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TITLE: Evaluation of Role 2 (R2) Medical Resources in the Afghanistan Combat Theater: Past, Present and Future

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CONTRACTING ORGANIZATION: The Geneva Foundation, Tacoma, WA

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14. ABSTRACT
There exists a continued lack of evidence about the impact of Role 2 (R2) medical resources in the combat theater. Although a R2 registry has been in place since 2008, no systematic evaluation for these data has been conducted. Without analysis of this information, military planners and medical leaders will be unable to best allocate R2 resources in future operations. Furthermore, the clinical competencies required for each medical team member to function optimally in this environment have yet to be clearly defined or systematically supported across the Tri-Services.
Objective: Describe and understand impact of R2 utilization during OEF and beyond, with emphasis on patient outcomes and provider competency
Aim 1: Descriptive study of all available information for combat casualties in Afghanistan
Aim 2: Identify the ideal provider training and competency assessment, sustainment and evaluation for medical staff (physicians, nurses, other licensed professionals, medics) deployed to R2 environment

15. SUBJECT TERMS
Combat Casualty Care; Critical Care; Nursing Competency; Protocol Development

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TABLE OF CONTENTS

Page

1. **Introduction……4**
2. **Keywords……4**
3. **Accomplishments……4**
4. **Impact……7**
5. **Changes/Problems……9**
6. **Products……9**
7. **Participants & Other Collaborating Organizations……11**
8. **Special Reporting Requirements……12**
9. **Appendices……12**

1. **INTRODUCTION:** There exists a continued lack of evidence about the impact of Role 2 medical resources in the combat theater. Although a Role 2 database has been in place since 2008, no systematic evaluation for these data has been conducted. Without analysis of this information, military planners and medical leaders will be unable to best allocate Role 2 resources in future operations. Furthermore, the clinical competencies required for each medical team member to function optimally in this environment have yet to be clearly defined or systematically supported across the Tri-Services.

2. **KEYWORDS:**

Battlefield
Combat Casualty Care (C3/CCC)
Competency
Dashboard
Department of Defense Trauma Registry (DoDTR)
Military Treatment Facility (MTF)
Operations
Role 2 (R2)
Role 3 (R3)
Standardized
Sustainment
Training
Tip-Top
Tri-Services

3. **ACCOMPLISHMENTS:**

Accomplished all CY16-CY21 Goals

What were the major goals of the project?

For the final report, the study progress and accomplishments directly aligned with the SOW deliverables below.

Specific Aim 1 – Initiate R2 Registry (R2R) analysis and conduct comprehensive review of training literature, individual experiences, and Tri-Service training resources.

All SOW deliverables were completed for specific aim 1, as described below:

Major Task 1
Subtask 1: Submit documents for HRPO approval
All protocols and amendments were routed to HRPO for 2nd level review/approval.

Milestone # 1 HRPO approval obtained
All protocols were routed and acknowledged/approved by HRPO

Subtask 2: Identify sources and initiate process to obtain data other than R2R.
The research team collaborated with other investigators to identify additional data sources. One example included identifying patients with ocular injuries in the Role 2 dataset. This analysis provided preliminary data another research effort in collaboration with Walter Reed Ocular Trauma Database, Theater Medical Data Store (TMDS), and Defense and Veterans Eye Injury and Vision Registry. Another example included a whole blood analysis from the Role 2 dataset. This analysis also provided preliminary data for another research effort in collaboration with DoDTR, ASBP, AFMES, TMDS, and WISPR.

Subtask 3: Describe all data available in R2R, conduct gap analysis
This research project has generated multiple publications and described trends/gaps. The research team continued to disseminate research findings/gaps and collaborate with the Joint Trauma System to improve the R2R (now part of the DoDTR).

Subtask 4: Compile and analyze all "lessons learned" regarding R2 operations during OEF/OIF
The research team continued to work alongside the Joint Trauma system (via data sharing agreement) to help improve the missing data in the DoDTR. The research team helped identify gaps in the current data variables within the Role 2 Registry (now in the DoDTR) and data collection processes required for enhanced future analysis. Several manuscript publications produced from this grant have described the 'lessons learned'. To identify gaps in the data collection processes we began a feedback loop with the JTS on DoDTR data quality. Our research team identified and sent implausible values found within the DoDTR dataset to the abstractors at JTS, who then updated their DoDTR records and adjusted their business rules for data entry accordingly.

Subtask 5: Describe all training assets available for R2 team members
Completed protocol H-16-022 "Evaluation of Healthcare Systems Training for Combat Casualty Care Skills" and published manuscript associated with this deliverable entitled "An assessment of pre-deployment training for Army Nurses and Medics. Military Medicine" (October 2020).

Subtask 6: Conduct survey of deployed R2 members for personal training experience, confidence upon deployment. A research protocol and survey from this grant H-16-022 (referenced above) aimed to address subtask 6. As mentioned above, we completed the initial survey and analysis, and published two manuscripts, "An assessment of pre-deployment training for Army Nurses and Medics. Military Medicine" and "Pre-deployment training of Army medics assigned to prehospital settings".

Subtask 7: Based on literature review, recommend best practice for R2 training
The implementation of the pre-deployment readiness training (pilot program) in the Army Burn Center/BAMC Level 1 Trauma Center was completed.

All SOW deliverables were completed for specific aim 2, as described below:

Specific Aim 2 – Develop R2R Performance Assessment Dashboard
Major Task 2
Subtask 1: Create metrics to evaluate R2 outcomes and team performance.
Subtask 2: Develop DoDTR report for near-real time feedback to deployed teams
Subtask 3: Track training and sustainment programs for R2 members
Subtasks 1-3. The Elsevier learning management System (available Tri-Service) will create and track pre-deployment training. Leadership determined that the DHA Nursing Readiness Working Group would be the best platform to continue these efforts. The DHA Nursing Readiness Working Group will identify champions, metrics, and process for data acquisition.

All SOW deliverables were completed for specific aim 3, as described below:

Specific Aim 3 – Expand R2 database to all deployed units to OEF/OIF
Major Task 3
Subtask 1: Obtain all identified data other than R2R
Finalized retrospective DoDTR dataset (formally known as R2 database), n=28,707 subjects.
Subtask 2: Create repository within DoDTR for these data
The DoDTR merged with the Role 2 database; therefore, this deliverable was completed.
Subtask 3: Conduct analysis and contrast by R2 unit and phase of conflict (entry, surge, and sustainment)

The research team complete this deliverable and presented “Forward Surgical Team Outcomes in Afghanistan, 2006-2015” via poster presentation at the SURF 2021 virtual conference.

All SOW deliverables were completed for specific aim 4, as described below:

Specific Aim 4 – Implement Tri-Service training and sustainment standard
Major Task 4
Subtask 1: Cross-walk all training programs for R2 team members
Subtask 2: Develop and validate knowledge assessment tool for combat-related skills
Subtask 3: Generate universal combat casualty skills for each provider type
Subtask 4: Develop and implement metrics for evaluating skill and knowledge retention
Completed subtasks 1-4 and the research team published their findings in the Delphi manuscript.

All SOW deliverables were completed for specific aim 5, as described below:

Specific Aim 5 – Implement Tip Top Pilot study at a military treatment facility (MTF)
Major Task 5
Subtask 1: Determine the number of preceptors and nurse trainees
Subtask 2: Identify and train 100% current nursing preceptors (n = x preceptors) on Tip-Top
Subtask 3: Identify and orient all new nurses on Tip Top (n = x nurse trainees)
Subtask 4: Collect data/outcome measures on completeness of the employee CAF folder, duration of preceptorship, and variation in competency
Subtask 5: Perform data analysis to evaluate critical thinking, reduce documentation burden, and increase the accuracy and completeness of competency documentation
Subtask 6: Troubleshoot the transition program or process
Milestone: Provide lessons learned on Tip-Top to standardize and improve nurses transitioning into specialty practice, and to provide a method to effectively track competency progression
Completed subtasks 1-6. The research team accomplished these aim and subtasks, and collaborators at the USAISR and BAMC have continued using the tools and transition program from the Tip-Top pilot study.

All SOW deliverables were completed for specific aim 6, as described below:

Specific Aim 6 – Evaluate long-term outcomes of patients treated at R2 facilities post.
Major Task 6
Subtask 1: Compare outcomes for patients treated at Role 2s
Subtask 2: Continue cleaning and analyzing the Role 2 and DoDTR datasets for ongoing research efforts. Continue collaborating with SMEs to improve data collection in collaboration with JTS.
Subtask 3: Finalize data analysis, dissemination efforts, and manuscript submissions.
Subtask 4: Remove identifiers from data and/or delete/archive identifiable datasets as required by the protocol/DHA.
Subtask 5: Closeout all ongoing research protocols as required by the institute, IRB, and DHA.
Completed subtasks 1-5. Completed all ‘outcome’ efforts for patients treated at Role 2s, including the recently published Role 2 Burn manuscript. Completed all data cleaning and research efforts including finalizing all data analysis, dissemination efforts and manuscript submissions. The efforts included the Role 2/military focused humanitarian research efforts that will be presented at the upcoming 2022 AMSUS and ASA conferences. Lastly, all protocols were closed (see attached closure confirmations), identifiers were removed from each dataset as required by the IRB/DHA.

What opportunities for training and professional development has the project provided?
Since the initiation of the award, the research team attended ongoing training and professional development. Conferences/presentations locations included:

AAST – American Association for the Surgery of Trauma
AMSUS - Association of Military Surgeons of the United States
ASA - American Surgical Association
ABA – American Burn Association
BAMC Nurses Week
CoSCCC – Committee on Surgical Combat Casualty Care
Defense Health Agency Nurses' Week Celebration
EAST – Eastern Association for the Surgery of Trauma
IMSH – International meeting on simulation in Healthcare
MHSRS - Military Health Systems Research Symposium SCCM – Society of Critical Care Medicine
National Museum of Health and Medicine Science Café presentation
Royal British Legion Centre for Blast Injury Studies' Annual Networking and Research conference - UK
SAGES – Society of American Gastrointestinal and Endoscopic Surgeons
SHOCK
Sothern Region Burn
STRAC – Southwest Texas Regional Advisory Council
SURF - San Antonio Military Health system (SAMHS) and Universities Research Forum SHORESH
THOR – Trauma Hemostasis and Oxygenation Research
TSNRP- Tri-Service Nursing Research Symposium
US Army Institute of Surgical Research Scientific Seminar
WTA - Western Trauma Association

How were the results disseminated to communities of interest?
All findings were disseminated through research presentations and publications (see section 6)

What do you plan to do during the next reporting period to accomplish the goals?
Nothing to Report. Final Report.

4. IMPACT:

What was the impact on the development of the principal discipline(s) of the project?
Overall, this research has had a positive impact on improved data collection by the Joint Trauma Systems (JTS) Department of Defense Trauma Registry (DoDTR). As a part of our research methods, our team utilized very large/robust DoDTR datasets. After our team cleaned and analyzed this retrospective dataset, we were able to identify gaps that contributed to the JTS DoDTR movement to improve future data capture regarding accurate injury severity and times of treatment and transport. Our ongoing research efforts and collaborations with the JTS helped inspire the DoDTR data dictionary, which helps researchers understand the variables within the DoDTR.

Results from our survey study resulted in two manuscript publications, which aimed to inform military leadership of nurse and medic training. We surveyed over 23,000 military nurses and medics to ask about their pre-deployment training experiences. Our research determined that most nurse and medic respondents were satisfied with the quality of their training and were prepared/confident to provide care.

This research grant provided a large-scale and systematic description of casualties treated at Role 2 facilities in Afghanistan. Combined findings from all of the projects published from this grant provide a detailed description of the training, injuries, and procedures at Role 2 facilities. This project could help optimize FST staffing and training, and these results should guide military medical leaders and planners to optimize forward surgical care.

As a result of this research grant, countless presentations were disseminated at more than 20 conferences, a total of 22 manuscripts were published, and at least two new awards received funding after using preliminary data from this grant. This project drew in more than 60 collaborators and experts since its initiation in 2016.

What was the impact on other disciplines?
Findings, results, and techniques that were developed throughout this project included improved current data collection, ongoing research, and data analysis. Research and performance improvement studies derived from this project included the following (11) protocols:

1. USAISR "Evaluation of Role 2 (R2) Medical Resources in the Afghanistan Combat Theater: Past, Present and Future"

2. USAISR "Analysis of Medical Interventions in the Combat Environment Related to Deployed Hospital Care"

3. USAISR "Evaluation of Healthcare Systems Training for Combat Casualty Care Skills"

4. USAISR "The Role 2 Experience: Comparing the Department of Defense Trauma Registry and Surgeon Case Logs from 2006 to 2017"

5. VMASC/Old Dominion University "Evaluation of Role 2 (R2) Medical Resources in the Afghanistan Combat Theater: Past, Present and Future"

6. VMASC/Old Dominion University "The Development of an Innovative Role 2 CPG-Based Trauma Knowledge-Assessment Instrument and Training Materials That Utilize Deliberative Practice and Mastery Training"

7. USAISR/PI determination "Tip-Top Pilot Study"

8. USAISR "A Comprehensive Evaluation of Patients Treated at Role 2 Surgical Units in Afghanistan
9. Redefining and Restoring the USAISR Preceptorship Program"

10. USAISR "Redefining and Restoring the USAISR Preceptorship Program"

11. USAISR "A Retrospective Review of U.S. Military Working Dogs Treated by Role 2 Surgical Teams in Afghanistan"

What was the impact on technology transfer? Nothing to Report

What was the impact on society beyond science and technology? Medecins Sans Frontieres/Doctors without borders (MSF) is unable to do a study like our military humanitarian study because they don't have the massive amounts of data like the military does. Our humanitarian study can be used by MSF to help them plan and prepare for treating patients in war zones.

Our research aimed to improve the trauma system to save lives. An example of this includes "Whole blood at the tip of the spear: A retrospective cohort analysis of warm fresh whole blood resuscitation versus component therapy in severely injured combat casualties" manuscript, which demonstrates a method to save lives.

5. CHANGES/PROBLEMS:

Changes in approach and reasons for change
During the course of the proposal, a change of PI was submitted and approved by the Sponsor.

Actual or anticipated problems or delays and actions or plans to resolve them
No cost extension was submitted and approved by Sponsor.

Changes that had a significant impact on expenditures NA

Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents NA

Significant changes in use or care of human subjects NA

Significant changes in use or care of vertebrate animals NA

Significant changes in use of biohazards and/or select agents NA

6. PRODUCTS:

Journal publications (2016 – 2021)

Antebi, B., Benov, A., Mann-Salinas, E. A., Le, T. D., Cancio, L. C., Wenke, J. C., . . . Gross, K. R. (2016). Analysis of injury patterns and roles of care in US and Israel militaries during recent conflicts: two are better than one. *Journal of trauma and acute care surgery, 81*(5), S87-S94.

Le, T. D., Orman, J. A., Stockinger, Z. T., Spott, M. A., West, S. A., Mann-Salinas, E. A., . . . Gross, K. R. (2016). The military injury severity score (mISS): a better predictor of combat mortality than injury severity score (ISS). *Journal of trauma and acute care surgery, 81*(1), 114-121.

Mann-Salinas, E. A., Le, T. D., Shackelford, S. A., Bailey, J. A., Stockinger, Z. T., Spott, M. A., . . . Hodgetts, T. (2016). Evaluation of role 2 (R2) medical resources in the Afghanistan combat theater: initial review of the joint trauma system R2 registry. *Journal of trauma and acute care surgery, 81*(5), S121-S127.

Boyer, S. (2017). Clinical Transition Framework: Efficient Solutions for Transitional Support Systems. *Nurse Leader, 15*(6), 425-428.

Lane, I., Stockinger, Z., Sauer, S., Ervin, M., Wirt, M., Bree, S., . . . Mann-Salinas, E. (2017). The Afghan Theater: a review of military medical doctrine from 2008 to 2014. *Military Medicine, 182*(suppl_1), 32-40.

Boyer, S. A., Mann-Salinas, E. A., & Valdez-Delgado, K. K. (2018). Clinical transition framework: Integrating coaching plans, sampling, and accountability in clinical practice development. *Journal for nurses in professional development, 34*(2), 84-91.

Kotwal, R. S., Staudt, A. M., Trevino, J. D., Valdez-Delgado, K. K., Le, T. D., Gurney, J. M., . . . Mann-Salinas, E. A. (2018). A review of casualties transported to Role 2 medical treatment facilities in Afghanistan. *Military Medicine, 183*(suppl_1), 134-145.

Kotwal, R. S., Staudt, A. M., Mazuchowski, E. L., Gurney, J. M., Shackelford, S. A., Butler, F. K., . . . Mann-Salinas, E. A. (2018). A US military Role 2 forward surgical team database study of combat mortality in Afghanistan. *Journal of trauma and acute care surgery, 85*(3), 603-612.

Nessen, S. C., Gurney, J., Rasmussen, T. E., Cap, A. P., Mann-Salinas, E., Le, T. D., . . . Holcomb, J. B. (2018). Unrealized potential of the US military battlefield trauma system: DOW rate is higher in Iraq and Afghanistan than in Vietnam, but CFR and KIA rate are lower. *Journal of trauma and acute care surgery, 85*(1S), S4-S12. doi:10.1097/ta.0000000000001969

Reeves, P. T., Auerbach, M. M., Le, T. D., Caldwell, N. W., Edwards, M. J., Mann-Salinas, E. A., . . . Borgman, M. A. (2018). Analysis of pediatric trauma in combat zone to inform high-fidelity simulation predeployment training. *Pediatric critical care medicine, 19*(4), e199-e206.

Staudt, A. M., Savell, S. C., Biever, K. A., Trevino, J. D., Valdez-Delgado, K. K., Suresh, M., . . . Mann-Salinas, E. A. (2018). En route critical care transfer from a Role 2 to a Role 3 medical treatment facility in Afghanistan. *Critical care nurse, 38*(2), e7-e15.

Staudt, A., Gurney, J., Valdez-Delgado, K., Suresh, M., Trevino, J., Le, T., . . . Mann-Salinas, E. (2018). Factors associated with trauma patients' length of stay at Role 2 facilities in Afghanistan, October 2009 to September 2014. *Journal of trauma and acute care surgery, 85*(1S), S140-S144.

Boyer, S., Mann-Salinas, E., Valdez-Delgado, K., & VanFosson, C. (2019). Using the Delphi Technique to Determine Core Components of a Nurse Competency Program. *Journal for nurses in professional development, 35*(5), 261-267.

Hahn, C., Staudt, A. M., Brockmeyer, J., Mann-Salinas, E. A., & Gurney, J. M. (2019). Characteristics of Iraqi patients treated during operation inherent resolve by a forward surgical team. *Military Medicine, 184*(Supplement_1), 301-305.

Gurney, J., Staudt, A., Cap, A., Shackelford, S., Mann-Salinas, E., Le, T., . . . Spinella, P. (2020). Improved survival in critically injured combat casualties treated with fresh whole blood by forward surgical teams in Afghanistan. *Transfusion, 60*, S180-S188.

Hudson, I. L., Blackburn, M. B., Staudt, A. M., Ryan, K. L., & Mann-Salinas, E. A. (2020). Analysis of Casualties That Underwent Airway Management Before Reaching Role 2 Facilities in the Afghanistan Conflict 2008–2014. *Military Medicine, 185*(Supplement_1), 10-18.

Staudt, A. M., Suresh, M. R., Gurney, J. M., Trevino, J. D., Valdez-Delgado, K. K., VanFosson, C. A., . . . Kotwal, R. S. (2019). Forward Surgical Team Procedural Burden and Non-operative Interventions by the U.S. Military Trauma System in Afghanistan, 2008–2014. *Military Medicine, 185*(5-6), e759-e767. doi:10.1093/milmed/usz402

Suresh, M. R., Valdez-Delgado, K. K., VanFosson, C. A., Trevino, J. D., Mann-Salinas, E. A., Shackelford, S. A., & Staudt, A. M. (2020). Anatomic injury patterns in combat casualties treated by forward surgical teams. *Journal of trauma and acute care surgery, 89*(2S), S231-S236. doi:10.1097/ta.0000000000002720

Gurney, J. M., Staudt, A. M., del Junco, D. J., Shackelford, S. A., Mann-Salinas, E. A., Cap, A. P., . . . Martin, M. J. (2021). Whole blood at the tip of the spear: A retrospective cohort analysis of warm fresh whole blood resuscitation versus component therapy in severely injured combat casualties. *Surgery*.

Suresh, M. R., Valdez-Delgado, K. K., Staudt, A. M., Trevino, J. D., Mann-Salinas, E. A., & VanFosson, C. A. (2021). An Assessment of Pre-deployment Training for Army Nurses and Medics. *Military Medicine, 186*(1-2), 203-211.

Suresh, M. R., Staudt, A. M., Trevino, J. D., Valdez-Delgado, K. K., VanFosson, C. A., & Rizzo, J. A. (2021). Characteristics of burn casualties treated at Role 2 in Afghanistan. *Journal of trauma and acute care surgery, Publish Ahead of Print*. doi:10.1097/ta.0000000000003161

Suresh, M. R., Valdez-Delgado, K. K., Staudt, A. M., Trevino, J. D., Papalski, W. N., Greydanus, D. J., . . . VanFosson, C. A. (2021). Pre-deployment training of Army medics assigned to prehospital settings. *Journal of Trauma and Acute Care Surgery*.

Presentations (upcoming)

- Accepted for podium presentation at American Surgical Association - ASA (2022) 142nd Annual Meeting for "Humanitarian Trauma Care Delivered by US Military Facilities During Combat Operations in Afghanistan, Iraq, and Syria"
- Accepted for poster presentation at Association of Military Surgeons of the United States – AMSUS (2022) "Humanitarian Trauma Care by US Military Treatment Facilities in Global Operational Environments"

Books or other non-periodical, one-time publications. Nothing to report

Other publications, conference papers and presentations. Nothing to report

Website(s) or other Internet site(s)
https://genevausa.org/news/story/evaluation-of-role-2-r2-medical-resources-in-the-afghanistan-combat-theater-past-present-and-future/

Technologies or techniques Nothing to report

Inventions, patent applications, and/or licenses Nothing to report

Other Products Nothing to report

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project? During the last reporting period, the following individuals worked on the project:

Name:	LTC Christopher VanFosson, PhD, RN
Project Role:	Principal Investigator
Nearest person month worked:	3
Contribution to Project:	LTC VanFosson has performed work in all areas of the study as the Principal Investigator including manuscript writing.
Funding Support:	NA
Name:	Amanda Staudt, PhD
Project Role:	Epidemiologist/Associate Investigator
Nearest person month worked:	3
Contribution to Project:	Dr. Staudt has performed work in all areas of the study, specifically manuscript writing and statistical support for all Role 2 related manuscript publications.
Funding Support:	NA/W81XWH-15-2-0085
Name:	Jennifer Trevino, MBA
Project Role:	Program Manager/Associate Investigator
Nearest person month worked:	3
Contribution to Project:	Ms. Trevino has performed work in all areas of the study, specifically program management, manuscript writing and regulatory support.
Funding Support:	NA/W81XWH-15-2-0085
Name:	Mithun Suresh, MD
Project Role:	Associate Investigator

Nearest person month worked:	1
Contribution to Project:	Dr. Suresh provided support with abstract and manuscript writing.
Funding Support:	NA/W81XWH-15-2-0085

Name:	COL Jennifer Gurney, MD
Project Role:	Associate Investigator
Nearest person month worked:	1
Contribution to Project:	COL Gurney provided support with abstract and manuscript writing.
Funding Support:	NA

Name:	Tuan D. Le, MD, Dr. PH
Project Role:	Associate Investigator
Nearest person month worked:	1
Contribution to Project:	Dr. Le provided support with abstract and manuscript writing.
Funding Support:	NA

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?
Nothing to report

What other organizations were involved as partners?
Nothing to report

8. SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS: Nothing to report

QUAD CHARTS: Attached

9. APPENDICES:

- FINAL Role 2 Manuscripts (collated/PDF)
- Final Manuscript List
- Protocol closure acknowledgement
    - H-15-010 USAISR
    - H-16-022 USAISR
    - H-16-023 USAISR
    - H-18-001 MRDC
- R2/Humanitarian collaboration
    - DHA DSAA #21-2708 signed/approved
    - Executed DHA DSA Approval confirmation
- R2/Humanitarian presentations
    - 2022 ASA abstract (accepted for podium) notification email and abstract
    - 2022 AMSUS abstract (accepted for poster)

Analysis of injury patterns and roles of care in US and Israel militaries during recent conflicts: Two are better than one

Ben Antebi, PhD, Avi Benov, MD, MHA, Elizabeth A. Mann-Salinas, PhD, RN, Tuan D. Le, MD, DrPH, Leopoldo C. Cancio, MD, Joseph C. Wenke, PhD, Haim Paran, MD, Avraham Yitzhak, MD, Bader Tarif, MD, MHA, Kirby R. Gross, MD, David Dagan, MD, *and* **Elon Glassberg, MD, MHA**, *Fort Sam Houston, Texas*

BACKGROUND: As new conflicts emerge and enemies evolve, military medical organizations worldwide must adopt the "lessons learned." In this study, we describe roles of care (ROCs) deployed and injuries sustained by both US and Israeli militaries during recent conflicts. The purpose of this collaborative work is facilitate exchange of medical data among allied forces in order to advance military medicine and facilitate strategic readiness for future military engagements that may involve less predictable situations of evacuation and care, such as prolonged field care.

METHODS: This retrospective study was conducted for the periods of 2003 to 2014 from data retrieved from the Department of Defense Trauma Registry and the Israel Defense Force (IDF) Trauma Registry. Comparative analyses included ROC capabilities, casualties who died of wounds, as well as mechanism of injury, anatomical wound distribution, and Injury Severity Score of US and IDF casualties during recent conflicts.

RESULTS: Although concept of ROCs was similar among militaries, the IDF supports increased capabilities at point of injury and Role 1 including the presence of physicians, but with limited deployment of other ROCs; conversely, the US maintains fewer capabilities at Role 1 but utilized the entire spectrum of care, including extensive deployment of Roles 2/2+, during recent conflicts. Casualties from US forces (n = 19,005) and IDF (n = 2,637) exhibited significant differences in patterns of injury with higher proportions of casualties who died of wounds in the US forces (4%) compared with the IDF (0.6%).

CONCLUSIONS: As these data suggest deployed ROCs and injury patterns of US and Israeli militaries were both conflict and system specific. We envision that identification of discordant factors and common medical strategies of the two militaries will enable strategic readiness for future conflicts as well as foster further collaboration among allied forces with the overarching universal goal of eliminating preventable death on the battlefield. (*J Trauma Acute Care Surg.* 2016;81: S87–S94. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

KEY WORDS: Combat casualty care; Israel Defense Forces; prolonged field care; roles of care; trauma; US Army.

Military medicine worldwide shares a universal objective: to advance combat casualty care (CCC) across the continuum of care and save lives.[1–3] Most systems of care are composed of levels of care with increasing capabilities with the overall objective of triaging, stabilizing, evacuating, and returning the soldier to duty as efficiently as possible. It begins at point of injury (POI) and continues through escalating roles of care (ROCs, formerly known as echelons), as each elevated role provides increased capabilities in terms of personnel, resources, and competencies.

Recent conflicts have provided the impetus to advance CCC in theater, evident by the reduction in the overall case fatality rate from previous wars.[4,5] These medical care improvements are the product of "lessons learned" using systematic examination of evidence-based casualty data acquired throughout the continuum of care.[6] However, although military medicine shares the collective objective of advancing CCC, no work to date has compared ROCs and injury patterns among different militaries for optimal medical management of casualties during combat. Examining different systems of care is now more relevant than ever as the future of CCC may require reappraisal and shift from the standard ROCs to less predictable situations of care and evacuation, such as prolonged field care.[7]

In addition, evaluation of medical experiences gained during recent conflicts and subsequent translation to civilian medicine are extremely timely as emergent data show that the leading cause of death to Americans (<46 years old) is trauma.[8] Accordingly, civilian medicine can benefit from a decade of military research to advance care, especially in cases of preventable trauma-related deaths.[9–14] As eloquently stated by the Committee on Military Trauma Care's Learning Health System and Its Translation to the Civilian Sector, "Improving trauma care will require unprecedented partnership across military and civilian

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sectors and a sustained commitment from trauma system leaders at all levels."[15]

The purpose of this collaborative work is twofold: (1) present ROCs implemented during recent conflicts and postulate whether their deployment affects patient outcome and (2) describe injuries sustained by both US and Israeli militaries in order to expand current knowledge and optimize CCC by supporting wider adaptation of lessons learned in hopes of facilitating strategic readiness for future military engagements.

PATIENTS AND METHODS

A retrospective registry review was performed following institutional regulatory approval with the US Army Institute of Surgical Research US Army Joint Trauma System (JTS) and the Israel Defense Force (IDF) Medical Corps Trauma and Combat Medicine Branch. Data regarding US military were retrieved from the Department of Defense Trauma Registry (DoDTR), which is maintained by the JTS. Data regarding IDF casualties were obtained from the IDF Trauma Registry, which is operated at the Surgeon General's Headquarters, following institutional review board approval of the IDF Medical Corps. The medical data acquisition and collection process of the two militaries were compared.

Roles of Care

In order to compare ROCs between the two military systems, information on the roles of combat care for US forces and IDF was obtained from official guidelines, regulations, and interviews with medical commanders of both armies. Because some variations exist in ROCs between the different US branches (i.e., Army, Air Force, Marines, and Navy), this analysis focused on comparing capabilities between the US Army and the IDF. Special Operations Command medical capabilities for each military were not included in this analysis. Specifically, capability-based ROCs were described and compared in terms of structure, medical staff, lifesaving interventions (LSIs), remote damage control resuscitation, damage control surgery (DCS), imaging capabilities, medical provider type, data collection systems, and evacuation systems of both armies. Evacuation platforms included CASEVAC: tactical evacuation without medical staff; MEDEVAC: tactical evacuation with medical staff; and STRATEVAC: planned, fixed-wing evacuation with medical staff. Lifesaving intervention was defined as a nonsurgical intervention that if not performed immediately would result in loss of life, which includes tourniquet placement (extremity or junctional), intubation, needle thoracocentesis, tube thoracostomy, application of hemostatic dressing, blood product transfusion, and surgical airway protection, as previously described.[16] Remote damage control resuscitation was defined as prehospital administration of blood products, hemostatic medications (e.g., tranexamic acid), and hypotensive resuscitation. Damage control surgery was defined as a surgical intervention that if delayed would result in death or limb loss, which includes, but is not limited to, thoracotomy, fasciotomy, amputation, laparotomy, decompressive craniotomy, or vascular shunt/ligation.

Injury Pattern Analyses

Analyses of battle injuries included all US military (Army, Air Force, Marine Corps, and Navy) injured during Operation Enduring Freedom, Operation Iraqi Freedom, and Operation New Dawn from 2003 to 2014 and Israeli soldiers (Army, Air Force, Navy) injured mostly during large-scale conflicts (e.g., 2006 Lebanon War and Operation Protective Edge) from 2003 to 2014. Nonbattle injuries, civilian casualties, non-American and non-Israeli soldiers, and those killed in action (KIA) were excluded from this analysis. Comparative analyses of the two cohorts included demographics (gender, age, Injury Severity Score [ISS]), wound distribution, mechanism of injury (MOI), and soldiers died of wounds (DOW), which is defined as death after arrival to a medical treatment facility (MTF), as described elsewhere,[5] but unlike previous works did not exclude those casualties who were injured in action and returned to duty within 72 hours. It is important to note that the definition of an MTF for the IDF included battalion aid stations with no requirement for surgical capabilities, whereas for the US Army an MTF was defined as Role 2 and above (i.e., sites with surgical capabilities thus not including battalion aid station), as reported in a previous study by Kotwal et al.[17]

Regional wound distribution was demarcated based on anatomical body region, as previously described,[10,11,18] and grouped into the following regions: (1) head and neck (including cervical spine); (2) face (including nose, mouth, eyes, and ears); (3) thorax (including thoracic spine and diaphragm); (4) abdomen and pelvic contents (including abdominal organs and lumbar spine); (5) extremities (including shoulder and pelvic girdle); and (6) external (skin, including burns). For consistency with previous epidemiologic studies,[10,11,18,19] MOI was grouped into three main categories: (1) explosion (including improvised explosive device, landmine, mortar, shrapnel, bomb, and grenade); (2) gunshot wound (including shrapnel originating from gunshots); and (3) other (including motor vehicle crash, fall and crush, multiple MOIs, and all other battle-associated injuries).

Statistical Analysis

Continuous data were presented as medians and interquartile ranges (IQRs); categorical data were presented as absolute numbers and percentages. Descriptive statistics were performed using *t* test or Wilcoxon-Mann-Whitney test for continuous variables and χ^2 test or Fisher exact test for categorical variable where appropriate. Significance was set at an α (p) < 0.05.

RESULTS

Roles of Care

Similar operational principles in systems of care are used by both militaries as each escalating ROC includes the capabilities of the previous level, plus its increased role-specific capabilities. However, when each ROC was examined and compared independently (Table 1), major differences were found in medical capabilities, particularly at POI/Role 1. Importantly, the US military has recently redefined its ROC designation to fit with that of the North Atlantic Treaty Organization (NATO), moving from five to four levels of care.[20] The main shift was in the definition of Role 4 to include what was previously known as Role 5 hospitals. Therefore, Role 4 is a fixed facility trauma center located in the continental United States (CONUS), and other safe havens.

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TABLE 1. Deployed ROCs in US and Israeli Militaries During Recent Conflicts

	Medical Personnel		Capabilities	
	US Army	**IDF**	**US Army**	**IDF**
POI, company level	Combat medic	FMS (physician/paramedic with two medics)	Tourniquet Fluid Analgesia Basic airway (Limited FWB)	Tourniquet Fluid TXA + FDP Analgesia Advanced airway Chest tube
Role 1, battalion level; battalion aid station	PA/NP Combat medics	2 ALS Providers (at least one physician)	Advanced airway FWB	MV Basic monitoring
Role 2, brigade level; FST	Resuscitation company (80) and a surgical team (20)	Resuscitation company (44) and a surgical team (10)	DCR DCS (two OR tables) MT Basic lab Basic radiology	DCR DCS (one OR table) MT Basic lab Basic radiology
Role 3, combat support hospital	Field hospital (245)	Field hospital (150) Deployed in full-scale war or humanitarian missions	Comprehensive surgery CT Scan Lab/BB	Comprehensive surgery CT Scan Lab/BB
Role 4 (OCONUS), fixed facility trauma center	Trauma center outside CONUS	Does not exist	Full spectrum/surgical care	N/A
Role 4 (CONUS), definitive care	Military hospital All specialties	Civilian hospital All specialties	Long term care/rehab	Long term care/rehab

Numbers in parentheses represent number of medical staff/soldiers.

BB, blood bank; CT, computed tomography; DCR, damage control resuscitation; FDP, freeze-dried plasma; FMS, forward medical squad; FWB, fresh whole blood; MV, mechanical ventilation; NP, nurse practitioner; PA, physician assistant; TXA, tranexamic acid; OCONUS, outside the continental United States; OR, operating room; MT, massive transfusion.

Point of Injury/Role 1

Role 1 is POI care, defined as care rendered by a first responder including self-aid, buddy aid, or a combat medic. At the fighting company level, the US Army maintains combat medics with different sets of skills that are able to perform a variety of LSIs, some of which include application of tourniquets, basic airway treatment, and administration of fluids and pain medications, whereas MEDEVAC personnel are trained to perform advanced airway management and chest tubes. Special Operation Command combat medics may be able to perform additional LSI but were not included in this analysis. At the fighting company level, the IDF maintains advanced life savers (ALSs; physician or paramedic)[21] who are able to provide all treatments given by a medic[22] as well as administer freeze-dried plasma, tranexamic acid, advanced airway management (including intubation), and chest tubes. In addition, units of packed red blood cells are available for use by ALS providers on board helicopters and may be provided by MEDEVAC personnel.[23]

At the battalion level, Role 1 serves as the battalion aid station to triage and initially treat casualties for subsequent evacuation in both forces. The battalion aid station is the forward-most temporary medical facility, typically within the range of enemy attack. The US military rarely has a physician at Role 1, but a licensed independent provider (physician's assistant or nurse practitioner) can provide similar capabilities. The US Army currently supports limited use of a "walking blood bank" concept to support transfusion of fresh whole blood at Role 1. Some MEDEVAC platforms have the capability to provide packed red blood cells or thawed plasma prior to arrival at the Role 2 forward surgical MTF ("Vampire" missions).[24,25] Of note, in the recent conflicts in Iraq and Afghanistan, the US Role 1 capability was not routinely utilized for trauma management because of the ability to evacuate casualties rapidly to definitive surgical care at the Role 2 or Role 3 MTFs. At the Role 1 level, the IDF maintains two to five physicians/ALS providers per battalion (two at the battalion aid station and up to three providers are embedded in the companies). In addition to the capabilities offered at the company level, the IDF maintains the ability to apply mechanical ventilation at Role 1, whereas this capability is rare in the US Army. Basic hemodynamic monitoring at Role 1 is available in both militaries.

Role 2/Role 2+

Role 2 capabilities include basic primary care, whereas Role 2+ capabilities include augmented surgical capability, which is typically provided by the Forward Surgical Teams (FST). The US Army defines Role 2 as an MTF with greater resuscitative capability than Role 1, and unlike NATO, DCS is not mandatory at Role 2. Differences in Role 2/2+ capabilities in the IDF and US Army include number of medical personnel in FST (10 vs. 20), operating capabilities (one vs. two operating tables), size of the mobile MTF (500 vs. 1,000 ft^2), and the extent of holding capabilities (24 vs. 72 hours), respectively. The concepts of damage control resuscitation and DCS are similar for both

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medical systems; however (similar to NATO), definition of Role 2 in the IDF includes DCS, whereas in the US Army DCS is available only at Role 2+. The Role 2 is 100% mobile, and the FST has been deployed extensively by the US forces during recent conflicts. In contrast, because of the proximity of civilian medical facilities, the IDF rarely deploys its Role2/2+, aside from humanitarian missions or full-scale war. In 2013, the IDF deployed a single Role 2+ facility for supporting a humanitarian aid mission to Syrian refugees near the Syrian-Israeli border.[21,26,27]

Roles III

Role 3 MTF is a combat support hospital capable of providing care to all categories of patients that is designed for holding causalities for a fixed length of time, which is typically up to 72 hours but will vary depending on the theater evacuation policy.[28] In both armies, an important exception to the evacuation policy during the more recent conflicts is the prolonged hospitalization of local nationals who could not be evacuated to host nation facilities because of the type or severity of their injuries (e.g., extensive burns). In the IDF, Role 3 has been deployed in times of full-scale war and humanitarian missions.[29]

Role 4

In the US Army, Role 4 MTFs are defined as hospitals located in CONUS and other designated safe havens (the "communication zone"). During recent conflicts, the US military used Landstuhl Regional Medical Center in Germany as a Role 4 MTF; this fixed facility provided the full spectrum of medical care for US combat casualties until transport to CONUS military hospitals could be facilitated. Role 4 facilities in CONUS were the Walter Reed National Medical Center, the San Antonio Military Medical Center, or the Naval Medical Center San Diego. By comparison, the IDF does not operate military hospitals, but instead relies on the civilian health system, which includes Levels I and II civilian trauma hospitals in Israel's major cities, because of the proximity of the battlefield to Israel's borders and to civilian medical facilities.

En Route Care

Of primary importance when contrasting the evacuation systems in the US forces and IDF is the understanding that IDF casualties are primarily mobilized within, or from the vicinity of, Israel's borders with rapid evacuation times to definitive care civilian trauma centers (Role 4), whereas evacuation of US casualties from POI requires medical support capabilities across multiple platforms (Roles 1–4) and locations. Despite that, the median time from POI to MTF was 70 minutes (IQR, 40–180 minutes) for the US forces and 87 minutes (IQR, 35–120 minutes) for the IDF (Table 2). It is important to note that in this context MTF in the US Army included Roles 2 and 3, whereas in the IDF "time to MTF" reflects evacuation directly to Role 4.

In terms of medical evacuation capabilities, the IDF uses identical medical teams for all ground (one physician and three medics) and aerial (two physicians/physician + paramedic and three medics) platforms, whereas the US military uses various configurations of medical personnel for each evacuation platform across ROCs. Again, the geographic challenges faced by the US forces required escalating capabilities across the continuum of care for global evacuation, as well as the size of the force at hand and the availability of physicians. Generally, a flight paramedic or combat medic is the highest level of provider through Role 2 evacuation; a critical care en-route nurse (registered nurse) may augment MEDEVAC from Role 2 to Role 3. Physicians are not routinely part of evacuation teams until STRATEVAC, where a physician, critical care registered nurse, and medic team transport patients from Role 3 to Role 4. In addition, STRATEVAC was routinely used by US military and rarely used by the IDF.

TABLE 2. Demographics of Combat Casualties in US Forces and IDF

2003–2014	US Forces	IDF	*p*
No. of patients	19,005	2,637	—
Male, n (%)	18,660 (98.2)	2,563 (97.2)	0.0005
Age, mean (SD)	25.8 (6.1)	22.0 (5.7)	<0.0001
Time from POI to MTF, median (IQR), min	70 (40–180)	87 (35–120)	—
DOW, n (%)	762 (4.0)	15 (0.6)	<0.0001

χ^2 And Wilcoxon-Mann-Whitney tests were used to compare (number and not percent) differences between US forces and IDF.
—, Statistical test was not performed.

Medical Data Acquisition Process

The data acquisition process in US military is fragmented and varies at the different ROCs with numerous registries that are typically difficult to query.[30] The JTS manages the DoDTR, which includes much of the same type of data as the IDF Trauma Registry for the IDF for casualties treated in theater and who arrived at an MTF. Data collection at, or close to, POI (Roles 1–2) was rarely performed in US military during the early years of the conflict, but in 2008, the Role 2 registry was developed. The Role 2 registry is a stand-alone database that is populated by clinical personnel who have not received training to abstract data, which leads to heterogeneity in data entries and missing information.[31] Unlike Role 2, the Role 3 data are entered into the registry by trained abstractors deployed into theater, which yield data that are more comprehensive and accurate. Nonetheless, all medical data entered into the JTS registry are validated by JTS personnel using available source documentation. Although rich in data, the JTS does not manage KIA data, as these data are collected and maintained by the Armed Forces Medical Examiner System.

In the IDF, the data sources obtained by the ITR include casualty cards filled by caregivers at POI. The casualty cards collect data that depict the following: vital signs, type of treatment given, type of ALS provider, demographics, MOI, and anatomic distribution of injuries.[21] Upon arrival at civilian hospitals, complementary data are obtained by trained IDF medical corps personnel through questioning staff and patients, interviewing evacuation teams, and the deployed ALS provider who treated the patient at POI. In this manner, all casualty data obtained from POI to MTF that is provided by military medical personnel is immediately uploaded to the ITR and is available for retrieval by Trauma and Combat Medicine Branch personnel. However, because the IDF does not hold dedicated military hospitals, data collected at the civilian hospital are released and uploaded

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manually to the ITR only after patient discharge, which typically delays considerably the availability of data.

The discrepancies in data acquisition between the two militaries were best exemplified when we attempted to collect LSI data. In the US military, data on LSI were not available from POI/Role 1 but only from the Role 2 registry, with a large amount of missing data. Conversely, early documentation of data from POI/Role 1 by the IDF facilitated the collection of all LSI data (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A819).

Study Populations

Examination of battle-related injuries for the period of 2003 to 2014 included 19,005 US service members and 2,637 IDF service members (Table 2). Of those US forces and IDF cohorts, casualties were predominantly male (98.2% and 97.2%) with a median (IQR) age of 24 years (IQR, 21–28 years) and 21 years (IQR, 19–22 years). More importantly, there was significantly higher percentage of casualties DOW in the US forces as compared with the IDF ($p < 0.0001$).

Wound Distribution

Injury severity score was similar in the IDF and US military. Evaluation of wound distribution of "all injuries" revealed that in both militaries "external" injuries (e.g., burns, skin lacerations, etc.) were the most frequent followed by injuries to the extremities and head and neck body regions (Table 3). However, injuries to the head and neck, face, and abdomen and pelvic regions were significantly more abundant in the IDF compared with the US forces ($p < 0.0001$). In contrast, injuries to the extremities were significantly more prevalent among US casualties compared with the IDF ($p = 0.0001$). There was no statistical difference in the average number of wounds per casualty.

Evaluation of critically injured patients (ISS ≥25) revealed different distributions of injuries. Specifically, external injuries were less prevalent in the critically injured as compared with "all injuries" in both US military and the IDF; instead, injuries were distributed more evenly among other body regions with a large increase in injuries to the "thorax" and "abdomen and pelvic" regions (Table 3). Importantly, the total wounds per casualty also increased dramatically (from 2.3 to 3.6 and from 2.2 to 3.5 in the US forces and the IDF, respectively), which logically follows as those that were critically injured had sustained more injuries overall.

Mechanism of Injury

In both cohorts, the majority of casualties sustained injuries because of explosion followed by gunshot wounds (Table 4). However, significant differences were found between the two cohorts as explosion accounted for 76.8% of injuries in the US forces compared with 40% of injuries in the IDF ($p < 0.0001$). Conversely, significantly more gunshot wounds accounted for injuries in the IDF (28.7%) compared with injuries in US military (18.5%) ($p < 0.0001$). Prevalent injuries in "other" MOI included motor vehicle collision, blunt trauma, or two or more MOIs, which were significantly more frequent in the IDF (31.3%), as compared with those of US military (4.7%) ($p < 0.0001$). Evaluation of critically injured patients did not change the distribution of MOIs.

DISCUSSION

Combat casualty care is markedly different from prehospital care that is rendered in the civilian sector. The tactical environment with its austere conditions should be taken into consideration when providing care on the battlefield.[1,32] The fact that injury pattern is dependent on the type of warfare, the deployed ROCs, the MOI, and the efficiency of the protective gear used, as well as the difficulty in the collection of casualty medical data considerably, limits our ability to advance CCC across the continuum of care.[33] Nevertheless, as new conflicts emerge, military medical organizations must evolve and adapt in order to face the ever-changing battlefield. This joint effort is the first to compare large-scale data among different military forces engaged in diverse types of asymmetric warfare.

In this study, comparison of ROCs implemented during recent US and Israeli conflicts revealed significant differences in capabilities and medical personnel. In 2012, the IDF medical corps initiated a 10-year strategic buildup plan coined as "My Brother's Keeper."[34] Inspired by the low case fatality rate reported by NATO, in this plan, the IDF set a goal of eliminating preventable deaths and improving the medical system as a whole.[34–36] In an attempt to increase survival rates, the IDF supports increased capabilities at POI compared with the US military because of the fact that the majority of deaths occur at (or close to) POI. Although no definitive conclusions can be made, the presence of a physician with advanced medical capabilities (advanced

TABLE 3. Distribution of Wounds by Anatomical Region in US Forces and IDF Casualties

	All Injuries			ISS ≥25		
	US Forces, n = 19,005	IDF, n = 2,637	*p*	US Forces, n = 1,960 (10.3%)	IDF, n = 208 (7.9%)	*p*
ISS, mean (SD)	10.1 (11.1)	10.5 (10.4)	0.13	35.6 (12.2)	36.0 (12.6)	0.66
Head and neck, n (%)	8,103 (18.7)	953 (16.2)	<0.0001	1,255 (17.8)	127 (17.4)	0.83
Face, n (%)	4,708 (10.9)	471 (8.0)	<0.0001	842 (11.9)	82 (11.3)	0.60
Thorax, n (%)	2,792 (6.4)	416 (7.1)	0.06	1,041 (14.7)	112 (15.4)	0.64
Abdomen and pelvic, n (%)	3,536 (8.2)	293 (5.0)	0.0001	1,061 (15.0)	112 (15.3)	0.79
Extremities, n (%)	9,098 (21.0)	1,632 (27.8)	0.0001	1,226 (17.4)	123 (16.9)	0.76
External, n (%)	15,093 (34.8)	2,103 (35.8)	0.71	1,641 (23.2)	172 (23.6)	0.81
Total wounds (per casualty)	43,330 (2.3)	5,868 (2.2)	—	7,066 (3.6)	728 (3.5)	—

χ^2 Test was used to compare anatomical wound distribution between US forces and IDF. Percent wound distribution was calculated based on the total of injuries per body region to the total number of wounds. Casualties KIA were excluded from this analysis.

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TABLE 4. Mechanism of Injury in US Forces and IDF

	MOI, All			MOI, ISS ≥ 25		
	US Forces, n = 19,005	IDF, n = 2,637	*p*	US Forces, n = 1,960 (10.3%)	IDF, n = 208 (7.9%)	*p*
Explosion, n (%)	14,592 (76.8)	1,054 (40)	<0.0001	1,490 (76.0)	78 (37.5)	0.0001
Gunshot wound, n (%)	3,512 (18.5)	758 (28.7)	<0.0001	413 (18.5)	62 (29.8)	0.005
Other, n (%)	901 (4.7)	825 (31.3)	<0.0001	57 (2.9)	68 (32.7)	0.0001

χ^2 Test was used to compare MOI between US forces and IDF for both MOIs. Casualties KIA were excluded from this analysis.

airway, chest tube, TXA, and FDP) in the IDF may potentially translate to improved short and long-term patient outcomes.[37] Due to missing data in both the US far forward roles of care as well patient outcome in the IDF cohort, this hypothesis is not presented here but should be further tested by evaluating patient outcome among the two military systems.

A comparison of evacuation time between militaries revealed a longer median time to MTF in the IDF (87 minutes) compared with the US military (70 minutes). Although this may seem contradictory at first because of Israel's short evacuation distances, a plausible explanation lies with the differences in MTFs; specifically, in the US military, "time to MTF" was primarily derived from POI to Roles 2 and 3. In contrast, in the IDF, the majority of casualties were evacuated to Role 4 facilities, because of the proximity of battlefield to civilian centers. Although a comparison of time to treatment by an ALS provider was not performed (not available in the DoDTR), it is most likely shorter for the IDF, where physicians and paramedics are deployed to the frontlines.

Prehospital data collection for the establishment of a prehospital registry has been the goal of military organizations in recent years, but remains a challenge.[38–40] Data collection, analysis, and evidence-based adjustments to clinical practice guidelines are fundamental steps in reaching this goal.[41] By comparing the two data collection systems, we have uncovered important strengths and weaknesses of each military system. Specifically, while the IDF focuses on POI/Role 1 data collection, the US military has only fragmented data of early point of care with the recent development and adaptation of the Role 2 registry (see Table, Supplemental Digital Content 1, http://links.lww.com/TA/A819). However, because of the dedicated military MTF in the US military, Roles 3 and 4 casualty data (including rehabilitation data) are an integral part of the trauma registry, whereas in the IDF, data acquired at civilian hospitals are uploaded manually to the ITR after a considerable delay (following patient's discharge).

Data acquisition and analysis followed by implementation of lessons learned while performing constant reappraisal constitute a fundamental working concept, which allows for timely, ongoing improvements that can be achieved by necessary adaptation of the CCC system. Gathering high-quality data from POI to rehabilitation and constructing a dedicated trauma registry serve as the basis for these fundamental improvement processes. It is our opinion that acquisition of data is the first and perhaps the most important aspect of translating evidence-based medicine to lives saved in both military and civilian sectors.

A comparison of injury severity revealed similar ISS in US military and the IDF. Interestingly, significantly fewer soldiers DOW in the IDF compared with the US military ($p < 0.0001$), a fact that may be also attributed to adequate treatment early after injury (at POI), or because of the different MOIs (e.g., greater proportion of gunshot wounds in IDF). Another factor that may explain why fewer casualties DOW lies with its definition; namely, DOW are soldiers who died after arriving to an MTF. Yet, although, by definition, an MTF in the IDF system includes Role 1, IDF casualties primarily arrive at definitive care hospitals (Role 4), which offer the entire spectrum of care. Therefore, whereas DOW in US forces provides a measure of field triage and care rendered at Roles 2 to 3,[18] DOW in the IDF more closely represents deaths treated at Role 4 that were most likely not potentially preventable.[37] Perhaps the fact that the IDF maintains ALS providers at the frontlines may also contribute to the lower DOW in the IDF compared with the US military. For example, the presence of ALS providers at POI/Role 1 in the IDF allows for an early declaration of death, which increases the KIA rates while reducing the proportion of casualties who DOW, as well as minimizes the risk for unnecessary evacuation. It is important to note, however, that the speculative opinions made by the authors regarding DOW rates necessitate appropriate methodological analysis for drawing a firm conclusion. For example, early advanced treatment at POI may potentially lower the rate of KIA by delaying the death of the more severely injured, which could translate into higher DOW rates.

Analysis of injuries by body region showed similar wound distribution in both militaries as external injuries were the most frequent, followed by extremities, head and neck, and face (Table 2). While the number of wounds per patients was similar among militaries, significant differences were found in all injured body regions ($p < 0.0001$) except for thoracic ($p = 0.06$) and external injuries. Interestingly, the IDF injury signature is somewhat similar to injuries sustained in low-intensity conflicts of previous years during the second Palestinian uprising as reported by Lakstein et al.,[42] where the predominant injured body regions were the head, face, and neck (54.2%) followed by the limbs (50.0%). This fact, along with the similar distribution of wounds in both armies, may suggest that current armor system may warrant further scrutiny and improvement.[10,36,43] This supposition is further supported by the fact that the proportion of injuries to the "thorax" and "abdomen and pelvic" body regions dramatically increased in patients who were critically injured (Table 3). For this purpose, as part of the "My Brother's Keeper" plan, the IDF is focusing on the development of more efficient personal body armor with special attention to junctional body regions (i.e., neck, armpit, groin), as well as a durable, lightweight, bulletproof helmet,[34] as lethal brain injuries are regarded as nonpreventable deaths.[44]

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Analysis of MOI revealed that in both cohorts the majority of casualties sustained injuries due to explosion followed by gunshot wounds (Table 4). However, a significantly higher proportion of injuries were sustained because of explosion in the US cohort compared with the IDF (76.8% vs. 40%, respectively, $p < 0.0001$). Conversely, significantly higher proportion of gunshot wounds accounted for injuries in the IDF compared with injuries in US military (28.7% vs. 18.5%, respectively, $p < 0.0001$). Finally, injuries classified as "other" (which include motor vehicle crash, fall and crash, multiple MOIs, smoke inhalation, and other battle-associated injuries) were significantly more frequent in the IDF compared with US military (31.3% vs. 4.7%, respectively, $p < 0.0001$). One factor that may contribute to the higher rates of injuries classified as "other" is the need of IDF soldiers to pacify violent disturbances. This varying MOI distribution between the two militaries points to a different type of warfare, which requires further evaluation that may contribute to future mission planning. For example, it is the authors' opinion that higher rates of gunshot wounds in IDF are due to the limited mission episodes in Israel, such as the Second Lebanon War (2006), Operation Cast Lead (2008–2009), and Operation Protective Edge (2014) lasting 34, 22, and 50 days, respectively. These recent conflicts were characterized by massive field maneuvers leading to close encounters with enemy forces and higher a proportion of gunshot wounds.

Our study has some important limitations. The first limitation concerns the retrospective nature of the study. The second limitation concerns the challenge of data collection from the battlefield during combat situations that leads to missing data, especially for US military data acquired at Role 2. Documentation at POI/Role 1 is limited in the US military but is much more comprehensive in the IDF.[26] Another challenge is the different definition of an MTF; in the IDF, Role 1 constitutes an MTF, whereas in the US military, the previous definition of an MTF described by Holcomb et al.,[5] which included Role 1, was recently updated by Kotwal et al.[17] to include surgical capabilities, which are offered only at Roles 2+. Moreover, the extended period of this study (2003–2014) introduces various unknown confounders that limit this comparative analysis. For example, standard definitions, ROC designations and capabilities, weaponry, tactics, armor systems, and the diverse theaters of operations have evolved dramatically throughout this study period. Another limitation exists with the analysis of data using ISS, which provides only an abstract of the dataset (three most severely injured body regions) and does not portray the entire injury pattern. In addition, because of the fact that DoDTR does not contain KIA data, the injury mechanism is missing for casualties who were KIA. Finally, because of inherent problems with the registries as outlined previously, our %DOW analysis differs in its standard definition from previous reports in that it does not exclude casualties who returned to duty from casualties who were wounded in action (WIA); that is, in our analysis, $\%\text{DOW} = \frac{\text{DOW}}{\text{WIA}} \times 100\%$, where WIA includes casualties who returned to duty within 72 hours; for fair comparison, however, the same analysis was performed for both militaries.

CONCLUSIONS

As these data suggest, combat is dynamic, and injury patterns are both conflict and system specific, evident by the significant differences in MOI and wound distribution among the two forces. Therefore, identifying discordant factors between the two forces and fostering collaboration with other militaries enable strategic preparation for future conflicts with the overarching goal of eliminating preventable death on the battlefield. Future collaborative studies should be carried out to examine casualty outcomes of the two systems, as well as different trauma systems to allow for iterative learning.

AUTHORSHIP

B.A. and A.B. equally contributed to the study design, data collection, analysis and interpretation, writing, and critical revisions. E.A.M.-S. and T.D.L. contributed to the study design, US data collection, analysis and interpretation, writing, and critical revisions. L.C.C., J.C.W., H.P., and K.R.G. provided data interpretation and critical revisions. E.G. contributed to the study design, data analysis and interpretation, writing, and critical revisions.

DISCLOSURE

The authors declare no conflicts of interest.

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The Military Injury Severity Score (mISS): A better predictor of combat mortality than Injury Severity Score (ISS)

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BACKGROUND: The Military Injury Severity Score (mISS) was developed to better predict mortality in complex combat injuries but has yet to be validated.

METHODS: US combat trauma data from Afghanistan and Iraq from January 1, 2003, to December 31, 2014, from the US Department of Defense Trauma Registry (DoDTR) were analyzed. Military ISS, a variation of the ISS, was calculated and compared with standard ISS scores. Receiver operating characteristic curve, area under the curve, and Hosmer-Lemeshow statistics were used to discriminate and calibrate between mISS and ISS. Wilcoxon-Mann-Whitney, *t* test and χ^2 tests were used, and sensitivity and specificity calculated. Logistic regression was used to calculate the likelihood of mortality associated with levels of mISS and ISS overall.

RESULTS: Thirty thousand three hundred sixty-four patients were analyzed. Most were male (96.8%). Median age was 24 years (interquartile range [IQR], 21–29 years). Battle injuries comprised 65.3%. Penetrating (39.5%) and blunt (54.2%) injury types and explosion (51%) and gunshot wound (15%) mechanisms predominated. Overall mortality was 6.0%.

Median mISS and ISS were similar in survivors (5 [IQR, 2–10] vs. 5 [IQR, 2–10]) but different in nonsurvivors, 30 (IQR, 16–75) versus 24 (IQR, 9–23), respectively ($p < 0.0001$). Military ISS and ISS were discordant in 17.6% (n = 5,352), accounting for 56.2% (n = 1,016) of deaths. Among cases with discordant severity scores, the median difference between mISS and ISS was 9 (IQR, 7–16); range, 1 to 59. Military ISS and ISS shared 78% variability ($R^2 = 0.78$).

Area under the curve was higher in mISS than in ISS overall (0.82 vs. 0.79), for battle injury (0.79 vs. 0.76), non–battle injury (0.87 vs. 0.86), penetrating (0.81 vs. 0.77), blunt (0.77 vs. 0.75), explosion (0.81 vs. 0.78), and gunshot (0.79 vs. 0.73), all $p < 0.0001$. Higher mISS and ISS were associated with higher mortality. Compared with ISS, mISS had higher sensitivity (81.2 vs. 63.9) and slightly lower specificity (80.2 vs. 85.7).

CONCLUSION: Military ISS predicts combat mortality better than does ISS. (*J Trauma Acute Care Surg.* 2016;81: 114–121. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic and epidemiologic study, level III.

KEY WORDS: Combat mortality; mAIS; Military Abbreviated Injury Scale; Military Injury Severity Score; mISS.

Since it was introduced by Baker et al.[1] in 1974, the Injury Severity Score (ISS) has become the most commonly used anatomic scoring method for determining injury severity,[2] predicting mortality and morbidity,[3] and as a tool for research and other applications (e.g., quality assurance).[1,4] The ISS is defined as the sum of the squares of the highest Abbreviated Injury Scale (AIS) scores in each of the three most severely injured body regions (BRs).[1] The six BRs that are defined in the AIS are the head/neck; face; thorax; abdomen and pelvic contents; extremities, shoulder, and pelvic girdle; and external and burn.

In the civilian population, the most common cause of injury death is motor vehicle traffic-related incidents,[5,6] and civilian trauma tends to involve less complex injury patterns. Conversely, combat-related injuries, which are frequently caused by destructive explosions (e.g., improvised explosive devices) and other high-energy weapons of modern warfare, tend be more complex and involve multiple BRs (polytrauma).[6–11] Because the ISS relies on only the most severe injury in each BR, it may underestimate the true severity of injury among complex military trauma, both among and within BRs. Furthermore, the AIS and ISS are inadequate for describing penetrating injuries,[6,12] which are frequently sustained in combat.[6] The performance of the ISS in predicting the mortality of patients with blunt trauma is also limited as shown in the systematic review by Tohira et al.,[13] in which the New Injury Severity Score (NISS) was found to be superior to the ISS. Despite these limitations, the ISS is the most commonly used scoring system globally to quantify injury severity in both civilian and military trauma.[14,15] To attempt to overcome limitations of the ISS, an expert panel of military trauma surgeons developed the Abbreviated Injury Severity Scale 2005–Military (mAIS).[16] Since 2005, the mAIS has been used to calculate the Military Injury Severity Score (mISS). The mISS takes complex and multiple injuries into account, whereas ISS does not. However, the mISS has not been validated in the combat trauma populations for which it was designed.

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The objectives of this study were to (1) examine the discrepancies between military and civilian injury severity scoring systems using anatomic injury scales (mAIS vs. AIS) and injury scores (mISS vs. ISS), (2) discriminate between the two injury severity scoring systems, and (3) determine whether the mISS is a superior injury severity scoring system for defining injury severity to compare treatment effects and injury outcomes (e.g., mortality) for combat trauma research and to inform trauma care process improvement. We hypothesized that the mAIS and mISS would be superior to the AIS/ISS in characterizing injury severity and predicting mortality in the combat-injured population.

