EMS-TRUSHOC - A PROSPECTIVE TRIAL OF LOW-DOSE, HIGH FREQUENCY, ON-SITE TRAINING TO IMPROVE TRAUMA FIELD CARE IN AUSTERE SETTINGS

Nee-Kofi Mould-Millman, MD (University of Colorado)
Lt Col Joseph K. Maddry, MD, MC USAF
MAJ Steven G. Schauer, DO, USA, MC
Shaheem de Vries, MBChB, MBA (Western Cape EMS)
Col Vikhyat S Bebarta, MD (University of Colorado)
Adit A. Ginde, MD, MPH (University of Colorado)

FINAL REPORT

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59th Medical Wing
Office of the Chief Scientist
1100 Wilford Hall Loop, BLDG. 4554
JBSA Lackland AFB, TX 78236-7517

DECLARATION OF INTEREST

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Air Force, Department of Defense, nor the U.S. Government. This work was funded by Project Code Number AC12EM01. Authors are military service members, employees, or contractors of the US Government. This work was prepared as part of their official duties. Title 17 USC §105 provides that 'copyright protection under this title is not available for any work of the US Government.' Title 17 USC §101 defines a US Government work as a work prepared by a military service member, employee, or contractor of the US Government as part of that person's official duties.

NOTICE AND SIGNATURE PAGE

"EMS-TRUSHOC - A PROSPECTIVE TRIAL OF LOW-DOSE, HIGH FREQUENCY, ON-SITE TRAINING TO IMPROVE TRAUMA FIELD CARE IN AUSTERE SETTINGS"

TAVISH.MICHELE.F.1031059280 Digitally signed by TAVISH.MICHELE.F.1031059280 Date: 2021.09.30 17:49:57 -05'00'

Michele Tavish, DAF
Program Analyst
En route Care Research Program
59MDW Office of the Chief Scientist

MALLORY.AMBER.MELANIE.1471210206 Digitally signed by MALLORY.AMBER.MELANIE.1471210206 Date: 2021.10.04 13:04:32 -05'00'

Amber Mallory, Ph.D.
Director, Trauma & Clinical Care
59MDW Office of the Chief Scientist

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6. AUTHOR(S)
Nee-Kofi Mould-Millman, MD (University of Colorado)
Lt Col Joseph K. Maddry, MD, MC USAF
MAJ Steven G. Schauer, DO, USA, MC
Shaheem de Vries, MBChB, MBA (Western Cape EMS)
Col Vikhyat S Bebarta, MD (University of Colorado)
Adit A. Ginde, MD, MPH (University of Colorado)

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
REGENTS OF THE UNIVERSITY OF COLORADO, THE
UNIVERSITY OF COLORADO- DENVER
13001 E 17TH PLACE F428, AURORA
(303) 724-0258

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2130 EIGHTH STREET, BUILDING 45
WRIGHT-PATTERSON AFB OH 45433-7541
KIMBERLY D CERNEY 937-713-9857, kimberly.cerney@us.af.mil

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14. ABSTRACT
Effective sustainment training is critical to survival after major trauma. We tested the effectiveness of a simplified bundle of hemorrhagic shock care ("EMS-TruShoC") delivered via a novel educational methodology ("H.E.E.T.") intended to pragmatically improve prehospital trauma morbidity and mortality. We assessed outcomes in three highly relevant areas: (i) clinical at the patient-level; (ii) implementation, and (iii) educational. The overall design was a Type 2 hybrid implementation-effectiveness study (equal focus on clinical and implementation outcomes). We conducted a quasi-experimental trial to introduce a novel intervention (EMS-TruShoC) which was implemented via a novel educational strategy (H.E.E.T). We enrolled 198 EMS providers and 770 critical patients. Patients in shock (due to penetrating injuries) who received the TruShoC intervention (delivered by BLS providers) had clinically improved (but statistically non-significant) clinical outcomes compared to control-site patients. We implemented the H.E.E.T. training program with high implementation fidelity (76% mean effectiveness, per RE-AIM). Knowledge and skills acquisition and retention (up to 12-months post-intervention) of TruShoC was superior in our intervention cohort.

15. SUBJECT TERMS
Prehospital; hemorrhage; shock; bundle of care; international; austere; resource-limited; clinical effectiveness; implementation effectiveness; educational effectiveness; shock index.

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19b. TELEPHONE NUMBER *(Include area code)*
303-724-1725

TABLE OF CONTENTS

Overall Summary of Project and Key Findings

Problem Statement:

Effective sustainment training is critical to survival after major trauma – traditional training is often prolonged, infrequent, and unfriendly to adult-learners with direct impact to skills retention and performance. Additionally, simplified clinical approaches, such as bundled care, can enhance delivery of basic life-saving interventions – simplified approaches may improve outcomes.

Overall Research Goal:

To test the effectiveness of a simplified bundle of hemorrhagic shock care ("EMS-TruShoC") delivered via a novel educational methodology ("H.E.E.T.") intended to pragmatically improve prehospital trauma morbidity and mortality. We assessed outcomes in three highly relevant areas: (i) clinical at the patient-level; (ii) implementation, and (iii) educational.

Approach:

The overall design was a Type 2 hybrid implementation-effectiveness study (equal focus on clinical and implementation outcomes). We conducted a quasi-experimental trial to introduce a novel intervention (below) which was implemented via a novel educational strategy (below):

- The Intervention: "EMS Traumatic Shock Care (EMS-TruShoC)" is a simplified bundle of hemorrhagic shock care that relies on basic, high-quality knowledge and skills. It is based on discrete learning objectives, and broken up into 6 discrete learning modules.
- Implementation Strategy: "High Efficiency EMS Training (H.E.E.T.)" is an innovative low-dose, high-frequency, peer-led, on-site training intervention designed to be delivered in the back of ambulances in 15-minutes, once-weekly, by trained paramedics to their peers using contemporary principles in adult-learning.

Research Aims:

1) To assess clinical outcomes:
    - We compared delta shock index (a measure of degree of hemorrhagic shock) in patients who received the intervention to controls.
2) To assess implementation outcomes:
    - We used the RE-AIM framework to assess reach, effectiveness, adoption, implementation fidelity, and maintenance.
3) To assess educational outcomes:
    - We compared knowledge-attitudes-skills assessments in the intervention site EMS providers to control site EMS providers, conducted pre-/post- and up to 12-months post-implementation.

Key Findings:

We successfully completed all aims, objectives, and milestones:

1) Clinical outcomes: We enrolled 198 EMS providers and 770 critical patients. Patients in shock (due to penetrating injuries) who received the TruShoC intervention (delivered by BLS providers) had improved clinical outcomes compared to control-site patients.
2) Implementation outcomes: We implemented the H.E.E.T. training program with high implementation fidelity (76% mean effectiveness, per RE-AIM). The H.E.E.T. format was highly enjoyable to learners, easy for trainers, and highly practical for on-the-job training.
3) Educational outcomes: Knowledge and skills acquisition and retention (up to 12-months post-intervention) of TruShoC was superior in our intervention cohort (which received H.E.E.T.) versus our control cohort (which received traditional trauma training).

Key Recommendations & Suggested Next Steps

→ **Civilian (in the Western Cape of South Africa):**

- Conduct further testing of the civilian H.E.E.T. training program using other trauma content outside of hemorrhagic shock. Potential topics for civilian EMS application, that are US military relevant, can include: tourniquet application; fracture care; and TXA administration. Testing educational content in these areas may help provide additional evidence that the H.E.E.T. training program is an effective platform suitable for a variety of clinical content and topics… while maintaining US military relevance.
    - *We have demonstrated that we can enroll ~120 EMS providers per ambulance base, and we have access to 6 bases for future studies.*

- Conduct a multi-center clinical trial to more robustly assess morbidity and mortality benefit of EMS-TruShoC to patients. We can scale up the TruShoC intervention across several EMS bases and assess patients' outcomes in hospitals (e.g., 24-hour mortality, need for blood products, need for operative intervention within 24-hours, etc). This will allow us to assess hospital-based outcomes, not just pre-hospital changes in physiology and shock.
    - *We can enroll ~300 hemorrhagic shock patients per year per EMS base.*

→ **Military studies:**

- We encourage relevant military stakeholders to adapt and consider testing the H.E.E.T. training platform within a specific group of combat trauma care providers (e.g., combat medics and/or combat lifesavers).
    - *We can tailor the implementation strategy, educational content and material, and the outcomes metrics to military needs. Training content could be a few relevant aspects of TCCC that are under-performed or poorly retained by existing sustainment training.*
    - *The study investigators can assist military investigators and stakeholders to ensure that contemporary implementation science principles and approaches are used in the adaptation and testing process.*

List of Appendices

**All products submitted to journals or conferences have received PAO approval by USAISR.*

Appendix 1 – Activities and Deliverables, per Statement of Work

1.1 WHAT WERE THE MAJOR GOALS OF THE PROJECT?

The overall (originally proposed) objective of this effort is to investigate:

[1] Implementation of EMS-TruShoC in a cohort of prehospital providers in a resource-limited, austere setting with a high case load of civilian penetrating trauma and frequent prolonged field care. **AIM #1.**
[2] Assessment of educational outcomes of EMS-TruShoC training versus traditional prehospital trauma training for prehospital traumatic shock care. **AIM #2**.
[3] Assessment of clinical outcomes of EMS-TruShoC training versus traditional prehospital trauma training for prehospital traumatic shock care. **AIM #3.**

All goals were completed per the following timeline:

Activities (per approved SOW)	2018		2019				2020				2021	
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2
Protocol approvals (USA & South Africa) [3-6 months]	✓											
Finalize materials & train data collectors [3-4-months]		✓	✓									
Baseline clinical & educational data collection [6-months]		✓	✓									
Implement TruShoC at intervention site (Aim 1) [3-months]		✓										
Collect data on educational outcomes (Aim 2) [15-months]		✓	✓	✓								
Collect data on clinical outcomes (Aim 3) [9-12-months]					✓	✓	✓					
On-going data analysis and statistical modelling							✓	✓	✓	✓		
Manuscript writing and dissemination of findings							✓	✓	✓	✓	✓	✓

Legend: (✓) completed activity.

No cost extension period

1.2 WHAT WAS ACCOMPLISHED UNDER THESE GOALS?

All activities and goals have been accomplished.
6 out of the 8 major activities were completed within the 2-year funding period, as originally proposed.
2 out of the 8 major activities required completion during the no-cost extension period.

1.3 Describe the Regulatory Protocol and Activity Status.

(a) Human Use Regulatory Protocols

TOTAL PROTOCOLS: 1

**** All enrollment and ethics approvals (including renewals) went according to plan****

PROTOCOL (1 of 1 total):

Protocol [HRPO Assigned Number]: N/A

Title: N/A

Target required for clinical significance: N/A

Target approved for clinical significance: N/A

SUBMITTED TO AND APPROVED BY:

- University of Cape Town Human Research Ethics Committee
  - Initial approval on March-16-2018, ref # 077/2018
  - Continuing renewal on July-25-2019, ref # 077/2018
- University of Colorado, Colorado Multiple Institutional Review Board (reliance on external IRB, agreement and approval # 18-0607).

STATUS:

(i) Number of subjects (EMS providers) recruited/original planned target: 232 / 232
Number of subjects (EMS providers) screened/original planned target: 269 / 269
Number of patients (EMS patients) enrolled/original planned target: 737 / 640
Number of patients (EMS patients) completed/original planned target: 640 / 640

(ii) Report amendments submitted to the IRB and USAMRMC HRPO for review:
All previously reported

(iii) Adverse event/unanticipated problems involving risks to subjects or others and actions or plans for mitigation: **Not applicable**

(b) Use of Human Cadavers for Research Development Test & Evaluation (RDT&E), Education or Training

TOTAL ACTIVITIES: No RDT&E, education or training activities involving human cadavers were performed to complete the Statement of Work (SOW)."

(c) Animal Use Regulatory Protocols

TOTAL PROTOCOL(S): No animal use research were performed to complete the Statement of Work.

1.4 PRODUCTS:

Implementation and Training Materials:

- Training modules and materials (see Appendix 5)
- Implementation manual and approach (see Appendix 6)

Peer-reviewed Manuscripts:

- Mould-Millman NK, Dixon J, Lamp A, de Vries S, Beaty B, Finck L, Colborn K, Moodley K, Skenadore A, Glasgow RE, Havranek EP. *A single-site pilot implementation of a novel trauma training program for prehospital providers in a resource-limited setting.* **Pilot and Feasibility Studies.** 2019 Dec 1;5(1):143.
- Nee-Kofi Mould-Millman MD, Julia M Dixon, MD, MPH, Bradley van Ster, BTech, Fabio Moreira, BEMC, Beatrix Bester, BTech, MPhil, Charmaine Cunningham, PhD, MBA, BSocSc, Shaheem de Vries, MBChB, MPhil, Brenda Beaty, MS, Krithika Suresh, PhD, Steven G Schauer, DO, MS, Joseph K Maddry, MD, Lee A Wallis, MD, Vikhyat S Bebarta, MD, and Adit A Ginde, MD, MPH. *Clinical Impact of a Prehospital Trauma Shock Bundle of Care in South Africa.* **African Journal of Emergency Medicine** (under peer review) – see Appendix 2

Peer-reviewed scientific abstracts & conference presentations:

- Nee-Kofi Mould-Millman, MD[1], Bradley van Ster, BTech[2], Julia Dixon, MD MPH[1], Binyamien Kariem, BTech[2], Michael Lee, CCA[2], Peter Lesch, CCA[2], Chrishando Staines, CCA[2], Wayne Philander, CCA[2], Aldrin Mackier, CCA[2], Craig Williams, CCA[2], Nico van Nierkerk, BTech[2], Shaheem de Vries[2], MBChB, MPhil[2], Amanda Skenadore, MPH[1], Lani Finck[1], Beatrix Bester, BTech[2], Charmaine Cunningham, B.Soc.Sc, MBA[3], MAJ Steven G. Schauer, DO[4], MAJ Joseph Maddry, MD[5], Col Vikhyat Bebarta, MD[1], Adit A Ginde, MD, MPH[1] *. "EMS-TruShoC: A Quasi-Experimental Trial of Hemorrhagic Shock Training using a Simplified Approach of Bundled Care."* **MHSRS 2020 annual meeting.** Kissimmee – Florida. *Accepted, but meeting cancelled.*
- Nee-Kofi Mould-Millman, MD[1]; Julia Dixon, MD MPH[1;], Bradley van Ster, BTech[2]; Chrishando Staines, CCA[2], Michael Lee, CCA[2;], Peter Lesch, CCA[2]; Lani Finck[1], Nico van Nierkerk, CAA[2], Shaheem de Vries, MBChB, MPhil[2], Kubendhren Moodley, MSHS[2], Radomir Cermak, MHS[2], Brenda Beaty, MSPH[3], Krithika Suresh, PhD[3], Beatrix Bester, BTech[2], Fabio Moreira, BEMC[2], Charmaine Cunningham, MBA[4], MAJ Steven G. Schauer, DO[5], Lt Col Joseph Maddry, MD[6], Col Vikhyat Bebarta, MD[1], Adit A Ginde, MD, MPH[1]. *High-Efficiency EMS Training (HEET) – a Novel Approach of Low-dose, High-frequency, On-the-job, Peer Training.* **Society for Academic Emergency Medicine, 2020** Annual Meeting (virtual).
- Nee-Kofi Mould-Millman, MD[1], Bradley van Ster, BTech[2], Julia Dixon, MD MPH[1], Binyamien Kariem, BTech[2], Michael Lee, CCA[2], Peter Lesch, CCA[2], Chrishando Staines, CCA[2], Wayne Philander, CCA[2], Aldrin Mackier, CCA[2], Craig Williams, CCA[2], Nico van Nierkerk, BTech[2], Shaheem de Vries[2], MBChB, MPhil[2], Amanda Skenadore, MPH[1], Lani Finck[1], Beatrix Bester, BTech[2], Charmaine Cunningham, B.Soc.Sc, MBA[3], MAJ Steven G. Schauer, DO[4], MAJ Joseph Maddry, MD[5], Col Vikhyat Bebarta, MD[1], Adit A Ginde, MD, MPH[1] *. "High Efficiency EMS Training (HEET): A novel, effective*

strategy for on-the-job trauma retraining in a low-resource international setting." **MHSRS 2019 annual meeting.** Kissimmee – Florida.

- Nee-Kofi Mould-Millman, MD[1], Bradley van Ster, BTech[2], Julia Dixon, MD MPH[1], Binyamien Kariem, BTech[2], Michael Lee, CCA[2], Peter Lesch, CCA[2], Chrishando Staines, CCA[2], Wayne Philander, CCA[2], Aldrin Mackier, CCA[2], Craig Williams, CCA[2], Nico van Nierkerk, BTech[2], Shaheem de Vries[2], MBChB, MPhil[2], Amanda Skenadore, MPH[1], Lani Finck[1], Beatrix Bester, BTech[2], Charmaine Cunningham, B.Soc.Sc, MBA[3], MAJ Steven G. Schauer, DO[4], MAJ Joseph Maddry, MD[5], Col Vikhyat Bebarta, MD[1], Adit A Ginde, MD, MPH[1] . *"EMS-TruShoC: A Quasi-Experimental Trial of Hemorrhagic Shock Training using a Simplified Approach of Bundled Care."* **MHSRS 2019 annual meeting.** Kissimmee – Florida.
- Mould-Millman NK, Dixon J, Moodley K, Cermak R, Beaty B, Colborn K, Skenadore A, De Vries S, Bebarta V, Ginde AA. 141EMF *High-Efficiency Emergency Medical Services Training: A Novel Approach of Low-Dose, High-Frequency, On-the-Job, Peer-Led Training.* **Annals of Emergency Medicine. 2019** Oct 1;74(4):S56.
- Nee-Kofi Mould-Millman, Julia Dixon, MD, Andrew Hopkinson, Andrew Lamp, Peter Lesch, Michael Lee, Binyamien Kariem, Wayne Philander, Aldrin Mackier, Craig Williams, Shaheem de Vries, MBChB, MPhil, MAJ Steven G. Schauer, DO, LTC Cord Cunningham, MD, MPH, Maj Joseph Maddry, MD, Col Vikhyat Bebarta, MD, Adit A Ginde, MD, MPH. *Effectiveness of a Novel Prehospital Trauma Training Program for Austere, High Volume Trauma, International Settings: a Prospective Study.* Abstract # MHSRS-18-1593 - Research in Prolonged Field Care and Pre-Hospital Tactical Combat Casualty Care. **MHSRS 2018 annual meeting**. Kissimmee – Florida. 2018.
- Mould-Millman NK, Dixon J, Thomas J, Burkholder T, Oberfoell N, Oberfoell S, McDaniel K, Meese H, de Vries S, Wallis L, Ginde A. *Measuring the Quality of Shock Care-Validation of a Chart Abstraction Instrument.* InA37. **American Thoracic Society. 2018** May (pp. A1482-A1482).
- Nee-Kofi Mould-Millman, Julia Dixon, Andrew Lamp, Peter Lesch, Michael Lee, Binyamien Kariem, Wayne Philander, Aldrin Mackier, Craig Williams, Shaheem de Vries, Adit A Ginde. *Implementation Effectiveness of a Novel EMS Trauma Training Program in South Africa.* **Society for Academic Emergency Medicine, 2018** annual meeting.

Appendix 2 – Clinical outcomes

Attached is a copy of a manuscript submitted for scientific journal peer-review (under review at the African Journal of Emergency Medicine, an Elsevier Journal: https://www.journals.elsevier.com/african-journal-of-emergency-medicine).

Notable Research Successes:

- We successfully enrolled 198 EMS providers
- We successfully enrolled 770 prehospital patients with severe injuries and shock
- The study was Africa's first prehospital hemorrhagic shock (quasi-experimental) trial

Notable South African Organizational Successes:

- We successfully trained a South African EMS team to implement the intervention
- We built very strong relationships and goodwill with EMS leaders and stakeholders
- The H.E.E.T. training program was used by Western Cape EMS for COVID training

Innovation:

- We innovatively studied bundled care as a solution for improving prehospital care
- We used contemporary and evidence-based implementation science principles
- We conducted this in an area with the highest global trauma prevalence and mortality

Key Results:

- There was no significant difference in physiologic outcomes between the entire EMS-TruShoC intervention group versus control groups
- In subgroup analyses, there were significant improvements in outcomes in penetrating trauma patients and patients who received care from BLS (i.e., basic EMS providers)
- Findings suggest that the EMS-TruShoC clinical intervention may be most beneficial to patients with penetrating injuries (usually hemorrhage and shock).
- Findings also suggest that the H.E.E.T. training program may benefit basic EMS providers the most, compared to intermediate and advanced providers.

See manuscript on the following pages…

African Journal of Emergency Medicine

Clinical Impact of a Prehospital Trauma Shock Bundle of Care in South Africa.

