Survival Times for Truncal Hemorrhage Patients in a Prolonged Care Trauma System: Implications for Combat Casualty Evacuation

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Article Contents

JOURNAL ARTICLE

Trauma Patient Survival Times in a Resource-Limited South African Trauma System: Implications for Combat Casualty Evacuation Timelines

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Abstract

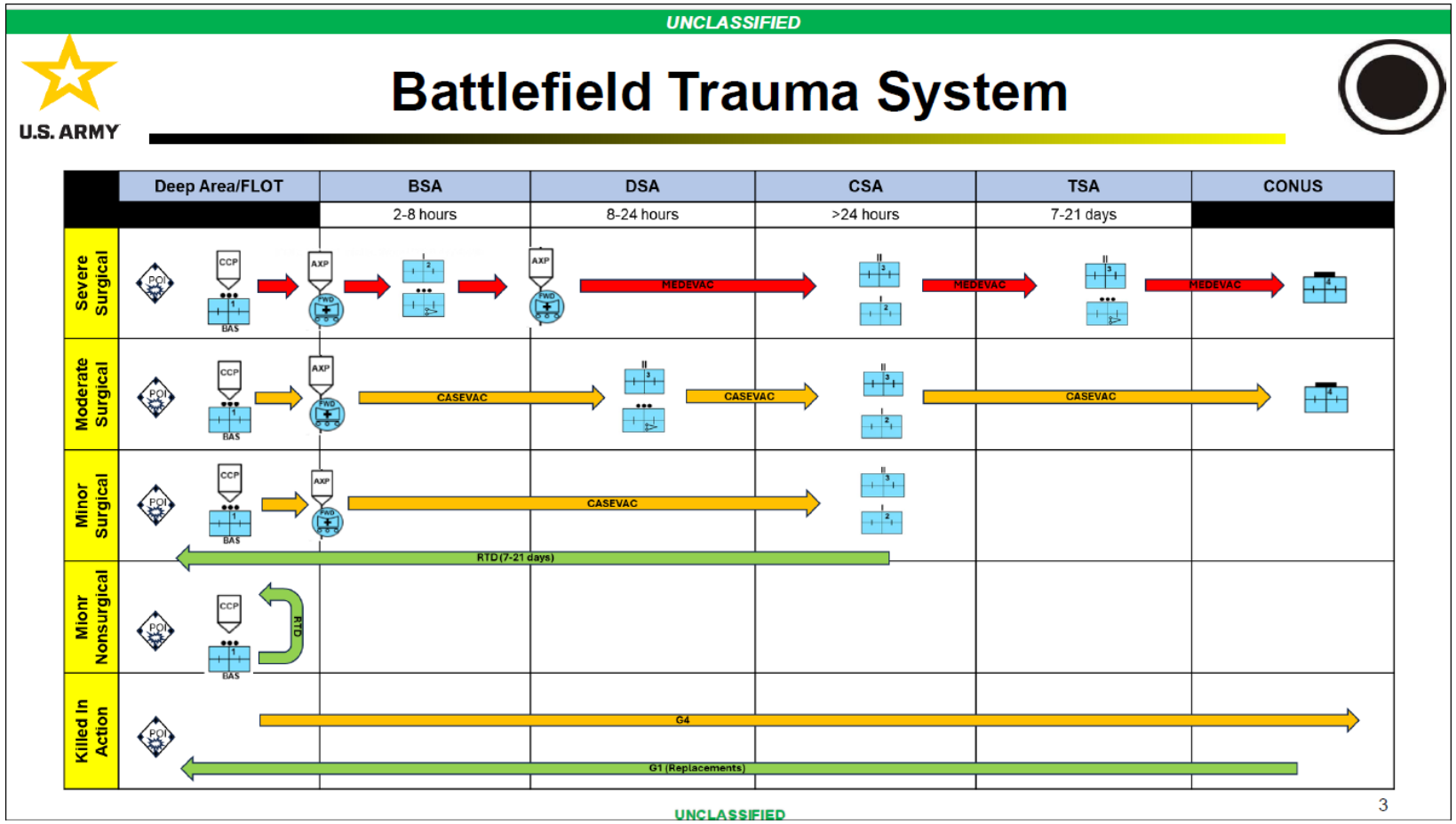
Introduction

Future United States military conflicts may involve near-peer adversaries and large-scale combat operations resulting in mass casualties with delayed evacuation. Health service support planning for such conflicts will require data informing patterns of survival among injured combatants. We determined the probability of survival to 24 hours post injury for trauma patients with blunt or penetrating non-compressible torso hemorrhage (NCTH) in a relatively resource-

Outline

I. Background
II. Methods
III. Results
    - Population
    - 24 hour survival
    - Subgroup analyses
IV. Conclusions
V. Q&A

Background



Courtesy of COL Jay Baker, MD (MHSRS 07-AUG-2025)

Background

- Operational Question:
  - In a prolonged care, resource-limited setting, what is the likelihood that an injured combatant will survive to 24 hours if they have already survived for X hours?

