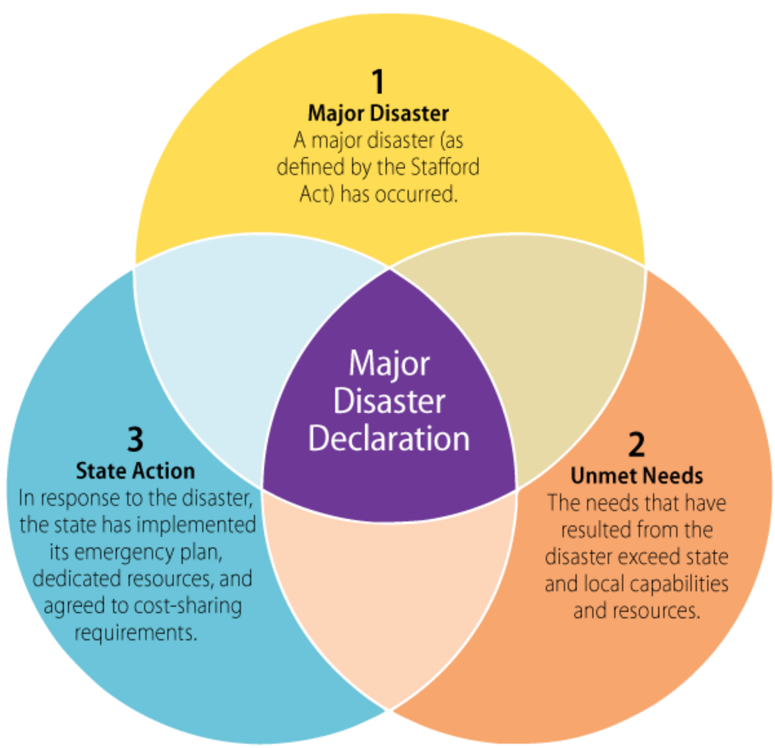

Figure 6. Major Disaster Declaration Criteria

Possible Funding Solutions after Disasters, Terrorist Acts, and Mass Shootings

As described in this article, one of the essential elements to provide long-term care to patients affected by disasters, mass shootings and terrorist acts is MONEY!!!! What funds, grants, or monetary resources will be available for affected patients in perpetuity? Two examples come to mind: the Asbestos Trust Funds (ATFs) and the September 11 Victim Compensation Fund. These funds are extremely specific for people affected by specific tragedies or exposure to carcinogenic fibers. They are examples of funds that can be legislated to help victims of disasters, mass shootings, and terrorist acts.

Asbestos Trust Fund

Asbestos is a group six mineral fibers that are known for their resistance to heat, corrosion, and electricity. It was used for construction materials and insulation due to its durability. The problem is that asbestos is carcinogenic and can lead to serious health issues, including lung cancer and mesothelioma. **Asbestos-containing materials (ACM)** manufacturers hid the truth about the dangers of asbestos for years. As early as the 1930s, health authorities warned the American people that asbestos was a carcinogen, and exposure would eventually increase the risk of developing mesothelioma or asbestosis. In the 1980s, many liable companies declare bankruptcy, due to the increased number of lawsuit files against them. Starting in 1955, the **Air Pollution Control Act (APCA)** was the first piece of legislation to identify asbestos fibers as toxic. In the 1970s doctors were diagnosing thousands of cases of mesothelioma and asbestosis, causing a flight of lawsuits against negligent, asbestos companies. In the late 1980s, the EPA tried to do a complete phase-out and ban all ACM. This effort was struck down in court. Manufacturers continue to put profits above safety and health of the population. In 1988, Congress enacted the **Asbestos Information Act (AIA)**. This legislation was designed to force manufacturers to label asbestos products with warnings of their potential health hazards.

In 1990, there was a growth of public fear of asbestos exposure. Congress enacted the **Asbestos Hazard Emergency Response Act (AHEA)** and declared a national emergency to deal with asbestos control. The primary target was addressing asbestos in schools and forming the first group of accredited asbestos inspectors. Asbestos litigation became the largest tort in the late 20th century. Certain civil acts were passed to deal with the incredible number of asbestos related litigations. Today, it is the longest-running mass tort in American legal history.

<u>Bankruptcy Reform Act of 1994</u> – allowed Asbestos companies to seek Chapter 11 protection of the U.S. Bankruptcy Code and establish an independently managed asbestos trust fund to pay the claimants.