PATIENTS AND METHODS

Patient Population

This performance improvement evaluation project was led by the Joint Trauma System at the US Army Institute of Surgical Research, Joint Base San Antonio–Fort Sam Houston, Texas. Data were extracted from the US Department of Defense Trauma Registry (DoDTR, identified as the Joint Theater Trauma Registry) prior to October 2012 and described previously.[17–19] The study population was US service members with trauma sustained in the Iraq or Afghanistan theaters of operation from January 1, 2003, through December 31, 2014. Retrospective data for a total of 31,033 patients were reviewed. The final study population was composed of 30,364 patients who met all four of the following inclusion criteria: (1) had both mISS and ISS scores, (2) had arrival and discharge data, (3) had complete casualty classification data (battle injury [BI] and non–battle injury [NBI]), and (4) had information about the type and mechanism of injury. Excluded patients (n = 669; 2.2%) did not have (1) documented mISS and/or ISS (n = 118), (2) discharge status (n = 169), or (3) BI and/or NBI data (n = 382) (Fig. 1).

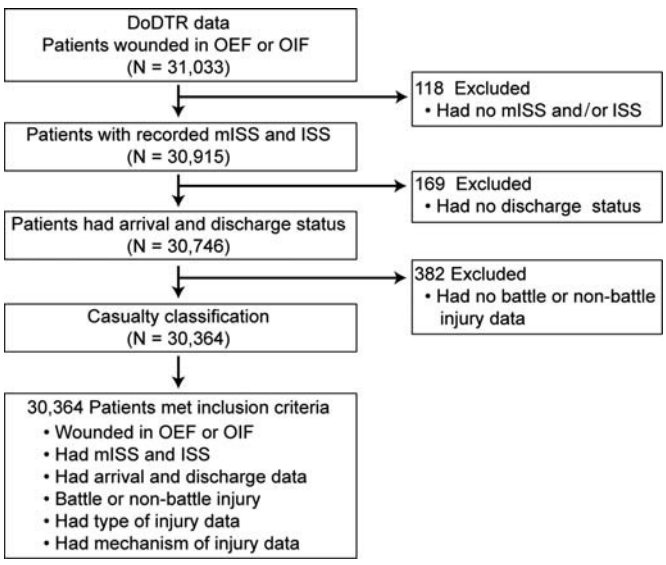

Figure 1. Study population and inclusion criteria. A total of 31,033 patients who were all US service members and wounded in Iraq (OIF) or Afghanistan (Operation Enduring Freedom) were recorded in the DoDTR. Of them, 30,364 patients met inclusion criteria for this study.

Study Definitions

The ISS, an anatomically based ordinal scale developed by Baker et al.[1] in 1974, incorporates the sum of the squares of the three most severe AIS scores from among six different BRs: head/neck (BR1), face (BR2), thorax (BR3), abdomen and pelvic contents (BR4), extremities and shoulder and pelvic girdles (BR5), and external and burn (BR6): The AIS level of severity is graded using a scale from 1 to 6 (1 = minor, 2 = moderate, 3 = serious, 4 = severe, 5 = critical, 6 = maximal/currently untreatable). Calculated ISS ranges from 1 to 75. The ISS in this analysis was constructed by using the AIS 2005 criteria modified in 2005 and updated in 2008 (AIS). The mISS, a variation of the ISS developed in 2005 by an expert panel of military trauma surgeons, is calculated as the sum of the squares of the three most severe AIS 2005–Military criteria and updated in 2008 (mAIS).[6,16] Severity in the mAIS is graded using the same scale from 1 to 6 as is used for the AIS, and mISS is also scored from 1 to 75; however, the severity scales are different between the civilian and military injury severity system (Supplementary Table 1 and Supplementary Table 2, Supplemental Digital Content 1, http://links.lww.com/TA/A746).

Discrepancies between mISS and civilian ISS were defined as dissimilar AIS values and dissimilar ISS values between the two injury scoring systems (military vs. civilian). Both the mISS and ISS values were grouped into four categories as mild (scored 1–9), moderate (10–15), severe (16–24), and critical (≥25).[20] Discordance in injury severity level was defined as differences in injury severity categories between the two injury scoring systems as shown in Figure 2*B*. Casualty classifications were categorized as battle injury (BI) and non-battle injury (NBI). Battle injury was defined as any injury that occurred because of battle-related activities or hostile action, including travel to and from the activities, as well as any injury caused by improvised explosive devices and/or mortars. Non–battle injury was defined as any injury not directly attributable to hostile action or terrorist activity and unintentional and/or self-inflicted injuries. The primary outcome was mortality defined as combat-related death that occurred prehospital or in-hospital, including killed in action (KIA), dead on arrival (DOA) at a medical treatment facility (MTF), and died of wounds (DOW).

Statistical Analysis

The values of mISS and ISS were extracted directly from the DoDTR data set and calculated using the AIS 2005–Military criteria and updated in 2008 (mAIS) for mISS and AIS 2005 criteria and updated in 2008 (AIS) for ISS. The patients were divided into two groups: those who died prehospital or in-hospital (nonsurvivors) and those who were alive at discharge from Role 2 or a higher level of care (survivors). The predictive performance of the mISS was compared with the ISS with mortality as the primary outcome. Analysis was first done on all patients, then by (1) subpopulations according to injury classification (BI or NBI), (2) by dominant injury type (penetrating or blunt), and (3) by dominant injury mechanism (explosion or gunshot wounds [GSWs]). The severity levels of mISS and ISS, categorized as mild (1–9), moderate (10–15), severe (16–24), and critical (≥25), were used to evaluate different associations with the likelihood of mortality between the two injury severity scoring systems. To compare sensitivity and specificity for predicting risk

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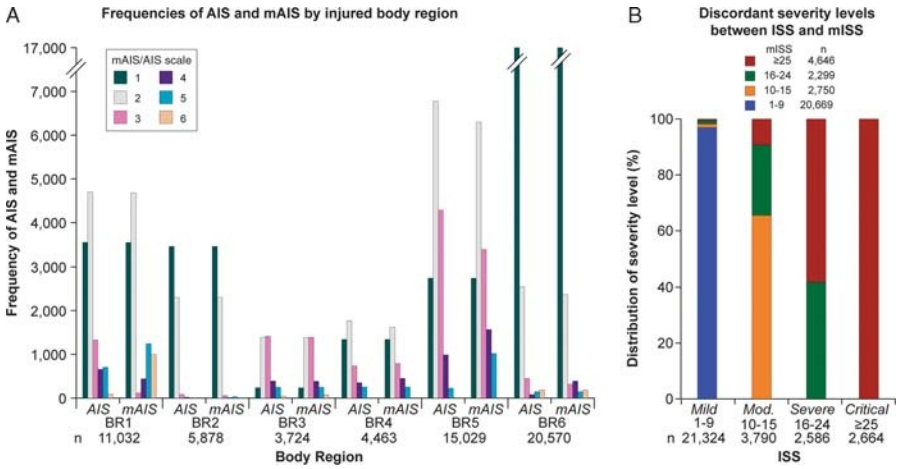

Figure 2. Discrepancies between the military and civilian injury scoring systems (mAIS vs. AIS and mISS vs. ISS) in 30,364 combat-related patients. (*A*) Different frequencies of the AIS by injured BR between the AIS 2005–Military criteria (mAIS) and the Civilian AIS 2005 criteria (AIS). Greek numerals 1 to 6 represent six scales of the mAIS and AIS, with 1 = minor to 6 = maximal/currently untreatable. In this panel, 10% (n = 6,055) injuries had dissimilar AIS values, and most of these dissimilar values occurred in BR1 (I) and BR5 (V). (*B*) Discordant injury severity levels categorized as mild (1–9), moderate (10–15), severe (16–24), and critical (≥25 or 25–75) between the mISS and the civilian Injury Severity Score (ISS). The numbers of injuries (n) in each BR or injury severity levels are shown.

of mortality, the mISS and ISS values were dichotomized as less than 16 or 16 or greater (defined as severe injury).[21]

Descriptive statistics were performed using χ^2 or Fisher exact test for categorical variables and Wilcoxon-Mann-Whitney or *t* test for continuous variables where appropriate. The receiver operating characteristic (ROC) curve generated using univariate logistic regression was used to discriminate between mISS and ISS as predictors of combat-related mortality in the overall population and in subpopulations. The area under the ROC curve (AUC), which was used as an index of accuracy[22] and the probability of correctly identifying the outcome of interest (e.g., mortality), was tested. The Hosmer-Lemeshow (H-L) goodness-of-fit test was used for calibration of the model between the mISS and ISS.[22–24] The Akaike information criterion (AIC) was also used to compare the model of best fit. Sensitivity (the proportion of true positives) and specificity (the proportion of true negatives) were used to quantify the overall reliability and usefulness of mISS and ISS.

To determine whether mISS is a better predictor of mortality, logistic regression was used to estimate the likelihood (odds ratio [OR]) of mortality associated with mISS and ISS level among those who arrived at the MTF alive (n = 29,425). Covariates that influenced the likelihood of mortality were determined using univariate logistic regression (Supplementary Table 3, Supplemental Digital Content 1, http://links.lww.com/TA/A746); specifically, each of the covariates found to be significantly associated with mortality in individual univariate (i.e., unadjusted) models was then included in the multivariate (adjusted) models. These covariates included gender, race/ethnicity, branch of service, casualty classification, theater of operation, year of injury, and physiologic parameters upon arrival at the MTF (e.g., pulse rate, respiratory rate, systolic blood pressure [SBP], and Glasgow Coma Scale [GCS]), as well as primary mechanism and type of injury.

Although missing rates for physiologic variables at arrival were small, 4.6% (pulse rate) to 11.8% (GCS) (Supplementary Table 4, Supplemental Digital Content 1, http://links.lww.com/TA/A746), they were not missing at random, which has been shown to contribute to bias in studies of outcomes such as mortality. In our study, higher mortality rates were found among those with missing data versus those with data available: 18.9% vs. 2.2% for the pulse variable, 25.8% vs. 1.7% for the SBP variable, 19.8% vs. 0.9% for the respiratory variable; and 5.2% vs. 2.7% for the GCS variable, all $p < 0.0001$ (Supplementary Table 2, Supplemental Digital Content 1, http://links.lww.com/TA/A746). Hence, the multiple imputation method recommended by Moore et al[25] may not be reliable.[26,27] Furthermore, sensitivity analysis, which is recommended for missing data not at random, is also not reliable because in our study patients with complete data for all vital signs had lower mortality rate than did those with incomplete data, 0.8% versus 12.0% respectively, $p < 0.0001$ (Supplementary Table 2, Supplemental Digital Content 1, http://links.lww.com/TA/A746). Therefore, to address the possibility of confounding due to missing data, we chose the simple approach of adjusting for them in the multivariate models by including them as a separate "missing" category.

Statistical significance was determined at the $p < 0.05$ level. Statistical analyses were performed using SAS, version 9.4 (SAS Institute Inc., Cary, NC).

RESULTS

Study Population

For this study, we evaluated data from the DoDTR for 30,364 service members wounded in the Afghanistan (Operation Enduring Freedom) or Iraq (Operation Iraqi Freedom [OIF]) theaters of operation. A description of the study population is presented in Table 1. The majority of patients in this data set were from OIF (63.0%). Most of the patients were male (96.8%) with a median age of 24 years (interquartile range [IQR], 21–29 years). Among patients with data available for race/ethnicity, white was predominant (38.9%); however, for

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TABLE 1. Characteristics of the Patients and Their Combat-Related Injuries

Variable	All	Nonsurvivors	Survivors	*p*
No. of patients, n (%)	30,364	1,807 (6.0)	28,557 (94.0)	
Theater of operation, n (%)				<0.0001
Afghanistan	11,246 (37.0)	604 (33.4)	10,642 (37.3)	
Iraq	19,118 (63.0)	1,203 (66.6)	17,915 (62.7)	
Gender, n (%)				0.0005
Male	29,383 (96.8)	1,774 (98.2)	27,609 (96.7)	
Female	981 (3.2)	33 (1.8)	948 (3.3)	
Age at injury, median (IQR), y	24 (21–29)	24 (21–29)	24 (21–29)	0.15
Race/ethnicity, n (%)				<0.0001
White	11,809 (38.9)	885 (49.0)	10,924 (38.2)	
Black	1,764 (5.8)	116 (6.4)	1,648 (5.8)	
Hispanic	893 (2.9)	33 (1.8)	860 (3.0)	
Other/unknown	15,898 (52.4)	773 (42.8)	15,125 (53.0)	
Branch of service, n (%)				0.0002
US Army	22,480 (74.0)	1,358 (75.1)	21,122 (74.0)	
US Air Force	824 (2.7)	32 (1.8)	792 (2.8)	
US Marine Corps	6,237 (20.5)	391 (21.6)	5,846 (20.4)	
US Navy	823 (2.7)	26 (1.4)	797 (2.8)	
Casualty classification, n (%)				<0.0001
BI	19,840 (65.3)	1,597 (88.4)	18,243 (63.9)	
NBI	10,524 (34.7)	210 (11.6)	10,314 (36.1)	
Primary mechanism of injury, n (%)				<0.0001
Explosion	15,414 (50.8)	1,127 (62.4)	14,287 (50.0)	
Gunshot wounds	4,447 (14.6)	475 (26.3)	3,972 (13.9)	
Vehicle crash	2,196 (7.2)	82 (4.5)	2,114 (7.4)	
Helicopter/plane crash	267 (0.9)	38 (2.1)	229 (0.8)	
Other/unknown	8,040 (26.5)	85 (4.7)	7,955 (27.9)	
Dominant BR (BR), n (%)				
Head/neck (BR1)	11,030 (36.3)	803 (44.4)	10,227 (35.8)	<0.0001
Face (BR2)	5,878 (19.4)	204 (11.3)	5,674 (19.9)	<0.0001
Thorax (BR3)	3,724 (12.3)	343 (19.0)	3,381 (11.4)	<0.0001
Abdomen (BR4)	4,463 (14.7)	300 (16.6)	4,163 (11.6)	0.02
Extremities (BR5)	15,029 (49.5)	533 (29.5)	14,496 (50.8)	<0.0001
External (BR6)	20,570 (67.7)	1,101 (60.9)	19,469 (68.2)	<0.0001
Primary type of injury, n (%)				<0.0001
Penetrating	11,986 (39.5)	1,224 (67.7)	10,762 (37.7)	
Blunt	16,471 (54.2)	448 (24.8)	16,023 (56.1)	
Burn	998 (3.3)	88 (4.9)	910 (3.2)	
Other/unknown	909 (3.0)	47 (2.6)	862 (3.0)	
ISS, median (IQR)				
Civilian (ISS)	5.0 (2.0–10.0)	24 (9–33)	5 (2–10)	<0.0001
Military (mISS)	5.0 (2.0–13.0)	30 (16–75)	5 (2–10)	<0.0001

The *p* values were calculated with the use of a χ^3, *t* test, or Wilcoxon-Mann-Whitney test as appropriate.

more than half of the study population (53.0%), this variable was categorized as "other/missing." Battle-related injuries accounted for 65.3% of total casualties. The most common mechanisms of injury were explosion (50.8%) and GSWs (14.6%) (Table 1). The leading injury types were blunt (54.2%) and penetrating (39.5%). The most common injured BRs were external and burn (67.7%), extremities (49.5%), and head/neck (36.3%) (Table 1). The median mISS and ISS were 5 (IQR, 2–13) and 5 (IQR, 2–10) overall, 5 (IQR, 2–10) and 5 (IQR, 2–10) among survivors, and 30 (IQR, 16–75) and 24 (IQR, 9–33) in nonsurvivors, respectively (Table 1). Overall mortality in this cohort, including KIA, dead on arrival at an MTF, and died of wounds, was 6.0% (n = 1,807) (Table 1).

Discrepancies Between the Military and Civilian Injury Scoring Systems

Dissimilar values between the two abbreviated injury scale systems, mAIS and AIS, are shown in Figure 2*A* and Supplementary Figure 1, *A–D* (Supplemental Digital Content 1, http://links.lww.com/TA/A746). A total of 60,668 AIS measures,

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defined as the maximum severe injury score for each BR, were captured from the entire cohort. Compared with the AIS, 10.0% (n = 6,055) of mAIS values were discrepant, including 8.2% with a mAIS score that was one level of severity higher than the AIS score, for example, AIS = 1 (mild) and mAIS = 2 (moderate), and 1.8% with a score two levels of severity higher (Supplementary Figure 1*A*, Supplemental Digital Content 1, http://links.lww.com/TA/A746). Most of these mAIS and AIS differences occurred in BR I (head/neck) and BR V (extremities/pelvic and shoulder girdle), 23.4% and 17.5%, respectively (Supplementary Figure 1*B*, Supplemental Digital Content 1, http://links.lww.com/TA/A746). Within BR I, 13.9% (n = 1,528) of mAIS scores were one level of severity higher, and 9.5% (n = 1,048) were two levels higher. Within BR V, 17.3% (n = 2,600) of mAIS scores were one level of severity higher, and 0.2% (n = 26) were two levels higher. Among the remaining BRs, within BR IV (abdomen/pelvic contents), 5.7% (n = 253) of mAIS scores were one level of severity higher than ISS, whereas the rest of the BRs had only small changes ranging from 0.5% to 2.7% (Supplementary Figure 1*C*, Supplemental Digital Content 1, http://links.lww.com/TA/A746). These incremental mAIS changes resulted in increases in the anatomic injury severity. Compared with civilian AIS at the critical (AIS = 5) and "untreatable" levels (AIS = 6), strikingly in BR I, the proportion of patients with mAIS at the critical level was 4.9% higher (11.3% [n = 1,245]) vs. 6.4% [n = 705]), and the proportion of patients at the "untreatable" level was 8.3% higher (9.1% [n = 1,002] vs. 0.8% [n = 90]). In BR V, the proportion with severity at the critical level (severity = 5) was 5.3% greater for mAIS versus civilian AIS (6.8% [n = 1,020] vs. 1.5% [n = 229], respectively). Smaller changes in mAIS were observed in the remaining BRs (Figure 2*A* and Supplementary Figure 1*D*, Supplemental Digital Content 1, http://links.lww.com/TA/A746).

Discrepancy Between mISS and ISS Severity Levels

The mISS and ISS shared 78% variability (R^2 = 0.78). Overall, 17.6% (n = 5,352) of patients showed discordant severity scores between mISS and ISS with the median difference between the mISS and ISS of 9 (IQR, 7–16); range, 1 to 59.

Within the category of ISS scores from 1 to 9 (mild), 3.1% (n = 655) had discordant mISS severity scores, including 1.3% with mISS of 10 to 15 (moderate), 1.2% with mISS of 16 to 24 (severe), and 0.6% with mISS of 25 or greater (critical). Within the ISS category of scores from 10 to 15, 34.5% (n = 3,795) had discordant severity scores in mISS, including 25.2% with mISS of 16 to 24, and 9.3% with mISS of 25 or greater. Among patients with ISS severity scores of 16 to 24, 58.2% (n = 2,586) had discordant severity scores classified by mISS as 25 or greater. All patients with ISS of 25 or greater were categorized in mISS within the critical severity level (≥25) (Fig. 2*B*). Patients within the critical severity level (≥25) of mISS included 2.7% with mild ISS scores (1–9), 7.6% with moderate ISS scores (10–15), 32.4% with severe ISS scores (16–24), and 57.3% with critical ISS scores (≥25) (Supplementary Figure 2*A*, Supplemental Digital Content 1, http://links.lww.com/TA/A746).

ROC for Mortality: Comparison Between mISS and ISS

The overall mortality rate was 6.0% (n = 1,807) (Table 1). A total of 82.4% (n = 25,012) of patients had similar mISS and ISS scores, accounting for 43.8% (n = 791) of all deaths, with a mortality rate of 3.2%. However, 17.6% (n = 5,352) of patients had discordant mISS and ISS scores, accounting for the remaining 56.2% (n = 1,016) of all deaths, with a mortality rate of 19.8%. Compared with the concordance of mISS versus ISS, discordance of mISS versus ISS was associated with higher mortality (Supplementary Figure 2*B*, Supplemental Digital Content 1, http://links.lww.com/TA/A746).

Figure 3 illustrates that the AUC was significantly higher for mISS than for ISS overall (0.82 vs. 0.79) (Fig. 3, *A* and *B*), by casualty classification: BI (0.79 vs. 0.76) and NBI (0.87 vs. 0.86), by type of injury: penetrating (0.81 vs. 0.77) and blunt (0.77 vs. 0.75), and by mechanism of injury: explosion (0.81 vs. 0.78) and GSWs (0.79 vs. 0.73), all $p < 0.001$ (Fig. 3*B*). Overall and for each subpopulation, the mISS had an AUC value that was 1.0% to 6.0% higher than the corresponding ISS. Using mISS or ISS of 16 or greater as an indicator of severe injury,

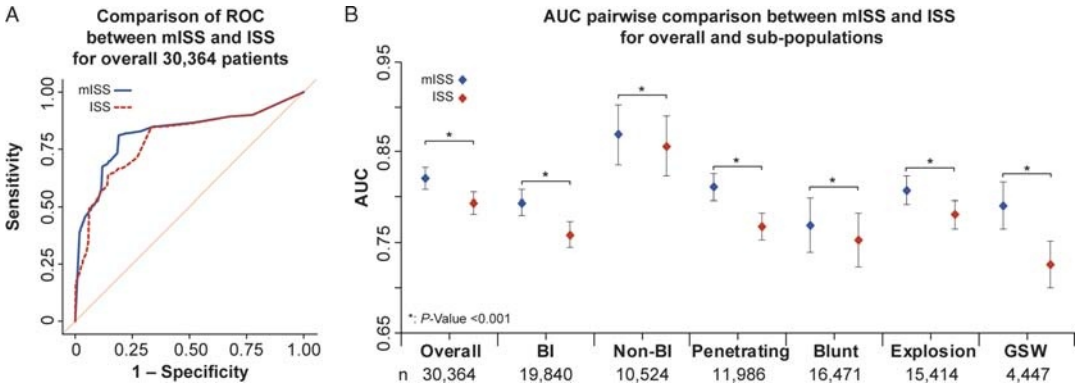

Figure 3. Receiver operating characteristic curve for mortality comparison between mISS and ISS. (*A*) A comparison of ROC between mISS and ISS for mortality in the overall patient population (n = 30,364). Overall AUCs for mISS and ISS are shown. (*B*) AUC pairwise comparisons between mISS and ISS for overall and subpopulations, regarding casualty classification (BI vs. NBI), type of injury (penetrating vs. blunt), and mechanism of injury (explosion vs. GSWs). The number of patients in each subpopulations and *p* values are shown.

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compared with ISS, overall mISS had a higher sensitivity (81.2 vs. 63.9) and slightly lower specificity (80.2 vs. 85.7).

The mISS as a Predictor of Combat-Related Mortality

Individuals with ISS (mISS and ISS) of 1 to 9 (mild) were used as the reference group in all models. Results are shown in Table 2. In the univariate analyses, among all those who arrived at an MTF alive (n = 29,425), both mISS and ISS severity levels were directly associated with a higher risk of mortality, and with the exception of mISS of 10 to 15 versus 1 to 9, the risk increased with increasing level of severity in all models, all $p < 0.0001$.

In multivariate models adjusted for possible confounding factors identified in the univariate analysis, compared with the mild severity level (1–9) in the mISS system, incrementally higher mISS injury levels were also independently associated with a higher likelihood of mortality by approximately 4-fold (OR, 3.66; 95% confidence interval [CI], 2.04–6.57), approximately 10-fold (OR, 10.48; 95% CI, 6.87–15.99), and 24-fold (OR, 24.16; 95% CI, 16.80–34.74) for moderate (10–15), severe (16–24), and critical (≥25), respectively. Similarly in the ISS system, incrementally higher ISS severity levels were also associated with a higher likelihood of mortality by approximately 5-fold (OR, 4.77; 95% CI, 3.16–7.20), approximately 7-fold (OR, 6.87; 95% CI, 4.67–10.09), and 18-fold (OR, 18.01; 95% CI, 12.66–25.60) for moderate (10–15), severe (16–24), and critical (≥25), respectively.

The AIC, a measure of the relative quality of a statistical model, showed the mISS system was better than the ISS system in both the univariate models (6,078 vs. 6,200) and the multivariate models (3,136 vs. 3,210) (Table 2). The H-L goodness-of-fit test used for calibration of the model also showed that the mISS system was better, especially in the multivariate models (10.46 [$p = 0.23$] vs. 15.08 [$p = 0.06$]) (Table 2).

DISCUSSION

In modern warfare, injuries are often caused by destructive explosions and other high-energy weapons and tend to be complex and involve multiple BRs. Conversely, injuries in the civilian population, which most often occur as a result of blunt and motor vehicle traffic-related incidents and falls, tend to involve fewer BRs. The AIS 2005–Military was developed as an adaptation of AIS 2005 in recognition of the differences in the epidemiology, nature and severity of military-associated wounds compared with civilian injuries.[16] However, the military injury scoring systems (mAIS and mISS) have not been implemented and institutionalized in the routine analysis of combat casualty care data. Our study validates the AIS 2005–Military, as proposed in 2010 as applied to the military population in the DoDTR, as a predictor of mortality in combat casualties. The mISS calculated using the AIS 2005–Military takes complex and multiple injuries within a single BR into account, whereas ISS does not address these important differences.

In the current study, the AIS 2005–Military was used to score more than 30,000 casualties with injuries incurred in theaters of operations. There are three main findings in this study. First, there are major anatomic severity scale (AIS) discrepancies between mISS and ISS, especially in BR I (head/neck, 23.4%) and BR V (extremities/shoulder and pelvic girdle, 17.5%). The mISS takes complex and multiple injuries into account, whereas ISS underestimates injury severity,[28] especially in BRs I and V.

Second, results of the ROC analysis confirmed that mISS has better discriminative ability than ISS for the prediction of mortality. Both better discrimination and goodness of fit of the models with mISS versus ISS were observed overall and within all of the subpopulations assessed: by casualty classification (BI vs. NBI), type of injury (penetrating vs. blunt), and mechanisms of injury (explosion vs. GSW). Specifically, greater discrimination for mISS versus ISS was observed for BI (0.79 vs. 0.76), penetrating (0.81 vs. 0.77), and GSWs (0.79 vs. 0.73), and lesser discrimination was found in the remaining subpopulations, especially for NBI (0.87 vs. 0.86).

Third, the results in this study indicate that the mISS is a more accurate predictor of combat-related mortality than ISS. The greater accuracy of the mISS in predicting mortality may lead to a better approach to quantify injury severity and patterns associated with mortality. This in turn may facilitate

TABLE 2. Likelihood of Mortality in Combat-Related Patients by Injury Severity Level Among Those Who Arrived at a Medical Treatment Facility Alive (n = 29,425)

	mISS				ISS			
	Univariate		Multivariate*		Univariate		Multivariate*	
	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*	OR (95% CI)	*p*
Severity level**								
10–15	1.27 (0.80–2.02)	0.32	3.66 (2.04–6.57)	<0.0001	2.24 (1.70–2.95)	<0.0001	4.77 (3.16–7.20)	<0.0001
16–24	8.82 (6.80–11.45)	<0.0001	10.48 (6.87–15.99)	<0.0001	6.78 (5.41–8.49)	<0.0001	6.87 (4.67–10.09)	<0.0001
≥25	29.34 (24.11–5.71)	<0.0001	24.16 (16.80–34.74)	<0.0001	30.56 (25.59–36.48)	<0.0001	18.01 (12.66–25.60)	<0.0001
Model fit								
AIC	6,078		3,136		6,200		3,210	
H-L goodness-of-fit test	<0.001	0.99	10.46	0.23	<0.001	0.99	15.08	0.06

*All multivariate models were adjusted for gender, race/ethnicity, military rank, branch of service, casualty classification, theaters of operation, and physiologic parameters upon arrival at the MTF, including pulse rate, respiratory rate, SBP, and GCS, as well as the primary mechanism and type of injury.

**Injury severity level: the mISS and ISS values were grouped into four categories as mild (scored 1–9), moderate (10–15), severe (16–24), and critical (≥25). The category of mild (1–9) was used as a reference group.

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performance improvement aimed at reducing mortality and morbidity in the military combat trauma population by providing more appropriate interventions.

This study assessed AIS 2005–Military for mortality only. Civilian AIS has also been validated as a predictor of morbidity and length of stay.[29–33] AIS 2005–Military, however, has not been assessed for these outcomes. In order to validate mISS for morbidity in our study population, further queries of the DoDTR will be needed to obtain the necessary data. With regard to length of stay, comparison of military and civilian findings will be challenging. In the military trauma care setting, the movement of patients across levels of care from theater to stateside and through multiple treatment facilities will impact length of stay differently than transfers from one facility to another in the civilian setting.

Our study has some limitations. First, because the DoDTR relies primarily on abstraction of medical records, not all casualties were included. In particular, KIAs could be missing from the data set. This may have contributed to the lower overall mortality rate in our study (6%) compared with that published in a Department of Defense report (10%).[34] Because, KIAs are among the most severely injured individuals with very complex injury patterns, their exclusion suggests that our findings that mISS is superior to ISS in characterizing the severity of more complex injuries are likely conservative. Second, we had some missing data, especially for physiologic variables measured at arrival (Supplementary Table 2, Supplemental Digital Content 1, http://links.lww.com/TA/A746). However, because the rates of missing data were low, and we adjusted for missing values in the multivariate statistical models, missing data likely did not greatly impact our findings. Third, the differences in AUCs between mISS and ISS, although statistically significant, were marginally different, indicating that the mISS may have limited prognostic and clinical advantages. Fourth, compared with ISS, a slightly lower specificity in mISS was observed; however, the overall benefit of higher sensitivity of mISS (fewer missed mortality cases/false negative) outweighs the lower specificity (slightly greater number of false positives) in predicting mortality. Finally, because the data were not available, we were unable to compare the mISS with the New Injury Severity Score. Future studies should also compare the mISS to this measure.

Our study provides important information validating the usefulness of the mISS for assessing injury severity among combat wounded. These findings indicate that development of the AIS 2005–Military represents a successful effort to further improve injury severity scoring for combat-related injury. Thus, the mISS would be a more effective tool than ISS for use in a research to evaluate outcomes of interest in combat casualty care (e.g., mortality, length of hospital stay, and complications). Our results suggest that even for NBI AIS 2005–Military was a better measure of severity. The next step in evaluating the ability of mISS to characterize more complex injury patterns will involve applying it to a population of civilian casualties to determine if it is also a better measure of injury severity for noncombat injuries.

CONCLUSIONS

The present study validates the superiority of the mISS over the civilian-derived ISS in providing better discriminatory ability to predict mortality in the military trauma population overall and within subpopulations with regard to injury classification, injury type, and mechanisms of injury.

AUTHORSHIP

T.D.L. and K.R.G. conceived of the study and designed the project. T.D.L. performed data analysis. J.A.O., Z.T.S., M.A.S., E.A.M-S., K.K.C., and K. R.G. oversaw the project and provided epidemiologic and clinical context. S.A.W. and M.A.S. obtained data for analysis. T.D.L. and K.R.G. drafted the manuscript, to which all authors have contributed to critical revision. All authors reviewed the manuscript.

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DISCLOSURE

The authors declare no conflicts of interest.
The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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EDITORIAL CRITIQUE

Le et al seek to confirm the validity of the Abbreviated Injury Score-Military 2008 (mAIS) and its associated Military Injury Severity Score (mISS) as compared to the standard AIS and ISS. Through a retrospective analysis of the DoD Trauma Registry, they examine over 30,000 U.S. service members wounded from 2003 to 2014. They demonstrate a significant discordance between the military and civilian scoring systems in non-survivors and effectively show that the mAIS and mISS are better predictors of mortality.

The mAIS was created in 2005 when a consensus panel of military surgeons adapted the Association for the Advancement of Automated Medicine's AIS by modifying 356 codes related to military trauma. For each injury, the severity code was adjusted to reflect multiple or complex injury patterns within a given body region. The mAIS was then validated with DoD casualty data and the single Maximum mAIS score was noted to be a stronger mortality indicator compared to the Maximum AIS score.

Interestingly, while the mISS has not been examined prior to this study, the deficiencies of the ISS in this population have been repeatedly described. The New Injury Severity Score (NISS) has the capacity to account for multiple injuries within a single region and may more accurately predict mortality in both blunt trauma and penetrating trauma. Since multiple or complex wounding within a body region was a principal reason for development of the mAIS, the NISS calculation may be more appropriate for assessing the overall injury burden in combat trauma. Likewise, a novel Military Combat Injury Score that is more predictive than either NISS or Maximum mAIS was introduced several years ago. How does the mISS compare to these other scores?

Finally, AIS 2015 will incorporate many of these combat and blast-related codes into its dictionary. With intentional mass casualty events occurring with increasing frequency in the civilian setting, lines between civilian and military injuries are less clear. Perhaps we need an inclusive score, rather than creating a separate military one?

Again, congratulations to COL Gross and colleagues at the Joint Trauma System on another informative study examining the unique characteristics of our combat wounded.

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Evaluation of role 2 (R2) medical resources in the Afghanistan combat theater: Initial review of the joint trauma system R2 registry

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BACKGROUND: A Role 2 registry (R2R) was developed in 2008 by the US Joint Trauma System (JTS). The purpose of this project was to undertake a preliminary review of the R2R to understand combat trauma epidemiology and related interventions at these facilities to guide training and optimal use of forward surgical capability in the future.

METHODS: A retrospective review of available JTS R2R records; the registry is a convenience sample entered voluntarily by members of the R2 units. Patients were classified according to basic demographics, affiliation, region where treatment was provided, mechanism of injury, type of injury, time and method of transport from point of injury (POI) to R2 facility, interventions at R2, and survival. Analysis included trauma patients aged ≥18 years or older wounded in year 2008 to 2014, and treated in Afghanistan.

RESULTS: A total of 15,404 patients wounded and treated in R2 were included in the R2R from February 2008 to September 2014; 12,849 patients met inclusion criteria. The predominant patient affiliations included US Forces, 4,676 (36.4%); Afghan Forces, 4,549 (35.4%); and Afghan civilians, 2,178 (17.0%). Overall, battle injuries predominated (9,792 [76.2%]). Type of injury included penetrating, 7,665 (59.7%); blunt, 4,026 (31.3%); and other, 633 (4.9%). Primary mechanism of injury included explosion, 5,320 (41.4%); gunshot wounds, 3,082 (24.0%); and crash, 1,209 (9.4%). Of 12,849 patients who arrived at R2, 167 (1.3%) were dead; of 12,682 patients who were alive upon arrival, 342 (2.7%) died at R2.

CONCLUSION: This evaluation of the R2R describes the patient profiles of and common injuries treated in a sample of R2 facilities in Afghanistan. Ongoing and detailed analysis of R2R information may provide evidence-based guidance to military planners and medical leaders to best prepare teams and allocate R2 resources in future operations. Given the limitations of the data set, conclusions must be interpreted in context of other available data and analyses, not in isolation. (*J Trauma Acute Care Surg.* 2016;81: S121–S127. Copyright © 2016 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiologic study, level IV.

KEY WORDS: Combat; trauma; forward surgical care; joint trauma system; role 2.

There has yet to be a comprehensive review of the impact of Role 2 (R2) medical resources in the combat theater. Although R2 registry (R2R) was established by the Joint Trauma System (JTS) in 2008, no systematic evaluation for these data has been reported. Analysis may provide military planners and medical leaders with information to support optimal team training and optimum allocation of R2 resources in future operations.

Combat casualty care occurs across a continuum within the US military evacuation system:

1) on-scene care ("point of injury", Role 1);
2) fixed or mobile facilities for immediate surgical stabilization and resuscitation (R2);
3) full-spectrum theater trauma care (Role 3 [R3]);
4) trauma care provided at fixed facilities outside of the United States (Role 4); and finally.
5) definitive care hospitals in the United States.

The North Atlantic Treaty Organization (NATO) defines R2 as a trauma unit with resuscitative capability that will routinely provide damage control surgery.[1]

While data are available documenting the operational impact of individual R2 elements,[2] no systematic and comprehensive evaluation of R2 use has been reported. Such analysis is further complicated by the existence of a variety of R2 elements available to each service, unit, country, and operational requirement. Each US Service has R2 for damage control surgery and resuscitation: US Army Forward Surgical Team, US Marine Corps Forward Resuscitative Surgical System, US Navy Fleet Surgical Teams and Expeditionary Resuscitative Surgical Systems, and US Air Force Surgical Team. Our NATO partners also have this same capability. For example, the United Kingdom (UK) has an R2 surgical team that can support damage control surgery in addition to resuscitative capability. Role 2s can be independently located on a forward operating base. Role 2s of any US Service can be collocated with the medical companies of a

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US Army brigade support battalion, a US Air Force mobile aeromedical staging facility, or a US Navy shock trauma platoon. Definitions of NATO from the Allied Joint Medical Support Doctrine (AJP-4.10A) clarify light maneuver and enhanced R2 elements.[1]

An R2 element is a medical capability that augments or enhances other assets by providing lifesaving surgical interventions and damage control resuscitation; however, R2 teams lack the capability for extended postoperative support, generally not intended to hold patients beyond 72 hours.[3] For example, most R2 units in Afghanistan were army forward surgical teams; teams were often "split" to support two geographic regions (Fig. 1). The basic US Marine Corps R2 (Forward Resuscitative Surgery System [FRSS]) contains only a single surgical table and less than half the personnel of an Army R2.

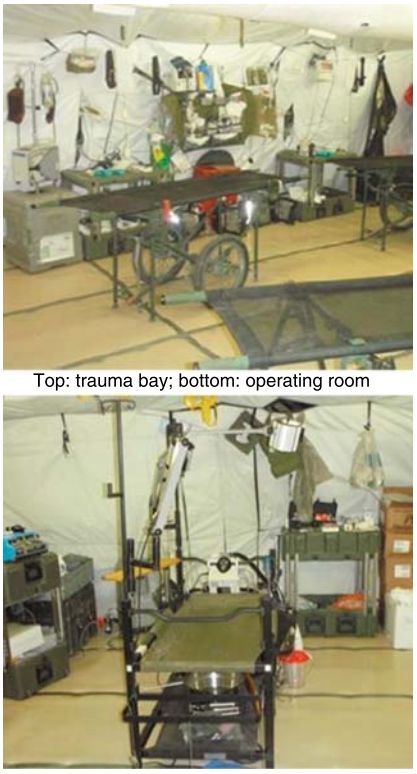
Although the Department of Defense Trauma Registry (DoDTR) does contain R2 casualties, initially, inclusion was limited until 2014 to casualties evacuated to and treated at a R3. Until the R2R was established in 2008, it is unknown how much of the medical care provided before R3 admission was fully captured; despite its implementation as a voluntary reporting system, it remains unknown what percentage of R2 workload has actually been captured by the R2R, but presumably, it captures more return-to-duty and R2 deaths than the DoDTR had previously. A number of published reports document the activities and performance of R2 elements during either Operation Enduring Freedom (OEF, 2001 to present) or Operation Iraqi Freedom (OIF, 2003 to 2011) before 2008. During OEF, most reports involved Army forward surgical teams with limited numbers of trauma casualties;[4–7] one report from a Naval surgical team described 46 combat-related casualties.[8] The most informative report included 761 patients with detailed patient type, mechanism of injury or disease, location of injury, severity scores, and surgical procedures performed.[9] Subsequent reports with fewer patients provided information on blood usage and associated outcomes,[10,11] and various R2 experiences without specific patient data.[12–18] Operation Iraqi Freedom and Operation New Dawn (OND) reports of R2 experiences were dominated by the experiences of the Navy's forward resuscitative surgical teams[19–24] with only two Army R2 experiences;[25,26] the OIF reports were before 2008. In summary, these published reports provide insufficient comprehensive information concerning the patients, injuries, and clinical interventions associated with R2 facilities. The purpose of this project was to describe the initial review of available R2R data as a first step toward understanding R2 use to support future deployment of forward surgical capabilities.

PATIENTS AND METHODS

A retrospective review of the JTS R2R was conducted following institutional regulatory approval.

Role 2 Registry Description

The R2R is a stand-alone Microsoft Access database that has remained unlinked to the larger DoDTR because it has not been fully verified against source patient medical records. This registry contains a convenience sample of patients treated at R2 facilities since 2008 at levels of medical care that previously did not have full trauma registry capabilities (trained and


Top: trauma bay; bottom: operating room

US Army Forward Surgical Team (FST)

72 hour continuous operations
- 2 Operating room (OR) tables; 10 cases/24 hours
- 4 Trauma beds; 4 recovery/intensive care beds
- Post-operative care; 8 patients (4 ventilated)/6 hours

Life-saving procedures
- Damage control surgery (DCS)
- Damage control resuscitation (DCR)
- General surgery
- Orthopedic stabilization

20-person team*
- 1 Orthopedic/3 General Surgeons
- 2 Nurse Anesthetists
- 3 Nurses: Emergency/Critical Care/Surgical
- 11 Technicians/Administrative Personnel

Supporting Medical Company
- X-ray, laboratory, Personnel, life support

*Teams may be "split" to support 2 geographic areas

Figure 1. US Army R2 Forward Surgical Team.

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dedicated trauma registrars). Members of R2 teams received basic training on the database once deployed and entered data on a voluntary basis; R2 personnel did not receive formal data management training before deployment. When available, source documentation was used to validate and complete the R2R data entry by trained data abstractors at the JTS located at the US Army Institute of Surgical Research, San Antonio, TX; however, less than 10% of the R2R records have been thus verified. The R2R includes prehospital data: mechanism of injury (explosion, gunshot wound, crash, other), type of injury (blunt, penetrating, burn, other), protective equipment, location within Regional Command, mode of transport, time from point of injury to R2 facility, and prehospital interventions and some vital signs (systolic blood pressure, diastolic blood pressure, respiratory rate, temperature, pulse, O_2 saturation, Glasgow Coma Scale, etc). R2-related data elements include arrival and discharge: patient status (alive or deceased), time, vital signs, and some laboratory results. Diagnosis, interventions, blood administration, and some complications are also included.

Study Methods

Deidentified data in the R2R were retrospectively reviewed for patients who received treatment at R2 facilities and met the following inclusion criteria: 1) adult patients (defined as age 18 year or older at the time of injury); 2) injured in Afghanistan during OEF; 3) trauma eligible, defined as battle injury and nonbattle injury; and 4) injured between February 2008 and September 2014. Patients who did not meet trauma-eligible criteria (e.g., isolated disease, or psychological or mental illness/disorder) were excluded.

Variables for analysis included age in years at time of injury, sex, Regional Command location, prehospital emergency care and en route care provided, time from point of wounding to R2, arrival status (dead/alive), diagnosis, and discharge status (dead/alive). Time to arrival at R2 was further categorized to reflect the 2009 "Golden Hour directive" by time equal to or less or greater than 60 minutes, as well as time before and after June 15, 2009.[27] To control for significant variability in arrival times, time to R2 within 160 minutes (75th percentile) was selected for comparison of pre- and post-Golden Hour times overall and by patient's affiliation.

Statistical Analysis

Descriptive statistics were used to compare the study groups of interest. Casualties were categorized according to their affiliation as [1] US-Force (US Army, US Air Force, US Marine Corps, and US Navy), [2] US other (US civilian and contractors), [3] NATO coalition, [4] Afghan forces (Afghan military and Afghan police), [5] Afghan civilians, and [6] other (non-NATO coalition, non-US civilian, combatant, and other). Regional distribution was categorized by Regional Command (RC)-North, South, Southwest, West, and East. Mechanism of injury was categorized as [1] explosion, [2] gunshot wounded (GSW), [3] motor vehicle crash (MVC), [4] explosion-GSW, [5] explosion-MVC, [6] explosion-helicopter/plane crash, and [7] other. Type of injury was defined as penetrating and nonpenetrating (blunt, penetrating, burn, other) injury. Chi-square or Fisher exact test, Student *t*-test or Mann-Whitney test, ANOVA, or Kruskal-Wallis test was used where appropriate.

RESULTS

A total of 15,404 patients were included in the R2R from February 2008 to September 2014; 12,849 patients (83%) met inclusion criteria (Fig. 2). Data availability included 100% demographic information, 33% en-route documentation, 99% diagnosis, and 98% mechanism of injury. Regional Command (RC) distribution was RC-East, 8,636 (67%); RC-South, 1,987 (16%); RC-Southwest, 1,158 (9%); RC-West, 894 (7%); and RC-North, 174 (1%).

Demographic and injury characteristics by affiliation are shown in Table 1, major patients' affiliations were US Force (36.4%) and Afghan Force (35.4%) followed by Afghan civilian (17%). Most patients were male (96.7%) with median age (interquartile range) of 25 (21–30) years. Battle injury was predominant (76.2%; Table 1 and Fig. 3). Overall, annual recorded casualties increased from year 2008 to the peak in 2011 then delined in number of both battle injury and nonbatlle injury casualties (Fig. 3).

Mechanisms of injury are described in Figure 4, which demonstrated complex trauma injuries. The most common mechanisms of injuries were explosion (41%), gunshot wounds (24%), and more than two causes of injuries (e.g., explosion and GSW or explosion and MVC) was 4.4% (Table 1 and Fig. 4). Penetrating injury was predominant (52.3%), followed by blunt injury (31.3%); 7.4% of the patients sustained both penetrating and blunt injury (Table 1 and Fig. 4). Overall median (interquartile range) arrival time was 75 (41–160) minutes, time varied among group affiliation ($p < 0.0001$); time from injury until arrival to a R2 facility was less than 60 minutes for 43% of patients (Table 1). Of patients transported to R2 within 160 minutes (75th percentile), time was reduced overall after the Golden Hour initiatve ($p = 0.02$). When compared by group affiliation, time after the initiave was consistently reduced for all groups except the US Force ($p = 0.28$). Dead upon R2 arrival was 1.3% (n = 167), and death on R2 discharge was 2.7% (342 of the 12,682 patients alive upon R2 arrival).

The R2R contains the following data for future analysis: 33.2% (n = 4,266) of patients had 10,802 documented prehospital interventions; 13.4% (n = 1,724) of patients had tourniquets; 15.6% (n = 2,036) of patients had 69,023 prehospital medications; and 52.1% (n = 6,697) of patients had 34,639 procedures performed at R2.

DISCUSSION

Although a dedicated R2R has been in place since 2008, no systematic evaluation of the data has been conducted. This analysis demonstrated variability based on group affiliation with regard to mechanism and type of injury, transport time, prehospital interventions, and death while at R2 facility. Without analysis of this information, military planners and medical leaders will be unable to best allocate R2 resources in future operations.

The best use of R2 assets within a developed theater of war remain undefined. In 2009, the Secretary of Defense mandated a trauma system capable of delivering casualties to surgical capability within 1 hour.[27] This resulted in a redistribution of medical evacuation (MEDEVAC) and surgical capabilities

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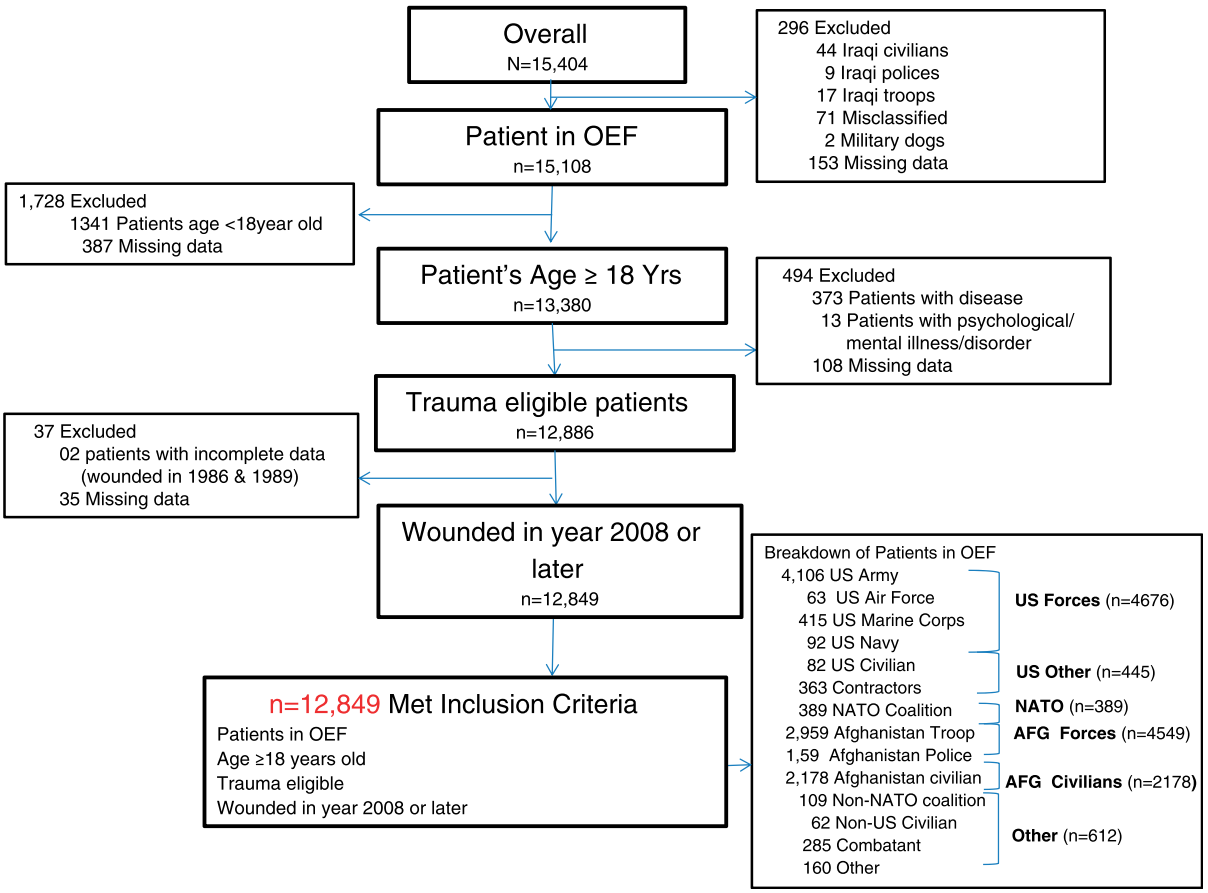

Figure 2. Included patients.

in theater, "splitting" of forward surgical teams, and automatic triage to the closest facility. While the mandate has been shown to have saved lives on the battlefield,[28] it is also important to consider historical civilian trauma experience that demonstrates that transporting severely injured patients to the closest facility is not always optimal, and direct transport to higher levels of care may improve outcomes.[29] Certainly, specifics of injury, time, distance, MEDEVAC, and R2 and R3 capabilities will affect outcomes within the trauma system. It is important that the evolution of the trauma system take into account such specific variables. A detailed analysis of R2 outcomes vis a vis capabilities will help provide evidence to inform further development of a deployed trauma system.

Because admission to a R3 facility was required for inclusion in the DoDTR until 2014, completeness of the R2R is unclear. Any patient treated at an R2 who did not subsequently transfer to a R3 hospital was not captured in the DoDTR until 2014. The DoDTR therefore excluded a significant number of patients treated at R2, including host nation casualties who were transferred directly to host nation facilities, patients returned to duty, and patients who died at the R2. Limited data directly reflecting the R2 experience is contained in the R2 database, albeit a convenience sample with almost no verification of accuracy. Additional exploration of both registries is required to identify patterns of missing informaiton and imporve capture of all patients treated at every role of care.

In addition to the JTS R2R, other sources of information exist that could be used to further characterize activities of R2 elements. The most extensive combat registry is the US DoDTR. This is the largest combat injury database in existence; it includes all services injury data derived from records with scoring of injuries, diagnoses and procedures, and patient outcomes. As of December 2015, there are 130,888 records that represent 79,795 unique patients (JTS, unpublished data, December 2015). Specialty modules and additional data sources include prehospital care, infectious diseases, blood transfusion, tactical evacuation times, ocular injury, outcomes, traumatic brain injury, acoustic injury, and en route care. The Armed Forces Medical Examiner Registry has information on all deaths in the combat theater and could inform analysis of died-of-wounds cases at R2 compared to R3. The US Navy and NATO allies (e.g., United Kingdom Joint Theater Trauma Registry) maintained robust registries, and the US Theater Medical Data Store contains source documentation of combat medical care. Unit and provider records are additional sources of valuable information regarding R2 treatment, particularly before the R2R development in 2008. Efforts are underway to incorporate all potential sources of R2 data into a comprehensive research data set.

Limitations to the JTS R2R include lack of data before the Registry implementation in 2008 and the voluntary nature of participation by R2 personnel to enter data. The members of the R2 teams did not receive the same level of training as

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TABLE 1. Demographic and Injury Characteristics of Patients in Study Data Set by Patient Affiliation

	Overall	US Force	US Other	NATO	AFG Force	AFG Civilian	Other	*p* Value
Number of patients, n (%)	12,849	4,676 (36.4)	445 (3.5)	389 (3.0)	4,549 (35.4)	2,178 (16.9)	612 (4.8)	
Male, n (%)	12,418 (96.7)	4,513 (96.5)	423 (95.1)	381 (97.9)	4,498 (98.9)	2,005 (92.1)	598 (97.7)	<0.0001
Age, median (IQR), y	25 (21–30)	24 (22–29)	30 (25–41)	28 (24–32)	24 (21–28)	27 (22–35)	25 (21–31)	<0.0001
Battle injury, n (%)	9,792 (76.2)	3,637 (77.8)	275 (61.8)	282 (72.5)	3,658 (80.4)	1,417 (65.1)	523 (85.5)	<0.0001
Mortality status, n (%)								
Arrival (DOA)	167 (1.3)	63 (1.4)	5 (1.1)	10 (2.6)	62 (1.4)	23 (1.1)	4 (0.7)	0.14
Discharge (DOW)	342 (2.7)	63 (1.4)	8 (1.8)	3 (0.8)	154 (3.4)	96 (4.5)	18 (3.0)	<0.0001
Elapsed time from wounded to MTF, min								
Patients with time available, n (%)*	6,827 (53.1)	2,750 (58.8)	242 (54.4)	215 (55.3)	2,258 (49.6)	1,073 (49.3)	289 (47.2)	
Arrival time, median (IQR)	75 (41–100)	68 (40–140)	56 (20–120)	50 (33–110)	81 (45–157)	87 (48–210)	77 (40–185)	<0.0001
Patients with arrival time ≤ 60 min, n (%)**	2,934 (43.0)	1,267 (46.1)	132 (54.6)	134 (62.3)	880 (39.0)	399 (37.2)	122 (42.2)	<0.0001
Mechanism of injury, n (%)								<0.0001
Explosion	5,320 (41.4)	2,245 (48.0)	187 (42.0)	169 (43.4)	1,890 (41.5)	653 (30.0)	176 (28.8)	
GSW	3,082 (24.0)	632 (13.5)	61 (13.7)	69 (17.7)	1,355 (29.8)	682 (31.3)	283 (46.2)	
MVC	1,209 (9.4)	223 (4.8)	25 (5.6)	41 (10.5)	553 (12.2)	333 (15.3)	34 (5.6)	
Helicopter/plane crash	63 (0.5)	43 (0.9)	8 (1.8)	7 (1.8)	1 (0.01)	2 (0.1)	2 (0.3)	
Explosion-GSW	118 (0.9)	26 (0.6)	3 (0.7)	2 (0.5)	57 (1.3)	20 (0.9)	10 (1.6)	
Explosion-MVC	453 (3.5)	308 (6.6)	9 (2.0)	35 (9.0)	69 (1.5)	26 (1.2)	6 (1.0)	
Other	1,713 (13.3)	873 (18.7)	118 (26.5)	46 (11.8)	337 (7.4)	279 (12.8)	60 (9.8)	
Unknown/missing	891 (6.9)	326 (7.0)	34 (7.6)	20 (5.1)	287 (6.3)	183 (8.4)	41 (6.7)	
Type of injury, n (%)								<0.0001
Penetrating	6,714 (52.3)	1,788 (38.0)	196 (44.0)	168 (43.2)	2,830 (62.2)	1,302 (59.8)	440 (71.9)	
Penetrating and blunt	951 (7.4)	270 (5.8)	29 (6.5)	17 (4.4)	416 (9.1)	187 (8.6)	32 (5.2)	
Blunt	4,026 (31.3)	2,104 (45.0)	156 (35.1)	172 (44.2)	1,017 (22.4)	488 (22.4)	89 (14.5)	
Other	633 (4.9)	333 (7.1)	45 (10.1)	26 (6.7)	126 (2.8)	81 (3.7)	22 (3.6)	
Unknown/missing	525 (4.1)	191 (4.1)	19 (4.3)	6 (1.5)	160 (3.5)	120 (5.5)	29 (4.7)	
En-route intervention, n (%)	4,266 (33.2)	1,257 (26.9)	122 (27.4)	149 (38.3)	1,814 (39.9)	667 (30.6)	257 (42.0)	<0.0001
Tourniquet use, n (%)	1,724 (13.4)	596 (12.8)	43 (9.7)	56 (14.4)	659 (14.5)	263 (12.1)	107 (17.5)	0.0002

*Number (%) patients had elapsed time or arrival time defined as time (minutes) from point of injury (wounded) to R2 MTF available.
**Number (percent) of patients arrived to MTF within 60 minutes/total patients who had elapsed time available.
AFG, Afghanistan; DOA, dead on arrival; DOW, died of wounds; IQR, interquartile range; MTF, medical treatment facility; US, United States.

the DoDTR registrars, and entry into the Registry remains voluntary. The US Navy R2 teams supporting the US Marine Corps maintained a separate registry, and these data are not yet integrated into the R2 research data set. Furthermore, the R2R is not and will not be directly linked with the larger DoDTR because it has not been validated against medical records. A significant shortcoming of the R2R is the lack of injury severity score and the inability to determine the most significant injury for patients with multiple documented injuries; future projects will ensure these scores and predominate injuries are linked with the DoDTR to facilitate meaningful analysis. There are limited transport time data before June 2009; thus, the trend toward improved US Force transport time was not statistically significant. During the course of the war, the Regional Command area of responsibility changed, most notably RC-South and RC-Southwest. Finally, and perhaps most importantly, because R2R use by deployed units was voluntary and inconsistent, there is no known denominator that would allow us to determine what proportion of R2 workload has actually been captured within the registry; thus, an unquantifiable but significant selection bias could exist.

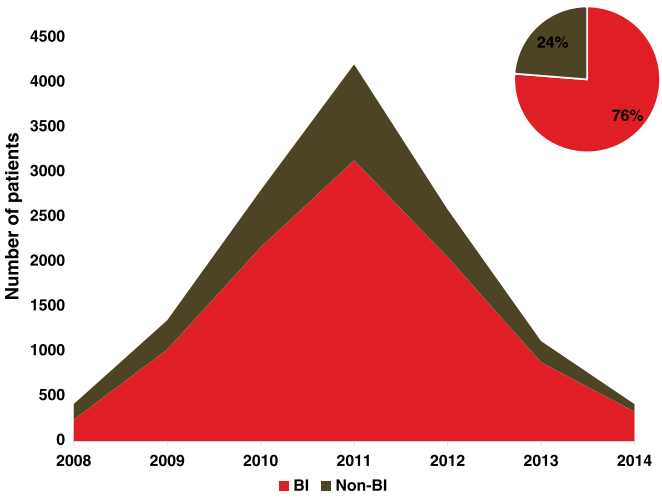

Figure 3. Battle injury (BI) compared to nonbattle injury (NBI) over time and as proportion of total.

This initial analysis of the R2R is intended as a prelude to a comprehensive review of various aspects of R2 care. For example, died-of-wounds rate, the patients who died while at the R2, was 2.7% in this analysis; the died-of-wounds rate in the DoDTR, comprised primarily of patients admitted to R3,

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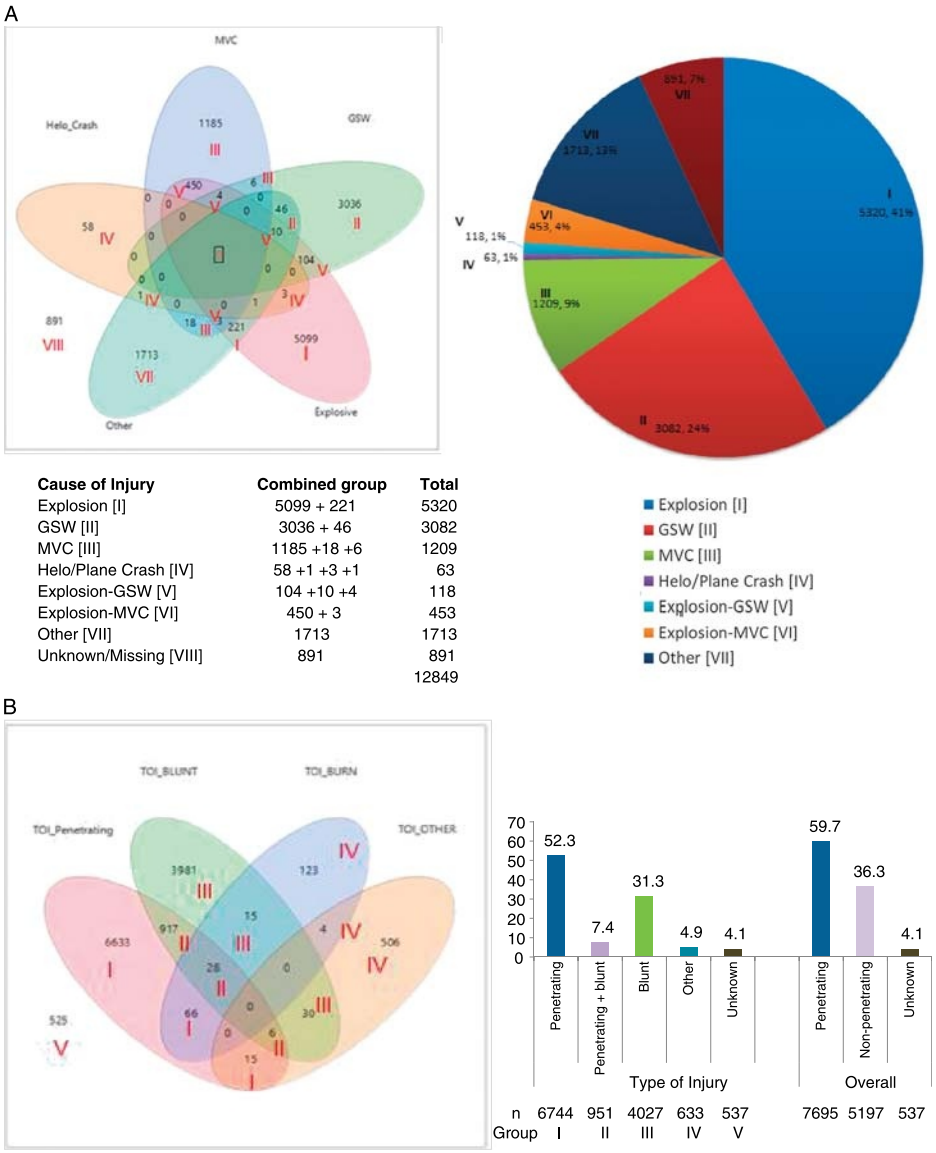

Cause of Injury	Combined group	Total
Explosion [I]	5099 + 221	5320
GSW [II]	3036 + 46	3082
MVC [III]	1185 +18 +6	1209
Helo/Plane Crash [IV]	58 +1 +3 +1	63
Explosion-GSW [V]	104 +10 +4	118
Explosion-MVC [VI]	450 + 3	453
Other [VII]	1713	1713
Unknown/Missing [VIII]	891	891
		12849

Figure 4. Mechanism (*A*) and type of injury (*B*). *Helo*, helicopter; *TOI*, type of injury.

was 2.2% (Unpublished data, DoDTR, 2015). Future analysis will carefully explore a range of outcomes for patients admitted to R2 compared to those who were admitted directly to an R3 following injury to identify whether significant differences exist between these groups. Efforts are ongoing to analyze specific populations (e.g., pediatrics, burns, brain-injured patients); differences in the mortality rates between US forces and others, perhaps due to personal protective equipment; interventions (e.g., tourniquet use, prehospital medications, and surgical procedures); effects of team training before deployment on quality of care, complications, and outcomes; and outcomes of R2 patients compared to similar patients admitted to R3 facility. The US Army is finalizing plans to adjust the composition of clinical specialty providers within the R2 Team, in particular, to include an emergency medicine physician; description of the surgical versus nonsurgical life and limb-saving interventions will provide objective support for this change. Of particular interest is improvement of interoperability with our NATO partners to optimize combat casualty care. This project is part of the United Kingdom and US Service Personnel, Families and Veterans Task Force initiated at the direction of President Barak Obama and Prime Minister David Cameron in April 2011.