- Answer(s) may help inform:
  - US MIL Health Service Support planning
  - Including simulations & exercies

Background

Background

Western Cape of South Africa

- High-trauma
- 50% penetrating
- Patient load >> resources
- Restricted surgical care
- Frequent prolonged care

U.S. Military Prolonged Care

Casualty Evacuation

Role 1 (e.g., Casualty Collection Point/Aid Station)

1-Hour

Tactical Medical Evacuation

Role 2 (e.g., Forward Resuscitative/Surgical Team)

1 to 24-Hours

Role 3 (e.g., Forward-Deployed Hospital)

24 to 72-Hours

Strategic Aeromedical Evacuation

Role 4 (e.g., Regional Medical Center)

Western Cape Trauma System

EMS Scene Care/Transport and Facility Stabilization

Western Cape EMS

Primary Level Facility

0.5 to 3-Hours

Basic surgical trauma care

Secondary Health Care Center (e.g., district hospitals)

12 to 48-Hours

Secondary Health Care Center (e.g., regional hospitals)

24 to 72-Hours

Definitive Care

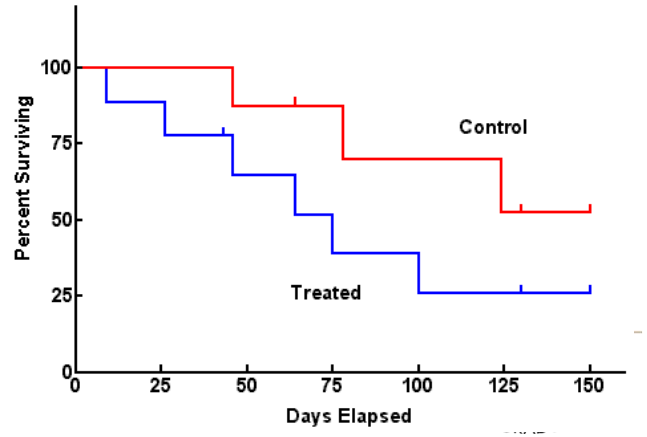
Tertiary Health Care Facility (e.g., specialized trauma care)

Figure from: Mould-Millman NK, Keenan S; et al. An Innovative Civilian Research Model to Inform Combat-Relevant Prolonged Casualty Care. Medical Journal, US Army Medical Center of Excellence (MEDCoE). 2022 Apr 1.

Background

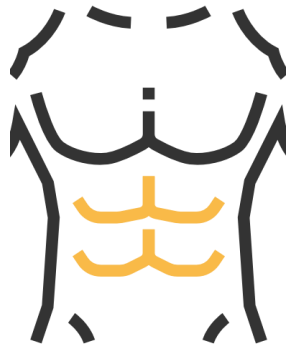
- Operational Question:
  - In a prolonged care, resource-limited setting, what is the likelihood that an injured combatant will survive to 24 hours if they have already survived for X hours?

- Research Question:
  - Among patients at risk for NCTH who survive to reach EMS or a fixed facility (role 1/2), what is the probability of survival to 24 hours given the casualty survives to an intermediate timepoint?



Methods

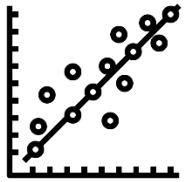
- Population:
  - ≥ 18 years
  - 3 years (SEP 2021 – DEC 2024)
- Inclusion:
  - Blunt or penetrating injury
  - NCTH
    - Anatomic: chest, abdomen, and/or pelvis (AIS ≥2)
    - Physiologic/lab/clinical: SBP ≤100, SI ≥1.0, labs, or death from hemorrhage
  - Severity strata: Mild, moderate, or severe
  - Alive at initial contact with EMS or Facility
- Exclusion:
  - Severe injuries outside torso (AIS ≥3)
- Primary Outcome:
  - 24-hr survival



Methods

- Specified intermediary timepoints:
  - ⇨ t = 1, 2, 3, 6, 12, and 18-hrs post-injury

- Kaplan Meyer survival curves
- Cox proportional hazards model → survival probabilities
  - ⇨ Adjusted for age, sex, NISS, TEWS