--Manuscript Draft--

Manuscript Number:	
Article Type:	Original article
Section/Category:	EMS
Keywords:	Prehospital; Emergency medical services; trauma; Africa; Bundle of Care; Shock
Corresponding Author:	Nee-Kofi Mould-Millman University of Colorado, School of Medicine Aurora, CO UNITED STATES
First Author:	Nee-Kofi Mould-Millman
Order of Authors:	Nee-Kofi Mould-Millman
	Julia M Dixon, MD, MPH
	Bradley van Ster, BTech
	Fabio Moreira, BEMC
	Beatrix Bester, BTech, MPhil
	Charmaine Cunningham, PhD, MBA, BSocSc
	Shaheem de Vries, MBChB, MPhil
	Brenda Beaty, MS
	Krithika Suresh, PhD
	Steven G Schauer, DO, MS
	Joseph K Maddry, MD
	Lee A Wallis, MD
	Vikhyat S Bebarta, MD
	Adit A Ginde, MD, MPH
Abstract:	Introduction. Patients experiencing traumatic shock are at a higher risk for death and complications. We previously designed a bundle of emergency medical services traumatic shock care (“EMS-TruShoC”) for prehospital providers in resource-limited settings. We assess how EMS-TruShoC changes clinical outcomes of critically injured prehospital patients. Methods : This is a quasi-experimental educational implementation of a simplified bundle of care using a pre-post design with a control group. The intervention was delivered to EMS providers in Western Cape, South Africa. Delta shock index (heart rate divided by systolic blood pressure, reported as change from the scene to facility arrival) from the 13 months preceding intervention were compared to the 13 months post-implementation. A difference-in-differences analysis examined the difference in mean shock index change between the groups. Results : Data were collected from 198 providers who treated 770 severe trauma patients. The patient groups had similar demographic and clinical characteristics at baseline. Over all time-points, both groups had an increase in mean delta shock index (worsening shock), with the largest difference occurring 4-months post-implementation (0.047 change in control arm, 0.004 change in intervention arm; -0.043 difference-in-differences, P=0.27). In pre-specified subgroup analyses, there was a statistically significant improvement in delta shock index in the intervention arm in patients with penetrating trauma cared for by basic providers immediately post-implementation (-0.372 difference-in-differences, P=0.02). Conclusion : Overall, there was no significant difference in delta shock index between the EMS-TruShoC intervention versus control groups. However, significant improvement in shock index in one subgroup suggests the intervention may be more

	likely to benefit penetrating trauma patients and basic providers.
Suggested Reviewers:	Jared Sun, MD, MBA, PhD Emergency Medicine Attending Physician jared.sun@gmail.com Emergency medicine specialist with extensive publications and experience with South African hospital and prehospital trauma care.
	Chelsea Dymond, MD Emergency Medicine Attending Physician chelsea.dymond@denverem.org Emergency medicine specialist with multiple publications and local expertise of South African trauma care and EMS.
	Alexander Bedard, MD, MPH, MHA Assistant Professor, US Air Force alexbedardmd@gmail.com Emergency medicine specialist with global health scientist training and extensive prehospital and combat deployment expertise.
Opposed Reviewers:	

African relevance

1. In resource-limited settings, simplified bundles of care that promote performance of basic evidence-based interventions are needed.
2. Prehospital recognition and management of shock is critical in Africa where a paucity of trauma centres and under-resourced hospitals contribute to delays in care and adverse outcomes.
3. Patients transported with severe shock or penetrating injuries had modest, clinically-relevant improvements in shock indices if the EMS provider received weekly in-ambulance training on traumatic shock care within 4 months of the clinical encounter.

Clinical Impact of a Prehospital Trauma Shock Bundle of Care in South Africa.

Nee-Kofi Mould-Millman, MD[a]; Julia M. Dixon, MD, MPH[a]; Bradley van Ster, BTech[b]; Fabio Moreira, BEMC[b]; Beatrix Bester, BTech, MPhil[b]; Charmaine Cunningham, PhD, MBA, BSocSc[c]; Shaheem de Vries, MBChB, MPhil[b]; Brenda Beaty, MS[d]; Krithika Suresh, PhD[d]; MAJ Steven G. Schauer, DO, MS[e]; Lt Col. Joseph K. Maddry, MD[f]; Lee A. Wallis, MD[c]; Col. Vikhyat S. Bebarta, MD[g]; Adit A. Ginde, MD, MPH[a]

a. University of Colorado Denver, School of Medicine, Department of Emergency Medicine, Aurora, Colorado, USA.

b. Western Cape Government, Department of Health, Emergency Medical Services, Cape Town, South Africa.

c. University of Cape Town, Department of Surgery, Division of Emergency Medicine, Cape Town, South Africa.

d. University of Colorado Denver, Adult and Child Consortium for Health Outcomes Research and Delivery Science, Aurora, Colorado, USA.

e. U.S. Army Institute of Surgical Research, Joint Base San Antonio-Ft Sam Houston, Texas, USA.

f. U.S. Air Force En Route Care Research Center, Joint Base San Antonio-Lackland, Texas, USA.

g. University of Colorado Denver, School of Medicine, Center for COMBAT Research, Aurora, Colorado, USA.

Corresponding Author:

Nee-Kofi Mould-Millman, MD

Associate Professor,

Department of Emergency Medicine,

University of Colorado, School of Medicine, Anschutz Medical Campus,

12631 E 17th Ave, Room 2612, MS C326, Aurora, CO 80045

Email: Nee-Kofi.Mould-Millman@CUAnschutz.edu

M: 1.404.558.1110 | O: 1.303.724.1725 | F: 1.720.848.7374

Co-author Contact Information:

Julia.Dixon@cuanschutz.edu, Bradley.VanSter@westerncape.gov.za,

Fabio.Moreira@westerncape.gov.za, Beatrix.Bester@westerncape.gov.za,

CCharmaine@live.co.za, Shaheem.DeVries@westerncape.gov.za,

Brenda.Beaty@cuanschutz.edu, Krithika.Suresh@cuanschutz.edu,

Steven.G.Schauer.mil@mail.mil, Joseph.K.Maddry.mil@mail.mil, Lee.Wallis@uct.ac.za,

Vikhyat.Bebarta@cuanschutz.edu, Adit.Ginde@cuanschutz.edu

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Clinical Impact of a Prehospital Trauma Shock Bundle of Care in South Africa

Abstract

Introduction: Patients experiencing traumatic shock are at a higher risk for death and complications. We previously designed a bundle of emergency medical services traumatic shock care ("EMS-TruShoC") for prehospital providers in resource-limited settings. We assess how EMS-TruShoC changes clinical outcomes of critically injured prehospital patients.

Methods: This is a quasi-experimental educational implementation of a simplified bundle of care using a pre-post design with a control group. The intervention was delivered to EMS providers in Western Cape, South Africa. Delta shock index (heart rate divided by systolic blood pressure, reported as change from the scene to facility arrival) from the 13 months preceding intervention were compared to the 13 months post-implementation. A difference-in-differences analysis examined the difference in mean shock index change between the groups.

Results: Data were collected from 198 providers who treated 770 severe trauma patients. The patient groups had similar demographic and clinical characteristics at baseline. Over all time-points, both groups had an increase in mean delta shock index (worsening shock), with the largest difference occurring 4-months post-implementation (0.047 change in control arm, 0.004 change in intervention arm; -0.043 difference-in-differences, P=0.27). In pre-specified subgroup analyses, there was a statistically significant improvement in delta shock index in the intervention arm in patients with penetrating trauma cared for by basic providers immediately post-implementation (-0.372 difference-in-differences, P=0.02).

Conclusion: Overall, there was no significant difference in delta shock index between the EMS-TruShoC intervention versus control groups. However, significant improvement in shock index in one subgroup suggests the intervention may be more likely to benefit penetrating trauma patients and basic providers.

Keywords

Prehospital; Emergency medical services; Trauma; Africa; Bundle of Care; Shock

African relevance

1. In resource-limited settings, simplified bundles of care that promote performance of basic evidence-based interventions are needed.
2. Prehospital recognition and management of shock is critical in Africa where a paucity of trauma centres and under-resourced hospitals contribute to delays in care and adverse outcomes.
3. Patients transported with severe shock or penetrating injuries had modest, clinically-relevant improvements in shock indices if the EMS provider received weekly in-ambulance training on traumatic shock care within 4 months of the clinical encounter.

Introduction

Traumatic injuries are the leading cause of mortality in persons under 45-years worldwide, and trauma causes significant long-term morbidity [1-5]. Further, injured people in low- and middle-income countries (LMICs) experience disproportionately worse outcomes compared to those in high-income countries [6-8]. South Africa, for example, has an age-standardized mortality rate from interpersonal violence that is seven-times higher than the global mean rate [7, 9, 10].

Amongst trauma patients, haemorrhage is the most common reason for death, and shock contributes to organ failure [11-14]. Yet, early death from traumatic shock is preventable through early and quality resuscitation, beginning with prehospital providers, and rapid transportation to definitive surgical care [15]. The need for prehospital recognition and management of shock is critical in LMICs where few trauma centres and under-resourced hospitals contribute to delays in care and adverse outcomes [16, 17].

Management of traumatic shock is an ideal target for intervention in the prehospital setting because shock is often identifiable, interventions are mostly basic and can be life-saving, and providers' skills can be quickly improved with effective training [11, 12, 18]. In 2016, we pilot tested an evidence-based, expert-informed, essential bundle of traumatic shock care (Emergency Medical Services Traumatic Shock Care – EMS-TruShoC) for prehospital care in resource-limited settings [18]. The core interventions within the EMS-TruShoC bundle of care include: early haemorrhage control (if applicable), maintaining short scene times (preferably, <10 minutes), direct transport to a trauma centre, establish a large bore intravenous (IV) catheter, deliver of oxygen (see Appendix B for EMS-TruShoC algorithm and bundle of care). Prior pilot testing of EMS-TruShoC in South Africa demonstrated high implementation effectiveness and improved providers' knowledge, attitudes, and skills in traumatic shock care [18].

Methods

The objective of this study was to assess how implementation of EMS-TruShoC bundled care amongst EMS providers influences clinical outcomes of critically injured patients in shock in a resource-limited, high-trauma international setting. We expected to find a larger improvement in patients' shock indices, measured between the scene and facility arrival, in the intervention cohort compared to the control cohort.

We performed a prehospital, quasi-experimental, pragmatic study using a pre-post design with a contemporaneous control group. The study settings were ambulance bases located in Khayelitsha and Mitchells Plain, two densely populated, high-trauma suburbs, within Cape Town, in the Western Cape Province of South Africa. These communities experience a high incidence of inter-personal and non-intentional trauma, and had among the world's highest burden of morbidity and mortality from trauma [7, 10, 19].

The organizational setting was a state-wide government-operated EMS system – Western Cape Government (WCG) Department of Health EMS [18, 20]. Study-eligible providers were 120 clinically-active EMS providers at each of the two participating bases with national qualifications of basic-, intermediate-, or advanced-life support (BLS, ILS, ALS, respectively). At the time of this study, foundational education for WCG EMS providers from across the Western Cape Province included a 6-week certificate courses for BLS, a 12-week course for ILS, and a 2-year (diploma) and 4-year (degree-earning) training for ALS providers [21]. Khayelitsha was selected as the intervention site, primarily due to the administrative readiness and capacity at the ambulance station to host the educational intervention, as determined by study investigators who were WCG EMS staff.

The intervention was EMS-TruShoC bundled care, which was pragmatically implemented by trained peers (paramedics, called “facilitators”) at Khayelitsha using a low-dose (15-minutes), high-frequency (once-weekly) structured program taught in the back of ambulances at the start of shifts (see Appendix C for learning objectives and Appendix D for full training materials). This training program has been previously described and proven to have high implementation effectiveness and strong educational outcomes [18]. Implementation at Khayelitsha occurred from August to November, 2018. The Mitchells Plain ambulance base served as a concurrent control arm, where EMS providers, patient population, and trauma caseloads were similar to Khayelitsha. There were no implementation activities at Mitchell Plain. There was a 1-month washout period in December, 2018, during which no training or clinical outcomes data were collected. Pre- and post-implementation data were collected for the 13 consecutive months preceding (i.e., August, 2017 through August, 2018) and following (i.e., January, 2019 through January, 2020) implementation, respectively.

Data were collected from EMS providers and patients at both sites using a previously validated standardized chart review and abstraction methodology [22]. Providers’ demographics, qualifications, years of practice, and number of training session attended were collected. EMS clinical outcome data was collected for any patient who was ≥18 years old, traumatically injured excluding burns, electrocutions and isolated severe traumatic brain injuries, received care by a provider at either the intervention or control site, alive or attempted resuscitation upon ambulance arrival, and had at least two sets of vital signs documented (which was critical for calculating the primary outcome). Clinical data for each patient included mechanism of injury, vital signs, time from scene to hospital and prehospital interventions and was limited to data available from EMS clinical charts.

The primary outcome was delta shock index (i.e., the change in a patient's shock index at the scene versus their shock index upon hospital arrival) in the intervention group compared to the control group. Shock index is heart rate divided by systolic blood pressure, and is validated to predict trauma outcomes, including the early need for blood products and mortality [23, 24]. A shock index of <0.7 is normal, between 0.7 to <1.0 is intermediate, and ≥1.0 is considered high [25, 26]. In this study, a negative delta shock index represents improved shock upon facility arrival. The target effect of the study was the difference between the intervention and control groups in mean change of delta shock index from pre- to post-implementation (i.e., difference-in-differences) [27]. A more negative difference-in-differences indicates that the intervention is performing better than the control.

The power calculation was based on an assumed sample size of 600 patients (300 per intervention and control arms each, and 150 pre- and 150 post-implementation) collected over a two-year period. Based on prior data, we assumed a mean delta shock index of -0.05 in the control and pre-implementation group and a standard deviation of 0.025 [24, 25, 27]. With 90% power, we could detect an effect size (difference-in-differences) of -0.013 (corresponding to a standardized effect size of 0.53). Thus, assuming that there was no change in the mean delta shock index in the control group (-0.05 both pre- and post-implementation), we could detect a decrease in the mean delta shock index in the intervention group pre- vs. post-implementation from -0.05 to -0.063.

Comparisons between the intervention and control groups for both provider and patient characteristics, pre- and post-implementation, were performed using Wilcoxon, chi-squared, and t-tests, based on the type and distribution of the variable. The primary analysis was a difference-in-differences analysis to examine the difference between the control and intervention groups in changes in delta shock index over time [27]. This analysis was performed using a mixed effects model with a random effect for provider to account for clustering of outcomes for patients cared for by the same provider. Due to lack of variability between providers, as suggested by an estimated random intercept variance closer to zero, a regression model assuming independence within providers was used. To estimate the difference-in-differences, an interaction between study period and group (Intervention/Control) was of primary interest. Study period for trauma cases was classified as pre-implementation, 0-4 months post-implementation, 5-8 months post-implementation, or 9-13 months post-implementation. We divided the study period into intervals to study the change in intervention effect over time. All models also adjusted for the predictors: provider qualification (BLS, ILS, ALS), patient sex, injury mechanism (blunt or penetrating), cause of shock (i.e., haemorrhagic or other), patient age in years, initial shock index, and pre-arrival minutes (time from injury to ambulance arrival). All statistical analyses were conducted using SAS version 9.4 (SAS Institute Inc., Cary, N.C.).

Ethics approval was granted by the University of Cape Town Human Research Ethics Committee (ref 077/2018), the primary oversight ethics board, with a single-IRB reliance agreement with the Colorado Multiple Institutional Review Board. A waiver of informed consent for patients was approved, and EMS providers' written informed consent was obtained for all participating providers.

Results

EMS Provider Characteristics

Data were collected from a total of 198 of 240 eligible providers, who treated 770 trauma patients (Fig. 1). Each provider cared for a median of 3 (IQR: 1-4) traumatic shock patients during the study, and 150 (76%) of providers cared for fewer than 5 traumatic shock patients during the study. There were no significant demographic differences in EMS providers' age, sex, or years of experience between the cohorts of EMS providers in the pre-implementation period. There was a significant difference in EMS qualification between the pre-implementation cohorts, with the control group having a significantly higher proportion of BLS providers than the intervention group (Table 1).

Table 1. Providers' demographics and characteristics.

Variable	Category	Overall (N=198)	Study Group		P-value
			Control (N=105)	Intervention (N=93)	
Provider Sex	Male	107 (54%)	60 (57%)	47 (51%)	0.35
	Female	91 (46%)	45 (43%)	46 (49%)	
Provider Qualification	BLS[b]	83 (42%)	57 (54%)	26 (28%)	<0.001
	ILS	83 (42%)	36 (34%)	47 (51%)	
	ALS	32 (16%)	12 (11%)	20 (22%)	
Mean (SD) age in years		37.2 (7.3)	37.6 (7.9)	36.6 (6.5)	0.38
Median (IQR) years of experience		8.0 (5.0-11.0)	8.0 (5.0-12.0)	8.0 (5.0-11.0)	0.56[a]

[a] Wilcoxon Test; [b] the differing proportions of BLS providers are taken into account in the modelling procedures by adjusting for provider type as a fixed effect in all of the multivariable mode.

Patient Characteristics

There were no significant differences in pre- or post-implementation patient demographic and physiologic characteristics between the control and intervention cohorts with respect to age, sex, blunt versus penetrating injury mechanism, initial systolic blood pressure, and initial heart rate (Table 2a and 2b). In both pre- and post-implementation periods, there were similar proportions of patients with severe shock (i.e., shock index >1.0) and intermediate shock (i.e., shock index 0.7-<1.0) in both the intervention and control groups. Providers spent a similar amount of time on scene 23-minutes (SD 13-35) and delivered similar volumes of intravenous (IV) fluids in the intervention and control groups (500mL; IQR, 200-500), although 73% of patients received no IV fluids.

Table 2a. Patients' pre-intervention demographic and physiologic characteristics.

Pre-Implementation (n=355)					
Variable	**Category**	**Overall (N=355)**	**Control (N=202)**	**Intervention (N=153)**	**P-value**
Median (IQR) patient age in years		30 (25-37)	30 (25-39)	30 (25-36)	0.34[a]
Patient sex	Female	84 (24%)	44 (22%)	40 (26%)	0.34
	Male	271 (76%)	158 (78%)	113 (74%)	
Primary injury mechanism	Blunt	166 (47%)	96 (48%)	70 (46%)	0.74
	Penetrating	189 (53%)	106 (52%)	83 (54%)	
Median (IQR) initial heart rate (BPM)		111 (102-118)	112 (104-118)	110 (98-119)	0.17[a]
Median (IQR) initial SBP (mm Hg)		112 (90-130)	114 (94-130)	110 (90-129)	0.12[a]
Median (IQR) Initial Shock Index		0.96 (0.85-1.10)	0.96 (0.85-1.11)	0.96 (0.87-1.09)	0.84[a]
Shock stage defined by initial Shock Index	High (>=1.0)	149 (42%)	87 (43%)	62 (41%)	0.18
	Intermediate (0.7-<1.0)	189 (53%)	109 (54%)	80 (52%)	
	Normal (<0.7)	17 (5%)	6 (3%)	11 (7%)	
Median (IQR) change in Shock Index from initial to final		-0.05 (-0.19-0.02)	-0.04 (-0.16-0.01)	-0.06 (-0.23-0.02)	0.24[a]
Median (IQR) minutes from incident to scene arrival (n=4, 1% missing)		16 (10-33)	17 (10-34)	15 (10-32)	0.93[a]
Median (IQR) minutes from scene arrival to scene departure		23 (13-35)	24 (12-36)	22 (14-32)	0.93[a]
Median (IQR) minutes from scene departure to hospital arrival		18 (10-27)	21 (12-29)	13 (9-22)	<.0001[a]

SBP = systolic blood pressure; [a] Wilcoxon Test

Table 2b. Patients' post-intervention demographic and physiologic characteristics

Post-Implementation (n=415)					
Variable	**Category**	**Overall (N=415)**	**Control (N=239)**	**Intervention (N=176)**	**P-value**
Median (IQR) patient age in years		30 (24-36)	30 (24-36)	30 (25-37)	0.42[a]
Patient sex (n=4, 1% missing)	Female	85 (21%)	53 (22%)	32 (18%)	0.35
	Male	326 (79%)	185 (78%)	141 (82%)	
Primary injury mechanism	Blunt	191 (46%)	109 (46%)	82 (47%)	0.84
	Penetrating	224 (54%)	103 (54%)	94 (53%)	
Median (IQR) initial heart rate (BPM)		111 (104-119)	111 (106-120)	110 (97-119)	0.06[a]
Median (IQR) initial SBP (mm Hg)		114 (91-130)	115 (100-130)	110 (90-129)	0.10[a]
Median (IQR) Initial Shock Index		0.96 (0.85-1.11)	0.95 (0.85-1.11)	0.97 (0.85-1.12)	0.96[a]
Shock stage defined by initial Shock Index	High (>=1.0)	176 (42%)	100 (42%)	76 (43%)	0.12
	Intermediate (0.7-<1.0)	226 (54%)	135 (56%)	91 (52%)	
	Normal (<0.7)	13 (3%)	4 (2%)	9 (5%)	
Median (IQR) change in Shock Index from initial to final		-0.03 (-0.14-0.05)	-0.03 (-0.12-0.04)	-0.04 (-0.18-0.06)	0.53[a]
Median (IQR) minutes from incident to scene arrival (n=7, 2% missing)		23 (13-47)	25 (15-51)	18 (12-41)	0.003[a]
Median (IQR) minutes from scene arrival to scene departure		18 (9-27)	17 (7-28)	19 (10-26)	0.25[a]
Median (IQR) minutes from scene departure to hospital arrival		15 (9-27)	16 (10-28)	14 (9-25)	0.43[a]

SBP = systolic blood pressure; [a] Wilcoxon Test

Difference-in-Differences of Entire Cohort

Overall, both the control and the intervention groups had an increase in mean delta shock index (i.e., worsening shock) in the 4 months post-implementation compared to pre-implementation (Fig. 2 and Table 3); although the increase in mean delta shock index was smaller in the intervention group compared to the control group, the difference in the change between the two groups was not statistically significantly different (0.047 change in control arm, 0.004 change in intervention arm; -0.043 difference-in-differences, P=0.27). There was no significant difference in change over time between the groups for any of the other time intervals (5-8 months: difference-in-differences 0.008, P=0.86; 9-13 months: difference-in-differences -0.021, P=0.59).

Table 3. Delta shock index by time interval and study group, for entire cohort (N=755)[a]

	Control		Intervention			
Time Interval	**Frequency**	**Estimated Delta SI (95% CI)**	**Frequency**	**Estimated Delta SI (95% CI)**	**Difference in Differences (95% CI) (Intervention-Control)**	**P-value**
Before - All	200	-0.071 (-0.101, -0.042)	151	-0.097 (-0.129, -0.064)		
Post - 0-4 months	73	-0.024 (-0.070, 0.022)	69	-0.093 (-0.140, -0.045)	-0.043 (-0.119, 0.033)	0.27
Post - 5-8 months	62	-0.044 (-0.094, 0.005)	39	-0.062 (-0.124, 0.001)	0.008 (-0.080, 0.097)	0.86
Post - 9-13 months	98	-0.028 (-0.067, 0.011)	63	-0.074 (-0.124, -0.025)	-0.021 (-0.095, 0.054)	0.59

SI = shock index. A more negative delta SI represents more improved shock.
[a]15 cases from the original sample of N=770 were excluded from this analysis due to missing data.