This evaluation of the R2R describes the patient's profile and common interventions performed at a sample of US R2 facilities in Afghanistan. Ongoing and detailed analysis of R2 information may provide evidence-based guidance to military planners and medical leaders to best allocate R2 resources in future operations and prepare teams for deployment.

AUTHORSHIP

E.A.M-S., T.D.L., J.A.B., Z.T.S., M.A.S., M.D.W., I.B.L., and K.R.G. contributed significantly to the design, data acquisition, analysis and interpretation of the data for this study. R.R. contributed significantly to the

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design, and analysis and interpretation of the data for this study. S.A.S., T. H., S.C., and K.N.R. contributed significantly to the analysis and interpretation of the data for this study.

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Clinical Transition Framework: *Efficient Solutions for Transitional Support Systems*

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What do ATMs, Velcro, and microwaves have in common conceptually? Origins from NASA and the space race—no, that doesn't include ATMs. They give you something—oops, Velcro is a misfit for that solution. So what do you think they have in common conceptually? Answer: They are a faster, easier way of doing things that did not exist when I was a child!

In the same manner, the Clinical Transition Framework (CTF) offers a faster, easier way of onboarding nursing staff with integration of a group of common professional development principles. The CTF evolved from over 15 years of implementation projects and research related to new graduate, new to specialty, and new hire transitional support. The CTF model provides a competency-based system that addresses the full scope of experience backgrounds, from new graduate to traveler. The evidence-based model offers a single framework for all hires that integrates sampling, concept-base, professional practice, accountability, coaching plans, and the 3 high-end apprenticeships recommended by Benner.[1]

This portion of the CTF overview examines competency assessment that uses precepts of sampling, concept-base, and professional practice. Application of these core concepts led the organization to substantiate competency validation with further literature evidence and clearly defined performance statements. Traditionally, onboarding documentation tools list the tasks and procedures faced within a particular role. It is rare that such lists design and deliver performance criteria in the manner in which we provide care. The format of the tool can make documentation challenging as the preceptor searches for the right line for charting the action or observation. Specialists in professional development often create tools that are all-inclusive and comprehensive, but may miss the critical thinking and clinical judgment aspects that are crucial to professional practice. These challenges emphasize the need for using sampling in a manner that makes the tool easier to complete instead of more complex; comprehensive, but achievable; and with performance criteria that are clear, concise, and concrete.

SAMPLING FOR COMPETENCY VALIDATION

The CTF competency tool engages the model of sampling for collecting evidence of capability. Sampling theory calls for taking a sample of performance skills, validate that the individual performs those skills in a competent manner, and extrapolate that they are competent overall. Sampling is an approach adopted within many academic settings as they prepare nurses for the challenges of clinical practice. The competency-based approach uses a variety of assessment techniques and addresses learner development with consideration for varied learning styles.[2] Competency-based education assessment often includes observation of practice or simulated case management, with each observation offering a sample of full clinical practice. In both academic and practice settings, each post-test established as a course component uses sampling to endorse the knowledge base of the learner.[3] One of the challenges within sampling is making the distinction between competency with a specific set of skills or tasks, and true competence, which requires being able to carry out the full responsibilities of the job. Educators frequently develop "skills labs" for the purpose of establishing task capability. Regrettably even with proficient skills lab performance, questions may remain pertaining to the professional's ability to integrate those tasks within care that adapts to the changing needs and priorities of a patient.

All research projects utilize a sample population for testing the hypothesis that is being studied.[4,5] Sampling is used routinely by the National Council of States Boards of Nursing (NCSBN) as they analyze evidence behind the role of simulation experience, National Council Licensure Examination (NCLEX) test construction and scoring requirements for passing grades.[6,7] In fact, each time nurse candidates complete their NCLEX exams on the computer with less than the total number of questions, a sample of a sample is being used to validate, or not, their licensure.[8]

Another frequent user of sampling is The Joint Commission. The accreditation organization evaluates health care agencies with the purpose of inspiring the provision of safe and effective care of the highest quality. To achieve this, The Joint Commission engages in agency assessment through onsite reviews wherein randomly selected patients, charts, employees, and/or their records are evaluated for compliance.[9] These randomly selected components are the sample that establish whether or not the surveyors document any requirements for improvement or confer accreditation.[10] Both The Joint Commission and the CTF validation serve the purpose of ensuring safe, effective, evidence-based patient care provided with quality. Both systems strive to verify nursing staff competence, while engaging sampling methodology to document the pertinent evidence.

APPLICATION OF SAMPLING WITHIN THE CLINICAL TRANSITION FRAMEWORK

The CTF competency tool identifies the sample with bold print. The directions for form completion state, "All items identified in bold are required elements to be validated within orientation." The competency policy template emphasizes the process with the statements: "Selected competencies are assessed at hire and during the orientation period for the job. Completion of orientation requires documenting all indicated competencies with a score of two (2) or better."

The use of sampling principles allows the tool to identify both initial and ongoing expectations for practice in that setting.[11] The orientation timeframe is insufficient for gaining evidence of proficient practice, yet it is a part of professional role expectations. The required elements within orientation include the high-risk, high-frequency elements of practice. The low-frequency and proficient/expert practice aspects are included on the form without a mandate for completion during orientation. If ongoing expectations are not delineated in the orientation tool, where and when are they communicated to the new hire?

More than the minimum required elements of competency validation are collected for most new hires. This is especially true with those new to the setting who need to learn the nursing science unique to that specialty. Within the CTF documentation, the requirement for completion of orientation is the same for all hires, from new graduate to traveler. The bolded items emphasize the high-risk, high-frequency aspects of care that exemplify nursing practice within that setting. Each agency determines their core sample and any additional elements identified within the agency as requiring attention. Annual competencies will address the high-risk, low-frequency elements of care along with new procedures, medications, or treatments, and elements identified by performance issues or quality improvement indicators.

As the preceptor observes the clinical performance of the new hire, 2 critical elements are revealed that establish the basis for safe patient care. The first element is acknowledgment of the limits of their own knowledge and skills. This factor links with the second, the expectation that they will access appropriate resources or assistance to ensure safe patient care. These are core safety criteria for professional practice in the field of health care.[12] The care provider that is unable to recognize, or unwilling to acknowledge, the limits of their ability is the one that may pose a threat to safe care. With the evolving nature of medicine, there will always be new, updated, and unique aspects of care that may challenge the nurse. Nurse learning is never complete, thus seeking assistance is a core competency of safe, effective practice.

The CTF integrates these 2 crucial elements within the scoring key and teaches preceptors about these essential principles of practice. With validation of each observed performance criteria, the preceptor confirms that the individual recognizes the limits of their ability and seeks assistance appropriately.

PROFESSIONAL PRACTICE CRITERIA AND CONCEPT-BASED APPROACH

Within the CTF, principles of concept-based competency evaluation are applied synergistically with a focus on professional practice criteria.[13] The CTF competency tool shifts from the traditional focus on tasks and procedures with its concept-based approach. Using this method within competency assessment brings 2 significant benefits to the preceptor/new hire team. First, it supports critical thinking development through revealing how aspects of our practice or prior learning carry over into new situations. A concept-based approach assists in critical thinking development as the preceptor asks the questions, "What's the same, what is different, how might we apply this concept to this situation?" Second, a concept-based tool emphasizes professional practice over the completion of tasks and procedures.[14] In addition, the concept-based approach incorporates multiple tasks within an overall goal for the patient. One aspect of professional practice is the ability to adapt care to the patient's changing needs and priorities as we integrate specific tasks and procedures. Another feature of professionalism is the acceptance of personal responsibility and accountability, while applying legal and ethical frameworks affecting clinical practice.[12]

The initial new graduate internship created the foundation for the competency tools used in the CTF. In 1999, the Competence Outcomes Performance Assessment (COPA) model was the only published competency model found for nurse development within the original literature search.[15] Finding this framework started the journey toward the current view of professional practice, but the initial revelation resulted in aspects of critical thinking being incorporated within orientation tools.[14,16] The 8 core practice competencies of the COPA model include foci on critical thinking and human caring. The subskill examples provide a starting point for writing clear, concise, and concrete performance criteria for each of the competency areas.[14]

Dr. Lenburg assisted with developing the initial tools and fostered writing the performance criteria at the highest possible level. This started the use of the top of Bloom's taxonomy as revised to *A Taxonomy for Teaching, Learning, and Assessment*.[13,17] The revised taxonomy specifically targets experiential learning, which is core to clinical competency development and validation. The top levels of the taxonomy target actions related to analyzing, evaluating, and creating—core aspects of professional practice.

The concept-based approach of development and performance validation works synergistically with the focus on reflective, professional practice.[13] Instead of targeting details of task, equipment use, and completing procedures, the CTF focuses on how these elements are used within the management of the patient. For example, professional nursing practice engages assessment, evaluation, and synthesis to adapt a plan of care to address dysrhythmia. This, rather than the technical aspects of taking an electrocardiogram (ECG), is essential professional practice. Taking an ECG is a component of care and one learning strategy within the overall patient-centered goal.

Within the CTF model, patient-centered care is the target of each goal statement for nurse competence validation. Professional practice goal statements focus on the patient instead of emphasizing task, procedure, role, or body system. When you consider your agency, is the purpose of the emergency department (ED) nurse assisting the physician, or supporting the patient undergoing a minor procedure? Keep in mind that the subject of our goal statement is the recipient of our time and attention.

Shifting our approach to concept based helps preceptors by presenting aspects of care in the manner in which we provide care. Performance criteria listed for that goal follow the pattern of care delivery, which eases documentation of observations. The ED nurse would be providing care for the patient presenting with chest pain. Within that care delivery are performance aspects of interpreting an ECG, determining appropriate response, administering meds, evaluating response to treatment/medications, considering differential diagnosis, managing intravenous therapy, and so on. Each of these performance criteria represents a high level of professional practice that integrates both critical thinking and clinical judgment.

An additional benefit of the concept-based approach is the role that it plays in developing critical thinking and clinical judgement capability. "How is this the same, how is it different, and so, what now?" are recurring questions used by preceptors to develop reflective learning and practice.[18] These questions are critical elements for developing critical thinking capability and supporting transition toward the effective clinical judgement that is inherent to professional practice.[19]

An additional benefit of CTF competency validation is use of the same tool for every new hire, from new graduate to traveler. Instead of creating a special tool for new graduate internships or residency programs, the standardized CTF tool communicates essential elements of professional practice from day 1 of employment. The tool provides consistent communication of both initial and ongoing practice expectations within the facility.

IMPLEMENTATION RESULTS

Implementation of the framework fosters a variety of positive outcomes. When the framework was used in Nebraska as part of

a new graduate transition program, significant savings and reduction of errors or "near miss" events was reported by participating preceptors and managers.[20] The project engaged implementation in both rural and urban settings, with specific preceptor education and competency tools provided by Vermont Nurses in Partnership (VNIP) faculty. Investigators from the Nebraska project emphasized the value of preparing preceptors as a teacher, coach, evaluator, and advocate for the new hire.

A level one trauma center in Texas found that the objective metrics within the competency tools enabled ongoing assessment and made training adaptable, individualized, and cost-effective.[21] The goal of their original performance improvement project was to identify and implement a program that would reduce the incidence of nursing turnover within their burn center. Analysis of project outcomes showed a decrease in the nurse turnover rate from 33.6% (prior to the program) to 16.5% in the year following completion of the program, a 50% decrease ($p < 0.1$).[21(p.4)] This agency estimated the savings associated with retaining just 1 specialty nurse at around $85,000, which could easily offset program administrative costs.

The agency also stressed the value of reducing the paperwork burden placed on preceptors. The competency validation tools used prior to the project required 683 preceptor signatures, whereas the CTF tools reduced that requirement to 164 signature lines for the same unit orientation. A reduction in signatures eases the workload for those collecting evidence of competence.

These 2 projects give examples of outcomes from CTF model implementation in 2 distinct studies. The VNIP website offers a listing of further evidence within the white paper *Clinical Transition Framework Evidence Base*.[22]

CONCLUSION

The call for a radical transformation in nursing education emphasizes the need for reflective learning and apprenticeships that address knowledge integration, ethical comportment, and professional formation.[1] The CTF integrates these crucial concepts within a set of tools and precepts that are adaptable to each setting, agency, and population. The CTF performance criteria have shifted from the traditional task-oriented tool to a concept-based approach, which engages the precepts of sampling to gather evidence of capability. The focus on professional practice raises the bar of role expectations beyond the technical skills to embrace critical reflection and judgment skills needed for 21st century health care. Sampling technique is at the core of making the entire process achievable within a clear, concrete, and concise framework. The CTF brings the model components together into a methodology that is applicable for new hires entering the agency at varied levels of practice experience. This model represents a faster, easier way of doing things that contrasts with the traditional, task- and detail-oriented approach to competency validation. NL

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The Afghan Theater: A Review of Military Medical Doctrine From 2008 to 2014

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ABSTRACT This article forms part of a series that will explore the effect that Role 2 (R2) medical treatment facilities (MTFs) had on casualty care during the military campaign in Afghanistan and how we should interpret this to inform the capabilities in, and training for future R2 MTFs. Key aspects of doctrine which influence the effectiveness of R2 MTFs include timelines to care, patient movement capabilities, and MTF capabilities. The focus of this analysis was to review allied doctrine from the United States, United Kingdom, and the North Atlantic Treaty Organization to identify similarities and differences regarding employment of R2 related medical assets in the Afghan Theater, specifically for trauma care. Several discrepancies in medical doctrine persist among allied forces. Timelines to definitive care vary among nations. Allied nations should have clear taxonomy that clearly defines MTF capabilities within the combat casualty care system. The R2 surgical capability discrepancy between United States and North Atlantic Treaty Organization doctrine should be reconciled. Medical evacuation capabilities on the battlefield would be improved with a taxonomy that reflected the level of capability. Such changes may improve interoperability in a dynamic military landscape.

INTRODUCTION

This article forms part of a series that will explore the effect that Role 2 (R2) Medical Treatment Facilities (MTF) had on casualty care during the military campaign in Afghanistan and how we should interpret this to inform the capabilities in and training for future R2 MTFs. Roles of care refer to the increasing medical capabilities available for the combat injured. Generally, at the point of injury, combat life savers (soldiers trained to perform basic first aid) and trained combat medics apply Tactical Combat Casualty Care interventions to stabilize casualties and prepare for evacuation.[1] Role 1 (R1) represents unit-level care at a field medical station, where a Licensed Independent Provider can provide advanced airway management and possibly initiate fresh whole blood transfusion in preparation for evacuation to surgical support. R2 provides more robust medical resources than R1, and is the first level of care where damage control surgery (DCS) and advanced resuscitation may be provided, but offers limited patient holding ability. R2 is the first MTF in the chain of evacuation, also referred to as Deployed Hospital Care. Role 3 (R3) is a deployed field hospital offering expanded surgical and imaging capabilities; patient holding duration is technically unlimited. Role 4 (R4) is a fixed facility that is in the home country of the deployed force or that of ally and offers all medical and surgical specialties from acute care to long-term rehabilitation.

The focus of this analysis is to review doctrine to identify similarities and differences regarding employment of R2 related medical assets in the Afghan Theater specifically for trauma care. The scope is limited to North Atlantic Treaty Organization (NATO) and United States (US)/United Kingdom (UK) joint and single Service doctrine, as the overwhelming majority of MTFs and evacuation assets in Afghanistan were from these two nations. An R2 Registry was implemented by the US Joint Trauma System in 2008 so doctrine from 2008 to 2014 was reviewed.

What Is Military Doctrine and How Is It Organized?

Military doctrine is the expression of how the military operates, linking theory, history, experimentation, and practice. Its objective is to describe how to think, not what to think. Yet, despite its centrality to military thinking, doctrine has been described[2] as ill-defined, confusing, and poorly understood. NATO's definition of doctrine,[3] used unaltered

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by many member nations including the US Department of Defense, is:

> "Fundamental principles by which military forces guide their actions in support of objectives. It is authoritative, but requires judgment in application."

It goes on to say that

> "policy, as agreed by the highest National Authorities, normally leads and directs doctrine, and that applied doctrine is necessary for effective coalition building."

The UK follows this line stating[4] that "Except where there is a specific need for national doctrine, the UK will adopt and employ NATO doctrine."

Military doctrine has been variously categorized but contemporary taxonomies tend not to align doctrine to a particular level of conflict or environment. The UK[5] advocates four broad levels: philosophy, principles, practices, and procedures. Describing the relationships between these levels as:[6]

> **"Philosophy** is conceptual, enduring, pervasive and largely descriptive. It provides understanding. **Principles**, which are more specific, build upon the philosophical foundations to summarize that understanding. Both are likely to provide clearer context than faster-moving doctrine can, provided they are malleable. **Practices** describe the ways in which activity is conducted. **Procedures** link practices together. Both are intended to be prescriptive. Lower-level doctrine could change relatively rapidly and pragmatically, often from a bottom-up direction. However, practices and procedures should always be consistent with the higher-level philosophy and principles, which change only as a result of measured consideration, which is usually a top-down process."

Using this template, Table I shows how the doctrine examined within this article fits into the organizational hierarchy.

Key aspects of operational factors which influence the effectiveness of R2 MTFs:

- Timelines to care
- Patient movement capabilities
- MTF capabilities

TIMELINES

Once injured, the principal factor that determines mortality, morbidity, and residual disability is time to required level of medical care. This is true of all medical emergencies, but is of overriding significance when dealing with surgical emergencies—particularly surgical control of hemorrhage in the combat setting. Hence, evacuation time is the major clinical driver dictating the type and location of medical assets in operations and conflicts, and timeliness in providing appropriate intervention to the wounded or ill is crucial. The provision of high-quality early intervention has been shown to improve outcomes, while any delay either before care is initiated or between subsequent levels of care, will be deleterious to patient outcomes.[7]

Allied Doctrine, Allied Joint Publication (AJP) 4-10 (A) was the extant NATO doctrine for the whole of the

TABLE I. Levels of Doctrine

Level	Doctrine Publication		
	Allied	US	UK
Philosophy		JP-1	BDD
Principles	AJP-01(D)	US Army capstone pub	JDP 01 Campaigning
	AJP 4-10 (A)	JP 4-02	ADP-Ops
		Army FM 4-02 (ATP 4-02)	JWP 4-03/JDP 4-03
			AMS Core Doctrine
Practices (Includes Joint and Allied Environmental, Functional and Thematic Doctrine)	AMedP-1	Army FM 4-02.25	AFM
	AMedP-2	ATP 4-02.3 (Army)	
	AMedP-13(A)	ATP 4-02.5	
		ATP 4-02.55	
		NWP 4-02 (Navy)	
		NTTP 4-02.2 (Navy)	
		MCRP 4-11.1G (USMC)	
		ANNEX 4-02 (USAF)	
Procedures		JTS CPGs	CGOs
			MIMMS
			BATLS

ADP, Army Doctrine Publication; AFM, Army Field Manual; AJP, Allied Joint Publication; AMedP, Allied Medical Publication; AMS, Army Medical Services; ANNEX, United States Air Force Doctrine; ATP, Army Technical Publications; BATLS, Battlefield Advanced Trauma Life Support; BDD, British Defence Doctrine; CGO, Clinical Guidelines for Operations; CPG, Clinical Practice Guidelines; FM, Field Manual; JDP, Joint Doctrine Publication; JP, Joint Publication; JTS, Joint Trauma System; JWP, Joint Warfare Publication; MCRP, Marine Corps Reference Publication; MIMMS, Major Incident Medical Management Support; NWP, Navy Warfare Publication; NTTP, Navy Tactics, Techniques, and Procedures.

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period. Its principal medical planning timeline was the 1-2-4 hour principle:

> "Primary (definitive) Surgery [8] for critically injured patients within one hour of wounding. If this is not achievable then Damage Control Surgery (DCS)[8] should be available within two hours followed by primary surgery within four hours."[8]

Subordinate NATO publications have not provided further guidance. Allied joint medical planning doctrine (AJMedP-1) recommends the planning of Medical support based on the consideration of "all factors,"[9] but does not explicitly mention time and its effect on a casualty. Allied joint doctrine for medical evacuation (AJMedP-2) provides categories for patient evacuation[10] (Priority 1 requiring immediate transfer, Priority 2 within 24 hours, and Priority 3 within 72 hours) but only referred to clinical timelines when discussing forward medical evacuation (MEDEVAC)[10] and did not specify any timelines by which casualties should reach a level of care. Standardization agreement (STANAG) 2087[11] contradicts AJMedP-2, prescribing a 2-hour evacuation time limit for urgent cases and 4 hours for priority cases.

UK Joint Doctrine initially (up to March 2011) was based on Joint Warfare Publication 4-03[12] which prescribed the 1:2:4 hour principle, albeit subtly different to the NATO description:

> "rapid access to first aid and BATLS (battlefield advanced trauma life support)/BARTS (battlefield advanced resuscitation techniques and skills) resuscitation within one hour of wounding; access to surgical resuscitation (e.g., DCS) for those who require it within two hours of wounding; and primary surgery within four hours of wounding."

It also recognized that when required by the unique operational environment the principle could be adapted accordingly. This was superseded by Joint Doctrine Publication (JDP) 4-03[13] which advocated a new clinical paradigm; 10(min)-1-2[14] (according to the Allied Command Operations Directive on Medical Support to Operations as cited by JDP)[13] where:

> "bleeding and airway control for the most severe casualties should be achieved as soon as possible—ideally within 10 minutes of wounding. MEDEVAC assets should reach the seriously wounding with skilled medical aid within one hour of wounding at the latest. Casualties that require surgery or further resuscitation should, where possible, be in an MTF equipped for this within two hours of wounding."

UK Army Doctrine[15] advocated the 10-1-2 timeline to guide decision making regarding the configuration and location of the MEDEVAC and MTFs, while recognizing the enduring utility of the 1-2-4 hour principle that focuses on the timeliness for casualty movement between DCS and Primary surgery. Both US Joint (JP4-10 2006)[16] and US Army (FM 4-02.2[17] May 2007) doctrine described patient precedence for evacuation as:

> "within two hours for Urgent cases, within four hours for Priority cases and within 24 hours for Routine cases."

The US position changed (as cited in Rasmussen, 2016), however, following Congressional Interest in late 2008 and 2009 and resulted in changes for prehospital evacuation of:

> "One hour for urgent and urgent surgical missions to appropriate medical care."[7,18]

This was incorporated into the Army FM 4-02.2[19] in July 2009 and remained extant in the October 2011 version (ATTP 4-02),[20] the August 2013 version of FM 4-02,[21] and the August 2014 version of ATP 4-02.[22] In these later publications, the guidance was that Urgent cases should be evacuated as soon as possible and within 1 hour, yet the "Urgent-Surgical" category does not specify time to surgical intervention.[22] Priority cases remained as within 4 hours and Routine as within 24 hours. These changes were not made to the Joint Doctrine until the current version was published in 2012.[23] Subordinate doctrine publications such as FM 4-02.25 (Employment of Forward Surgical Teams [March 2003]) offered no further guidance regarding timelines to care. US Army doctrine is generally stated as implementing or being in consonance with the North NATO STANAG. The US Joint Medical Doctrine referenced ABCA (America, Britain, Canada, Australia/New Zealand) publications but no Allied documents.[24]

In summary, there were differing doctrinal timelines in use over the January 2008 to October 2014 time period in the Afghan theater of operations as described in Table II.

TABLE II. Evacuation Time Planning Policy

Organization	Evacuation Time Planning Policy	Time Period
NATO	1-2-4 hours	(January 8–October 14)
UK	1-2-4 hours	(January 8–March 11)
UK	10 minutes-1 hour-2 hours	(March 11–October 14)
US	2 hours for Urgent Cases and 4 hours for Priority Cases	(January 8–July 9)
US	1 hour for Urgent cases and 4 hours for Priority Cases	(July 9–October 14)

NATO, North Atlantic Treaty Organization; UK, United Kingdom; US, United States.

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In terms of what level of care should be reached within these timelines, NATO Doctrine explicitly states that it should be to definitive surgery, ideally within 1 hour but if not DCS within 2 hours. The UK advocates skilled medical aid within 1 hour and surgery within 2 hours, whereas the US started the campaign with a 2-hour guideline for evacuation of urgent cases without explicitly stating to what level of care. This was changed to 1 hour in July 2009 with the addition of the statement to "appropriate medical care."[18]

PATIENT MOVEMENT CAPABILITIES

Evacuation of casualties is a crucial part of the deployed Health Service Support system and requires specific medical personnel and assets. Time to care creates interdependency between evacuation, treatment, and the theater-holding policy,[25] with each directly impacting the other if the standard of patient care is to be maintained. Thus patient movement is not simply a transportation task but is part of the continuum of care and a medical responsibility.

NATO doctrine[8,10] advocates that a medical evacuation system should have the following capabilities:

(a) The ability to evacuate casualties to a MTF 24/7, in all weather, over all terrain and in any operational circumstances
(b) The provision of the necessary clinical care throughout the journey
(c) The ability to regulate the flow and types of patients.

Unlike the Roles used to describe MTFs, NATO doctrine[8,10] describes MEDEVAC, be it ground or air (Aeromedical Evacuation [AE]), in terms of where along the chain of evacuation it operates giving three main categories:

(a) **Forward MEDEVAC/AE**—Point of wounding to the initial MTF. This is required by operational circumstances to meet clinical timelines.
(b) **Tactical MEDEVAC/AE**—between MTFs within the Joint Operational Area.
(c) **Strategic MEDEVAC/AE**—from the Joint Operational Area, to the home nation or other country/safe area.

Although NATO doctrine states the priorities and dependency of patients requiring evacuation[26] (see above), it provides no guidance as to the levels of medical capability required; the focus is on the transport assets and the process to control them. Where specific skills are mentioned, guidance remains broad. AJP 4-10(A)[8] merely states the range of potential capabilities when discussing prehospital ground evacuation transportation:

> "There is variation in terms of capabilities and patient capacity. Most will be equipped for basic life support only, but at the top of the scale are advanced support units, staffed with emergency care medical specialists and/or trained specialist paramedic personnel who can provide extended resuscitative care, administer drugs, and begin administration of intravenous fluids in addition to providing basic first aid."

It takes a similar line with Tactical AE of pre- and post-operative patients, recognizing only the requirement for specialist clinical staff and equipment. AJMedP-2[27] in its discussion on Incident Response Teams suggest that medical capability could range from paramedical staff to primary health care professionals with advanced resuscitation training, to specialist secondary care teams.

US Joint Doctrine[24] focuses on transport assets, priorities and process although in the Appendices of both publications reference is made to the Critical Care Air Transport Team requiring specialty or critical care capability. US Army doctrine[28,29] focuses on the priorities for evacuation and not medical capabilities. UK Joint Doctrine does not contain a specific section of medical transfer/evacuation[13] and like the Allied and US doctrine it focuses on priorities and responsibilities rather than capabilities. Guidance in the later UK Joint doctrine[30] refers only to appropriately trained medical staff except when describing the Medical Emergency Response Team (MERT) capability:

> "It is based on para-medics or emergency medicine nurses but may be augmented by medical officers experienced in skills such as advanced airway management, rapid sequence induction and the maintenance of anesthesia."

UK Army doctrine also acknowledges that the MERT requires crew augmentation for prehospital emergency care interventions but does not specify further.

MEDICAL TREATMENT FACILITIES

NATO MTF Role Terminology should provide a common language that enables planners to determine the theater laydown and facilitates interoperability. In practice, however, national caveats and mission specific nuances have blurred the boundaries over the last 10 to 15 years.

AJP 4-10(A) categorizes MTFs into four tiers or Roles on a progressive basis (Table III).[31–33] Each Role of care is defined by a minimum clinical capability and not by its capacity or maneuverability. In principle, each MTF contains the minimum capabilities of the Roles below it, while an MTF cannot be reduced below the minimum capabilities of its given numeric descriptor. UK Joint Doctrine initially[30] used NATO terminology, but in the later publication,[30] more caveats are introduced. UK Army Doctrine[15] uses NATO terminology without exemptions but does note that boundaries can be blurred. The earlier versions of US Joint Doctrine[34] did not use the term Roles, instead describing healthcare capabilities from prevention through to definitive care, and only referred to the NATO definitions in a later chapter.[34] This changed in July 2012[24] when the NATO definitions were included in the main text. US Army Doctrine[28] initially uses the term "Levels" rather than Roles

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TABLE III. Levels (Roles) of Trauma Injury Care

Levels (Roles) of Trauma and Injury Care	
Current Levels (Roles) of Care	Function
Role I	Initial level of care/immediate lifesaving measures.
Battlefield Care to Battalion Aid Station	Emphasis on stabilizing casualty for evacuation to next level of care. Similar to civilian first responders. Also includes: Battlefield Care (Self-Aid/Buddy Aid, Combat Lifesaver and Combat Medic). Battalion Aid Station (far forward aid station with at least one physician available.
Role II	Small, highly mobile, austere surgical team.
Forward Surgical Team	Provides life-and-limb saving surgical care and typically the first level of surgery available. Limited capabilities, some laboratory, X-ray, mental health and dental services may be available.
Role III	High volume trauma center.
Combat Surgical Hospital	Highest level of treatment within the area of military operations.
Air Force Theater Hospital	Provides full range of surgical, medical, laboratory, and radiology capability. Care also includes dental, physical therapy, mental health, obstetrics/gynecology, and primary care services.
Role IV OCONUS	Definitive medical and surgical care.
Example: Landstuhl Regional Medical Center	Outside of area of military operations or combat, but not within CONUS. Stabilization point before evacuation to CONUS.
Role IV CONUS Walter Reed National Military Medical Center, Brook Army Medical Center	Definitive medical and surgical care OCONUS.

Adapted from Horne et al, 2014; Silva 2014; Cubana et al, 2013.[32–35]

but, in broad terms, they describe the same medial capability. This changed in the later doctrine[21,29] with Roles replacing Levels in line with the NATO terminology. Its R2 description remained consistent throughout, stating that they have the capability to provide packed red blood cells (liquid), limited x-ray, and clinical laboratory support but not surgery. A note emphasizing this appears in the October 2011 publication highlighting the differences with the Allied publications (See below). There are minimal differences in the definitions of R1 and R3 MTFs used in Allied,[8,15] UK,[13,15,30] and US[28,29,34] doctrine; Joint or single Service. The significant differences are in the descriptions of what constitutes a R2 capability.

R2 MTF

NATO defines R2 as:[35,36]

> "providing an intermediate capability for the reception and triage of casualties, as well as being able to perform resuscitation and treatment of shock to a higher level than Role 1. It will routinely include DCS and may include a limited holding facility for the short term holding of casualties until they can be returned to duty or evacuated. It may be enhanced to provide basic secondary care including primary surgery, intensive treatment unit and nursed beds."

NATO doctrine[36] also introduced a delineation in R2 capabilities; those able to support R2 light maneuver (R2[LM]) and the more clinically capable variant R2 enhanced (R2[E]). The R2(LM) MTFs are described[36] as able to conduct triage and advanced resuscitation procedures up to DCS. They will usually evacuate postsurgical cases to R3 (or R2[E]). In addition to R1 capabilities, R2(LM) will include

(a) Specialist medical officer led resuscitation with required support elements
(b) Routine DCS with postoperative care
(c) Field Laboratory capability
(d) Basic imaging capability
(e) Reception, regulation and evacuation of patients
(f) Limited holding capacity.

The same doctrine[38] describes R2(E) MTFs as:

> "small field hospital providing basic secondary health care, built around primary surgery, ICU and nursed beds. It is able to stabilize post-surgical cases for evacuation to Role 4 without needing to put them through a Role 3 MTF first."

In addition to R2(LM), R2(E) will include

(a) Primary (definitive) surgery
(b) Surgical and medical intensive care capability
(c) Nursed beds
(d) Enhanced field laboratory including blood provision.

Initially, UK Joint Doctrine[13] did not recognize the NATO subdivision but merely stated that R2 MTFs "may, in certain circumstances, include DCS when it will be known as R2+." This is rectified in a later publication[30] describing R2(LM) as providing "advanced resuscitation up to DCS" and R2(E) MTFs able to provide Primary surgery and evacuate directly to R4. The later doctrine also includes blood availability but only at R2(E) MTFs. UK Army doctrine[15] from March 2012

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is coherent with the joint doctrine in its definitions of both R2(LM) and R2(E).

US Joint Doctrine initially[34] acknowledged Allied terms only adopting them in the July 2012[24] publication. US Army Doctrine, however, retained its definition and added a note to this effect in October 2011:[38]

> "Note. The R2 definition used by NATO forces (Allied Joint Publication-4.10[A]) includes [the following] terms and descriptions not used by US Army. US Army doctrine subscribe to the basic definition of a R2 MTF providing greater resuscitative capability than is available at Role 1. It does not subscribe to the interpretation that a surgical capability is mandatory at this Role per the NATO doctrine. The NATO descriptions are
>
> – A medical company with a collocated forward surgical team may be referred to as a light maneuver R2 facility.
> – An enhanced R2 MTF may be used in stability operations scenarios and consists of the medical company, forward surgical team, and other specialty augmentation as deemed appropriate by the situation."

It should be noted that one of the key capabilities of Forward Resuscitative Surgical Teams is its ability to function effectively when independent of a R2 MTF. US Army Forward Surgical Teams, US Air Force Mobile Field Surgical Teams and US Navy Forward Resuscitative Surgical Squadrons are all able to integrate with traditional R2 MTFs but are also designed to rely on evacuation assets to rapidly clear stabilized patients, sometimes immediately after surgical procedures are completed. One damage control surgical capability, the US Air Force Tactical Critical Care Evacuation Team–Enhanced, took the next logical step of integrating forward resuscitative surgical care directly into the evacuation platform—allowing evacuation and surgical stabilization to occur in concert. During the Afghanistan conflict, tactical evacuation capabilities routinely served this role and compensated for the increased patient acuity by providing advanced clinical providers (Emergency Medical Technician-Paramedics, Critical Care Nurses, and Emergency Medicine Physicians) when needed.

DISCUSSION

How have operations in Afghanistan impacted on medical doctrine? For the most part this article has focused on the higher levels of doctrine which we noted change only as a result of measured consideration, usually a top-down process. The one significant example of change at this level (US time to care, the "Golden Hour Initiative")[18] only occurred after direction from the Executive authority (highest National Authorities), but even this failed to make it into the joint doctrine until 2012. Otherwise it can be argued that higher level doctrine did not change during the period to reflectreality on the ground; a reality that saw the medical approach to trauma develop significantly. The changes that did occur were captured in the lower tactical levels as standard operating procedures and tactics, techniques, and procedures which were able to react to these changes through bottom up demand. In his thesis "A Revolutionary Approach to Improving Combat Casualty Care," Hodgetts makes the case that over this period we have seen a revolution in military medical affairs. A summary of the doctrinal changes Hodgetts states in his thesis is at Table IV.

These changes are prescriptive and are more about "what" to do rather than "how" to think. That said, the effect these changes have had on the outcomes for trauma casualties on the Battlefield cannot be disputed. The lessons from this campaign will influence higher level doctrine but before changes can be incorporated it is necessary to be clear about what is enduring and applicable universally rather than adaptations specific to that theater of operations or campaign. The question now is how should our experiences in Afghanistan shape our higher level doctrine for the future?

Some change has already occurred; the latest edition of the Allied Joint Doctrine for Medical Support (AJP 4-10[B]) now includes the 10-1-2 guidelines and the level of care to be reached within each time frame[39] as well as the concept of Damage Control Resuscitation (DCR). Yet, despite a stated willingness to adopt Allied doctrine there are still many national caveats regarding what constitutes a R2 MTF and the time lines to a particular Level of Care. R2 MTFs can, under current guidance, be anything from a higher capability than a R1 MTF to a small hospital. This span is probably too great and hinders both planners and interoperability among allies when different capabilities are mandated (e.g., lack of required surgical capability for US R2 elements). As the R2(E) is accepted as being a "deployed hospital" then perhaps it would be simpler if "R3" identified any "deployed hospital" with a suffix denoting its level of capability (level I, II, III). The Afghan campaign highlighted the nonlinear nature of medical support where patients can move from point of injury to surgical care without any

TABLE IV. Significant Doctrinal Changes During Period of Operation Enduring Freedom (c. 2002 to 2014)

Significant Doctrinal Changes
ABC to <C>ABC
Tourniquet Use
4 Stages of Combat Resuscitation
Rapid Primary Survey
MIST Report
Clinical Guidelines for Operations
Damage Control Resuscitation
Hemostatic Resuscitation
Immediate Surgical Intervention Upon MTF Arrival

ABC, airway, breathing, circulation; "<C>," catastrophic hemorrhage; MIST, mechanism, injuries, symptoms, treatment; MTF, medical treatment facility.

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intermediate steps. Thus there is no need to categorize deployed hospitals as a R2 simply to show that it is further forward. Ultimately, this would then allow R2 MTFs to focus on the intermediary nonsurgical capability on the way to the deployed hospital, and subsequently, allow the use of the term for MTFs without surgery. This is something the US has kept within its doctrine as it envisages such facilities being the norm in any larger scale near-peer conflict.

The UK Joint doctrine has now been archived and replaced by AJP 4-10(B), but still retains a caveat stating the UK uses the 10-1-2+2 timeline.[39] US doctrine remains is as it was in October 2014 and they too have recorded reservations in AJP 4-10(B) specifically regarding the timelines and the level of care available.[39] The primary difference for the US is that R2 does not have to contain surgical capability, therefore timelines are to an appropriate MTF within an hour and not to surgery. This less demanding position is necessary in the higher doctrine as it needs to be relevant to all future campaigns and not just what happened during the most recent operation. Doctrine must also reflect the realities of a large-scale conflict with a near peer opponent.

Conversely, another potential solution would be to disassociate forward surgical capabilities from the entanglements of the Role definitions. The tactical advantage of small surgical teams integrated into a joint trauma system can melt away if encumbered by doctrinal attachment to MTFs designed primarily to support trauma care delivery. These small teams can functionally bring lifesaving capabilities to operational areas that would otherwise be supported at the R1 (R1) level, fully integrate with R2 MTFs and augment R3 advance surgical capabilities to increase surgical throughput. If forward surgical care doctrine is to be most effective in future operational environment against near peer adversaries, it must recognize the tactical advantage of small size and unencumbered mobility of forward surgical capabilities operating independent of MTFs and reliant on tactical evacuation for relief of limited holding bed capability. This concept is consistent with most existing NATO and other doctrine that focuses on time to appropriate surgical intervention/DCR as opposed to defined Role of care.

One of the significant changes seen in Afghanistan was the increase in the range and the medical capabilities carried on patient movement assets. Typically there were three levels of capability available to the Patient Evacuation Coordination Cell to task described in Table V. There may be an advantage in having levels of MEDEVAC assets in the same way we have levels of MTFs, each with an agreed level of medical capability (probably not far off those above). In the same way MTF capabilities assists planners in configuring the theater laydown, so will agreed MEDEVAC capabilities. It will equally help develop the mutual understanding required if the higher levels of interoperability are to be achieved. This will then drive changes that support the intelligent tasking of the various MEDEVAC capabilities; a requirement for quicker more timely medical information and the availability of a Medical Common Operating Picture.

Limitations in this review include the limited scope of the analysis from 2008 to 2014; future evaluation will focus on allied doctrine from 2014 and beyond. The primary goal of this review was trauma-related combat casualty care, yet primary care and disease nonbattle injury comprises much of deployed medical care and is the driving force behind much of the current R2 doctrine, particularly for the US Army. These doctrinal differences were not addressed in this article.

A larger and more difficult question may be the definition of an alliance or Joint force. Currently there is no mandate to reach consensus on doctrine, yet failure to do so inherently hinders interoperability. Perhaps the solution is more integrated war-gaming and sharing of resources and greater inter-agency and inter-national compromise to reach consensus.

CONCLUSION

Several discrepancies in medical doctrine persist among allied forces. Timelines to definitive care vary among nations. We as allied nations should have clear taxonomy that clearly defines MTF capabilities within the combat casualty care system. The R2 surgical capability discrepancy between US and NATO doctrine should be reconciled. Medical evacuation capabilities on the battlefield would be improved with a

TABLE V. Casualty Evacuation Platforms

Casualty Evacuation Type	Highest Level of Medical Provider	"Level" of Medical Capability	Offensive Arms
Lift of Opportunity	Combat Life Saver	<1	Y
US Army Air Ambulance ("DUSTOFF")	Flight Paramedic	1	N
US Army Air Ambulance (Augmented)	Critical Care Registered Nurse and Flight Paramedic	2	N
US Air Force Rescue Squadron ("PEDRO")	Para-medic	2	Y
US Air Force Tactical Combat Casualty Evacuation Team (TCCET)	Emergency Medicine Physician, Nurse Anesthetist, Emergency or Critical Care Nurse	3	N
US Air Force Tactical Critical Care Evacuation Team–Enhanced (TCCET–E)	Surgeon, Emergency Physician, Nurse Anesthetist, Emergency Nurse, Operating Room Technician	3+ (Surgical capability)	N
Medical Emergency Response Team (MERT), United Kingdom)	2 Physicians, Emergency Nurse, 4 Para-medics	3	Y

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taxonomy that reflected the level of capability. Such changes may improve interoperability in a dynamic military landscape.

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Clinical Transition Framework

Integrating Coaching Plans, Sampling, and Accountability in Clinical Practice Development

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The clinical transition framework (CTF) is a competency-based practice development system used by nursing professional development practitioners to support nurses' initial orientation or transition to a new specialty. The CTF is applicable for both new graduate and proficient nurses. The current framework and tools evolved from 18 years of performance improvement and research projects engaged in both acute and community care environments in urban and rural settings. This article shares core CTF concepts, a description of coaching plans, and a professional accountability statement as experienced within the framework.

The Vermont Organization of Nurse Leaders developed the initial clinical transition framework (CTF) competency validation tools in response to an identified, statewide need for structured internship or residency programs for nursing students, new graduates, and new to specialty nurses. The initial new graduate program underwent testing through 2 years of multiagency pilot. Subsequent pilot projects applied the concepts and tools for nurses' transition to new specialties. The positive outcomes, including decreased costs, increased retention, and improved nurse satisfaction, encouraged further collaboration between the nonprofit organization Vermont Nurses in Partnership (VNIP) and various agencies on a regional and national basis (Delfino, Williams, Wegener, & Homel, 2014; Hawkins & Exstrom, 2014; Robbins et al., 2017). The expanded work established an evidence base that reflects framework use in rural, urban, critical access, tertiary care, and clinic settings across the continuum of care (VNIP, 2017a).

The comprehensive CTF evolved from a new nurse graduate internship to a comprehensive competency onboarding framework through a rapid cycle quality improvement process (Etchells, Ho, & Shojania, 2016; VNIP, 2016). The CTF is more than an internship or residency, preceptorship or orientation program. VNIP coined the title of *Clinical Transition Framework* because the other terms as listed describe components within the framework but may be limited in their scope, target audiences, and application process. The CTF combines all of these elements to produce a systematic, standardized approach for developing and validating competency in the clinical setting, while protecting patient safety in a conscious, specific manner. To achieve this end, the CTF incorporates concepts from new graduate residency, preceptor development and support, and orientation elements and adds specific concepts related to sampling theory and professional accountability. As a competency-based system, the length, intent, instruction, and outcomes requirements are adapted to the individual and the expertise that he or she brings to the clinical setting.

The resulting competency framework establishes the same standards and documentation to provide evidence of competence for all registered nurse hires, no matter their background or experience (Boyer, Valdes-Delgado, Huss, Barker, & Mann-Salinas, 2017). The CTF engages preceptors as crucial competency validation professionals and is applicable for initial orientation, cross-training, new graduate internships, and/or support for new specialty transition (VNIP, 2016). The framework is an evidence-based model with demonstrated success and consistent implementation across a diverse set of specialties within tertiary, primary, and home care settings (Delfino, Williams, Wegener,

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& Homel, 2014; Hawkins & Exstrom, 2014; Peterson & Donehower, 2015; Robbins, et al., 2017).

Within the CTF, the preceptor development system and three high-end apprenticeships add focus to critical thinking development for those using the CTF for onboarding new or transitioning nurses. Orientation tools within the CTF gather a sample of evidence related to clinical competence and conclude with a statement attesting to the individual's accountability as a professional nurse. The CTF clinical coaching plans guide both the preceptor and new hire while offering a concrete tool for reflective learning. The framework provides an evidence-based, progressive means of onboarding new staff that integrates high-end apprenticeships for developing specialty knowledge base, skilled know-how, and ethical comportment as recommended by Benner, Sutphen, Leonard, and Day (2010). VNIP faculty and nursing professional development (NPD) specialists established the CTF with tools that engage clinical coaching, sampling, accountability, and evidence-based preceptor development and support.

The purpose of this article is twofold: first, to disseminate crucial features of the CTF as developed through broad-based collaborative efforts, and second, to share two specific tools that evolved out of framework utilization—a coaching plan and an accountability statement.

ROLE OF APPRENTICESHIPS IN NURSE DEVELOPMENT

In 2010, Benner et al. called for a radical transformation of nursing education. Three high-end apprenticeships are outlined in the recommendations for change. The apprenticeships target (a) learning nursing science specific to the specialty, (b) developing skilled know-how through deliberate practice, and (c) an apprenticeship in ethical comportment and professional formation. Although the apprenticeships occur synergistically throughout a nurse's development, each may take precedence within a specific period of the novice-to-expert continuum, as shown in Figure 1. The three apprenticeships are integrated within individualized development plans and preceptorships.

Preceptors implement coaching plans within the CTF that provide a written outline of the nursing science unique to the domain of practice and engage the learner in developing skills at a level aligning with the individual nurse's learning needs. For example, consider the clinical performance goal of *Addressing unique needs of the geriatric patient* versus one of *Coordinating individualized care within a multipatient assignment*. The multipatient assignment requires more advanced skills and work coordination than addressing age-specific care with a single patient. The preceptor–new hire team determines which goals are appropriate to the individual, then work to complete any learning strategies that are needed to fill gaps in cognition or clinical skills. With guidance outlined within the coaching plan, the preceptor fosters deliberate clinical practice and reflective learning as the new nurse integrates specialty practice knowledge with clinical capability.

As CTF components, the three high-end apprenticeships build from a simple knowledge base toward complex integration of knowledge within skilled, professional practice. During orientation, a nurse's discipline-specific knowledge develops from initial learning modules, then builds to conceptual understanding, integration of protocols, to safe clinical practice, to development of reasoning skills and clinical judgment that is unique to a certain specialty. Support for this development is achieved within the CTF via use of written coaching plans that outline standardized knowledge and incorporate specific reflective learning questions with structured discussion to foster critical thinking. Weekly conferences with the preceptor or educator engage the newly hired nurse in active reflection strategies that portray holistic patient care. As new nurses develop skills needed to provide holistic care of patients, they expand their focus on ethical affect, demeanor, and formation as a professional (Benner et al., 2010).

A focus on critical thinking and clinical judgment is core to professional practice and reflective learning (Miraglia & Asselin, 2015). Critical thinking processes, such as clinical reasoning, problem solving, and nursing judgment, intertwine with one's factual knowledge to foster appropriate responses to commonly recurring patient situations. Specialty knowledge becomes part of the nurse's cognitive base, which requires reinforcement via application and repetition to install it in long-term memory (Alfaro-LeFevre, 2016; Benner et al., 2010). This knowledge is the fuel that allows creative critical thinking to develop. Experiential learning in the clinical setting provides practical wisdom that expands reasoning skills. Professionalism and clinical reasoning are crucial steps leading to the individual's acceptance of accountability for their actions and inactions. Preceptors serve as clinical guides for transitioning nurses' developing attitudes and responses that integrate learned knowledge into responsible, effective patient care and professional accountability.

CLINICAL COACHING PLANS

Coaching plans are clinical teaching plans that guide the practice of precepting and foster the development of clinical reasoning skills in the newly hired nurse (Delfino et al., 2014; Nielsen, Lasater, & Stock, 2016; Robbins et al., 2017). The plans provide written guidelines and support that may stimulate development of individual capability, ethical conduct, accountability, and professionalism (VNIP, 2016). Two quasiexperimental studies show positive outcomes from the use of coaching plans with new nurses (Boyer et al., 2017; Robbins et al., 2017).

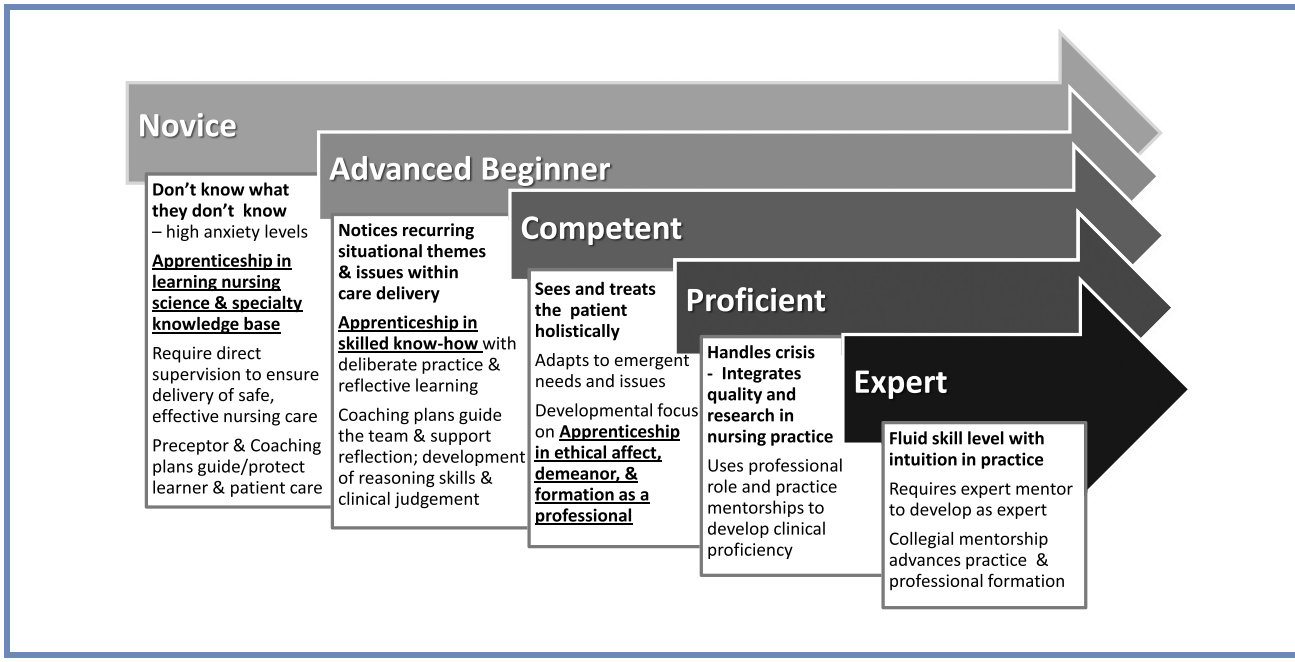

FIGURE 1 Integrating high-end apprenticeships and coaching plans within transitional support. © 2016 S. Boyer. All rights reserved. No copying or printing without permission. Contact info: boyer274@mail.com.

Coaching plans enhance planning and documentation of a nurse's clinical practice. They also help to ensure consistent communication between preceptors and present specific questions that foster development of critical thinking.

The structure of a coaching plan includes (a) directions for use; (b) a goal statement presented in the manner of providing care; (c) outline of related policies, standardized knowledge, and instructional resources; (d) elements of performance criteria, and (e) reflective learning strategies. Each coaching plan targets a specific goal written in a patient-centered manner and identifies both the standardized knowledge and aspects of practice unique to the specific setting. In coaching plan design, the first step establishes a set of goal statements that target patient-centered care within the specific practice setting. For example, the goal statements in Table 1 outline the specialty of medical-surgical nursing.

Each goal statement becomes the heading for a single-page coaching plan. Within the written plan, the NPD specialist outlines the standardized knowledge with titles of policy or procedure resources, instructional modules, and learning activities recommended for achievement of the goal. By providing a specific outline of cognitive requirements along with instructional strategies, use of the coaching plan encourages the learner to take personal responsibility for content mastery (Robbins et al., 2017). Each plan targets a specific nursing performance goal statement, outlines standardized knowledge that is specific to that goal, and details clinical performance criteria that reveal aspects of goal achievement.

Specific performance criteria outline the core evidence of meeting the overall patient-centered goal statement. The NPD specialist avoids using terms such as *knows, understands, able to*, or *demonstrates* when writing the measurable statements, as these verbs are vague and difficult to measure (Nicolas et al., 2012). Instead, specific action verbs such as *assesses*, *monitors*, *applies*, and *reflects* are used to provide a clear statement of what the learner is expected to achieve. The performance criteria focus on patient care, assessment, planning, and evaluation—rather than focusing simply on the tasks and procedures involved in care. When written at a high level of performance expectations, the coaching plan and care goals prioritize professional nursing practice over completion of the task or procedure (Nielsen et al., 2016). For example, the task of performing an electrocardiogram is inherent to the performance criteria of, "Determines rhythm changes that require immediate intervention" or it moves a step further in complexity with, "Engages correct intervention for specific cardiac rhythm change."

The process of coaching includes self-assessment questions that foster critical thinking development in the new or transitioning nurse. These questions may appear on the coaching plan or on a weekly conference form used for reflective learning. The answers given by the learner are a foundation for discussion and exploration of "what ifs" with the preceptor or educator. Reflective learning occurs with feedback sessions, discussion, storytelling, and questioning strategies engaged by the preceptor or clinical educator (Miraglia & Asselin, 2015). Questions on the coaching plan create a platform for

TABLE 1 Performance Goal Statements That Encompass Medical-Surgical Nursing Specialty

Medical-Surgical Nursing Specialty
1. Provides geriatric patient care that integrates core issues unique to the population
2. Manages the surgical patient presenting with underlying medical issues
3. Prioritizes a multipatient assignment
4. Anticipates special needs and possible complications seen in medical-surgical patients
5. Maintains best possible health and well-being for immunocompromised patient
6. Manages care of patient undergoing orthopedic surgery or fracture stabilization
7. Ensures optimal health and preventative care for diabetic patient
8. Manages care of the patient with compromised cardiovascular or respiratory system
9. Adapts plan of care for the unique needs of pediatric patients from varied age groups
10. Alleviates patient distress: pain, psychosocial, spiritual, and physical
11. Addresses unique needs of patients presenting with substance abuse, withdrawal, suicidal ideation, depression, or other mental health issue

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establishing reflection as a deliberate process of thinking critically about clinical experiences to gain personal and professional insight.

When preceptors use coaching plans as designed, they foster development of critical thinking and reflective practice in the new nurse, while documenting evidence of competence or learning needs. The coaching plan is a concrete means of providing "hand-off" communications for subsequent preceptors to track and communicate progression of the new hire. Figure 2 offers an example of the format used for a clinical coaching plan. Formats may vary, but the concepts of presenting standardized knowledge, specific performance criteria, and reflective learning strategies are essential to establish clearly defined expectations, integrate support, and foster critical thinking development (Boyer et al., 2017).

Coaching plans provide a rubric for both learning and competency validation. The plans foster success by providing specific strategies to address discrepancies between various preceptors' performance expectations (Fredickson & Moore, 2014). Using coaching plans also saves time and effort by ensuring concrete, clear communication from one preceptor to the next. The 10–16 statements comprising a set of unit-specific goals or coaching plan statements outline the specialty practice and provide documented evidence of competent practice. Within the CTF, unit-specific coaching plans address the specialty and give evidence of safe and effective nursing practice that adheres to protocol, policies, and procedures within the learner's organization.

SAMPLING AND CONSISTENCY

The CTF applies concepts of *sampling* to competency evaluation to produce systematic, role-specific, evidence collection related to nurse capability. Sampling is defined as the process, act, or technique of choosing a part of a population or set of elements for the purpose of determining characteristics or limitations of the whole (Merriam-Webster, 2017). Although sampling has been used extensively with medical research and population studies, it is less common to consider sampling concepts as part of orientation. A sampling-based competency system extrapolates overall nurse capability to provide safe and effective patient care from observation of a selected sample of competency criteria (Guenter et al., 2015; Lakanmaa et al., 2014; Perla, Provost, & Murray, 2013). Application of sampling concepts allows selection of required competency elements, which reduces the signature requirements within the form, thus decreasing workload for preceptors. The sampling-based approach is seen with national nursing licensure exams, oversight surveys for organizational accreditation, and pharmacological or therapeutic research. When a candidate passes a licensure exam with completion of less than 100 questions, for example, he or she is gaining licensure based on a sample of a sample (Williams, Kim, & Dickison, 2014).

Orientation tools track and record aspects of a transitioning nurse's practice completed according to the organization's policies, procedure, or established protocols. The appropriate sample of orientation performance criteria include high-risk, high-frequency aspects of patient care and nursing judgment, such as medication administration or intravenous therapy management. Orientation tools frequently detail the minutiae of nursing practice with various tasks, procedures, or pieces of equipment that comprise clinical care. Delineating aspects of clinical reasoning is more challenging to achieve (Alfaro-LeFevre, 2016; Nielsen et al., 2016). To meet this challenge, the NPD specialist uses current evidence and professional expertise in writing performance-based criteria as observed in clinical practice. They also ensure adherence to the KISS principle—in this case representing an effort to *Keep It Short and Simple*! This principle helps to guide preceptors and protect them, per se, from the extra workload created by extensive,

Clinical Coaching Plan

Orientee _____ **Date** _____

- **Daily -** *start the day with establishing goals and expectations with the new hire. Move from Simple to Complex.*
- ***Recap what happened the previous day***. Emphasize the successes of the novice and encourage their development of critical thinking skills
- ***Each day, review the charting and computer skills of the new hire***. Assure that care delivery routine is conducive to protecting the safety, complete care, and accurate documentation of the unit's busy flow of patients.
- ***Update the checklist daily***, meet with the educator as needed to discuss goal achievement, include coach/manager if indicated.

Goal Statement: Protects patient wellbeing via prompt, appropriate, intervention for those presenting with complaints of chest pain

Learning Strategies:	
Reviews Protocols related to: Medication management; frequently used cardiac medication drips & their use; transfer of cardiac patients; vasoactive medications; therapeutic hypothermia; ROSC patients; external defibrillation; 12 lead EKG; STEMI Practice lead placement for Phillips 5 lead 6-lead monitor system and EKG	Reviews BLS, ACLS, PALS, and AHA guidelines Complete basic dysrhythmia course **Complete computer or unit based modules for:** Synchronized cardioversion; Transcutaneous Cardiac Pacing; External Defibrillation; Cardiac Rhythms Class; Cardiac Monitor Set up and Lead Placement; Concepts and Life-Threatening Arrhythmias: Foundational Concepts - (Possible) Train the Trainer with Hospital Education on the use of the Life Pak defibrillator

Performance Criteria	Self-assess	Comments	Inits. /Date
Determines cardiac origins of symptoms - Differentiates between Cardiac and GERD symptoms - Considers differential diagnoses - Initiates MONA treatment, if appropriate			
Delivers care based on cardiac rhythm, history & assessment - Interprets 12 lead EKG within 10 minutes of arrival in ED - Differentiates lethal from non-lethal rhythms - Anticipates complications and/or patient change - Initiates STEMI protocol when indicated			
Manages patient's changing needs & ongoing assessment - Monitors for electrolyte or acid/base imbalance - Modifies plan based on assessment of patient status & response to treatments/meds			
Performs external pacing, defibrillation and/or cardioversion - Determines care needs for specific rhythm configurations - Utilizes adult code cart and monito, pacer, or defibrillator			
Assists with cardiac resuscitation - Documents Code Blue accurately - Describes care and issues for the ROSC patient - Explains the use / concerns with Therapeutic Hypothermia - Notifies organ bank and medical examiner as appropriate - Transports patient to receiving unit			

Describe positive experiences, work, accomplishments that occurred this week and why it was positive?

Describe the most challenging experiences or work that occurred this week.

What might have been done differently, to improve outcomes or process?

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FIGURE 2 Example of clinical coaching plan.

detailed competency checklists and multifaceted scoring systems. While adhering to the KISS principle, competency validation tools must also be comprehensive and should include both initial and ongoing performance expectations (Beaver et al., 2016). The use of a sampling approach communicates the expectation of proficient aspects of practice, without holding the new hire responsible for that aspect of performance within the first weeks of practice in the agency or specialty. To ensure safe and effective patient care, competency criteria must track elements of whether a nurse (a) provides safe and effective care that adheres to protocols, (b) adapts plan of care to patient's changing needs and priorities, (c) acknowledges limits of own capability or cognition, and (e) seeks assistance and/or resources appropriately

(Beaver et al., 2016; Nicolas et al., 2012; VNIP, 2016). While observing the transitioning nurse's specific clinical performance, the competency validator or preceptor monitors for trends in practice, for example, willingness to ask questions or seeking assistance with tasks.