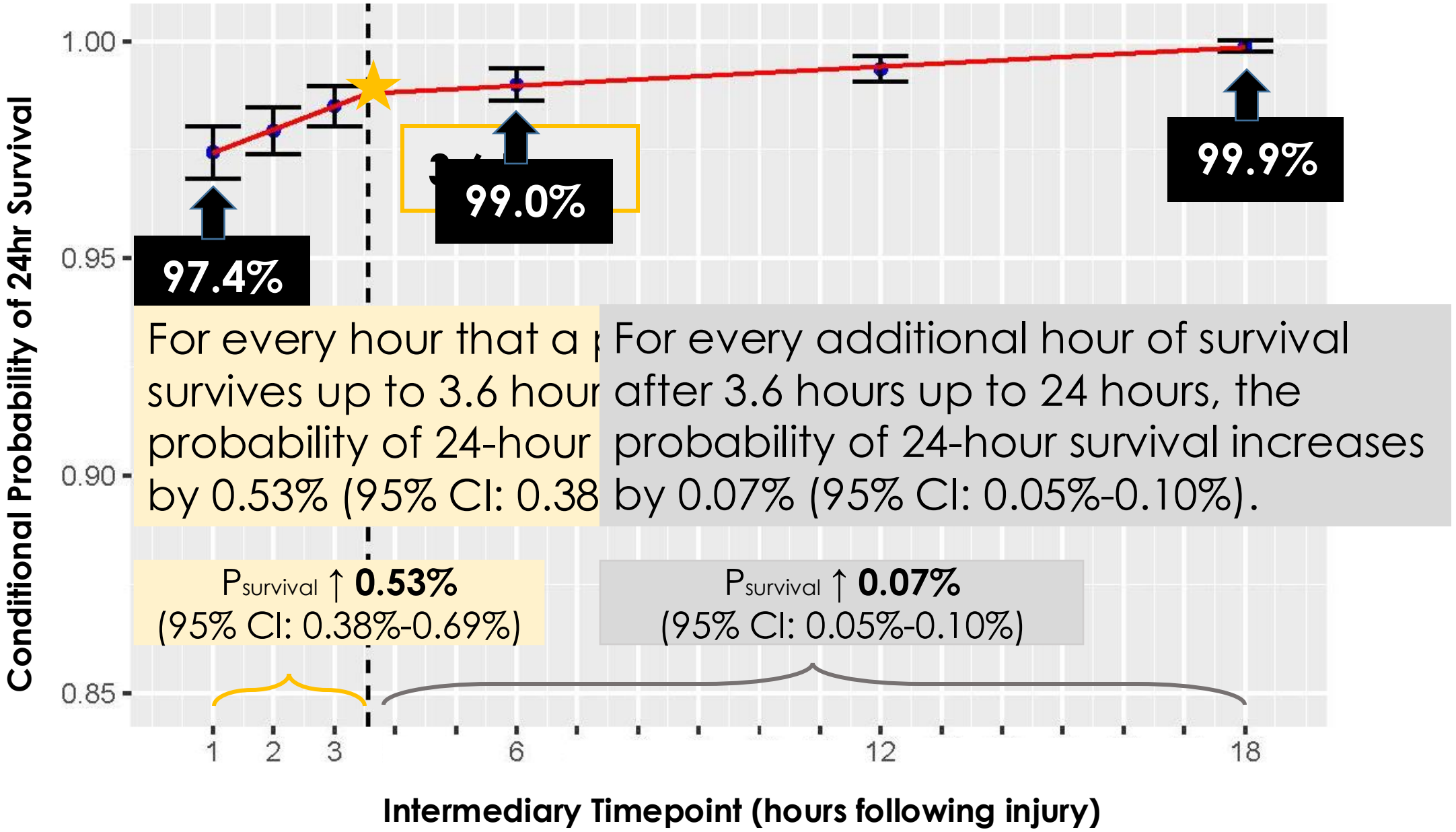
- Segmented linear regression
  - ⇨ Trend line plotted with one breakpoint

- Subgroup analyses
  - (1) Injury force type, (2) NISS; (3) LSIs; (4) Torso injury severity

