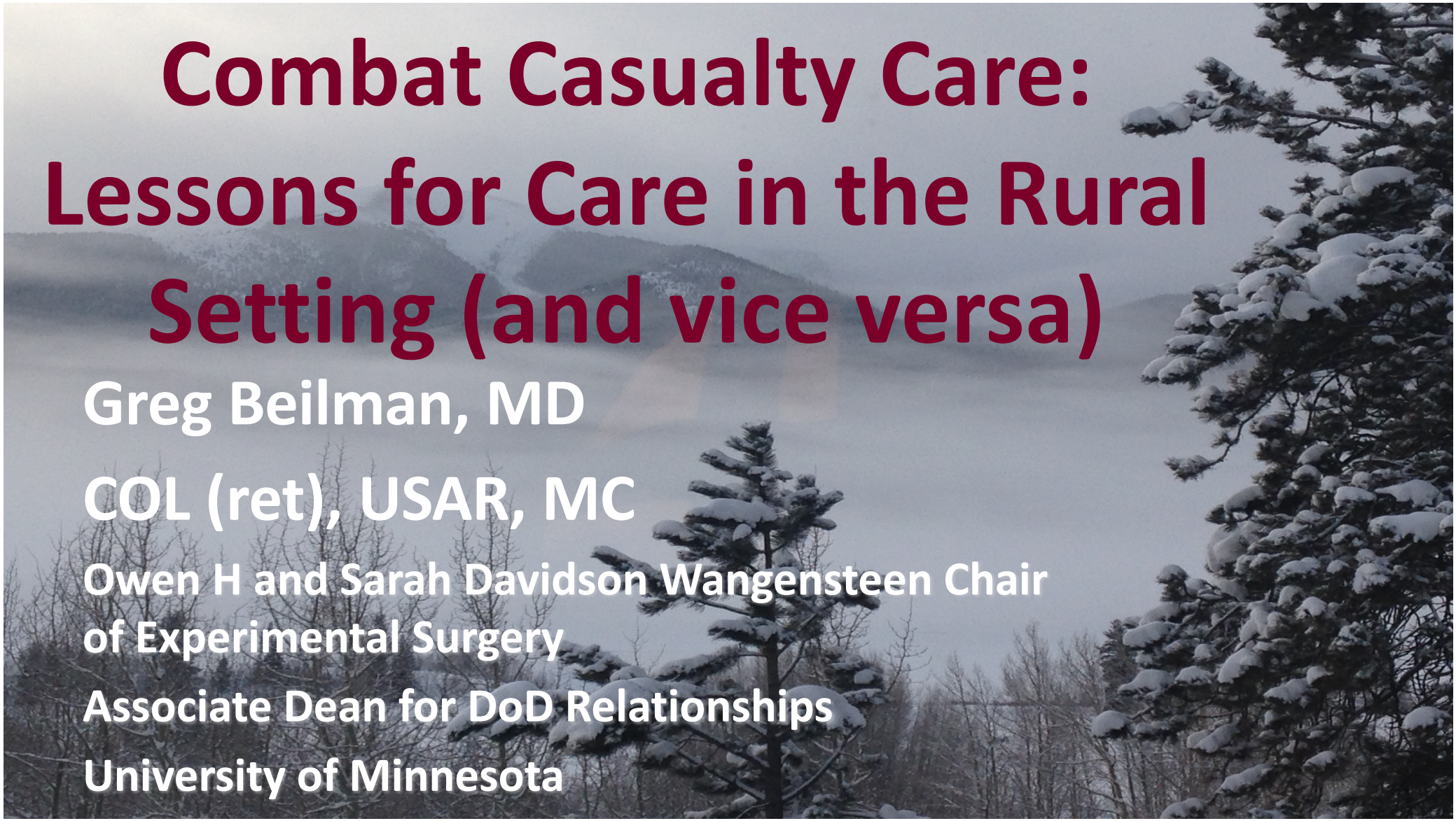


Combat Casualty Care: Lessons for Care in the Rural Setting (and vice versa)

Greg Beilman, MD

COL (ret), USAR, MC

Owen H and Sarah Davidson Wangensteen Chair of Experimental Surgery

Associate Dean for DoD Relationships

University of Minnesota

Disclosures/Disclaimer

- **Many pictures from internet! These are displayed using the doctrine of "fair use" as an academic use of this material**
- NIH: T32, P, and R grants
- DoD: 2 grants
- Patent holder: BHB/melatonin
- Industry: 3M, Boston Scientific

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

Gadeamus igitur, by John Stone, 1983

…For this is the day you know too little
against the day when you will know too much

For you will be invincible
and vulnerable in the same breath
which is the breath of your patients

For their breath is our breathing and our reason
For the patient will know the answer

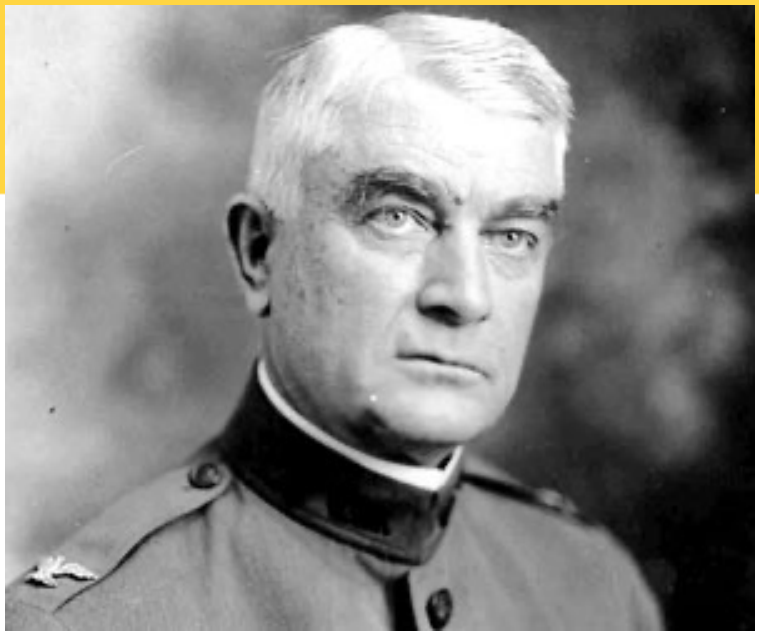
and you will ask him

ask her…

Fleming, Bettendorf, JAMA June 9, 2023

Outline

- History of Combat Casualty Care
- The Last War
- The Next War
- What does this have to do with Minnesota?
- Efforts of TCRTC