When considering competency assessment across systems and diverse sites, the NPD specialist must select appropriate performance criteria that encompass clinical practice in the specialty setting (Beaver et al., 2016). The high-risk, high-frequency skills are relatively easy to identify, but writing performance criteria that include nursing judgment requires prioritizing analysis, synthesis, evaluation, and creation over basic aspects of knowledge. The original Bloom's taxonomy contained six levels of development addressing the cognitive base (Bloom, 1956). Although knowledge is a necessary precondition for deep thinking, the practice of nursing is dependent upon thinking well. The development of nurse thinking requires targeting the highest levels of Bloom's cognitive taxonomy and engaging reflective and experiential learning, as well as addressing upper levels within the affective and psychomotor realms (Alfaro-LeFevre, 2016; Benner et al., 2010; Nielsen et al., 2016).

The CTF competency tools detail both initial and ongoing performance expectations for the RN (Beaver et al., 2016). Competence validation is achieved by a preceptor's documentation of observed clinical practice or by verbalization by the new nurse—a method sometimes used with core skills that occur less frequently. The competency tool identifies required elements within the orientation sample with bold script. Directions for the form specify both what sample is required and how evidence is to be collected. Preceptors often document more than the minimum requirements, especially when working with new graduate or new to specialty nurses, but the required elements detail the same expectations for all within a specific nursing role. These elements are the minimum requirements, just as all RNs will complete a minimum of 75 questions on the licensure examination (Williams et al., 2014). In this manner, newly hired nurses, travelers, contractors, and new graduates are held to the same standard requirement for competence validation.

PROFESSIONAL ACCOUNTABILITY

Accountability is an entry-level competency expected of new graduates; yet, a literature search reveals that historically new graduate nurses are not consistently able to demonstrate this crucial trait (Dyess & Sherman, 2009; Krautscheid, 2014). Accountability is defined as the quality or state of accepting responsibility for one's actions—a willingness or obligation to be answerable for one's reasons, causes, outcomes, or motives (Merriam-Webster, 2017). Health professionals often use accountability and responsibility interchangeably; however, accountability means being answerable to a higher authority for one's actions, and responsibility equates with having control or authority over someone or something (Griffith, 2015). Every nurse must be mindful of their level of responsibility, position within the public eye, and accountability as a professional. Accountability is a characteristic of professional practice that includes aspects of actions, inactions, learning, recognition of the limits of capability, and seeking assistance when indicated (Oyetunde & Brown, 2012; Zittel, Moss, O'Sullivan, & Siek, 2016).

The competency tools within the CTF use a statement to detail the critical elements of accountability related to orientation and specialized practice. The new nurse attests to accountability with his or her signature on the competency tool. The accountability statement reads:

> As a licensed, professional nurse, I acknowledge the fact that orientation cannot provide exposure to all aspects of patient care delivery within any specialty. I accept accountability for my professional practice and continued learning. When asked to engage skills, tasks, or other responsibilities that are not familiar, I will access appropriate resources for assistance, information, or guidance. These resources may include written directions, procedure manuals, a learning module, or the expertise of colleagues. I will ensure that each patient that comes under my supervision receives safe, effective care that adheres to all established protocols (VNIP, 2017b, p. 6)

The agency educator or preceptor introduces the orientation forms and this concept of accountability during initial discussions with the newly hired nurse. A crucial issue with accountability is the nurse's ability to recognize the limits of his or her own expertise, understanding, or competency and to respond in a proactive manner. When new nurses recognize that they have reached the limits of their practice, the appropriate response is to engage assistance, resources, or colleagues to ensure safe, effective patient care that adheres to protocols and standards of practice. In this manner, accountability includes responsibility for knowledge and skills development related to any gap in cognition or capability (Zittel et al., 2016). Observation of clinical practice provides evidence of the clear, concrete, accountability criteria as delineated by NPD specialists.

PRECEPTOR DEVELOPMENT AND SUPPORT

A unique feature of the CTF is integration of the preceptor development system as a core, comprehensive, and essential component (Delfino et al., 2014; Mann-Salinas et al., 2014; Robbins et al., 2017). Preceptors provide significant protection as they safeguard both patient and learner while fostering a new nurse's clinical reasoning development (Nielsen et al., 2016). While ensuring this safe learning environment, the preceptor collects evidence

of clinical performance via the competency-based orientation tools. Although preceptor development and support is a core component of the CTF, a future article will address the unique aspects of both preceptor development and their unique roles within the framework.

IMPLEMENTATION

The CTF has been implemented in part or whole in numerous agencies across the nation, including urban, rural, critical access, and tertiary care centers (VNIP, 2017a). The VNIP website, www.vnip.org, hosts a white paper outlining research and implementation projects occurring since the original new graduate internship program. The organization currently collaborates with military treatment facilities as they adapt and adopt the framework for their unique, diverse environment (Boyer et al., 2017; Robbins et al., 2017).

Although many agencies have engaged the CTF accountability statement within their orientation tools, analysis of the impact of this statement is incomplete. In the meantime, the statement itself stimulates scrutiny of the concepts of accountability. One nursing program dean requested the accountability statement as published, for use within their academic program. The statement provides a foundation for discussions with nursing students related to accountability concepts within the reality of professional nursing. Nurse leaders and educators in some settings have welcomed the specific, concrete statement and the intrinsic message related to professional practice and continuous learning expectations.

The collaborative, nonprofit VNIP organization developed coaching plan tools to address development of work organization skills and core elements of specialty practice for multiple acute care settings, especially a burn intensive care unit, emergency department, adult intensive care units, and maternal child health units. Implementation studies engaged quasiexperimental use of coaching plans with positive feedback from participants (Delfino et al., 2014; Hawkins & Exstrom, 2014; Robbins et al., 2017). A recurring theme of study responses shows that coaching plans provide structure for standardized knowledge, planning, competency assessment, and critical thinking development. The study results showed positive impacts on retention, a reduction in potential errors, and reported savings on orientation costs (Delfino et al., 2014; Hawkins & Exstrom, 2014; Robbins et al., 2017).

The CTF coaching plan delivers a rubric for learning with linked performance criteria that give evidence of a learner's meeting the overall goal statement. A study in an urban medical center revealed the value of having a clinical judgment model and rubric (Nielsen et al., 2016). Findings from the study indicate that a structured framework provided objective means of performance evaluation, while fostering clinical judgment in the new nurse. Coaching plans are only one component of the CTF intervention; however, participant comments reveal the advantages of added structure, standardized knowledge outlines, concrete performance criteria, and specific reflective learning strategies (Robbins et al., 2017).

CONCLUSION

The call for a radical transformation in nursing education emphasizes the need for accountability, reflective learning, and apprenticeships that address knowledge integration, ethical comportment, and professional formation (Benner et al., 2010). The use of competency sampling, a specific accountability statement, and integration of the three high-end apprenticeships within standardized coaching plans are core concepts addressed within the CTF. The framework targets professional practice with performance criteria written in a patient-centered manner. The CTF integrates these core concepts within a tested delivery framework that adapts to the setting and specialty. Sampling technique is at the core of making the process achievable within a framework that simplifies the added effort and responsibility of precepting. The tools incorporate CTF concepts within a set of forms and precepts that are adaptable to each setting, agency, and population. Framework components come together into a methodology that is applied to new hires entering the agency at varied levels of practice experience. NPD specialists are responsible for ensuring a form that clearly identifies professional practice, supports critical thinking development, ensures documentation of specific evidence, and communicates the issue of accountability.

Preceptors familiar with coaching plans support the concept and reality of having resource files of standardized plans in the same manner that nursing has used standardized nursing care plans. Within the CTF, the focus of the plan shifts from the patient to the new care provider. The practice of using standardized coaching plans taps into the current evidence, "brain trust," and specialty expertise provided within a collaborative, professional network. NPD specialists and preceptors individualize selected coaching plans to the unit, patient population, and learning needs of the preceptee. These plans provide concrete, concise, and clear directions for both learning and performance expectations, while guiding development of critical thinking capability. Overall, the CTF represents an efficient system for new staff on-boarding or clinical transition to a new specialty that holds professional nurses accountable for their practice, professionalism, and learning.

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A Review of Casualties Transported to Role 2 Medical Treatment Facilities in Afghanistan

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ABSTRACT Critically injured trauma patients benefit from timely transport and care. Accordingly, the provision of rapid transport and effective treatment capabilities in appropriately close proximity to the point of injury will optimize time and survival. Pre-transport tactical combat casualty care, rapid transport with en route casualty care, and advanced damage control resuscitation and surgery delivered early by small, mobile, forward-positioned Role 2 medical treatment facilities have potential to reduce morbidity and mortality from trauma. This retrospective review and descriptive analysis of trauma patients transported from Role 1 entities to Role 2 facilities in Afghanistan from 2008 to 2014 found casualties to be diverse in affiliation and delivered by various types and modes of transport. Air medical evacuation provided transport for most patients, while the shortest transport time was seen with air casualty evacuation. Although relatively little data were collected for air casualty evacuation, this rapid mode of transport remains an operationally important method of transport on the battlefield. For prehospital care provided before and during transport, continued leadership and training emphasis should be placed on the administration and documentation of tactical combat casualty care as delivered by both medical and non-medical first responders.

INTRODUCTION

Time and treatment capability are important factors for the survival of critically injured combat casualties.[1] Prehospital treatment capability, rapid prehospital transport, and early hospital and surgical treatment capability have been shown to improve trauma outcomes.[1–8] For combat and other overseas contingency operations, U.S. military doctrine delineates a progressive and integrated system for casualty care designed to ensure opportunity for timely treatment of critically injured casualties.[9–12] This system begins with the casualty at the point of injury and ends in a hospital located outside of the active area of operations.

The U.S. military trauma system and care continuum has been organized into four "roles" of care, with a commensurate increase in capability with each higher role number.[9–12] Role 1 consists of emergency first responder and tactical combat casualty care (TCCC) provided by self, buddy, medic, or other provider, at the point of injury, casualty collection point, or aid station. Role 2, or limited hospital capability, consists of advanced damage control resuscitation and surgery provided by small, mobile, forward-positioned medical treatment facilities and surgical teams. Role 3, or full but short-term hospital capability, consists of surgery, intensive care, postoperative care, and specialty care provided by large, semi-permanent medical treatment facilities (e.g., combat support hospitals). Casualties requiring full but longer term hospital capability can receive such care at Role 4 medical treatment facilities located in safe havens outside of the continental U.S., or ultimately, within the continental U.S.

Military prehospital combat trauma care, known as TCCC, consists of three phases of care: care under fire, tactical field care, and tactical evacuation (TACEVAC) care.[12–15] For the TACEVAC phase of care, air, ground, and water modes of transportation have been utilized to transfer patients from Role 1 to other roles of care. Based on doctrine,[12] tactical or prehospital patient transports have also been further categorized as medical evacuation (MEDEVAC) and casualty evacuation (CASEVAC). Published definitions for these evacuation or patient movement terms remain imprecise and vary between military services, thus leaving room for interpretation and debate as well as resultant confusion in the literature.

The doctrinal intent of providing appropriate and effective medical capability at or near the anticipated point of injury is to optimize time to treatment and subsequently casualty survival. Given that critically injured combat casualties can potentially benefit from early prehospital care, rapid transport, en route care, and early hospital care, this study proposed to

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characterize battlefield casualties who underwent TACEVAC from a Role 1 entity to a Role 2 medical treatment facility as evaluated through data available for type and mode of transport. Specific aims of the study included providing accurate definitions for casualty transport methods that could be used as a standard for future studies; utilizing a prehospital and in-hospital combat mortality index to evaluate injury severity; characterizing the study population by patient affiliation, type and mode of transport, and year of transport; and identifying type and frequency of prehospital interventions and medications utilized.

METHODS

Conducted was a retrospective descriptive sub-analysis of previously described trauma casualties from a Role 2 registry.[16] The Role 2 registry used for this study was maintained and consolidated by the Department of Defense Joint Trauma System. Role 2 registry data were previously collected and entered into the registry by Role 2 facility members immediately following casualty events. Patients included in this current study received treatment at a Role 2 medical treatment facility, were 18 yr or older, sustained traumatic injury in Afghanistan from February 2008 to September 2014, had data available for TACEVAC transport type (MEDEVAC and CASEVAC) and mode (Air, Ground, Water), and were alive at the time they were picked up by patient transport. Transport times reported reflect the total time interval from initial injury to Role 2 facility arrival. This study met U.S. Army Institute of Surgical Research regulatory requirements.

Medical regulating has previously been defined as a process that selects destination medical treatment facilities for patients being medically evacuated and provides identification of and assignment to medical treatment facilities capable of providing required definitive, recuperative, or restorative care.[17] For this study, MEDEVAC was defined as a designated, dedicated, and regulated or unregulated prehospital patient transfer platform utilized by an ambulance unit that has medical personnel and medical equipment assets to perform en route care, and CASEVAC was defined as a designated or non-designated, non-dedicated, and unregulated prehospital patient transfer platform utilized by a non-ambulance unit that may or may not have medical personnel and medical equipment assets to provide en route care. As both MEDEVAC and CASEVAC provide tactical or prehospital transport on the battlefield, they were grouped into an overarching category termed TACEVAC (Table I).

The Combat Mortality Index (CMI) Prehospital (PH) and In Hospital (IH) are measures used to predict mortality among battlefield casualties. These measures were used in this study as a surrogate for trauma injury severity among study patients due to the lack of injury severity score in the dataset. The CMI was developed by Le and colleagues at the U.S. Army Institute of Surgical Research.[18] Preliminary efforts and comparisons demonstrate that the CMI was a better predictor of mortality than the existing revised trauma score, field triage score, and shock index. The CMI scoring system uses clinical variables of heart rate (HR), systolic blood pressure (SBP), Glasgow coma score (GCS), base deficit (BD), and International Normalized Ratio (INR) in a dichotomous (HR and SBP) or integral (GCS, INR, BD) manner to develop a CMI-PH score ranging from 0 to 4 and a CMI-IH score ranging from 0 to 8.

In this study, CMI-PH was calculated using available prehospital vital signs (SBP n = 1,635; HR n = 1,775); otherwise, CMI-PH admission vital signs (SBP n = 8,452; HR n = 8,363) were used to calculate CMI-PH. Admission vital signs and lab results were used to calculate CMI-IH. If a patient arrived to a Role 2 facility and was documented as "dead," and was not successfully resuscitated, the patient was classified as dead on arrival.

In the case of a patient with multiple injury types or mechanisms, burn was generalized as the dominant injury type, whereas explosion was generalized as the dominant injury mechanism. Therefore, injury type was categorized as (1) any burn injury, (2) penetrating injury, (3) blunt injury, and (4) penetrating and blunt injury, whereas mechanism of injury was categorized as (1) any explosion, (2) gunshot wound, (3) motor vehicle crash, (4) fall, and (5) other.

Descriptive analyses were used to evaluate patient characteristics by affiliation, transport type and mode, and year. Categories of patient characteristics included demographics, transport time, injury type and mechanism, combat mortality index, mortality, and prehospital interventions and medications. Chi-square or Fisher's exact test was used to determine significant differences where appropriate. Analyses were performed using Stata (StataCorp. 2015. Stata Statistical Software: Release 14. College Station, TX, USA: StataCorp LP).

RESULTS

Of 15,310 patient records available for review, 4,751 did not meet inclusion criteria (Fig. 1). Remaining were a total of 10,559 patients available for exploratory analysis by patient affiliation (Table II), transport type and mode (Table III), and year (Table IV). Given the large proportion of missing data on type and mode of transport, we compared the demographic characteristics of the study population (n = 10,559) with the population missing type and mode of transport data (n = 2,221) to identify any differences. There were differences in some of the demographics of the study population (n = 10,559) versus population missing type and mode of transport data (n = 2,221); thus, the data are not missing completely at random (i.e., the probability of "missingness" does not depend on the values of observed or unobserved data). However, we believe that this difference is not related to the type or mode of transport; therefore, the data are missing at random.[19]

Casualties included in this study had a median age of 25 (IQR 21–30) yr and were primarily male (97.1%; 10,253/10,559).

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TABLE I. Glossary of Terms for Type of Transport for the Purposes of this Study

Medical Evacuation (MEDEVAC)	Designated, dedicated, and regulated[a] or unregulated prehospital patient transfer platform utilized by an ambulance unit that has medical personnel and medical equipment assets to perform en route care.
Casualty Evacuation (CASEVAC)	Designated or non-designated, non-dedicated, and unregulated prehospital patient transfer platform utilized by a non-ambulance unit that may or may not have medical personnel and medical equipment assets to provide en route care.
Tactical Evacuation (TACEVAC)	Overarching category for both medical evacuation and casualty evacuation.

[a]Medical regulating is the process that selects destination medical treatment facilities for patients being medically evacuated and provides identification of and assignment to medical treatment facilities capable of providing required definitive, recuperative, or restorative care.

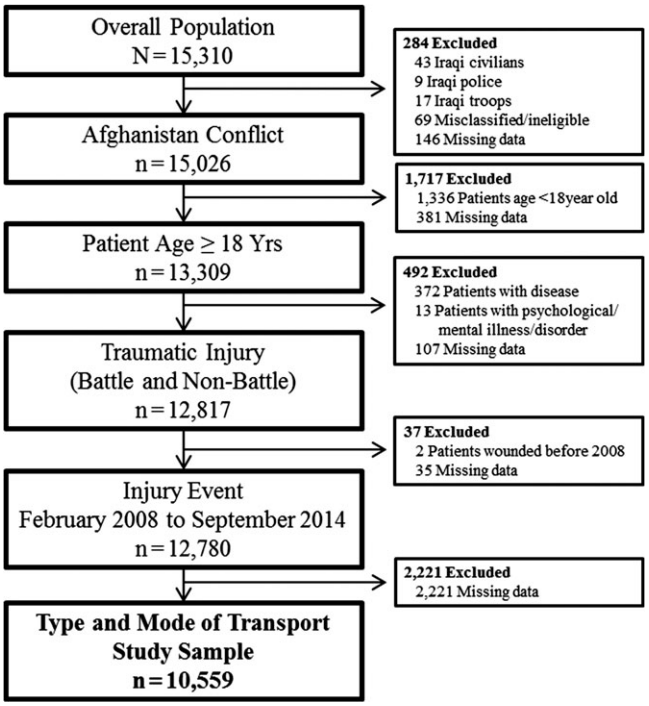

FIGURE 1. Study sample (n = 10,559) from Role 2 registry maintained by the Department of Defense Joint Trauma System by inclusion and exclusion criteria.

Most patients were categorized as battle injury (80.3%; 8,479/10,559). Patient affiliation included 37.1% (3,914/10,559) U.S. military, 40.2% (4,244/10,559) non-U.S. military, and 22.7% (2,401/10,559) civilian or unknown. Most patients (76.6%; 8,085/10,559) were injured from 2010 to 2012. In 2008 and from 2011 through 2014, most patients were non-U.S. military, whereas in 2009 and 2010, most patients were U.S. military.

Transport Type and Mode, and Transport Time

No documented mode of transport by water was found in the study sample. As per Table III, casualties were primarily transported by MEDEVAC Air (76.8%; 8,109/10,559), followed by MEDEVAC ground (10.8%; 1,137/10,559), CASEVAC ground (9.6%; 1,017/10,559), and then CASEVAC air (2.8%; 296/10,559). Of the 52.8% (5,575/10,559) of the study sample who had transport times, the most rapid method of transport was by CASEVAC air with a median time of 48 (IQR 30–96) min, followed by CASEVAC ground at 68 (IQR 30–180) min, MEDEVAC air at 75 (IQR 45–137) min, and then MEDEVAC ground at 87 (35–224) min. By patient affiliation (Table II), U.S. military forces received the most rapid transport with a median time of 67 (IQR 41–130) min, followed by civilian or unknown at 77 (IQR 44–180) min, and then non-U.S. military at 80 (IQR 45–154) min. More patient transports occurred in the year 2011 (33.8%; 3,570/10,559) as compared with other years (Fig. 2). Additionally, MEDEVAC air was the dominant type and mode of transport from 2008 to 2013, then CASEVAC ground became dominant in 2014. Median transport time was fastest in 2012 (64 min; IQR 40–126 min), and slowest in 2014 (86 min; IQR 45–179 min).

Injury Type and Mechanism

Overall, the most common injury type was exclusively penetrating (53.5%; 5,644/10,559), followed by exclusively blunt, combined penetrating and blunt, and then burn. By patient affiliation (Table II), penetrating injury was also the leading type of injury for non-U.S. military (60.7%; 2,575/4,244) and civilian or unknown (62.3%; 1,497/2,401); however, for U.S. military, blunt injury was the leading type (43.8%; 1,714/3,914). Overall, the dominant mechanism of injury was explosion (48.3%; 5,101/10,559), followed by gunshot wound, and motor vehicle crash. This order for injury mechanism was the same by each patient affiliation (Table II), transport type and mode (Table III), and during each year (Table IV).

Combat Mortality Index and Mortality

Overall, for both CMI-PH and CMI-IH, most patients, with a CMI available, were categorized as mild (55.7%, 5,881/10,559; 26.4%, 2,789/10,559, respectively). This pattern was also consistent by year (Table IV). For CMI-PH, differences were seen between patient affiliation groups (Table II) in all categories with U.S. military having the highest percent of patients rated as mild and the lowest percent of patients rated as moderate, severe, and critical. Differences for CMI-PH were also seen between transport type and mode groups (Table III) for mild and severe categories with CASEVAC air transporting a lower percent of patients rated as mild and MEDEVAC ground transporting a higher percent of patients rated as severe. For CMI-IH, differences were seen between patient affiliation groups (Table II) in all categories with U.S. military having the highest percent of patients rated as mild

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TABLE II. Study Characteristics by Patient Affiliation for Trauma-Eligible Adult Patients (n = 10,559) Treated at Role 2 Medical Treatment Facilities During Afghanistan Conflict from February 2008 to September 2014

Category	All, No. (%)	Patient Affiliation, No. (%)			p-Value
		Military, U.S.	Military, Non-U.S.[a]	Civilian or Unknown	
Patients	10,559 (100.0)	3,914 (37.1)	4,244 (40.2)	2,401 (22.7)	
Age, median (IQR), yr	25 (21–30)	24 (22–29)	24 (21–28)	26 (22–35)	<0.001
Male	10,253 (97.1)	3,791 (96.9)	4,203 (99.0)	2,259 (94.1)	<0.001
Battle injury	8,479 (80.3)	3,239 (82.8)	3,473 (81.8)	1,767 (73.6)	<0.001
Non-battle injury	2,080 (19.7)	675 (17.2)	771 (18.2)	634 (26.4)	<0.001
Transport type and mode to Role 2					
Medical Evacuation, air	8,109 (76.8)	3,475 (88.8)	2,952 (69.6)	1,682 (70.1)	<0.001
Medical Evacuation, ground	1,137 (10.8)	151 (3.9)	644 (15.2)	342 (14.2)	<0.001
Casualty Evacuation, air	296 (2.8)	76 (1.9)	142 (3.3)	78 (3.2)	<0.001
Casualty Evacuation, ground	1,017 (9.6)	212 (5.4)	506 (11.9)	299 (12.5)	<0.001
Transport time, injury to Role 2 arrival	5,575 (52.8)	2,292 (58.6)	2,100 (49.5)	1,183 (49.3)	
Time >60 min	3,189 (30.2)	1,237 (31.6)	1,250 (29.5)	702 (29.2)	0.054
Time ≤60 min	2,386 (22.6)	1,055 (27.0)	850 (20.0)	481 (20.0)	<0.001
Elapsed time, median (IQR), min	75 (44–150)	67 (41–130)	80 (45–154)	77 (44–180)	<0.001
Injury type	9,887 (93.6)	3,583 (91.5)	4,040 (95.2)	2,264 (94.3)	
Penetrating	5,644 (53.5)	1,572 (40.2)	2,575 (60.7)	1,497 (62.3)	<0.001
Blunt	3,248 (30.8)	1,714 (43.8)	1,017 (24)	517 (21.5)	<0.001
Penetrating and blunt	795 (7.5)	242 (6.2)	362 (8.5)	191 (8.0)	<0.001
Burn	200 (1.9)	55 (1.4)	86 (2.0)	59 (2.5)	0.009
Injury mechanism	9,930 (94.0)	3,676 (93.9)	3,999 (94.2)	2,255 (93.9)	
Explosion	5,101 (48.3)	2,277 (58.2)	1,941 (45.7)	883 (36.8)	<0.001
Gunshot wound	2,600 (24.6)	572 (14.6)	1,234 (29.1)	794 (33.1)	<0.001
Motor vehicle crash	959 (9.1)	183 (4.7)	499 (11.8)	277 (11.5)	<0.001
Falls	379 (3.6)	224 (5.7)	93 (2.2)	62 (2.6)	<0.001
Other	891 (8.4)	420 (10.7)	232 (5.5)	239 (10.0)	<0.001
Combat mortality index – prehospital[b]	9,452 (89.5)	3,592 (91.8)	3,757 (88.5)	2,103 (87.6)	
0 Mild	5,881 (55.7)	2,507 (64.1)	2,225 (52.4)	1,149 (47.9)	<0.001
1 Moderate	2,465 (23.3)	885 (22.6)	970 (22.9)	610 (25.4)	0.024
2 Severe	631 (6.0)	107 (2.7)	319 (7.5)	205 (8.5)	<0.001
3–4 Critical	475 (4.5)	93 (2.4)	243 (5.7)	139 (5.8)	<0.001
Combat mortality index – in hospital	4,102 (38.8)	1,715 (43.8)	1,547 (36.5)	840 (35.0)	
0–1 Mild	2,789 (26.4)	1,358 (34.7)	955 (22.5)	476 (19.8)	<0.001
2–3 Moderate	928 (8.8)	280 (7.2)	387 (9.1)	261 (10.9)	<0.001
4–5 Severe	283 (2.7)	52 (1.3)	149 (3.5)	82 (3.4)	<0.001
6–8 Critical	102 (1.0)	25 (0.6)	56 (1.3)	21 (0.9)	0.006
Mortality	470 (4.5)	126 (3.2)	219 (5.2)	125 (5.2)	
Died en route or dead on arrival	83 (0.8)	33 (0.8)	36 (0.8)	14 (0.6)	0.440
Died while at Role 2	387 (3.7)	93 (2.4)	183 (4.3)	111 (4.6)	<0.001
Documented prehospital intervention	16,766 (100.0)	5,546 (33.1)	7,268 (43.3)	3,952 (23.6)	
Bleeding intervention, tourniquet	1,539 (9.2)	549 (9.9)	651 (9.0)	339 (8.6)	0.061
Bleeding intervention, other[c]	3,422 (20.4)	923 (16.6)	1,679 (23.1)	820 (20.7)	<0.001
Airway intervention[d]	895 (5.3)	208 (3.8)	438 (6.0)	249 (6.3)	<0.001
Breathing intervention[e]	164 (1.0)	37 (0.7)	85 (1.2)	42 (1.1)	0.014
Circulation intervention[f]	1,017 (6.1)	321 (5.8)	457 (6.3)	239 (6.0)	0.501
Hypothermia intervention[g]	6,975 (41.6)	2,409 (43.4)	2,893 (39.8)	1673 (42.3)	<0.001
Documentation, prehospital en route	2,179 (13.0)	855 (15.4)	827 (11.4)	497 (12.6)	<0.001
Other prehospital intervention[h]	575 (3.4)	244 (4.4)	238 (3.3)	93 (2.4)	<0.001
Documented prehospital medication	2,754 (100.0)	918 (33.3)	1,168 (42.4)	668 (24.3)	
Analgesic, morphine	622 (22.6)	269 (29.3)	226 (19.3)	127 (19.0)	<0.001
Analgesic, fentanyl	377 (13.7)	153 (16.7)	139 (11.9)	85 (12.7)	0.005
Analgesic, ketamine	140 (5.1)	39 (4.2)	72 (6.2)	29 (4.3)	0.086
Analgesic, other	406 (14.7)	159 (17.3)	167 (14.3)	80 (12.0)	0.011
Antibiotic	406 (14.7)	88 (9.6)	201 (17.2)	117 (17.5)	<0.001
Other or unknown medication	803 (29.2)	210 (22.9)	363 (31.1)	230 (34.4)	<0.001

[a]Non-U.S. military includes North Atlantic Treaty Organization (NATO) and Afghan forces.
[b]Prehospital combat mortality index was calculated using prehospital vital signs or initial vital signs upon presentation to Role 2.
[c]Other bleeding interventions include direct pressure, hemostatic dressing, field dressing, and other or unknown dressing.
[d]Airway interventions include prehospital airway, definitive airway, and airway adjuncts to assist respiration.
[e]Breathing interventions include needle decompression, chest seals and other occlusive dressings, and chest tubes.
[f]Circulation interventions include intravenous access, interosseous access, and cardiopulmonary resuscitation (CPR).
[g]Hypothermia interventions include blanket, body bag, hypothermia prevention management kit, space blanket, and other warming devices.
[h]Other prehospital interventions include splints, C-spine immobilization, and eye shields.

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TABLE III. Study Characteristics by Transport Type and Mode for Trauma-Eligible Adult Patients (n = 10,559) Treated at Role 2 Medical Treatment Facilities During Afghanistan Conflict from February 2008 to September 2014.

		Type and Mode of Transport, No. (%)				
		Medical Evacuation		Casualty Evacuation		
Category	All, No. (%)	Air	Ground	Air	Ground	p-Value
Patients	10,559 (100.0)	8,109 (76.8)	1,137 (10.8)	296 (2.8)	1,017 (9.6)	
Age, median (IQR), yr	25 (21–30)	25 (21–30)	25 (21–30)	25 (21–28)	25 (22–30)	0.088
Male	10,253 (97.1)	7,902 (97.4)	1,088 (95.7)	284 (95.9)	979 (96.3)	0.001
Battle injury	8,479 (80.3)	6,710 (82.7)	784 (69.0)	256 (86.5)	729 (71.7)	<0.001
Non-battle injury	2,080 (19.7)	1,399 (17.3)	353 (31.0)	40 (13.5)	288 (28.3)	<0.001
Patient affiliation						
Military, U.S.	3,914 (37.1)	3,475 (42.9)	151 (13.3)	76 (25.7)	212 (20.8)	<0.001
Military, non-U.S.[a]	4,244 (40.2)	2,952 (36.4)	644 (56.6)	142 (48)	506 (49.8)	<0.001
Civilian or unknown	2,401 (22.7)	1,682 (20.7)	342 (30.1)	78 (26.4)	299 (29.4)	<0.001
Transport time, injury to Role 2 arrival	5,575 (52.8)	4,229 (52.2)	547 (48.1)	171 (57.8)	628 (61.8)	
Time >60 min	3,189 (30.2)	2,471 (30.5)	338 (29.7)	59 (19.9)	321 (31.6)	0.001
Time ≤60 min	2,386 (22.6)	1,758 (21.7)	209 (18.4)	112 (37.8)	307 (30.2)	<0.001
Elapsed time, median (IQR), min	75 (44–150)	75 (45–137)	87 (35–224)	48 (30–96)	68 (30–180)	<0.001
Injury type	9,887 (93.6)	7,578 (93.5)	1,070 (94.1)	282 (95.3)	957 (94.1)	
Penetrating	5,644 (53.5)	4,292 (52.9)	584 (51.4)	175 (59.1)	593 (58.3)	0.001
Blunt	3,248 (30.8)	2,504 (30.9)	389 (34.2)	67 (22.6)	288 (28.3)	<0.001
Penetrating and blunt	795 (7.5)	634 (7.8)	75 (6.6)	33 (11.1)	53 (5.2)	0.001
Burn	200 (1.9)	148 (1.8)	22 (1.9)	7 (2.4)	23 (2.3)	0.727
Injury mechanism	9,930 (94.0)	7,619 (94.0)	1,059 (93.1)	287 (97.0)	965 (94.9)	
Explosion	5,101 (48.3)	4,145 (51.1)	425 (37.4)	145 (49.0)	386 (38.0)	<0.001
Gunshot wound	2,600 (24.6)	1,918 (23.7)	271 (23.8)	96 (32.4)	315 (31.0)	<0.001
Motor vehicle crash	959 (9.1)	587 (7.2)	215 (18.9)	16 (5.4)	141 (13.9)	<0.001
Falls	379 (3.6)	292 (3.6)	51 (4.5)	6 (2.0)	30 (2.9)	0.115
Other	891 (8.4)	677 (8.3)	97 (8.5)	24 (8.1)	93 (9.1)	0.851
Combat mortality index – prehospital[b]	9,452 (89.5)	7,328 (90.4)	1,020 (89.7)	214 (72.3)	890 (87.5)	
0 Mild	5,881 (55.7)	4,624 (57.0)	600 (52.8)	123 (41.6)	534 (52.5)	<0.001
1 Moderate	2,465 (23.3)	1,895 (23.4)	261 (23.0)	60 (20.3)	249 (24.5)	0.494
2 Severe	631 (6.0)	459 (5.7)	94 (8.3)	17 (5.7)	61 (6.0)	0.007
3–4 Critical	475 (4.5)	350 (4.3)	65 (5.7)	14 (4.7)	46 (4.5)	0.204
Combat mortality index – in hospital	4,102 (38.8)	3,233 (39.9)	445 (39.1)	53 (17.9)	371 (36.5)	
0–1 Mild	2,789 (26.4)	2,245 (27.7)	279 (24.5)	35 (11.8)	230 (22.6)	<0.001
2–3 Moderate	928 (8.8)	697 (8.6)	118 (10.4)	13 (4.4)	100 (9.8)	0.006
4–5 Severe	283 (2.7)	214 (2.6)	36 (3.2)	5 (1.7)	28 (2.8)	0.528
6–8 Critical	102 (1.0)	77 (0.9)	12 (1.1)	0 (0.0)	13 (1.3)	0.257
Mortality	470 (4.5)	346 (4.3)	62 (5.5)	22 (7.4)	40 (3.9)	
Died en route or dead on arrival	83 (0.8)	65 (0.8)	11 (1.0)	1 (0.3)	6 (0.6)	0.622
Died while at Role 2	387 (3.7)	281 (3.5)	51 (4.5)	21 (7.1)	34 (3.3)	0.004
Documented prehospital intervention	16,766 (100.0)	13,677 (81.6)	1,180 (7.0)	644 (3.8)	1,265 (7.5)	
Bleeding intervention, tourniquet	1,539 (9.2)	1,284 (9.4)	66 (5.6)	74 (11.5)	115 (9.1)	<0.001
Bleeding intervention, other[c]	3,422 (20.4)	2,469 (18.1)	306 (25.9)	186 (28.8)	461 (36.4)	<0.001
Airway intervention[d]	895 (5.3)	753 (5.5)	78 (6.6)	34 (5.3)	30 (2.4)	<0.001
Breathing intervention[e]	164 (1.0)	138 (1.0)	5 (0.4)	16 (2.5)	5 (0.4)	<0.001
Circulation intervention[f]	1,017 (6.1)	861 (6.3)	38 (3.2)	63 (9.8)	55 (4.3)	<0.001
Hypothermia intervention[g]	6,975 (41.6)	5,804 (42.4)	545 (46.2)	173 (26.8)	453 (35.8)	<0.001
Documentation, prehospital en route	2,179 (13.0)	1,934 (14.1)	96 (8.1)	64 (9.9)	85 (6.7)	<0.001
Other prehospital intervention[h]	575 (3.4)	434 (3.2)	46 (3.9)	34 (5.3)	61 (4.8)	0.001
Documented prehospital medication	2,754 (100.0)	2,320 (84.2)	94 (3.4)	129 (4.7)	211 (7.7)	
Analgesic, morphine	622 (22.6)	560 (24.1)	13 (13.8)	21 (16.3)	28 (13.3)	<0.001
Analgesic, fentanyl	377 (13.7)	325 (14)	6 (6.4)	19 (14.7)	27 (12.8)	0.195
Analgesic, ketamine	140 (5.1)	114 (4.9)	6 (6.4)	13 (10.1)	7 (3.3)	0.037
Analgesic, other	406 (14.7)	348 (15)	13 (13.8)	10 (7.8)	35 (16.6)	0.123
Antibiotic	406 (14.7)	333 (14.4)	23 (24.5)	17 (13.2)	33 (15.6)	0.052
Other or unknown medication	803 (29.2)	640 (27.6)	33 (35.1)	49 (38.0)	81 (38.4)	<0.001

[a]Non-U.S. military includes North Atlantic Treaty Organization (NATO) and Afghan forces.
[b]Prehospital combat mortality index was calculated using prehospital vital signs or initial vital signs upon presentation to Role 2.
[c]Other bleeding interventions include direct pressure, hemostatic dressing, field dressing, and other or unknown dressing.
[d]Airway interventions include prehospital airway, definitive airway, and airway adjuncts to assist respiration.
[e]Breathing interventions include needle decompression, chest seals and other occlusive dressings, and chest tubes.
[f]Circulation interventions include intravenous access, interosseous access, and cardiopulmonary resuscitation (CPR).
[g]Hypothermia interventions include blanket, body bag, hypothermia prevention management kit, space blanket, and other warming devices.
[h]Other prehospital interventions include splints, C-spine immobilization, and eye shields.

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TABLE IV. Study Characteristics by Year for Trauma-Eligible Adult Patients (n = 10,559) Treated at Role 2 Medical Treatment Facilities During Afghanistan Conflict from February 2008 to September 2014

Category	All, No. (%)	Year, No. (%)							p-Value
		2008	2009	2010	2011	2012	2013	2014	
Patients	10,559 (100.0)	233 (2.2)	975 (9.2)	2,192 (20.8)	3,570 (33.8)	2,323 (22.0)	936 (8.9)	330 (3.1)	
Age, median (IQR), yr	25 (21–30)	25 (21–28)	25 (22–30)	24 (21–29)	25 (21–30)	25 (22–30)	25 (22–30)	25 (22–30)	0.010
Male	10,253 (97.1)	221 (94.8)	951 (97.5)	2,135 (97.4)	3,434 (96.2)	2,276 (98.0)	915 (97.8)	321 (97.3)	0.001
Battle injury	8,479 (80.3)	179 (76.8)	803 (82.4)	1,783 (81.3)	2,772 (77.6)	1,897 (81.7)	768 (82.1)	277 (83.9)	<0.001
Non-battle injury	2,080 (19.7)	54 (23.2)	172 (17.6)	409 (18.7)	798 (22.4)	426 (18.3)	168 (17.9)	53 (16.1)	<0.001
Patient affiliation									
Military, U.S.	3,914 (37.1)	64 (27.5)	473 (48.5)	964 (44.0)	1,305 (36.6)	730 (31.4)	311 (33.2)	67 (20.3)	<0.001
Military, non-U.S.[a]	4,244 (40.2)	121 (51.9)	308 (31.6)	761 (34.7)	1,357 (38.0)	1,005 (43.3)	484 (51.7)	208 (63.0)	<0.001
Civilian or unknown	2,401 (22.7)	48 (20.6)	194 (19.9)	467 (21.3)	908 (25.4)	588 (25.3)	141 (15.1)	55 (16.7)	<0.001
Transport type and mode, to Role 2									
Medical Evacuation, air	8,109 (76.8)	189 (81.1)	866 (88.8)	1,951 (89)	2,854 (79.9)	1,634 (70.3)	507 (54.2)	108 (32.7)	<0.001
Medical Evacuation, ground	1,137 (10.8)	31 (13.3)	108 (11.1)	223 (10.2)	388 (10.9)	233 (10.0)	123 (13.1)	31 (9.4)	0.127
Casualty Evacuation, air	296 (2.8)	0 (0.0)	0 (0.0)	0 (0.0)	69 (1.9)	136 (5.9)	59 (6.3)	32 (9.7)	<0.001
Casualty Evacuation, ground	1,017 (9.6)	13 (5.6)	1 (0.1)	18 (0.8)	259 (7.3)	320 (13.8)	247 (26.4)	159 (48.2)	<0.001
Transport time, injury to Role 2 arrival	5,575 (52.8)	92 (39.5)	455 (46.7)	1,078 (49.2)	1,700 (47.6)	1,437 (61.9)	534 (57.1)	279 (84.5)	
Time >60 min	3,189 (30.2)	63 (27.0)	264 (27.1)	637 (29.1)	1,012 (28.3)	745 (32.1)	301 (32.2)	167 (50.6)	<0.001
Time ≤60 min	2,386 (22.6)	29 (12.4)	191 (19.6)	441 (20.1)	688 (19.3)	692 (29.8)	233 (24.9)	112 (33.9)	<0.001
Elapsed time, median (IQR), min	75 (44–150)	83 (60, 124)	74 (45, 120)	76 (45, 153)	78 (45, 180)	64 (40, 126)	77 (41, 167)	86 (45, 179)	<0.001
Injury type	9,887 (93.6)	225 (96.6)	691 (70.9)	2,132 (97.3)	3,458 (96.9)	2,198 (94.6)	888 (94.9)	295 (89.4)	
Penetrating	5,644 (53.5)	141 (60.5)	335 (34.4)	1,133 (51.7)	1,962 (55.0)	1,313 (56.5)	551 (58.9)	209 (63.3)	<0.001
Blunt	3,248 (30.8)	44 (18.9)	269 (27.6)	732 (33.4)	1,225 (34.3)	669 (28.8)	249 (26.6)	60 (18.2)	<0.001
Penetrating and blunt	795 (7.5)	32 (13.7)	69 (7.1)	234 (10.7)	200 (5.6)	173 (7.4)	67 (7.2)	20 (6.1)	<0.001
Burn	200 (1.9)	8 (3.4)	18 (1.8)	33 (1.5)	71 (2.0)	43 (1.9)	21 (2.2)	6 (1.8)	0.471
Injury mechanism	9,930 (94.0)	219 (94.0)	722 (74.1)	2,145 (97.9)	3,366 (94.3)	2,277 (98.0)	878 (93.8)	323 (97.9)	
Explosion	5,101 (48.3)	107 (45.9)	381 (39.1)	1,143 (52.1)	1,727 (48.4)	1142 (49.2)	460 (49.1)	141 (42.7)	<0.001
Gunshot wound	2,600 (24.6)	69 (29.6)	152 (15.6)	502 (22.9)	866 (24.3)	629 (27.1)	254 (27.1)	128 (38.8)	<0.001
Motor vehicle crash	959 (9.1)	20 (8.6)	51 (5.2)	235 (10.7)	355 (9.9)	206 (8.9)	66 (7.1)	26 (7.9)	<0.001
Falls	379 (3.6)	8 (3.4)	42 (4.3)	95 (4.3)	132 (3.7)	62 (2.7)	32 (3.4)	8 (2.4)	0.058
Other	891 (8.4)	15 (6.4)	96 (9.8)	170 (7.8)	286 (8.0)	238 (10.2)	66 (7.1)	20 (6.1)	0.002
Combat mortality index – prehospital[b]	9,452 (89.5)	224 (96.1)	917 (94.1)	2,007 (91.6)	3,095 (86.7)	2,104 (90.6)	850 (90.8)	255 (77.3)	
0 Mild	5,881 (55.7)	143 (61.4)	569 (58.4)	1,245 (56.8)	1,966 (55.1)	1,342 (57.8)	497 (53.1)	119 (36.1)	<0.001
1 Moderate	2,465 (23.3)	49 (21.0)	265 (27.2)	546 (24.9)	771 (21.6)	511 (22.0)	234 (25.0)	89 (27.0)	0.001
2 Severe	631 (6.0)	17 (7.3)	49 (5.0)	130 (5.9)	205 (5.7)	144 (6.2)	60 (6.4)	26 (7.9)	0.507
3–4 Critical	475 (4.5)	15 (6.4)	34 (3.5)	86 (3.9)	153 (4.3)	107 (4.6)	59 (6.3)	21 (6.4)	0.012
Combat mortality index – in hospital	4,102 (38.8)	33 (14.2)	370 (37.9)	988 (45.1)	1,271 (35.6)	950 (40.9)	430 (45.9)	60 (18.2)	
0–1 Mild	2,789 (26.4)	13 (5.6)	264 (27.1)	699 (31.9)	911 (25.5)	626 (26.9)	250 (26.7)	26 (7.9)	<0.001
2–3 Moderate	928 (8.8)	13 (5.6)	72 (7.4)	214 (9.8)	265 (7.4)	225 (9.7)	126 (13.5)	13 (3.9)	<0.001
4–5 Severe	283 (2.7)	3 (1.3)	27 (2.8)	59 (2.7)	72 (2.0)	67 (2.9)	39 (4.2)	16 (4.8)	0.001
6–8 Critical	102 (1.0)	4 (1.7)	7 (0.7)	16 (0.7)	23 (0.6)	32 (1.4)	15 (1.6)	5 (1.5)	0.009
Mortality	470 (4.5)	5 (2.1)	32 (3.3)	79 (3.6)	171 (4.8)	122 (5.3)	46 (4.9)	15 (4.5)	

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TABLE IV. Continued

Category	All, No. (%)	Year, No. (%)							*p*-Value
		2008	2009	2010	2011	2012	2013	2014	
Died en route or dead on arrival	83 (0.8)	0 (0.0)	10 (1.0)	10 (0.5)	41 (1.1)	17 (0.7)	5 (0.5)	0 (0.0)	0.024
Died while at Role 2	387 (3.7)	5 (2.1)	22 (2.3)	69 (3.1)	130 (3.6)	105 (4.5)	41 (4.4)	15 (4.5)	0.016
Documented prehospital intervention	16,766 (100.0)	236 (1.4)	982 (5.9)	2,155 (12.9)	6,095 (36.4)	4,709 (28.1)	1,909 (11.4)	680 (4.1)	
Bleeding intervention, tourniquet	1,539 (9.2)	24 (10.2)	125 (12.7)	268 (12.4)	519 (8.5)	393 (8.3)	154 (8.1)	56 (8.2)	<0.001
Bleeding intervention, other[c]	3,422 (20.4)	0 (0.0)	0 (0.0)	3 (0.1)	1,270 (20.8)	1,336 (28.4)	561 (29.4)	252 (37.1)	<0.001
Airway intervention[d]	895 (5.3)	31 (13.1)	104 (10.6)	187 (8.7)	267 (4.4)	199 (4.2)	77 (4.0)	30 (4.4)	<0.001
Breathing intervention[e]	164 (1.0)	0 (0.0)	0 (0.0)	2 (0.1)	44 (0.7)	76 (1.6)	31 (1.6)	11 (1.6)	<0.001
Circulation intervention[f]	1,017 (6.1)	0 (0.0)	0 (0.0)	1 (0.0)	356 (5.8)	452 (9.6)	180 (9.4)	28 (4.1)	<0.001
Hypothermia intervention[g]	6,975 (41.6)	164 (69.5)	647 (65.9)	1,413 (65.6)	2,381 (39.1)	1,522 (32.3)	646 (33.8)	202 (29.7)	<0.001
Documentation, prehospital en route	2,179 (13.0)	17 (7.2)	106 (10.8)	279 (12.9)	1,043 (17.1)	524 (11.1)	130 (6.8)	80 (11.8)	<0.001
Other prehospital intervention[h]	575 (3.4)	0 (0.0)	0 (0.0)	2 (0.1)	215 (3.5)	207 (4.4)	130 (6.8)	21 (3.1)	<0.001
Documented prehospital medication	2,754 (100.0)	0 (0.0)	0 (0.0)	4 (0.1)	900 (32.7)	1,149 (41.7)	581 (21.1)	120 (4.4)	
Analgesic, morphine	622 (22.6)	0 (0.0)	0 (0.0)	1 (25.0)	282 (31.3)	227 (19.8)	94 (16.2)	18 (15.0)	<0.001
Analgesic, fentanyl	377 (13.7)	0 (0.0)	0 (0.0)	2 (50.0)	103 (11.4)	175 (15.2)	78 (13.4)	19 (15.8)	0.026
Analgesic, ketamine	140 (5.1)	0 (0.0)	0 (0.0)	0 (0.0)	7 (0.8)	41 (3.6)	80 (13.8)	12 (10.0)	<0.001
Analgesic, other	406 (14.7)	0 (0.0)	0 (0.0)	0 (0.0)	141 (15.7)	168 (14.6)	87 (15.0)	10 (8.3)	0.275
Antibiotic	406 (14.7)	0 (0.0)	0 (0.0)	0 (0.0)	140 (15.6)	170 (14.8)	81 (13.9)	15 (12.5)	0.854
Other or unknown medication	803 (29.2)	0 (0.0)	0 (0.0)	1 (25.0)	227 (25.2)	368 (32.0)	161 (27.7)	46 (38.3)	0.001

[a]Non-U.S. military includes North Atlantic Treaty Organization (NATO) and Afghan forces.
[b]Prehospital combat mortality index was calculated using prehospital vital signs or initial vital signs upon presentation to Role 2.
[c]Other bleeding interventions include direct pressure, hemostatic dressing, field dressing, and other or unknown dressing.
[d]Airway interventions include prehospital airway, definitive airway, and airway adjuncts to assist respiration.
[e]Breathing interventions include needle decompression, chest seals and other occlusive dressings, and chest tubes.
[f]Circulation interventions include intravenous access, interosseous access, and cardiopulmonary resuscitation (CPR).
[g]Hypothermia interventions include blanket, body bag, hypothermia prevention management kit, space blanket, and other warming devices.
[h]Other prehospital interventions include splints, C-spine immobilization, and eye shields.

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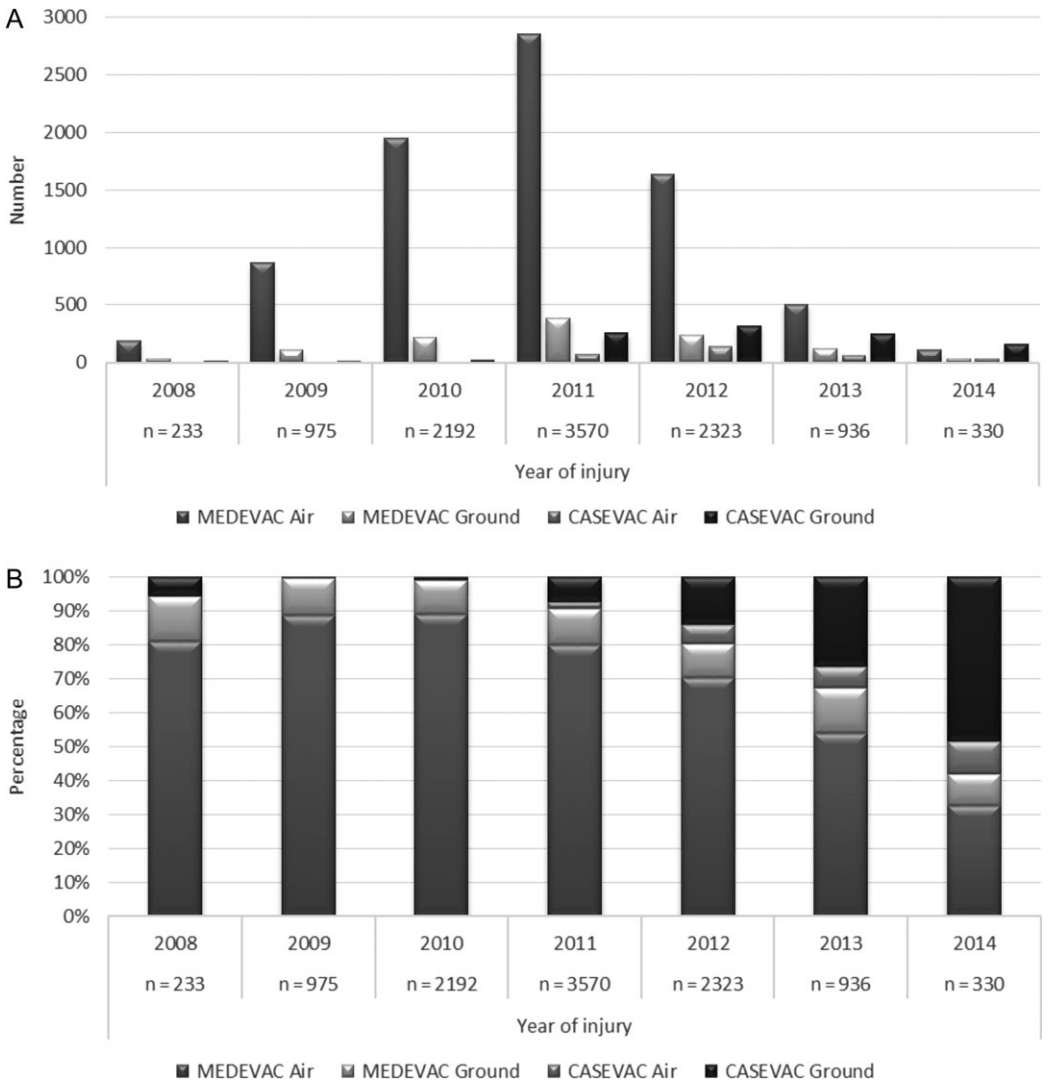

FIGURE 2. Number (A) and percentage (B) of transport type (Medical Evacuation [MEDEVAC], Casualty Evacuation [CASEVAC]) and mode (air, ground) for trauma-eligible adult patients (n = 10,559) treated at Role 2 medical treatment facilities during Afghanistan conflict by year, 2008–2014.

and the lowest percent of patients rated as moderate, severe, and critical. Non-U.S. military casualties had the highest percent rated by CMI-IH as critical. Differences for CMI-IH were also seen between transport type and mode groups (Table III) for mild and moderate categories with CASEVAC air transporting a lower percent of patients rated as mild and moderate.

The total study population mortality was 4.5% (470/10,559). For mortality during transport from Role 1 to Role 2, less than 1% of patients overall died en route or were dead on arrival (0.8%; 83/10,559). This was also consistent by patient affiliation (Table II) and by transport type and mode (Table III), but not by year (Table IV) as this percent was exceeded in 2011 (1.1%; 41/3,570). Also of note is that 82.0% (73/89) of casualties initially categorized as died en route or dead on arrival also had documented vital signs and/or attempted resuscitation through interventions, of which 8.2% (6/73) were successfully resuscitated and ultimately survived. For patients who died while at Role 2, 3.7% (387/10,559) died overall, a lower percent was seen in U.S. military (2.4%; 93/3,914) versus other patient affiliations (Table II), and a higher percent was seen following transport by CASEVAC air (7.1%; 21/296) versus other types and modes of transport (Table III).

Prehospital Interventions and Medications

Prehospital documentation was available for 20.6% (2,179/10,559) of the study sample, was most robust in the year 2011 (29.2%; 1,043/3,570) (Table IV), and occurred most frequently on MEDEVAC air (23.9%; 1,934/8,109) (Table III) and particularly for U.S. military casualties (21.8%; 855/3,914) (Table II). For documented prehospital interventions captured by this study, hypothermia interventions (41.6%; 6,975/16,766) were provided most frequently followed by bleeding interventions (29.6%; 4,961/16,766). By patient affiliation (Table II), non-U.S. military received the most interventions (43.3%;

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7,268/16,766) and civilian or unknown the least (23.6%; 3,952/16,766). By transport type and mode (Table III), most interventions were provided to patients transported by MEDEVAC air (81.6%; 13,677/16,766) and the least to patients transported by CASEVAC Air (3.8%; 644/16,766). By year (Table IV), most interventions were provided to patients from 2011 to 2012 (64.4%; 10,804/16,766). For prehospital medications, analgesics (56.1%; 1,545/2,754) were administered most frequently, with morphine noted as the dominant analgesic used during en route care. By patient affiliation (Table II), most medications were administered to non-U.S. military patients (42.4%; 1,168/2,754) and the least to civilian or unknown (24.3%; 668/2,754). By transport type and mode (Table III), most medications were provided to patients transported by MEDEVAC air (84.2%; 2,320/2,754) and the least to patients transported by MEDEVAC ground (3.4%; 94/2,754). Documentation of prehospital medications became more common starting in the year 2011 (Table IV).

DISCUSSION

Understanding the epidemiology of battlefield prehospital trauma care and transport is a vital component of TCCC and trauma system performance improvement. The current descriptive study and analysis was undertaken to develop a better understanding of the TACEVAC phase of TCCC care that occurred for casualties transported to a Role 2 medical treatment facility during the Afghanistan conflict. Although tactical and environmental factors must also be considered, medically, the most efficient and effective means of transport for trauma casualties relies on the appropriate selection of type and mode of transport commensurate with accurate triage of injured patients, as under-triage can affect patient outcomes and over-triage can affect trauma system resources.

Several battlefield articles and studies of prehospital[1,20–27] and inter-hospital[28,29] patient transport, as well as Role 2 facilities,[30–37] have been published from the recent conflict in Afghanistan. This current article is unique in that it provides a comprehensive study of prehospital trauma patients by type and mode of transport from Role 1 to Role 2 entities in Afghanistan. For the casualties depicted in this study, the most common injury type was penetrating, and the dominant injury mechanism was explosion. The predominant type and mode of transport in this study was MEDEVAC air, which was also observed to have provided the most en route care through both prehospital interventions and medications. The most rapid transport time by type and mode of transport was CASEVAC air, which was also found to provide the least prehospital interventions and also ultimately demonstrated a higher percentage of casualties who died while at Role 2. By patient affiliation, U.S. military casualties received the most rapid transport time in spite of non-U.S. military casualties having a larger proportion of prehospital interventions and critical patients as documented by CMI-IH. However, as the majority (79.4%) of casualties in our study were missing prehospital documentation and associated data, we can only assume and not conclude with certainty these statements on prehospital interventions and medications.

The U.S. Army is the only service with designated and dedicated prehospital air evacuation capability. The other military services do not have dedicated prehospital transport and exclusively use designated or non-designated transport, the latter of which are platforms of opportunity. However, during the study time frame, the U.S. Air Force combat search and rescue aircraft and paramedics were redirected to assist the U.S. Army with its MEDEVAC mission, and thus, this group was categorized as MEDEVAC air for the purposes of this study. Otherwise, this analysis is hindered by the fact that it could not be determined what medical assets, if any, were aboard CASEVAC platforms. It is therefore possible that the higher CASEVAC mortality was due to patient movements with no medical care provided, despite more rapid transportation. The successful United Kingdom prehospital use of the Medical Evacuation Response Team in Afghanistan, which deployed a team of experienced providers (anesthesiologists or emergency medicine physicians, critical care or emergency medicine nurses, respiratory therapists, and paramedics) on armed utility helicopters, demonstrated survival benefit for critically injured casualties through advanced expertise and capability.[21,23] The U.S. Army use of critical care–trained flight paramedics in Afghanistan, versus basic emergency medical technicians, also demonstrated a survival benefit.[22] Both of these examples suggest that it is also medical capability and expertise, and not solely a rapid transportation platform, that is paramount to success.

As designated and dedicated U.S. Army MEDEVAC platforms have been and will remain a finite resource for worldwide efforts, CASEVAC platforms must continue to be ready to fill the gap for widely dispersed and austere military operations. The contingency use of CASEVAC, through mission aircraft and other readily available transport platforms of opportunity, can save time and therefore some lives; however, it should not come at a cost of other lives that could be saved through improved prehospital medical training and equipment among non-medical providers on unregulated platforms. Although CASEVAC air achieved the quickest transport times in our study, the higher mortality observed in casualties evacuated by this type and mode of transport supports the need to improve en route care on these platforms through TCCC training and equipment, particularly as these casualties were not noted to be sicker by CMI. It has been previously recommended that all personnel on the battlefield should receive training in TCCC.[38–42] This TCCC standard must occur on standard and non-standard evacuation platforms, and throughout air, ground, and water forces as future conflicts will not have the guarantee of air superiority, or the luxury of manageable areas of operations

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compared with theaters such as Africa and the Pacific, in which to achieve the "golden hour" trauma goal.

Review of the medical literature on patient evacuation is confounded by the use of terminology that is either not defined or contradictory within U.S. and NATO military doctrine. For example, although some authors refer to TACEVAC as prehospital patient movement from point of injury to a medical treatment facility, this conflicts with NATO doctrine (approved by the U.S.) that labels this patient movement as "forward evacuation," with TACEVAC defined as patient movement between medical treatment facilities within a given theater of operations.[43] Similarly, many authors refer to MEDEVAC as being dedicated evacuation platforms and CASEVAC as a lift or platform of opportunity, whereas U.S. military doctrine distinguishes the two by whether the patient movement is regulated (i.e., medical treatment facility destination is directed by a patient evacuation coordination cell).[17] This is also confounded by the U.S. Army being the only military service that has true dedicated MEDEVAC air capability, even though all services regulate patient movement. The U.S. Army generally uses dedicated and regulated MEDEVAC assets such as ground and air ambulances, whereas the U.S. Navy usually relies on non-dedicated, unregulated, and non-standardized platforms of opportunity. The U.S. Marine Corps has some dedicated ground transport assets and also relies on designated air and other platforms of opportunity. If U.S. Air Force assets are needed for transport of patients from Role 1 to Role 2, platforms of opportunity may be used. Although confusing, this is why definitions of MEDEVAC, CASEVAC, and TACEVAC had to be clearly defined for this analysis.

In addition to environmental factors (e.g., weather, illumination, altitude, and terrain) and the innate hazards of combat, patient hand offs, transfers, and transports are precarious transition periods for trauma patients, where documentation and communication of injuries and treatment are vital. In an effort to increase historically suboptimal prehospital documentation,[44] the Joint Trauma System has developed and implemented simple and functional prehospital documentation and registry tools in order to facilitate the capture of data from the tactical field care and TACEVAC phases of care.[25,45–48]

Medical regulation and intelligent tasking of patient transport assets require accurate and real-time clinical information in order to coordinate appropriate type and mode of transport, destination treatment facility, and ultimately improve patient outcomes. Collectively, clinical information at and between roles of care is required for performance improvement of military trauma systems. Although significant advances were made during the Afghanistan conflict, data capture has been most robust at Role 3 and Role 4 medical treatment facilities, where scanned and electronic medical records can be readily transmitted. The closer one gets to the point of injury, the less clinical information is captured. This is due to lack of time before prehospital evacuation, fragmented ownership and decision-making for prehospital initiatives, and problems with resources, interoperability, and connectivity at Role 1 and Role 2.

The Role 1 prehospital trauma registry and the Role 2 registry were therefore implemented by the JTS as standalone software programs to allow combat casualty care data capture by the individual forward units. These registries therefore rely on the willingness and compliance of individual units to use the registry (e.g., volunteer versus mandate), their dedication and consistent and continuous use of the registry (e.g., personality-based versus systems-based, an additional task to conduct if time is available versus an integral part of their expected duties), and how they choose to enter the data (e.g., standard data fields versus free text entries). Thus, by the intrinsic nature of these registries, data may be very complete, incomplete, or nonexistent depending on individuals and location. Therefore, data from the Role 2 registry are not necessarily representative and inclusive of all combat casualty care experiences and data at these roles of care. Additionally, patients who died during transport may not have been entered into the Role 2 registry, as criteria for entry was treatment at a Role 2 facility. Furthermore, limited Role 2 registry data were validated against source medical records at the time data were pulled for this study. Regardless of these identified limitations and shortfalls, these data are the best available source of information for this type of study population at the present time.