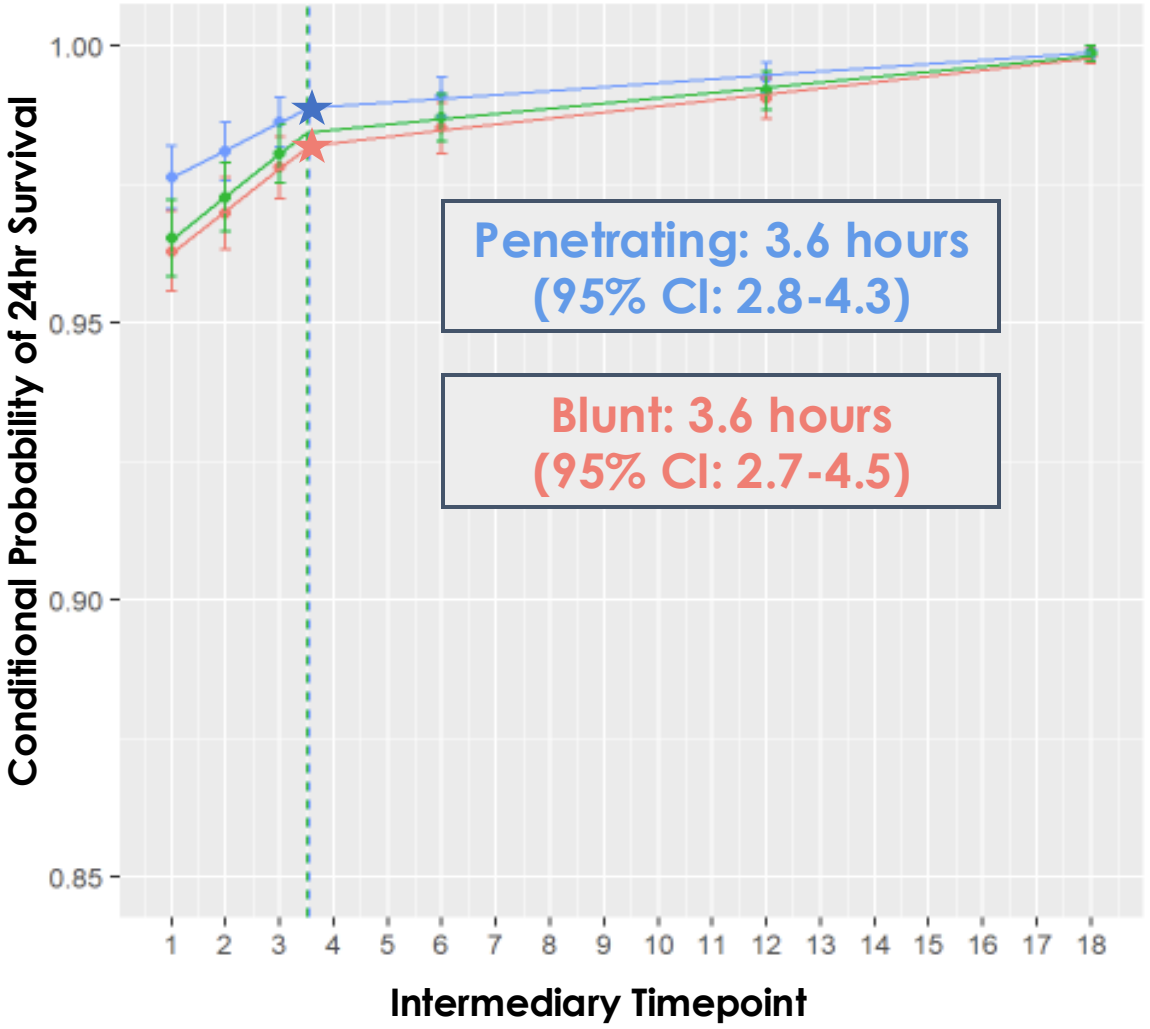
Results

	Overall (N=2,685; 100%)	24-hour deaths (N=111; 4.1%)	24-hour survivals (N=2,574; 95.9%)
Age, median (IQR)	30.7 (24.9-37.8)	32.9 (25.9-41.0)	30.7 (24.8-37.6)
Sex			
Male	2,416 (90.0%)	99 (89.2%)	2,317 (90.0%)
Female	269 (10.0%)	12 (10.8%)	257 (10.0%)
NISS, median (IQR)	14 (9-26)	43 (33-57)	14 (9-25)
TEWS, median (IQR)	5 (4-6)	9 (7-12)	5 (4-6)
Hemorrhage severity			
Mild	1,047 (39.0%)	0 (0.0%)	1,047 (40.7%)
Moderate	922 (34.3%)	5 (4.5%)	917 (35.6%)
Severe	716 (26.7%)	106 (95.5%)	610 (23.7%)
Patient died, n(%)	175	111	64
Time to mortality (hrs), median (IQR)	10.6 (2.3-63.5)	3.0 (1.4-7.2)	92.1 (51.6-269.6)