<u>Fairness in Asbestos Injury Resolution (FAIR) Act of 2006</u> – intended to streamline the thousands of asbestos lawsuits in the U.S. civil courts. Critics complain this act is unfair to both defendants and plaintiff.

<u>Asbestos is NOT fully banned in the United States!</u> – There are currently 60 active asbestos trusts holding over $30 billion for victims. More than 70 asbestos manufacturers have created funds after bankruptcy. It is estimated that $20 billion has been paid since the 1980s as compensation for individuals diagnosed with asbestos related diseases.

<u>September 11th Victims Compensation Fund (VCF)</u> – This legislation also known as 9/11 Victim Compensation Fund and was created by Congress just days after the terrorist attacks of September 11, 2001. The main objective was to compensate victims quickly and fairly without needing proof of fault, avoiding years of litigation. The second objective was prevention of massive lawsuits against the airline and related industries. The Victims who accepted the VCF payoff waived their rights to sue the airlines or any other related industry. The fund was initially administered by the U.S. Department of Justice. The current tally is $7 billion paid to over 97% of eligible families. Due to the long-term consequences of ground zero exposure and the thousands of responders, residents, and survivors who developed cancers and chronic illnesses, the VCF now exists to compensate long-latency illnesses.

CONCLUSIONS

I hope this presentation immerses the reader in the sobering reality faced by thousands who, through no fault of their own, endure the long-term consequences of disasters, terrorist acts, and mass shootings – often in silence. The data exist. The mechanisms exist. What is missing is sustained action to repair a system whose attention span rarely extends beyond two weeks.

The SECOND WAVE remains largely invisible, obscured by the speed of the news cycle and by our collective reluctance to confront long-term complications – particularly those that are unseen, such as PTSD and other psychological injuries.

By contrast, the systematic, ethical, and humane long-term care provided to survivors of the atomic bombings of Hiroshima and Nagasaki by Japan and the United States stands as a model of what is possible. Since 1957, the Atomic Bomb Casualty Commission (ABCC), and later the Radiation Effects Research Foundation (RERF), has provided an unparalleled scientific foundation for radiation protection worldwide. More importantly, these institutions established a durable framework for lifelong survivor care. This framework offers a roadmap toward a gold standard for long-term care of survivors of disasters, mass shootings, and terrorist acts. Funding, personnel, and political agenda will remain the only meaningful barriers to a future in which those affected by catastrophic events are no longer relegated to the margins of society.

I have presented concrete legislative strategies to improve survivor outcomes – strategies that would ensure equitable distribution of funds, remove unnecessary bureaucratic barriers within insurance systems, and deter fraudulent exploitation of resources intended for survivors. My hope is that, in the near future, legislators enact a Mass Violence Compensation Fund designed to close the persistent gaps in care for survivors who fall outside the current statutory definitions of disaster or terrorism.

This critical fault line in our system – one that can be repaired if we work collectively to establish a safety net without an expiration date. A safety net for survivors – not “victims” (never victims) – of mass shootings, disasters, and terrorist acts.

Remember: you have the power to make a difference – starting today.

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WHEN THE DUST SETTLES: THE ART OF AN EFFECTIVE AFTER ACTION REPORT

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I. INTRODUCTION

A. Overview of disaster response complexity

B. Importance of performance evaluation following incidents

C. Definition and role of After-Action Reports (AARs)

D. Variability in AAR effectiveness across organizations

II. PURPOSE AND ORGANIZATIONAL VALUE OF AFTER-ACTION REPORTS

A. Capturing lessons learned

B. Improving preparedness and response capabilities

C. Enhancing interagency coordination

D. Supporting accountability and transparency

E. Preserving institutional knowledge

III. FOUNDATIONAL PRINCIPLES OF EFFECTIVE AFTER-ACTION REPORTS

A. Objectivity and Evidence-Based Analysis

1. Importance of data-driven evaluation
2. Use of operational logs, communication transcripts, and outcome data
3. Example: Ambulance response delays caused by logistical barriers

B. Inclusiveness and Stakeholder Engagement

1. Incorporating frontline responder perspectives
2. Multi-agency participation
3. Example: Wildfire evacuation patient loading improvements