"He who wishes to be a surgeon should go to war"

-Hippocrates

"Medicine is the only victor in war"

–William J Mayo

Ambrois Pare

- French Barber Surgeon
- 1510-1590
- Pioneer of Battlefield Medicine
- *“I bandaged him, God healed him”*
- Ligature for bleeding wounds

The Civil War 1861-65

- The bloodiest US war (750,000 deaths)
- Most injuries from musketry
- Advances
  - US Sanitary Commission (too late!)
  - Three-tiered evacuation system
- Most common operation: Amputation
- No understanding of germ theory

International

JONATHAN LETTERMAN
He went on from Antietam.

Fabian, J Trauma, 2017

Blood Transfusion

If any single medical program can be credited with the saving of countless lives in World War II and in the Korean War, it was the prompt and liberal use of whole blood. **Lt General Leonard D. Heaton**

FIGURE 159.—Administration of plasma on beach, only few feet from surf, to survivor of landing craft sunk off coast in first days of invasion of Normandy, June 1944.

Brooke Army Medical Center/ISR

- Established 1947: focused initially on mass casualties due to nuclear thermal injury
- Major advances in Burn and Combat Casualty Care over ensuing 5 decades
  - Initial resuscitation of Burn Injuries (Brooke formula)
  - Extensive characterization of metabolic stress response
  - Long-distance aeromedical evacuation of injured patients
  - Extensive research in multiple areas of combat casualty care

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Costs of War: GWOT

- DoD costs (CENTCOM): $2.3 trillion
- US Costs: $8 trillion
- **7,054 US servicemembers killed, 58,802 wounded**
- **900,000 deaths: US military members, allied fighters, opposition fighters, civilians, journalists, humanitarian aid workers**

Brown University, Cost of War Project, Apr 2023

Global War on Terrorism

- Rapid Hemorrhage control
  - Tourniquets
  - Training
  - DCR
  - Pharmacologic adjuncts
- Tools
- Training
- Systems

"One hospital, three continents"

Combat-Related Trauma
IED, IDF, GSW

< 1 hour	2-3 days	12 hours	1-4 days	12 hours	3 months
Field care TX to Role II or Role III facility En route care Hemorrhage control	1º resuscitation 1º surgical stab In-theater TX to Role III 2º surgical eval, care	CCATT TX To Role IV (LRMC)	Ongoing surgical stab Initial Dx and Rx of Complications (ARDS, Renal failure, PE, others) 1^0 Eval of Blast injury	CCATT TX To Role V in CONUS	Definitive surgical Rx ID and Rx of complications Rehabilitation
Role I	Role II, Role III		Role IV		Role V

The Next War

- Near-peer conflict
- Lack of air superiority
- Large scale dispersed operations

Implications for CCC

- Several days before evac to higher level of care
- "Golden hour" no longer possible
- Lower level of expertise (independent duty corpsmen)
- Prolonged Casualty Care:
  - **Stabilization of shock**
  - Pain control
  - Airway management
  - Standard nursing care

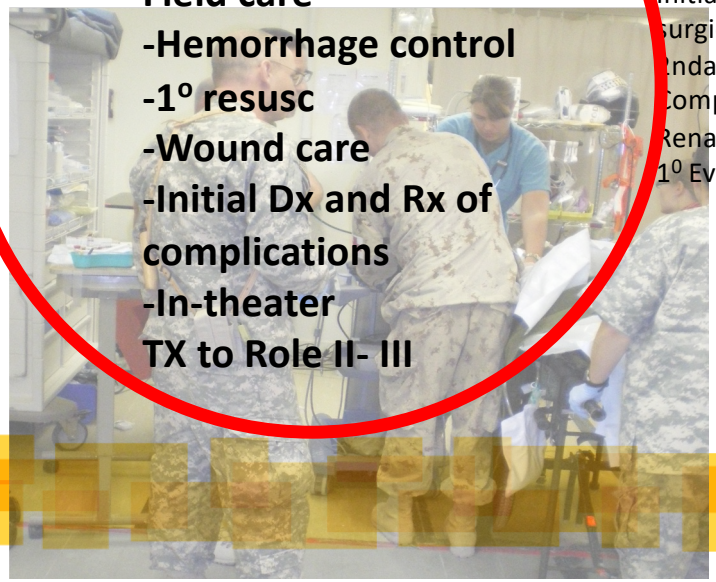
“One hospital, three continents??”

Combat-Related Trauma
IED, IDF, GSW

Role I-II

3-5 days

Field care
-Hemorrhage control
-1º resusc
-Wound care
-Initial Dx and Rx of complications
-In-theater TX to Role II- III



Role II, Role III

2-3 days

Initial and secondary surgical stab
Secondary Dx and Rx of Complications (ARDS, Renal failure, PE, others)
1º Eval of Blast injury