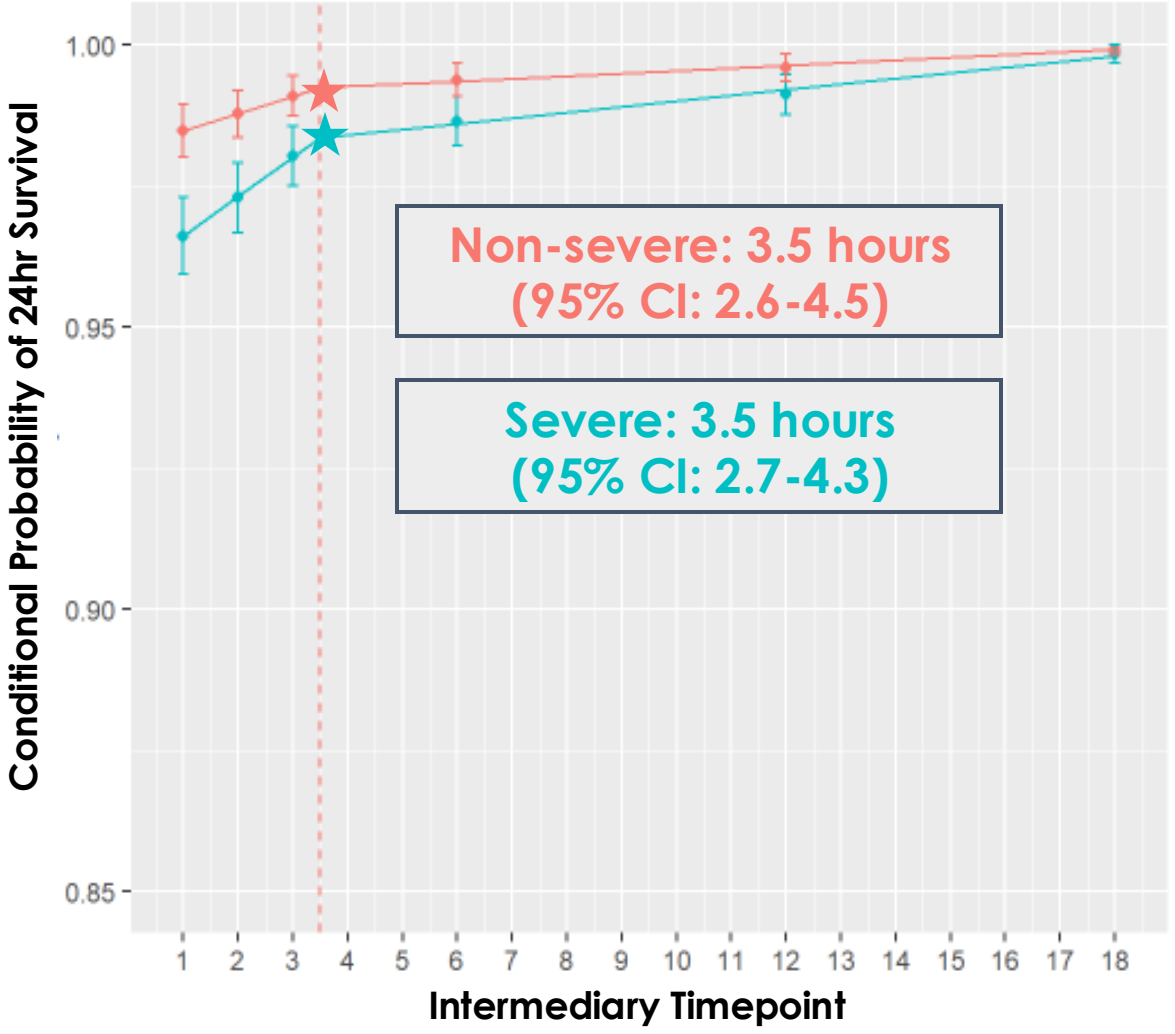
Plotted Conditional Survival Probability Among 2,685 Patients



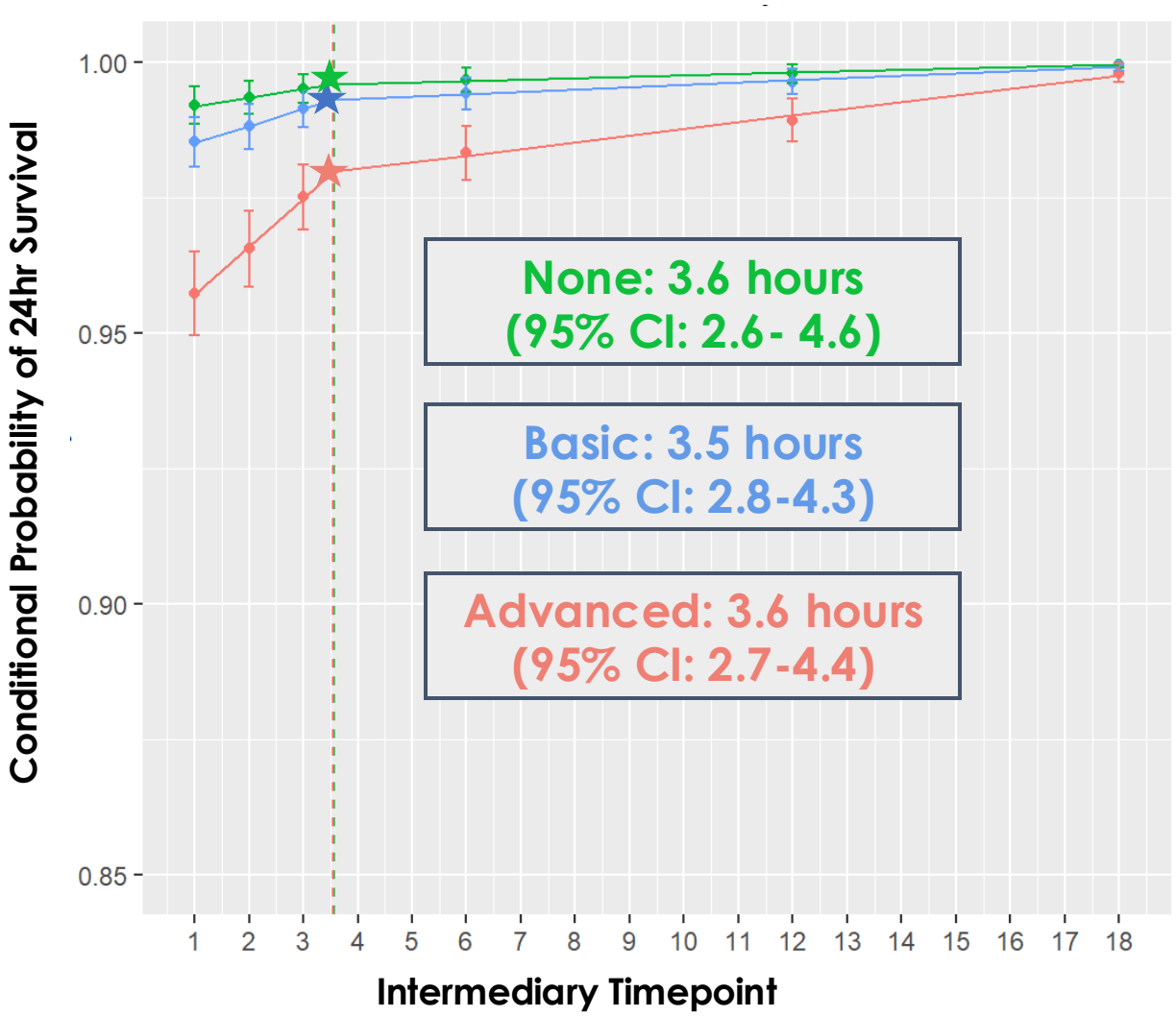
Injury Force Type (Penetrating vs Blunt)