Established in 2001, the Committee on TCCC has since facilitated a revolution in prehospital combat casualty care.[41,49] With the establishment of the Committee on En Route Combat Casualty Care in 2016, the potential exists to do the same for battlefield care administered during all types and modes of patient transport. As both of these committees reside within the Department of Defense Joint Trauma System, they have the potential to work synergistically to improve policy, doctrine, and requirements; develop and standardize evidence-based best-practice clinical guidelines and commensurate combat-related techniques, tactics, and procedures; improve documentation and data collection practices; shape and influence training based on tasks, conditions, and standards; and ultimately reduce morbidity and mortality on the battlefield through seamless practices and joint service efforts.

Although previous combat casualty care statistics and preventable death studies have demonstrated that the majority of deaths occur in the prehospital versus hospital environment,[50–55] future preventable death studies must also distinguish preventable deaths at each role of care and each type and mode of patient transport in order to better direct performance improvement and research in appropriate areas. Currently, the critical area for performance improvement and research remains Role 1, the prehospital period before and during transport to surgical care. Continued migration of damage control resuscitation capability, such as whole blood and blood products,[56–58] closer to the point of injury have great potential to eliminate preventable death. Future research must also focus on innovative methods to advance pre-surgical care on the battlefield through prehospital

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internal or non-compressible hemorrhage control, evaluation and treatment of intracranial bleeding, and prevention and management of shock.

CONCLUSIONS

Role 2 medical treatment facilities in Afghanistan received a diverse population of casualties that arrived by various types and modes of transport. The majority of patients in this analysis were transported by MEDEVAC air. The shortest time for transport but higher mortality was seen with CASEVAC air. Although less data were available for CASEVAC air, this rapid mode of transport remains an operationally critical method of battlefield patient evacuation. This analysis underscores the need to improve prehospital data capture, particularly from combat missions that utilize primary or contingency platforms of opportunity for TACEVAC. Findings also support the continued and steadfast emphasis on TCCC training and standardization for non-medical and medical personnel providing en route care, particularly during CASEVAC air.

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PRESENTATIONS

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CONFLICT OF INTEREST

The authors have no financial interests that warrant disclosure.

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A US military Role 2 forward surgical team database study of combat mortality in Afghanistan

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BACKGROUND: Timely and optimal care can reduce mortality among critically injured combat casualties. US military Role 2 surgical teams were deployed to forward positions in Afghanistan on behalf of the battlefield trauma system. They received prehospital casualties, provided early damage control resuscitation and surgery, and rapidly transferred casualties to Role 3 hospitals for definitive care. A database was developed to capture Role 2 data.

METHODS: A retrospective review and descriptive analysis were conducted of battle-injured casualties transported to US Role 2 surgical facilities in Afghanistan from February 2008 to September 2014. Casualties were analyzed by mortality status and location of death (pretransport, intratransport, or posttransport), military affiliation, transport time, injury type and mechanism, combat mortality index–prehospital (CMI-PH), and documented prehospital treatment.

RESULTS: Of 9,557 casualties (median age, 25.0 years; male, 97.4%), most (95.1%) survived to transfer from Role 2 facility care. Military affiliation included US coalition forces (37.4%), Afghanistan National Security Forces (23.8%), civilian/other forces (21.3%), Afghanistan National Police (13.5%), and non-US coalition forces (4.0%). Mortality differed by military affiliation ($p < 0.001$). Among fatalities, most were Afghanistan National Security Forces (30.5%) civilian/other forces (26.0%), or US coalition forces (25.2%). Of those categorized by CMI-PH, 40.0% of critical, 11.2% of severe, 0.8% of moderate, and less than 0.1% of mild casualties died. Most fatalities with CMI-PH were categorized as critical (66.3%) or severe (25.9%), whereas most who lived were mild (56.9%) or moderate (25.4%). Of all fatalities, 14.0% died prehospital (pretransport, 5.8%; intratransport, 8.2%), and 86.0% died at a Role 2 facility (posttransport). Of fatalities with documented transport times (median, 53.0 minutes), most (61.7%) were evacuated within 60 minutes.

CONCLUSIONS: Role 2 surgical team care has been an important early component of the battlefield trauma system in Afghanistan. Combat casualty care must be documented, collected, and analyzed for outcomes and trends to improve performance. (*J Trauma Acute Care Surg.* 2018;85: 603–612. Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Therapeutic/Care Management, level IV.

KEY WORDS: Afghanistan; combat casualty care; mortality; role 2 forward surgical team; trauma.

The United States and other North Atlantic Treaty Organization countries have structured their military trauma systems into four "roles" of care that depict a continuum of increasing capability with each higher role number.[1–3] At Role 2 facilities, damage control resuscitation and surgery provided by forward surgical teams can bridge the time, space, and capability gap between Role 1 prehospital care provided at or near the point of wounding and Role 3 and Role 4 medical treatment facilities that have more robust hospital, intensive, and definitive care as well as holding capacity.

The survival of critically injured combat casualties is contingent upon timely delivery of optimal care.[4–8] Although a recent topic of debate,[9,10] it was with the premise that critically injured casualties would benefit from reduced time between injury and surgical care that forward-positioned surgical teams were deployed and utilized on the battlefield of Afghanistan.[11–14] Time to surgical capability was further reduced with the increase in number and dispersion of these surgical teams across the battlefield and with a mandate for reducing the time of prehospital transport of critically injured combat casualties to 60 minutes or less.[4]

Despite challenges innate to small, mobile Role 2 surgical facilities with limited personnel and resources, mortality outcomes measured through died-of-wound rates were previously found to be no different when compared with Role 3 surgical facilities for combat casualties during the conflict in Iraq.[14] Although a comprehensive study of combat casualties in Afghanistan did find died-of-wounds mortality to be higher for critically injured

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casualties initially treated at Role 2 versus Role 3 facilities,[4] a follow-on analysis of the same data demonstrated that casualties first delivered to a Role 2 facility had lower odds of killed-in-action mortality compared with those first delivered to a Role 3 facility.[6] Although strategic, operational, and tactical differences between the conflicts in Afghanistan and Iraq shaped and impacted respective trauma systems and outcomes within those countries,[15] all these studies highlight a need for additional detailed study and analysis of mortality outcome by evacuation time, prehospital interventions, and role of care.

In addition to analyzing trauma system data in its entirety, data pertaining specifically to each component of trauma care delivery at and between roles of care are essential to military trauma system performance improvement. Although significant advances in documentation and data collection were made during the conflict in Afghanistan, data capture was most robust at Role 3 and Role 4 facilities, where personnel, automation, and other resources were more abundant and tasked to facilitate such activities. However, working within the construct of a resource-constrained environment, documentation tools and a Role 2 database were developed by the US Department of Defense Joint Trauma System to aggregate data from Role 2 surgical facilities in order to inform leaders and gain insight on casualties, trauma care delivery, and morbidity and mortality outcomes.[16–18] Using data from the Role 2 database, the primary outcomes measured and purpose of this current study were to compare casualties by mortality status (lived vs. died) and evaluate fatalities by location of death (pretransport, intratransport, or posttransport to Role 2 facilities) and military affiliation and secondarily to further examine US fatalities by injury severity and body region injured.

METHODS

A review and data analysis were conducted using the Department of Defense Joint Trauma System Role 2 Database. This database collected patient data (i.e., diagnosis, Role 1 and 2 treatment, and outcomes) from clinical providers at Role 2 facilities. Adult (≥18 years) trauma patients were eligible for study if a battle injury was incurred during the Afghanistan conflict from February 2008 to September 2014. Patients were excluded from study if they had an unknown discharge status or were categorized with a nonbattle injury. This study was reviewed and approved by the US Army Institute of Surgical Research regulatory department and was determined to be exempt.

Patients were classified by demographic characteristics. Military affiliation included US coalition forces, non-US coalition forces, Afghanistan National Security Forces (ANSF), Afghanistan National Police, and civilian or other forces, where other forces included patients from an undisclosed nation who were engaged in fighting but were not a prisoner of war.

A dominant injury type was assigned for each patient among four categories: penetrating, blunt, penetrating and blunt, and burn. If a patient incurred multiple injury types to include burn, the dominant injury type was categorized as burn. A dominant mechanism of injury was assigned for each patient among four categories: explosion, gunshot wound, motor vehicle crash, and other (e.g., falls). If circumstances indicated multiple mechanisms of injury to include explosion, the dominant mechanism of injury was categorized as explosion.

As traditional hospital documentation practices were not mandated and enforced for Role 2 facilities, injury severity scores were not assessed. Thus, no specific injury severity score data were available in the Role 2 database. However, as a surrogate, the combat mortality index–prehospital (CMI-PH) as developed by Le and colleagues[19] at the US Army Institute of Surgical Research was used as a measure of physiological trauma injury severity as well as a predictor of mortality among battlefield casualties. The CMI-PH was calculated using Role 1 and Role 2 admission vital signs (i.e., heart rate [HR], systolic blood pressure, and Glasgow Coma Scale [GCS] score). The CMI-PH was calculated using the following equation: CMI-PH = HR + SBP + GCS-total, where HR equals 0 if patient HR was 60 to 100 beats/min or 1 if patient HR was less than 60 or greater than 100 beats/min; systolic blood pressure (SBP) equals 0 if patient SBP was 100 mm Hg or greater or 1 if patient SBP was less than 100 mm Hg; and GCS-total equals 0 if patient GCS-total was 14 or greater, 1 if patient GCS-total was 9 to 13, or 2 if patient GCS-total was 3 to 8. A CMI-PH score of 0 was categorized as mild, 1 as moderate, 2 as severe, and 3 or 4 as critical.

Additionally, US coalition force fatality data were matched to the Armed Forces Medical Examiner System database to further evaluate these casualties by maximum Abbreviated Injury Scale (mAIS) score and New Injury Severity Score (NISS). The mAIS is the highest injury severity code assigned to a patient (range, 1–6). Patients may have multiple distinct injuries coded equally as highest in the same body region and/or different body regions. The NISS is the sum of the squares of the top three injuries with the highest injury severity codes regardless of body region (range, 1–75). If a patient has an injury with an mAIS of 6, the NISS is automatically a 75. The primary injured body region was determined by where the mAIS occurred. If the mAIS occurred in more than one primary injured body region, this was noted.

Locations of death were pretransport, intratransport, or posttransport to Role 2 facilities. As locations of death were not explicitly documented in the patient record, they were ascertained using other documented parameters. Pretransport death included patients whose record indicated that the patient died in the field prior to transport and/or received no en route care coupled with lack of documented vital signs. Intratransport death included patients who were determined to be alive when placed on a transport platform, had recorded vital signs or en route care, but died prior to arrival or were designated as dead on arrival to a Role 2 facility. Posttransport death included patients who were alive at time of Role 2 facility arrival but died prior to Role 2 transfer. Patients were determined to be alive at arrival if they had any documented vital signs depicting life, if the patient record had any comment indicating signs of life, or if the patient received treatment at a Role 2 facility. Heroic resuscitative efforts and diagnostic interventions (e.g., cardiopulmonary resuscitation, endotracheal tube, central line placement, focused abdominal sonography for trauma, abdominal wound exploration) were not used as evidence for proof of life.

Prehospital interventions included those used for hemorrhage control (e.g., tourniquet, pressure dressing,

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hemostatic dressing), airway (e.g., nasopharyngeal airway, cricothyroidotomy, oral or nasal intubation), breathing (e.g., needle decompression, chest tubes, chest seals and other occlusive dressings, bag-valve mask or tube ventilation), circulation (e.g., intravenous or intraosseous access, parenteral fluids and blood, cardiopulmonary resuscitation), hypothermia (e.g., blanket, hypothermia prevention management kit, space blanket), and other care (e.g., splints, cervical spine immobilization, eye shields).

Descriptive statistics were used to analyze casualties by mortality status (lived vs. died) and location of death (pretransport, intratransport, or posttransport) and fatalities by military affiliation. Other characteristics evaluated included demographics, transport time, time at Role 2 facility, injury type, injury mechanism, CMI-PH, prehospital intervention, and prehospital medication. Additional US coalition force fatality characteristics included mAIS, NISS, and primary injured body region. A χ^2 or analysis of variance was used to determine significant differences as appropriate. Because of the small sample size of some categories, comparisons included (1) all patients who died versus patients who lived and (2) US coalition forces versus all other patients. Analyses were performed using SAS, version 9.4 (SAS Institute, Inc., Cary, NC).

RESULTS

Of 15,310 patient records available for review, 12,780 patients had potential for further study based on country, age, traumatic injury, and date range criteria (Fig. 1). An additional 428 patients were excluded because of "unknown" discharge status or misclassification, and 2,795 patients were excluded because of nonbattle injury. Of the remaining 9,557 patients available for final analysis, 9,092 lived and 465 died before or during treatment at Role 2 facilities. Characteristics are provided for all casualties by mortality status and location of death (Table 1) and for fatalities by military affiliation (Table 2). The study population had a median age of 25.0 years (interquartile range [IQR], 21.0–30.0 years) and was primarily male (97.4%; 9,308/9,557), and most (95.1% [9,092/9,557]) survived to transfer from Role 2 facility care.

Military Affiliation

The distribution of casualties by military affiliation included US coalition forces (37.4% [3,578/9,557]), ANSF (23.8% [2,271/9,557]), civilian/other forces (21.3% [2,034/9,557]), Afghanistan National Police (13.5% [1,290/9,557]), and non-US coalition forces (4.0% [384/9,557]). Mortality differed by military affiliation ($p < 0.001$), with most fatalities categorized as either ANSF (30.5% [142/465]), civilian/other forces (26.0% [121/465]), or US coalition forces (25.2% [117/465]).

Transport Time and Time at Role 2 Facility

Of the 53.6% (5,122/9,557) of the study population with a documented interval transport time from injury to Role 2 arrival, 56.9% (2,916/5,122) had a time that was greater than 60 minutes, and 43.1% (2,206/5,122) had a time that was 60 minutes or less. The total population median transport time was 75.0 minutes (IQR, 45.0–157.5 minutes), and the median time of stay at a Role 2 facility was 3.0 hours (IQR, 1.25–5.93 hours). Of the 39.4% (183/465) of fatalities with documented transport times (median [IQR], 53.0 minutes [30.0–80.5 minutes]), most (61.7% [113/183]) were evacuated within 60 minutes, and the median time at a Role 2 facility was 1.0 hours (IQR, 0.20–1.99 hours). Documented times from point of injury to death were available for 32.3% (150/465) of fatalities, with a median time of 1.69 hours (IQR, 0.88–3.28 hours).

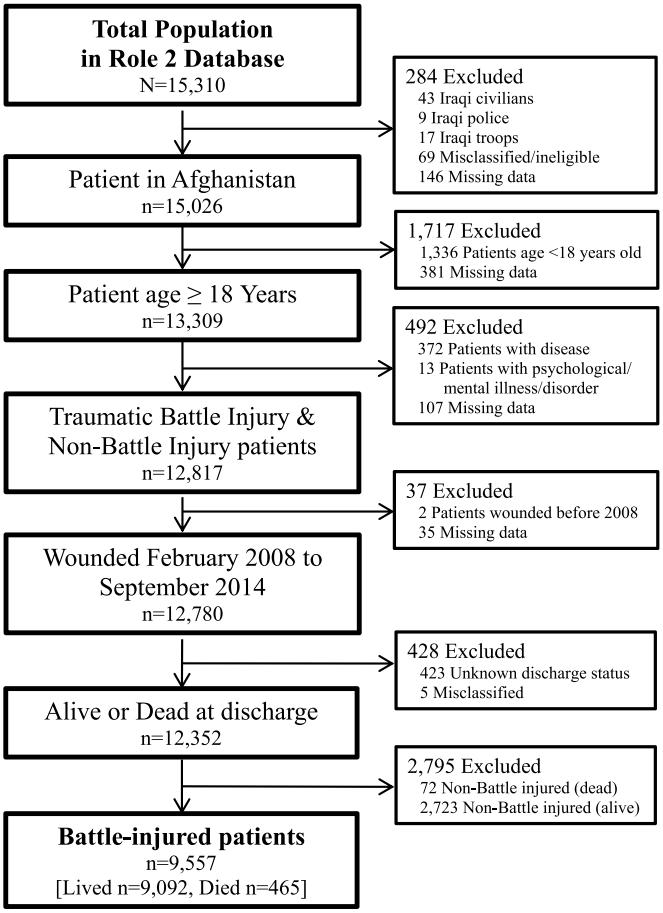

Figure 1. Study sample (n = 9,557) from Role 2 database maintained by the Department of Defense Joint Trauma System by inclusion and exclusion criteria.

Injury Type and Mechanism

Penetrating injury was the most frequently observed injury type in both those who lived (60.8% [5,524/9,092]) and died (75.9% [353/465]). Explosion was the most frequently observed mechanism of injury in both those who lived (58.8% [5,349/9,092]) and died (50.1% [233/465]). A greater proportion of gunshot wounds were seen among fatalities (lived 27.8% [2,531/9,092] vs. died 41.7% [194/465]) when compared with explosion (lived 58.8% [5,349/9,092] vs. died 50.1% [233/465]), motor vehicle crash (lived 2.0% [183/9,092] vs. died 2.4% [11/465]), and other mechanisms (lived 5.9% [538/9,092] vs. died 1.7% [8/465]). Thus, lethality was greatest for gunshot wounds (7.1% [194/2,725]), followed by motor vehicle crash (5.7% [11/194]), explosion (4.2% [233/5,349]), and other (1.5% [8/546]).

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TABLE 1. Study Characteristics by Mortality Status of Casualties (n = 9,557) Injured in Battle During Afghanistan Conflict From February 2008 to September 2014

			Died								
	Total		Pretransport		Intratransport		Posttransport		Lived		
Table 1	n	%	n	%	n	%	n	%	n	%	*p**
Casualties	9,557	100.0	27	0.3	38	0.4	400	4.2	9,092	95.1	
Age, median (IQR), y	25.0	21.0, 30.0	28.0	21.0, 34.0	25.0	21.0, 30.0	25.0	21.0, 30.0	25.0	22.0, 30.0	0.717
Male	9,308	97.4	25	92.6	36	94.7	388	97.0	8,859	97.4	0.832
Military affiliation											<0.001
Coalition, US	3,578	37.4	15	55.6	8	21.1	94	23.5	3,461	38.1	
Coalition, non-US	384	4.0	1	3.7	2	5.3	10	2.5	371	4.1	
ANSF	2,271	23.8	5	18.5	12	31.6	125	31.3	2,129	23.4	
Afghanistan National Police	1,290	13.5	0	0.0	7	18.4	65	16.3	1,218	13.4	
Civilian/other forces	2,034	21.3	6	22.2	9	23.7	106	26.5	1,913	21.0	
Transport time, injury to Role 2 arrival	5,122	53.6	15	55.6	12	31.6	156	39.0	4,939	54.3	<0.001
Time ≤60 min	2,206	23.1	8	29.6	8	21.1	97	24.3	2,093	23.0	
Time >60 min	2,916	30.5	7	25.9	4	10.5	59	14.8	2,846	31.3	
Transport time, median (IQR), min	75.0	45.0, 157.5	60.0	36.0, 100.0	58.0	35.0, 110.0	50.0	30.0, 80.0	78.0	45.0, 165.0	0.204
Time at Role 2, median (IQR), h	3.00	1.25, 5.93	0.00	0.03, 0.53	0.00	0.03, 0.33	1.00	0.25, 2.22	3.00	1.33, 6.17	0.136
Injury type	9,045	94.6	27	100.0	36	94.7	395	98.8	8,587	94.4	<0.001
Penetrating	5,877	61.5	16	59.3	27	71.1	310	77.5	5,524	60.8	
Blunt	2,279	23.9	5	18.5	1	2.6	31	7.8	2,242	24.7	
Penetrating and blunt	740	7.7	6	22.2	7	18.4	41	10.3	686	7.6	
Burn	149	1.6	0	0.0	1	2.6	13	3.3	135	1.5	
Injury mechanism	9,047	94.7	26	96.3	35	92.1	385	96.3	8,601	94.6	<0.001
Explosion	5,582	58.4	13	48.2	17	44.7	203	50.8	5,349	58.8	
Gunshot wound	2,725	28.5	11	40.7	18	47.4	165	41.3	2,531	27.8	
Motor vehicle crash	194	2.0	2	7.4	0	0.0	9	2.3	183	2.0	
Other	546	5.7	0	0.0	0	0.0	8	2.0	538	5.9	
Combat Mortality Index–Prehospital	8,510	89.0	3	11.1	14	36.8	238	59.5	8,255	90.8	<0.001
Mild	5,172	54.1	0	0.0	0	0.0	2	0.5	5,170	56.9	
Moderate	2,326	24.3	0	0.0	0	0.0	18	4.5	2,308	25.4	
Severe	590	6.2	0	0.0	0	0.0	66	16.5	524	5.8	
Critical	422	4.4	3	11.1	14	36.8	152	38.0	253	2.8	
Documented prehospital intervention	13,398	100.0	10	0.1	81	0.6	969	7.2	12,338	92.1	
Bleeding intervention, tourniquet	1,532	11.4	6	60.0	8	9.9	109	11.2	1,409	11.4	0.960
Bleeding intervention, other	2,807	21.0	0	0.0	14	17.3	171	17.6	2,622	21.3	0.0010
Airway intervention	834	6.2	0	0.0	21	25.9	208	21.5	605	4.9	<0.001
Breathing intervention	161	1.2	0	0.0	1	1.2	26	2.7	134	1.1	<0.001
Circulation intervention	1,651	12.3	0	0.0	13	16.0	164	16.9	1,474	11.9	<0.001
Fluids	673	5.0	0	0.0	0	0.0	29	3.0	644	5.2	<0.001
Blood	80	0.6	0	0.0	0	0.0	6	0.6	74	0.6	1.000
Hypothermia intervention	5,984	44.7	4	40.0	22	27.2	277	28.6	5,681	46.0	<0.001
Other prehospital intervention	429	3.2	0	0.0	2	2.5	14	1.4	413	3.3	<0.001
Documented prehospital medication	2,348	100.0	0	0.0	1	<0.1	70	3.0	2,277	97.0	
Analgesics	1,297	55.2	0	0.0	0	0.0	31	44.3	1,266	55.6	0.052
Fentanyl	338	14.4	0	0.0	0	0.0	10	14.3	328	14.4	1.000
Ketamine	125	5.3	0	0.0	0	0.0	6	8.6	119	5.2	0.273
Morphine	534	22.7	0	0.0	0	0.0	5	7.1	529	23.2	0.001
Other	300	12.8	0	0.0	0	0.0	10	14.3	290	12.7	0.718
Antibiotics	382	16.3	0	0.0	0	0.0	6	8.6	376	16.5	0.073
Other or unknown medication	669	28.5	0	0.0	1	100.0	33	47.1	635	27.9	<0.001

*Comparison is between all patients who died and patients who lived.

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TABLE 2. Study Characteristics by Military Affiliation for Battle-Injured Fatalities (n = 465) Who Died Before or During Treatment at Role 2 Surgical Facilities During Afghanistan Conflict From February 2008 to September 2014

	Total		Coalition Forces				ANSF		Afghanistan National Police		Civilian/Other Forces		
			US		Non-US								
	n	%	n	%	n	%	n	%	n	%	n	%	*p**
Fatalities	465	100.0	117	25.2	13	2.8	142	30.5	72	15.5	121	26.0	
Age, median (IQR), y	25.0	21.0, 30.0	24.0	21.0, 28.0	26.0	24.0, 29.0	24.0	21.0, 28.0	25.0	23, 30.0	25.0	21.0, 35.0	<0.001
Male	449	96.6	117	100.0	13	100.0	139	97.9	70	97.2	110	90.9	0.076
Mortality location													<0.001
Posttransport	400	86.0	94	80.3	10	76.9	125	88.0	65	90.3	106	87.6	
Intratransport	38	8.2	8	6.8	2	15.4	12	8.5	7	9.7	9	7.4	
Pretransport	27	5.8	15	12.8	1	7.7	5	3.5	0	0.0	6	5.0	
Transport time, injury to Role 2 arrival	183	39.4	52	44.4	8	61.5	45	31.7	32	44.4	46	38.0	0.099
Time ≤60 min	113	24.3	37	31.6	6	46.2	26	18.3	18	25.0	26	21.5	
Time >60 min	70	15.1	15	12.8	2	15.4	19	13.4	14	19.4	20	16.5	
Transport time, median (IQR), min	53.0	30.0, 80.5	43.0	25.0, 80.0	56.0	42.5, 74.0	41.0	27.0, 96.0	60.0	35.0, 106	58	45.0, 75.0	0.663
Time at Role 2, median (IQR), h	1.00	0.20, 1.99	0.00	0.19, 0.85	1.00	0.13, 1.05	1.00	0.18, 1.92	2.00	0.23, 3.72	1.00	0.32, 2.22	0.794
Time from injury to death	150	32.3	35	29.9	7	53.8	38	26.8	28	38.9	42	34.7	
Injury to death, median (IQR), h	1.69	0.88, 3.28	1.27	0.72, 2.98	1.28	0.75, 1.70	1.75	0.92, 3.37	2.92	1.16, 5.85	1.69	0.87, 2.65	
Injury type	458	98.5	116	99.1	13	100.0	140	98.6	70	97.2	119	98.3	0.372
Penetrating	353	75.9	86	73.5	10	76.9	107	75.4	54	75.0	96	79.3	
Blunt	37	8.0	13	11.1	2	15.4	10	7.0	4	5.6	8	6.6	
Penetrating and blunt	54	11.6	15	12.8	1	7.7	17	12.0	9	12.5	12	9.9	
Burn	14	3.0	2	1.7	0	0.0	6	4.2	3	4.2	3	2.5	
Injury mechanism	446	95.9	115	98.3	12	92.3	137	96.5	69	95.8	113	93.4	0.551
Explosion	233	50.1	65	55.6	8	61.5	68	47.9	38	52.8	54	44.6	
Gunshot wound	194	41.7	44	37.6	4	30.8	66	46.5	28	38.9	52	43.0	
Motor vehicle crash	11	2.4	3	2.6	0	0.0	2	1.4	2	2.8	4	3.3	
Other	8	1.7	3	2.6	0	0.0	1	0.7	1	1.4	3	2.5	
Combat Mortality Index–Prehospital	255	54.8	52	44.4	3	23.1	85	59.9	47	65.3	68	56.2	<0.001
Mild	2	0.4	0	0.0	0	0.0	1	0.7	0	0.0	1	0.8	
Moderate	18	3.9	0	0.0	0	0.0	7	4.9	5	6.9	6	5.0	
Severe	66	14.2	2	1.7	1	7.7	26	18.3	13	18.1	24	19.8	
Critical	169	36.3	50	42.7	2	15.4	51	35.9	29	40.3	37	30.6	
Documented prehospital intervention	1,025	100.0	278	27.1	43	4.2	318	31.0	183	17.9	203	19.8	
Bleeding intervention, tourniquet	123	12.0	42	15.1	6	14.0	30	9.4	18	9.8	27	13.3	0.066
Bleeding intervention, other	185	18.0	35	12.6	11	25.6	64	20.1	38	20.8	37	18.2	0.006
Airway intervention	229	22.3	69	24.8	8	18.6	63	19.8	50	27.3	39	19.2	0.273
Breathing intervention	27	2.6	7	2.5	0	0.0	11	3.5	4	2.2	5	2.5	1.000
Circulation intervention	142	13.9	49	17.6	6	14.0	45	14.2	22	12.0	20	9.9	0.042
Fluids	29	2.8	4	1.4	0	0.0	10	3.1	6	3.3	9	4.4	0.137
Blood	6	0.6	0	0.0	0	0.0	2	0.6	1	0.5	3	1.5	0.198

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TABLE 2. *(Continued)*

	Total		Coalition Forces				ANSF		Afghanistan National Police		Civilian/Other Forces		
			US		Non-US								
	n	%	n	%	n	%	n	%	n	%	n	%	p*
Hypothermia intervention	303	29.6	73	26.3	12	27.9	101	31.8	47	25.7	70	34.5	0.166
Other prehospital intervention	16	1.6	3	1.1	0	0.0	4	1.3	4	2.2	5	2.5	0.578
Documented prehospital medication	71	100.0	6	8.5	1	1.4	40	56.3	14	19.7	10	14.1	
Analgesics	31	43.7	3	50.0	1	100.0	15	37.5	3	21.4	5	50.0	0.679
Fentanyl	10	14.1	1	16.7	0	0.0	5	12.5	1	7.1	3	30.0	1.000
Ketamine	6	8.5	1	16.7	0	0.0	4	10.0	0	0.0	0	0.0	0.384
Morphine	5	7.0	1	16.7	0	0.0	0	0.0	0	0.0	1	10.0	0.172
Other	10	14.1	0	0.0	1	100.0	6	15.0	2	14.3	1	10.0	0.580
Antibiotics	6	8.5	0	0.0	0	0.0	4	10.0	1	7.1	1	10.0	1.000
Other or unknown medication	34	47.9	3	50.0	0	0.0	18	45.0	9	64.3	4	40.0	1.000

*Comparison is between US coalition force patients and all other patients.

Combat Mortality Index and Location of Death

From the total study population, 89.0% (8,510/9,557) had sufficient data needed to evaluate injury severity by CMI-PH. As categorized by CMI-PH, 40.0% (169/422) of critical, 11.2% (66/590) of severe, 0.8% (18/2,326) of moderate, and less than 0.1% (2/5,172) of mild casualties died. Most fatalities with CMI-PH were categorized as critical (66.3% [169/255]) or severe (25.9% [66/255]), whereas most who lived were mild (56.9% [5,170/8,255]) or moderate (25.4% [2,308/8,255]).

Of all fatalities, 14.0% (65/465) died prehospital (pretransport 5.8% [27/465]; intratransport 8.2% [38/465]), and 86.0% (400/465) died at a Role 2 facility (posttransport). Subtracting the 65 prehospital deaths from the total study population of 9,557 battle-injured casualties provided a remaining casualty population of 9,492 who received treatment at a Role 2 facility. As 400 of these casualties died, the percentage died of wounds (%DOW) at Role 2 facilities in this study population was equal to 4.2% ([400/9,492] × 100).

Prehospital Interventions and Medications

All documented prehospital interventions, except tourniquets and blood, differed between those who lived and those who died. When comparing those who lived with those who died, a larger proportion of casualties who lived received more other bleeding interventions (21.3% [2,622/12,338] vs. 18.0% [185/1,025]; $p < 0.001$) and hypothermia interventions (46.0% [5,681/12,338] vs. 29.6% [303/1,025]; $p < 0.001$). Additionally, a smaller proportion of casualties who lived received more airway (4.9% [605/12,338] vs. 22.3% [229/1,025]; $p < 0.001$), breathing (1.1% [134/12,338] vs. 2.6% [27/1,025]; $p < 0.001$), and circulation (11.9% [1,474/12,338] vs. 13.9% [142/1,025]; $p < 0.001$) interventions. For documented medications administered, a larger proportion of casualties who lived received more morphine (23.2% [529/2,277] vs. 7.0% [5/71]; $p = 0.001$), whereas other or unknown medications were provided in greater proportion to casualties who died (27.9% [635/2,277] vs. 47.9% [34/71]; $p < 0.001$).

US Coalition Force Fatalities

All 117 US coalition force fatalities captured by this study were matched to the Armed Forces Medical Examiner System database. Characteristics for these fatalities by primary injured body regions (Table 3 and Fig. 2) include a median NISS of 50.0 (IQR, 41.0–66.0) and an mAIS of 4 or greater in 95.7% (112/117) of this population. Only one primary injured body region was affected in 72.6% (85/117) of fatalities, two primary injured body regions in 25.6% (30/117), and three primary injured body regions in 1.7% (2/117). The primary injured body region most frequently involved in these fatalities was the thorax (38.5% [45/117]), followed by the head (27.4% [32/117]) and lower extremity, pelvis, and buttocks (25.6% [30/117]). The primary injured body region with the highest median NISS was the head (75.0 [IQR, 57.0–75.0]), which also had the most fatalities with an mAIS of 6, as well as the most fatalities having only one isolated primary body region. As 35.9% (42/117) of fatalities had head and/or spine primary body regions affected, the remaining 64.1% (75/117) of fatalities had damage and hemorrhage solely in other primary injured body regions.

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TABLE 3. Maximum Abbreviated Injury Scale Primary Injured Body Region of US Coalition Force Fatalities Matched to Armed Forces Medical Examiner System Database (n = 117) Who Died of battle Wounds During Afghanistan Conflict From February 2008 to September 2014

		First Primary Body Region								
		Head	Face	Neck	Thorax	Abdomen	Spine	Upper Extremity	Lower Extremity, Pelvis, Buttocks	External (Skin) and Thermal Injuries
Second primary body region	None	25	1	2	23	14	5	0	15	0
	Head		0	0	3	0	2	1	0	0
	Face			0	0	0	0	0	0	0
	Neck				1	0	0	0	0	0
	Thorax					5	2	1	10*	0
	Abdomen						1	1	3	0
	Spine							0	0	0
	Upper extremity								1	0
	Lower extremity, pelvis, buttocks									1
	External (skin) and thermal injuries									

*Two of these fatalities also had a third primary body region affected, one of "head" and the other of "abdomen".

Of the 117 US coalition force fatalities, 23 were Role 1 prehospital deaths and 94 were Role 2 facility deaths. Subtracting the 23 US prehospital deaths from the total US casualty population of 3,578 battle-injured casualties provided a remaining US casualty population of 3,555 who received treatment at a Role 2 facility. As 94 of these casualties died, the US coalition % DOW at Role 2 facilities in this study population was equal to 2.6% ([94/3,555] × 100).

DISCUSSION

Increasing the rate of casualty survival from traumatic injury at and between each role of care should be a primary goal for performance improvement efforts within a military trauma system. Hemorrhage and its sequela are a major cause of death in trauma patients.[8,20–24] During the recent conflicts in Afghanistan and Iraq, hemorrhage accounted for 90.9% of prehospital and 80.1% of in-hospital deaths from potentially survivable injuries.[22,23] Thus, hemorrhage control should remain an important area of focus for military trauma systems, along with reducing the time between critical injury and receiving a lifesaving or limb-saving medical capability. As Role 3 and Role 4 medical treatment facilities have more robust resources to provide hospital, intensive, and definitive care, it is especially important to assess patient transport, care, and outcomes that occur prior to reaching these facilities, in the more austere and resource-constrained Role 1 prehospital and Role 2 forward surgical team environments.

The importance of data from Role 1 and Role 2 databases and their ability to translate gaps and lessons learned have been reported.[8,16–18,25–28] Previous Role 2 database studies of casualties from the Afghanistan conflict have provided descriptive

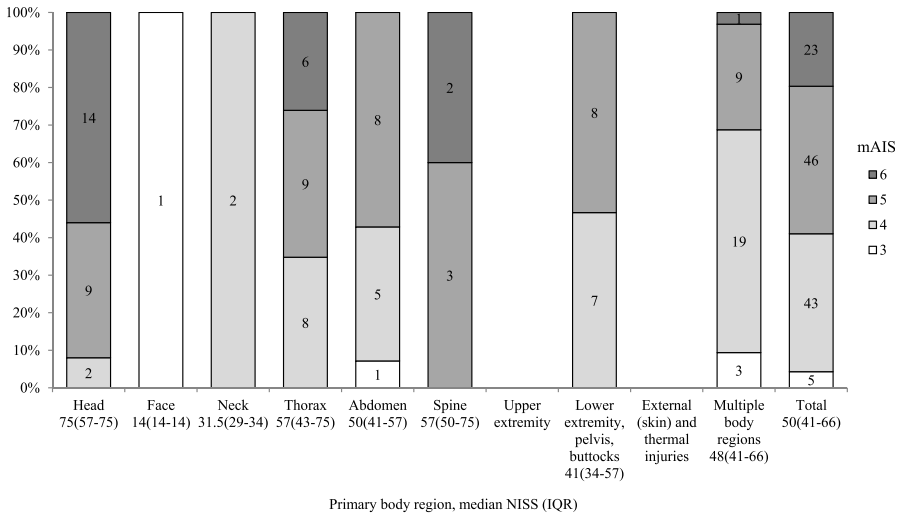

Figure 2. Maximum Abbreviated Injury Score and NISS by primary body region for US coalition force fatalities matched to Armed Forces Medical Examiner System database (n = 117).

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analyses on patient profiles of and common injuries treated at Role 2 facilities[16] and type and mode of prehospital transports used to evacuate casualties from Role 1 to Role 2 facilities,[17] as well as transport and en route treatment of casualties between Role 2 and Role 3 facilities.[18] This current study expands beyond previous studies by assessing mortality outcomes among battle-injured casualties transported to and treated at Role 2 facilities during the Afghanistan conflict by location of death and military affiliation. However, for all these studies, data were limited primarily to the Role 2 database, which was not designed to capture details for all injuries, casualties, and fatalities on the battlefield.

Although the study sample distribution by military affiliation noted the largest proportion of casualties was from US coalition forces, the largest proportion of fatalities was seen among ANSF, even though more fatalities were categorized as critical among US coalition forces, and the median prehospital transport times to Role 2 facilities among US coalition forces and ANSF fatalities were not found to be statistically different. However, for those who had documented transport times, a larger proportion of US coalition force fatalities (31.6%) were found to have been evacuated within 60 minutes as compared with ANSF fatalities (18.3%). Although autopsy data were not available for other military affiliation categories, for US coalition force fatalities, of note was that 38.5% had affected primary body regions in noncompressible areas (thorax), and 27.4% had multiple affected primary body regions.

In contrast to a higher proportion of prehospital fatalities reported in previous casualty mortality studies of Afghanistan and Iraq,[20,21,23] most (86.0%) of current study sample fatalities died after arrival and while receiving Role 2 facility care. This may be somewhat artifactual of the Role 2 database given that entry into the database was contingent upon activation of Role 2 surveillance. As the current study relied on casualties that activated Role 2 surveillance, as well as Role 2 personnel to collect and report these data to the Role 2 database, the totality of prehospital deaths was not accounted for during the study time period. This may be particularly so for those casualties who died overtly and near instantaneously, as well as patients who died during transport, as criteria for entry into the Role 2 database were treatment at a Role 2 facility. As observed by a 2012 composite of battlefield deaths in Afghanistan and Iraq,[23] 35.2% of fatalities were instantaneous, 52.1% were acute (minutes to hours) prehospital, and only 12.7% of casualties died of wounds after reaching a medical treatment facility.

In addition to not capturing all prehospital casualties and fatalities, the Role 2 database also did not capture individuals that bypassed Role 2 facilities, as well as data and morbidity and mortality outcomes from non–Role 2 facilities. Furthermore, not all Role 2 casualties and fatalities that occurred were recorded and collected by the Role 2 database, as this database was reliant on Role 2 personnel to capture such data while constrained by resources. Thus, overall case fatality rate, as well as prehospital deaths as percentage killed in action, could not be determined. However, %DOW for Role 2 facility casualties and fatalities was calculated and found to be 4.2%. Although 43.1% of casualties were transported in 60 minutes or less compared with 67.1% in a previous study on transport time,[4] this DOW value was analogous to the overall %DOW of 4.3% previously reported for Afghanistan.[4,8,15] As %DOW is an outcome that can be monitored by a Role 2 facility,[29] this metric can be used and reported for performance improvement by individual surgical teams as well as in aggregate.

Substantial advances in medical documentation and data collection were made during the Afghanistan and Iraq conflicts, amassing the largest repository of combat trauma data in US history. However, data were most robust from Role 4 and Role 3 medical treatment facilities and progressively less so at Role 2 and Role 1 closer to the point of injury. Although the Department of Defense Joint Trauma System implemented standalone software programs to facilitate combat casualty care data capture by forward battlefield providers, these databases rely on resources, connectivity, and the consistent and continuous willingness and compliance of numerous individual units and personnel to use the programs in an environment where data collection and reporting were additional tasks to conduct if time were available versus an integral and expected part of duties. Additionally, data that were captured were being done so mostly by untrained personnel. Therefore, there is nominal assurance of accuracy of reporting, coding, or even data entry.

Subsequently, Role 2 casualty data may be complete, partially complete, or nonexistent, depending on the facility. Thus, the data from the Role 2 database may not be completely representative or inclusive of all casualties treated at or before this role of care. As non-US casualties and fatalities were often lost to follow-up, outcomes and autopsies were not available for further analysis. Without complete autopsies, an accurate description and extent of injuries cannot be provided for fatalities.

After almost 17 years of combat operations, resulting in nearly 60,000 US casualties[30] and innumerable non-US casualties, nonmedical and medical leaders must mandate, train, resource, and enforce comprehensive and continuous documentation and data collection practices at Role 2 facilities. These efforts are needed to support performance improvement, optimize trauma care delivery, and ensure compliance that would otherwise be lost to lack of time, interest, or willingness. If damage control resuscitation and surgery are expectations of a Role 2 facility on the battlefield, the US Department of Defense should also require and facilitate the documentation and data collection of such major interventions.

As hemorrhage continues to be a major cause of death in both battlefield and nonbattlefield environments,[8,20–24] future research efforts must include novel and evolutionary methods to prevent, recognize, and treat hemorrhagic events as soon after injury as possible, particularly from noncompressible truncal hemorrhage, which is currently in need of viable prehospital solutions. Advancements must occur for truncal hemostasis and blood resuscitation to support both presurgical and forward surgical efforts.[31–33] These advances must cover the full spectrum, from point of injury hemostatic interventions to transfusion strategies to medical and procedural interventions, which prevent and mitigate the physiological consequences of hemorrhage. Important areas of focus should include increased involvement from both medical and nonmedical senior leadership; public awareness and education; noncompressible hemorrhage control; prevention, recognition, and treatment of hemorrhagic shock; and evaluation and treatment of intracranial bleeding.

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CONCLUSIONS

Role 2 facility care and prehospital care prior to and during transport to Role 2 facilities are important early components of a military joint service battlefield trauma system. Efforts to mandate, train, resource, and enforce medical documentation and data collection practices are required. Filling gaps in data will help to identify medical capability gaps, direct training and equipment procurement, and support future performance improvement and research efforts. Ultimately, meaningful and comprehensive data are paramount to further reduction of battlefield morbidity and mortality.

AUTHORSHIP

R.S.K. and A.M.S. had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. R.S.K. and A.M.S. were involved in study concept and design. A.M.S., E.L.M., and E.A.M.-S. were involved in data collection, consolidation, and organization. R.S.K. and A.M.S. were involved in statistical analysis. R.S.K., A.M.S., E.L.M., J.M.G., S.A.S., F.K.B., Z.T.S., J.B.H., S.C.N., and E.A.M.-S. were involved in acquisition, analysis, or interpretation of data. R.S.K. and A.M.S. drafted the manuscript. R.S.K., A.M.S., E.L.M., J.M.G., S.A.S., F.K.B., Z.T.S., J.B.H., S.C.N., and E.A.M.-S. critically revised the manuscript for important intellectual content. E.A.M.-S. provided administrative, technical, or material support. R.S.K. and E.A.M.-S. supervised the study.

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DISCLOSURE

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Unrealized potential of the US military battlefield trauma system: DOW rate is higher in Iraq and Afghanistan than in Vietnam, but CFR and KIA rate are lower

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LEVEL OF EVIDENCE: Observational/retrospective/historic controls, level IV. (*J Trauma Acute Care Surg.* 2018;85: S4–S12. Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.)
KEY WORDS: Afghanistan; Iraq; Vietnam; died of wounds; case fatality rate.

The recent conflicts in Afghanistan and Iraq resulted in significant advancements in our understanding of combat casualty care. Important advancements include a better understanding of tourniquet use, blood transfusion therapy, and the use of extracorporal lung oxygenation for pulmonary salvage. These advancement and others, firmly grounded in scientific study, saved many lives over more than a decade of war in Afghanistan and Iraq. However, throughout the conflict, researchers, clinicians, and medical leaders have been vexed by the consistently high died of wound percentage (%DOW) as compared with Vietnam War, and its relationship to an apparently improved case fatality rate (CFR), and a decrease in Service Members killed in action (%KIA).

Further complicating the problem is variability in the way died of wounds is calculated, how those excluded from the equation as return to duty wounded are defined, and how variability in data collection can impact the results. Uncontrollable variables that change over time and even within conflicts further impact our ability to understand the significance of the changes in %DOW and can lead to assumptions that may not be valid. It is important, then, to understand as much as possible the medical and non-medical factors that confound our understanding of combat casualty statistics.

This paper reports that although CFR and %KIA have improved, the %DOW has increased. The authors also report the relationship of the CFR, %KIA, %DOW, and Injury Severity Score (ISS) over time for Operations Enduring and Iraqi Freedom. Importantly, the literature is sampled in such a way as to begin to understand the aforementioned confounders that, correctly interpreted, will allow the prioritization of research and performance improvement initiatives required to improve surgical outcomes on future battlefields.

Operation Enduring Freedom in Afghanistan and Operation Iraqi Freedom in Iraq were the Nation's first prolonged wars since Vietnam that generated significant numbers of casualties. Given that many of the elements of a modern trauma system were present during the Vietnam, Iraq, and Afghanistan conflicts, a comparative analysis of outcomes is appropriate and may reveal evidentiary gaps in battlefield trauma care delivery.

The combat casualty care statistics most commonly referred to when evaluating combat casualties are the killed in action rate or percentage (%KIA), died of wounds rate or percentage (%DOW), and the case fatality rate (CFR)[1] (Table 1). The %KIA measures fatalities that occur before admission to a military treatment facility (MTF). The %DOW considers those wounded who died after reaching a MTF in relationship to all admissions. The CFR considers all deaths including those who die pre-MTF and those who die of wounds any time after admission.[1]

The %DOW has the potential to broadly, without unit, facility, or team level granularity, assess surgical outcomes. The %KIA accounts for severity of wounding and pre-hospital care and CFR is a summary statistic of both KIA and DOW, encompassing all factors that influence both lethality and survivability on the battlefield.[1] Although much has changed since the Vietnam War, some of the components of the modern battlefield trauma system were

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TABLE 1. Combat Mortality: Definitions and Statistics

Combat mortality	Definition	Equations
Killed in action (KIA)	The number of combat deaths that occur before reaching a MTF	$\%\text{KIA} = \frac{\text{Deaths before MTF}}{\text{KIA} + (\text{WIA}-\text{RTD})} \times 100$
Died of wounds (DOW)	The number of deaths that occur after reaching a MTF	$\%\text{DOW} = \frac{\text{Died after reaching MTF}}{(\text{WIA}-\text{RTD})} \times 100$
Case fatality rate (CFR)	A measure of overall lethality in all those wounded; all deaths compared with all wounded included those who DOW	$\text{CFR} = \frac{\text{KIA}+\text{DOW}}{\text{KIA}+\text{WIA}} \times 100$

MTF, medical treatment facility; WIA, wounded in action; Holcomb et al.[1]

present in both eras; therefore, understanding whether %KIA, %DOW, and CFR achieved in Afghanistan and Iraq is higher or lower as compared with Vietnam is potentially informative of gaps in the current combat trauma system.

The objectives of this paper were to compare the %KIA, %DOW, and CFR achieved in Afghanistan and Iraq to those of Vietnam; determine the trends in %KIA, %DOW, CFR, and ISS; understand how to best analyze MTF battlefield outcomes to propose future methods of rapid assessment as well as optimal and timely performance improvement; and identify potential gaps to focus future military research efforts.

PROCESS

The period of the Vietnam conflict was November 1955 to May 1975, Afghanistan October 2001 to December 2014, and Iraq March 2003 to August 2010. All databases are updated when a US Service Member dies of wounds and were last checked December 8, 2017.

The mortality rate trends for US Service Members treated in MTFs during these periods were analyzed. Data sources for this study include [1] monthly aggregate numbers of KIA and DOW from the Defense Manpower Data Center's Defense Casualty Analysis System (DCAS), [2] monthly aggregate numbers of returned to duty (RTD) from U.S. Central Command (CENTCOM), and [3] records of U.S. military service members who sustained injury and were registered in the Department of Defense Trauma Registry (DODTR). DCAS aggregate data were used to calculate combat mortality parameters %KIA, %DOW, and CFR using the formulas in Table 1. Monthly aggregate KIA and DOW data were extracted from the DCAS, and combined with the CENTCOM data to ascertain numbers of RTD. DCAS data were used to calculate %KIA and %DOW for Vietnam and includes all casualties and a subset of Army-only data from November 1955 to May 1975. The RTD wounded for Vietnam are those 150,341 injured who were either immediately returned to duty (carded for record only) or treated at a non-surgical facility and then RTD (Fig. 1).

DODTR data were used to calculate ISS among Afghanistan and Iraq patients; ISS could not be determined for Vietnam injuries. Primary outcome was combat mortality expressed as %KIA, %DOW, and CFR comparing the recent conflicts to Vietnam with RTD patients both excluded and included. Secondary outcomes were evaluations of annual trends in these parameters, and trends in injury severity from 2003 to 2014. The %KIA, %DOW, and CFR were calculated using the formulae in Table 1. Trends in ISS, %KIA, %DOW, and CFR were calculated using the weighted moving average (WMA) method and by linear regression. The WMA method, a simple form of smoothing technique, was used to filter out random noise by smoothing random fluctuations and accounting for seasonal trends. Linear regression of %KIA, %DOW, CFR, and ISS on time by years was used to test for linear trend. The χ^2 test was used to determine significant associations in %KIA, %DOW, and CFR between Afghanistan, Iraq, and Vietnam. Other descriptive statistical tests were used where appropriate. Analyses were performed using SAS (version 9.4; SAS Institute, Cary, North Carolina, USA).

FINDINGS

Demographic data are provided in Table 2. The %KIA, %DOW, and CFR are reported with and without RTD patients in Table 3. Both are included for the purpose of clarity as these parameters with RTD *included* have been compared with Vietnam statistics with RTD *excluded*.[2,3] The remainder of this paper will present %KIA and % with RTD patients excluded.

CFR and %KIA have Improved Since Vietnam

CFR and %KIA significantly improved in Afghanistan and Iraq, when compared to Vietnam (all $p < 0.0001$). CFR for Afghanistan was 15.1, Iraq 21.4, and Vietnam 23.2. The %KIA for Afghanistan was 11.3, Iraq 16.4, and Vietnam 20.5 (Table 3).

%DOW Has Increased Since Vietnam

The %DOW was higher for Afghanistan and Iraq compared with Vietnam (all $p < 0.0001$). The average combined Afghanistan/Iraq %DOW was 5.3% with a %DOW of 4.3% for Afghanistan and %DOW of 6.0% for Iraq as compared with Vietnam %DOW of 3.3% (Table 3).

Combat Mortality Trends

The %KIA and CFR decreased in both Iraq and Afghanistan ($p < 0.0001$). The %DOW trended lower in general in Afghanistan, but variability was noted and this decrease did not reach significance ($p = 0.09$). However, the observed increase of %DOW over time in Iraq was significant ($p < 0.0001$). ISS increase over time was small but did not reach significance in Afghanistan ($p = 0.07$) nor Iraq ($p = 0.09$). The relationship and trends between the combat mortality parameters and ISS are illustrated for Iraq (Fig. 2A) and Afghanistan (Fig. 2B). Figure 3 shows trends for DOW in Afghanistan/Iraq.

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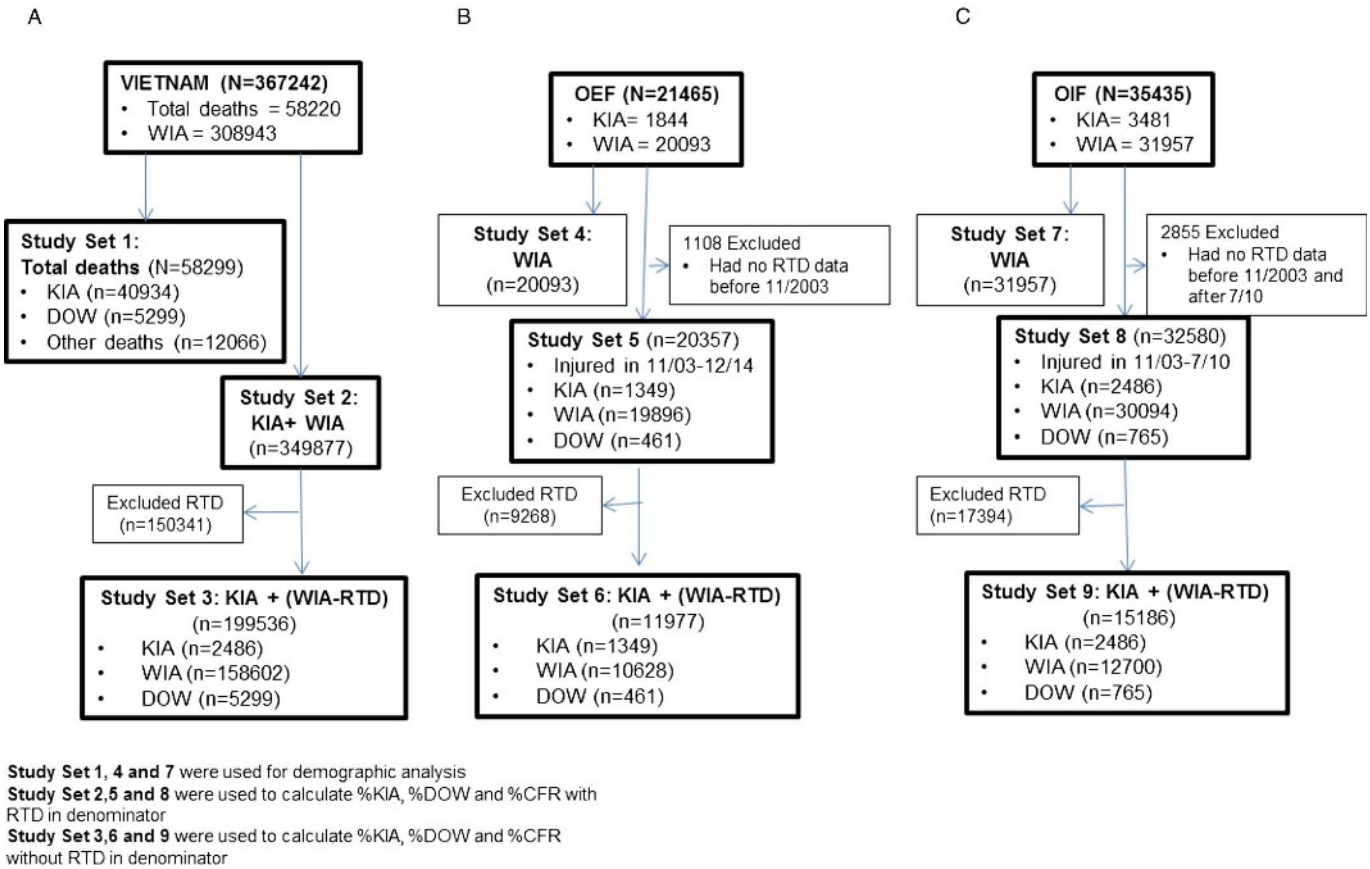

Figure 1. Cohort description and inclusion criteria. Figure 1 illustrates cohort description and inclusion criteria. Nine study sets were stratified and used for specific purposes as described at the bottom left of the figure.

These data demonstrate CFR and %KIA decreased in recent conflicts compared with Vietnam, and CFR and %KIA improved in both Afghanistan and Iraq.[1,4] However, %DOW increased in Afghanistan and Iraq compared with Vietnam, and although %DOW appears to have decreased in Afghanistan, it increased in Iraq.

The %KIA is considered a measure of weapons lethality, point of injury, and pre-hospital care; CFR is a composite measure of overall battlefield mortality.[1] Bellamy emphasized three factors when considering the "magnitude of the percentage of the population who are KIA": weapons lethality, "feasibility of first-aid", and evacuation of the patient to effective treatment.[5] Of these factors, weapons lethality is historically the most consequential given that 82% of battlefield deaths have been near instantaneous because of the lethality of military weapons, whereas medical care and transport times are modifiable factors.[6] Advances in pre-hospital tactical combat casualty care have been mitigating factors; it has been estimated that optimal pre-hospital care and rapid evacuation can prevent death in up to 25% of those with previously fatal injuries.[7]

The %DOW reflects care provided once a casualty has reached a battlefield MTF; the patient must arrive alive at the MTF (a measure of available and quality pre-hospital care and transport time) where these units are usually equipped with surgical capability. The %DOW has historically been 3.5%, with an inverse relationship between KIA and DOW.[1,5] Because the CFR is an aggregate summary statistic and accounts for all who die, it will change according to %KIA and %DOW while taking into account the total number wounded. Given that over 80% of combat casualties are KIA, CFR trend usually follows %KIA. In recent conflicts, weapons lethality was the most prominent factor in those who died before reaching a MTF. Therefore, if %KIA is predominantly considered a measure of weapons lethality and %DOW a measure of MTF trauma care, then overall battlefield lethality has decreased in Afghanistan/Iraq compared with Vietnam, whereas MTF mortality has increased.

Battlefield statistical measures pivot based on the complex and multifactorial nature of the combat environment. The %KIA, %DOW, and CFR are composite statistics and may change significantly based on medical and non-medical factors such as weapons lethality, tactics, body armor, vehicle armor, point-of-injury care, medical evacuation capabilities, and availability and types of surgical capabilities.[1] To understand the effects of external confounders, the significance of decreased CFR and %KIA, and the increase in %DOW, patient-specific data are required. However, although patient-specific data are available for Afghanistan and Iraq since the establishment of the DODTR, these are unavailable for Vietnam. However, it is possible to understand relevant wounding mechanisms, injury types, evacuation times, weapons lethality, and causes of deaths by briefly reviewing the available literature from Iraq, Afghanistan, and Vietnam.

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TABLE 2. Demographic Characteristics of Casualties in OEF, OIF, and Vietnam War

	OEF*	OIF**	Vietnam/Deaths†	*p* Value
N	20,093	31,957	58,220	
Male, n (%)	19,644 (97.8)	31,220 (97.7)	58,212 (99.99)	
Age, n (%)				<0.0001
<22	4,927 (24.4)	8,893 (27.8)	35,375 (60.8)	
22–24	5,713 (28.4)	7,998 (25.0)	11,170 (19.2)	
25–30	5,911 (29.4)	7,554 (23.6)	6,677 (11.5)	
31–35	1,847 (9.2)	3,064 (9.6)	2,539 (4.4)	
>35	1,534 (7.6)	2,865 (9.0)	2,459 (4.2)	
Unknown	161 (0.8)	1,593 (5.0)	—	
Race/ethnicity				<0.0001
White	16,366 (81.5)	25,909 (81.1)	49,830 (85.6)	
Black	1,408 (7.0)	2,727 (8.5)	7,243 (12.4)	
Other	2,319 (11.5)	3,321 (10.1)	1,147 (2.0)	
Military service				<0.0001
Air Force	520 (2.6)	502 (1.4)	450 (1.4)	
Army	14,205 (70.7)	25,463 (68.5)	22,230 (69.6)	
Marine	4,945 (24.6)	9,649 (26.0)	8,626 (27.0)	
Navy	423 (2.1)	753 (2.0)	650 (2.0)	
Officer, n (%)	1,325 (6.6)	2,307 (6.2)	1,880 (5.9)	

p Values were calculated from χ^2 test.

OEF, Afghanistan, Operation Enduring Freedom; OIF, Iraq, Operation Iraqi Freedom.

*Casualties by demographic data for OEF were extracted from https://dcas.dmdc.osd.mil/dcas/pages/casualties_oef.xhtml retrieved on December 8, 2017.

**Casualties by demographic data for OIF were extracted from https://dcas.dmdc.osd.mil/dcas/pages/casualties_oif.xhtml retrieved on December 8, 2017.

†Casualties by demographic data for OIF were extracted from https://dcas.dmdc.osd.mil/dcas/pages/casualties_vietnam.xhtml retrieved on December 8, 2017.

*,**WIA data were used for demographic characteristics in OEF and OIF.

†No WIA data are available. Thus, data were used for demographic characteristics of U.S. Service members in the Vietnam War included total deaths (DOW, KIA, non-hostile deaths, and missing and captured presumed deaths). Presumed/other deaths included missing in action—declared dead (n = 1,085), captured—declared dead (n = 116), missing—presumed dead (n = 123), and other deaths (n = 10,663).

Pre-Hospital Deaths: Vietnam

Maughon analyzed death certificates of 2,600 US Service Members KIA in Vietnam and found the most common body regions associated with death were head (39.3%), chest (37%), abdomen (9%), neck (7.3%), and extremities (7.4%).[8] An analysis of 8,000 Vietnam casualties from the Wound Data and Munitions Effectiveness Team's data, collected from 1967 to 1969, determined the most common body regions involved in fatal wounds were head (38%), chest (24%), and abdomen (9%). Over 72% of soldiers KIA from head wounds suffered massive non-survivable brain injuries. Similarly, over 62% of chest injuries resulted in near-immediate death with injuries to the heart, great vessels, trachea, and lung. About 17% of abdominal injuries resulted in pre-hospital death from hemorrhage involving major vascular structures or the liver. Extremity injuries were the primary site of injury in 3% of pre-hospital deaths.[5] The primary pathophysiological cause of death in Vietnam was exsanguination (44%) followed by central nervous system injuries (36%).[5]

Pre-Hospital Deaths: Afghanistan and Iraq

The most comprehensive study of pre-hospital deaths in Afghanistan and Iraq was an evaluation of 4,596 battlefield deaths led by Eastridge. They found that the head was the primary site of fatal injury in 34.2% and chest in 23.1%. Dismemberment (multiple body regions) accounted for fatal injury in 12.8%, high spinal cord injury 3.3%, and the abdomen 2.3%. Of these injuries, 75.7% were deemed non-survivable with fatal injuries similar to those observed in Vietnam including destructive brain injury, heart and great vessel injury, and destructive abdominal vascular injuries. Extremity injuries were the primary site of fatal injury in 3.7%.[9] Depending on whether the pathophysiological cause of death in dismemberment is hemorrhage, 42% to 55% of deaths in these patients appear to be from exsanguination. Eastridge also reported 87% of deaths in Afghanistan/Iraq occurred before MTF admission, which is similar to the 88% reported rate in Vietnam.[5] The autopsy papers from

TABLE 3. Comparison of %KIA, %DOW, and CFR With and Without Minor Wounds (RTD) Included in the Equation

						Included RTD*			Excluded RTD**		
Study population	**KIA**	**DOW**	**WIA**	**RTD**	**WIA-RTD**	**%KIA**	**%DOW**	**CFR**	**%KIA**	**%DOW**	**CFR**
OIF† and OEF‡											
OIF + OEF	3,835	1,226	49,990	26,662	23,328	7.1	2.5	9.4	14.1	5.3	18.6
OIF	2,486	765	30,094	17,394	12,700	7.6	2.5	10.0	16.4	6.0	21.4
OEF	1,349	461	19,896	9,268	10,628	6.3	2.3	8.5	11.3	4.3	15.1
Vietnam War§											
Total	40,934	5,299	308,943	150,341	158,602	11.7	1.7	13.3	20.5	3.3	23.2
Army	27,047	3,610	205,135	104,723	100,412	11.6	1.8	13.2	21.2	3.6	24.0

Data were expressed as numbers unless otherwise noted.