1 week to 3 months

CCATT TX
To Role IV or V in CONUS

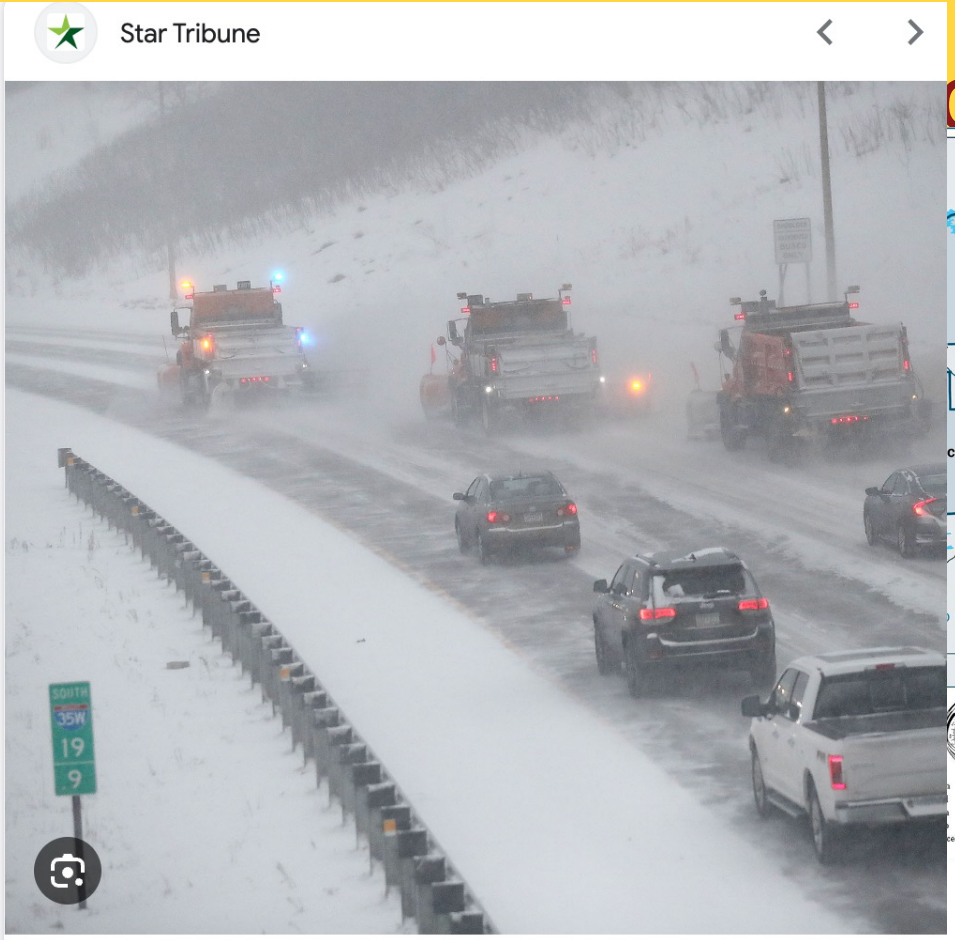
Definitive surgical Rx
ID and Rx of complications
Rehabilitation

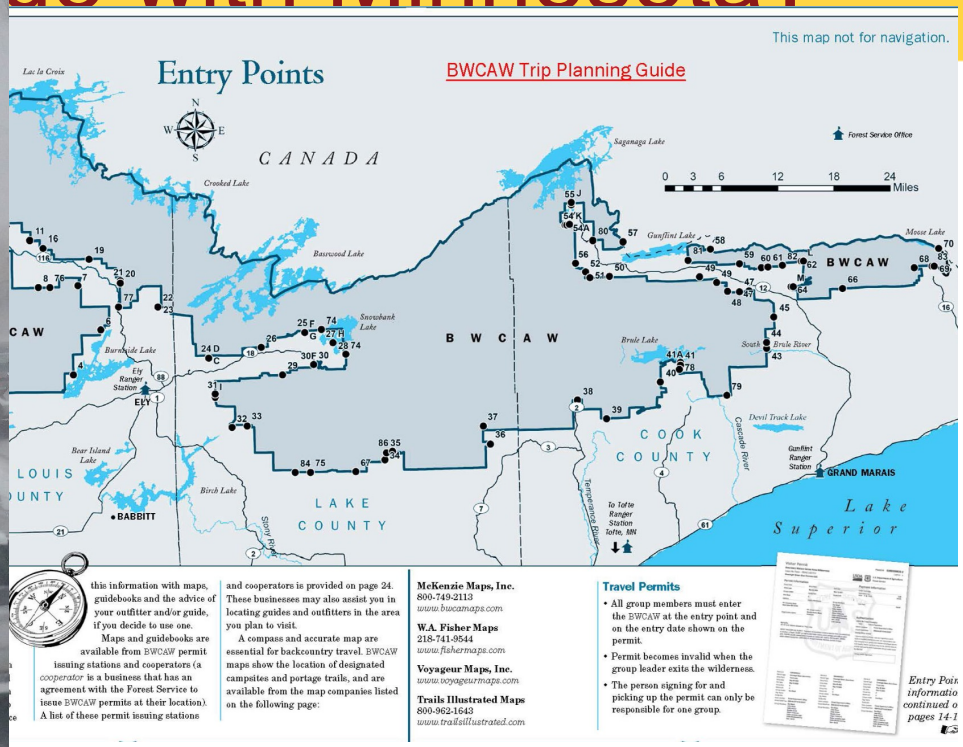
Role IV-V

Specific Problems

- **Stabilization of Shock**
- Monitoring
- Wound Care
- Medic Training
- Communication

W do with Minnesota?





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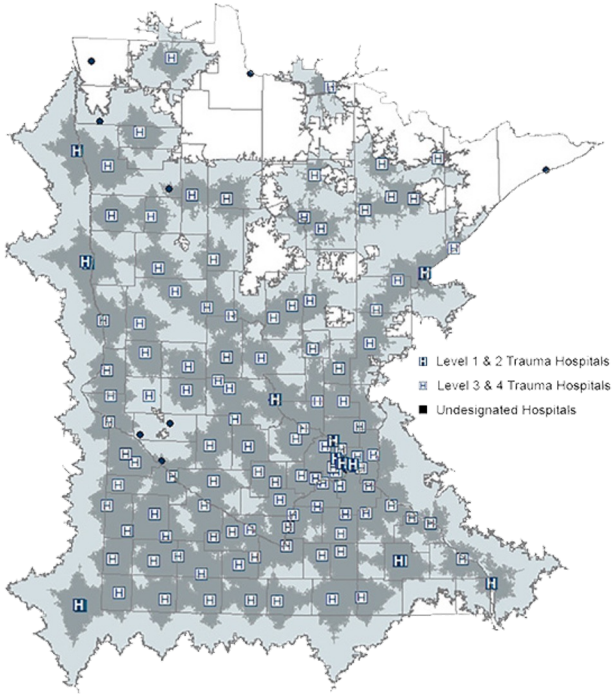
Unmet Needs: An Unexpected Alignment

Minnesota

#4
Trauma remains the 4th highest cause of death for Minnesotans[1]

$2.5 billion
Annual healthcare costs for Minnesotans[2]

26% vs 63%
26% of all vehicle crashes happen in rural Minnesota, but 63% of fatal crashes occur in rural areas [3]