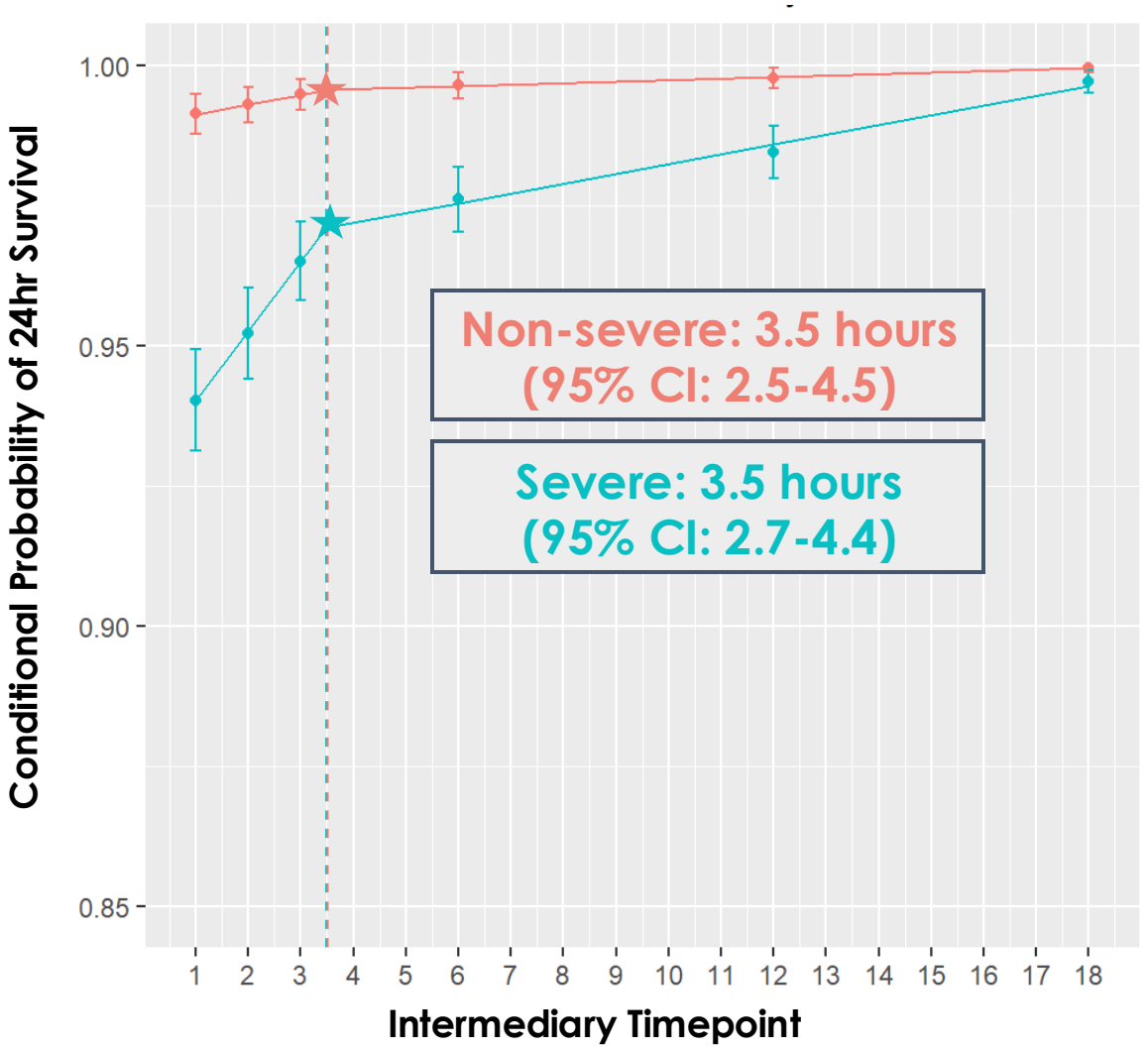
Overall Anatomic Injury Severity (NISS ≤15 vs >15)