Difference-in-Differences of Subgroups

In pre-specified subgroup analyses, there was no statistically significant difference between cohorts of patients based on the following individual characteristics: mechanism of injury (i.e., penetrating versus blunt); patients in severe shock at the scene (i.e., initial shock index ≥ 1.0); EMS provider qualification (i.e., BLS, ILS, BLS+ILS); mechanism of injury (i.e., penetrating versus blunt); or combinations of provider and patient factors (i.e., BLS +/- ILS with severe shock; BLS +/- ILS with penetrating injury).

In the following four pre-specified groups, we observed a clinically relevant, but not statistically significant, improvement of delta shock indices in the intervention arm compared to control arm: entire cohort, cases with BLS providers, penetrating injury cases, and severe initial shock (Table 4 and Fig. 1). Notably, the greatest clinical improvement in delta shock index in the intervention versus control arm consistently occurred at the immediate post-implementation (i.e., 0-4-month) period, and decreased with later time periods (i.e., 5-8 months and 9-13 months). Further, the largest (and most clinically significant) relative improvement of delta shock index in the intervention arm occurred in the subgroup of penetrating trauma cases cared for by BLS providers in the 0-4 month post-implementation phase (-0.163 difference-in-differences, P=0.07) (Table 4).

Table 4. Difference-in-differences by time interval and study group

Time Interval	N Control	N Intervention	Difference in Differences (95% CI) (Intervention-Control)	P-value
Group=Overall[a]				
Before - All	200	151		
Post - 0-4 months	73	69	-0.043 (-0.119, 0.033)	0.27
Post - 5-8 months	62	39	0.008 (-0.080, 0.097)	0.86
Post - 9-13 months	98	63	-0.021 (-0.095, 0.054)	0.59
Cases with BLS Provider				
Before – All	81	37		
Post - 0-4 months	39	9	-0.163 (-0.336, 0.011)	0.07
Post - 5-8 months	28	8	-0.035 (-0.219, 0.149)	0.71
Post - 9-13 months	44	9	0.051 (-0.120, 0.222)	0.56
Cases with ILS Provider				
Before – All	97	70		
Post - 0-4 months	20	39	0.023 (-0.091, 0.136)	0.70
Post - 5-8 months	15	23	0.090 (-0.042, 0.221)	0.18
Post - 9-13 months	32	36	-0.074 (-0.178, 0.029)	0.16
Cases with ALS Provider				
Before – All	22	44		
Post - 0-4 months	14	21	-0.009 (-0.158, 0.139)	0.90
Post - 5-8 months	19	8	-0.044 (-0.214, 0.127)	0.62
Post - 9-13 months	22	18	0.008 (-0.133, 0.149)	0.91
Penetrating Injury Only				
Before – All	104	81		
Post - 0-4 months	47	34	-0.050 (-0.165, 0.065)	0.39
Post - 5-8 months	35	23	0.019 (-0.112, 0.150)	0.78
Post - 9-13 months	45	36	-0.081 (-0.195, 0.033)	0.16
Initial Shock Index >= 1.0				
Before - All	86	60		
Post - 0-4 months	37	26	-0.078 (-0.208, 0.051)	0.24
Post - 5-8 months	24	23	0.001 (-0.141, 0.144)	0.99
Post - 9-13 months	36	25	-0.033 (-0.164, 0.097)	0.62
Penetrating Injury with BLS Providers				
Before - All	44	23		
Post - 0-4 months	26	3	-0.372 (-0.674, -0.070)	0.02
Post - 5-8 months	18	3	0.029 (-0.283, 0.341)	0.86
Post - 9-13 months	20	7	-0.015 (-0.247, 0.218)	0.90

[a]*15 cases from the original cohort of N=770 were excluded from this analysis due to missing data.*

Discussion

To our knowledge, this is the first prehospital traumatic shock clinical study conducted in a low- or middle-income country. We implemented a simplified bundle of traumatic shock care, EMS-TruShoC, among 240 EMS providers in South Africa and assessed 770 patient's delta shock index at the scene versus upon hospital arrival, and compared the pre- versus post-implementation delta shock index to a control arm. Overall, there was no statistically significant difference between arms. In pre-planned exploratory analyses, we did, however, observe clinically relevant and statistically significant improvements in shock index in specific EMS-TruShoC intervention subgroups consisting of patients with severe initial shock, cases with BLS providers, and penetrating injuries, and we noted consistently superior improvements in shock indices in the immediate post-implementation phase (i.e., 0-4 months).

There is plausibility to support the four subgroups in which we measured the most significant improvements in shock index in our intervention cohort. *A-priori*, we hypothesized that BLS providers were likely to benefit most from our bundle of care intervention, compared to ILS and ALS providers, due to limited baseline BLS provider training in recognizing and managing haemorrhagic shock commensurate with their narrow training and scope of practice [21]. Next, it is widely reported that penetrating trauma is more likely than blunt trauma to cause haemorrhage, promulgate shock and increase mortality [28]. Coupled with the fact that penetrating injury is more amenable to EMS management compared to blunt trauma, it is not surprising that EMS-TruShoC improved shock physiology in the penetrating trauma subgroup [28]. Similarly, patients with severe initial shock (i.e., those who had the most deranged systolic blood pressure and/or heart rate at the scene) experienced physiologic improvements, which is also the expected effect of the bundle of care. Last, we noted a consistent trend across all subgroups that delta shock indices were more improved in the intervention cohort during the immediate post-implementation period compared to later periods. This may be explained by decay in EMS-TruShoC knowledge, attitudes, and skills with advancing time, which has been well-described in prior emergency care literature [29]. As an aggregated effect, we noted that BLS providers who cared for penetrating trauma cases in the immediate post-implementation phase experienced the largest improved shock indices (median improvement of 0.37) which was statistically significant.

Notwithstanding these clinically modest improvements in selected subgroups, most findings in this study did not reach statistical nor clinical significance which warrant further exploration via a contextual understanding of our clinical bundle, the sensitivity of shock index, prehospital resources and provider capabilities.

First, three core components of our EMS-TruShoC shock bundle may confer no immediate prehospital physiologic advantage, namely: large IV catheter, scene time <10 minutes, and transport to trauma centre. The expert panel purposefully included large bore IV catheter insertion in the bundle, in lieu of prescribing an IV fluid regimen, as both a patient safety measure and to help enhance implementation feasibility across diverse EMS systems [30]. Additional studies have demonstrated that short scene times and rapid transport to trauma centres have been strongly correlated with improved survival in severe trauma and are considered ‘best practices’, but neither core component directly influences prehospital patient physiology [28].

However, delivery of oxygen and haemorrhage control may be more likely to directly improve prehospital shock index by dampening tachycardia and hypotension [23, 25].

Second, despite several advantages, delta shock index may be limited in its ability to detect early and subtle physiologic changes in haemorrhagic shock. Shock index outperforms traditional vital signs in predicting adverse trauma outcomes; and shock index is non-invasive and more practical to collect than laboratory markers, such as lactic acid [23-25, 31]. Yet, the shock index area under the receiver-operated curve (AUROC) is modest (0.63 to 0.68) for predicting 48-hour mortality in undifferentiated trauma patients [23, 31, 32]. Further, despite being intuitive to interpret, there is sparse data regarding the utility of the delta value of shock index. The median delta shock index in our study ranged between 0.03 and 0.05 (post- and pre-implementation, respectively) which may be too small of a physiologic change compared to the discriminative ability of delta shock index reported by Cannon *et al*. [25].

Third, it is conceivable that prehospital haemorrhage control resources and variability in provider care (i.e., factors beyond our control) may have influenced our results and prevented us from measuring a difference in physiology between cohorts. It is also possible that EMS providers implemented our bundle variably, as is typical in prehospital practice [33].

Overall, this study contributes valuable preliminary evidence to the under-researched field of prehospital resuscitation in trauma, especially in resource-limited settings globally. All prior prehospital traumatic shock studies published in peer-reviewed journals were conducted in high-income countries, mostly in North America and Europe, [34-39] and mostly published in the past decade with a predominant focus on the effect of fluid resuscitation (often, blood products or crystalloids) on patient outcomes e.g., PAMPer, PROMMTT, PROPPR, and COMBAT trials [34-36, 38, 39]. However, in resource-limited settings, simplified bundles of care that promote performance of basic evidence-based interventions are needed.

This study was limited to analysis of data available in standard prehospital documentation, therefore detailed information about the final injuries necessary to calculate ISS or AIS were not available and SI was selected as the best surrogate for injury severity. Additionally, the final hospital outcome could not be assessed. A primary outcome of delta SI was selected due to the more consistently available vital signs throughout the prehospital course and correlation with outcomes in other trauma studies. In our study setting providers work in pairs, frequently changing work partners; it would not have been possible to randomly assign providers at a given base to the intervention without contamination and patients receiving a mix of intervention and control providers throughout the course of the study. Therefore, a quasi-experimental study design was used which allows for assessment of the impact of the intervention but not causality. Consequently, data collectors could not be blinded to intervention.

Conclusion

In conclusion, educationally implementing a prehospital bundle of care, EMS-TruShoC, for treatment of patients with traumatic haemorrhagic shock did not result in a statistically significant improvement in shock indices from scene to hospital arrival. However, we observed modest clinically-relevant improvements in shock index in patients receiving care from EMS-TruShoC-trained BLS providers in the first four months after the intervention was implemented.

Patients with initial severe shock and those with penetrating injuries, in the EMS-TruShoC arm, also experienced small clinical improvement in their shock index following implementation of the intervention. Additional work is needed to identify which components of the bundle of care had the most impact on shock index and to identify critical prehospital interventions associated with hospital morbidity and mortality.

Dissemination of results

Results from this study were disseminated via e-mail reports and in-person presentations to the various leaders of the relevant units that contributed to the data collection.

Authors' contributions

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content:

NM contributed 35%; JD contributed 20%; BBes contributed 10%; BBea, KS, BvS, FM, and CC contributed 4% each; AG, LW, SS, JM, SdV, and VB contributed 2.5% each.

All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declared no conflicts of interest. The views expressed in this article are those of the authors and do not reflect the official policy or position of any listed institution, including the

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Fig. 1. Study flow diagram.

Fig. 2. Mean change in shock between EMS arrival at the scene of injury to hospital arrival by whole cohort (1a), cases with BLS providers (1b), penetrating injury (1c) and severe shock (1d). The more negative the change in shock index value is, the more improved the shock.

Appendix B. EMS-TruShoC Algorithm and Bundle of Care Supplementary Material.

Appendix C. Emergency Medical Services Traumatic Shock Care (EMS-TruShoC) Learning Objectives.

Appendix D. EMS-TruShoC Training Materials.

Figure 1_Flow Diagram

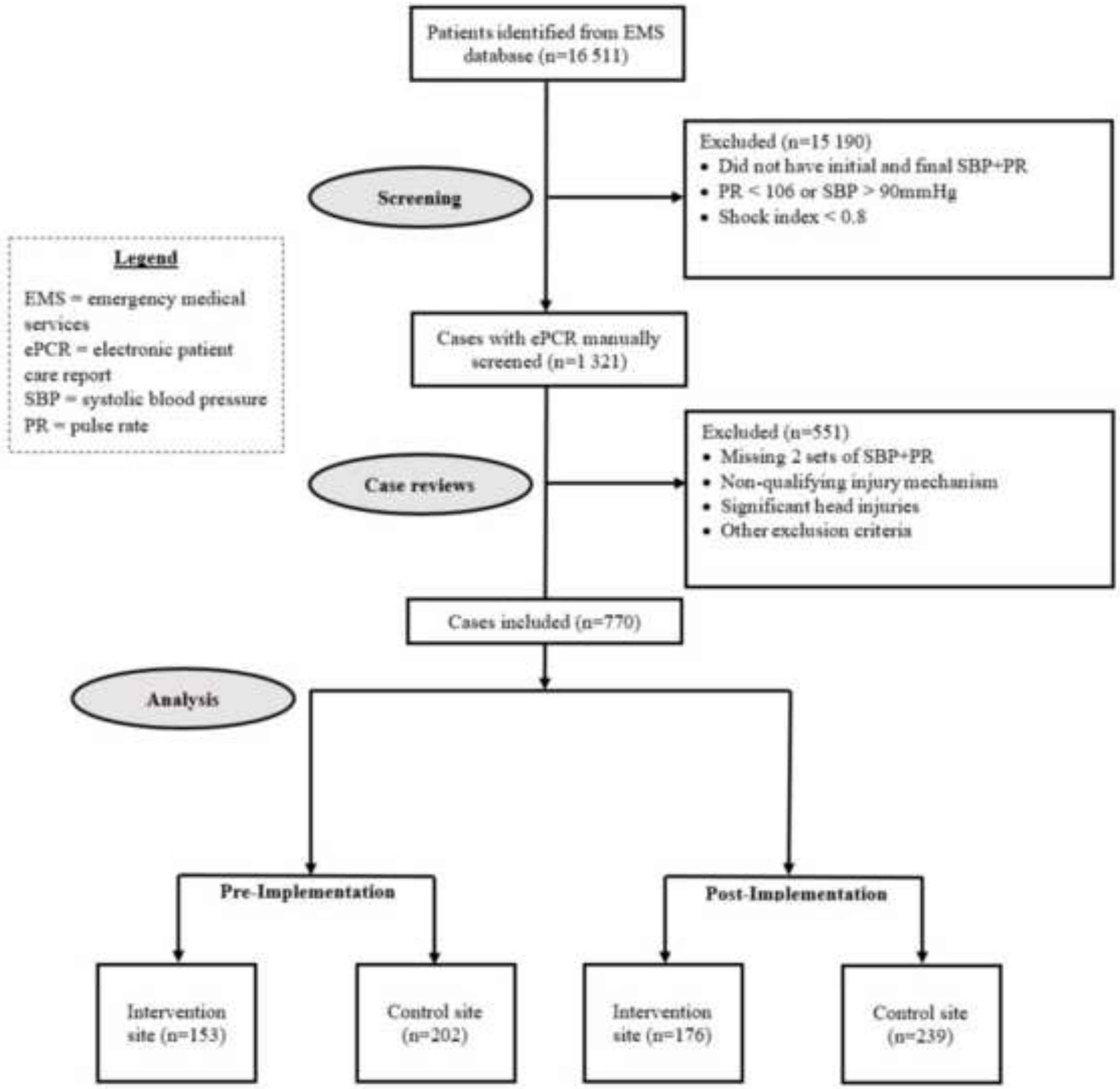
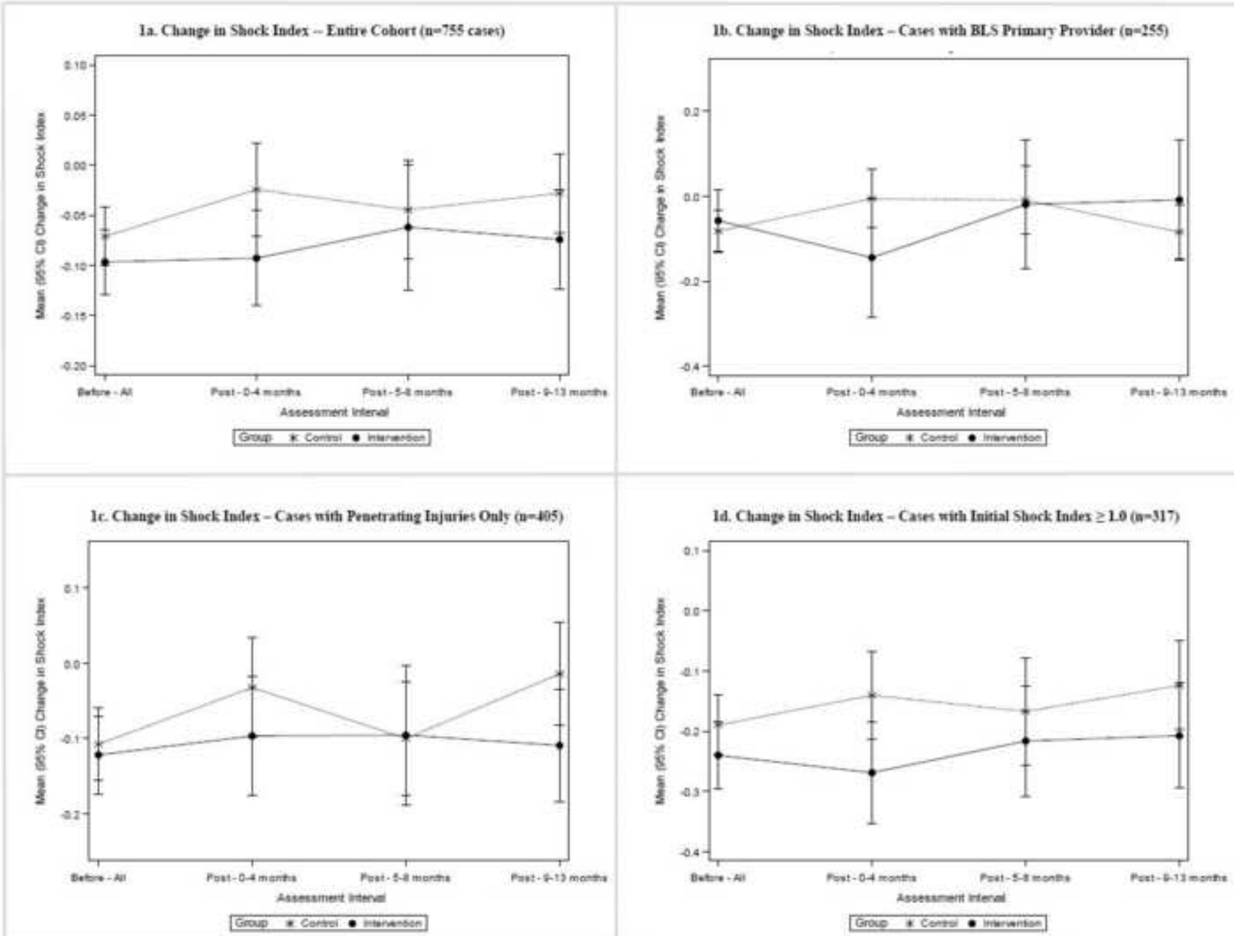


Figure 2. Change in Shock



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Dr. Nee-Kofi Mould-Millman

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Dissemination of results

Results from this study were disseminated via e-mail reports and in-person presentations to the various leaders of the relevant units that contributed to the data collection.

Authors' contributions

Authors contributed as follow to the conception or design of the work; the acquisition, analysis, or interpretation of data for the work; and drafting the work or revising it critically for important intellectual content:

NM contributed 35%; JD contributed 20%; BB contributed 10%; BB, KS, BvS, FM, and CC contributed 4% each; AG, LW, SS, JM, SdV, and VB contributed 2.5% each.

All authors approved the version to be published and agreed to be accountable for all aspects of the work.

Declaration of Competing Interest

The authors declared no conflicts of interest. The views expressed in this article are those of the authors and do not reflect the official policy or position of any listed institution, including the U.S. Army Medical Department, U.S. Department of the Army, U.S. Department of Defense, or the U.S. Government.

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Appendix B

Click here to access/download

Supporting File

Appendix B_ EMS-TruShoC Algorithm.pdf

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Supporting File

Appendix C_EMS-TruShoC Learning Objectives.docx

Click here to access/download
Supporting File
Appendix D_EMS_TruShoC Training Materials.pdf

Appendix 3 – Implementation science outcomes

Attached is a copy of a peer-reviewed abstract presented at the Military Health System Research Symposium in 2019. The abstract summarizes the main implementation science outcomes and findings.

Notable Research Successes:

- We successfully enrolled 198 EMS providers
- We successfully enrolled 770 prehospital patients with severe injuries and shock
- The study was Africa's first prehospital hemorrhagic shock (quasi-experimental) trial

Notable South African Organizational Successes:

- We successfully trained a South African EMS team to implement the intervention
- We built very strong relationships and goodwill with EMS leaders and stakeholders
- The H.E.E.T. training program was used by Western Cape EMS for COVID training

Innovation:

- We innovatively studied bundled care as a solution for improving prehospital care
- We used contemporary and evidence-based implementation science principles
- We conducted this in an area with the highest global trauma prevalence and mortality

Key Results:

- There was no significant difference in physiologic outcomes between the entire EMS-TruShoC intervention group versus control groups
- In subgroup analyses, there were significant improvements in outcomes in penetrating trauma patients and patients who received care from BLS (i.e., basic EMS providers)
- Findings suggest that the EMS-TruShoC clinical intervention may be most beneficial to patients with penetrating injuries (usually hemorrhage and shock).
- Findings also suggest that the H.E.E.T. training program may benefit basic EMS providers the most, compared to intermediate and advanced providers.

See scientific abstract on the following page…

High Efficiency EMS Training (HEET): A novel, effective strategy for on-the-job trauma training in a low-resource international setting.

Department of Emergency Medicine
SCHOOL OF MEDICINE
UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

Nee-Kofi Mould-Millman, MD[1], Bradley van Ster, BTech[2], Julia Dixon, MD MPH[1], Binyamien Kariem, BTech[2], Michael Lee, CCA[2], Peter Lesch, CCA[2], Chrishando Staines, CCA[2], Wayne Philander, CCA[2], Aldrin Mackier, CCA[2], Craig Williams, CCA[2], Nico van Nierkerk, BTech[2], Shaheem de Vries, MBChB, MPhil[2], Lani Finck[1], Beatrix Bester, BTech[2], Charmaine Cunningham, MBA[3], MAJ Steven G. Schauer, DO[4], Maj Joseph Maddry, MD[5], Col Vikhyat Bebarta, MD[1], Adit A Ginde, MD, MPH[1]

1 University of Colorado, School of Medicine, Department of Emergency Medicine, Aurora, CO – USA
2 Western Cape Government Health, Emergency Medical Services, Cape Town – South Africa
3 University of Cape Town, Division of Emergency Medicine, Cape Town – South Africa
4 US Army Institute of Surgical Research, Fort Sam Houston, TX – USA
5 USAF En route Care Research Center/59th MWD/USAISR, Fort Sam Houston, TX – USA

Western Cape Government
Health

BACKGROUND

- Up to 25% of US combat deaths are potentially preventable
- Prehospital care is an early opportunity to improve survival
- Effective on-going training is a leading impediment
- 'Hip pocket' training is an informal military training strategy
- But is often inconsistent and unstructured
- H.E.E.T. (High-Efficiency EMS Training) is novel low-dose, high-frequency, on-the-job trauma re-training program.