Military

1 in 4
Potentially survivable pre-medical treatment facility US combat fatalities between 2001-2011[4]

Prolonged field care
New technologies/knowledge products needed due to future battlefield settings increasing evacuation time

[1]cdc.gov
[2]health.stats.mn.us
[3]Eastridge, Journal Trauma Acute Care Surgery, 2012
[4]Minnesota Motor Vehicle Crash Facts, 2020

Rural Trauma

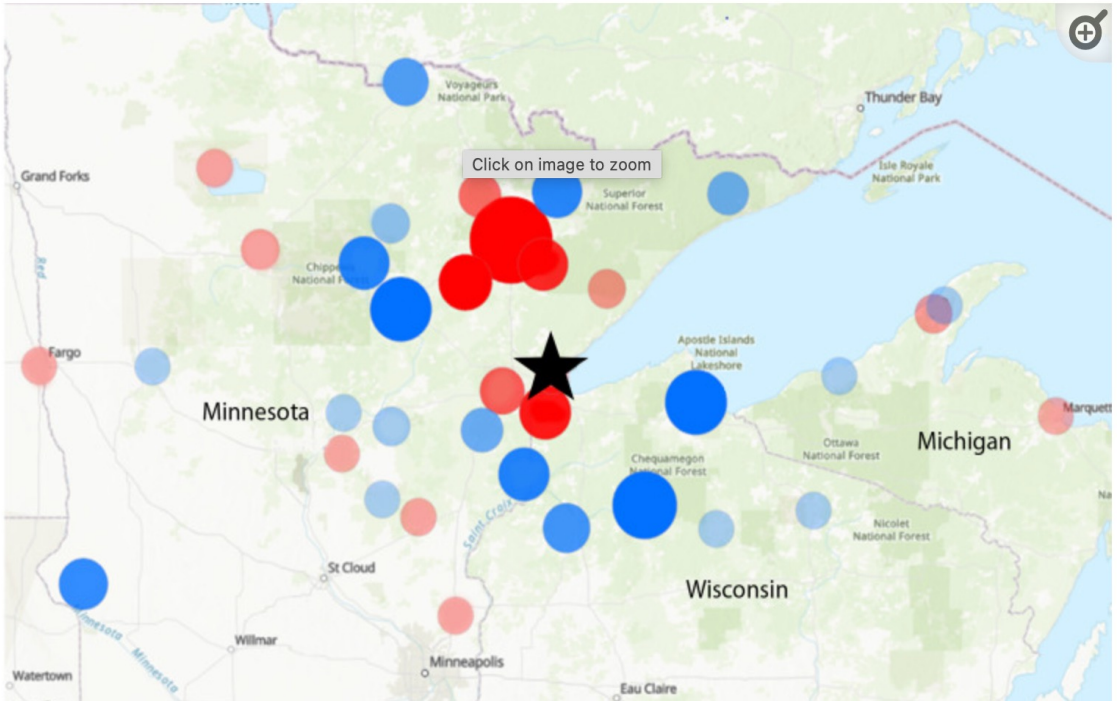
- Most common cause of death age <46 years
- Deaths from MVC, occupational injury, drowning, unintentional firearm injury increase with increasing rurality
- Death at scene: 72% rural, 41% urban

Why?

- Time of transport (Waalijk, JTACS, 2022)
- Undertriage (Deeb, JTACS, 2020)
- Lack of resources (Newgard, JAMA, 2017)

Delay Matters!

- Level I Trauma Center
- Rural Trauma transfers 2016-19
- 1887 patients transferred
- 398 femur fractures



- **Increased time to fracture fixation associated with increased LOS, higher complication rates, decreased discharge to home**

Larson, et al, Trauma Surgery Acute Care, 2021

Literature regarding prehospital care and prolonged transport or rurality

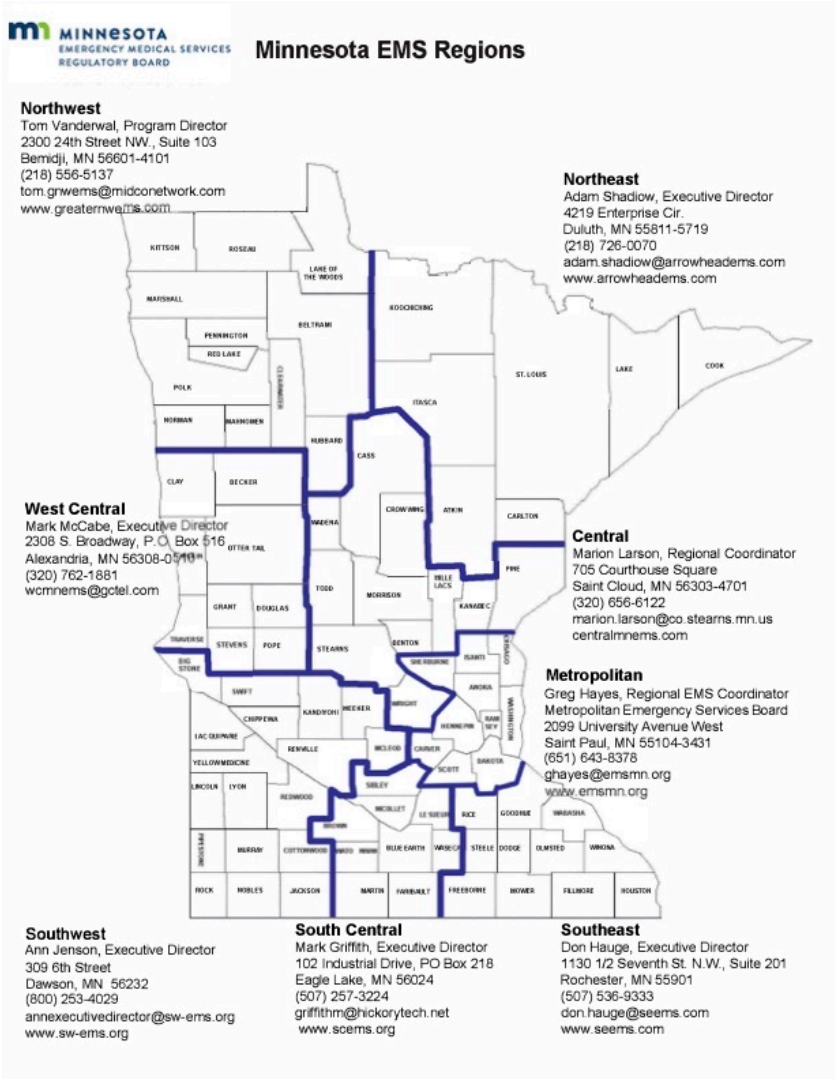
Prehospital Variable	# studies (prehospital/trauma total vs rural/or time)	Outcome
Tourniquet	25/10	Time based complications (ex. >4 hours)
Needle decompression/pleural thoracostomy	153/16	Failure rates ~50%, minimal complications (higher in '90s, focused on 2000+)
Pelvic binder	25/19	Varying percentages of when appropriately placed, missed pelvic ring injuries
Blood products/TXA	641/15	Prehospital blood product administration can reduce mortality, time-dependent
Traumatic arrest	22/1	Minimal survival, ?initial cardiac rhythm more important than duration of arrest
Airway/intubation	933/83	Numerous surrounding TBI Peds, ~high prehospital failure rates, supporting prehospital BVM if adequate oxy/ventilation, improved success with prehospital training programs
Transport time	134	Decreased time better outcomes, longer on scene time better for certain scenarios (ex. undifferentiated hemodynamically stable)
Level of Training	16	Higher training may delay care in penetrating trauma
Life-Saving Interventions (as a whole)	53/4	Depends on judgement, varying triage