Life-Saving Interventions



Torso Injury Severity (AIS)



Conclusions

Among 2,685 civilians experiencing torso injury with mild, moderate, or severe risk of hemorrhage:

- The probability of 24-hr survival was high:
  - Generally >95% P-survival to 24hrs if pt. survived 1hr or longer
  - Likely due to (1) inclusion of mild torso injuries and (2) exclusion of catastrophic injuries (dead on scene).
- Inflexion point between 3-4 hours
  - NCTH patients realize less survival benefit after 3.6 hrs
  - 0-3.6 hrs may be an important window for evac/interventions
  - 3.5-3.6 hr inflexion was consistent across stratified analyses

Conclusions

Among 2,685 civilians experiencing torso injury with mild, moderate, or severe risk of hemorrhage:

- This quantifies a known phenomenon (survival bias):
  - The longer a pt. survives, the more likely to survive to 24 hrs
  - Consistent with a 2015 EMS systematic review (Harmsen *et al*)
- Extrapolation & planning for future US MIL conflicts**:
  - Triage & evac in PCC? MASCAL?
  - Training and simulation exercises?
- Next steps:
  - Repeat on different injury profiles
  - Examine cases who needed surgery but did not receive it

Thank You

- LTC Michael D. April, MD DPhil MSC
- Combat Casualty Care Research Portfolio

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Thank you. Questions?

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Western Cape Government
Health

Reserve Slides

TEWS (Triage Early Warning Score): 0-17

ADULT TRIAGE SCORE © South African Triage Group 2008

	3	2	1	0	1	2	3	
Mobility				Walking	With Help	Stretcher/ Immobile		**Mobility**
RR		less than 9		9-14	15-20	21-29	more than 29	**RR**
HR		less than 41	41-50	51-100	101-110	111-129	more than 129	**HR**
SBP	less than 71	71–80	81-100	101-199		more than 199		**SBP**
Temp		Cold OR Under 35		35-38.4		Hot OR Over 38.4		**Temp**
AVPU		Confused		Alert	Reacts to Voice	Reacts to Pain	Unresponsive	**AVPU**
Trauma				No	Yes			**Trauma**