OBJECTIVES

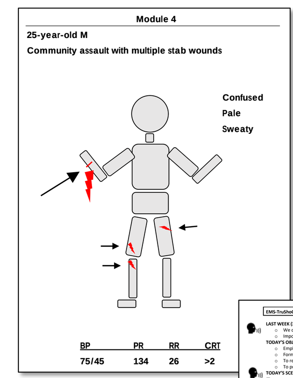
- We report a novel implementation strategy, and related outcomes, from implementation of the H.E.E.T. program in a high-trauma, austere, civilian EMS setting.

METHODS

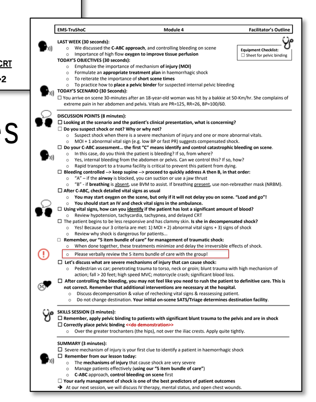
- Design: Prospective hybrid implementation-effectiveness study (type II)
- Period: August to November, 2018
- Setting: Resource-limited civilian prehospital (EMS) system in the Western Cape Province of South Africa.
- Population: This region has similarities to combat casualty care, with 8-times the global trauma mortality, 40-65% penetrating trauma and prolonged field care.
- EMS providers: 98 EMTs and 19 paramedics eligible
- Intervention: Bundled essential traumatic shock care (EMS-TruShoC), similar to TCCC-based interventions
- Implementation strategy: H.E.E.T. (see annotated image)
- Data Collection: Assessments, surveys, interviews (to populate the RE-AIM evaluation framework).
- QUAN Analysis: Mean effectiveness size (MES), %
- QUAL Analysis: Deductive analysis to fit RE-AIM framework

H.E.E.T. (High Efficiency EMS re-Training) Program

- Low-dose (15-20 mins per session)
- High-Frequency (once weekly)

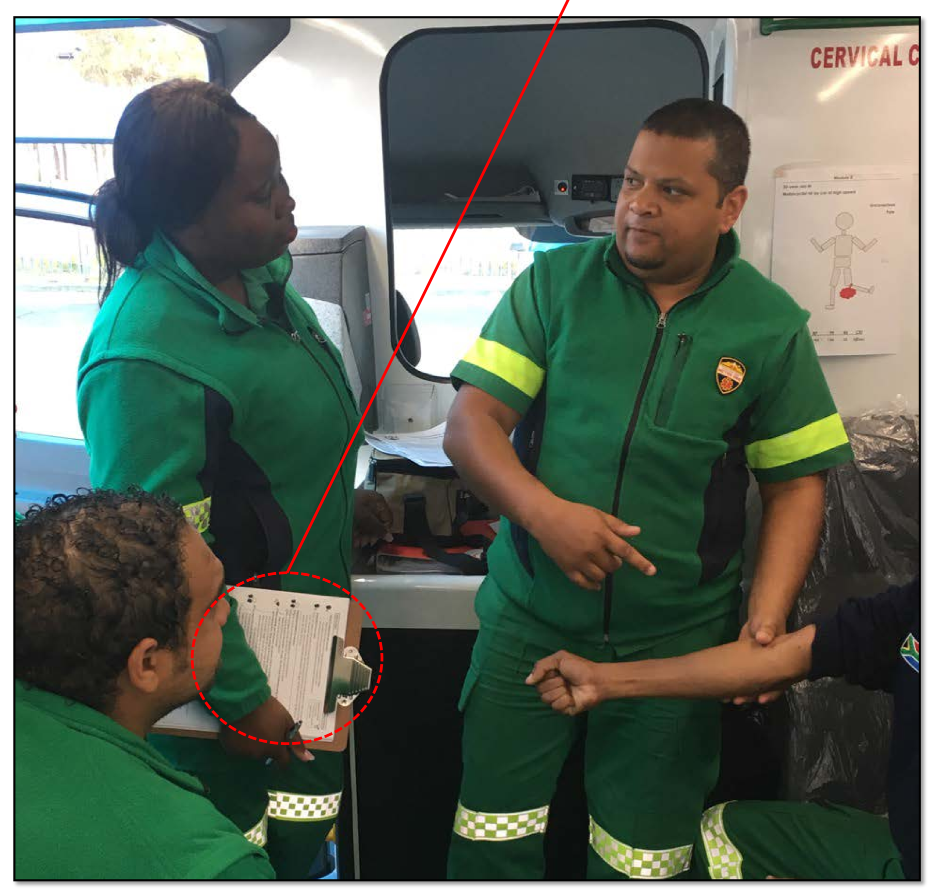


Visual aides



Trainer manual

- In back of ambulance
- Peer-led (paramedics teaching EMTs)
- Highly structured: objectives, modules and content
- Case-based discussion, simulation, & conditioning
- Knowledge-attitudes-skills training in all sessions



LIMITATIONS

- Single-site implementation and evaluation
- Content was focused on hemorrhagic shock
- Basic- and intermediate-life support providers trained

RESULTS (quant & qual)

Reach	• **High participation rate (MES=74%):** ➢ 72 of 98 providers ("learners") completed ➢ (+) factors: on-shift timing, inside vehicles
Effectiveness	• **Improvements in assessments (MES=69%):** ➢ 77% improved trauma knowledge ➢ 83% improved trauma skills ➢ 47% improved trauma self-efficacy
Adoption	• **Strong adoption by EMS (MES=89%):** ➢ 95% (18 of 19) trainers participated ➢ Sessions well-rated by learners (4.6/5) ➢ 100% (12) stated HEET is a good fit and a cost-effective EMS educational solution
Implementation Fidelity	• **High implementation fidelity (MES=81%):** ➢ 86% (4.3/5) was average quality score ➢ 2:1 learner:trainer ratio in 42% of sessions ➢ 100% of content delivered as planned ➢ 54% of sessions delivered +/-15-mins of goal ➢ (+) factors: motivated trainers & managers
Maintenance	• **Measurement deferred:** ➢ N/A to interventions lasting <6-months
OVERALL	**76% mean effectiveness size (MES)**

CONCLUSIONS

- HEET achieved strong implementation effectiveness
- HEET is a successful implementation strategy for on-the-job re-training of civilian providers in an austere EMS system
- Major factors: short-burst trainings scheduled during shift time, using motivated well-trained near-peer trainers, managerial oversight, and the hands-on interactive sessions
- US military-specific studies are needed to explore how HEET may be adapted for battlefield medical providers' training.

Funding provided by: Defense Health Agency (FA8650-18-2-6934); NIH NHLBI K12 IMPACT (1K12HL137862-01); Emergency Medicine Foundation.

Questions? Nee-Kofi.Mould-Millman@UCDenver.edu

Authors have no conflicts of interest.

Appendix 4 – Educational outcomes

Attached is a copy of a peer-reviewed abstract presented at the US Society for Academic Emergency Medicine in 2020. The presentation summarizes the main educational outcomes and conclusions.

Notable Research Successes:

- We successfully enrolled a high number of EMS providers(198)
- We successfully conducted 728 assessments of the 198 providers
- High retention of enrolled EMS providers = 75% intervention site and 77% control site.

Notable South African Organizational Successes:

- We built a multi-disciplinary training team comprised of Western Cape EMS educators, managers, and quality improvement personnel.
- The multi-disciplinary team gained expertise in novel educational program design and implementation and assessment strategies.
- The team held its last meeting in June, 2021 – they are planning the formal inclusion the H.E.E.T. program as a key part of the Western Cape EMS training strategy.

Innovation:

- We conducted the first training program in the back of the ambulance, using peer trainers, with training sessions occurring on-duty with usually available equipment.

Key Results:

The H.E.E.T. training program:

- improved educational effectiveness (knowledge and skills had highest effect)
- sustained knowledge and skills retention at least until 12-months post-training
- is practical to execute in a resource-constrained pre-hospital system

See presentation on the following pages…

High-Efficiency EMS Training (HEET):

A novel approach of low-dose, high-frequency, on-the-job, peer-led training.

Nee-Kofi Mould-Millman, MD

Associate Professor, Emergency Medicine

Senior Investigator, Center for Global Health

University of Colorado, Anschutz Medical Campus

Department of Emergency Medicine
SCHOOL OF MEDICINE
UNIVERSITY OF COLORADO **ANSCHUTZ MEDICAL CAMPUS**

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Collaborators

Nee-Kofi Mould-Millman, MD[1]; Julia Dixon, MD MPH[1;], Bradley van Ster, BTech[2]; Chrishando Staines, CCA[2], Michael Lee, CCA[2;], Peter Lesch, CCA[2]; Lani Finck[1], Nico van Nierkerk, CAA[2], Shaheem de Vries, MBChB, MPhil[2], Kubendhren Moodley, MSHS[2], Radomir Cermak, MHS[2], Brenda Beaty, MSPH[3], Krithika Suresh, PhD[3], Beatrix Bester, BTech[2], Fabio Moreira, BEMC[2], Charmaine Cunningham, MBA[4], MAJ Steven G. Schauer, DO[5], Lt Col Joseph Maddry, MD[6], Col Vikhyat Bebarta, MD[1], Adit A Ginde, MD, MPH[1].

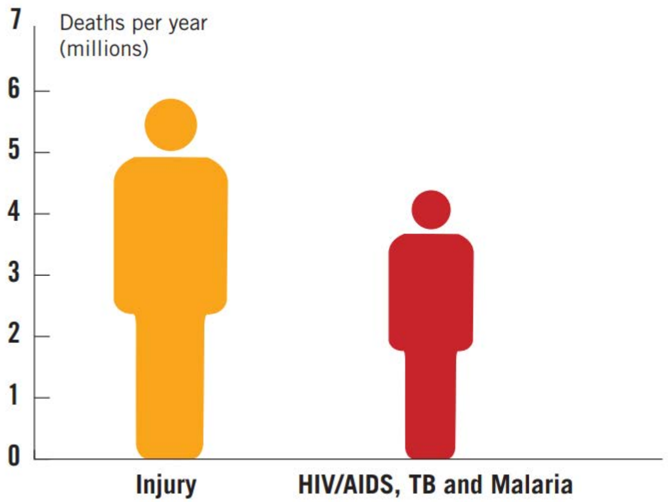
1. University of Colorado, School of Medicine, Department of Emergency Medicine, Aurora, CO – USA
2. Western Cape Government Health, Emergency Medical Services, Cape Town – South Africa
3. University of Colorado, Adult and Child Consortium for Health Outcomes Research and Delivery Science, Aurora, CO - USA
4. University of Cape Town, Faculty of Health Sciences, Division of Emergency Medicine, Cape Town – South Africa
5. US Army Institute of Surgical Research, Fort Sam Houston, TX – USA
6. US Air Force, En route Care Research Center/59th MWD/USAISR, Fort Sam Houston, TX – USA

Conflicts/Disclosures

- No conflicts of interest.
- Financial disclosures:
  - Defense Health Agency (FA8650-18-2-6934)
  - NIH NHLBI (1K12HL137862-01)
  - Emergency Medicine Foundation

Background

- Low-and-middle income countries experience 90% of global trauma deaths.
- Continuing trauma education is promising but often ineffective.
- HEET (High-Efficiency EMS Training) is a promising model.
- Objective: to assess longitudinal educational effectiveness of HEET in a LMIC.



Methods

- Design: Quasi-experimental trial
- Setting: South Africa; resource-limited EMS
- Period: August, 2018 – January, 2020
- Population: High trauma, high mortality
- Sites: Intervention & matched control site
- QUANT: knowledge, attitudes, skills
- Time: pre (T_0), post (T_1), mo-4 (T_4), mo-12 (T_{12})
- QUAL: Semi-structured interviews at T_1.

Methods

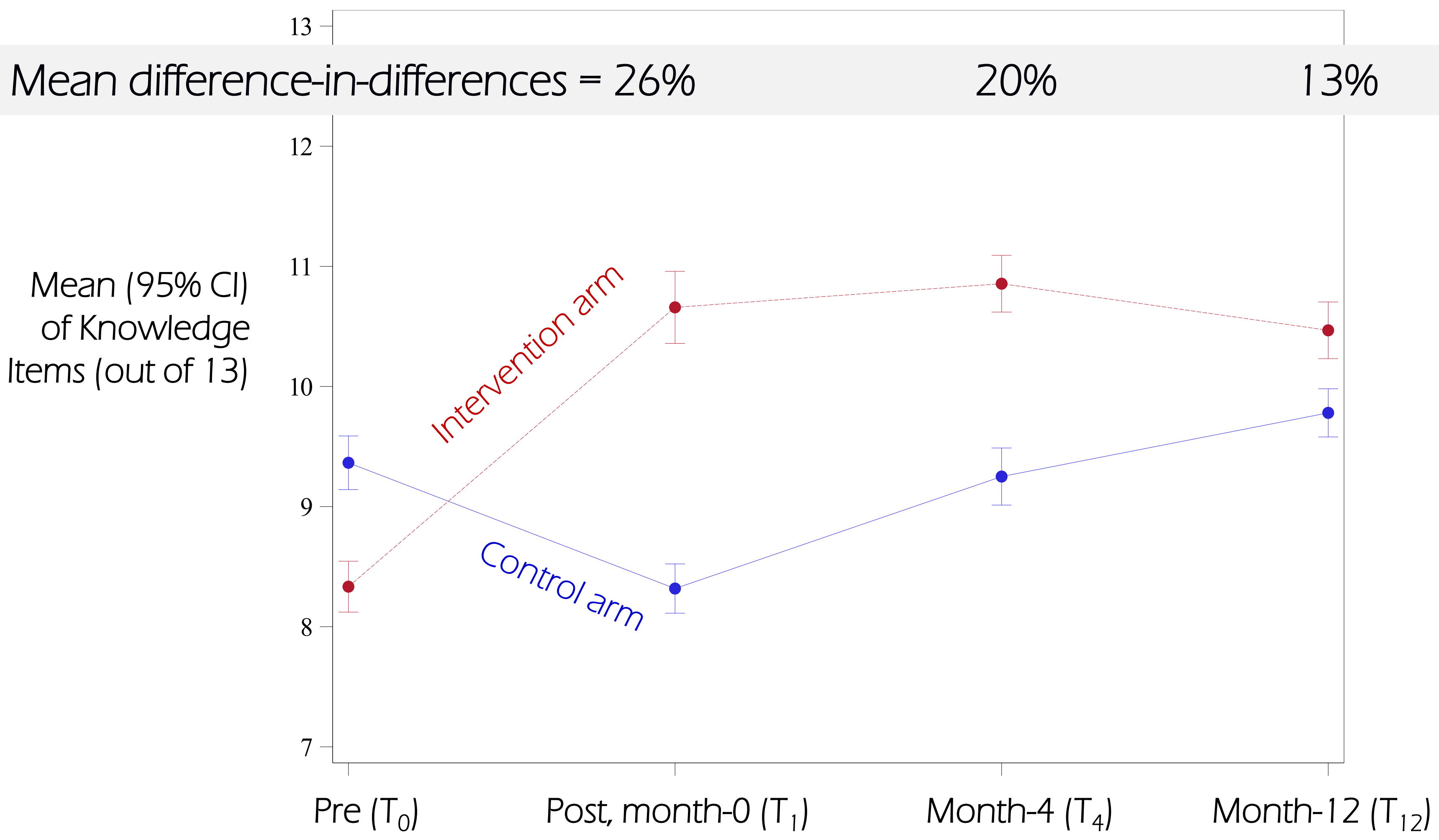
- <u>HEET implementation strategy:</u>
  - Low-dose (15-minutes),
  - High-frequency (weekly),
  - Peer led (trained paramedics),
  - At shift start (07h00, 19h00)
  - In the back of ambulances
  - Content = hemorrhagic shock
- <u>Analysis:</u>
  - QUANT: difference-in-differences
  - QUAL: exploratory; converged w/ quant

Results

- 728 unique assessments (n=269):
  - 193 at T_0, 167 at T_1, 175 at $T_{4,}$ and 193 at T_{12}
  - No diff in recruitment rates:
    - 75% intervention site
    - 77% control site
- No diff in demographics:
  - Mean age (38-years)
  - Gender (55% male)
  - EMS rank (45% BLS)
  - Experience (8-years)

Results (knowledge)

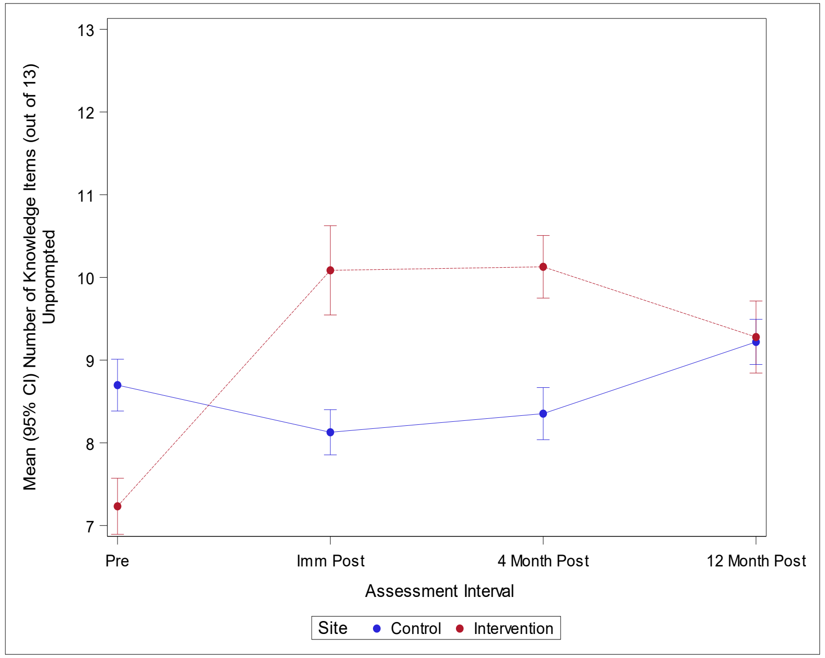
Mean difference-in-differences = 26% 20% 13%



T_1 = 26% (3.3/13; p<0.001)
T_4 = 20% (2.7/13; p<0.001)
T_{12} = 13% (1.7/13; p<0.001)
AVG = 20% improvement

Results (knowledge) – subgroups

BLS



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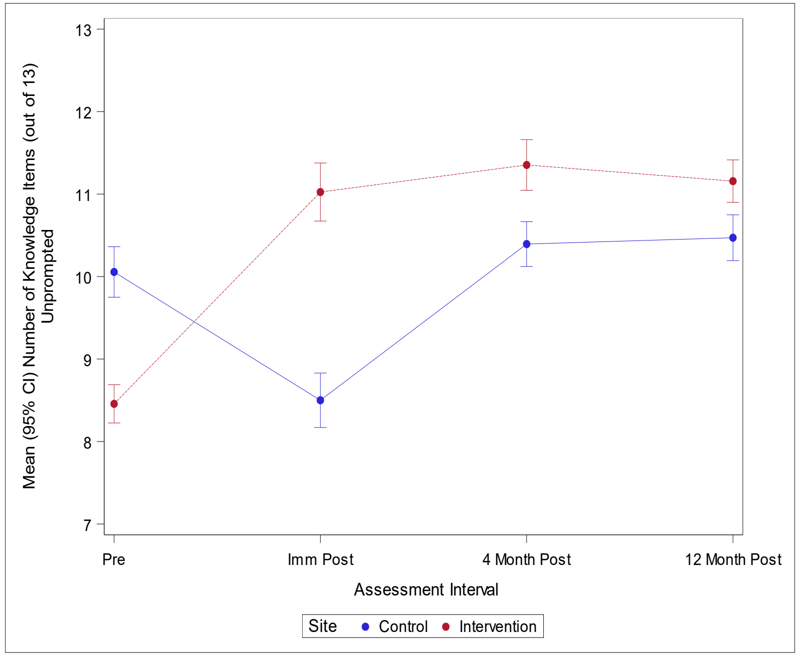