Prehospital Care

- Reasonable amount of literature on prehospital trauma care
  - Gaps in knowledge on outcomes aside from mortality, ICU admission, ED/hospital disposition (some other outcomes, but smaller studies)
- Only a few other states/regions with linked prehospital and hospital data (more than general outcomes)
  - Western PA, CA (one hospital, feasibility, working on statewide), AZ (statewide), TX (manual)
  - New South Wales, Alberta

Minnesota Trauma System

- **MN Emergency Medical Services Regulatory Board** includes 15 members appointed by the Governor. The EMSRB monitors prehospital emergency care. (https://mn.gov/emsrb/about/missionvalues/)
- **MN Dept of Health Statewide Trauma System** is focused on designation of Trauma Hospitals: statewide, the number of designated trauma hospitals has increased from 5 hospitals in 2005 to 129 hospitals currently. (https://www.health.state.mn.us/facilities/traumasystem/index.html)

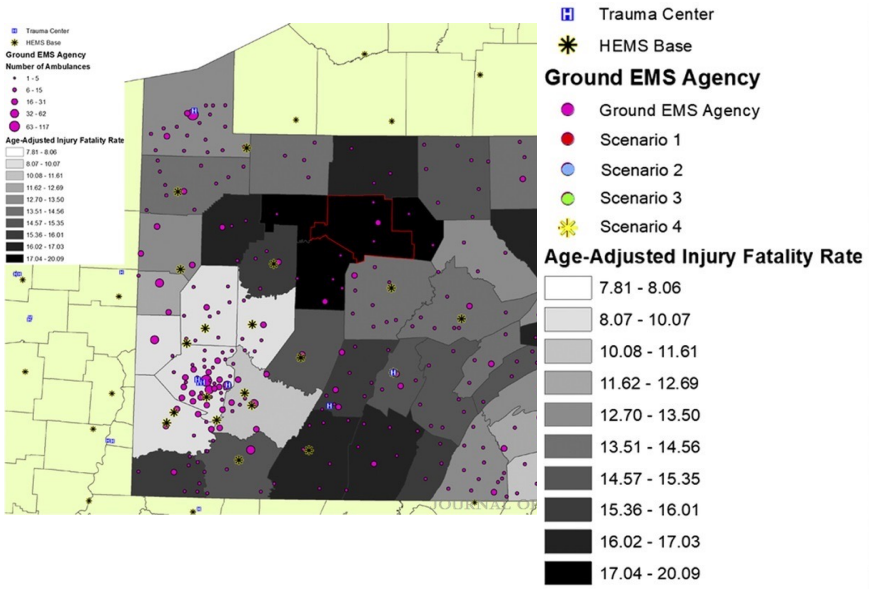


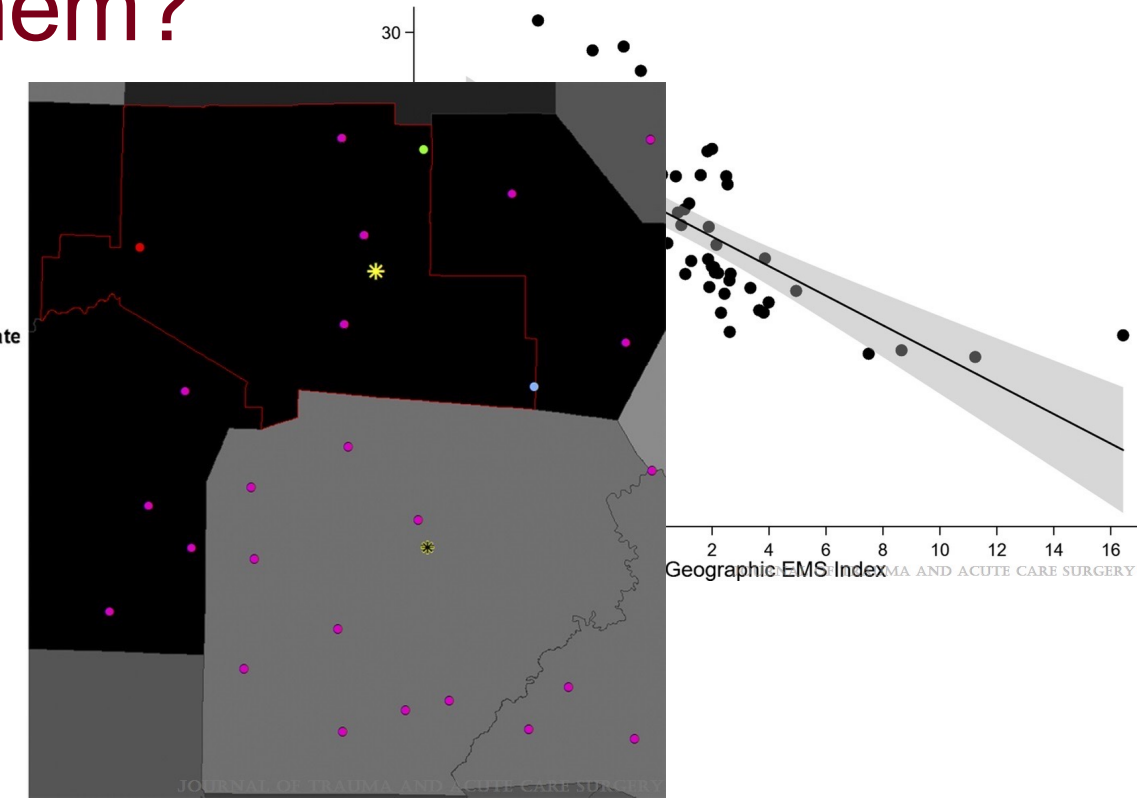
Defining Geographic Emergency Medical Services Coverage in Trauma Systems: Where do we put them?