over 12 years / taller than 150cm

Colour	RED	ORANGE	YELLOW	GREEN	BLUE
TEWS	7 or more	5-6	3-4	0-2	DEAD

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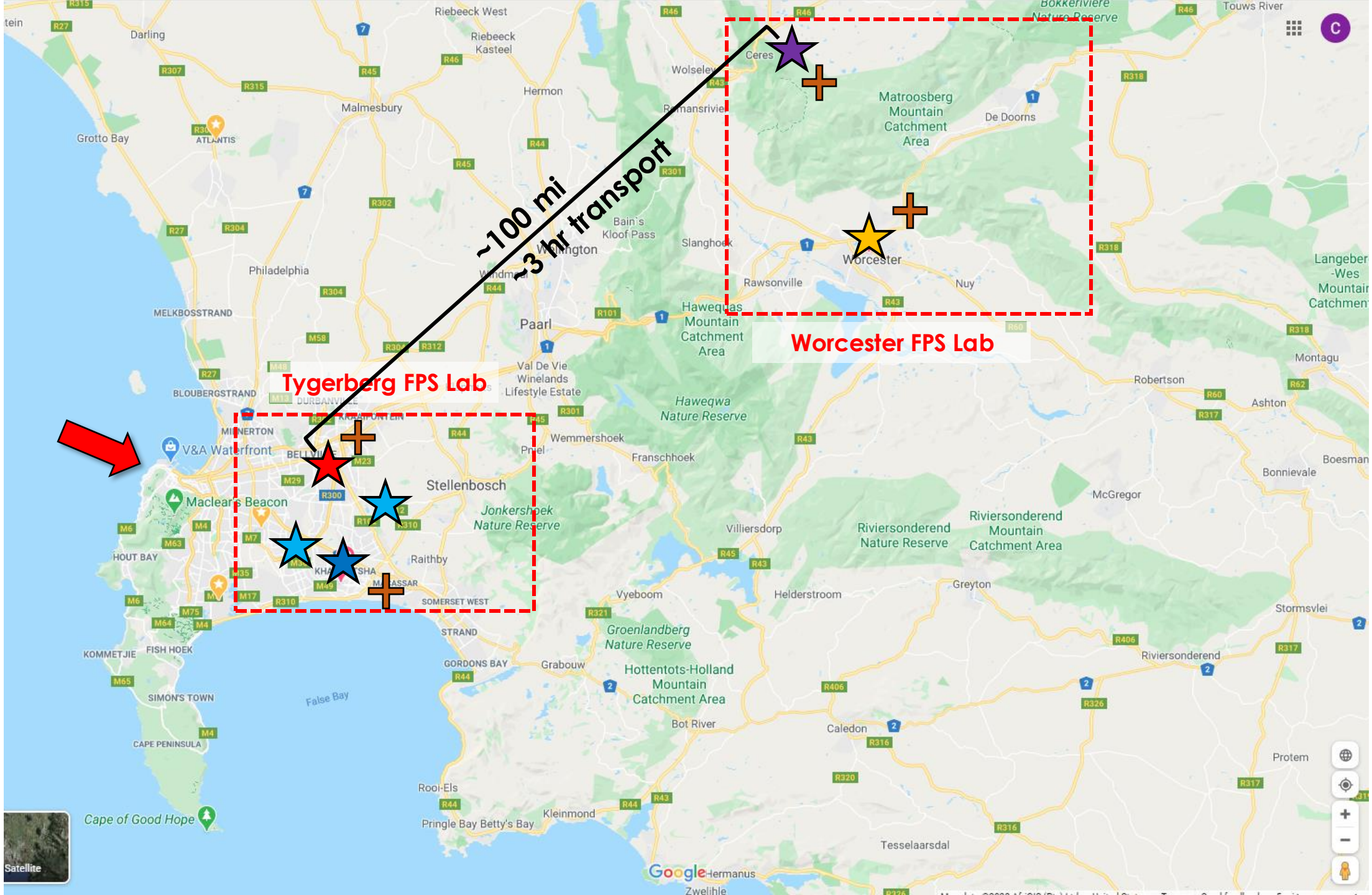
Inclusion/Exclusion Criteria

Inclusion:

- Blunt or penetrating trauma
- Torso injury
  - AIS chest/abdo/pelvis ≥ 2
- Mechanism of Death = Hemorrhage
- Hemorrhage risk:
  - ✓ SBP ≤100 mmHg or shock index ≥1.0;
    and/or
  - ✓ SOFA cardiovascular score ≥3
  - ✓ initial lactate ≥4.0,
  - ✓ initial base deficit ≥6, or
  - ✓ initial pH ≤7.2 within 24 hours arrival

Exclusion:

- Injuries >24 hours
- AIS non-torso ≥ 3
- AIS head ≥ 3
- Dead on scene


~100 mi
~3 hr transport
Worcester FPS Lab
Tygerberg FPS Lab
Ceres
Worcester
Matroosberg Mountain Catchment Area
De Doorns
Rawsonville
Nuy
Slanghoek
Bain's Kloof Pass
Wolseley
Hermon
Malmesbury
Riebeeck West
Riebeeck Kasteel
Darling
Grotto Bay
ATLANTIS
Philadelphia
MELKBOSSTRAND
BLOUBERGSTRAND
MILNERTON
V&A Waterfront
BELLVILLE
Maclear's Beacon
HOUT BAY
KOMMETJIE
FISH HOEK
SIMON'S TOWN
CAPE PENINSULA
Cape of Good Hope
False Bay
Paarl
Val De Vie Winelands Lifestyle Estate
Wemmershoek
Franschhoek
Haweqwa Nature Reserve
Hawequas Mountain Catchment Area
Stellenbosch
Jonkershoek Nature Reserve
Raithby
SOMERSET WEST
STRAND
GORDONS BAY
Grabouw
Vyeboom
Villiersdorp
Riviersonderend Nature Reserve
Riviersonderend Mountain Catchment Area
Helderstroom
Greyton
McGregor
Groenlandberg Nature Reserve
Hottentots-Holland Mountain Catchment Area
Bot River
Caledon
Rooi-Els
Pringle Bay
Betty's Bay
Kleinmond
Hermanus
Tesselaarsdal
Robertson
Montagu
Ashton
Bonnievale
Boesmans
Stormsvlei
Riviersonderend
Protem
Touws River
Langeberg-Wes Mountain Catchment
Satellite
Google

Limitations

- Selection bias
  - We excluded DOS patients
- Confounding
  - Due to observational design
  - Potentially offset by covariate adjustment
- 1, 2, 3, 6, 12, 18 hrs timepoints:
  - Arbitrary
  - May not be sufficiently granular