KIA, killed in action; DOW, died of wounds; CFR, case fatality rate; WIA, wounded in action; RTD, returned to duty; OIF, Iraq, Operation Iraqi Freedom; OEF, Afghanistan, Operation Enduring Freedom.

*Number of patients with injuries regardless of minor injury or RTD within 72 hours were included in the denominator of %KIA, %DOW, and CFR calculation.

**Number of patients with minor injuries and RTD within 72 hours were not included in the denominator of %KIA, %DOW, and CFR calculation.

†Study time period for OIF was from November 2003 to July 2010, retrieved on December 8, 2017 from https://dcas.dmdc.osd.mil/dcas/pages/casualties_oif.xhtml and combined with the given DMDC data and RTD data from CENTCOM.

‡Study time period for OEF was from November 2003 to December 2014, retrieved on December 8, 2017 from https://dcas.dmdc.osd.mil/dcas/pages/casualties_oef.xhtml and combined with the given DMDC data and RTD data from CENTCOM.

§Vietnam War data were extracted from DCAS data in time period of November 1955 to May 1975, retrieved on December 8, 2017 from https://dcas.dmdc.osd.mil/dcas/pages/report_vietnam_sum.xhtml.

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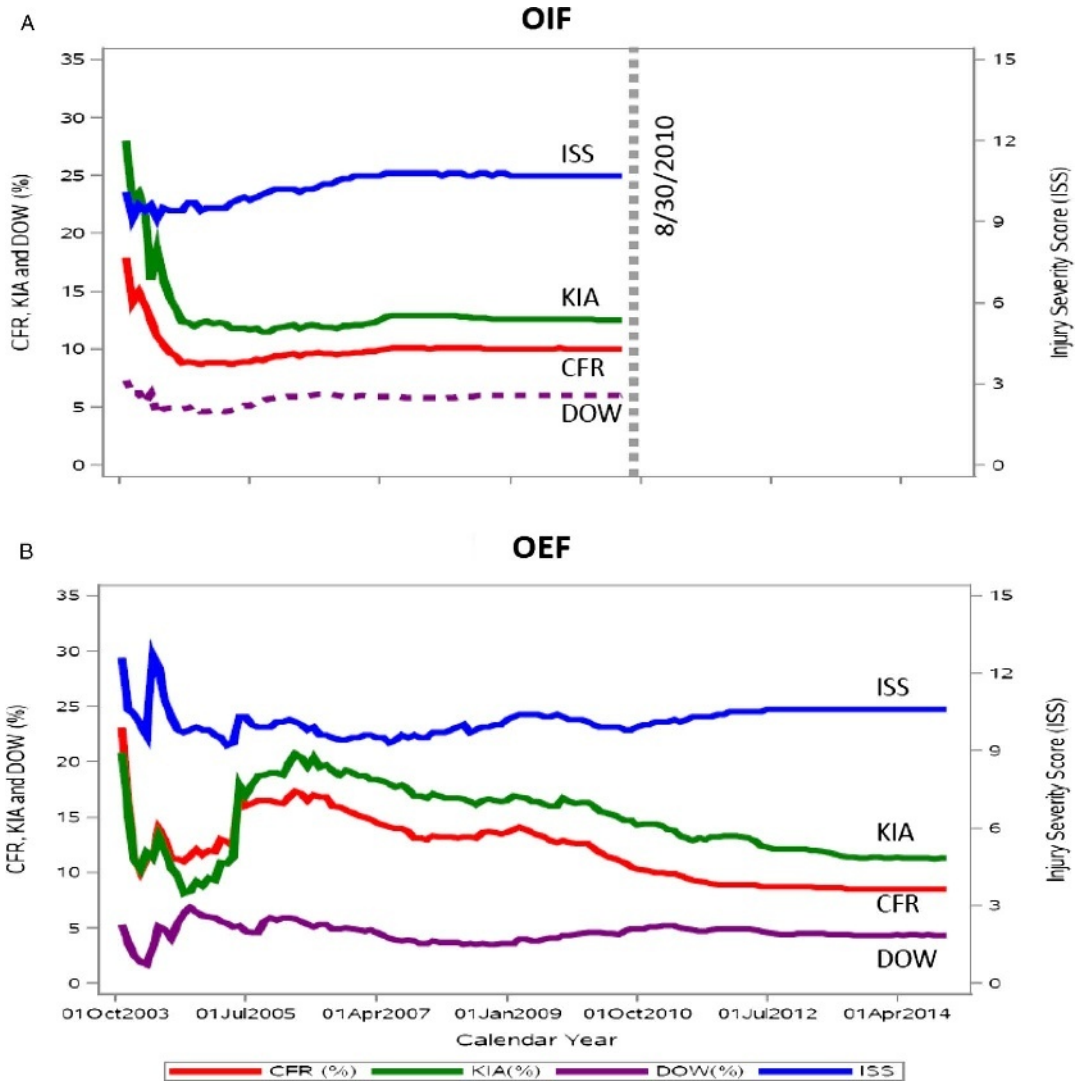

Figure 2. Trends in mortality and severity of combat casualty in OEF and OIF. Figure 2 illustrates trends in killed in action (%KIA), died of wounds (%DOW), case fatality rate (CFR), and Injury Severity Score (ISS) in Iraq, Operation Iraqi Freedom (OIF) in (A) and in Afghanistan, Operation Enduring Freedom (OEF) in (B). The left *y*-axis indicates CFR, %KIA, and %DOW. The right *y*-axis indicates ISS value. OIF ended on August 30, 2010.

Afghanistan/Iraq also evaluated potentially survivable deaths, which accounted for up to 25% of KIAs.[5] Therefore, it appears causes of total KIA casualties are similar between conflicts and were most commonly caused by destructive damage to the head/thorax or exsanguination.

Weapons Lethality Between Conflicts

Although the mechanisms of fatal injury between conflicts are similar, ratios of KIA to WIA casualties differ. In Vietnam, there were 40,934 total KIA deaths and 150,344 wounded (Table 3). This resulted in 1:4 KIA/WIA ratio for Vietnam. In Afghanistan/Iraq, there were 3,835 KIA deaths and 23,328 wounded (Table 3) resulting in a KIA/WIA ratio of 1:7. These ratios suggest weapons lethality was potentially higher in Vietnam than in Afghanistan/Iraq. One factor supporting this possibility is known lethality effects of ballistic assault weapons compared with fragmentation weapons (including improvised explosive devices) and the essential "zone of injury" of the casualty. The probability of death from fragmentation wounds ranges from 1:5 to 1:7 whereas the probability of death from high-velocity gunshot wounds is about 1:3.[5] In Vietnam, 51% of deaths were the result of gunshot wounds and 47% resulted from fragmentation weapons, booby traps, and mines.[10] Eastridge showed 73.7% of fatal wounds were caused by explosive (fragmentation) devices and 22.1% by gunshot wounds in Afghanistan/Iraq.[9] Although ISS scores are not available from Vietnam for comparison, it is interesting that 83% of wounded in Afghanistan/Iraq had wounds categorized as minor or moderate by ISS (see Fig. 4). Additionally, 53.3% of Afghanistan/Iraq wounded were categorized RTD whereas in Vietnam 48.7% of wounded were categorized RTD (Table 3).

A significant confounder is the use of advanced body armor in the recent conflicts. Information on the protective effects of body armor is not entirely understood as extensive data

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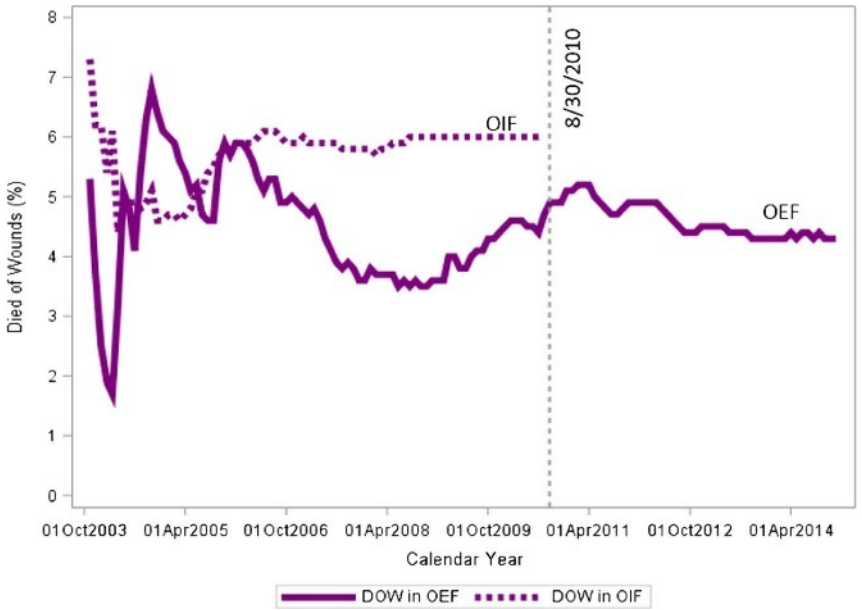

Figure 3. %DOW in OIF and OEF. Figure 3 exhibits trends of %DOW in Iraq, Operation Iraqi Freedom (OIF) and Afghanistan, Operation Enduring Freedom (OEF) during the study period. Vertical referent line indicates that OIF was ended on August 30, 2010.

regarding its protective effects are classified; however, it can be presumed to decrease the lethality of certain weapons or has the potential to convert fatal wounds into non-fatal wounds, and in some cases completely prevent injury. The wide-scale use of body armor by US Service Members in Operation Desert Storm resulted in a reduction in thoracic injuries to 5% from the 13% that occurred in Vietnam.[11] This reduction in thoracic injuries was sustained in Afghanistan and Iraq.[11] Another similar confounder is the protective effects of armored vehicles reflected in the variations of wounding patterns between mounted and dismounted troops.[12]

Improved Pre-Hospital Care in Afghanistan/Iraq

The %KIA can be affected by care provided from point of injury and by availability and speed of patient evacuation to surgery. Eastridge reported that tourniquet implementation resulted in a decrease of preventable deaths from extremity hemorrhage from 23.3 deaths per year before implementation to 3.5 per year after implementation.[9] Similarly, Kotwal reported %KIA improved significantly from 16.0% to 9.9% and CFR improved from 13.7% to 7.6% in Afghanistan after a mandate requiring transport of wounded to a surgical capability within 1 hour of wounding was implemented.[4] This change decreased median evacuation time from 90 to 43 minutes, and was achieved in part by increasing the number of MEDEVAC helicopters by 25% to 18 total aircraft in Afghanistan, and increasing the number of forward surgical teams available.[4] The end result of increasing both helicopters and surgical units was faster time to surgical intervention. Additionally, Shackelford

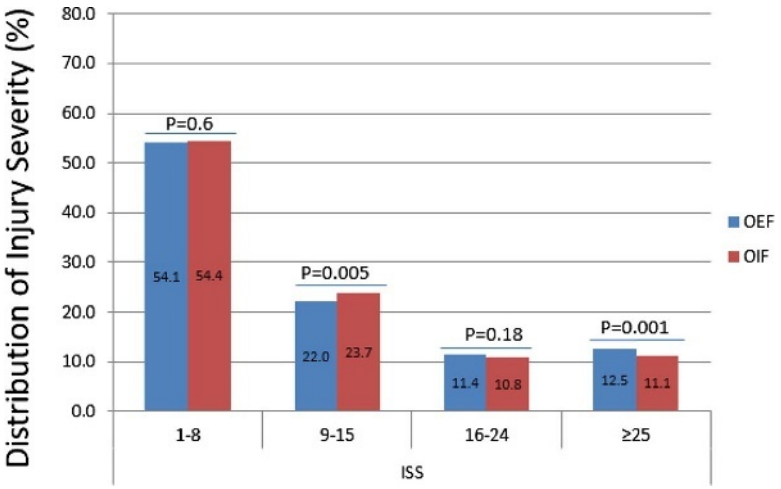

Figure 4. Distribution of injuries severity levels in OEF and OIF. Figure 4 shows a comparison of four injury severity levels: 1–8 (mild), 9–15 (moderate), 16–24 (severe), and ≥25 (critical injury) between Afghanistan, Operation Enduring Freedom (OEF) and Iraq, Operation Iraqi Freedom (OIF). Significant differences were observed in moderate injury (OIF > OEF) and in critical injury (OEF > OIF).

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reported substantial improvement in outcomes with pre-hospital blood product transfusion within 15 minutes of injury; survival improved from 23% to 13%.[13] It is reasonable to conclude that tourniquet placement, pre-hospital blood product transfusion, and improved evacuation times accounted, in part, for improvements in the %KIA and CFR within Afghanistan and Iraq.

Evaluating effects of tourniquets and evacuation times on %KIA and CFR when comparing Vietnam with the recent conflicts is challenging because little data exist on tourniquet use and effectiveness from Vietnam. However, in Vietnam, average patient evacuation times were reported to have generally been within 1 hour, and at the peak of the Vietnam War in 1968, 116 MEDEVAC helicopters were available to transport wounded to 19 field hospitals distributed throughout South Vietnam.[14] This capability was reported to have contributed to the improvement in CFR from 26.3% in Korea to 19.0% in Vietnam and is thought to have resulted in hospital mortality of 2.5% in Korea to 2.6% in Vietnam because more severely wounded arrived alive from the battlefield.[10] Whether evacuation times were substantially different between recent conflicts and Vietnam is difficult to know. However, reduction of time to blood and surgery in Afghanistan and Iraq did contribute to improvement in the CFR and %KIA.

%DOW Higher in Afghanistan/Iraq Compared with Vietnam

Though the absolute value and change is relatively small, this analysis demonstrated the %DOW in Afghanistan and Iraq was significantly higher than the %DOW in Vietnam ($p < 0.001$).[1,4] It is difficult to determine the cause of this change without ISS from Vietnam; however, this finding deserves further analysis and is certainly hypothesis generating. A comparative analysis of individual MTF outcomes as well as wound burden may further elucidate this observation.

Hospital Outcomes: Vietnam

Arnold et al. performed the largest Vietnam study of hospital outcomes of 132,996 admissions to 19 hospitals in South Vietnam from January 1969 to December 1969.[15] There were 1,162 (1.97%) deaths in combat-related surgical patients. Hemorrhage accounted for 23.9% of all deaths and 61% of those deaths occurred with 24 hours. Head injuries were responsible for 42.5% of all deaths after admission (Table 4).

TABLE 4. Causes of In-Hospital Deaths (DOW)

Author	N	Head (%)	Hemorrhage (%)	Burn (%)	Sepsis/ MOF (%)	Other (%)
OIF/OEF						
Nessen et al. (2009)	16	37	25	13.0	13.0	12.0*
Eastridge et al. (2011)	558	45	49**	0.0	4.0	2.0
Martin et al. (2009)	151	45	32	9.0	7.0	7.0
Vietnam						
Arnold et al. (1978)	1,162	42.5	23.9	3.1	11.7	6.1
Feltis et al. (1970)	121	***	53.6	0.0	19.7	26.7

DOW, died of wounds; OEF, Afghanistan, Operation Enduring Freedom; OIF, Iraq, Operation Iraqi Freedom; MOF, multisystem organ failure.

*Hemorrhage from multiple sources.

**Hemorrhage in this study was defined as truncal, junctional, and extremity.

***Traumatic brain injured patients not treated at this hospital.

Feltis et al. reported the outcomes of 6,927 patients admitted to a single Evacuation Hospital from January 1966 to June 1968.[16] Interestingly, this hospital did not receive patients with neurological injuries who were sent to a specialty hospital. Of 121 deaths reported (1.8%), hemorrhage was the cause of death in 53.6% overall with 86.8% of those patients succumbing within 24 hours (Table 4). Wound distribution was 11.3% head/neck, 10.1% thorax, 14.0% abdomen, and 64.6% extremity (Table 5).

Heaton evaluated outcomes of 7,896 hospitalized patients from October 1965 to January 1966.[16] Of 214 deaths (2.72%), 60% died within 24 hours of admission. Wound distribution was head and neck 12%, thorax 7.2%, abdomen 7.1%, and extremity 63% (Table 5). Body regions involved were head/neck 8.5%, thorax 7.9%, abdomen 9.3%, and extremities 1.7%; 49.6% suffered fragmentation injury and 42.7% suffered gunshot wounds.[17]

Hospital Outcomes: Afghanistan and Iraq

Zouris reporting on 279 wounded Sailors and Marines in Iraq (2003) found intracranial head injury 3.9%, head/neck/face injury 14.7%, chest injury 5.0%, abdomen/pelvis injury 3.6%, and extremity injury 68.4% (Table 5). Fragmentation wounds was the most prevalent wounding mechanism (32%) followed by gunshot wounds (25.1%).[18]

In Afghanistan, Nessen reported the outcomes of a forward surgical team's treatment of 761 patients treated at two locations.[19] This study removed RTD patients and included wounded local nationals and reported a %DOW of 2.36% among all casualties and 1.45% for U.S. Service Members. The average ISS among those who died of wounds was 47.1. The distribution of wounds for Service Members was head/neck 13.9%, thorax 3.7%, abdomen 2.6%, and extremities 54.3% (Table 5). The causes of death were head (37%), thorax (1%), burns (13%), and abdominal hemorrhage (25%) (Table 4). Explosive devices were responsible for injury in 57.3% of Service Members with gunshot wounds accounting for 16.9% of injuries in this study.[19] Owens reported on the 1,566 combat wounded Service Members in Afghanistan from October 2001 to January 2005.[20] This study excluded RTD patients and reported a %DOW of 3.4%. Fragmentation injuries from improvised explosive devices caused 79% of wounds whereas GSW accounted for 19%. The distribution of wounds was head/neck in 29.4%, thorax in 5.6%, abdomen in 10.7%, and extremities in 54.1% (Table 5). This paper did not report the causes of death in DOW casualties.[20]

Belmont reporting on 7,877 combat casualties in Afghanistan/Iraq from 2005 to 2009 found head/face/neck injury 28.1%, chest 9.9%, abdomen 10.1%, and extremity injury 51.9% (Table 5). Wounding mechanism was explosive 74.4% and gunshot wounds 19.9%. The %DOW was reported 8.98% for Iraq and 7.70% for Afghanistan.[21]

In an autopsy study, Eastridge reported on 558 Afghanistan/Iraq Service Members who died of wounds from October 2001 to June 2009.[21] They categorized patients as having potentially survivable (PS) (51.4%) or non-survivable wounds (NS) (48.6%). Wounding mechanisms were explosive (72%) and gunshot (25%). The predominant cause of death in NS patients was head injury (83%) and hemorrhage (80%) for PS. Interestingly, 51%

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TABLE 5. Patterns of Wounding

Author	N	Head (%)	Head/neck/face (%)	Chest (%)	Abs/pelvis (%)	Extremity (%)	Other + (%)
OIF/OEF							
Nessen et al. (2009)	761	6.1	13.9	3.9	2.6	54.3	19.2
Owen et al. (2008)	1,566	8.0	22.0	6.0	11.0	54.0	0.0
Belmont et al. (2012)	7,896	0.0*	28.1	9.9	10.1	51.9	0.0
Vietnam							
Heaton et al. (1966)	6,927	0.0*	12.0	7.2	7.1	63.0	10.7
Feltis et al. (1970)	6,927	0.0*	11.3	10.1	14.0	64.6	0.0
Neel (1973)	**	0.0*	14.0	7.0	5.0	54.0	20.0

Abs, abdominal cavity; OEF, Afghanistan, Operation Enduring Freedom; OIF, Iraq, Operation Iraqi Freedom.
+ Other: vascular, uro/gyn, spine, soft tissue, multiple wounds, or not defined by author.
*Head, neck, facial wounds not distinguished from intracranial injury by authors.
**Source: Statistical Data on Army Troops Wounded in Vietnam, January 1965–June 1970, Medical Statistics Agency, Office of the Surgeon General, U.S. Army.

of patients categorized PS arrived with cardiopulmonary resuscitation in progress, which suggests that their survival required more effective pre-hospital care as opposed to surgical care. The regions of PS hemorrhage were listed as truncal (48%), peripheral extremity (31%), and junctional (21%).

Martin reviewed 151 deaths (including local nationals) for opportunities for improvement at a single combat support hospital in Iraq from January 2007 to January 2008.[22] Cause of death was head injury in 45% and hemorrhage in 32% (Table 4). Interestingly, in this study, gunshots were responsible for 47%, and explosion injuries for 42% of wounds, which demonstrates theater trends may vary over time at the regional level; and as noted earlier, gunshot wounds are relatively deadlier than fragmentation weapons. Their study found that high preventability scores were related to hemorrhage control pre-hospital and during the early hospital resuscitation phase; preventability of death could be attributed to the individual provider level in 70% of cases; and opportunities for improvement were found in 78% of non-expectant deaths. The authors concluded that imperfect trauma care and hemorrhage control early in the process contributed to later deaths in the operating room and recovery. They also concluded that opportunities for improvement existed at all levels of the trauma system. The authors concluded, "Process improvement efforts should focus on both fully supporting the needed training and supplies, but also on policies that remove barriers or delays and make critical aspects of trauma care as automated a process as possible."[23]

This limited review of the available literature on patients surviving to hospital admission in Afghanistan, Iraq, and Vietnam demonstrated predominate causes of mortality continue to be head injury and hemorrhage. Previous studies have shown thoracic injuries and abdominal injuries were more common in hospitalized patients in Vietnam compared with Afghanistan/Iraq.[12] Extremity injures were prevalent in both periods (Table 5). Wounded surviving to admission were also more likely to have a fragmentation mechanisms of injury. Although mechanism and cause of death seem similar, it is not possible to precisely explain the increase in %DOW in Afghanistan/Iraq without patient specific wound severity data, particularly as it relates to traumatic brain injury and anatomical site of hemorrhage.

Died of Wounds Trends in Afghanistan and Iraq

The %DOW trended downward in Afghanistan. Figure 3 shows the most improvement from 2005 to 2008, after which %DOW increases. In Iraq, the trend is upward starting in 2005 with relative stabilization after 2006. Understanding these trends will be important to effective battlefield performance improvement and future studies should be focused in this area.

Injury Severity Stable Over time in Operation Enduring Freedom/Operation Iraqi Freedom

Injury Severity Scores did not significantly change over time in Afghanistan and Iraq. However, it is possible regional and local increases in injury severity affected %DOW as mortality rates are associated with injury severity. Langan studied casualties who received a massive transfusion and died of wounds before and after damage control resuscitation guidelines were established, and found mean ISS had increased from 22.5 to 26.7.[24] Patel demonstrated %DOW in Afghanistan/Iraq was correlated to injury severity, and significant regional variation occurred within units and hospitals, which may not be apparent at the theater level, especially considering 83% of wounded received minor or moderate injuries.[25]

Limitations

This study has limitations intrinsic to the retrospective nature of the analysis, those associated with large data repositories and historical aggregated reports from Vietnam including misclassification bias, observer bias, survivor bias, and data integrity. These problems are likely exacerbated when combining databases. Difficulty in obtaining data before a casualty arriving at a combat support hospital in the recent conflict may have resulted in survivor bias in the DODTR and could specifically affect ISS, CFR, %KIA, and %DOW by excluding patients who died at forward surgical teams and were not included in the database.

CONCLUSION

The CFR and %KIA achieved during Afghanistan and Iraq were improved compared with Vietnam and improved during the recent conflicts. The %DOW in Iraq and Afghanistan is higher than in Vietnam. Although summary statistics are dependent on multiple medical and non-medical confounders, the

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increase of %DOW compared with Vietnam as well as the increase in %DOW over time in Iraq is concerning and warrants further investigation. A vital component of any trauma system is continuous performance improvement in order to improve survivability from injury.[26] This analysis indicates that systems should be implemented supporting rapid battlefield performance improvement measures capable of detecting changes in outcome measures like %DOW, %KIA, or CFR to enable responsive performance improvement measures. Developing sustainable, robust, accurate, and timely performance improvement mechanisms has the potential to not only improve the battlefield trauma system but also the civilian trauma system. These findings should prompt study of the effectiveness and capabilities of the current DOD battlefield trauma system, including individual pre-hospital and surgical units. Understanding the causal factors of both increases and improvement of the %DOW over time will be critical to effective and sustainable battlefield performance improvement of surgical units.

AUTHORSHIP

S.C.N., J.G., A.P.C., E.M.-S., T.D.L., S.S., T.E.R., and J.B.H. contributed to study design, data acquisition, analysis and interpretation and were actively involved in the drafting and critical revision of the manuscript and who provided final approval of the version to be published.
K.N.R., K.A., B.E., D.J., Z.S., C.K.M., K.G., J.S., and R.M. contributed significantly to study analysis and interpretation of data and were actively involved in the drafting and critical revision of the manuscript and have provided final approval of the version to be published.

DISCLOSURE

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Analysis of Pediatric Trauma in Combat Zone to Inform High-Fidelity Simulation Predeployment Training

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Objectives: The military uses "just-in-time" training to refresh deploying medical personnel on skills necessary for medical and surgical care in the theater of operations. The burden of pediatric care at Role 2 facilities has yet to be characterized; pediatric predeployment training has been extremely limited and primarily informed by anecdotal experience. The goal of this analysis was to describe pediatric care at Role 2 facilities to enable data-driven development of high-fidelity simulation training and core knowledge concepts specific to the combat zone.

Setting and Patients: A retrospective review of the Role 2 Database was conducted on all pediatric patients (< 18 yr) admitted to Role 2 in Afghanistan from 2008-2014.

Interventions: Three cohorts were determined based on commercially available simulation models: Group 1: less than 1 year, Group 2: 1-8 years, Group 3: more than 8 years. The groups were sub-stratified by point of injury care, pre-hospital management, and Role 2 facility medical/surgical management.

Measurements and Main Results: Appropriate descriptive statistics (chi square and Student t test) were utilized to define demographic and epidemiologic characteristics of this population. Of 15,404 patients in the Role 2 Database, 1,318 pediatric subjects (8.5%) were identified. The majority of patients were male (80.0%) with a mean age of 9.5 years (± SD, 4.5). Injury types included: penetrating (56%), blunt (33%), and burns (7%). Mean transport time from point of injury to Role 2 was 198 minutes (±24.5 min). Mean Glasgow Coma Scale and Revised Trauma Score were 14 (± 0.1) and 7.0 (± 1.4), respectively. Role 2 surgical procedures occurred for 424 patients (32%). Overall mortality was 4% ($n = 58$).

Conclusions: We have described the epidemiology of pediatric trauma admitted to Role 2 facilities, characterizing the spectrum of pediatric injuries that deploying providers should be equipped to manage. This analysis will function as a needs assessment to facilitate high-fidelity simulation training and the development of "pediatric trauma core knowledge concepts" for deploying providers. (*Pediatr Crit Care Med* 2018; XX:00–00)

Key Words: military; pediatric; simulation; trauma

The modern battlespace presents many unique challenges to military medical providers due to an ever-changing and evolving combat environment. Military medical treatment facilities (MTFs) are positioned in a manner designed to mitigate potential risk to combatants as well as

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This work was prepared as part of the official duties of Drs. Reeves, Le, Caldwell, Edwards, Gurney, Stockinger, and Borgman who are employed by the United States Army and Air Force. The views expressed in this article are those of the authors and do not reflect the official policy or position of the United States Army, Air Force, Department of Defense, or the U.S. Government. Title 17 U.S.C. 105 provides that "Copyright protection under this title is not available for any work of the United States Government." Title 17 U.S.C. 101 defines a United States Government work as a work prepared by a military service member or employee of the United States Government as part of that person's official duties.

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to treat anticipated casualties. Given the shift to asymmetrical combat actions, the "Role 2" (R2) MTF, which typically has modest inpatient management and holding capability and limited surgical capability (e.g., Forward Surgical Teams [FSTs]), has become the most widely used medical asset on the modern battlefield. Compared to the Role 1 aid station which provides basic first aid and emergency care with a single medical provider with very limited resources, R2 boasts a greater capacity for acute resuscitation, limited inpatient management, and the augmented ability to perform initial surgical procedures. R2 MTFs with FSTs are capable of damage control resuscitation (with blood products) and surgery, as well as other life and limb-saving procedures, prior to transfer to R3 MTFs which are the highest level of care on the battlefield. Role 3 facilities have longer holding capacity with some specialty care and ancillary support but are limited by their logistical needs and lack of mobility. By comparison, the need to put emergency surgical services close to the point of injury in a very large area of operations, most surgical care is performed at the smaller and more mobile R2 facilities (1, 2). However, both R2 and R3 facilities can provide compassionate nonsurgical, nontrauma care based on the medical rules of engagement, available resources, and tactical situation.

One of the missions for medical teams at the R2 is to support the local national population including injured children who are frequently the unintended victims of war. The management of these children involves initial stabilization, resuscitation, and transport to a role of care or host nation facility with the necessary capabilities. R2 MTFs provide life-saving interventions in order to bridge the gap between wounding and definitive care. Reports on the epidemiology of pediatric care at Role 3 (R3) Combat Support Hospitals (CSHs) have noted that 10% of bed-days are for children (3–5). To date, the description of care provided to children at R2 has been limited to small case series.

To prepare medical providers for deployments, the military frequently employs "just-in-time" training to refresh certain skills necessary to optimize medical and surgical care in the theaters of operation (6). The challenge with current predeployment training is fitting a variety of important modules into a limited amount of time (7). Additionally, pediatric training has been essentially nonexistent and relies on anecdotal sharing of lessons learned rather than a comprehensive analysis of actual patient data and translation into a training paradigm (6, 8, 9). In spite of the documented need to provide pediatric care, predeployment training inclusive of this concept is neither standardized nor required prior to deployment. The goal of this qualitative and quantitative analysis of pediatric care provided at R2 MTFs is to provide a comprehensive "needs assessment" to inform future training and educational objectives. Using Kern's six-step approach to curriculum development, the descriptive analysis provided in this study will serve as the "problem identification and needs assessment." (10) This will facilitate a targeted needs assessment of providers which will be the basis for developing goals and objectives. Our hypothesis is that this methodology will enable the design of a data-driven, high-fidelity simulation training curriculum focusing on the management of pediatric patients in the combat zone.

METHODS

This is a retrospective cohort analysis of data compiled from the Joint Trauma System (JTS) R2 Database (R2DB) on pediatric patients (< 18 yr) admitted to R2 facilities in Afghanistan from 2008 to 2014. Patients age greater than 18 years, those without age documentation, and those with "estimated ages" assigned by providers were excluded from this review. Previously described in whole by Mann-Salinas et al (11), the R2DB is an electronic database containing demographic, epidemiologic, and clinical data collected as a voluntary sample of R2 locations ($n = 28$) from traumatically wounded patients. This database contains information beginning at point of injury through discharge from a R2 MTF (11). We defined "prehospital" as the time interval from point of injury to initial arrival and entry at a R2 MTF. Nontrauma care was not recorded. Data queried included demographic data (age, gender), injury characteristics (mechanism and type of injury, admission diagnoses, Revised Trauma Score [RTS], Pediatric Trauma BIG Score [base deficit + (2.5 × international normalized ratio) + (15 − Glasgow Coma Scale [GCS])]), vital signs, laboratory values (hematocrit, hemoglobin, international normalized ratio, base deficit), prehospital management (crystalloids administered, assisted respiratory rate, tourniquet use, c-collar placement, reintubation), R2 medical management (surgery, massive transfusion protocol activation, IV fluids and blood/blood product administration), and complications (12). Traumatic brain injury (TBI) was defined as those with a head injury with any documented altered mental status. Life-saving surgery was defined as any procedure that, if not performed, the patient would have died. Anemia was defined as stabilized blood loss with hemoglobin less than 8 g/dL. See the R2R study and R2DB user guide for all clinical definitions (11, 13).

Three study groups based on age were determined in order to correspond to commercially available simulation models and existing civilian courses such as Pediatric Advanced Life Support: group 1: less than 1 year, group 2: 1–8 years, group 3: greater than 8 years. The groups were analyzed according to demographic data and were further substratified based on point of injury care, prehospital management, and medical/surgical management at the R2 MTF. Descriptive statistics were employed to define demographic and epidemiologic characteristics of the cohort. A p value of less than 0.05 was considered statistically significant. This study was approved by the U.S. Army Institute of Surgical Research Regulatory Compliance Division.

RESULTS

Of 15,404 patients included in the R2DB, 1,318 pediatric subjects (8.5%) were identified (**Fig. 1**). Four hundred seventy-eight patients cared for at a R2 MTF were not included in this R2DB query due to a lack of age documentation.

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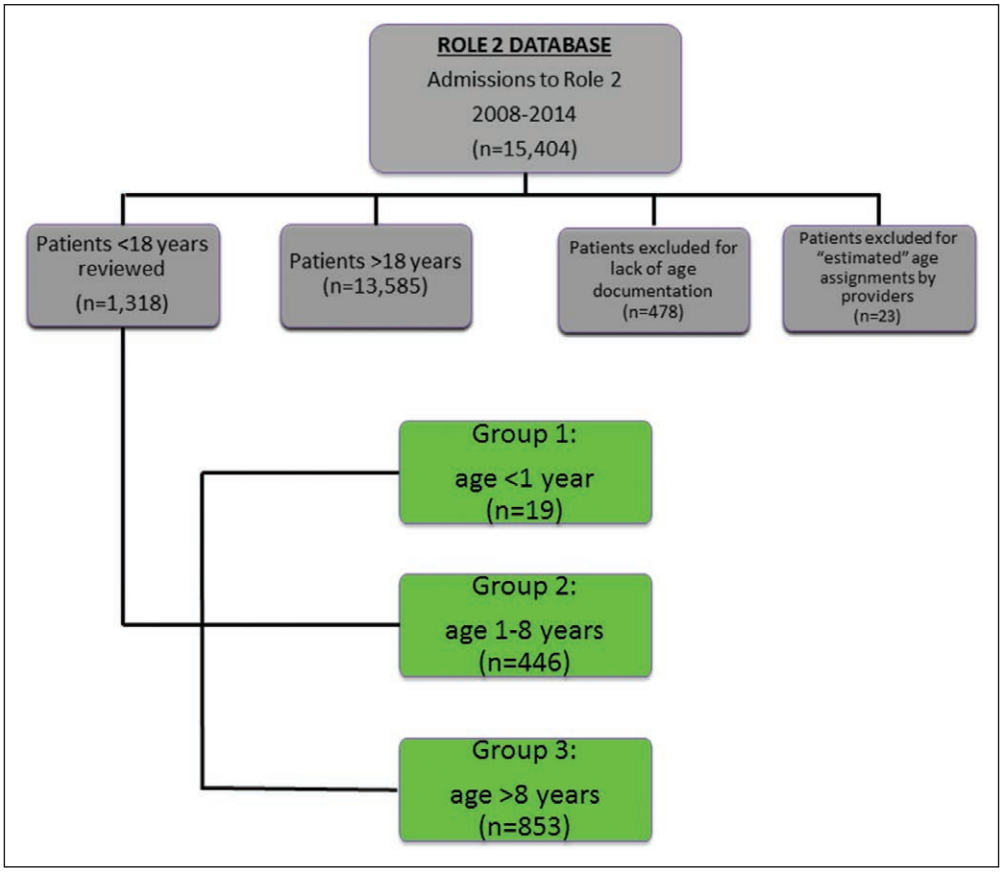

Figure 1. Study flowchart.

Twenty-three additional subjects in the R2DB were excluded from our study due to receiving "estimated age" assignments by providers in the field as opposed to cataloguing a stated age by the patient or caregiver. Patients' demographic and injury characteristics are outlined in **Table 1**. The majority of patients in this cohort were male (80.0%) with a mean age of 9.5 years (± SD, 4.5). The leading primary type of injury was penetrating (56%), followed by blunt (33%), and burn (7%). No difference in transport time from point of injury to R2 MTF (combining both aeromedical or ground resource utilization) for the three groups was found with an overall mean of 198 minutes (± 24.5 min) (p = 0.67). The lapsed aeromedical time from point of injury to arrival at a R2 MTF was a mean of 202 minutes (± 431 min), median 117 minutes (interquartile range [IQR], 60–219 min) (n = 317 patients). The ground transport times were mean 134 minutes (±119 min), median 88 minutes (IQR, 47–178 min) (n = 177 patients). Only 15% (n = 12) were transported in under 60 minutes. The mean GCS and RTS were 14 (± 0.1) and 7.0 (± 1.4), respectively. Prehospital management of patients is displayed in **Table 2**. Medical management and surgical interventions are catalogued in **Table 3**. The mean BIG Score calculated was 10.8 (n = 325 complete data). RTS calculated was 7.0 (n = 823 complete data). Overall mortality was 4% (n = 58). Clinical complications identified during the course of the R2 MTF care are illustrated in **Table 4**.

Group 1 (n = 19) formed only 1.4% of the study population. Of these subjects, 68% were male with mean (± SD) age of 0.4 years (± 0.08 yr). Demographic and prehospital information is displayed in Tables 1 and 2, respectively. With concern to mechanism of injury, group 1 demonstrated a significantly greater percentage of burns compared with the other groups (15.8%; $p < 0.01$) (Table 1). This group was also most likely to receive colloid infusions (10.5%; $p < 0.01$) (Table 2). Mortality in this group was 10.5% (n = 2). Both subjects who died suffered from gunshot/penetrating wounds (Table 1).

Group 2 accounted for 446 patients (33.8% of the study population). Sixty six percent were male. The mean age was 4.8 years (± 0.1 yr). Demographic and prehospital information is displayed in Tables 1 and 2, respectively. Group 2 showed a greater percentage of blunt trauma victims ($p < 0.05$) compared with the remainder population. Correspondingly, group 2 subjects demonstrated a significant trend for either TBI ($p < 0.01$) or skull fracture ($p < 0.01$) compared with the other groups. Mortality was 4.7% (n = 21). Of those who died in this group, the initial diagnoses were TBI (n = 9, 43%), penetrating injury (n = 6, 29%) (gunshot wound), burn (n = 5, 24%), and respiratory failure (n = 1, 5%) (not significant).

Group 3 was the largest group and accounted for 64.7% of the population. Male gender was predominant (86.6%), and the mean age was 12.1 years (±0.1 yr). Demographic and prehospital information is displayed in Tables 1 and 2, respectively. The members of group 3 were most likely to be treated for battle injury ($p < 0.01$) and suffered from a significantly greater percentage of penetrating wounds ($p < 0.01$) compared with the rest of cohort. In addition to penetrating traumas or battle injuries, group 3 subjects were significantly more likely to require in-field tourniquet placement ($p < 0.01$). A significantly greater percentage of group 3 members required resuscitation including crystalloids ($p < 0.01$), packed RBCs ($p < 0.01$), or plasma ($p < 0.01$). There was no significant difference among the groups receiving fresh whole blood or facility massive transfusion protocol activation. Group 3 subjects required both a greater percentage of orthopedic procedures ($p < 0.01$) and life-saving surgical interventions ($p < 0.01$). Group 3 subjects also exhibited a significantly greater

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TABLE 1. Patient Demographics Including Diagnoses Associated With Mortality for the Entire Cohort With Subcohorts Analyzed by Age

Variable	Overall	Study Group			*p*
		< 1 yr	1–8 yr	> 8 yr	
Number of patients, *n* (%)	1,318 (100.0)	19 (1.4)	446 (33.8)	853 (64.7)	
Age, mean (SD), yr	9.5 (4.5)	0.4 (0.5)	4.9 (2.2)	12.2 (2.9)	
Gender, male, *n* (%)	1,050 (80.0)	13 (68.4)	298 (66.8)	739 (86.6)	0.0001
Primary type of injury, *n* (%)					
Penetrating	739 (56.0)	7 (36.8)	178 (39.9)	554 (64.9)	< 0.0001
Blunt	432 (33.0)	7 (36.8)	170 (38.1)	255 (29.9)	0.01
Burn	87 (7.0)	3 (15.8)	53 (11.9)	31 (3.6)	< 0.0001
Other/unknown	60 (4.6)	2 (10.5)	45 (10.1)	13 (1.5)	NS
Time, mean (SD), min					
Injury to arrival *n* (SD), *n* = 494	198 (24.5)	116.8 (30.8)	184.3 (23.3)	207.5 (23.9)	NS
Battle injury, *n* (%)	638 (48.0)	9 (47.4)	155 (34.8)	474 (55.6)	< 0.0001
BIG Score, mean (SD), *n* = 325	10.8 (7.3)	17.3 (5.2)	11.5 (0.8)	10.4 (0.5)	NS
Revised Trauma Score, mean (SD), *n* = 823	7.0 (1.4)	7.3 (0.7)	7.1 (1.3)	7.0 (1.5)	NS
Glasgow Coma Scale, mean (SD)	14 (3.2)	12 (1.3)	13 (0.2)	14 (0.1)	NS
Final disposition, *n* (%)					
Deceased, overall	58 (4.0)	2 (10.5)	21 (4.7)	35 (4.1)	NS
Primary diagnoses of mortality, *n* (% of deceased by group)					
Burn	11 (18.9)	2 (10.5)	5 (23.8)	4 (11.4)	NS
Traumatic brain injury	17 (29.3)	0 (0.0)	9 (42.8)	8 (22.8)	NS
Penetrating injury (gunshot)	20 (34.4)	0 (0.0)	6 (28.5)	14 (40.0)	NS
Respiratory failure	1 (1.7)	0 (0.0)	1 (4.7)	0 (0.0)	NS
Blunt injury	5 (8.6)	0 (0.0)	0 (0.0)	5 (14.2)	NS
Improvised explosive devices	2 (3.4)	0 (0.0)	0 (0.0)	2 (5.7)	NS
Drowning	1 (1.7)	0 (0.0)	0 (0.0)	1 (2.8)	NS
Snakebite	1 (1.7)	0 (0.0)	0 (0.0)	1 (2.8)	NS

NS = not significant.

BIG Score was calculated as using base deficit, international normalized ratio and Glasgow Coma Scale. The *p* values were calculated with the use of a chi-square or Fisher exact test where appropriate. Note: "23 patients were excluded from the Role 2 Database due to receiving" estimated age assignments by providers in the field.

percentage of patients developing with anemia compared with the other groups ($p < 0.01$). Finally, overall mortality in this group was 4% ($n = 35$) (Table 1). Of those who died in this study group, initial diagnoses included penetrating injury (40%, $n = 14$), TBI (23%, $n = 8$), blunt injury (14%, $n = 5$), burns (11%, $n = 4$), improvised explosive devices (IEDs) (6%, $n = 2$), drowning (3%, $n = 1$), and snakebite (3%, $n = 1$) (not significant).

DISCUSSION

This is the first multicenter review of pediatric combat casualty care provided at R2 facilities collated into a single database. Injuries were significant for a higher proportion of burns in infants, TBI in children 1–8 years, and penetrating injuries in older children. These epidemiologic data "identify the problem" and serve as a general needs assessment for training needs for deploying providers at these facilities. Previously, there have been several analyses of pediatric care at individual R2 facilities which were also limited because the comparatively short time period of the analysis (19–28). Our investigation stands apart due to its larger sample size and longer duration of examination, thus producing a more robust dataset to help inform training.

In the oldest subpopulation, group 3, a significant majority of pediatric injuries were due to battle ($p < 0.05$). Furthermore, group 3 suffered a higher rate of injury due to penetrating

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TABLE 2. Prehospital Management of Pediatric Patients in the Combat Zone Prior to Admission at Role 2

Variable	Overall	Study Group			*p*
		< 1 yr	1–8 yr	> 8 yr	
Number of patients, *n* (%)	1,318 (100.0)	19 (1.4)	446 (33.8)	853 (64.7)	
Prehospital procedures, *n* (%)					
Assisted respirations	86 (6.5)	4 (21.1)	33 (7.4)	49 (5.7)	0.018
Tourniquet	101 (7.7)	1 (5.3)	12 (2.7)	88 (10.3)	< 0.0001
C-collar placed	276 (20.9)	1 (5.3)	88 (19.7)	187 (21.9)	Not significant
Crystalloids	52 (3.9)	2 (10.5)	10 (2.2)	40 (4.7)	0.03

The *p* values were calculated with the use of a chi-square test.

TABLE 3. Medical and Surgical Care Employed for the Study Patients by Type and Frequencies

Variable	Overall	Study Group			*p*
		< 1 yr	1–8 yr	> 8 yr	
Number of patients, *n* (%)	1,318 (100.0)	19 (1.4)	446 (33.8)	853 (64.7)	
Interventions in first 24 hr, *n* (%)					
Reintubation 24 hr	3 (0.2)	0 (0)	1 (0.2)	2 (0.2)	NS
Crystalloid	928 (70.4)	9 (47.4)	278 (62.3)	641 (75)	< 0.0001
Colloid	37 (2.8)	1 (5.3)	3 (0.7)	33 (4)	0.003
Packed RBCs	245 (18.6)	2 (10.5)	57 (12.8)	186 (22)	0.0003
Plasma	95 (7.2)	1 (5.3)	9 (2.0)	85 (10)	< 0.0001
Whole blood	21 (1.6)	0 (0)	3 (0.7)	18 (2)	NS
Massive transfusion	15 (1.1)	0 (0)	2 (0.4)	13 (2)	NS
Surgical procedures, *n* (%)					
Laparotomy	161 (12.2)	0 (0)	47 (10.5)	114 (14)	NS
Neurosurgery	8 (0.6)	1 (5.3)	4 (0.9)	3 (0.3)	0.02
Orthopedic	211 (16.0)	0 (0)	54 (12.1)	157 (19)	0.004
Life-saving surgery	221 (16.8)	3 (15.8)	52 (11.7)	166 (19)	0.002
Patients requiring surgery	424 (32.1)	4(21.1)	117 (26.2)	303 (36)	0.002

24 hr = provided within the first 24 hr of hospital stay, NS = not significant.
The *p* values were calculated with the use of a chi-square or Fisher exact test.

mechanisms than the rest of the study population ($p < 0.05$). Similar to Role 3 populations studied separately by Coppola and Edwards (14–16), penetrating traumas as a result of IEDs comprised the greatest type of injuries at the R2 MTF. Children have previously been described as being at greater risk of falling victim to landmines or IEDs, and our study demonstrates that children admitted to R2 MTFs require a similar type of care (17, 18).

Twenty percent of R2 pediatric patients suffered from TBI. In group 2, of the 5% of patients who suffered from TBI, 18% were due to motor vehicle crash. This is likely multifactorial and potentially secondary to poor condition of third-world roadways and lack of basic child motor vehicle safety restraints (19, 20). Notably, 43% ($n = 9$) of group 2 fatalities were related to TBI. Of these group 2 subjects with TBI who died, the average GCS was 6 (range, 3–12), demonstrating the severity of these injuries presenting at austere surgical facilities which has been previously described (21).

In recent military literature, burns comprise a large percentage of pediatric admissions (22). We also found that burns are more common in younger patients (age, 0–8 years), though this was a small group.

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TABLE 4. Clinical Complications Identified During the Course of the Role 2 Medical Treatment Facilities Care

Variable	Overall	Study Group			*p*
		< 1 yr	1–8 yr	> 8 yr	
Number of patients, *n* (%)	1,318 (100.0)	19 (1.4)	446 (33.8)	853 (64.7)	
Clinical problem, *n* (%)					
Anemia	60 (4.5)	1 (5.3)	9 (2.0)	50 (5.9)	0.007
Extremity compartment syndrome	10 (0.7)	0 (0)	2 (0.4)	8 (0.9)	NS
Abdomen compartment syndrome	1 (0.1)	0 (0)	1 (0.2)	0 (0)	NS
Cellulitis	1 (0.1)	0 (0)	0 (0)	1 (0.1)	NS
Hemothorax	4 (0.3)	0 (0)	0 (0)	4 (0.5)	NS
Hypothermia	98 (7.4)	3 (15.8)	27 (6.1)	68 (8.0)	NS
Hypovolemia	31 (2.3)	0 (0)	6 (1.3)	25 (2.9)	NS
Pleural effusion	1 (0.1)	0 (0)	0 (0)	1 (0.1)	NS
Acute neurologic change	22 (1.7)	0 (0)	11 (2.5)	11 (1.3)	NS
Seizure	4 (0.3)	1 (5.3)	2 (0.4)	1 (0.1)	0.0002
Shock	22 (1.7)	0 (0)	9 (2.0)	13 (1.5)	NS
Acute respiratory distress syndrome	3 (0.2)	0 (0)	2 (0.4)	1 (0.1)	NS
Cardiopulmonary resuscitation	16 (1.2)	2 (10.5)	3(0.7)	11 (1.3)	0.0006
Arrhythmia	3 (0.2)	0 (0)	2 (0.4)	1 (0.1)	NS
Respiratory failure	11 (0.8)	0 (0)	4 (0.9)	7 (0.8)	NS
None	1,075 (81.6)	14 (73.7)	364 (81.6)	697 (81.7)	NS

NS = not significant.
The *p* values were calculated with the use of a chi-square or Fisher exact test.

Due to the asymmetric nature of modern warfare, villages and civilian populations tend to run parallel to lines of battle (23, 24). The average transport time of a pediatric patient from point of injury to R2 MTF is longer when compared with transport durations of active service members. Kotwal et al (25) previously described the prehospital helicopter transport time to definitive surgical care (either R2 FST or R3 CSH) for U.S. military casualties in Afghanistan: mean = 66 ± 103.6 minutes, median = 43 minutes (IQR, 29–57 min). By comparison, the R2DB demonstrated that the lapsed aeromedical time from point of injury to arrival at a R2 MTF was much greater for pediatric patients. This further highlights the importance of pediatric predeployment training for evacuation personnel, specifically to cover en route pediatric care. Factors that contribute to longer transport time required for aeromedical transport of local pediatric casualties include evolving tactical situations that determine the flow of patient care and may preclude the transport of civilians, lack of adequate, safe transportation by victims' families, absence of dedicated evacuation assets, delaying of care by parents and families following an injury, and initiating of treatment of these pediatric patients at civilian facilities prior to transport. In comparison, the documented pediatric lapsed ground time from point of injury to R2 MTF for casualties calculated was less than the aeromedical duration. Prolonged pediatric transport times have the potential to delay definitive care for traumatic injuries and may require further point of care management by on-site providers. This may indirectly indicate the need for further predeployment training of medical providers in the care and transport of the traumatically wounded child.

The pediatric mortality observed upon discharge at R2 was 4% (*n* = 58). Of those, the predominant injury associated with mortality was TBI, 29% (*n* = 17). We were unable to examine the severity of injury for the entire database. While Injury Severity Score was not recorded in our population, the mean BIG Score for 325 patients with all data elements was 10.8 (Table 1). Of those who had BIG Score calculated, the mortality was 4.9% (*n* = 16) compared with the BIG Score predicted mortality of 4.5% (*n* = 60); however, this comparison cannot be extrapolated to the overall cohort given the potential nonrandom nature of the missing data elements (12). For the patients with a calculated RTS, the overall mortality was 1.0% (*n* = 12), slightly higher than the predicted mortality for an RTS of 7.0 of approximately 3.1% (26). Again, given the missing data elements, no overall conclusions should be made based off of these numbers. As a point of reference, pediatric mortality rates of Role 3 facilities listed by Borgman et al (5, 27) were 5.8% and 6.9%, respectively. As a

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reference, pediatric civilian trauma centers in the United States have reported mortality around 2.7% (28).

Management of older children was more likely to include tourniquet use as well as fluid resuscitation, demonstrated by higher use of crystalloids, plasma, and packed RBCs within the first 24 hours of admission ($p < 0.05$). Group 3 also required the largest percentage of MTF massive transfusion activations (2%, $n = 13$). This reflects injuries from blast and penetrating trauma and is similar to what is seen in the adult combat casualty literature (8, 29).

Unlike the broader capabilities of a Role 3 MTF, R2 embedded forward surgical elements are significantly smaller and may consist of one to three general surgeons, zero to two orthopedic surgeons, one to two nurse anesthetists, zero to two operating room nurses, and zero to three operating room technicians, and sometimes a primary care or emergency department physician, along with a variable number of emergency medical technician-trained medics or corpsman (30-32). Frequently, these FSTs are split into smaller elements in order to have surgical capabilities as close to the point of injury as possible. In our 4-year study, 32% ($n = 424$) of children treated underwent a surgical procedure at a R2 MTF. Of these, older subjects were more likely to require surgery ($p < 0.01$). This does not take into account the unknown number of patients transferred to R3 for surgical intervention due to R2 limitations (e.g., provider or equipment). These results can inform the future preparedness for the surgical care of children in the combat zone.

There were significant variations by age regarding nonsurgical care. Older children were more likely to exhibit anemia during care compared with the rest of the population in the study ($p < 0.01$). It is noteworthy to state that infants were more likely to have in-facility seizures ($p < 0.01$) and require cardiopulmonary resuscitation ($p < 0.05$) during admission. This underscores the importance of pediatric advanced life support at R2 facilities.

This analysis demonstrates the continued need for predeployment training and knowledge of the JTS Clinical Practice Guidelines. In particular, knowledge, skills, and attributes concerning the management of pediatric head injuries, burns, penetrating injury, and damage control resuscitation principles appear critical to providers at the R2 location (33–37). This R2 study will allow our team to develop predeployment simulations and core knowledge topics with the intent to improve our medical practices for current and future engagements. We would suggest that these simulations and concepts would inform a course for providers in the predeployment phase for those that may encounter pediatric casualties. While concepts are similar for adult and pediatric trauma victims, immersive simulation training could significantly improve confidence for those without pediatric experience. Additionally, for psychomotor skills that are unique in small children (e.g., chest tubes, venous access, airways), a rotation in a pediatric trauma center would be ideal. This training model would also be appropriate for providers caring for children in a noncombat environment but who still occasionally encounter pediatric victims, such as adult trauma centers or those going on mission to care for pediatric trauma in humanitarian settings in austere environments. We would also suggest that immersive simulations should closely approximate scenarios that providers will encounter based on epidemiologic reviews to maximize training effectiveness. Although it may be helpful to have these concepts or courses integrated into graduate medical training programs, these skills and confidence degrade over time so a "just-in-time" or "predeployment" training model, if feasible, would be ideal.

There were several limitations in this study. Foremost among this study's limitations is the fact that the R2DB has not been validated through systematic review with comparison to patient records. In addition, the voluntary nature of the R2DB data entry served as a multifactorial limitation including: data entry was performed by clinical staff who were not trained in data abstraction, injury coding or registry management, and data entry was voluntary and self-reported. There was potentially a reporting bias of diagnoses, so the true frequencies cannot be known. By extension, the R2DB was designed to describe adult casualties, and unfortunately does not include patient weights. Although this would have enhanced our analysis of pediatric trauma and would have allowed us to capture more patients with missing ages, it was not the primary purpose of the R2DB to provide description of pediatric injuries and the care rendered. The R2DB only contains information concerning traumatic injuries. The primary injury mechanism was not recorded in 4.6% of patients. Additionally, cause of death was not captured in this database. Furthermore, the inherent, demonstrable difference between the R2DB and Department of Defense Trauma Registry in terms of validation should compel readers to interpret any conclusions drawn from R2DB with caution (11, 23). The small sample size of group 1 ($n = 19$) limited making conclusions on this younger group. Selection bias is a final, significant limitation of this study. Not all injured children in Afghanistan were cared for at R2 MTFs due to Medical Rules of Engagement and a limited access to care. Thus, our R2DB analysis should not be interpreted as a true cross sectional analysis of all injuries in this population. Despite the limitations of the R2DB, these broad generalizations of age stratifications were vital to inform our dedicated simulations for real-world application. In the future, the study results will be linked with data describing Role 3 pediatric casualty care in order to better elucidate training needs.

CONCLUSIONS

U.S. military operations in Afghanistan since 2008 demonstrate the volume and significance of pediatric trauma care in the combat zone. We have described the spectrum of pediatric injuries admitted to R2 facilities. Given this analysis, we have concluded that predeployment training should include concepts unique to the pediatric trauma patient (e.g., anatomic and physiologic variations from adults), skills related to pediatric trauma (e.g., pediatric/infant intubation, intraosseous line placement, chest tube insertion), and attitudes (e.g., confidence in managing the care of traumatically injured children). This study has functioned primarily as a needs assessment to fulfill the initial steps integral to the Kern Model for curriculum building. Further implementation will focus on the creation of high-fidelity human patient simulation scenarios and didactics to enhance core concepts

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for the traumatic care of pediatric casualties. These scenarios can both aid in targeted needs assessment for individuals and serve as part of an overall educational strategy. Finally, this use of retrospective analysis as a needs assessment to inform and develop high-fidelity models for medical training represents a model that can be applied elsewhere in expeditionary and austere military medicine.

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En Route Critical Care Transfer From a Role 2 to a Role 3 Medical Treatment Facility in Afghanistan

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BACKGROUND En route care is the transfer of patients requiring combat casualty care within the US military evacuation system. No reports have been published about en route care of patients during transfer from a forward surgical facility (role 2) to a combat support hospital (role 3) for comprehensive care.
OBJECTIVE To describe patients transferred from a role 2 to a role 3 US military treatment facility in Afghanistan.
METHODS A retrospective review of data from the Joint Trauma System Role 2 Database was conducted. Patient characteristics were described by en route care medical attendants.
RESULTS More than one-fourth of patients were intubated at transfer (26.9%), although at transfer fewer than 10% of patients had a base deficit of more than 5 (3.5%), a pH of less than 7.3 (5.2%), an international normalized ratio of more than 2 (0.8%), or temporary abdominal or chest closure (7.4%). The en route care medical attendant was most often a nurse (35.5%), followed by technicians (14.1%) and physicians (10.0%). Most patients (75.3%) were transported by medical evacuation (on rotary-wing aircraft).
CONCLUSION This is the first comprehensive review of patients transported from a forward surgical facility to a more robust combat support hospital in Afghanistan. Understanding the epidemiology of these patients will inform provider training and the appropriate skill mix for the transfer of postsurgical patients within a combat setting. (*Critical Care Nurse*. 2018;38[2]:e7-e15)

Since the early 19th century, war fighters have recognized the benefit of early stabilization and rapid transport of people injured on the battlefield. However, the extensive use of forward surgical teams and support hospitals in the theater of war has evolved only recently during the conflicts in Iraq and Afghanistan.[1,2] Combat casualty care occurs across a continuum within the US military evacuation system, from point of injury to initial resuscitation and surgery, in and between military medical treatment facilities (MTFs), and ultimately to US-based facilities for definitive care and rehabilitation. The continuum of care consists of roles of care that are typically defined by capability: Role 1 is on-scene

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care and includes basic and advanced first aid (eg, tourniquet application, fracture stabilization, and application of sterile dressings); role 1 may also include a battalion aid station, where a physician assistant or physician may initiate resuscitation, airway management, or other nonsurgical lifesaving interventions before transfer; role 2 MTFs may be fixed or mobile facilities used for immediate resuscitation and surgical stabilization; role 3 combat support hospitals have multiple surgical specialties and intensive care; role 4 MTFs provide the full spectrum of trauma care at fixed facilities outside of the United States, and include definitive care hospitals in the United States.[3,4] Prehospital care of the injured also continues during transport from point to point on the continuum of care; ideally the care during transport will maintain the same level of care as the sending facility when moving to higher levels of care.

Of patients transported from role 2 to role 3, most patients were attended by a nurse.

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Transport platforms in the US combat theater in Afghanistan included ground and air evacuation. The 2 primary US rotary-wing (helicopter) medical evacuation platforms included the Army air ambulance and the Air Force pararescue squadron. The fixed-wing (airplane) platform was used by US Air Force Critical Care Air Transport Teams (CCATTs) and medical evacuation teams, who transported patients within the theater of war from role 2 to role 3 MTFs, as well as out of the theater to role 4 facilities. In the CCATT, physicians and nurses are assigned to this evacuation platform, whereas traditional Army rotary-wing medical evacuation does not have assigned physicians or nurses. However, in 2010, critical care nurses were assigned routinely to the US Army's medical evacuation companies to provide transport of critically ill and postoperative patients. Air Force medical evacuation (fixed-wing) teams include registered nurses; from 2010 through 2012, dedicated critical care transport was available through Air Force medical evacuation (fixed-wing) teams that included critical care flight paramedics. From 2011 through 2013, the Air Force rotary-wing tactical combat en route transportation teams were also deployed with critical care capabilities to support transfer patients from role 2 to role 3 MTFs. The level of provider varied depending on the platform and personnel availability, from basic emergency medical technician (EMT) to critical care flight paramedic to a team with physicians and critical care nurses.[5]

Rapid evacuation is essential in a combat environment after damage control resuscitation and damage control surgery in an austere role 2 surgical facility.[3] The goal of damage control efforts is to control hemorrhage and prevent or correct hypothermia, acidosis, and coagulopathy. Treatments may include advanced hemorrhage control, decompression of pneumothorax, advanced airway management, and surgery. The goal is to transport these patients to a role 3 or higher level of care as soon as they are clinically stable, ideally within 4 to 8 hours, but patients may be held at the role 2 facility as long as 72 hours. Patients may or may not be stable and may require en route critical care, presenting a unique challenge to the en route care provider.[3] The benefits of tactical combat casualty care focusing on treatment at the point of injury and during tactical evacuation have been well described.[6-10] A similar emphasis on improvements

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in en route care after initial care at a role 2 MTF also may promote survival.

Research has been conducted on many aspects of combat casualty care, but information is limited about the role 2 patient population and the transport of patients from a role 2 to a role 3 facility. No reports have been published about en route care of patients from a role 2 to a role 3 MTF. The purpose of this study was to describe patients transferred from a role 2 MTF to a US role 3 MTF in Afghanistan, as a first step in understanding this patient population and the skill level of medical attendants, with the goal of gaining data about best practices for en route care.

Methods

Approval for this exempt research study was received from the US Army Institute of Surgical Research Regulatory Department. This study consisted of a retrospective review of data from the Joint Trauma System Role 2 Database. The database included prehospital data, arrival and discharge status, diagnoses, interventions, blood administration, and complications data.[11] In the Role 2 Database, 15310 patient records were available. Of those records, 4534 patients were eligible (ie, these patients had transportation data available from a role 2 to a role 3 facility) for the study.