- Located Ground and Air-Based Emergency Medical Services for State of PA, Trauma Center Locations
- All locations ”geocoded” and mapped
- Calculated distance from ground and air EMS base to nearest trauma center.
- Age-adjusted transportation injury fatality rates for 6 years obtained for each county
- County-level ISS/prehospital time calculated using individual patient date from Pennsylvania State Trauma Registry

Brown, et al, J Trauma, 2019

Where Do We Put Them?





GEMSI: Geographic EMS Index

Re-Siting of Helicopter Base in Elk County reduced predicted Injury fatality rate by 22%

UMN Translational Center for Resuscitative Trauma Care

Vision

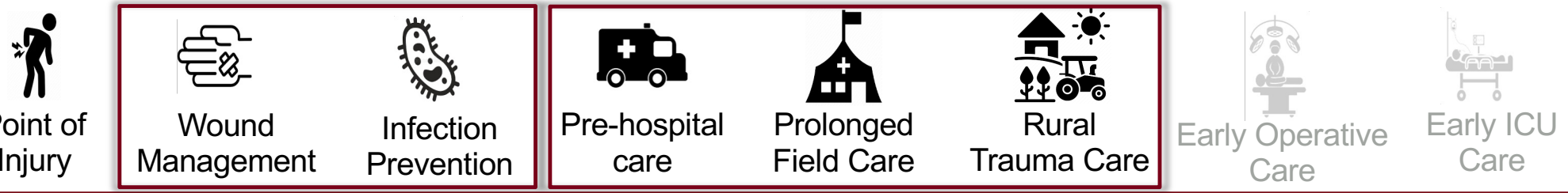
Create a multidisciplinary, translational research center that brings together trauma and emergency care research across the state of Minnesota into a single entity.

Trauma Mortality Timeline

Time from Injury	minutes	10 min-6 hours	1-7 days	weeks
Type of Death	**Immediate** (massive injury)	**Early** (hemorrhage)	**Intermediate** (TBI)	**Late** (MOF, nosoc infect, complications)
Potential Intervention Strategies	**Prevention** -Body armor -Vehicle design -Decrease risky behaviors	**Identification of Pts at Risk (**Scoring, monitors) **Tourniquets/hem dressings** **Damage Cont Resus** **Experimental Rx** -Hibernation-based Rx	**Prevention** **Experimental Rx** -Examples? **Early Rx of Hypotension**	**Good ICU Care** -DVT prophylaxis -"Bundles" -ICU service
Percent total Mortality (WAG)	**70%**		20%	10%

Ideal Work Products from the Center

- Focused on ***early*** evaluation and / or intervention
- Translatable to ***limited-resource, austere*** environments
- ***Innovative*** solutions
  - Technologies, pharmacotherapies, knowledge products
- Applicable to ***first responders*** and ***health care workers***



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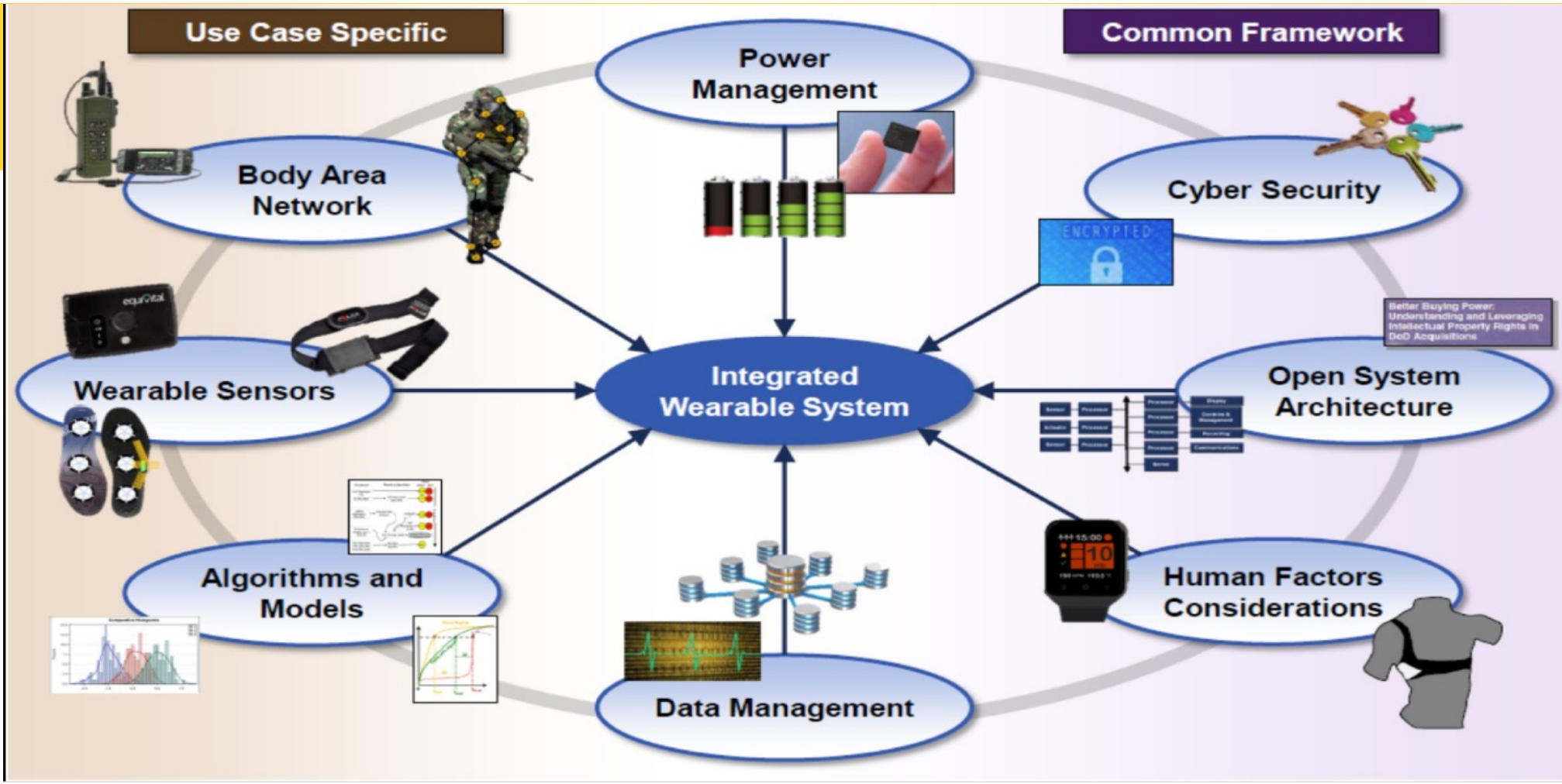
- Only a few other states/regions with linked prehospital and hospital data (more than general outcomes)
  - Western PA, CA (one hospital, feasibility, working on statewide), AZ (statewide), TX (manual)
  - New South Wales, Alberta
- Initial goals:
  - Feasibility study of data linkage with Fairview EMS/Medical Center, eventually hospitals across state within the data collaborative (Regions, NMMC, Essentia, St. Luke's, CentraCare), ideally state-wide database with ONGOING updates to data
  - Determine targetable areas of improvement in prehospital care for patients with prolonged transport and/or rural areas.