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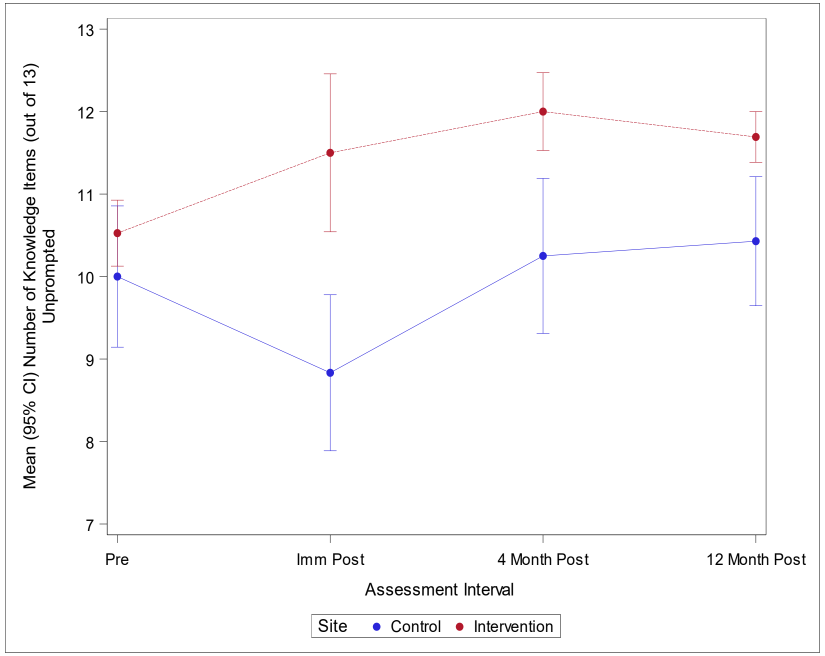
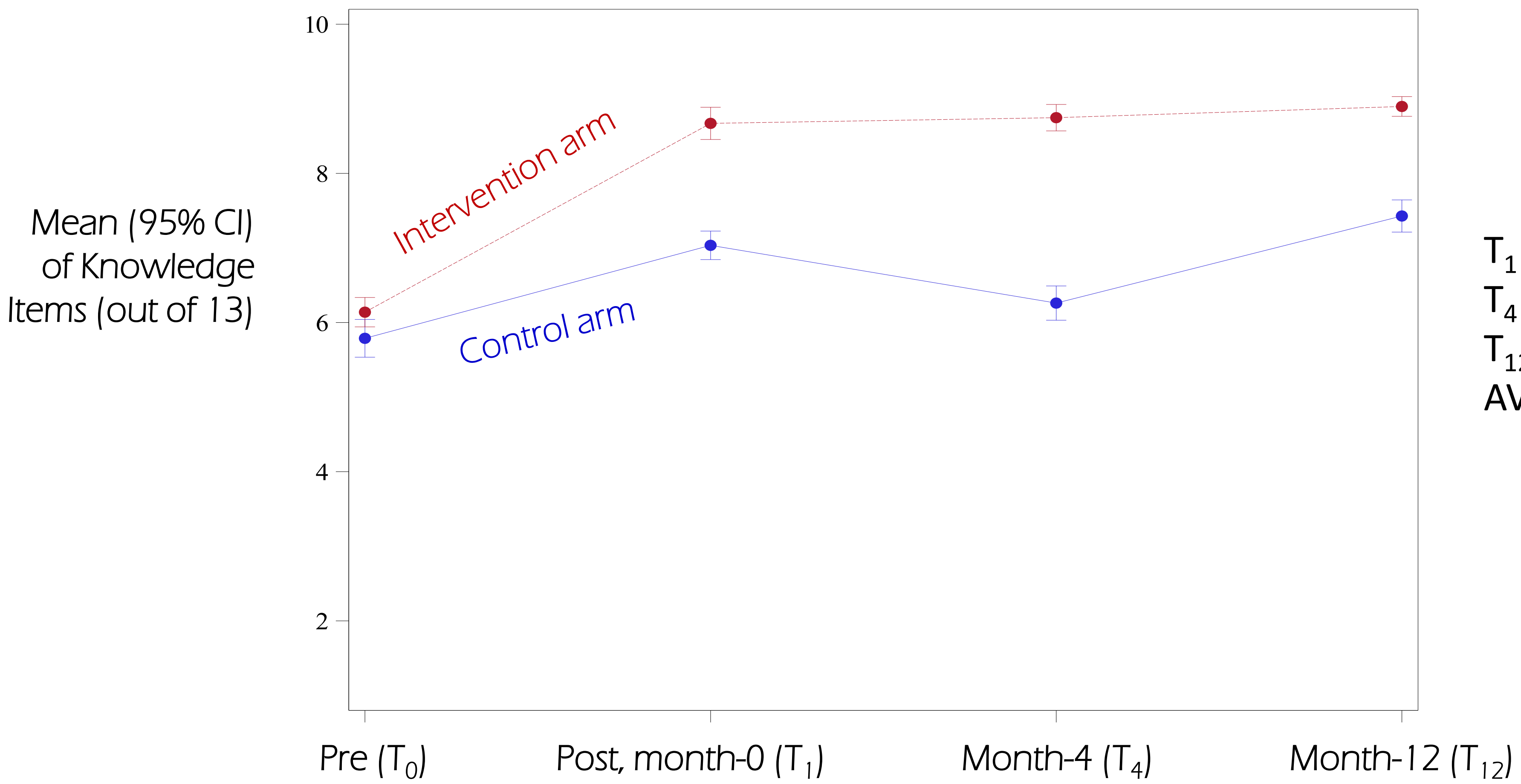


Results (skills)

Mean difference-in-differences = 13% 21% 11%



T_1 = 13% (1.3/10; $p<0.001$)
T_4 = 21% (2.2/10; $p<0.001$)
T_{12} = 11% (1.1/10; $p=0.005$)
AVG = 15% improvement

Results (skills) – subgroups

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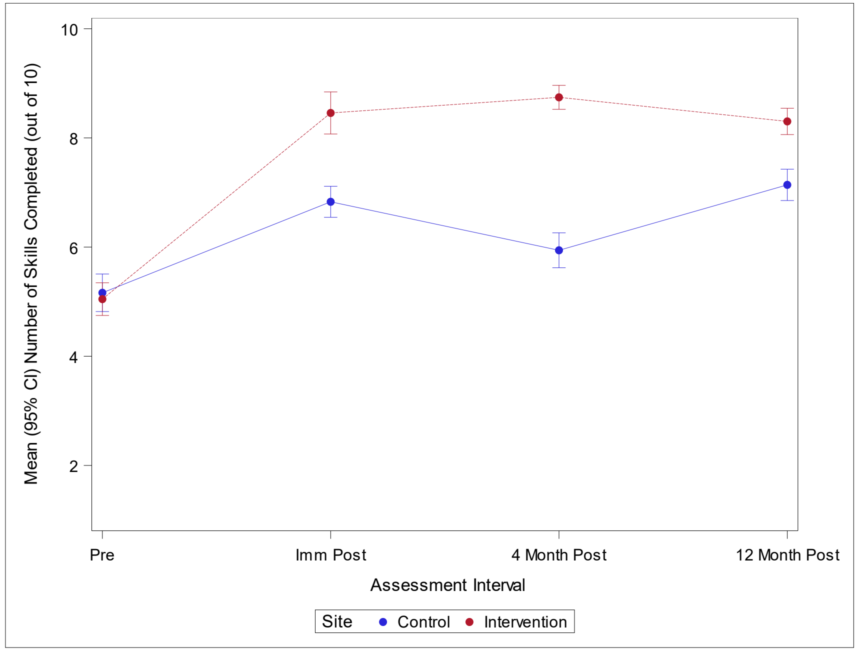

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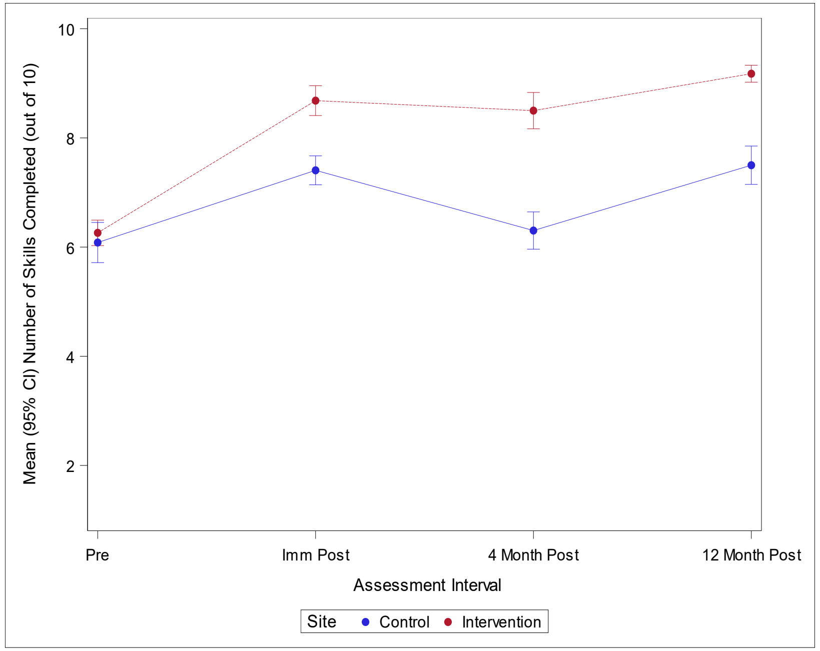

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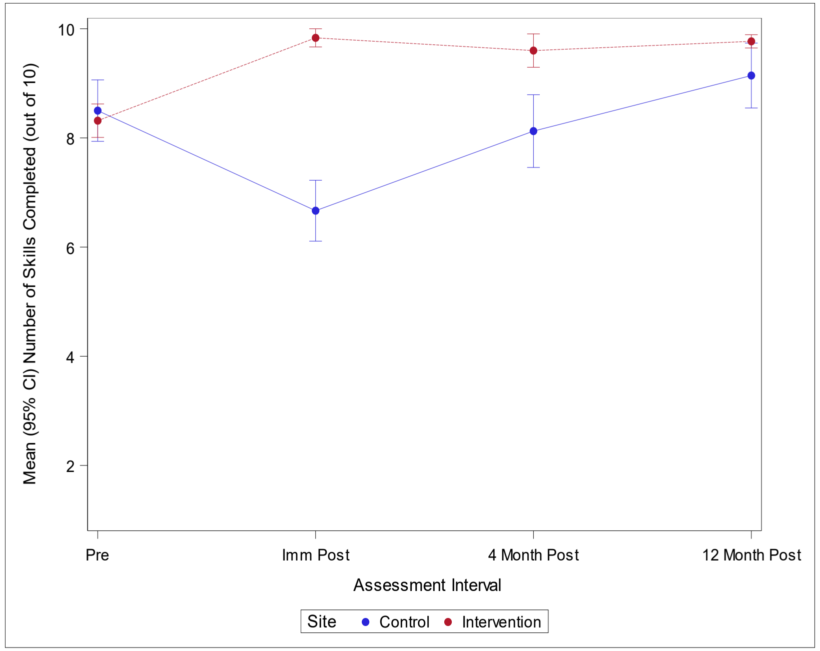
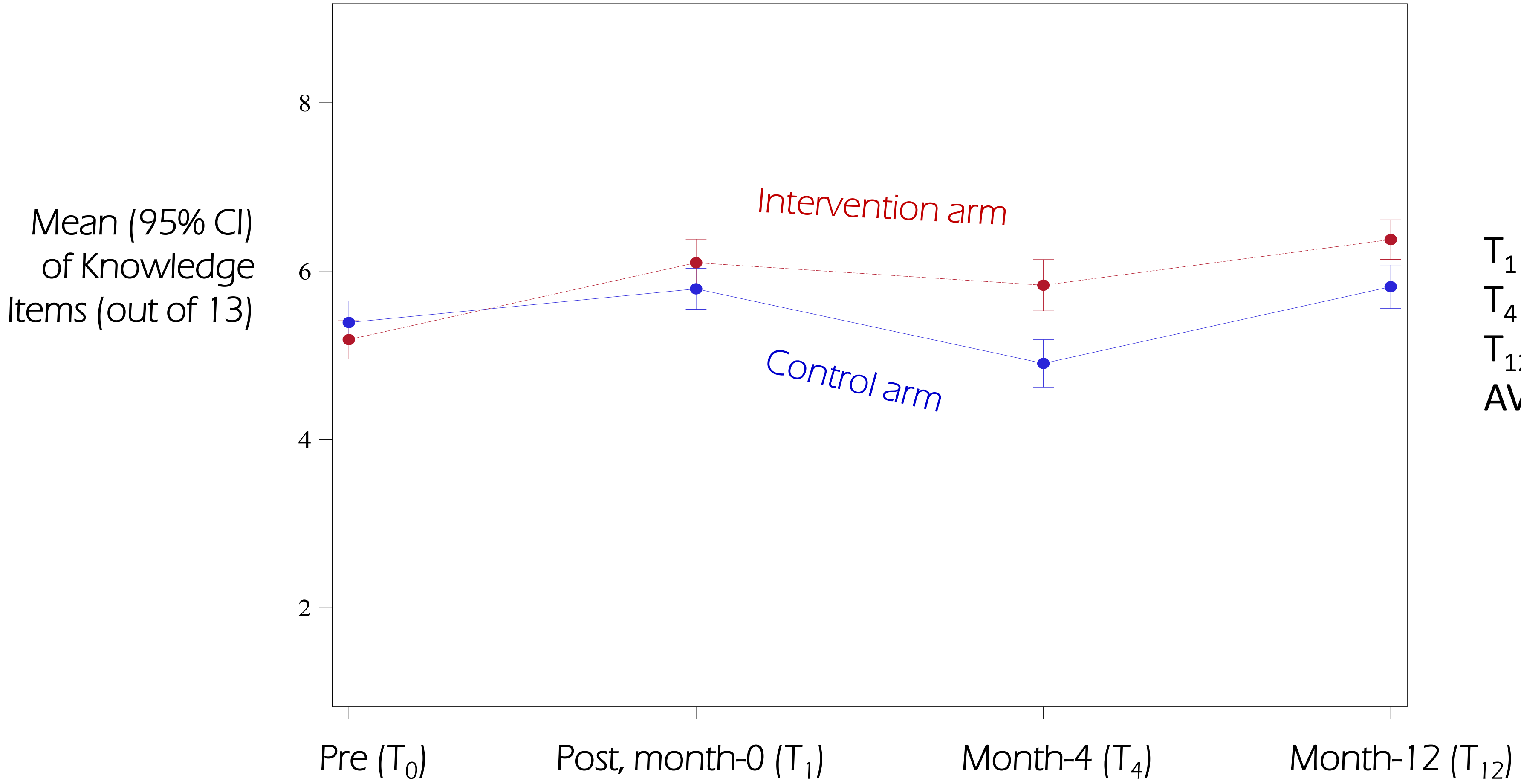


Results (self-efficacy)

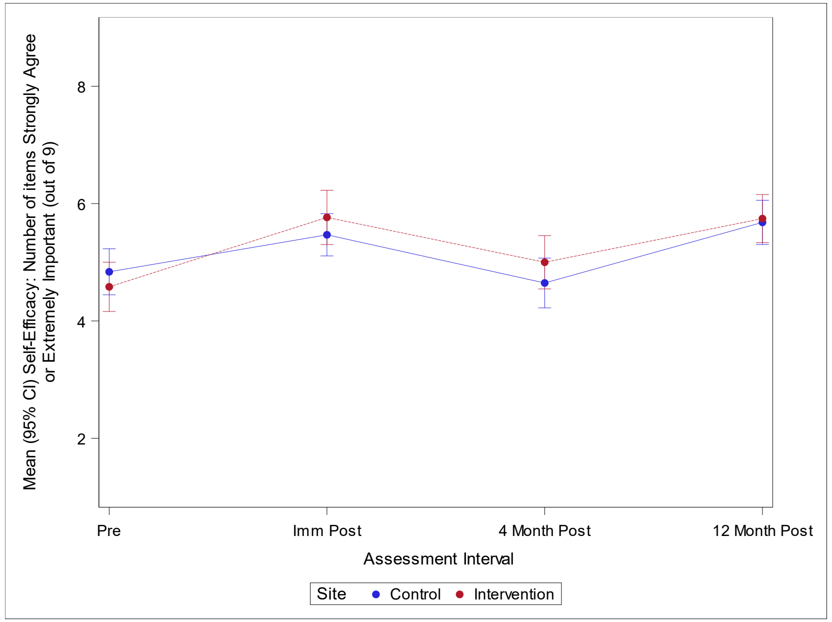
Mean difference-in-differences = 6% 14% 10%



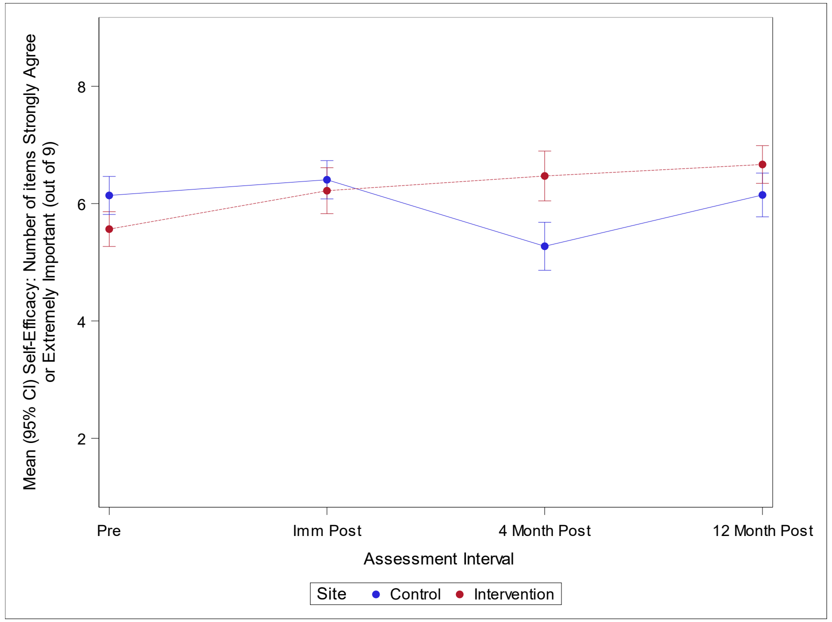
T_1 = 6.4% (0.51/8; p=0.13)
T_4 = 14% (1.13/8; p=0.03)
T_{12} = 10% (0.76/8; p=0.14)
AVG = 10% improvement

Results (self-efficacy) – subgroups

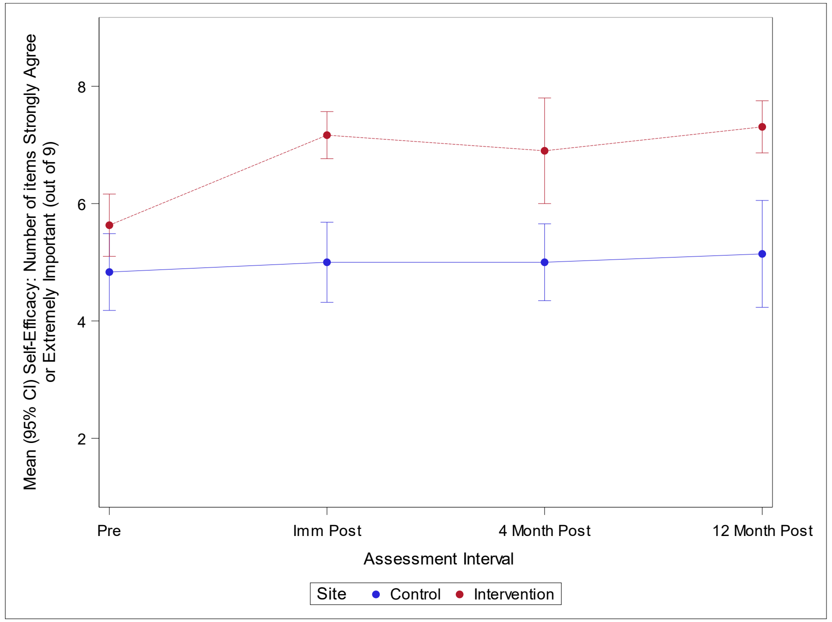
BLS



ILS



ALS



Conclusions

- HEET improved educational effectiveness:
  - Knowledge > skills > self-efficacy
  - Modest effect sustained at 12-months
- HEET is practical to implement in a resource-constrained EMS system:
  - Demonstrated by this & a prior pilot study

Nee-Kofi.Mould-Millman@UCDenver.edu

Appendix 5 – EMS-Traumatic Shock Care (TruShoC) learning modules and materials

See training materials on the following pages…

'EMS-TruShoC'

A Bundle of EMS Traumatic Shock Care

TRAUMA SHOCK RECOGNITION

In adult injury w/ high risk mechanism*

RIGHT PATIENT?
High risk mechanism of injury
and
Age ≥16 years.

Yes ↓

1 or more abnormal vitals screen for shock

VITAL SIGNS?
Pulse rate >100-bpm,
and/or
Systolic BP <100-mmHg,
and/or
Capillary refill time >2-secs,
and/or
Non-palpable pulses.

Yes ↓

1 or more symptoms for decompensated shock.

CLINICAL PICTURE?
Active external bleeding
And/or
Contained (internal) bleeding
and/or
Altered Mentation
and/or
Skin Color Change
and/or
Sweating/diaphoresis.

***Mechanism of injury placing patient at high risk for shock:**

- **PENETRATING:**
  Gunshot wound (head, neck, torso, groin, proximal extremity)
- **BLUNT:**
  Fall from height (>6m)
  Motor vehicle collision (high speed, ejection)
  Motor cycle crash
  Pedestrian struck by vehicle
  Assault (with high energy transfer)
- **AMPUTATION:**
  Of limbs (proximal to wrist and ankles)
- **ACTIVE BLEEDING:**
  Uncontrollable external bleeding
  Physical signs of contained (internal) hemorrhage

TRAUMA SHOCK MANAGEMENT

CORE BUNDLE OF CARE

1. On-scene time is ≤ 10-minutes
2. Destination is trauma center
3. Large bore IV (≥18G) catheter placed
4. Oxygen is administered (appropriate route)
5. External bleeding is controlled (per protocol)

*All 5 performed on 100% of shock trauma cases.

↓

NON-CORE BUNDLE OF CARE

Circulation:
- Control hemorrhage
- Give intravenous fluids
- Immobilize grossly unstable fractures

Airway:
- Open, Suction, & Secure

Breathing:
- Oxygenate & Ventilate

Disability:
- Prevent further neurologic injury

Continuous assessment
- Repeat: primary & secondary surveys
- Repeat vital signs (at least 2 sets)

↑ Perform C-A-B-D on 100% of cases ↑

Special considerations if shock and the ff:
- Uncontrolled arterial bleed = tourniquet
- Blunt pelvic injury = pelvic binding
- Tension PTX = needle decompression
- Loss of motor/sensory = cervical collar
- Cardiac arrest = consider CPR / ACLS
- Obvious pregnancy = left lateral decubitus

↑ Perform only when clinically indicated ↑

Updated: Jun-12-2017, Nee-Kofi Mould-Millman, MD

Equipment Checklist:
☐ BP Cuff
☐ Stethoscope

INTRODUCTION (30 seconds):
☐ How do you feel about treating trauma patients in shock? Can we improve?
☐ 1 in 10 of our trauma patients are in shock. But most are not well-managed.