C. Timeliness

1. Importance of rapid post-incident evaluation
2. Impact on participant recall and engagement

D. Actionability

1. Importance of measurable corrective actions
2. Components of actionable recommendations

E. Psychological Safety and Organizational Culture

1. Encouraging honest feedback
2. Avoiding blame-focused evaluation
3. Impact on learning and participation

IV. CORE COMPONENTS OF AN EFFECTIVE AFTER-ACTION REPORT

A. Executive Summary

1. Purpose and leadership value
2. Strategic communication of findings

B. Incident Overview

1. Event timeline and scope
2. Participating agencies
3. Operational objectives
4. Example: Flood disaster response overview

C. Methodology

1. Data collection methods
2. Surveys, interviews, and document review
3. Importance of transparency and credibility

D. Capability-Based Performance Analysis

1. Evaluation of operational functions
2. Alignment with preparedness frameworks

E. Strengths and Areas for Improvement

1. Reinforcing successful practices
2. Identifying systemic operational gaps

F. Improvement Plan

1. Converting findings into corrective actions
2. Assigning responsibility and timelines
3. Performance monitoring

V. METHODOLOGY FOR DEVELOPING EFFECTIVE AFTER-ACTION REPORTS

A. Pre-Incident Evaluation Planning

1. Establishing performance benchmarks
2. Developing documentation procedures

B. Data Collection Strategies

1. Operational documentation review

2. Performance metric analysis
3. Qualitative participant feedback

C. Facilitated After Action Meetings

1. Structured discussion techniques
2. Role of facilitators
3. Encouraging collaborative evaluation

D. Root Cause Analysis

1. Identification of systemic issues
2. Use of structured analytical tools

VI. COMMON PITFALLS IN AFTER-ACTION REPORT DEVELOPMENT

- Blame-focused analysis
- Litigation and Criminal Investigations
- Vague or non-measurable recommendations
- Failure to track implementation of improvements
- Excessively technical or lengthy reports
- Reduced usability for leadership decision-making

VII. BEST PRACTICES FOR EFFECTIVE AFTER-ACTION REPORTS

A. Use of Standardized Evaluation Frameworks

1. Homeland Security Exercise and Evaluation Program (HSEEP)

B. Leadership Engagement

1. Role of executive support in improvement implementation

C. Improvement Tracking Systems

1. Monitoring corrective action progress
2. Ensuring accountability

D. Integration of Technology

1. Incident management software
2. Geographic information systems
3. Communication archives
4. Example: GIS mapping of disaster response performance

VIII. ORGANIZATIONAL CULTURE AND CONTINUOUS LEARNING

A. Influence of transparency and accountability

B. Leadership responsibility in promoting learning environments

C. Example: Military structured AAR processes

IX. CASE STUDY APPLICATIONS IN EMERGENCY MANAGEMENT AND HEALTHCARE

A. Disaster response coordination lessons

B. Flood response communication improvements

C. Public health emergency evaluation

D. Active Shooter incidents

X. CONCLUSION

A. Summary of effective AAR development principles

B. Importance of structured and inclusive evaluation

C. Role of AARs in strengthening emergency response capability

D. Emphasis on continuous organizational learning E. Final statement on the importance of evaluation in public safety and disaster response

MEDICAL DISASTER RESPONSE 2027

Sunday • March 14, 2027

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ADVANCE REGISTRATION FORM

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Mary Allen, Program Coordinator
Trauma & Critical Care Foundation
6300 West Loop South, Suite 655
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Call (713) 798-4557 or e-mail (redstart@aol.com) if you have questions about either conference.