Study Inclusion Criteria

To be included in the study, patients had to have (1) been injured in Afghanistan; (2) been at least 18 years of age; (3) sustained trauma (ie, battle or nonbattle injury); (4) been injured between February 2008 and September 2014; and (5) received treatment at a role 2 MTF and been transferred to a US role 3 MTF.

Definitions

In this study, the term *en route medical attendant* was defined as the medical attendant (ie, physician, registered nurse, medical technician) with the highest clinical capability. *Medical technician* refers to an EMT or a paramedic. Patient affiliation was classified as (1) military, US (US Army, US Air Force, US Marine Corps, and US Navy); (2) military, non-US (Afghanistan police, Afghanistan military, NATO (North Atlantic Treaty Organization) coalition, combatants, and non-NATO coalition); and (3) civilian or unknown (Afghanistan civilian, contractor, non-US civilian, US civilian, and other). Mode of transfer out of a role 2 to a role 3 included medical evacuation by fixed wing, rotary wing, and ground transportation; and nonmedical evacuation by rotary-wing and ground transportation.

Injury and Intervention Categories

Using the methods of a previous study by Ingalls and colleagues,[12] patient diagnoses were categorized as orthopedic injuries, soft tissue trauma, penetrating extremity injuries, brain injuries, penetrating injuries, gastrointestinal/abdominal injuries, ears/nose/mouth/teeth/throat injuries, pulmonary/thoracic injuries, vascular injuries, genitourinary/renal injuries, burns, or other injuries. In addition, orthopedic injuries were divided into more specific categories: fracture, amputation, and other injuries. Penetrating injuries were classified according to body region: extremity or other. *Battle injury* included patients who were injured during hostile actions or battle-related activities, whereas *nonbattle injury* included nonbattle-related activities or hostile action and unintentional or self-inflicted injuries.

Blood transfusion at a role 2 MTF was defined as receiving any blood product (ie, whole blood, packed red blood cells, platelets, cryoprecipitate, or plasma/fresh frozen plasma), whereas massive transfusion at a role 2 MTF was defined as receiving more than 10 U of packed red blood cells within 24 hours. Surgery at a role 2 facility was identified by categorizing procedure descriptions into surgical (eg, bowel surgery, amputation) or nonsurgical procedures (eg, computed tomography scan, radiograph). Shock index (ie, heart rate divided by systolic blood pressure) was used to demonstrate trauma injury severity among study patients; a shock index of ≥0.9 indicated a patient with severe to critical injuries.[13] Injury types were categorized by all burn injuries, penetrating injury, blunt injury, or penetrating and blunt injury. Mechanism of injury was categorized by all explosions, gunshot wound, motor vehicle crash, fall, and other. Patient characteristics and interventions (eg, intubation, vasopressor use, shock index) were described by the en route care medical attendant.

Deployment of much smaller teams into more austere settings results in limited resources for definitive care, longer holding times, and extended evacuation times.

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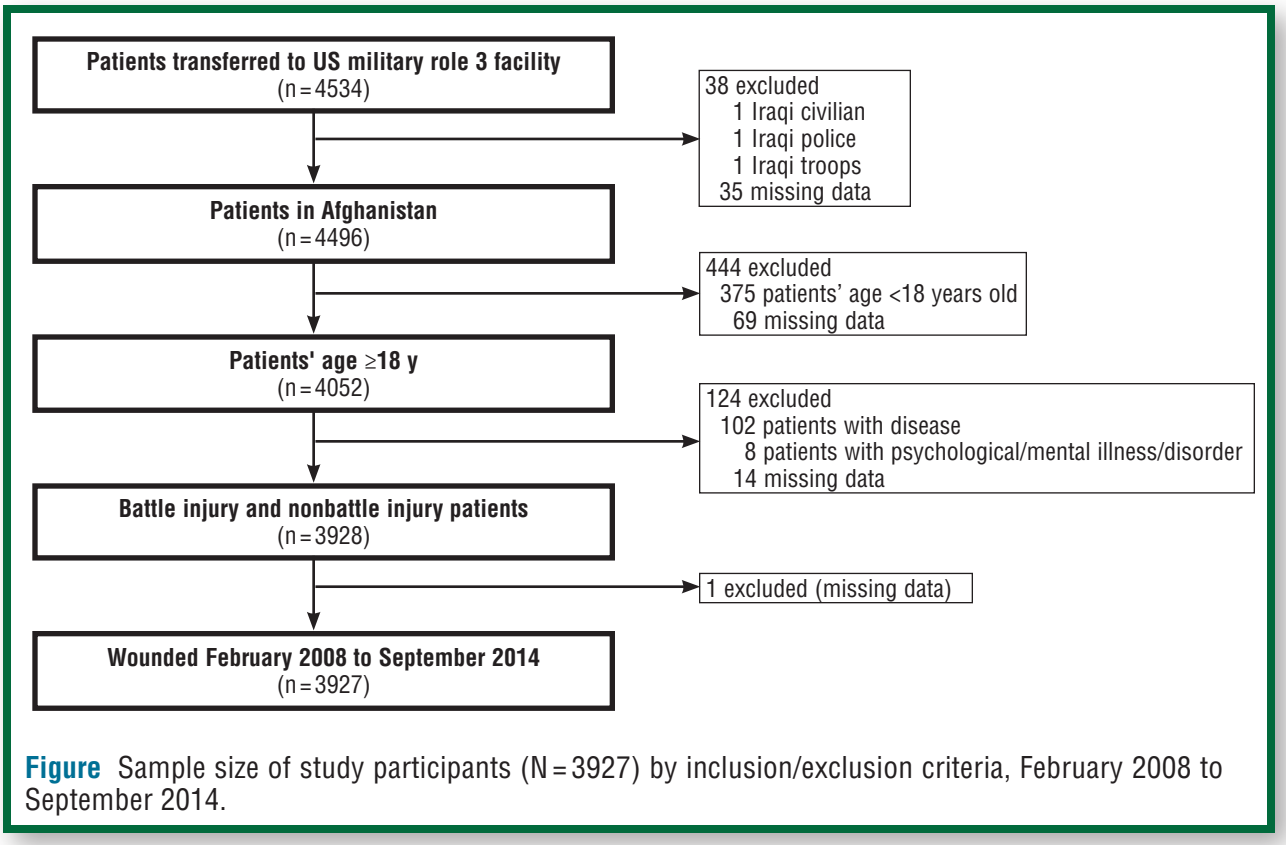

Figure Sample size of study participants (N = 3927) by inclusion/exclusion criteria, February 2008 to September 2014.

Statistical Analysis

Fisher's exact test, χ^2, or analysis of variance tests were used to determine significant differences in patient characteristics where appropriate. For the en route care medical attendant analysis, only physicians, nurses, and technicians were compared, because the unknown category was not mutually exclusive for nurses, physicians, and technicians. Analyses were performed using SAS, version 9.4 (SAS Institute, Inc).

Results

Based on the inclusion criteria, 3927 patients transferred to a US role 3 MTF were included in the study (see Figure). Study patients had a median (interquartile range) age of 25 (22-30) years; about half of the study population was US military (49.6%; n = 1949) (Table 1). Most patients were male (96.5%; n = 3791), had a battle injury (81.8%; n = 3214), were injured by an explosion (51.5%; n = 2023), had a penetrating injury (52.5%; n = 2060), or had a shock index less than 0.9 (75.8%; n = 2978). Among the study patients, 37.9% (n = 1489) had surgery at a role 2 MTF, and 24.5% (n = 963) received a blood transfusion and 4.7% (n = 183) received a massive transfusion at a role 2 MTF.

Injury diagnoses are described in Table 2 according to highest level of transport medical attendant. Orthopedic injuries made up the largest number of diagnoses (38.6%; n = 1517) for trauma-eligible adult patients treated and transferred from role 2 MTFs, followed by soft tissue trauma (23.9%; n = 938), penetrating extremity injuries (13.8%; n = 543), and brain injuries (13.3%; n = 521). After stratifying by medical attendant, the top 2 injury diagnoses remained the same (orthopedic injuries and soft tissue trauma) among all attendants, and penetrating injury and brain injuries remained in the top 5 diagnoses.

Many records (40.4%; n = 1588) did not have a defined en route care provider; about one-third of patients transferred from a role 2 to a role 3 facility had en route care provided by a nurse (35.5%; n = 1394), followed by technicians (14.1%; n = 554) and physicians (10.0%; n = 391; Table 3). More than one-fourth of patients were intubated at transfer (26.9%; n = 1056) and more of these patients were transported by physicians (38.9%; 152 of 391) or nurses (39.7%; 553 of 1394) than by technicians (7.2%; 40 of 554; $P < .001$). Patients transported with vasopressors differed significantly by en route medical attendant capability (physicians, 3.8% [15 of 391];

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Table 1 Study characteristics of eligible adult trauma patients (N = 3927)[a] treated and transferred from role 2 medical treatment facilities during Afghanistan conflict from February 2008 to September 2014

Characteristics	No. (%)
Male sex	3791 (96.5)
Battle injury	3214 (81.8)
Mechanism of injury	
Explosion	2023 (51.5)
Gunshot wound	941 (24.0)
Other	324 (8.3)
Motor vehicle crash	303 (7.7)
Fall	151 (3.8)
Type of injury	
Penetrating	2060 (52.5)
Blunt	1232 (31.4)
Penetrating and blunt	341 (8.7)
Burn	78 (2.0)
Shock index upon arrival at role 2 facility	
< 0.9	2978 (75.8)
≥ 0.9	781 (19.9)
Patient affiliation	
US military	1949 (49.6)
Non-US military	1139 (29.0)
Civilian or unknown	839 (21.4)
Surgery at role 2 facility	
Yes	1489 (37.9)
No	838 (21.3)
Blood transfusion at role 2 facility	
Yes	963 (24.5)
No	1140 (29.0)
Massive transfusion at role 2 facility	
Yes	183 (4.7)
No	1874 (47.7)

[a] Median (interquartile range) age was 25 (22-30) years old.

nurses, 2.3% [32 of 1394]; technicians, 0.4% [2 of 554]; $P = .001$). Compared with patients transported by technicians, more patients attended by a physician or nurse had a base deficit of more than 5 at transfer (physicians, 5.1% [20 of 391]; nurses, 5.0% [70 of 1394]; technicians, 1.4% [8 of 554]; $P = .04$), pH less than 7.3 at transfer (physicians, 7.2% [28 of 391]; nurses, 7.2% [101 of 1394]; technicians, 2.7% [15 of 554]; $P = .05$), and an international normalized ratio of more than 2 at transfer (physicians, 2.3% [9 of 391]; nurses, 1.1% [16 of 1394]; technicians, 0%; $P = .03$). Fewer patients transported by technicians (3.1% [17 of 554]) had temporary abdominal or chest closure at transfer compared with physicians (8.7% [34 of 391]) or nurses (11.1% [155 of 1394]; $P < .001$). The distribution of patient mode of transportation differed by medical attendant ($P < .001$), although most patients, regardless of type of en route medical attendant, were transported by rotary-wing medical evacuation. More patients transported by physicians (4.9% [19 of 391]) or nurses (6.7% [94 of 1394]) had a massive transfusion at a role 2 facility, compared with patients transported by technicians (1.3% [7 of 554]). Technicians transported patients with lower mean (SD) pulse at departure (84.0 [16.3]) compared with physicians (92.9 [20.7]) and nurses (92.0 [21.7]; $P < .001$).

Discussion

This study represents the first detailed description of the en route care of trauma-eligible adult patients transferred from a role 2 to a role 3 MTF in Afghanistan. In this study, we compared trauma-eligible adult patients transferred from role 2 MTFs to US role 3 MTFs by en route care medical attendant capability. Of patients with a documented en route care provider, most patients were attended by a nurse. Among study patients, the top 4 diagnoses were orthopedic injury, soft tissue trauma, brain injury, and penetrating extremity injury. In this study, the physiological status of patients differed by medical attendant. Proportionally, patients attended by physicians or nurses were in worse physiological condition at transfer (ie, intubated and receving vasopressors, base deficit >5, pH <7.3, international normalized ratio >2, temporary abdominal or chest closure, or massive transfusion at role 2) than patients transported by technicians. Specifically, more than 25% of patients transferred from a role 2 were intubated, and the highest level of medical attendant at transfer was a technician for 40 of these intubated patients. A traditional EMT is not trained to care for an intubated patient. In addition, nearly 40% of study patients were postoperative patients. Although a combat-trained medic can retrieve a battle casualty from point of injury, a postoperative patient tends to require specialized care that may be outside the scope of an EMT or paramedic, necessitating a higher and specialized provider skill level.

Previous studies have identified outcomes for trauma casualties transported from point of injury to surgical capability and cared for by nonphysician providers with varying levels of training. In the study by Mabry et al,[14] among patients transported from point of injury to first MTF, mortality was lower in patients cared for by critical

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Table 2 Diagnoses for eligible adult trauma patients (N = 3927) treated and transferred from role 2 medical treatment facilities during Afghanistan conflict by highest level of en route medical attendant[a] from February 2008 to September 2014

	Total (N = 3927)	Physician (n = 391)	Nurse (n = 1394)	Technician (n = 554)	Unknown (n = 1588)
Diagnosis	No. (%)	No. (%)	No. (%)	No. (%)	No. (%)
Orthopedic injury, total	1517 (38.6)	174 (44.5)	778 (55.8)	182 (32.9)	383 (24.1)
Fracture	1069 (27.2)	144 (36.8)	536 (38.5)	119 (21.5)	270 (17.0)
Amputation	157 (4.0)	14 (3.6)	91 (6.5)	14 (2.5)	38 (2.4)
Other injury	291 (7.4)	16 (4.1)	151 (10.8)	49 (8.8)	75 (4.7)
Soft tissue trauma	938 (23.9)	77 (19.7)	469 (33.6)	129 (23.3)	263 (16.6)
Penetrating injury, extremity	543 (13.8)	36 (9.2)	287 (20.6)	69 (12.5)	151 (9.5)
Brain injury	521 (13.3)	47 (12.0)	196 (14.1)	83 (15.0)	195 (12.3)
Other injury	275 (7.0)	44 (11.3)	135 (9.7)	24 (4.3)	72 (4.5)
Penetrating injury, other regions	221 (5.6)	21 (5.4)	116 (8.3)	23 (4.2)	61 (3.8)
Gastrointestinal/abdominal injury	193 (4.9)	24 (6.1)	109 (7.8)	12 (2.2)	48 (3.0)
Ears/nose/mouth/teeth/throat injury	138 (3.5)	14 (3.6)	77 (5.5)	12 (2.2)	35 (2.2)
Pulmonary/thoracic injury	138 (3.5)	15 (3.8)	81 (5.8)	13 (2.3)	29 (1.8)
Vascular injury	104 (2.6)	10 (2.6)	65 (4.7)	6 (1.1)	23 (1.4)
Genitourinary/renal injury	91 (2.3)	13 (3.3)	50 (3.6)	5 (0.9)	23 (1.4)
Burn injury	45 (1.1)	3 (0.8)	26 (1.9)	4 (0.7)	12 (0.8)

[a] En route medical attendant was defined as the medical attendant with the highest capability.

care flight paramedics than in patients treated by EMTs, who have a lower level of training (mortality, 8% vs 15%, respectively; $P = .011$). Dissimilarly, in a comparison of patient outcomes among EMTs, paramedics, and advanced-level providers from point of injury to first MTF (which includes physicians, physician assistants, and nurses), Maddry and colleagues[5] did not report a difference. These null findings may be due to (1) restrictions of care because of the confined space of the transport platform or (2) a minimization of the need for lifesaving en route interventions due to reduced transport times because of the golden hour policy (ie, the mandate that medical evacuation platforms must deliver causalities from point of injury to surgical capability within 1 hour of request[2]). However, transport of a relatively stable postoperative patient using a regulated system differs from the transport of a patient from the point of injury or role 1 to initial surgical care at the role 2.

Multiple studies have been conducted evaluating the en route care of patients during transport from point of injury to first MTF (role 2 and/or 3)[5,12,14-22] and out of theater to the role 4 medical center in Landstuhl, Germany.[12,19-28] A few published reports have described patients treated by individual forward surgical teams (role 2) during specific deployments, but these studies do not include information related to patient transport. These reports described cases and procedures performed by the surgical teams from data sets collected prospectively by the surgical team. The data elements compiled varied from report to report, limiting the ability to combine data.[29-38] The Joint Trauma System established its Role 2 Database in 2008; however, only 1 preliminary report using this database has described the profiles of patients treated in all role 2 facilities.[11] Ultimately, our study is the first comprehensive description of the types of trauma patients evacuated from a role 2 surgical facility to a higher level of care in a combat setting.

Limitations

Several limitations of our study must be considered along with the interpretation of study results. The data used in this study have not been validated using quality control methods, such as cross-checking the data against the patient's medical records. Another limitation is that we are unable to differentiate critical care flight paramedics, who have a higher level of training, from traditional combat flight medics, as these attendants are grouped

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Table 3 Study characteristics by en route medical attendant[a] of trauma-eligible adult patients (N = 3927) treated and transferred from role 2 medical treatment facilities during Afghanistan conflict from February 2008 to September 2014

Characteristics	Total No. (%)	Physicians No. (%)	Nurses No. (%)	Technicians No. (%)	Unknown No. (%)	P[b]
Patients	3927 (100.0)	391 (10.0)	1394 (35.5)	554 (14.1)	1588 (40.4)	
Intubated at transfer						<.001
Yes	1056 (26.9)	152 (38.9)	553 (39.7)	40 (7.2)	311 (19.6)	
No	2521 (64.2)	235 (60.1)	799 (57.3)	491 (88.6)	996 (62.7)	
Receiving vasopressors at transfer						.001
Yes	64 (1.6)	15 (3.8)	32 (2.3)	2 (0.4)	15 (0.9)	
No	3426 (87.2)	369 (94.4)	1291 (92.6)	523 (94.4)	1243 (78.3)	
Base deficit >5 at transfer						.049
Yes	138 (3.5)	20 (5.1)	70 (5.0)	8 (1.4)	40 (2.5)	
No	2467 (62.8)	299 (76.5)	1043 (74.8)	297 (53.6)	828 (52.1)	
pH <7.3 at transfer						.05
Yes	203 (5.2)	28 (7.2)	101 (7.2)	15 (2.7)	59 (3.7)	
No	2414 (61.5)	292 (74.7)	1015 (72.8)	298 (53.8)	809 (50.9)	
INR >2 at transfer						.03
Yes	32 (0.8)	9 (2.3)	16 (1.1)	0 (0.0)	7 (0.4)	
No	2011 (51.2)	261 (66.8)	818 (58.7)	209 (37.7)	723 (45.5)	
Temporary abdominal or chest closure at transfer						<.001
Yes	292 (7.4)	34 (8.7)	155 (11.1)	17 (3.1)	86 (5.4)	
No	2745 (69.9)	319 (81.6)	1055 (75.7)	413 (74.5)	958 (60.3)	
Mode of transfer						<.001
Medical evacuation (fixed wing)	183 (4.7)	60 (15.3)	46 (3.3)	8 (1.4)	69 (4.3)	
Critical care air transport team	80 (2.0)	39 (10.0)	15 (1.1)	1 (0.2)	25 (1.6)	
Medical evacuation (rotary wing)	2956 (75.3)	259 (66.2)	1197 (85.9)	495 (89.4)	1005 (63.3)	
Medical evacuation (ground)	34 (0.9)	1 (0.3)	5 (0.4)	11 (2.0)	17 (1.1)	
Nonmedical evacuation (air)	74 (1.9)	2 (0.5)	32 (2.3)	16 (2.9)	24 (1.5)	
Nonmedical evacuation (ground)	15 (0.4)	1 (0.3)	3 (0.2)	1 (0.2)	10 (0.6)	
Other	165 (4.2)	29 (7.4)	84 (6.0)	19 (3.4)	33 (2.1)	
Massive transfusion						<.001
Yes	183 (4.7)	19 (4.9)	94 (6.7)	7 (1.3)	63 (4)	
No	1874 (47.7)	196 (50.1)	753 (54.0)	242 (43.7)	683 (43)	
	Total Mean (SD)	**Physicians Mean (SD)**	**Nurses Mean (SD)**	**Technicians Mean (SD)**	**Unknown Mean (SD)**	**P[b]**
Pulse at departure, beats/min	89.1 (20.4)	92.9 (20.7)	92.0 (21.7)	84.0 (16.3)	86.9 (19.6)	<.001
Respiratory rate at departure, breaths/min	16.9 (4.1)	16.5 (3.9)	16.9 (4.3)	17.3 (4.0)	16.8 (3.9)	.17
Systolic blood pressure at departure, mm Hg	125.3 (17.9)	123.9 (19.4)	124.2 (19.0)	124.2 (15.4)	127.5 (17.0)	.98
Oxygen saturation at departure, %	98.1 (4.0)	97.5 (7.9)	98.4 (4.1)	97.8 (3.3)	98.0 (3.2)	.06

Abbreviation: INR, international normalized ratio.
[a] En route medical attendant was defined as the medical attendant with the highest capability.
[b] *P* value is a comparison between physician, nurse, and technician.

together. In addition, given that data are recorded voluntarily by health care professionals with limited training on data entry, we are unsure of the proportion of role 2 workload that has been captured. Therefore, selection bias is a possibility in this study. Finally, because of the high proportion of missing data (eg, en route care interventions, physiological status, patient outcomes), this analysis serves as only an initial evaluation of patients evacuated from role 2 to higher level of care.

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Implications for Future Practice

The model of role 2 MTFs has been successful in recent conflicts in demonstrating outcomes comparable to a combat support hospital and in establishing the use of fresh whole blood in an austere setting.[39-41] However, we are reaching limits of effectiveness in terms of how much farther "forward" we can place teams or units with surgical capability.[42] Deployment of much smaller teams into more austere settings results in limited resources for definitive care, longer holding times, and extended evacuation times. This limit is important, because delays in the application or performance of definitive lifesaving interventions lead to more critically ill patients with worse outcomes.[43] Moreover, even if resources are available for placing teams and units farther forward, the geography of the combat theater may be a limiting factor, as was the case in Afghanistan compared with Iraq.[44] Consequently, in the future, improved outcomes are not only going to come from physicians, but from other health care providers who also have significant training and experience (ie, flight paramedics, critical care nurses).[42] Given our study results, we must specifically train medical attendants to care for postoperative patients, train flight paramedics in critical care, and individually assign critical care nurses to transport patients to ensure standardization of an appropriate skill level for critical care transport; these teams could be augmented by a physician assistant or physician as needed.

In addition, the traditional role 2 facility is located in an austere setting, often without an airfield capable of accommodating a fixed-wing aircraft, which may make the routine use of medical evacuation (fixed wing) or CCATTs impractical for future combat scenarios. Therefore, in future conflicts, the advantage of more highly trained providers may become more apparent if shorter patient transport times are not possible.[5]

The time frame for this study was from 2008 through 2014, and multiple changes in capabilities and resource allocation occurred during that time. Future studies may be more meaningful if they focus on a later, shorter time period when practices are more consistent. In addition, future studies need to examine the actual care provided during transport from role 2 to role 3 MTFs and include an analysis of short- and long-term outcomes based on provider skill level. The results of these studies can provide valuable information about en route care training requirements, clinical practice guidelines, and the use of resources. In addition, understanding the care needs of patients closest to the battlefield in recent conflicts may help shed light on prolonged field care scenarios.

Finally, approximately half of the study population was a non-US military member or civilian or unknown. Documentation of care provided at the role 2 and during transportation of these patients within the austere environment of the US military evacuation system is challenging but critical, because providers need to know what interventions occurred before arrival at the next level of care. Innovations in the transfer of medical information and records to host-nation treatment facilities are needed.

Conclusion

This study is the first comprehensive review of patients transported from a forward surgical facility to a more robust combat support hospital in Afghanistan. Understanding the epidemiology of these patients will inform provider training and appropriate skill mix for the transfer of postsurgical patients within a combat setting. CCN

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En Route Critical Care Transfer From a Role 2 to a Role 3 Medical Treatment Facility in Afghanistan

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Factors associated with trauma patients' length of stay at Role 2 facilities in Afghanistan, October 2009 to September 2014

Amanda Staudt, PhD, Jennifer Gurney, MD, Krystal Valdez-Delgado, Mithun Suresh, MD, Jennifer Trevino, MBA, Tuan Le, MD, PhD, Jason Seery, MD, Stacy Shackelford, MD, Shawn Nessen, MD, *and* **Elizabeth Mann-Salinas, PhD**, *Houston, Texas*

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BACKGROUND: Understanding patients' length of stay at far-forward Role 2 surgical units may help to determine support needs, stabilization requirements, predeployment training, and necessity of increased care capability before or during transport to a higher level of care. The objectives of this study were to (1) evaluate the amount of time patients spent at Role 2 and (2) determine the factors associated with trauma patients' length of stay at Role 2.

METHODS: We conducted a secondary data analysis of the Joint Trauma System Role 2 Database. Logistic regression was used to determine factors associated with extended length of stay at Role 2.

RESULTS: There were 7,912 study patients, and the overall median (interquartile range) amount of time patients spent at Role 2 was 2.5 (1.2–5.5) hours. The adjusted odds ratio (aOR) of extended stay for civilian/other forces and non–US military patients were 1.2 (95% confidence interval [CI], 1.0–1.4) and 1.4 (95% CI, 1.2–1.7) times higher as compared with US military patients, respectively. The aOR of extended stay were higher for patients who received blood transfusions (aOR, 1.4; 95% CI, 1.2–1.6), surgical procedures (aOR, 1.6; 95% CI, 1.4–1.8), or did not use a tourniquet (aOR, 1.2; 95% CI, 1.0–1.5). As compared with those injured by an explosion, the adjusted odds of extended stay were 1.2 (95% CI, 1.0–1.4) times higher for patients injured by another mechanism. The odds of extended stay were lower (aOR, 0.3; 95% CI, 0.2–0.5) for patients who died and higher (aOR, 1.4; 95% CI, 1.2–1.6) for transferred patients as compared with patients who returned to duty.

CONCLUSION: In this study, interventions, patient affiliation, discharge status, and injury mechanism were associated with length of stay at Role 2. Our study results will help inform training and current Role 2 logistic and personnel support needs. (*J Trauma Acute Care Surg.* 2018;85: S140–S144. Copyright © 2018 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Prognostic, level III.

KEY WORDS: Combat casualty care; time; battlefield; length of stay; role 2.

Extended length of stay (LOS) in civilian hospitals is associated with poor health outcomes, congestion in the continuum of care, and increased medical attendant workload.[1–3] The effects of extended LOS at differing roles of care on the battlefield are not known, but may also be associated with poor outcomes. On the battlefield, reasons for extended length of patient stay are inherently different from those in civilian hospitals and may include patients who are too unstable to move, limited or unavailable medical evacuation assets, inability of higher capability facilities to receive patients due to high census or shortages of medical personnel, equipment, and supplies. Therefore, results from studies on LOS in civilian hospitals are generally not applicable to the Role 2 combat casualty care setting as postoperative casualties are generally immediately transferred to the appropriate level of care after surgical stabilization.

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The primary purpose of Role 2 surgical units is to provide damage control resuscitation (DCR) and damage control resuscitation (DCS) close to the point of injury to provide stabilization before the patient transporting to definitive care. Given the limited resources and holding capacity at these small surgical units, rapid evacuation to more capable hospitals is imperative. Understanding the factors associated with extended LOS at Role 2 may help determine perioperative support needs, pretransport stabilization requirements, and required predeployment training for medical providers to positively affect outcomes; additionally, it may also identify additional capability requirements of Role 2 surgical units operating in austere environments remote from more capable Role 3 hospitals. The objectives of this study were to (1) evaluate the amount of time patients spent at Role 2 surgical units and (2) determine factors associated with trauma patients' LOS at Role 2.

PATIENTS AND METHODS

We conducted a retrospective study that analyzed patients treated in Afghanistan at Role 2s. Role 2 surgical teams are fixed or mobile facilities used to provide resuscitation and surgical stabilization (i.e., DCR, DCS, general surgery, orthopedic stabilization) of combat causalities before transfer to a higher level of medical care.[4] These units have limited bed capacity and limited capabilities beyond DCR/DCS and blood transfusion.[5,6] Once

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the patient is stabilized at a Role 2 surgical unit, the patient is discharged or transferred to the next higher level of care.

We used deidentified data from the Joint Trauma System Role 2 Database, which includes prehospital data, arrival/discharge status, diagnosis, interventions, blood administration, and complications data.[4] The Role 2 Database is a convenience sample of patients cared for by Role 2 surgical teams. Data are entered by clinical personnel; this differs from the Department of Defense Trauma Registry which is populated from verified source documents by trained personnel. Adult patients who were battle or non–battle-injured in Afghanistan between February 2008 and September 2014 were eligible for this study. Additional details on the eligible study population can be found in the study by Kotwal et al.[7] We included patients who stayed at Role 2s for up to 72 hours as Role 2s were designed to hold patients for this amount of time. Patients were excluded if they had missing covariate data or if they were dead on arrival at Role 2. Patients were classified as dead on arrival if they were not resuscitated or did not receive any other treatment beyond cardiopulmonary resuscitation, endotracheal tube or central line placement, focused abdominal sonography for trauma, or abdominal wound exploration in the emergency room. The dependent variable, LOS, was defined as time interval in hours from admission to discharge. LOS was categorized as standard (i.e., ≤8 hours) or extended stay (i.e., >8 hours). This time cut point was chosen because Role 2 surgical teams were designed with the intended capability of providing postoperative intensive care for critically injured patients for 6 hours[8] and the estimated mean time for surgery at Role 2 facilities was 2 hours. Role 2 emergency department times were presumed to be minimal for this analysis.

Independent variables included: blood transfusion, surgical procedures, prehospital tourniquet, patient affiliation (US military, non–US military, civilian/other), injury mechanism (explosion, gunshot, other), and discharge status (returned to duty, dead, transferred). Blood transfusion included whole blood, packed red blood cells, platelets, cryoprecipitate, or plasma received at Role 2s or prehospital. Surgical procedures were identified by reviewing the patient's record. Tourniquet use was indicated in the prehospital data elements. Patient affiliation was categorized as US Military, non–US military (including Afghan National Army and Afghanistan Police Forces) and civilians, including contractors. Injury mechanism was defined as explosion (improvised explosive devices, aerial bombs, landmines, hand grenades, explosively formed penetrator, rocket propelled grenades, improvised rocket assisted munitions, mortar rockets, or other explosives). At discharge, patients were classified as dead, transferred (e.g., Afghanistan hospital or another military facility), or returned to duty from a Role 2 (i.e., discharged, admitted for observation or follow-up, had a minor injury, or patient hold). Civilians were considered returned to duty if they were discharged home.

Median (interquartile range [IQR]) time was calculated for the study patient population overall and then by study covariates. Logistic regression was used to determine which factors were associated with the amount of time patients spent at a Role 2. The final multivariate regression model was as follows:

$$\begin{aligned} &Logit\left(P_{extended\ stay}\right) \\ &= b_0 + b_1\,discharge\ status + b_2\,prehospital\ tourniquet \\ &+ b_3\,blood\ transfusion + b_4\,patient\ affiliation + b_5\,injury\ mechanism \\ &+ {}_{b6}\,surgical\ procedure, \end{aligned}$$

where $_{P\text{extended stay}}$ equals the probability of extended stay at a Role 2. The intercept is denoted by b_0, and (b_1, b_2, …, b_6) are the beta coefficients of all linear factors. Covariates were identified using model selection. Using model selection, we identified the best fit model. Initially, we ran a full model, which included covariates used in the final model plus complications (yes, no), volume of patients (<5 patient/hour, ≥5 patients/hour), age (years), sex (male, female), injury type (penetrating, nonpenetrating), admission temperature (<97 °F, ≥97 °F), and shock index (i.e., admission heart rate/systolic blood pressure) (<0.9, ≥0.9). All covariates from the full model which were found to be significant ($p < 0.05$) were included in the reduced model. Then, nonsignificant covariates from the full model were added individually to the reduced model to check for significance.

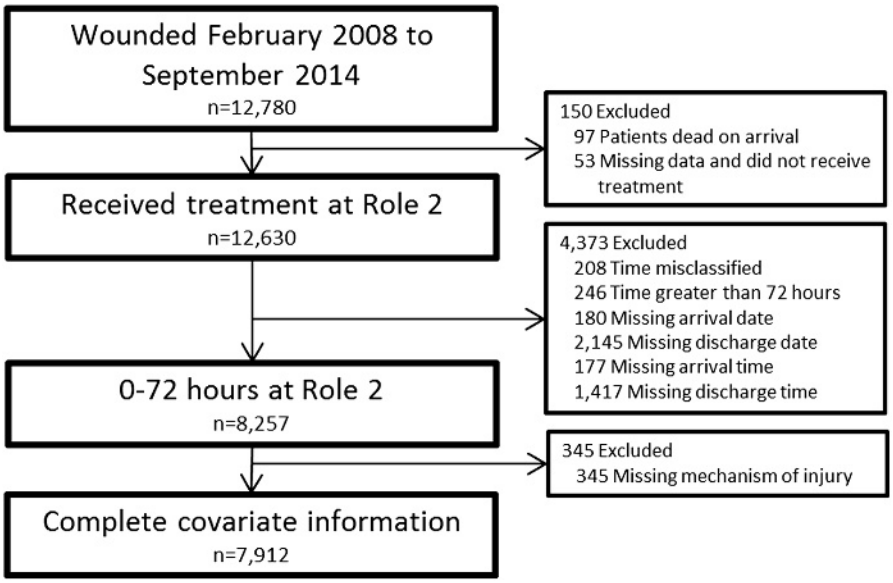

Figure 1. Flow diagram of study patients (n = 7,912) by inclusion/exclusion criteria, October 2009 to September 2014.

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TABLE 1. Number and Percentage of Study Patients Treated at Role 2 Facilities in Afghanistan, October 2009 to September 2014

Variables	n	%
Total	7,912	100.0
Age: (median, IQR), y	25.0	21.0–30.0
Temperature: (median, IQR), °F	98.2	97.6–98.9
Shock index (median, IQR)	0.7	0.6–0.8
Sex		
Male	7,675	97.0
Female	177	2.2
Affiliation		
Military, US	3,023	38.2
Military, non-US	1,841	23.3
Civilian/other	3,048	38.5
Injury mechanism		
Explosion	3,972	50.2
Gunshot	1,991	25.2
Other	1,949	24.6
Injury type		
Penetrating	4,873	61.6
Nonpenetrating	2,691	34.0

None of the nonsignificant covariates became significant; therefore, these variables were not included in the final model. Besides significance testing, model fit was also determined using Hosmer-Lemeshow's goodness of fit test, Akaike information criterion value, and the pseudo R^2 value. All analyses were completed using Stata (StataCorp. 2015. Stata Statistical Software: Release 14; StataCorp LP, College Station, TX).

RESULTS

There were 12,780 patients eligible for our study. A total of 7,912 (61.9%) patients were included in the study (Fig. 1). Role 2 admission dates for these patients ranged from October 2009 to September 2014. The median age of patients was 25.0 years (IQR, 21.0–30.0), and the majority of patients were male (97.0%, n = 7,675) and members of the armed forces (US Military 38.2%, n = 3,023; non–US Military = 23.3%, n = 1,841). Most patients had a penetrating injury (61.6%, n = 4,873) and/or were injured by an explosion (50.2%, n = 3,972) (Table 1). The majority of patients stayed at Role 2 ≤ 8 hours (83.1%, n = 6,578), while 16.9% (n = 1,334) of patients had an extended stay.

Table 2 shows the difference in the amount of time spent at Role 2 by study variables. The overall median amount of time patients spent at Role 2 was 2.5 hours (IQR, 1.2–5.5 hours). US Military (median, 1.9 hours; IQR, 0.9–4.4 hours) patients spent less time at Role 2 as compared with non–US military (median, 3.1 hours; IQR, 1.5–6.4 hours) and civilian/other (median, 2.9 hours; IQR, 1.3–5.9) patients. Patients with gunshot wounds (median, 3.2 hours; IQR, 1.5–6.3) stayed at Role 2s longer than those injured by an explosion (median, 2.5 hours; IQR, 1.2–5.3). Patients who died at Role 2 spent less time (median, 0.9 hours; IQR, 0.3–2.2) at these facilities as compared with those who were transferred (median, 3.6 hours; IQR, 1.9–6.5) or returned to duty (median, 1.4; IQR, 0.8–2.9).

The relationship between patient characteristics and the odds of extended stay is shown in Table 3. After controlling for injury mechanism, interventions (i.e., procedures, tourniquet use, and blood transfusion), and discharge status, the odds ratio of extended stay for civilian/other forces and non–US military patients were 1.2 (95% confidence interval [CI], 1.0–1.4; $p = 0.018$) and 1.4 (95% CI, 1.2–1.7; $p < 0.001$) times higher as compared with US military patients, respectively. As compared with those injured by an explosion, the adjusted odds of extended stay were similar (1.0; 95% CI, 0.9–1.2; $p = 0.899$) among those with gunshot wounds and 1.2 (95% CI, 1.0–1.4; $p = 0.010$) times higher for patients injured by another mechanism of injury. The odds of extended stay varied by intervention. The adjusted odds (aOR) of extended stay were higher for patients who had surgical procedures (aOR, 1.6; 95% CI, 1.4–1.8; $p < 0.001$) or a blood transfusion (aOR, 1.4; 95% CI, 1.2–1.6; $p < 0.001$) and lower for patients who used a tourniquet (aOR, 0.8; 95% CI, 0.7–1.0; $p = 0.029$) as compared with patients who did not. As compared with patients who returned to duty, the odds of extended stay were lower (aOR, 0.3; 95% CI, 0.2–0.5; $p < 0.001$) for patients who died and higher (aOR, 1.4; 95% CI, 1.2–1.6; $p < 0.001$) for transferred patients.

DISCUSSION

The overall median LOS at Role 2 was 2.5 hours, and extended LOS longer than 8 hours was associated with interventions, patient affiliation, injury mechanism, and final patient disposition. While interventions, such as blood transfusion and surgical procedures, were associated with extended LOS, patients who did not use tourniquets had reduced odds of extended stay. This may be due to tourniquet patients

TABLE 2. Median and IQR Time Study Patients Were Treated at Role 2 Facilities in Afghanistan, October 2009 to September 2014

		Hours	
Variables	n	Median	IQR
Total	7,912	2.5	1.2–5.5
Affiliation			
Military, US	3,023	1.9	0.9–4.4
Military, non-US	1,841	3.1	1.5–6.4
Civilian/other	3,048	2.9	1.3–5.9
Injury mechanism			
Explosion	3,972	2.5	1.2–5.3
Gunshot	1,991	3.2	1.5–6.3
Other	1,949	2.0	1.0–4.8
Procedure			
No	5,081	1.8	0.9–4.1
Yes	2,831	4.0	2.3–7.2
Tourniquet use			
No	6,807	2.4	1.1–5.3
Yes	1,105	3.6	1.9–6.3
Blood transfusion			
No	6,427	2.2	1.1–4.7
Yes	1,485	4.5	2.5–7.6
Discharge status			
Returned to duty	2,852	1.4	0.8–2.9
Dead	341	0.9	0.3–2.2
Transferred	4,719	3.6	1.9–6.5

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TABLE 3. OR and Corresponding 95% CI for Extended Stay in Study Patients (n = 7,912) Treated at Role 2 Facilities in Afghanistan, October 2009 to September 2014

	Unadjusted			Adjusted		
Variables	**OR**	**95% CI**	***p***	**OR**	**95% CI**	***p***
Affiliation						
Military, US	1.0	Reference		1.0	Reference	
Military, non-US	1.7	1.4–2.0	<0.001	1.4	1.2–1.7	<0.001
Civilian/other	1.4	1.2–1.6	<0.001	1.2	1.0–1.4	0.018
Injury mechanism						
Explosion	1.0	Reference		1.0	Reference	
Gunshot	1.2	1.1–1.4	0.008	1.0	0.9–1.2	0.899
Other	1.1	1.0–1.3	0.065	1.2	1.0–1.4	0.010
Procedure						
No	1.0	Reference		1.0	Reference	
Yes	1.8	1.6–2.1	<0.001	1.6	1.4–1.8	<0.001
Tourniquet use						
No	1.0	Reference		1.0	Reference	
Yes	1.1	0.9–1.3	0.354	0.8	0.7–1.0	0.029
Blood transfusion						
No	1.0	Reference		1.0	Reference	
Yes	1.7	1.5–1.9	<0.001	1.4	1.2–1.6	<0.001
Discharge status						
Returned to duty	1.0	Reference		1.0	Reference	
Dead	0.4	0.3–0.7	<0.001	0.3	0.2–0.5	<0.001
Transferred	1.7	1.5–1.9	<0.001	1.4	1.2–1.6	<0.001

having a different injury pattern (i.e., extremity injuries and no abdominal injuries) as compared with non-tourniquet patients. When compared with other patient affiliations, US military patients stayed at Role 2s for less time versus other patients. We posit a potential reason for the difference in LOS in US military versus non–US military may be limited use of body armor in host nation military members, which may have led to worse initial patient injuries. In addition, as compared with patients injured by an explosion, patients with gunshot wounds had similar odds of extended LOS, while those injured by another mechanism had greater odds of staying at Role 2s longer. Lastly, LOS varied by final patient disposition. Generally, patients, those who died at Role 2, died shortly after arriving, which supports the need for having Role 2s dispersed as close to the point of injury as possible. Among patients who lived, patients who were transferred spent more time at Role 2s as opposed to patients who returned to duty.

There is limited published literature available on the LOS for combat casualties at Role 2 and Role 3 facilities. A study by Stankorb et al.[9] set at a combat support hospital (i.e., Role 3) in Iraq reported early enteral nutrition was associated with reduced LOS. Likewise, Riha et al.[10] identified the impact of length of patient stay in combat causalities from point of injury to transfer to a US facility and found the incident rate of abdominal procedures at a regional evacuation hub (i.e., Role 4) increased 1.1 times for every day increase in pre-US LOS. Of the studies including data on patient LOS at far-forward Role 2 or similar units,[11,12] there are no comprehensive reports describing factors associated with length of patient stay at Role 2s.

This study represents the first detailed description of casualties' LOS at Role 2s in Afghanistan. At forward mobile surgical facilities located in Kuwait and Iraq in 2003, Walker et al.[11] reported 33.3% (428/1,286) of patients were discharged in 1 hour or less, while 29.4%, 10.3%, and 15.7% were discharged at 1 hour to 6 hours, 6 hours to 12 hours, and 12 hours to 24 hours, respectively. These results were similar to the time frame reported in our study, but the difference in location between the studies, as well as injury demographics given the period of the conflict, makes the comparison difficult. Conversely, in a case series of 30 patients treated in Iraq in 2003 by the Navy's forward-deployed echelon II medical unit, Bohman et al.[12] found the median LOS was 7.8 (IQR, 5.8–14.1) hours. The location, treatment facility, and immaturity of the operational environment and trauma/evacuation system differed from our study. The longer LOS reported by Bohman et al. may be related to the dynamic nature (e.g., inconsistency of available medical assets) of the invasion of Iraq in 2003. Our study occurred several years after initial entry into Afghanistan, which presumably means that the theater was more stable and medical evacuation assets were more consistently available. Lastly, previous studies have captured LOS at higher levels of care.[10,13,14] However, comparisons between these studies are difficult due to the differences in strategic functions of Role 2 and facilities providing higher levels of care. Moreover, given that Role 2s have limited patient holding capabilities, it is more appropriate to measure LOS in hours, whereas facilities with the ability to manage patients for extended durations may measure LOS in days. Doctrinally, Role 2 surgical teams are not intended to be placed without the larger Role 2 medical support elements that offer a holding capability. It is notable that during this study period, virtually all Role 2 teams conducted split operations and were oftentimes not supported by the doctrinal model.

As compared with our study, other studies reported similar factors associated with extended LOS at various medical treatment facilities. Our results reflect the association between LOS and blood transfusion, which was also reported in other studies.[15,16] Research also shows a decreased LOS for US forces as compared with other forces.[14,17,18] Spinella et al.[18] posited the shorter LOS for US forces might be due to rapid evacuation of these patients. Similar to our study, Riha et al.[10] found that LOS was associated with abdominal procedures. Dissimilar to our results, Bograd et al.[16] reported that abdominal complications were associated with total hospital LOS at Role 3 facilities in Iraq and Afghanistan ($p = 0.035$). Our results did not show a significant association between complications at Role 2 and LOS, but this difference may be due to the relatively short amount of time patients spent at Role 2. Furthermore, Bograd et al.[16] also reported injury severity score was associated with total intensive care unit and hospital LOS ($p = 0.017$, $p = 0.006$, respectively). We did not have data on anatomic injury severity in our database; therefore, we could not control for this potential confounder.

This study has several limitations. The Role 2 database was voluntarily recorded by health care professionals with limited training on data entry; therefore, we are unsure of the proportion of the Role 2 workload captured within the database and the database lacks data entry standardization. In addition, these data have not been validated against medical records, which make it difficult to corroborate the accuracy of the information in the database. The Role 2 Database lacks specific injury severity

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data, injury type and mechanisms were ranked according to injury severity in general. Misclassification of primary injury type or mechanism is possible in patients with multiple injuries. Furthermore, the database lacks calculated injury severity scores and patient outcomes after discharge from the Role 2 facility. Lastly, the Role 2 Database has missing data concerns. The database does not include data on nonmedical delays in patient transfer (i.e., mission, enemy, terrain, troops, or time) or anatomic injury severity. The database does not have information on Role 2 unit size and availability of supporting capabilities, such as medical company support; consequently, residual confounding may exist in our study results. Furthermore, a large proportion of potential study patients were excluded because they had misclassified or missing time and date data. However, we believe any potential differences in the excluded patients and the study patients were not due to the Role 2 LOS, and, therefore, that the data were missing at random (i.e., the analytical response was ignorable). Despite the important limitations of the Role 2 Database, it is the largest source of data available on patient medical care at Role 2.

Understanding the LOS at Role 2 is important, as civilian studies have shown LOS could impact patient outcomes.[1] Shorter LOS at Role 2 may be better for some casualties, because they would arrive at facilities with greater care capabilities sooner. Furthermore, faster evacuation out of Role 2 would minimize congestion along the combat casualty continuum of care.[2] However, these potential benefits may not be realized if patients were evacuated too quickly and did not receive adequate resuscitation and stabilization at Role 2. This would place these patients at risk for adverse outcomes during transport and at Role 3. Consequently, more research is needed on optimal timing for patient transfer, because this likely depends on several patient and tactical factors. From this analysis, it appears that utilization of the Role 2 surgical teams was adequate with regard to relatively rapid transfer. However, a higher-intensity and higher-volume scenario may overwhelm the current system. Military planners must adjust risk assessments to reflect the limited capacity and throughput of the Role 2 surgical teams as they have been employed in Afghanistan and Iraq.

Interventions, patient affiliation, discharge status, and injury mechanism were associated with LOS at Role 2. Understanding LOS at Role 2 may provide insight for future conflicts in different scenarios, but these results may not be generalizable to all combat environments, based on mission, enemy, terrain, troops, or time. Our study results will help guide training and current Role 2 support needs, particularly with regard to postoperative nursing care associated with delays in transfer to higher levels of medical care. More research is needed in this area, and future studies should focus on defining optimal timing of patient transfer based on injury type and stability, identifying the patient population that would gain the most outcome benefit from Role 2 interventions, and determining the association of LOS at Role 2 with long-term patient outcomes.

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DISCLOSURES

The authors declare no conflicts of interest.
Opinions, interpretations, conclusions and recommendations are those of the author and are not necessarily endorsed by the Department of Defense. A.S., J.G., T.L., and E.M.S. contributed to study design. A.S. contributed to data analysis. A.S., J.G., J.S., S.N., and E.M.S. contributed to data interpretation. A.S. wrote the manuscript and A.S., J.G., K.V.D., M.S., J.T., T.L., S.S., S.N., and E.M.S. critically revised the manuscript.

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Using the Delphi Technique to Determine Core Components of a Nurse Competency Program

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This modified Delphi study determined consensus on core nurse competency program components that apply across the continuum of transition to initial practice, to new specialty practice, to a new role, or within general nursing orientation. The literature review found no published agreement on support and systems for universal transition programs. This broad-based study addressed this gap by identifying core elements within a competency or transition program and then ranking their importance within program structure.

Competency programs are used to establish evidence of clinical capability of new professional staff members in diverse settings and roles (Blegen et al., 2015; Boyer, Mann-Salinas, & Valdez-Delgado, 2018). These programs may address transitions of student to nurse, from one specialty to another, to a new setting or agency, and nurse to nurse practitioner. The nurse professional development (NPD) practice model identifies *partner for practice transitions* as one of seven key NPD roles and competency management as an essential throughput. This places management of Nurse Competency or Transition Program structure at the core of this specialized practice. Throughout this article, we refer to "competency program" and "transition program." Both of these terms address the structure and systems established to develop and validate care provider competency in the clinical setting.

The need for this project was identified when seeking to update and optimize the on-boarding or orientation system for a tertiary care center within the military health system (Boyer, Valdes-Delgado, Huss, Barker, & Mann-Salinas, 2017; Robbins et al., 2017). Work within the military health system agency introduced multiple concepts that were unfamiliar to the nurse leadership group, thus expert opinion and further evidence was sought. A literature review exposed limited evidence-based data on competency framework recommendations and a lack of consistency in tools used for instruction, competence assessment, and/or evaluation (Edwards, Hawker, Carrier, & Rees, 2015; Kinghorn, Halcomb, Froggatt, & Thomas, 2017; Pasila, Elo, & Kääriäinen, 2017). This study addresses the identified gap in evidence for programs that address foundational competency development and validation, as opposed to annual competency models (Strauss, Ovnat, Gonen, Lev-Ari, & Mizrahi, 2016). Cycles of questions, analysis, feedback, and intervention first outlined contemporary, expert opinion on core program elements and then ranked the components in order of importance. Respondent demographic data allowed analysis of responses as divided by role, experience, education, and military versus civilian medical systems.

PURPOSE

This modified Delphi study identifies and prioritizes contemporary, expert opinion on optimal program components within a nurse competency development and validation model. Expert consensus establishes core elements for programs that facilitate new specialty knowledge and skill development—whether the transition is onboarding new nurses or guiding experienced nurse transition into a new agency, specialty area, or role.

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LITERATURE REVIEW

The literature review presented a broad set of articles targeting new graduate transition to practice or residency programs (Edwards et al., 2015; Goode, Reid Ponte, & Sullivan Havens, 2016; Pasila et al., 2017). The nurse residency programs show great variation in program length and a lack of standardized evidence-based curriculum. Comprehensive reviews completed in 2014 and 2017 show that, "No integrative literature review could be found to summarize available guidelines facilitating transition of final year nursing students to professional nurses" (van Rooyen, Jordan, ten Ham-Baloyi, & Caka, 2018, p. 35). With no comprehensive syntheses to inform program development, there is significant imbalance and variation in the quality of transition programs. The search also exposed a lack of consistency in tools used for instruction, competence assessment, and/or evaluation (Pasila et al., 2017; van Rooyen et al., 2018).

Current publications on competency-based orientation disclose that little is shared regarding specific content recommendations, objectives, or program structure used to support successful transition of nurses into specialty practice (Peltokoski, Vehviläinen-Julkunen, & Miettinen, 2016). Gaps in literature were found related to both identifying program elements and the evaluation of program impact on healthcare outcomes. One integrative review identified the complexity of the orientation or transition phenomena while reporting that current research evidence is not strong. The absence of evidence makes it difficult to establish a comprehensive orientation (Kinghorn et al., 2017; Peltokoski et al., 2016; Strauss et al., 2016).

METHODOLOGY

Delphi methodology is a research approach that is suitable when seeking to solve real-world problems wherein expert opinion is appropriate. Three distinguishing features of the technique include iteration with controlled feedback, anonymity, and statistical representation of participant responses (McPherson, Reese, & Wendler, 2018). The process uses consensus to determine what responses and data are valid and is often used within a mixed methodology model. This makes the model particularly useful for reaching consensus with a diverse, widely spread panel of respondents (Collins, Yen, Phillips, & Kennedy, 2017; Hsu & Sandford, 2007; Naderifar, Goli, & Ghaljaie, 2017).

An independent institutional review board (IntegReview) determined that the study was exempt from human subject research oversight. The study facilitator collected data via a web-based survey system that was not linked with any healthcare agency. The survey tool collected a minimum of publicly available demographic information for the purpose of categorizing responses based on participant experience, education, or background characteristics.

The *credibility* and *dependability* aspects of the study were supported through use of a *study team* for data management and documentation. The decisions, actions, and potential biases of the study facilitator were checked and scrutinized by this team of four reviewers, two of which are nurse scientists with extensive management experience. These experienced researchers hold doctoral (PhD) degrees and ensured fidelity to methodology and an audit trail for study progression. The study team addressed each process step as outlined in Table 1. The component identification phase determined an initial list of program elements based on the literature search, expertise of the study team, and review by nurse leaders in the agency (Collins et al., 2017). Further refinement occurred with evaluation and comparison of current documents and processes.

Within multiple rounds of the Delphi study, participants shared opinions and knowledge based on their experience and expertise in working with transition programs. The facilitator reviewed the material and developed a revised set of summary statements based on each round of feedback. The data analysis and revised elements were reviewed by the full study team prior to the next survey round, and the process continued until participants reached consensus on core program elements. The technique was an iterative process that solicited a broad range of opinions from respondents. Both the level of consensus and the occurrence of "no new data elements proposed" (data saturation) determined the final round, wherein the program elements are prioritized (Hsu & Sandford, 2007).

SAMPLING METHOD: PANEL SELECTION AND SIZE

The study used a purposeful snowball sample composed of over 120 participants that include both military and civilian healthcare settings (Britten, Traynor, Osmond, & Chenoweth, 2018; Collins et al., 2017). The purposive sampling strategy combined with encouraged sharing (snowballing) of the survey link recruited participants from diverse regions and settings (Naderifar et al., 2017). Recruitment efforts targeted a professional web forum (LinkedIn), regional nurse leadership groups, military health clinical nurse leaders, and affiliate groups of the Association for Nursing Professional Development. Distribution of the first round of the Delphi study occurred via e-mail communications, and survey participants were invited to forward the survey link within their network of nurse leaders and clinical educators (Collins et al., 2017). The study protocol did not limit the number of participants, and "snowballing" of respondents expanded the sample size beyond the initial target groups.

The study team recognized that expertise comes in many guises and may include those who are "experts by experience." Thus, the study sought to include respondents from groups representing both decision makers who will use the outcomes and professional staff members

TABLE 1 Process for Identifying Core Program Components

Development Phase	Process Steps Engaged	Methods Utilized
Component identification	1. Clarify expected concepts and current practice	√ Environmental scan using key terms to identify initial list of components
	2. Generate a component list	√ Complete line-by-line document analysis of forms and process in current use
	3. Review of list by study team and clinical nurse leaders/educators	
E-Delphi survey process and analysis to expand, condense, and clarify listing of components	4. Consider inclusion, merging, modification, or removal of items based on Delphi responses—Rounds 1 and 2	√ E-Delphi via survey in three rounds with assessment for clarity, content, and face validity
	5. Evaluate survey comments for elimination or clarification of listed elements	√ Multivoting, survey, comments collected and analyzed for adapting list of identified components
Ranking of identified program components	6. Third Delphi round to finalize program components	√ Final Delphi round to include ranking of items on a Likert scale of 1–5 along with further comments
	7. Likert ranking scale engaged for prioritizing list of components	√ Content validity ratio ranking

from transition to practice support teams (Hsu & Sandford, 2007). The expertise of the respondents provides one measure of validity as respondents apply their leadership background, graduate education, and experience to identify specific elements for competency or transition program delivery. Basic demographic information submitted with each survey allowed grouping of data based on participant settings, role, education, and practice experience to determine if those variations generated any trends within responses.

Ayre and Scally (2014, p. 85) produced a table of exact values for content validity ratio (CVR) that detailed the number of experts agreeing that an element is essential. Based on their work, the minimum sample size was set at 40 respondents. With this sample, the CVR table required agreement of greater than 65% for statistical validity.

DEVELOPMENT OF THE FIRST QUESTIONNAIRE

An environmental scan and a document review were completed as part of gap analysis and study plan development. The search terms of "competency," "orientation," "transition program," and "new specialty" were used in CINAHL, PubMed, and Google Scholar. The component identification phase included this literature review plus line-by-line analysis of the agency's competency program documents by an NPD specialist (Collins et al., 2017). Based on current practice and the literature review, an initial list of 39 survey items was detailed and categorized under section headings of Demographics, Transition Program Structure, and Program Documentation. Nurse managers and clinical specialists from the involved tertiary care center reviewed the proposed list of elements to identify possible gaps or concerns. The resultant list provided a starting point for the Delphi Study data collection. Six of the 39 items solicited demographic data in the initial survey, leaving 33 items specific to program components, documents, and delivery.

CONDUCTING THE STUDY

The study team engaged the Delphi technique to distribute a list of program elements that could be refined based on respondent feedback. Rounds 1 and 2 were conducted with program elements presented within a survey form, along with specific directions. Respondents were asked to identify whether they believed that each element should be (a) included in the competency program framework, (b) included with modifications, or (c) excluded from the program (Britten et al., 2018). The instructions requested specific recommendations for modification of the statement or an explanation of "why exclude?" if that option was selected. Respondent comments were used to modify statements, expand upon stated rationale or examples, combine related items, and/or "add to" the elements where indicated. With a high level of consensus achieved after Round 2, the third study round asked respondents to also rank the level of importance of each element.

DATA AND ANALYSIS

Within data analysis, recommendations for revisions, additions, merging, and deletions held equal importance to

accepting the element as stated. Data were reviewed using an iterative process to identify salient themes and concerns related to transition program delivery (Hsu & Sandford, 2007). In each round, the respondent's comments, recommendations, and wording were used to revise the stated program elements or add to the rationale, and then the study team moved to the next process step. Participant demographic data did not track which respondents participated in prior rounds, but the final sample size was larger than the previous samples, indicating either more extensive sharing of the survey link or increased response rate from those receiving study communications.

The total number of respondents for Round 1 was 97 with 73 usable responses. Of the thirty-nine items in the survey, the first six were directed at demographic data, leaving 33 items that offered potential program components. There were occasional votes that requested elimination of an item, although often the "reason for deletion" was absent, revealed misunderstanding of the item, or referred to unrelated issues. From a total of 296 comments submitted by respondents, 33 were linked with a vote for elimination. Frequently, the rationale for exclusion recommended merging the content with another item. Compiled data for each program element showed support for inclusion at 94% or greater; thus, none were deleted. Integration of participant feedback resulted in adding detail to rationale and/or examples for each program element from this round, and the format of demographic information was changed to address all characteristics within a single-survey item where participants selected "all that apply."

The second round of the Delphi study engaged 81 respondents with 55 usable surveys. Of the 33 potential program elements, 23 received 100% respondent support or a recommendation for merging with another survey item. There were a total of 247 respondent comments from this round, with 50 of those linked to a vote for merging or elimination. With related items merged as directed by respondents, the list of remaining core components contained 20 elements. Data analysis supported retaining the full set of 20 modified statements.

The third and final survey round solicited responses from a total of 118 participants, with an 84% (n = 99) completion rate. Demographic data from the final round reveals that 95% of the respondents had 6 years or more of experience, with 68% reporting more than 16 years. In this round, less than 10% (n = 6) worked in a military medical agency, and 55% identified themselves as clinical educators. Of the 99 respondents, 21% identified as preceptors, 76% reported holding a master's degree, and 29% had completed doctoral studies. Certifications were held by more than 50% of respondents, with many of those focused on NPD. About 10% reported a mixed set of roles that included research, nursing science, or coordinator roles specific to a Magnet program, clinical support, or training specialist (with the third round offering 99 responses, the percentage and count numbers match when numbers are rounded down).

In this final round, participants ranked the importance level of the 20 program items, as well as offering a final set of comments. The survey tool directed a ranking for each element on a 5-point Likert scale of 5 = *very important* to 1 = *not important*. Participants were allowed to skip elements upon which they held no opinion; thus, the total responses for each item in the final round were either 98 or 99, with the blanks scattered across various elements. Initial data analysis included descriptive statistics to determine the mean, mode, range, and standard deviation for each program element as charted in Table 2. Although a small majority of items ranked within a range of 3 points, Table 2 shows Item 6 as being the only element that was ranked within a range of 4 points. That element is stated as, "Apply concepts of sampling to the selection of competency validation criteria that require confirmation within an agency and unit orientation." This proposed program element raised the most questions and concerns from respondents. Comments included the statements, "Not sure about this one. I worry about the verbiage"; "This statement cannot stand alone. I don't think the average NPD specialist is going to know what 'the concept of sampling' means"; and "teach preceptors and educators about sampling concepts and application."

The next step of analysis determined the percentage of agreement on importance for each element, which is core to calculating the level of CVR validity. The study outcomes detailed in Table 3 significantly exceeded the critical value of 65% agreement for a panel size of 40. With a panel size of 99 respondents, the lowest ranked item gained 80% level of agreement, and more than half the items ranked above 90%. When the chart of program elements was sorted based on their percentage ranking, the statements are set in a measured order of high to low agreement on importance. Along with prioritizing program elements, participants submitted an additional 112 comments related to competency program structure, documentation, and delivery issues. None of the 20 program components was recommended for elimination in the final round.

DISCUSSION

The modified Delphi process was used to determine and shape statements and examples to communicate specific elements that comprise a nurse competency program. Response rates varied for each study round. Changes in number of respondents may have been predictable as the study did not limit subsequent rounds to prior participants and sharing of the survey link was encouraged. Round 1 produced 73 usable survey responses, whereas the final round gained 99 responses. The expanded participant sample served to affirm *transformability* and

TABLE 2 Descriptive Statistics for Competency or Transition Program Elements

Program Item	Mean	Median	Mode	*SD*	Range
Item 1	4.78	5	5	0.42	1
Item 2	4.56	5	5	0.58	2
Item 3	4.71	5	5	0.56	3
Item 4	4.54	5	5	0.64	2
Item 5	4.35	4	5	0.73	3
Item 6	4.23	4	4	0.79	4
Item 7	4.35	5	5	0.77	3
Item 8	4.60	5	5	0.65	3
Item 9	4.57	5	5	0.61	2
Item 10	4.28	4	4	0.74	3
Item 11	4.66	5	5	0.48	1
Item 12	4.35	4	5	0.72	3
Item 13	4.31	4	5	0.79	3
Item 14	4.38	4	5	0.68	2
Item 15	4.63	5	5	0.58	2
Item 16	4.43	5	5	0.72	3
Item 17	4.17	4	5	0.82	3
Item 18	4.50	5	5	0.65	3
Item 19	4.33	4	4	0.64	2
Item 20	4.58	5	5	0.64	3

some aspects of *confirmability* for program elements as stated within the surveys. As new participants were enrolled for subsequent study rounds, they submitted feedback that supported previously contributed data and reflected the fit of results to their own experiences.