TODAY'S OBJECTIVES (30 seconds):
☐ In today's session, we will:
- **Define** and **identify** haemorrhagic shock in trauma
- Practice **how** to take accurate vital signs, and discuss **when** to repeat them
- Know when to call for an ALS back up
- Learn to **value** self-reflection and **value** admitting when we don't know something or need help

TODAY'S SCENARIO (30 Seconds):
☐A 45-year-old man with a stab wound to his thigh. You see blood rapidly oozing from a proximal thigh wound down his leg. There is a large amount of blood on the floor. The man appears pale, sweaty, and confused. Vitals: PR=120, BP=80/50, CRT >2 seconds.

DISCUSSION POINTS (5 minutes):
☐**Looking at the scenario and the patient's clinical presentation, what is concerning?**
- Severe MOI includes: gunshot, ejection from vehicle, pedestrian hit by car, fall from >3 metres.
- Shock symptoms: Pale, cold, clammy, and lots of blood that has been lost on the floor
- Shock vital signs: that suggest shock: tachycardia (PR 120) and hypotension (BP 80/50) and a delayed capillary refill time (CRT=5 secs)

☐**Tell me what you know about the progression of haemorrhagic shock in trauma?**
- Blood loss → poor tissue perfusion → organ malfunction (brain, heart, etc.) → eventual death.
- Shock is inadequate tissue perfusion that results from internal or external blood loss.
- Inadequate perfusion of organs or tissues can lead to malfunction of organs and eventual death.
- Organs commonly affected in shock include brain, lungs, heart, kidneys, and the skin.
- Inadequate perfusion of those organs causes the symptoms of decompensated shock.
  - Confusion, pale skin, clammy and sweating, etc.

☐**3 things can always help us identify an injured patient in shock:**
[1] Severe mechanism of injury (e.g. gunshot or pedestrian hit by a car)
[2] Symptoms of shock (e.g. confusion, sweating, cool or pale skin)
[3] Vital signs of shock (specifically, SBP <90, PR >100bpm, and CRT>2-seconds)

☐ **Let's say it is a long transport and your patient dies before hospital arrival. You have 1 set of vital signs. Would another set of vital signs have been useful?**
- **Yes!** Vital signs provide an indicator of how the patient is doing.
- We need at least 2 sets of vital signs on all patients. Every 5 minutes is ideal if shock.
- Worsening vital signs can change our prehospital management. Document all vitals accurately.
- You should also use worsening symptoms (like confusion or pallor or sweating) to guide your management.

☐**When would you call for an ALS back up?**
- When the patient is deteriorating. **Call for ALS early.**
- Do not sit and wait for ALS. Continue moving to facility**. ALS will intercept you**.

☐**In today's case, what interventions can help save this patient in haemorrhagic shock?**

[1] Control catastrophic haemorrhage (at the scene)
[2] High flow oxygen (non-rebreather mask)
[3] Place a large bore IV catheter
[4] Short scene time, <10 minutes (so, "load and go")
[5] Transport to appropriate trauma centre

The "5 item bundle of care" for haemorrhagic shock.

SKILLS SESSION (5 minutes)
☐ Remember, it is OK to say "I don't know" or "I don't feel confident"… that is how we learn and improve.

☐ **What are the correct steps in checking systolic BP?**
- Correct cuff size and location, underneath clothing, keep arm level with heart.
- What BP number is concerning for shock? → SBP less than 90 (also called "hypotension").
- It can be tough to get an accurate BP, especially in a moving ambulance.

    - Ask the students if they feel comfortable asking for help to get a BP if they don’t think they are getting an accurate reading.

☐**What are the correct steps in checking <u>pulse rate</u>?**

- Check radial pulse first (count to 30-secs, multiply by 2), not on monitor.
- Remember: rate, rhythm, depth → remember that rate and depth are more relevant to trauma.
- What pulse rate value is concerning for shock? → pulse rate over 100 (also called “tachycardia”)
- Remember → a pulse rate is checked on a patient, and not the monitor (not all beats on the monitor may capture).

☐**What are the correct steps in checking <u>capillary refill time</u>?**

- Hold for 5 seconds on thumb nail bed, then release (locations are thumb, forehead, or chest)
- <u>Remember: 1-2 seconds is normal. >2 seconds is abnormal.</u> The root cause is insufficient blood in the cardiovascular system.
- CRT is less reliable than PR or BP.

SUMMARY (3 minutes):

☐Our case today was a trauma patient in shock. <u>It is critical we identify shock</u> early so we can start managing it.

- **We identified shock using 3 things: 1) mechanism of injury, 2) shock symptoms, 3) shock vital signs.**
- **Severe MOI** includes: gunshot, ejection from vehicle, pedestrian hit by car, fall from >3 metres.
- **Shock symptoms** include depressed consciousness, sweaty/pale/cool skin.
- **Shock vital signs** include hypotension (SBP<90), tachycardia (PR>100), prolonged CRT (>2 secs)

☐**Remember to repeat vital signs**, ideally, every 5 minutes.

☐**Being comfortable with calling for back up** when needed is critical for best patient outcome.

☐**Being open and honest about what we don’t know** is critical to learning and improving our care.

☐**We can save lives** of severely injured patients with timely and quality treatment using the bundle of care.

➔ Thanks for being an excellent group today. See you next week.

INTRODUCTION (30 seconds):
☐ How do you feel about treating trauma patients in shock? Can we improve?
☐ 1 in 10 of our trauma patients are in shock. But most are not well-managed.

Equipment Checklist:
☐ BP Cuff
☐ Stethoscope

TODAY'S OBJECTIVES (30 seconds):
☐ In today's session, we will:
- **Define** and **identify** haemorrhagic shock in trauma
- Practice **how** to take accurate vital signs, and discuss **when** to repeat them
- Know when to call for an ALS back up
- Learn to **value** self-reflection and **value** admitting when we don't know something or need help

TODAY'S SCENARIO (30 Seconds):
☐ A 45-year-old man with a stab wound to his thigh. You see blood rapidly oozing from a proximal thigh wound down his leg. There is a large amount of blood on the floor. The man appears pale, sweaty, and confused. Vitals: PR=120, BP=80/50, CRT >2 seconds.

DISCUSSION POINTS (5 minutes):
☐ **Looking at the scenario and the patient's clinical presentation, what is concerning?**
- Severe MOI includes: gunshot, ejection from vehicle, pedestrian hit by car, fall from >3 metres.

☐ **Tell me what you know about the progression of haemorrhagic shock in trauma?**
- Blood loss → poor tissue perfusion → organ malfunction (brain, heart, etc.) → eventual death.

☐ **3 things can always help us identify an injured patient in shock:**
[1] Severe mechanism of injury (e.g. gunshot or pedestrian hit by a car)
[2] Symptoms of shock (e.g. confusion, sweating, cool or pale skin)
[3] Vital signs of shock (specifically, SBP <90, PR >100bpm, and CRT>2-seconds)

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- **Yes!** Vital signs provide an indicator of how the patient is doing.
- We need at least 2 sets of vital signs on all patients. Every 5 minutes is ideal if shock.
- Worsening vital signs can change our prehospital management. Document all vitals accurately.

☐ **When would you call for an ALS back up?**
- When the patient is deteriorating. **Call for ALS early.**
- Do not sit and wait for ALS. Continue moving to facility**. ALS will intercept you**.

☐ **In today's case, what interventions can help save this patient in haemorrhagic shock?**
[1] Control catastrophic haemorrhage (at the scene)
[2] High flow oxygen (non-rebreather mask)
[3] Place a large bore IV catheter
[4] Short scene time, <10 minutes (so, "load and go")
[5] Transport to appropriate trauma centre

The "5 item bundle of care" for haemorrhagic shock.

SKILLS SESSION (5 minutes)
☐ Remember, it is OK to say "I don't know" or "I don't feel confident"… that is how we learn and improve.

☐ **What are the correct steps in checking systolic BP?**
- Correct cuff size and location, underneath clothing, keep arm level with heart.
- Remember: a SBP less than 90 ("hypotension") is concerning for shock!

☐ **What are the correct steps in checking pulse rate?**
- Check radial pulse first (count to 30-secs, multiply by 2), not on monitor.
- Remember: a pulse rate over 100 ("tachycardia") is concerning for shock!

☐ **What are the correct steps in checking capillary refill time?**
- Hold for 5 seconds on thumb nail bed, then release
- Remember: 1-2 seconds is normal. >2 seconds is abnormal. But CRT is less reliable than PR or BP.

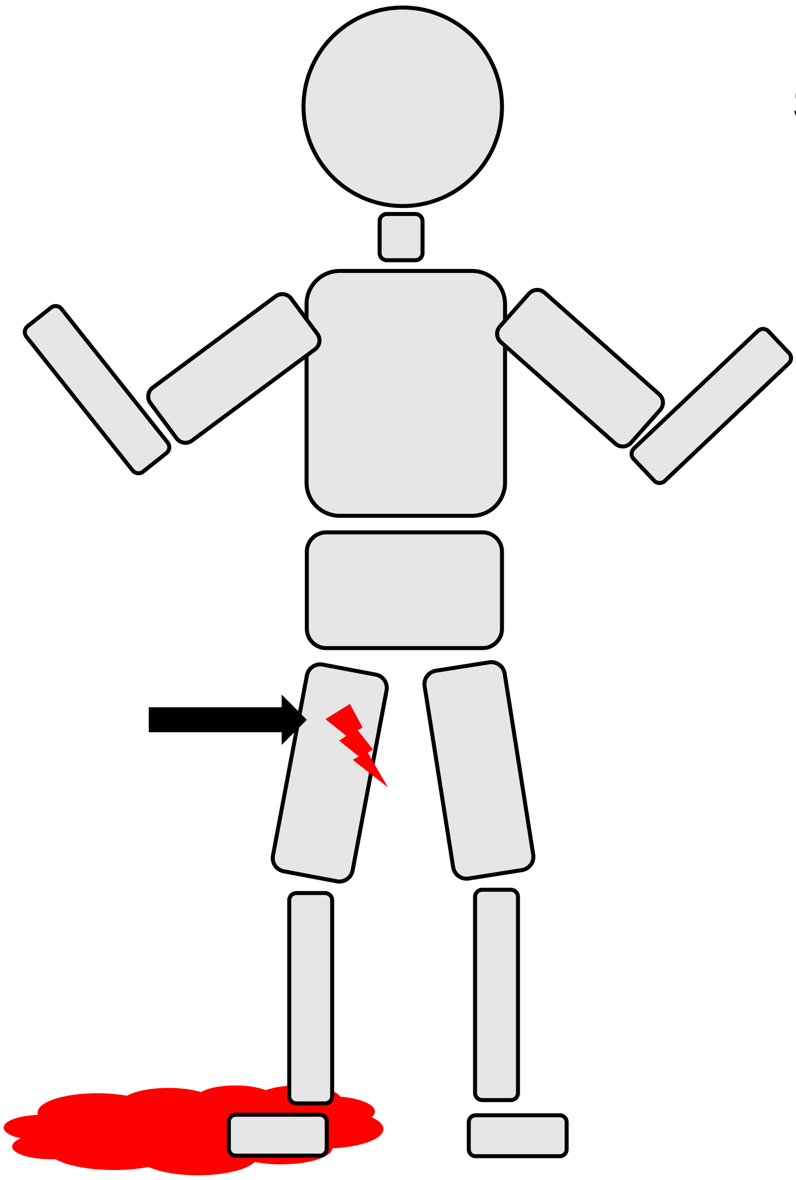
SUMMARY (3 minutes):
☐ Our case today was a trauma patient in shock. It is critical we identify shock early so we can start managing it.
- **We identified shock using 3 things: 1) mechanism of injury, 2) shock symptoms, 3) shock vital signs.**

☐ **Remember to repeat vital signs**, ideally, every 5 minutes.
☐ **Being comfortable with calling for back up** when needed is critical for best patient outcome.
☐ **Being open and honest about what we don't know** is critical to learning and improving our care.
☐ **We can save lives** of severely injured patients with timely and quality treatment using the bundle of care.
➔ Thanks for being an excellent group today. See you next week.

Module 1

45-year-old M

Stab wound to right thigh



Pale

Sweaty

Confused

BP	PR	CRT
80/50	120	>2

Equipment Checklist:
☐ Tourniquet
☐ Gauze/dressings
☐ Pressure bandages

LAST SESSION (30 seconds):

☐We identified haemorrhagic shock using 3 things:
- **1)** Severe mechanisms of injury, **2)** Shock symptoms, **3)** Shock vital signs.

☐We introduced the 5-item bundle of care

☐In this training program, we also want you to feel comfortable to admit when you don't know.

TODAY'S OBJECTIVES (30 seconds):
- **Feel confident** recognizing and managing shock
- Understand the priorities in **controlling active bleeding**
- **Discuss various reasons** why patients may be in shock
- Distinguish **compensated from decompensated** shock
- **Practice techniques** to control arterial and venous bleeding

TODAY'S SCENARIO (30 Seconds):

☐A 25-year old man was assaulted by multiple people. The patient has several oozing stab wounds to his lower extremities, as well as a partial amputation of his right forearm with pulsating bleeding. He was also kicked repeatedly in his abdomen. BP=75/45, PR=134, RR=26, CRT=4

DISCUSSION POINTS (8 minutes):

☐**Looking at the scenario and the patient's clinical presentation, what is concerning?**
- Severe mechanism of injury: multiple stabs, assaulted by several people, partial amputation
- Severely abnormal vital signs: low BP, high PR, high RR, slow CRT
- Symptoms of shock: This patient doesn't have any yet since they are still in compensated shock. You are looking for signs of altered mentation, clammy skin, sweating, pale skin.

☐ **What is going to kill this patient first?**
- Active arterial bleeding. So, what is our priority in management? To control bleeding.
- **Pulsating/shooting/spurting bleeding** is the priority as it is **arterial bleeding**
  - Apply firm, continuous pressure. If the wound is oozing through the gauze, apply another layer of gauze DO NOT remove the first layer to look at the wound
  - If you can control bleeding with manual pressure, then you can apply a pressure dressing
  - Then use tourniquet if the bleeding is still uncontrolled.
  - *If bleeding on the head, neck, groin, or torso, you must apply direct pressure*
- Treatment of **active venous bleeding** comes after treatment of arterial bleeding.

☐**There are three main <u>types of trauma</u> that can place a patient at high risk for haemorrhagic shock:**
- **PENETRATING -** GSW, stab wound
- **BLUNT -** hit by a car, hit by a club, kicking and punching, fall from height
- **AMPUTATION -** deep cut by a power tool, slashing wound from a large knife or machete

<u>***MECHANISM OF INJURY PLACING PATIENT AT HIGH RISK FOR SHOCK:**</u>
- **PENETRATING:**
  Gunshot wound (head, neck, torso, groin, proximal extremity)
- **BLUNT:**
  Fall from height (>6m)
  Motor vehicle collision (high speed, ejection)
  Motor cycle crash
  Pedestrian struck by vehicle
  Assault (with high energy transfer)
- **AMPUTATION:**
  Of limbs (proximal to wrist and ankles)
- **ACTIVE BLEEDING:**
  Uncontrollable external bleeding
  Physical signs of contained (internal) hemorrhage

☐ **Remember that active bleeding from injuries can be internal or external (i.e. hidden or obvious).**
- Don't only focus on obvious external bleeding. At least consider there can be internal bleeding

☐**Let's discuss compensated versus decompensated stages of shock:**
- **Compensated shock =** slightly abnormal vital signs and no symptoms
- **Decompensated shock =** very abnormal vitals and abnormal symptoms
  - Abnormal vitals include tachycardia ± faint/absent pulses ± low BP.
  - Abnormal symptoms include confusion ± pallor ± sweating.
- **We are equally worried about compensated & decompensated shock,** because shock progresses…
- Even if you feel the shock is well controlled, the patient still needs to go to a trauma center.

☐You repeat vital signs on your way to the hospital. The PR=150, and BP=60/40. Patient is getting sweaty and confused, not opening his eyes. He has progressed from compensated to decompensated shock.

☐**In shock, tissues are dying, which leads to organ malfunction, then death. Time is of the essence!**

☐**Keep in mind that accurate documentation is critical for medical-legal reasons and for handoff.**
- Please document how exactly you stopped the bleeding in the ePCR.

SKILLS SESSION (5 minutes):

☐**VENOUS:**
- **Show the learner direct pressure technique**
- **Then show pressure dressing technique**

☐ **ARTERIAL:**
- **Show the learner direct pressure technique,**
  - Preferably, place 1 or 2 fingers directly over the bleeding artery
- **Then demonstrate how to apply a tourniquet**
  - Underneath clothing, at least 2 centimeters above wound, not directly over a joint.
  - Be sure to document the time the tourniquet was applied

SUMMARY (1 minute):

☐Our patient had multiple injuries and at first was in compensated shock from blood loss:
- **If internal or external bleeding, think of haemorrhagic shock**
- **Compensated shock can quickly progress to decompensated shock**
- Starting treatment in compensated shock will help prevent irreversible damage and death
- **You should feel confident in identifying compensated or decompensated shock.**

➔ Next week, we will discuss scene times, destination hospitals, and shock management.

Equipment Checklist:
☐ Tourniquet
☐ Gauze/dressings
☐ Pressure bandages

LAST SESSION (30 seconds):

☐ We identified haemorrhagic shock using 3 things:
- **1)** Severe mechanisms of injury, **2)** Shock symptoms, **3)** Shock vital signs.

☐ We introduced the 5-item bundle of care

☐ In this training program, we also want you to feel comfortable to admit when you don't know.

TODAY'S OBJECTIVES (30 seconds):
- **Feel confident** recognizing and managing shock
- Understand the priorities in **controlling active bleeding**
- **Discuss various reasons** why patients may be in shock
- Distinguish **compensated from decompensated** shock
- **Practice techniques** to control arterial and venous bleeding

TODAY'S SCENARIO (30 Seconds):

☐ A 25-year old man was assaulted by multiple people. The patient has several oozing stab wounds to his lower extremities, as well as a partial amputation of his right forearm with pulsating bleeding. He was also kicked repeatedly in his abdomen. BP=75/45, PR=134, RR=26, CRT=4

DISCUSSION POINTS (8 minutes):

☐ **Looking at the scenario and the patient's clinical presentation, what is concerning?**
- Severe mechanism of injury
- Severely abnormal vital signs
- Symptoms of shock

☐ **What is going to kill this patient first?**
- Active arterial bleeding. So, what is our priority in management? To control bleeding.
- **Pulsating/shooting/spurting bleeding** is the priority as it is **arterial bleeding**
  - Apply firm, continuous pressure. If oozing, DO NOT remove the first layer to look at the wound
  - If bleeding uncontrolled use tourniquet. *On the head, neck, groin, or torso, apply direct pressure*
- Treatment of **active venous bleeding** comes after treatment of arterial bleeding.

☐ **There are three main <u>types of trauma</u> that can place a patient at high risk for haemorrhagic shock:**
- PENETRATING, BLUNT, AMPUTATION (provide examples of each)

☐ **Remember that active bleeding from injuries can be internal or external (i.e. hidden or obvious).**
- Don't only focus on obvious external bleeding. At least consider there can be internal bleeding

☐ **Let's discuss compensated versus decompensated stages of shock:**
- **Compensated shock =** slightly abnormal vital signs and no symptoms
- **Decompensated shock =** very abnormal vitals and abnormal symptoms
  - Abnormal vitals include tachycardia ± faint/absent pulses ± low BP.
  - Abnormal symptoms include confusion ± pallor ± sweating.
- **We are equally worried about compensated & decompensated shock,** because shock progresses…

☐ You repeat vital signs on your way to the hospital. The PR=150, and BP=60/40. Patient is getting sweaty and confused, not opening his eyes. <u>He has progressed from compensated to decompensated shock.</u>

☐ **In shock, tissues are dying, which leads to organ malfunction, then death. Time is of the essence!**

☐ **Keep in mind that accurate documentation is critical for medical-legal reasons and for handoff.**
- Please document how exactly you stopped the bleeding in the ePCR.