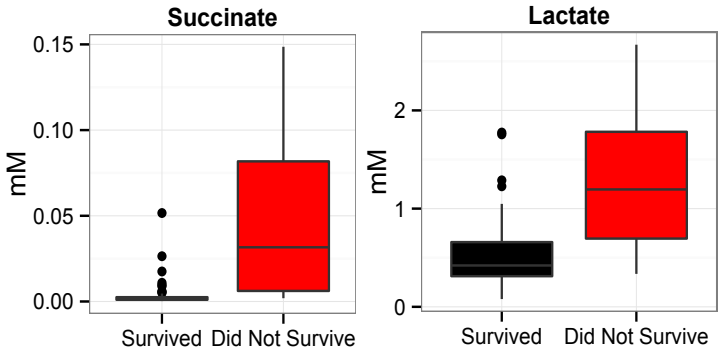
Monitoring

- Monitoring for development of shock/endpoints of resuscitation/tissue metabolism
- Monitor for organ failure (circ/resp)
- Monitoring for development of issues requiring intervention (e.g. infection/sepsis)
- Brain/neuromonitoring (return to duty)
- Pain management

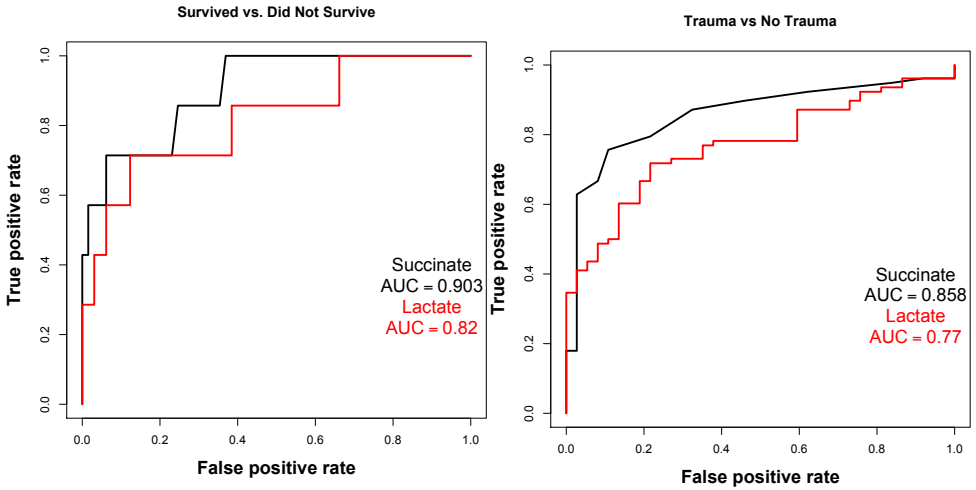


Friedl, et al, J Science and Medicine in Sport, 2018

Preliminary Succinate Data in Combat Casualties



N=90
- 83 lived
- 7 died



Lusczek, Journal of Trauma and Acute Care Surgery, 2017

Summary: Succinate has superior performance in distinguishing presence of trauma and mortality

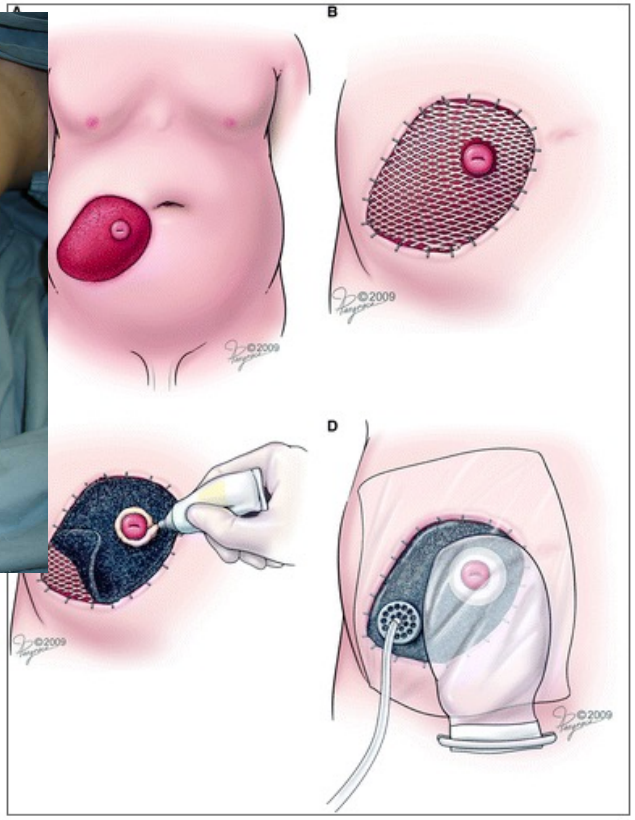
Next steps: Succinate detector development