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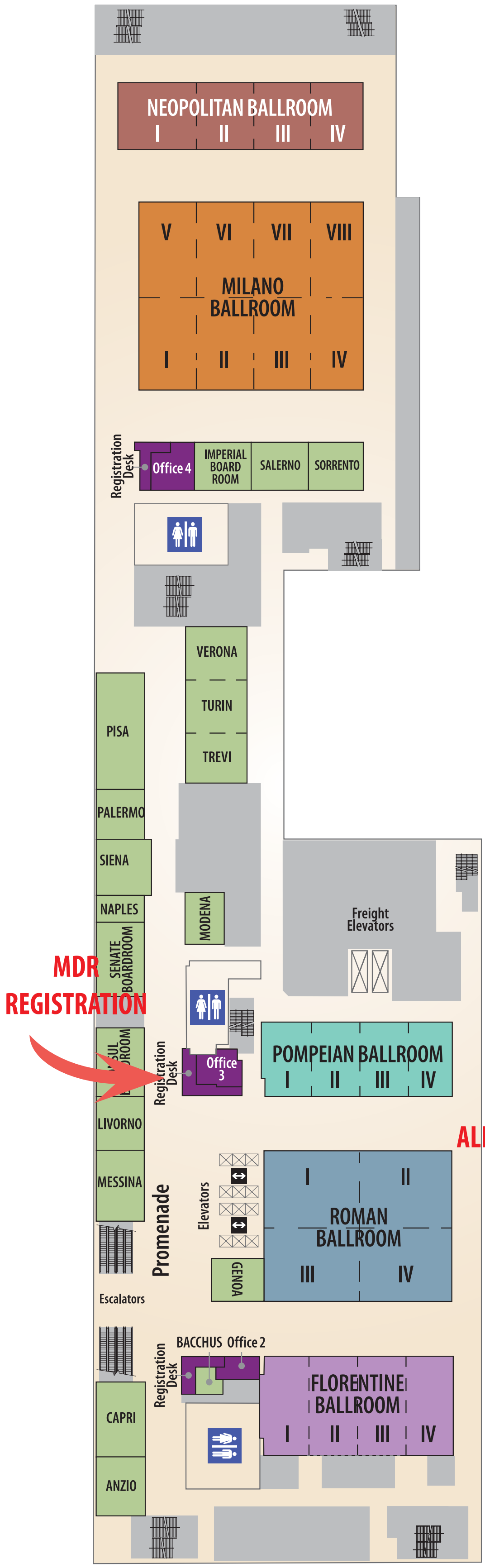
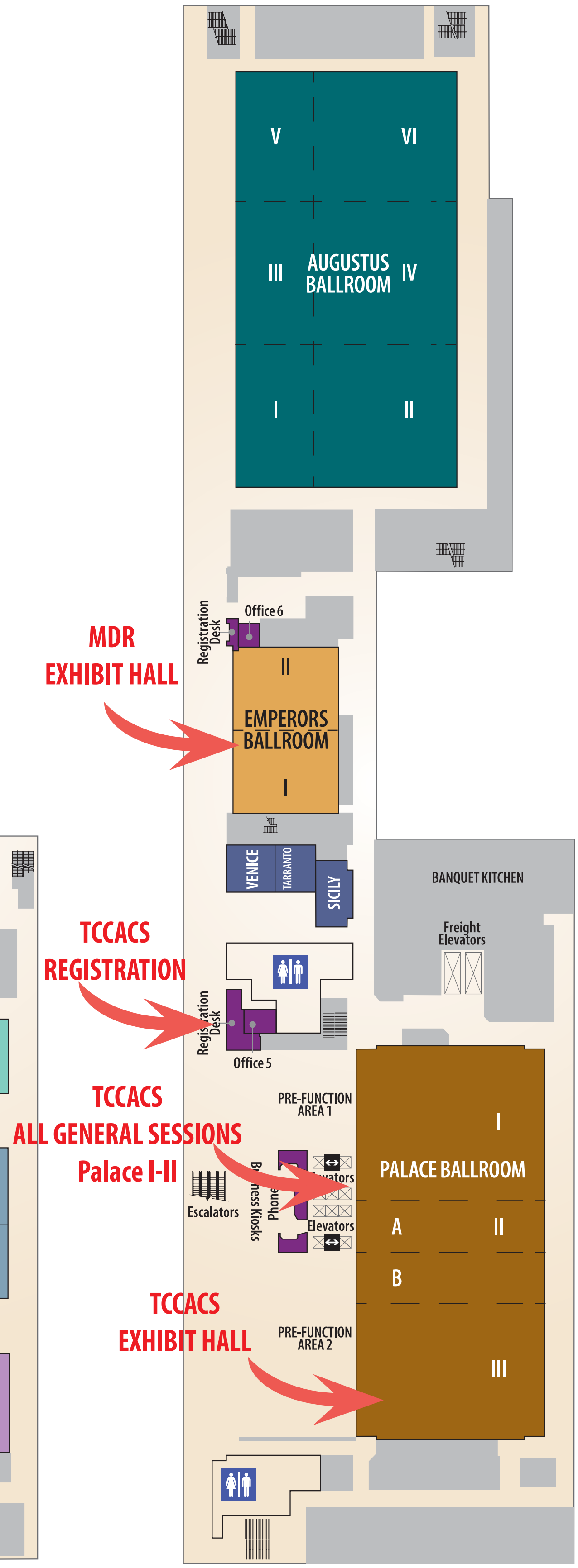
PROMENADE LEVEL



EMPERORS LEVEL



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