SKILLS SESSION (5 minutes):

☐ **VENOUS:** <<show the learner direct pressure technique, then show pressure dressing technique>>

☐ **ARTERIAL:** <<show the learner direct pressure technique, then demonstrate how to apply a tourniquet>>
- Underneath clothing, at least 2 centimeters above wound, not directly over a joint.
- Be sure to document the time the tourniquet was applied

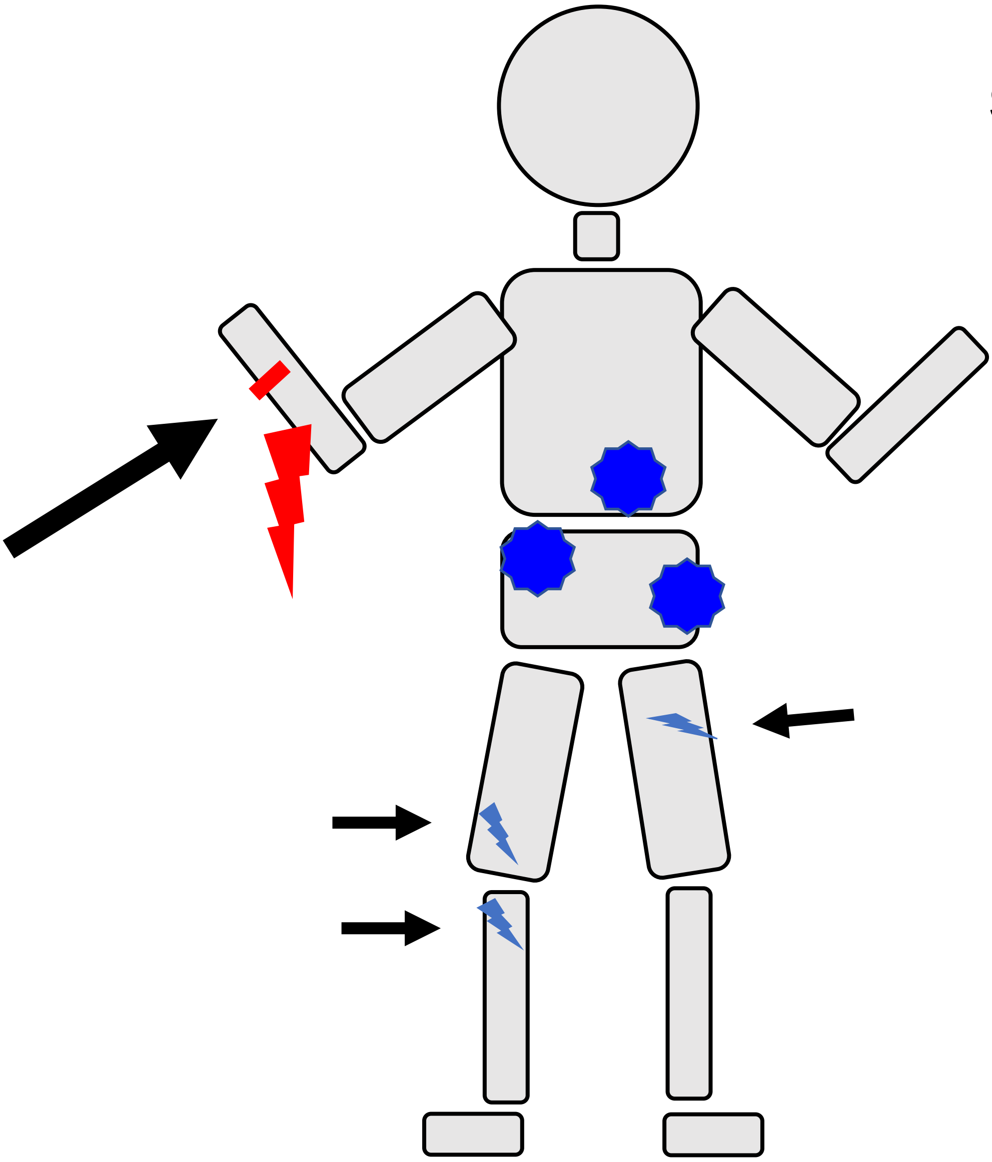
SUMMARY (1 minute):

☐ Our patient had multiple injuries and at first was in compensated shock from blood loss:
- **If internal or external bleeding, think of haemorrhagic shock**
- **Compensated shock can quickly progress to decompensated shock**
- Starting treatment in compensated shock will help prevent irreversible damage and death
- **You should feel confident in identifying compensated or decompensated shock.**

➔ Next week, we will discuss scene times, destination hospitals, and shock management.

25-year-old M

Community assault with multiple stab wounds



Pale

Sweaty

Confused

BP	PR	RR	CRT
75/45	134	26	>2

Equipment Checklist:
☐ DTT Handout (pg 8 only)
☐ Non-rebreather mask
☐ Oxygen cylinder (portable)

LAST WEEK (30 seconds):
- We discussed importance of early identification of haemorrhagic shock
- Compensated shock can quickly progress to decompensated shock

TODAY'S OBJECTIVES (30 seconds):
- Review the trauma **primary assessment** (using C-ABC approach)
- Discuss importance of **short scene times**
- Know the appropriate **trauma facilities**
- Discuss when and how to give **high flow oxygen** to patients in shock

TODAY'S SCENARIO (30 Seconds):

☐You are called to the scene of a 24-year old man with a gunshot wound to his abdomen. The man appears pale and sweaty. Vitals: PR=140, BP=85/55, RR=34, CRT=5.

DISCUSSION POINTS (8 minutes):

☐**Use the C-ABC approach** to do a primary assessment in trauma patients:
- **Remember, the first "C" means control catastrophic haemorrhage.**
- **This means that at the scene you should control bleeding, first:**
  - **Arterial bleeding** <<Describe how to identify **external arterial** bleeding…>>
    - Pulsatile; bright red; This is the most concerning type of bleeding because large arterial bleeds can cause death in a matter of minutes.
  - **Venous bleeding** <<Describe how to identify **external venous** bleeding…>>
    - Oozing; not pulsatile; often darker red
  - **Internal bleeding** <<Describe how to identify **internal bleeding**…>>
    - *Remember, abdominal distension may mean internal abdomainl bleeding. Other forms of internal bleeding exist, such as in pelvis, or in chest, or in thighs, or in scalp.*
    - May have severe bruising and purpling; may have rigid abdomen; keep in mind, sometimes there will be no obvious bleeding, but you must maintain a suspicion for internal haemorrhage based on the MOI (specifically, severe injury to abdomen or pelvis area), the patients vital signs, and the patients symptoms
- After you control catastrophic bleeding (first "C") complete your usual A-B-C-D's and vital signs.
- Treat as you go. If you find an airway issue ("A"), that gets taken care of before moving onto breathing ("B").

☐So, back to our case. You approach the scene of the gunshot victim. It appears safe.

☐**Looking at the scenario and the patient's clinical presentation, what is concerning?**
- He had a severe MOI (GSW), abnormal vitals, and symptoms of shock.

☐**Which vital signs in this case help <u>identify</u> that the patient is in shock?**
- Discuss: Low BP (i.e. SBP<90), fast PR (>100), delayed CRT (>2 secs)

☐ **Remember, compensated SHOCK = severe MOI + abnormal vital signs.**
- **In decompensated SHOCK there can also be symptoms, in addition to abnormal vital signs.**
- Here, the patient is pale and sweaty, signs that the skin is not being perfused adequately.
- ☐On examining him you can see that he is in shock, most likely from internal bleeding in his abdomen. <u>DO NOT DELAY ON SCENE. Control bleeding then "load and go!"</u> He needs a trauma facility immediately. You can start oxygen and continue assessing in the ambulance en route to a trauma center.

☐**Can you guess the average time spent on scene with haemorrhagic shock patients in Cape Town?**
- It is about 30-minutes! The goal is to <u>spend less than 10-minutes on scene</u>.

☐**When deciding what hospital to take him to, consider that:**
- Patients in shock need a trauma surgeon. Surgical care if the most important thing for hemorrhagic shock
- Call for ALS backup if you need help, but do not delay on scene for ALS. Meet them enroute.

☐**Which hospitals in the area are the designated severe trauma facilities?**
- **Review DTT handout (pg 8):** TBH (adults), GSH (adults), RedX (children under 16)

☐Let us review the "5 item bundle of care" for patients in haemorrhagic shock:

[1] Control catastrophic haemorrhage (at the scene)
[2] High flow oxygen (non-rebreather mask)
[3] Place a large bore IV catheter
[4] Short scene time, <10 minutes (so, "load and go")
[5] Transport to appropriate trauma centre

The "5 item bundle of care" for haemorrhagic shock.

SKILLS SESSION (3 minutes):

☐ "Now, we'll practice how to deliver effective oxygen for traumatic shock patients. Recall that in shock the injury to organs and tissues is from a lack of oxygen (due to a lack of blood) One way we can help patients is to give them supplemental oxygen and improve tissue perfusion. A non-rebreather mask can deliver up to 90% of oxygen, when used correctly. By giving oxygen, we allow the patient to continue to perfuse important organs even while suffering from blood loss. Primarily, the oxygen will help buy important minutes before irreversible ischemia sets into the patient's critical organs like the brain."

- **Place non-rebreather mask on patient with elastic straps behind their head**
- **Set oxygen to 15 lpm flow rate**
- Lower rates do not deliver sufficient oxygen; remember, the biggest problem with shock is the patient is not getting oxygen to their organs. We want to make sure that their blood is as saturated as possible with oxygen.
- Ensure the oxygen reservoir inflates to 2/3rd its volume, if it doesn't inflate, you can use your finger to cover the valve.

☐**Remember, the patient must be breathing on their own (normal rate and inspiratory volume).**

SUMMARY (2 minutes):

☐**Now let's put everything together. We have a patient with a gunshot to the abdomen who is in shock.**

- Use the **C-ABC method** for primary assessment and management.
- The first "C" stands for "control catastrophic bleeding"… best to start this at the scene.
  - Even without obvious bleeding, consider shock if the vital signs, MOI, and over all clinical picture point to it
- Patients need **short scene time** and **transport to trauma center**, as well as high flow oxygen (NRM)
- Recall the **other items in our bundle** of care: control bleeding and large bore IV catheter

➔ Next week, we will discuss management of traumatic shock

Equipment Checklist:
☐ DTT Handout (pg 8 only)
☐ Non-rebreather mask
☐ Oxygen cylinder (portable)

LAST WEEK (30 seconds):
- We discussed importance of early identification of haemorrhagic shock
- Compensated shock can quickly progress to decompensated shock

TODAY'S OBJECTIVES (30 seconds):
- Review the trauma **primary assessment** (using C-ABC approach)
- Discuss importance of **short scene times**
- Know the appropriate **trauma facilities**
- Discuss when and how to give **high flow oxygen** to patients in shock

TODAY'S SCENARIO (30 Seconds):

☐ You are called to the scene of a 24-year old man with a gunshot wound to his abdomen. The man appears pale and sweaty. Vitals: PR=140, BP=85/55, RR=34, CRT=5.

DISCUSSION POINTS (8 minutes):

☐ **Use the C-ABC approach** to do a primary assessment in trauma patients:
- **Remember, the first "C" means control catastrophic haemorrhage.**
- **This means that at the scene you should control bleeding, first:**
  - **Arterial bleeding** <<Describe how to identify **external arterial** bleeding…>>
  - **Venous bleeding** <<Describe how to identify **external venous** bleeding…>>
  - **Internal bleeding** <<Describe how to identify **internal bleeding**…>>
  - *Internal bleeding can occur in the abdomen, pelvis, chest, thighs, scalp.*
- After you control catastrophic bleeding (first "C") complete your usual A-B-C-D's and vital signs...

☐ So, back to our case. You approach the scene of the gunshot victim. It appears safe.

☐ **Looking at the scenario and the patient's clinical presentation, what is concerning?**

☐ **Which vital signs in this case help identify that the patient is in shock?**
- Discuss: Low BP (i.e. SBP<90), fast PR (>100), delayed CRT (>2 secs)

☐ **Remember, compensated SHOCK = severe MOI + abnormal vital signs.**
- **In decompensated SHOCK there can also be symptoms, in addition to abnormal vital signs.**

☐ On examining him you can see that he is in shock, most likely from internal bleeding in his abdomen. DO NOT DELAY ON SCENE. Control bleeding then "load and go!" He needs a trauma facility immediately.

☐ **Can you guess the average time spent on scene with haemorrhagic shock patients in Cape Town?**
- It is about 30-minutes! The goal is to spend less than 10-minutes on scene.

☐ **When deciding what hospital to take him to, consider that:**
- Patients in shock need a surgeon. Surgical care if the most important thing for hemorrhagic shock
- Call for ALS backup if you need help, but do not delay on scene for ALS. Meet them enroute.

☐ **Which hospitals in the area are the designated severe trauma facilities?**
- **Review DTT handout (pg 8):** TBH (adults), GSH (adults), RedX (children under 16)

☐ Let us review the "5 item bundle of care" for patients in haemorrhagic shock:

[1] Control catastrophic haemorrhage (at the scene)
[2] High flow oxygen (non-rebreather mask)
[3] Place a large bore IV catheter
[4] Short scene time, <10 minutes (so, "load and go")
[5] Transport to appropriate trauma centre

} The "5 item bundle of care" for haemorrhagic shock.

SKILLS SESSION (3 minutes):

Now, we'll practice how to administer oxygen correctly for traumatic shock patients. We can help patients by administering oxygen to improve tissue perfusion. A non-rebreather mask can deliver up to 90% of oxygen.

☐ **Set oxygen to 15 lpm flow rate**
☐ **Ensure the oxygen reservoir inflates to 2/3rd its volume**
☐ **Remember, the patient must be breathing on their own (normal rate and inspiratory volume).**

SUMMARY (2 minutes):

☐ **Now let's put everything together. We have a patient with a gunshot to the abdomen who is in shock.**
- Use the **C-ABC method** for primary assessment and management.
- The first "C" stands for "control catastrophic bleeding"… best to start this at the scene.
- Patients need **short scene time** and **transport to trauma center**, as well as high flow oxygen (NRM)
- Recall the **other items in our bundle** of care: control bleeding and large bore IV catheter

➔ Next week, we will discuss management of traumatic shock

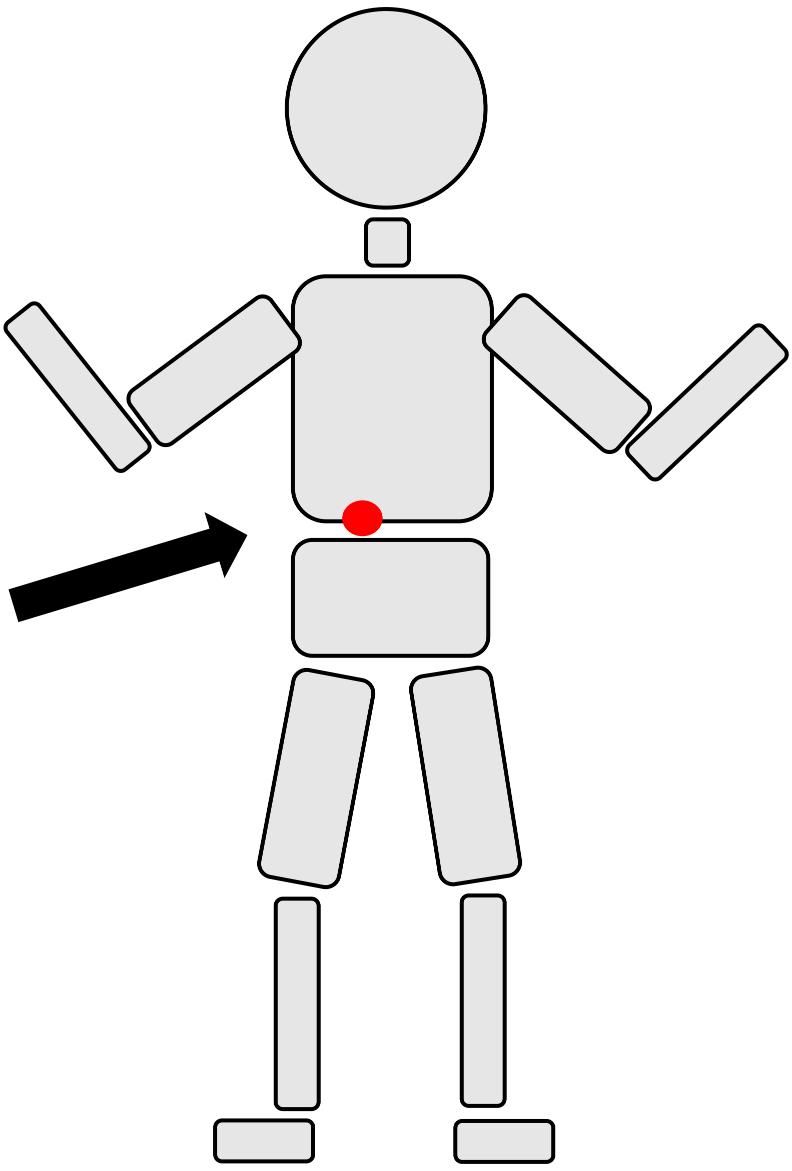
Module 3

24-year-old M

Gunshot wound to the abdomen

Pale

Sweating



BP	PR	RR	CRT
85/55	140	34	5 secs

Equipment Checklist:
☐ Sheet for pelvic binding

LAST WEEK (30 seconds):

- We discussed the **C-ABC approach**, and controlling bleeding on scene
- Importance of **oxygen to improve tissue perfusion** in hemorrhagic shock

TODAY'S OBJECTIVES (30 seconds):

- Emphasize the importance of **mechanism of injury (MOI)**
- Formulate an **appropriate treatment plan** in haemorrhagic shock
- To reiterate the importance of **short scene times**
- To practice how to **place a pelvic binder** for suspected internal pelvic bleeding

TODAY'S SCENARIO (30 Seconds):

☐You arrive on scene 30-minutes after an 18-year-old woman was hit by a bakkie at 50-Km/hr. She complains of extreme pain in her abdomen and pelvis. Vitals are PR=125, RR=26, BP=100/60.

DISCUSSION POINTS (8 minutes):

☐**Looking at the scenario and the patient's clinical presentation, what is concerning?**

- Serious MOI (pedestrian vs vehicle), abnormal vital signs (fast PR, fast RR)

☐**Do you suspect shock or not? Why or why not?**

- Suspect shock when there is a severe mechanism of injury and one or more abnormal vitals.
- MOI + 1 abnormal vital sign (e.g. low BP or fast PR) suggests compensated shock.
- If the patient has MOI + 1 abnormal vital + symptoms of shock, this suggests the patient is in decompensated shock

☐ **Do your C-ABC assessment… the first "C" means identify and control catastrophic bleeding on scene**.

- In this case, do you think the patient is bleeding? If so, from where?
- Yes, internal bleeding from the abdomen or pelvis. Can we control this? If so, how?
  - Controlling internal bleeding is done through surgical intervention. This patient needs to be seen by a trauma surgeon as soon as possible.
  - The interventions you can make prehospital are important (giving oxygen, giving fluids) but the most important thing for this patient is rapid transport to a trauma center.

☐ **Bleeding controlled --> keep supine --> proceed to quickly address A then B, in that order:**

- "A" – if the **airway** is blocked, you can suction or use a jaw thrust
  - Avoid head tilt-chin lift for patients who have a traumatic injury, as it can damage their C-spine
- "B" - if **breathing** is <u>absent</u>, use BVM to assist. If breathing <u>present</u>, use non-rebreather mask (NRBM).

☐**After C-ABC, check detailed vital signs as usual**

- **You may start oxygen on the scene, but only if it will not delay you on scene. "Load and go"!**
- **You should start an IV and check vital signs in the ambulance.**

☐ **Using vital signs, how can you <u>identify</u> if the patient has lost a significant amount of blood?**

- Review hypotension, tachycardia, tachypnea, and delayed CRT
- As the patient loses blood, the heart starts pumping faster to maintain circulation. Usually the first abnormal vital sign you see will be a rapid heart rate, since the veins and arteries can constrict to maintain blood pressure. As the patient continues to lose blood, the veins and arteries can not compensate for this and blood pressure starts to fall. This is also when symptoms of inadequate perfusion due to low blood pressure start to be seen (confusion, pale and clammy skin).

☐ The patient begins to be less responsive and has clammy skin. **Is she in decompensated shock?**

- Yes! Because our 3 criteria are met: 1) MOI + 2) abnormal vital signs + 3) signs of shock
- Review why shock is dangerous for patients…

☐ **Remember, our "5 item bundle of care" for management of traumatic shock:**

- When done together, these treatments minimize and delay the irreversible effects of shock.
- Please verbally review the 5 items bundle of care with the group!

☐ **Let's discuss what are severe mechanisms of injury that can cause shock:**

- Pedestrian vs car; penetrating trauma to torso, neck or groin; blunt trauma with high mechanism of action; fall > 20 feet; high speed MVC; motorcycle crash; significant blood loss.

☐ **After controlling the bleeding, you may not feel like you need to rush the patient to definitive care. This is not correct. Remember that additional interventions are necessary at the hospital.**

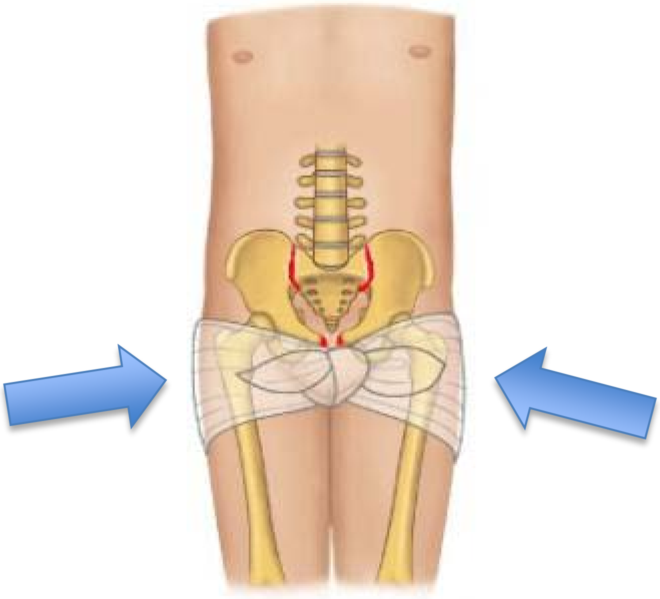
- Discuss decompensation & value of rechecking vital signs & reassessing patient.
- The patient will need definitive care at a trauma centre. The interventions done pre-hospital are very important, but they are not permanent. Additionally, the patient may not be able to compensate for the loss of blood over a long period of time and will start to decompensate even though they are not loosing any more blood.
- Do not change destination. **Your initial on-scene SATS/Triage determines destination facility**.

SKILLS SESSION (3 minutes):

☐**Remember, apply pelvic binding to patients with significant blunt trauma to the pelvis and are in shock**

☐**Correctly place pelvic binding <<do demonstration>>**

- Over the greater trochanters (the hips), not over the iliac crests. Apply quite tightly.



SUMMARY (3 minutes):

☐ Severe mechanism of injury is your first clue to identify a patient in haemorrhagic shock

☐ **Remember from our lesson today:**

- The **mechanisms of injury** that cause shock are very severe
    - The most common are listed, but also use judgment. If it seems like a serious MOI, think about shock for the patient.
- Manage patients effectively (**using our "5 item bundle of care"**)
- **C-ABC** approach, **control bleeding on scene** first

☐**Your early management of shock is one of the best predictors of patient outcomes**

➔ At our next session, we will discuss IV therapy, mental status, and open chest wounds.

Equipment Checklist:
☐ Sheet for pelvic binding

LAST WEEK (30 seconds):
- We discussed the **C-ABC approach**, and controlling bleeding on scene
- Importance of high flow **oxygen to improve tissue perfusion**

TODAY'S OBJECTIVES (30 seconds):
- Emphasize the importance of mechanism **of injury (MOI)**
- Formulate an **appropriate treatment plan** in haemorrhagic shock
- To reiterate the importance of **short scene times**
- To practice how to **place a pelvic binder** for suspected internal pelvic bleeding

TODAY'S SCENARIO (30 Seconds):

☐ You arrive on scene 30-minutes after an 18-year-old woman was hit by a bakkie at 50-Km/hr. She complains of extreme pain in her abdomen and pelvis. Vitals are PR=125, RR=26, BP=100/60.