Wounds

- Fracture care
- Prevention of Infection
- Wound care

Negative Pressure Wound Therapy

- VAC Dressings
  (Potential benefits)
  - Fewer dressing changes
  - Fewer skin problems
  - Easier nursing care
  - Improved drainage management



Medic Training

- Triage initial Injuries
- Best “Field” Care
  - Airway
  - IV access
  - Wound care
  - “Nursing” care
- Pain management

Medic Resources

- Documentation
- Communication
- Patient movement
- En route care

Battlefield Documentation

- BATDOK: Point of Injury Software tool: Android smartphone
- 711th Airwing
- Benefits: Reduce cognitive workload
- Improved documentation/collaboration
- Secure data transfer

Chief Master Sgt. Robert Bean, an Air Force pararescue jumper, demonstrates how the Battlefield Assisted Trauma Distributed Observation Kit can be worn on the wrist, providing awareness of the health status of multiple patients. Developing BATDOK required Air Force medical researchers to embed with pararescue jumpers on live missions to ensure the tool met the rigorous standards required by combat Airmen. (Courtesy photo)

Assessment

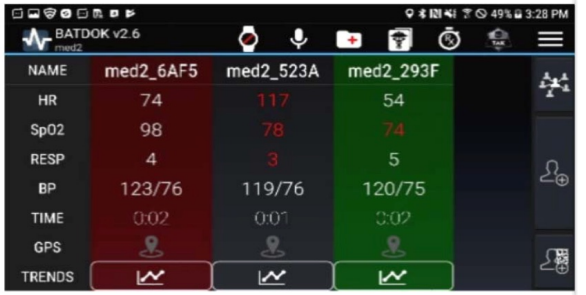
- Remote monitoring of multiple patients
- Supports all commonly used wireless protocols
- Currently monitors vital signs; easily adaptable to other FDA sensors
- Quick sensor pairing and connection – NFC, QR code
- User definable alert thresholds
- Medicine administration time and alerts
- Vitals trending graph
- Rack and stack for prioritized viewing
- Interoperable with Smartwatches

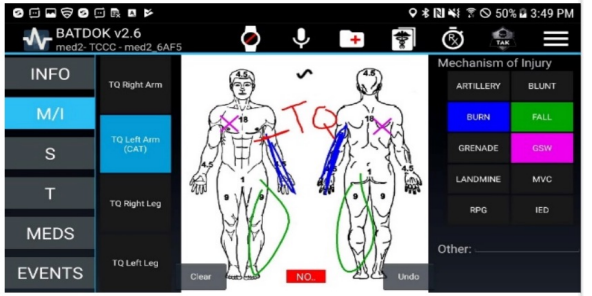
Documentation

- Digital generation of patient documentation
  - Executive patient summary
  - Burn resuscitation flow sheet
  - Med Evac 9 line etc.
- 128-bit Advanced Encryption Standard, AES, data encryption
- Encrypted storage of patient records
- Unique 16 bytes patient ID code
- NFC, RF-ID intervention documentation of treatments, medicine, fluids etc.
- Supports audio recording
- User definable intervals for automatic logging

Collaboration

- Supports network sensors though XML
- Exports and imports XML messages (team collaboration)
  - Vitals
  - Patient documentation
  - AHLTA-T EHS
- Digital map integration through BATDOK plugin (team awareness)
- Team lead patient accountability and planning tool





References

- Interactive medical cards
- Quick reference medical documents
- User defined medical references. Open source libraries are not included in source code - but reference to them is included in the build.Gradle file

Coordination

- GPS patient tagging
- 128-bit AES data encryption
- Digital map integration through BATDOK plugin (C2 and rescue assets awareness)
- Team lead patient accountability and planning tool (CASEVAC planning)

Transfer

- Supports secure air gap transfer of patient data using QR Codes
- Record compression and packaging for bandwidth efficient transfer
- AHLTA-T interoperable (patient data transmission to EHS)
- Patient documentation sharing (NFC)

Overview of USU-Minnesota funding opportunity

- Purpose: Support research projects to address healthcare requirements of the Department of Defense
- Proposed research **must**
  - Include a partner at USU
  - Be focused on topics and focus areas in the funding announcement
- Proposed research is encouraged to include
  - Cross organizational collaborations with Fairview Health Services and Medical Alley
  - Trainees (medical, nursing, graduate, or undergraduate students)

Approximate Schedule for FY23

Activity	**Deadline**
Funding Opportunity Announcement	July 2023
Full Application	~end of September 2023
Scientific Peer Review	December 2023
Award Notification	February 2024

MTEC: Medical Technology Enterprise Consortium

- Non-profit consortium designed to promote the development and delivery of innovative medical technologies to improve the health and safety of military personnel, veterans, and civilians.
- Projects generally range from $50,000 to $25M in size
- MTEC projects are funded via a mechanism called “Other Transaction Agreement (OTA)”.
- Each MTEC project must pay a project assessment fee to MTEC of 2% of the total funds obligated by the sponsoring agency.
  - For guidance on paying fees, Medical School PIs should contact Greg Beilman. CSE PIs should contact Joe Konstan. All other PIs should contact Pat Stryzyk in SPA.
- Confidential or proprietary information may be disclosed to UMN from other consortium members or from us to another member. This initiative requires that all confidential information be kept confidential for a period of 10 years.

Conclusions

- Significant advances in trauma care during 20 years of GWOT
- Next war challenges: distributed, peer-peer, lack of air superiority
- Many similarities between CCC and rural trauma care
- Major adaptations necessary in prolonged casualty care in both settings