DISCUSSION POINTS (8 minutes):

☐ **Looking at the scenario and the patient's clinical presentation, what is concerning?**

☐ **Do you suspect shock or not? Why or why not?**
- Suspect shock when there is a severe mechanism of injury and one or more abnormal vitals.
- MOI + 1 abnormal vital sign (e.g. low BP or fast PR) suggests compensated shock.

☐ **Do your C-ABC assessment… the first "C" means identify and control catastrophic bleeding on scene**.
- In this case, do you think the patient is bleeding? If so, from where?
- Yes, internal bleeding from the abdomen or pelvis. Can we control this? If so, how?
- Rapid transport to a trauma facility is critical to prevent this patient from dying.

☐ **Bleeding controlled --> keep supine --> proceed to quickly address A then B, in that order:**
- "A" – if the **airway** is blocked, you can suction or use a jaw thrust
- "B" - if **breathing** is absent, use BVM to assist. If breathing present, use non-rebreather mask (NRBM).

☐ **After C-ABC, check detailed vital signs as usual**
- **You may start oxygen on the scene, but only if it will not delay you on scene. "Load and go"!**
- **You should start an IV and check vital signs in the ambulance.**

☐ **Using vital signs, how can you identify if the patient has lost a significant amount of blood?**
- Review hypotension, tachycardia, tachypnea, and delayed CRT

☐ The patient begins to be less responsive and has clammy skin. **Is she in decompensated shock?**
- Yes! Because our 3 criteria are met: 1) MOI + 2) abnormal vital signs + 3) signs of shock
- Review why shock is dangerous for patients...

☐ **Remember, our "5 item bundle of care" for management of traumatic shock:**
- When done together, these treatments minimize and delay the irreversible effects of shock.
- Please verbally review the 5 items bundle of care with the group!

☐ **Let's discuss what are severe mechanisms of injury that can cause shock:**
- Pedestrian vs car; penetrating trauma to torso, neck or groin; blunt trauma with high mechanism of action; fall > 20 feet; high speed MVC; motorcycle crash; significant blood loss.

☐ **After controlling the bleeding, you may not feel like you need to rush the patient to definitive care. This is not correct. Remember that additional interventions are necessary at the hospital.**
- Discuss decompensation & value of rechecking vital signs & reassessing patient.
- Do not change destination. **Your initial on-scene SATS/Triage determines destination facility**.

SKILLS SESSION (3 minutes):

☐ **Remember, apply pelvic binding to patients with significant blunt trauma to the pelvis and are in shock**

☐ **Correctly place pelvic binding <<do demonstration>>**
- Over the greater trochanters (the hips), not over the iliac crests. Apply quite tightly.

SUMMARY (3 minutes):

☐ Severe mechanism of injury is your first clue to identify a patient in haemorrhagic shock

☐ **Remember from our lesson today:**
- The **mechanisms of injury** that cause shock are very severe
- Manage patients effectively (**using our "5 item bundle of care"**)
- **C-ABC** approach, **control bleeding on scene** first

☐ **Your early management of shock is one of the best predictors of patient outcomes**

➔ At our next session, we will discuss IV therapy, mental status, and open chest wounds.

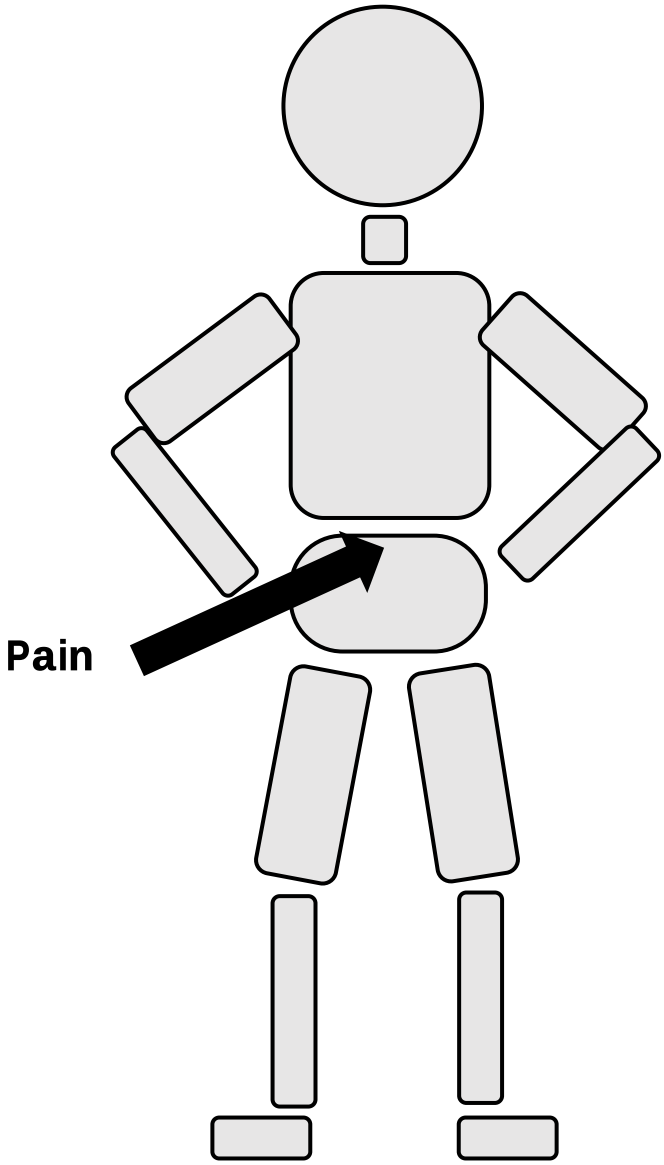
Module 4

18-year-old F

Pedestrian hit by bakkie

Confused

Pale



BP	PR	RR
100/60	125	26

Equipment Checklist:
☐ IV tourniquets
☐ IV catheters (14/16/18G)
☐ 1 bag of IV fluids (LR)
☐ 3-way dressing

LAST SESSION (30 seconds):
- We Identified shock and treated patients in shock using the bundle of care

TODAY'S OBJECTIVES (30 seconds):
- Understanding the **importance of large bore IVs** and giving IV fluids
- To **practice placing large bore IV catheters** in a proximal vein
- How to assess stages of depressed mental status **using AVPU**
- How to **apply a 3-way dressing** to an open chest wound

SCENARIO (30 Seconds):

☐ A 24-year-old man with a stab wound to his right upper chest from a broken bottle. You see foaming, red blood coming from the wound on his chest. The man appears pale, sweaty, and is rapidly gasping for air. The patient is opening his eyes only when your talk to him. Vitals: PR=140, BP=85/55, RR=34.

DISCUSSION POINTS (5 minutes):

☐**Looking at the scenario and the patient's clinical presentation, what is concerning?**
- He is not being very responsive and seems to be seriously injured

☐**How can you identify that the patient is in shock?**
- Penetrating wound to the chest, rapid PR, rapid RR, low BP

☐**What is his mental status, using AVPU? Answer = V**
- Recall: A-Alert, or V-responsive to Voice, or P-responsive to Pain, or U-completely Unresponsive.
- A change in mental status is very concerning for decompensated shock. This patient needs to be seen by a trauma surgeon as soon as possible.

☐ **Foaming red blood from a chest wound is concerning for a pneumothorax or haemothorax.**
- On auscultation, **you find decreased breath sounds** on the side of the injury and the patient is taking rapid and shallow breaths
  - A **sucking chest wound** can become a tension pneumothorax.
  - For an **open pneumothorax**, apply a 3-way dressing
    - The 3-way dressing allows air and blood to leave the chest cavity, but keeps additional air from getting in. This will ideally slow the progression of the pneumothorax or haemothorax.
  - If it is a **closed or** there are signs of **tension pneumothorax (hypotension, tracheal deviation)**, then use needle decompression according to protocols and level of training.

☐ **You placed a 20G IV in a small vein in the patient's right hand and start administering fluid in the ambulance. While driving to the hospital, the patient's BP continues to decrease.**
- **What IV fluids** do we give for haemorrhagic shock?
  - LR or NS – either is perfectly fine for EMS.
- **Why do we give IV fluids** for haemorrhagic shock?
  - To prevent the BP from going so low that there is poor perfusion of tissues and organs.
- Would **placing a larger IV catheter** be beneficial to give more fluid to the patient? What size and where?
  - The purpose of fluids is to try to replace some of the volume the patient has lost through haemorrhage. For many patients in shock, this is a large quantity of fluids that you will want to be able to give the patient quickly.
- You want an 16 gauge or larger in the patient's ACF
  - Remember, placing large bore IVs implies a vein large enough to take that much fluid.
- **Which veins** are most appropriate for large bore IV catheters?
  - Remember: placing IV lines depends on your qualification.
- What is the **ideal fluid and the rate** to give in shock from trauma?
  - LR or NS in 500mL bolus, reassess the clinical picture, and repeat as necessary.

☐**What are the important simple things you can do (as a bundle) to improve outcomes?**

[1] Control catastrophic haemorrhage (at the scene)
[2] High flow oxygen (non-rebreather mask)
[3] Place a large bore IV catheter
[4] Short scene time, <10 minutes (so, "load and go")
[5] Transport to appropriate trauma centre

} The "5 item bundle of care" for haemorrhagic shock.

SKILLS SESSION (5-7 minutes):

"I would like someone to act as the patient we just discussed, and 1 person to be the Emergency Care Officer to talk us through placing a large bore IV into the patient's ACF as well as treating open chest wounds."

☐**Correctly place a large bore IV** **<<demonstration only... do not insert the actual IV catheter>>**

- Should grab an 16 gauge needle or larger and show that they would put it into a large vein

☐**3-way dressing**

- Demonstrate: bottom edge un-taped to form a flutter-type valve
- Use lots of tape. Blood is not great for an adhesive, and you don't want the dressing to come off during transport

SUMMARY (2-3 minutes):

☐<u>In summary, this case had</u> a chest wound with significant blood loss, termed an open haemothorax.

- Place a **3-way dressing** for an open chest wound.
- **Large bore IV** placement... 14 or 16 gauge is best in the ACF (depends on your qualification level)
- **Give IV fluids**... 500mL bolus NS or LR for adults, then reassess the entire clinical picture
- **AVPU score** of V, P, or U means a change in mental status, which can be a sign of worsening shock
  - Remember, confusion is a sign that the brain is not getting enough oxygen and is an important sign for decompensated shock

➔ **Congrats! This was the last module. Applying these skills will help improve your patient's outcomes!**

Equipment Checklist:
- ☐ IV tourniquets
- ☐ IV catheters (14/16/18G)
- ☐ 1 bag of IV fluids (LR)
- ☐ 3-way dressing

LAST SESSION (30 seconds):
- We Identified shock and treated patients in shock using the bundle of care

TODAY'S OBJECTIVES (30 seconds):
- Understanding the **importance of large bore IVs** and giving IV fluids
- To **practice placing large bore IV catheters** in a proximal vein
- How to assess stages of depressed mental status **using AVPU**
- How to **apply a 3-way dressing** to an open chest wound

SCENARIO (30 Seconds):

☐ A 24-year-old man with a stab wound to his right upper chest from a broken bottle. You see foaming, red blood coming from the wound on his chest. The man appears pale, sweaty, and is rapidly gasping for air. The patient is opening his eyes only when your talk to him. Vitals: PR=140, BP=85/55, RR=34.

DISCUSSION POINTS (5 minutes):

☐ **Looking at the scenario and the patient's clinical presentation, what is concerning?**

☐ **How can you identify that the patient is in shock?**

☐ **What is his mental status, using AVPU? Answer = V**
- Recall: A-Alert, or V-responsive to Voice, or P-responsive to Pain, or U-completely Unresponsive.

☐ **Foaming red blood from a chest wound is concerning for a pneumothorax or haemothorax.**
- On auscultation, **you find decreased breath sounds** on the side of the injury and the patient is taking rapid and shallow breaths
  - A **sucking chest wound** can become a tension pneumothorax.
  - For an **open pneumothorax**, apply a 3-way dressing
  - If it is a **closed or** there are signs of **tension pneumothorax (hypotension, tracheal deviation)**, then use needle decompression

☐ **You placed a 20G IV in a small vein in the patient's right hand and start administering fluid in the ambulance. While driving to the hospital, the patient's BP continues to decrease.**
- **What IV fluids** do we give for haemorrhagic shock?
  - LR or NS – either is perfectly fine for EMS.
- **Why do we give IV fluids** for haemorrhagic shock?
  - To prevent the BP from going so low that there is poor perfusion of tissues and organs.
- Would **placing a larger IV catheter** be beneficial to give more fluid to the patient? What size and where?
  - Remember, placing large bore IVs implies a vein large enough to take that much fluid.
- **Which veins** are most appropriate for large bore IV catheters?
  - Remember: placing IV lines depends on your qualification.
- What is the **ideal fluid and the rate** to give in shock from trauma?
  - LR or NS in 500mL bolus, reassess the clinical picture, and repeat as necessary.

☐ What **are the important simple things you can do (as a bundle) to improve outcomes?**

[1] Control catastrophic haemorrhage (at the scene)
[2] High flow oxygen (non-rebreather mask)
[3] Place a large bore IV catheter
[4] Short scene time, <10 minutes (so, "load and go")
[5] Transport to appropriate trauma centre

} The "5 item bundle of care" for haemorrhagic shock.

SKILLS SESSION (5-7 minutes):

"I would like someone to act as the patient we just discussed, and 1 person to be the Emergency Care Officer to talk us through placing a large bore IV into the patient's ACF as well as treating open chest wounds."

☐ **Correctly place a large bore IV <<demonstration only... do not insert the actual IV catheter>>**

☐ **3-way dressing**
- Demonstrate: bottom edge un-taped to form a flutter-type valve

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SUMMARY (2-3 minutes):

☐ <u>In summary, this case had</u> a chest wound with significant blood loss, termed an open haemothorax.
- Place a **3-way dressing** for an open chest wound.
- **Large bore IV** placement... 14 or 16 gauge is best in the ACF (depends on your qualification level)
- **Give IV fluids**... 500mL bolus NS or LR for adults, then reassess the entire clinical picture
- **AVPU score** of V, P, or U means a change in mental status, which can be a sign of worsening shock

➔ **Congrats! This was the last module. Applying these skills will help improve your patient's outcomes!**

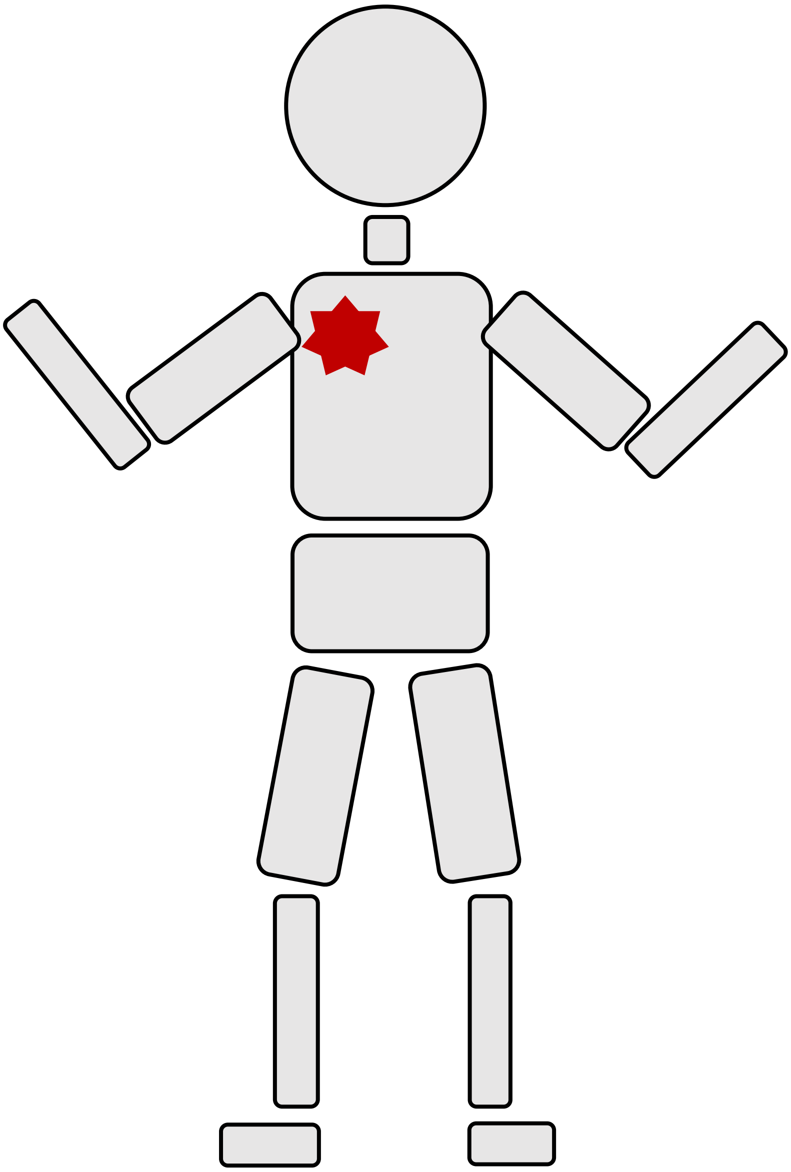
Module 5

32-year-old M

Stabbed with a bottle neck

Opens eyes to voice

Pale



BP	PR	RR	CRT
85/55	140	34	>2 sec

Appendix 6 – H.E.E.T. Implementation manual and approach

See implementation manual and guidance on the following pages…

High Efficiency EMS Training Programme

H.E.E.T. Programme

Facilitators' Manual for modules focused on:

EMS-TruShoC

[EMS Traumatic Shock Care]

Implementation at Eastern Division,
from September 2018 to December 2018

A collaboration between:

Department of Emergency Medicine
SCHOOL OF MEDICINE
UNIVERSITY OF COLORADO ANSCHUTZ MEDICAL CAMPUS

Western Cape Government
Health

The purpose of this document is to be used as an implementation guide for the Western Cape Government EMS System. However, this implementation guide may be adapted for other systems.

Please refer to planning documents for planning documents including prior work, key outcomes and organisational structure of the HEET team.

Brief background

The core aspects of the HEET implementation strategy includes training that are

- Provided in lose doses (<15-minutes)
- With high-frequency (approx. once weekly)
- Delivered on-site (i.e., at EMS base, in back on ambulance)
- Delivered on-shift (shift start is preferred)
- Rendered by a peer (ALS or ILS providers)

The non-core aspects include training that occurs in the three domains e.g. knowledge, attitude and skill.

It is recommended that the training occur at shift change.

Some benefits of the HEET program include that it addresses staff complacency, providing a simple way of remaining current, improving knowledge and improving communication lines between the different levels of healthcare providers e.g. ALS and BLS.

Planning for data

Inputs	Creating training manuals Doing training sessions for facilitators Forms to track feedback, experiences, and participation
Outputs	Feedback forms Assessments Surveys Interviews
Outcomes	Culture change Changes to knowledge, Attitude and Skills Changes to patient outcomes and EMS processes

Checklists for program

Planning that occurs once a year		**Frequency**	[redacted]
Note: Some of the items listed below form part of the WC EMS annual strategic planning			
1	WC EMS units work with HEET Steering committee to select HEET topics	Annually	
2	Steering committee meet with stakeholders to agree on learning objectives and outcomes for selected topics	Annually	
3	Steering committee oversees development of new content learning objectives	Annually	
4	Steering committee and HRD schedules times for roll outs for following year	Annually	
5	Steering committee oversees development of new content	Annually	
6	Steering committee approves newly developed content	Annually	
7	Steering committee develops and submits budget to EMS head	Annually	
8	Annual review of programs conducted during the year	Annually	
9	HEET Coordinator sets up annual composite report	Annually	
10	Set dates for facilitator training	Quarterly	

Planning prior to roll out

It is recommended that this checklist is reviewed approximately 3 months prior to roll out, so that enough time can be allocated to procure materials and equipment. Further, early and continuous communication with the district and base management will help to obtain buy-in.

Approximately one month prior to roll out		[redacted]
1	Steering committee email materials to HRD coordinators for printing and distribution	
2	Materials to be sent	
	• Training manuals • Evaluation forms • Assessment forms	
3	Send equipment e.g. tourniquets (if applicable)	
4	HRD remind district/shift managers of pending roll out	
5	District/shift managers start awareness campaign with staff	
6	HRD inform control centre of roll out and dates	
7	Set up roll out plan using staff lists and persal numbers	
8	Ensure scanning and printing device at base	

Facilitator training

		[redacted]
1	Collaborate with district manager	
2	Organise administrative support	
3	Organise venue	
4	Print manuals and all documentation	
5	Determine availability of trainers	
6	Set course program	
7	Confirm logistics e.g. overtime	

Planning during roll out

Daily during roll out		[redacted]
1	Daily oversight from the HRD representative at the base during early roll out phase	
2	HRD Representative report challenges to steering committee	
3	HEET Coordinator ensures that data collection is done smoothly	
4	HEET Coordinator provides continuous feedback to HRD/ Station managers	
5	District manager is responsible for continuous communication with control room to resolve issues as it occur	

Post roll out

Within four weeks post roll out		[redacted]
1	HEET Coordinator enters data and cleans it up	
2	HEET Coordinator performs analysis using performance metrics	
3	HEET Coordinator completes monitoring and evaluation report is completed	
4	HEET Coordinator distribute relevant findings back to steering committee	
5	HRD issues CPD certificates for training	
6	District manager drafts certificates are drafted and sign it	
7	District managers hands out certificates	
8	Steering committee arranges for 3-monthly post re-evaluation is done	

Budget items to consider

Item	**Comment**
Accommodation	If applicable to setting for facilitator training or Steering Committee site visits
Subsistence	If applicable for participants and/or facilitators
Transport costs	If applicable for participants and/or facilitators
Training location	If none at base

Overtime	If applicable for participants and/or facilitators