With extensive demographic questions posed at the beginning of the survey, many respondents completed that section without entering any responses specific to core program elements. To address this issue of incomplete surveys, subsequent tools were revised to request all applicable demographics be identified within a single survey item. This format gained sufficient data to sort the submissions by education, experience, credentials, and practice setting once the raw data were formatted in a chart. With the demographics condensed, the percentage of completed surveys rose. Analysis of the various demographic groupings determined that there were no significant differences in responses from respondent subsets.

It is not surprising that all elements ranked at or above a Likert score of four in the final round, as the elements had been reviewed and adapted based on two rounds of feedback. This level of support gave evidence of the efficacy of the prior process steps and the resulting list of core program elements. Ten items had mean scores of 4.5 or higher (see Table 2) when ranked as to level of importance. These point averages may indicate that these elements are especially essential to effective program structure and delivery. Higher rankings may also represent greater familiarity with those program elements as used within current practice, with the remaining elements being less commonly applied in transition programs.

The initial presentation of program elements included examples and/or rationale for only a few selected items. Respondent comments revealed the need to include examples and expand upon rationale to clarify the intent of each and every statement. Panelist responses provided a rich resource of rationale and examples for the statements. Feedback also identified possible gaps in understanding related to certain aspects of program structure. This was especially evident with the two lowest ranking elements of *applying sampling principles within a competency framework* and *concepts of standardized knowledge base*. Feedback for these elements may reveal a need for further inquiry into how the element is used within a competency program.

As the study progressed, the response rate improved, revealing a high level of interest in the project and outcomes. The final list of program elements represents consensus from both civilian and military personnel, inclusive of leadership, clinical preceptors, and nurses from diverse backgrounds and geographic settings. Respondent comments added depth and breadth to the ideas and concepts being analyzed within the study. A total of 645 participant comments were submitted, with many related to program elements, but others addressing core implementation challenges and issues. The comments connected to specific elements often provided strong examples or rationales that were added to the element description. In this manner, the Delphi process created work breakdown structures, identified risks and opportunities, and compiled lessons learned from the experience of multiple NPD and education-focused specialists.

LIMITATIONS AND RECOMMENDATIONS

Although the large sample size and absence of prescriptive participant requirements added diversity, there is no way to quantify that the sample addressed all aspects and populations involved in transition program delivery. This study recruited respondents from nursing education and professional development groups rather than broader healthcare audiences. Further implementation studies are needed to determine whether the program elements are generalizable

TABLE 3 Final List of Program Elements Ranked in Order of Percentage Agreeing on Importance

Core Components of a Nurse Competency or Transition Program		% Agree Important
Item 1	Include systems and planning to ensure safe patient care with effective supervision of learners and transitioning orientees.	100
Item 11	Include an evidence-based delivery system within program structure (such as preceptor program).	100
Item 3	Incorporate strategies for individualized development of critical thinking, competency, and clinical judgment.	97
Item 2	Establish competency development and validation documentation requirements that minimize the administrative work burden for preceptors, educators, and managers.	96
Item 15	Provide clear, concise, concrete, objective and measurable competency criteria within statements of expected performance elements.	95
Item 20	Clarify individual accountability for clinical practice, knowledge base, and ongoing learning as a healthcare professional.	94
Item 18	Ensure "hand-off communications" from one preceptor to the next.	94
Item 8	Establish guidelines for clear communication among transitioning orientees, preceptors, facilitators, and leadership.	93
Item 9	Integrate ongoing formative feedback and evaluation to ensure continuous, prompt development for program, orientee, system, tools, and preceptor.	93
Item 4	Present program criteria that support early identification of those who (a) can complete competency validation quickly, (b) might not be suited to the specialty, or (c) might pose a threat to safe care.	92
Item 19	Include clear directions and scoring key with each set of forms.	91
Item 16	Present clinical performance goals in the manner in which care delivery occurs, where subtasks are inherent to achieving the overall goal.	89
Item 14	Address elements of professional practice at various experiential levels, cultural, and situational awareness—based on role and clinical setting.	89
Item 12	Define and explain appropriate assignment, communication, assertiveness, supervision, roles, and responsibilities.	88
Item 10	Provide time and topics for development and growth, both in and outside clinical time, during and after formal transition program.	88
Item 5	Accommodate varied learning styles and skill development that progresses from simple to complex within an individualized development plan.	87
Item 7	Use a form, format, and process consistent with national standards and facility practices that is adaptable for clinical setting, specialty, or role.	86
Item 13	Present both initial and ongoing performance criteria in the competency validation tool—thus communicating both immediate and ongoing performance expectations.	86
Item 6	Apply concepts of sampling to the selection of competency validation criteria that require confirmation within agency and unit orientation.	85
Item 17	Outline knowledge content related to each performance goal that is standardized within the specialty.	80

to the full continuum of nursing care and for our allied healthcare teammates.

The study identified expert opinion regarding core elements of a competency program. With data submission, study participants also expressed concern that implementation of program elements will face staffing, resource availability, and clinical workload barriers. Additional survey comments revealed gaps in understanding related to specific program elements. Challenging concepts include statements related to accountability, sampling, standardized knowledge, and immediate versus ongoing expectations within professional practice. These elements ranked lower on the scale

of importance and generated multiple comments and questions from survey respondents. Additional focus on challenging concepts deserves consideration for future work, research, and instructional support.

CONCLUSION

This Delphi Study identified and ranked 20 core components of nursing transition or competency programs. As listed in Table 3, the elements may establish guidelines for program structure and documentation. The mean and percentage scores reveal a high level of consensus and support regarding the importance of each element in the final listing.

Study results provide foundational work toward delineating an evidence-based approach for transition or competency program objectives, content, development, and evaluation. Within the survey tools, each program item was further delineated with examples and rationale statements. The additional information will be a necessary component of using these elements to establish an effective transition program. An additional step of transposing the elements into an evaluation tool could further validate specific items and determine efficacy of the concepts in program evaluation.

Considering the significant resources required to support effective transitions within professional practice, refining common program components can ensure that agencies invest scarce resources with the greatest possible efficacy. Program efficacy may impact retention of both new graduate and experienced nurses at the agency, thus improving return on investment in professional development. Further work is warranted to formally communicate what was learned about program elements, related examples/rationale, and implementation issues related to specific program components.

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Characteristics of Iraqi Patients Treated During Operation Inherent Resolve by a Forward Surgical Team

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ABSTRACT Introduction: The combat experience during the re-entry stages of Operation Inherent Resolve was distinct from other recent operations, but there is no published literature regarding these "initial entry operations" experiences among forward surgical teams (FSTs) deployed to Role 2 facilities A descriptive analysis of patients treated by FSTs may provide valuable information for Role 2 surgical teams preparing to deploy in support of initial entry operations. The purpose of this analysis was to describe injury mechanism, wounding patterns and interventions performed by a small FST in the re-entry phase in Iraq. Materials and Methods: From July 17, 2015 to January 31, 2016, a split surgical team with two surgeons and an ER physician documented care for all patients treated by their FST located in Iraq. Given their austere environment, FSTs have limited holding capacity, blood supply, and ability to triage and perform advanced procedures. Patients, who arrived to the Role 2 in asystole, were ineligible for the study. The patient population was Iraqi Security Forces as well as Iraqi civilians. No follow-up data were obtained. Using descriptive statistics, we described the basic demographics, health status, blood utilization, injury severity, and injury pattern of the patient population. Results: The final study population included 300 Iraqi casualties. The majority of patients (96%) were discharged alive. Many patients were 16 years or older (96%), male (96%), Iraqi soldiers (86%), and injured during battle (96%). Over one-third of patients (35%) had a form of metabolic acidosis, 7% were hypothermic, and 18% were in shock at admission. The median amount of blood products used was 6 (interquartile ranges (IQR) = 2–12) units, while the median red blood cells:fresh frozen plasma ratio was 1.2:1. Six or more units of blood were given to 67 (22%) patients. The top three diagnoses were laceration (n = 197, 21%), penetrating injury (n = 185, 19%), and fracture (n = 174, 18%). A high number of injuries occurred in the extremities/pelvis and buttocks (n = 360, 38%) and in the abdomen and pelvic contents (n = 145, 15%). Over a quarter of patients (26%) had critical injuries (i.e., military injury severity score ≥25). Conclusions: Given the Role 2 configuration, these results demonstrate FSTs must be capable of managing critically ill patients with markedly limited resources. This management will include general operations in both adult and pediatric patients, resuscitation with a limited blood supply, and patient assessment with minimal to no diagnostic tools. This analysis can inform resident training, pre-deployment training, as well as sustainment training for surgeons after residency.

INTRODUCTION

The U.S. Army utilizes small mobile surgical teams in far-forward austere environments to perform damage control resuscitation and surgery in order to bridge the time/space gap between wounding and definitive surgical care. These teams are a component of Role 2 care on the battlefield and while there are a few different service-specific configurations of these units, Forward Surgical Teams (FST) have been the most frequently utilized on the battlefield.[1] When deployed in its entirety, the FSTs doctrinally consist of 20 personnel with the ability to perform two simultaneous major surgeries. The FSTs are equipped with red blood cells (RBC), fresh frozen plasma (FFP), and limited quantities of unpooled cryoprecipitate. Often times, these FSTs perform split operations, whereby 10 personnel set up a one-bed operating room at two different geographical sites.[2] With this configuration, both the capacity and capability are diminished: only one surgery can be performed at a time; holding capacity is decreased; and ability to triage and perform advanced trauma life support procedures is reduced. Despite the inherent limitations of a 10 man team, splitting the FST facilitaties surgical coverage for dispersed operations.

There are several publications describing the Role 2 environment and some of the clinical and operational challenges;[3–9] however there is a lack of information in the literature regarding the recent "initial entry operations" from Operation Inherent Resolve experiences at far-forward Role 2 facilities. Initial entry operations in Iraq were unique because logistical support and the patient transport system were unestablished and immature. From July 17, 2015 to January 31, 2016, half of a conventional 20 man FST (10 personnel) were deployed to Iraq. This team was augmented by an additional five personnel (emergency room physician/nurse, operating room technician/nurse, and a certified

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registered nurse anesthetist). To our knowledge, this was the first surgical team to repopulate and work in the austere, immature theater of operations. A descriptive analysis of the workload, injury patterns, and patients treated by this FST may provide valuable information for other Role 2 surgical teams preparing to deploy in support of initial entry operations. The purpose of this analysis was to describe injury mechanism, wounding patterns and interventions performed by a small surgical team in the re-entry phase in Iraq; lessons learned may help inform the manning, training and equipping of Role 2 surgical teams in the future operating environment.

METHODS

This descriptive study was reviewed and approved by the United States Army Institute of Surgical Research regulatory department and was determined to be exempt from review by the Institutional Review Board. Data were recorded by a split surgical team with two surgeons and an emergency room (ER) physician. The data were entered into the Role 2 Database at the United States Army Institute of Surgical Research Joint Trauma System by a single surgeon. The patient population was made up of Iraqi Security Forces to include the Iraqi Army, Federal Police, the Iraqi Counter-Terrorism Service, both Sunni and Shia Militia Groups, as well as Iraqi civilians. All patients arrived to the FST by ground, either by ambulance or personal vehicle. The evacuation times from the point of injury were approximately 90–120 minutes. The FST had minimal holding capability. All patients were evacuated to Iraqi hospitals after stabilization and operative procedures. Most patients were evacuated to Baghdad, usually by Iraqi ground assets. No follow-up data were able to be obtained. No treatment or interventions were given to patients who arrived to the Role 2 in asystole; thus, these patients were ineligible for the study.

The following procedures conducted in the ER were excluded from the analysis: endotracheal Tube ($n = 122$), central line placement ($n = 72$), focused abdominal sonography for trauma ($n = 279$), and abdominal wound exploration ($n = 16$). Patients were recorded as being in shock if their systolic blood pressure (SBP) was less than 90 mmHg. For one patient, the temperature would not register on a medical grade thermometer, so the temperature was recorded as unreadable.[10] All laboratory values were obtained from either a venous or arterial blood sample. A base deficit >2 was considered metabolic alkalosis, while a base deficit <−2 was considered metabolic acidosis, which was further categorized as: minor <−2 to ≥−10; serious <−10 to ≥−20; and critical <−20.

The military Injury Severity Score (mISS), which was identified by using a form of the abbreviated injury scale, was calculated according to the methods used by Champion et al.[11] Patient injuries were classified according to mISS as follows: mild (1–9), moderate (10–15), severe (16–24), and critical (≥25). In this study, a patient could have more than one classification for mechanism of injury, cause of injury, and injury diagnosis. The causes of injury for patients in this study were categorized as: gunshot, burn, mortar/rocket (i.e., weapon that fires shells at low velocities, short ranges, and high-arching ballistic trajectories), blast (i.e., improvised explosive device or small bomb), and other. Basic demographics, health status, blood utilization, surgical procedures, mISS, and injury pattern of Iraqi patients were described.

All categorical data are presented as count (percent), while continuous data are presented using medians (interquartile ranges [IQR]). Statistical analyses were performed using Stata 14 (College Station, TX, USA).

RESULTS

The final study population included 300 Iraqi casualties. Only 4.0% ($n = 12$) of the study patients died before Role 2 discharge. The majority of patients were adult, male Iraqi soldiers injured during battle, and transported out of the

TABLE I. Demographics, Characteristics, Vital Signs, and Laboratory Measurements of the Iraqi Patients ($n = 300$) Treated at a Role 2 in Al Taqqadum, Iraq from July 17, 2015– January 31, 2016

Variable	*n*(%)
Male	289 (96)
Battle injury	288 (96)
Dead at discharge	12 (4)
RBC:FFP ratio, median (IQR)	1.2:1 (1:1, 1.7:1)
Age at injury	
0–15 years	8 (3)
16+ years	287 (96)
Affiliation	
Iraqi soldier	259 (86)
Civilian	30 (10)
Other	11 (4)
Departure transportation	
Ambulance	239 (80)
Helicopter	36 (12)
Other	5 (2)
Base deficit	
Metabolic alkalosis	15(5)
Normal	102 (34)
Minor metabolic acidosis	85 (28)
Serious metabolic acidosis	13 (4)
Critical metabolic acidosis	6 (2)
Blood transfusion	
0 units	180 (60)
1–5 units	53 (18)
6+ units	67 (22)
Shock	
Yes	54 (18)
No	232 (77)
Temperature	
≤95° F	20 (7)
>95 and ≤97° F	27 (9)
>97° F	218 (73)

RBC, red blood cells; FFP, fresh frozen plasma; IQR, interquartile range.

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Role 2 by an ambulance (Table I). There were 11 patients who arrived with pulseless electrical activity or had cardiopulmonary resuscitation on arrival. Of those 11 patients, three (27%) were resuscitated. Over one-third of patients had a form of metabolic acidosis (n = 104, 35%) with a base deficit as low as −28 recorded. Of the patients with recorded critical base deficits, 4 (67%) died. There were 20 (7%) patients with a temperature less than or equal to 95°F. Almost one-fifth (n = 54, 18%) of patients arrived to the Role 2 in shock, and, of those patients, 23 (43%) had a SBP lower than 70.

Nearly 1,000 units of blood products were transfused (x = 971) (Table II). The median amount of blood products used was 6 (IQR = 2–12) units, while the median RBC:FFP ratio was 1.2:1. Six or more units of blood were given to 67 (22%) patients. RBC's accounted for the majority of the blood product used (x = 553, 57%). The largest amount of blood products were used in August (x = 158, 16%), September (x = 208, 21%), and December (x = 159, 16%), which were also the months with the highest number of surgical procedures (x) and total number of patients (n) (August- x = 193 (19%), n = 65 (22%); September- x = 178 (18%), n = 54 (18%); and December- x = 165 (16%), n = 43 (14%)). Patients treated in the month of August had the highest median mISS (16, IQR = 5–30).

The top three diagnoses were laceration (x = 197, 21%), penetrating injury (x = 185, 19%), and fracture (x = 174, 18%) (Table III). A high number of injuries occurred in the extremities/pelvis and buttocks (x = 360, 38%) and in the abdomen and pelvic contents (x = 145, 15%). Patients injured by a blast (n = 146, 44%) accounted for the highest cause of injury with an average of 2.7 ± 1.7 body regions injured per patient, requiring the highest number of procedures (x = 531, 53%). According to the mISS categorization of this study, 43% (n = 129) of patients had mild injuries, followed by critical injuries (n = 77, 26%). Of the critical patients, 10 (13%) died at the Role 2, and in the severe category, two patients (4%) died. A description of procedures (x = 1,005) is shown in Table IV.

DISCUSSION

In this study, the majority of injuries sustained were penetrating trauma (i.e., blast, mortar or rocket, and/or gunshot wounds), and a disproportionately higher number of procedures occurred in patients injured by blast or mortar/rockets as compared to gunshot wounds. Blast mechanism of injury is common in combat and has been linked to higher injury severity and fatality. In Iraq in 2006, Bird and Fairweather reported a high lethality of improvised explosive devices, linking them to the cause of 62% of hostile deaths.[12] Among Israeli patients with terror-related injuries, a larger proportion of patients sustained explosion injuries as compared to those injured by gunshots had multiple body regions injured (62% versus 47%) and an injury severity score ≥25 (46% versus 34%), respectively.[13] In this study, multiple body areas injured and more than one mechanism of injury for many patients translated into high injury severity scores; complicated wounding patterns required the performance of multiple surgical procedures and transfusion of blood products. Many patients required at least one unit of blood product and over a fifth required more than 6 units of blood. Approximately 1,000 units of blood products were transfused in 7 months with a RBC:FFP ratio nearing the goal 1:1 ratio.[14] Although 40% of the patients were transfused blood product, 34% had metabolic acidosis, and 45% recorded a severe to critical military injury severity score, only 4% of patients died of wounds.

All casualties treated by this FST were Iraqi, either part of the many branches of the Iraqi Security Forces or Iraqi

TABLE II. Blood Utilization, Surgical Procedures, and mISS by Month in Iraqi Patients at a Role 2 in Al Taqqadum, Iraq from July 17, 2015 to January 31, 2016

Month	Blood Product in Units, x(%)				Surgical Procedures, x(%)	Median mISS (IQR)	Total Patients, n(%)
	RBCs	FFP	Cryoprecipitate	Total			
July	49	29	0	78	114	8.5	40
	(9)	(8)	(0)	(8)	(11)	(2–16)	(13)
August	107	51	0	158	193	16	65
	(19)	(14)	(0)	(16)	(19)	(5–30)	(22)
September	123	85	0	208	178	10	54
	(22)	(23)	(0)	(21)	(18)	(4–26)	(18)
October	64	38	4	106	122	10	37
	(12)	(10)	(7)	(11)	(12)	(2–25)	(12)
November	62	47	19	128	132	12	37
	(11)	(13)	(35)	(13)	(13)	(5–17)	(12)
December	80	59	20	159	165	10	43
	(14)	(16)	(36)	(16)	(16)	(5–21)	(14)
January	68	54	12	134	101	15	24
	(12)	(15)	(22)	(14)	(10)	(9.5–20)	(8)
Total	553	363	55	971	1,005	11.5	300
	(57)	(37)	(6)	(100)	(100)	(5–25)	(100)

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TABLE III. Injury Pattern of Iraqi Patients Treated at a Role 2 in Al Taqqadum, Iraq from July 17, 2015–January 31, 2016

Variable	Count (%)
Diagnosis	
Laceration	197 (21)
Penetrating injury	185 (19)
Fracture	174 (18)
Penetrating skin injury	59 (6)
Amputation	43 (5)
Pneumothorax	42 (4)
Burn	38 (4)
Ear injury	37 (4)
Hemopneumothorax	31 (3)
Avulsion	17 (2)
Eye injury	17 (2)
Inhalation injury	16 (2)
Body region	
Lower extremity/pelvis and buttocks	200 (21)
Upper extremity	160 (17)
Abdomen and pelvic contents	145 (15)
Thorax	144 (15)
Face	136 (14)
External	97 (10)
Head, neck and spine	75 (8)
Military Injury Severity Score	
Mild	129 (43)
Moderate	38 (13)
Severe	56 (19)
Critical	77 (26)
Cause of injury	
Gunshot	119 (40)
Burn	27 (9)
Mortar/rocket	19 (6)
Blast	146 (49)
Other	19 (6)
Number of procedures	
Gunshot	368 (37)
Burn	70 (7)
Mortar/rocket	82 (8)
Blast	531 (53)
Other	42 (4)

TABLE IV. Procedures for Iraqi Patients Treated at a Role 2 in Al Taqqadum, Iraq from July 17, 2015–January 31, 2016

Procedure	*x* (%)
Debridement	221 (22)
Other	117 (12)
Suture	115 (11)
Irrigation	108 (11)
Reduction	82 (8)
Insertion	81 (8)
Amputation	41 (4)
Ligation	39 (4)
Exploration	35 (3)
External fixator	33 (3)
Resection	31 (3)
Laparotomy	29 (3)
Splinting	28 (3)
Fasciotomy	23 (2)
Anastomosis	22 (2)

civilians to include women and children. Of the casualties treated, 10% were Iraqi civilians. Similarly, Chambers et al reported 13% of casualties were civilians treated by a US Marine Corps' Surgical Shock Trauma Platoon, comparable to an Army FST in personnel and capability, in Iraq from March 1, 2004 to February 28, 2005.[15] Indigenous forces are often not equipped with the protective gear that has become the standard for USA and Coalition military personnel. While there were a high number of extremity wounds, the lack of sufficient body armor, protective helmets and eye protection by Iraqi Security Forces may have resulted in the high numbers of thoracic, abdominal and ophthalmic injuries.

There are some limitations to consider when interpreting the results of this study. Prehospital transport to the FST was lengthy, unregulated, and point of injury and transport care was non-existent; thus, a survival bias may exist in these results as patients may have died before reaching the FST. In addition, there is no follow-up data available on these patients. All patients were immediately transferred out of the FST after recovery from the postoperative period to host nation hospitals. Despite the clinical outcomes limitations and the survival bias, one of the strengths of this study is that it portrays the realistic scenario of host national care in early entry operations and what care looks like without an established trauma system. Another strength of this analysis is that every patient cared for at this FST was captured in this dataset, therefore providing valuable information regarding workload in this type of environment as well as and accurate representation of injuries seen in initial entry (or in this care re-entry) operations.

The results of this study may be generalizable to Iraqi patients injured in an austere environment with limited resources that included: blood, some diagnostic tools, and communications for quick transfer of patients. Additionally, since the majority of patients were without body armor, the injury patterns were not typical of U.S. military casualties and may represent injury patterns observed in mass shooter and terrorist attacks. This analysis is also relevant to humanitarian missions in areas that do not have a good prehospital system of care given that the patients in this analysis frequently arrived in extremis with complex wounding patterns due to insufficient protective gear, long transit times and no prehospital care.

In conclusion, the combat experience of this single split-operations FST during the re-entry stages of Operation Inherent Resolve was distinct from other recent utilizations of FSTs, Forward Surgical Elements, and Damage Control Resuscitation Teams. Given the unique challenges of early entry operations: lack of established logistical support; immature patient transport system; lack of holding capacity at far-forward sites; and lack of fixed location – this analysis can inform manning and equipping for potential future operating environments. Given the large volume of blood products transfused to this study population, to prepare for future operations, we need to ensure blood is available as far forward as possible. Additionally, this analysis can also help inform

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training in terms of case type and workload. As we look towards the future and as we continue to have a changing operational environment in the U.S. Central Command Theater of Operations – it is paramount that surgical teams are capable of managing severely injured and critically ill patients in an austere far-forward environment with markedly limited resources. Surgeons should have training in patient assessment with little to no diagnostic modality, resuscitating with a limited supply of blood products, and operating independently on all body regions in both adults and children. This analysis will help facilitate overall preparedness for the future operating environment.

PREVIOUS PRESENTATION

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SUPPLEMENT ARTICLE

Improved survival in critically injured combat casualties treated with fresh whole blood by forward surgical teams in Afghanistan

Jennifer Gurney,[1,2] *Amanda Staudt*,[1] *Andrew Cap*,[1,3] *Stacy Shackelford*,[2] *Elizabeth Mann-Salinas*,[2] *Tuan Le*,[1] *Shawn Nessen*,[3] *and Philip Spinella*[4]

BACKGROUND: The objective of this study was to assess transfusion strategies and outcomes, stratified by the combat mortality index, of casualties treated by small surgical teams in Afghanistan. Resuscitation that included warm fresh whole blood (FWB) was compared to blood component resuscitation.

STUDY DESIGN AND METHODS: Casualties treated by a Role 2 surgical team in Afghanistan from 2008 to 2014 who received 1 or more units of red blood cells (RBCs) or FWB were included. Patients were excluded if they had incomplete data or length of stay less than 30 minutes. Patients were separated into two groups: 1) received FWB and 2) did not receive FWB; moreover, both groups potentially received plasma, RBCs, and platelets. The analysis was stratified by critically versus noncritically injured patients using the prehospital combat mortality index. Kaplan-Meier plot, log-rank test, and multivariable Cox regression were performed to compare survival.

RESULTS: In FWB patients, median units of FWB and total blood product were 4.0 (interquartile range [IQR], 2.0-7.0) and 16.0 (IQR, 10.0-28.0), respectively. The Kaplan-Meier plot demonstrated that survival was similar between FWB (79.1%) and no-FWB (74.5%) groups ($p = 0.46$); after stratifying patients by the combat mortality index, the risk of mortality was increased in the no-FWB group (hazard ratio, 2.8; 95% confidence interval, 1.2-6.4) compared to the FWB cohort.

CONCLUSION: In forward-deployed environments, where component products are limited, FWB has logistical advantages and was associated with reduced mortality in casualties with a critical combat mortality index. Additional analysis is needed to determine if these effects of FWB are appreciable in all trauma patients or just in those with severe physiologic derangement.

Whole blood transfusion was standard therapy for hemorrhage during both world wars and the Korean and Vietnam conflicts.[1,2] Then, for the 3 decades after the Vietnam conflict, component therapy and crystalloid resuscitation became the standard of care without comparative efficacy studies demonstrating improved outcomes.[1–3] Recent conflicts involving US military forces over the past 2 decades saw a resurgence in the use of whole blood on the battlefield, initially using warm fresh whole blood (FWB) from "walking blood banks," and since 2016 adding cold-stored, fully tested whole blood. The

ABBREVIATIONS: CMI-PH = prehospital combat mortality index; DODTR = Department of Defense Trauma Registry; FWB = fresh whole blood; ISS = injury severity score; MTFs = medical treatment facilities.

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use of FWB has been associated with improved outcomes for combat wounded.[4,5] Over the past 2 decades, damage control resuscitation has evolved, and deployed trauma teams transfuse blood components in ratios recapitulating whole blood, while collecting warm FWB for the exsanguinating casualty.[6] The Armed Services Blood Program data indicate that over 10,700 units of warm FWB have been transfused by US military teams during the recent conflicts in Iraq and Afghanistan.[7]

In the current battlefield system of care, casualties move from point of injury through increasing levels of care on the battlefield. Damage control resuscitation is initiated at the point of injury (Role 1 care) with aggressive control of external hemorrhage using tourniquets and hemostatic dressings, avoidance of crystalloids, early administration of tranexamic acid, and resuscitation using whole blood.[8–12] Role 2 medical treatment facilities (MTFs) provide forward resuscitative care and damage control surgery, with limited resources and 8 to 20 personnel. A Role 3 MTF is the highest level of care in the combat zone and has the capability to store and transfuse blood components, including apheresis platelets collected on site, and provide specialty surgical care and extended intensive care. Role 4 MTFs are outside the combat zone and are comprehensive health care facilities. Since Role 2 MTFs are meant to bridge the time/space gap from wounding to definitive hemorrhage control by using damage control principles, they are designed to be mobile and have minimal resources and a limited blood supply. Care at Role 2 MTFs is intrinsic to the damage control battlefield paradigm in that these small surgical teams provide rapid surgical hemorrhage control and then transfer patients to Role 3 MTFs. Since the initial descriptions of damage control resuscitation, battlefield resuscitation practices have dramatically changed to incorporate these principles based on focused empiricism and supporting data.[4,5,8,13–15]

Indications for a walking blood bank and FWB transfusion in the far-forward combat environment include an inadequate supply of fully tested cold-stored whole blood or component therapy or when component therapy is deemed to be ineffective.[16] Surgical teams in austere environments collect FWB from prescreened donors and transfuse it shortly after collection. Having a robust and well-rehearsed walking blood bank is a necessity for forward-deployed surgical teams. The existing literature regarding whole blood outcomes is limited but suggests improved survival when FWB is administered to combat casualties.[4,5] Previous studies of FWB use may have been biased, even though they had the advantage of the injury severity score (ISS) to assess anatomic injury burden, they did not assess outcomes based on the severity of physiologic burden; additionally, survivor bias is difficult to overcome in retrospective studies assessing transfusion outcomes.[4,5,15] The objective of this study was to assess outcomes of critically injured patients who received FWB as compared to those who received no FWB and partial

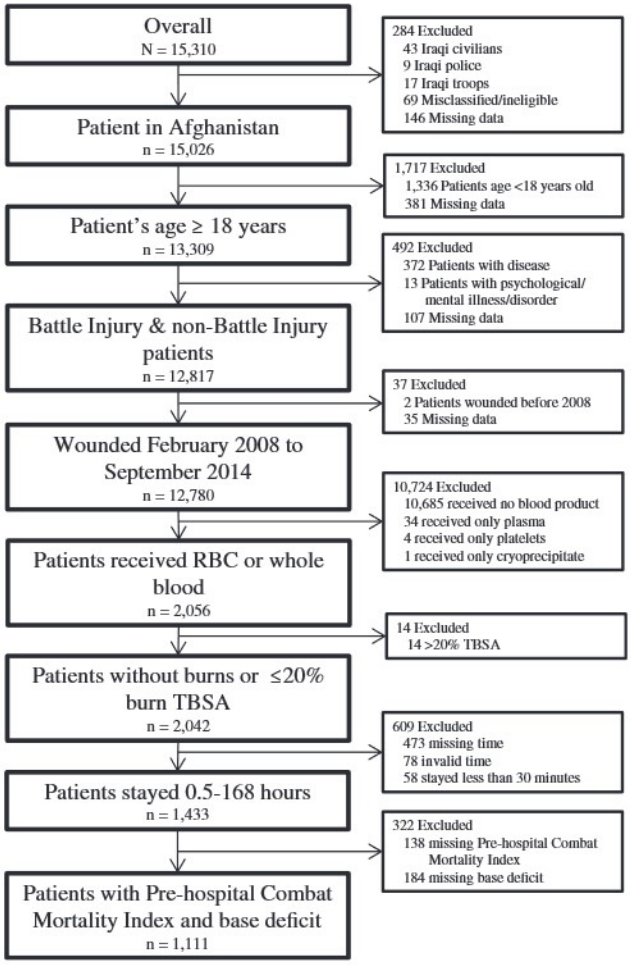

Fig. 1. Flow diagram of patients (n = 1111) in Role 2 Database by inclusion and exclusion criteria, October 2009 to September 2014. TBSA = total burn surface area.

STUDY DESIGN AND METHODS

This study was reviewed and approved by the US Army Institute of Surgical Research regulatory department and was

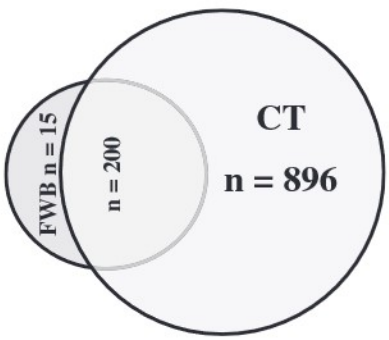

Fig. 2. Venn diagram of study patients (n=1111) treated at

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(i.e., no platelets) or complete (i.e., with platelets) component therapy by Role 2 surgical teams.

Role 2 facilities in the Afghanistan combat theater, October 2009 to September 2014. CT = partial or complete component therapy.

TABLE 1. Demographics and patient characteristics of study patients (n = 1111) treated at Role 2 facilities in the Afghanistan combat theater by FWB use, October 2009 to September 2014

	FWB (n = 215)		No FWB (n = 896)		
Variable	n	%	n	%	p value
Male	212	98.6	862	96.2	0.0962
Age, median (IQR)	25.0	22.0 to 30.0	25.0	22.0 to 30.0	
Battle-injured	199	92.6	811	90.5	0.3490
Affiliation					<0.0001
Military, US	83	38.6	151	16.9	
Military, non-US	77	35.8	451	50.3	
Other	55	25.6	294	32.8	
Injury mechanism					0.3698
Explosion	113	52.6	423	47.2	
Gunshot wound	81	37.7	372	41.5	
Mortality at discharge	17	7.9	54	6.0	0.3114
Base deficit, median (IQR)	−7.0	−12.0 to 4.0	−5.0	−8.0 to −2.0	<0.0001
Blood product, units, median (IQR)	16.0	10.0 to 28.0	6.0	4.0 to 12.0	<0.0001
FWB	4.0	2.0 to 7.0	N/A	N/A	
RBC	6.0	3.0 to 10.0	4.0	2.0 to 6.0	<0.0001
FFP	5.0	2.0 to 8.0	3.0	1.0 to 5.0	<0.0001
Platelets	0.0	0.0 to 0.0	0.0	0.0 to 0.0	0.1825
Crystalloid, L, median (IQR)	3.7	2.1 to 5.6	3.0	2.0 to 4.1	<0.0001
CMI					0.0008
Mild	41	19.1	277	30.9	
Moderate	74	34.4	323	36.0	
Severe	57	26.5	159	17.7	
Critical	43	20.0	137	15.3	

CMI = combat mortality index; FFP = fresh frozen plasma; FWB = fresh whole blood; IQR = interquartile range; N/A = not applicable.

determined to be exempt. This was a secondary analysis that used data from adult trauma patients that required transfusion and included both battle and nonbattle injuries occuring in Afghanistan from February 2008 to September 2014. Data were obtained from the Joint Trauma System Role 2 Database. The Role 2 Database was initiated in 2008 and is a database into which Role 2 personnel enter trauma patient data from the clinical records; 24 Role 2 locations were included in this analysis. The strength of this database is that it includes a significantly large amount of patients which did not get captured by the Department of Defense Trauma Registry (DODTR); up until 2014, a patient had to be admitted to a Role 3 MTF to be captured by, and entered into, the DODTR.

Patients eligible for inclusion in this analysis received at least 1 unit of red blood cells (RBCs) or FWB. Patients were excluded on the basis of 1) incomplete data; 2) more than 20% total body surface area burn; or 3) died of wounds in less than 30 minutes after MTF arrival to compare as equal groups as possible, given that FWB requires approximately 30 minutes to collect and process prior to initiation of transfusion.[15]

Patients were divided into two groups: 1) received FWB and 2) did not receive FWB. Both groups potentially received plasma, RBCs, or platelets. The primary outcome was survival to Role 2 discharge. Blood products (FWB, RBCs, platelets, and plasma) and volume of crystalloid delivered prehospital and in the first 24 hours after admission were included in the analysis. The plasma-to-RBC ratio was calculated as number small number of Role 2 surgical teams had access to platelets during the study time frame.

Potential confounders determined a priori included physiologic injury severity defined by prehospital combat mortality index (CMI-PH) (critical, less critical), admission base deficit, battle or nonbattle injury, and patient affiliation (US military, non-US military, other). The CMI-PH was developed by researchers at the US Army Institute of Surgical Research to quantify injury severity with use of physiologic parameters, prehospital heart rate, Glasgow Coma Scale, and systolic blood pressure.[18] CMI-PH is classified as mild

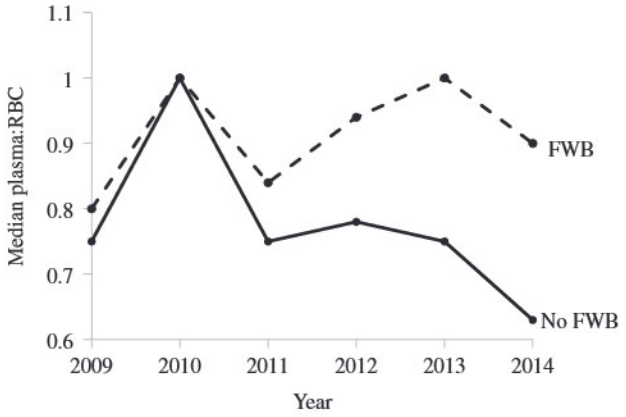

Fig. 3. Median plasma: RBC ratio by FWB use over time for study

of plasma units plus FWB units divided by RBC units plus FWB units.[17] Platelet ratios were not analyzed because only a

patients (n=1111) treated at Role 2 facilities in the Afghanistan combat theater, October 2009 to September 2014.

(CMI = 0), moderate (CMI = 1), severe (CMI = 2), or critical (CMI ≥ 3). The CMI score was developed and used in this analysis because ISS and the Abbreviated Injury Scale was not available in the Role 2 Database.

When prehospital vital signs were not available, admission vital signs were substituted for the calculation of CMI-PH. Injury severity was stratified as less critical CMI-PH less than 3 and critical CMI-PH of 3 or greater. To account for differences in injury location and pattern of injury, we adjusted for battle injury, which includes all injuries that occurred during a hostile action or battle compared to traumatic injury form nonbattle injuries such as accidental gunshot wounds, falls, or vehicle injuries. Patient affiliation was included as a covariate to adjust for variation in baseline health status and use of protective gear. Patient affiliation included US military, non-US military (i.e., NATO,

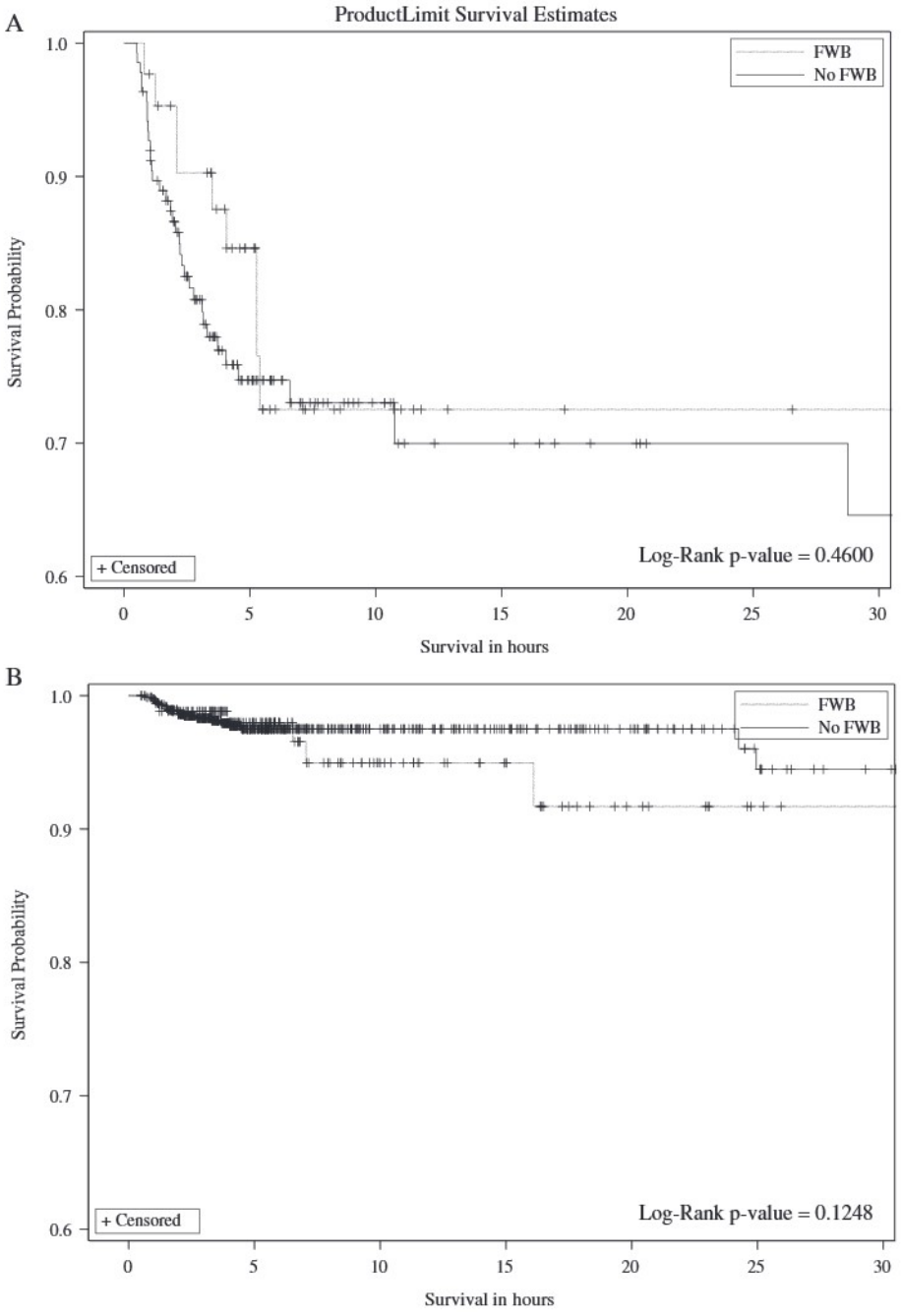

Fig. 4. Kaplan-Meier curve for survival to Role 2 discharge by fresh whole blood (FWB) use in A) critically (n=180) and B) noncritically (n=931) injured study patients treated at Role 2 facilities in the Afghanistan combat theater, October 2009 to September 2014.

TABLE 2. Multivariate Cox regression of mortality for critical* patients (n = 180) and noncritical patients (n = 931) treated at Role 2 facilities in the Afghanistan combat theater, October 2009 to September 2014

	HR (95% CI)			
	Critical patients		Noncritical patients	
Variable	Unadjusted	Adjusted	Unadjusted	Adjusted
No FWB versus FWB	1.3 (0.6-2.8)	**2.8 (1.2-6.4)**	0.5 (0.2-1.2)	0.9 (0.4-2.0)
Base deficit	**0.9 (0.9-1.0)**	**0.9 (0.9-1.0)**	**0.8 (0.8-0.9)**	**0.8 (0.8-0.9)**
Battle-injured	0.9 (0.4-2.1)	0.8 (0.3-2.0)	**0.3 (0.1-0.6)**	**0.2 (0.1-0.6)**
Affiliation				
Military, non-US	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Military, US	**2.3 (1.1-4.9)**	**3.1 (1.4-7.2)**	0.2 (<0.1-1.2)	0.2 (<0.1-1.4)
Other	1.1 (0.6-2.3)	0.9 (0.4-1.8)	0.7 (0.3-1.5)	0.6 (0.2-1.3)

CI = confidence interval; FWB = fresh whole blood; HR = hazard ratio.
* Critical patients were defined by Combat Mortality Index (CMI), where critical patients had a CMI≥3 and non-critical patients had a CMI < 3.

Afghanistan National Security Force, Afghanistan police), and other (local national civilians, Department of Defense civilians, enemy combatants, and unspecified patients).

Demographic characteristics, CMI-PH, vital signs, blood product, and crystalloid transfusion were compared between study groups. Continuous variables were presented as median (interquartile range [IQR]), while categorical variables were presented as counts and proportions. The chi-square and Mann-Whitney U test were used to test for differences between study groups. Kaplan-Meier log-rank was used to compare unadjusted Role 2 survival between FWB and no-FWB study groups. Multivariable Cox regression was used to adjust for confounding effects on survival to Role 2 discharge. The final Cox regression models had the lowest Akaike information criterion, which indicated the best quality of the final statistical models relative to the other tested models. The Kolmogorov-Type Supremum Tests indicated the final Cox regression models met the proportional hazards assumption.

Statistical significance was determined at the $p < 0.05$ level (two-sided). All analyses were conducted with computer software (SAS version 9.4, SAS Institute, Inc).

RESULTS

Of the 15,310 available patient records, 12,780 patients were eligible based on patient age, injury type, location, and date. From the eligible study population, there were 2056 patients who received RBCs or whole blood. Excluded were 14 patients who had more than 20% total burn surface area, 609 patients were excluded because they were dead on arrival or died within 30 minutes of arrival, and 322 patients with missing covariate data. The final study population included 1111 patients (Fig. 1). Of the study population, 215 (19.4%) patients received FWB, while 896 (80.6%) patients received component therapy only (Fig. 2). Among the 896 patients in the no-FWB group, 101 (11.3%) received platelets.

The two groups were similarly made up of young adult males injured in battle (Table 1). Study groups varied by patient to no-FWB group, more FWB patients had a critical (20.0% vs. 15.3%) or severe (26.5% vs. 17.7%) CMI-PH. FWB patients received median 4.0 (IQR, 2.0-7.0) units of FWB and more total component therapy (RBC, fresh frozen plasma, platelets) products (16.0; IQR, 10.0-28.0) compared to the no-FWB group (6.0; IQR, 4.0-12.0). The median length of stay at Role 2 was 5.0 (IQR, 3.1-9.3) hours with a 90th percentile of 21.0 hours.

During the study period, the median plasma-to-RBC ratio was 1:1 (range, 0.8-1.0) for the FWB group as compared to 0.8:1 (range, 0.6-1.0) for the no-FWB group ($p < 0.0001$) (Fig. 3). Survival was similar between critical (79.1% vs. 74.5%; $p = 0.4600$) and less critically (95.4% vs. 97.5%; $p = 0.1248$) injured FWB and no-FWB groups, respectively (Fig. 4). In the critically injured patient group (CMI-PH ≥ 3), the median number total blood products transfused was 21.0 (IQR, 14.0-33.0) units for those who received FWB and 9.0 (IQR, 4.0-16.0) for those who did not receive FWB ($p < 0.0001$). The median (IQR) ratio of FWB given (i.e., FWB/(FWB + platelets + cryoprecipitate + plasma + RBC)) was 0.29 (0.18-0.47) among FWB patients. In the less critically injured patient group (CMI-PH < 3), the median number of blood products transfused was 15.0 (IQR, 9.0-25.0) units for those who received FWB and 6.0 (IQR, 3.0-11.0) units for those who did not receive FWB ($p < 0.0001$).

In adjusted analyses, there was no significant difference in mortality of less critical patients who received no FWB versus FWB (hazard ratio [HR], 0.9; 95% CI, 0.4-2.0; $p = 0.74$). After adjusting for admission base deficit, battle injury, and patient affiliation in the Cox regression, the risk of mortality at Role 2 discharge was elevated in critically injured patients who received no FWB (HR = 2.8; 95% CI, 1.2-6.4; $p = 0.0166$) compared to patients who received FWB (Table 2).

DISCUSSION

Among critically injured patients treated by Role 2 surgical teams, FWB transfusion was associated with an optimal hemostatic resuscitation ratio of plasma to RBC transfusion;

affiliation. The FWB group had more US military members (38.6% vs. 16.9%) compared to the no-FWB group. Compared a higher average CMI-PH score; and improved survival to Role 2 discharge compared to those casualties who did not

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receive FWB in a setting where platelets were usually not available to support component therapy. This project captures data from Role 2 forward surgical teams and includes data not included in the DODTR. Until 2014, a casualty had to arrive at a Role 3 MTF to be captured in the DODTR; casualties who died prior to arriving at the Role 3 or host nation casualties whose highest level of care was at the Role 2 before being transferred to the host nation hospitals were not included. This analysis is also unique in that we used the CMI-PH to differentiate patient response to FWB transfusion since the data from the Role 2 Database did not have validated ISS data; the CMI was developed by researchers at the ISR to overcome this limitation.[18] This analysis demonstrates lower survival in patients with a higher CMI-PH who received a balanced component transfusion strategy compared to transfusion with FWB.

Outcomes evaluated survival to Role 2 discharge as the chosen outcome for this analysis given that data from this population could not always be captured beyond the Role 2 MTFs during the study dates. Also, given that data from civilian trauma centers demonstrates that hemorrhagic deaths occur rapidly, with the median time to death being 2.0 to 2.6 hours from admission and that 85% of hemorrhagic deaths occur within 6 hours; patients who survived to discharge from the Role 2 MTFs would have a low probability of subsequent death from hemorrhage.[19]

The plasma-to-RBC ratio was similar between the study groups at the beginning of the study period, but the median ratios of the groups started to diverge in 2011. Patients who received FWB had a median plasma-to-RBC ratio of 1:1, while patients who did not receive FWB had a plasma-to-RBC ratio of 0.8:1; both of these ratios would be considered "balanced" given that the definitive ratio has not been precisely demarcated—the overall consensus remains that the closer to 1:1 the better. One possibility for this observation is that those units that used more FWB recognized the importance of use of hemostatic transfusion rations. In addition, the FWB group received more blood product and included a larger proportion of patients with a critical or severe CMI-PH as compared to those who did not receive FWB. Patients who received FWB had worse physiological derangement based on the CMI-PH scare compared to those who did not receive FWB. In critically injured patients, we found the adjusted risk of mortality to be almost three times greater in the no-FWB group as compared to the FWB group. This may be due in part to the fact that only 11.3% of the no-FWB group received platelets, whereas the FWB group received platelets in the whole blood.

Our results are in concordance with the two previously published studies of whole blood use in combat casualties. Spinella et al.[5] analyzed 100 combat casualties from 2004 to 2007 who received FWB in addition to RBCs and plasma versus 254 casualties who received RBCs, plasma, and apheresis reported nonregistry data collected from six Role 2 Forward Surgical Teams from 2005 to 2010 in which 94 casualties treated with FWB plus partial (no platelets) component therapy had improved survival to discharge as compared to 394 patients who received partial component therapy. These studies are suggestive that FWB may contribute to improved survival.

Contrary to our results, Perkins et al.[15] analyzed combat casualties who received a massive transfusion (defined as >10 units transfused in 24 hr) and reported no difference in 30-day survival for 85 patients who received whole blood use versus 284 patients who received a transfusion strategy including platelets. In the Perkins analysis, less FWB was transfused (proportional to total blood products in the Spinella analysis), and survival at 24 hours approached significance. The interpretation of their results may mean: 1) FWB and component therapy including platelets have the same effect on outcomes in patients who received a massive transfusion, or 2) stratifying patients by massive transfusion may impart a dual selection bias. First, the authors may have excluded patients who died before meeting massive transfusion criteria. Second, the need for massive transfusion may be determined not only by severity of the injury but also by initial blood product intervention such that the initial transfusion intervention could reduce total blood product requirements and preferentially exclude patients from the analysis.

Given that it takes approximately 30 minutes to request, collect, and process FWB, patients who died within 30 minutes of arrival at a Role 2 MTF were not eligible for this study; however, that may be the patient cohort who would have the most clinically impressive response to WB if it could have been transfused immediately.[15] Recently, Shackelford et al.[14] demonstrated the importance of including early deaths in the analysis because it was this group of patients who had the potential to benefit the most from early transfusion. By excluding the early deaths, this study has the potential for selection bias. We tried to overcome this selection bias by excluding all early death in both the FWB and no-FWB cohorts to minimize this bias; however, by overcoming the selection bias, we introduced a survival bias and also potentially excluded the most significantly hemorrhaging patients who may have benefited from the FWB intervention. The intent of excluding all early deaths is that we analyzed casualties who survived long enough to actually receive either product and therefore could observe the effect of the intervention even though the early deaths may actually be the ones who are hemorrhaging rapidly and would therefore benefit most from FWB transfusion. Retrospective transfusion studies assessing outcomes have inherent biases, but considering that FWB is not a Food and Drug Administration–approved product and that these data were from far-forward austere surgical teams in the combat zone, these data are extremely important, despite the limitations; however, the potential survival bias needs to be further investigated.

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platelets; they reported an association between whole blood transfusion and 30 day survival. In addition, Nessen et al.[4]

In this study, all whole blood was collected from a walking blood bank and used immediately as a warm product.

Research has demonstrated warm FWB may be better than cold-stored whole blood as the storage process may decrease the function of components.[20–23] Currently, in the military operations in Iraq, Afghanistan, and Syria, many of the Role 2 surgical teams are equipped with low Group O titer whole blood stored at 4°C, allowing them to transfuse whole blood at the point of injury, en route to a Role 2 facility, or within minutes of arrival. The association of survival and low Group O titer whole blood is currently lacking; however, it has been anecdotally embraced, not just because of the logistical advantages of whole blood but because of feedback from the continuum of care of observed improved clinical outcomes. Further studies examining all patients, and not excluding the early deaths, can be conducted in patients who receive low Group O titer whole blood and will help further elucidate the potential benefit of early whole blood transfusion in trauma, although these potential study groups will differ from the current study, given that our study included only FWB transfusions. Research has demonstrated there are in vitro differences in the efficacy of cold-stored blood versus warm FWB; these differences also require further clinical investigation.[15,16,20,22,23]

Although the group that did not receive FWB had a ratio below 1:1, both study groups received a plasma to RBC ratio close to 1:1, and current evidence suggests that this is optimal.[8] Another possibility for significant difference in the outcomes, even more so than the plasma:RBC ratio accounting for the differential outcomes observed in this study is the fact that the FWB group received fresh, functional platelets, compared to only 11.3% (101/896) of the no-FWB group that received platelets. The importance of platelet transfusion for hemostasis in life-threatening traumatic hemorrhage has been demonstrated, most recently in a large randomized controlled trial.[8] Additional consideration in the outcomes may be attributed to differential capabilities of the surgical teams; it is possible that teams that were better able to initiate damage control resuscitation in a 1:1 manner, were also more likely to transfuse FWB, and were overall more prepared to care for hemorrhaging combat casualties. Role 2 surgical teams are usually split into two teams to provide surgical coverage for a larger area, especially in Afghanistan, where the topography precludes easy evacuation; because of this, most Role 2 MTFs are minimally manned (8-10 people) and are not augmented by extra personnel to assist with resuscitation. Therefore, the simpler process of hanging 1 unit of whole blood versus 3 units of blood components may facilitate a quicker response to meet transfusion requirements. And while there are challenges to run a walking blood bank during casualty resuscitations, Role 2 MTFs usually rely on training other medical elements on the forward-deployed bases to assist with walking blood banks. These issues are specific to forward-deployed military surgical teams but may also impact rural civilian hospitals, where platelets and additional manpower are not readily available.

severity data were available in the Role 2 Database; this is a huge limitation when performing any analysis on the patient population cared for by far-forward surgical teams before 2014 when the DODTR started to include Role 2 patients. To overcome this significant hindrance, we used the CMI-PH to adjust for physiologic injury severity. The CMI-PH was developed as a surrogate for injury severity and includes physiologic scoring; in austere military health care settings, CMI-PH is a better predictor of mortality when compared to other scoring systems, such as revised trauma score, shock index, and field triage score.[18] Another benefit to using CMI-PH was that these data were collected before the intervention and outcome, which is not always the case for ISS. Oftentimes, ISS is assessed by providers after intervention and outcomes, which may present a source of collider bias, given that patients who die immediately at the point of injury have limited documentation of injuries that can be viewed externally, while patients receiving extensive medical care will be assessed using documentation of both external and internal injuries, and the US military patients will also undergo a full autopsy i.e., computed tomography scans).[24] Therefore, while not published currently, the CMI-PH appears to be a better predictor of mortality than other scoring systems in the military population.[18] In addition to no anatomic injury severity data, the Role 2 Database does not include information on time to transfusion. We did include prehospital administration of blood in the calculation of total blood product the patient received, but this data set was limited by a lack of information about the amount of time between point of injury and initiation of blood transfusion. Furthermore, the Role 2 Database does not include follow-up information on these patients, and we are able to assess only survival to Role 2 discharge. In trauma that results in a hemorrhage injury, the risk of bleeding to death is associated with time to resuscitation and hemorrhage control and earlier end points are needed to better understand death from hemorrhage.[19] Thus, we believe this limitation to our analysis is minimal as we are assessing patients during their greatest risk of death. Other limitations of the Role 2 Database include the following: It is not validated against medical records; the proportion of Role 2 patients captured in this database are unknown, given that data were voluntarily collected by health care providers; and the data lack entry standardization. Despite the limitations of the Role 2 Database, it is the largest source of Role 2 forward surgical team data during this time period, which is especially important given the impact of time on trauma outcomes.[14,25]

Despite the limitations in this analysis and given the challenges of obtaining clinical data from far forward, austere and resource-constrained environments, this study has unique and compelling features that lay the foundation for future military and civilian investigations. This analysis represents the largest analysis of far forward whole blood transfusion at Role 2 surgical facilities. Not only do these results

Several limitations of the study must be taken into consideration when interpreting these results. No anatomic injury support the feasibility of using FWB in the forward combat environment with a limited blood supply, but the results

suggest that FWB transfusion, especially in patients who presented with significant physiologic derangement, may improve early survival. This analysis of FWB use spans the longest period of time in which WB transfusion practices have been in our trauma system and used a novel physiologic scoring system to stratify patients. These results may not only be generalizable to hemorrhaging adult trauma patients being treated in austere environments with a limited blood supply, but they also warrant further investigation in robust stateside Level 1 trauma centers.

These results corroborate previous studies demonstrating lower mortality in patients who received FWB. In addition, over time, the plasma-to-RBC ratio in the FWB patients was closer to 1:1 as compared to patients who did not receive FWB. FWB was the only source of platelets in these patients, which may have impacted survival. Despite limitations of this study, whole blood transfusion in the combat wounded may confer a survival advantage to those who are critically injured. Further investigation is warranted in both military and civilian populations to determine if there is a threshold or ratio at which whole blood transfusion confers a survival advantage; if there are differential effects of whole blood transfusion among patient populations; and if the timing of whole blood transfusion effects survival. Robust multicenter trials are needed to compare the potential benefits of whole blood to component therapy for patients with traumatic hemorrhage.

CONCLUSIONS

Whole blood transfusion of traumatically injured combat casualties at Role 2 MTFs is associated with transfusion of optimized component ratios, a critical CMI-PH, and improved survival to discharge from forward surgical teams compared to component therapy often lacking platelets. FWB confers a clear logistic advantage in the austere environment given that each unit transfused contains a full complement of components given simultaneously and may confer a survival advantage in critically injured patients. As further data emerge regarding the benefits of whole blood, small surgical teams could be optimized with cold-stored, universal-donor whole blood for resuscitation while awaiting FWB. Further research is needed to compare the potential benefits of whole blood to optimal component therapy for patients with traumatic hemorrhage.

ACKNOWLEDGMENTS

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CONFLICT OF INTEREST

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Analysis of Casualties That Underwent Airway Management Before Reaching Role 2 Facilities in the Afghanistan Conflict 2008–2014

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ABSTRACT Introduction: Airway compromise is the second leading cause of potentially survivable death on the battlefield. The purpose of this study was to better understand wartime prehospital airway patients. Materials and Methods: The Role 2 Database (R2D) was retrospectively reviewed for adult patients injured in Afghanistan between February 2008 and September 2014. Of primary interest were prehospital airway interventions and mortality. Prehospital combat mortality index (CMI-PH), hemodynamic interventions, injury mechanism, and demographic data were also included in various statistical analyses. Results: A total of 12,780 trauma patients were recorded in the R2D of whom 890 (7.0%) received prehospital airway intervention. Airway intervention was more common in patients who ultimately died (25.3% vs. 5.6%); however, no statistical association was found in a multivariable logistic regression model (OR 1.28, 95% CI 0.98–1.68). Compared with U.S. military personnel, other military patients were more likely to receive airway intervention after adjusting for CMI-PH (OR 1.33, 95% CI 1.07–1.64). Conclusions: In the R2D, airway intervention was associated with increased odds of mortality, although this was not statistically significant. Other patients had higher odds of undergoing an airway intervention than U.S. military. Awareness of these findings will facilitate training and equipment for future management of prehospital/prolonged field care airway interventions.

INTRODUCTION

Airway compromise is the second leading cause of potentially survivable death on the battlefield after hemorrhage.[1] Prehospital airway management is controversial in civilian practice, for both medical and trauma applications, with some authors stating that prehospital airway management contributes to excess mortality, while others show no difference.[2–4] Several studies have been performed in recent years regarding airway management in the military context, including comprehensive assessments of patients presenting to combat support hospitals having had emergency airway management,[5] analysis of combat casualties with prehospital cricothyrotomies,[6] success rates of serial endotracheal intubations (INTs) and cricothyrotomies,[7] management and outcomes of combat casualty airways by battlefield medics,[8] a case-level examination of casualties with airway compromise and potentially survivable wounds,[9] and analysis of a dataset dedicated to military prehospital trauma management.[10] Proportions of airway procedures are variable across other military studies, perhaps owing to the wide differences in perspective, patient severity or trends over time; Wound Data Munitions Effectiveness Team data from the Vietnam War documented airway intervention less than a third that of the lowest intervention figures from modern conflict analyses; even these latter analyses show inconsistencies within the combat theater medical system (Table I). Studies have generally been either from the point of view of the combat support hospital—the last line of medical intervention in the combat theater, reached after nontrivial amounts of time, even after implementation of the "Golden Hour" mandate[11]—or at the point of injury, fraught with incomplete data by virtue of the expedient needs of patient care and evacuation.[12]

The military divides its casualty care into four roles, which patients move through as their needs, stability, and logistics of movement dictate. Role 1 (point of injury, early evac, battalion aid station) encompasses emergency first responders (often combat medics) applying tactical combat casualty care using what is available in an individual first aid kit, the medic's bag, or "tailgate medicine"—whatever can be afforded from a transport vehicle—through a small aid station which will generally have more advanced medics and medical officers. Role 2 has limited hospital capabilities and can be augmented by the presence of a surgical team but is often still near the original point of injury.[19] Role 3 is a larger in-theater installation, more fixed but potentially moveable, having enhanced imaging, laboratory, surgical, and medical specialty support, though it is often far removed from the battlespace. Role 4 is a traditional fixed facility hospital, well out of the combat theater. Because of the nature of emergency stabilizing care while potentially under fire at Roles 1 and 2, it has been difficult to identify the frequency of airway procedures performed in this space. We previously attempted to assess this using the Prehospital Trauma Registry database, but it was limited by the number of patients available and completeness of data.[10] The Role 2 database (R2D) was established in 2008 in order

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TABLE I. Studies Focused on Airway Interventions in the Combat Setting and Reported proportions

Primary Author	Year	Context	Airway Intervention Proportion (%)	Airway Intervention Success
Bellamy[13]	1991	Vietnam War MTF	1.3	NR
Adams[5]	2008	Role 3 MTF	4.2	95.7%
Gerhardt[14]	2008	Role 1 MTF	6	NR
Haldane[15]	2010	UK MERT Afghanistan	10.5	96.9%
Lairet[16]	2012	Combat prehospital	7.0	91.4%
Katzenell[7]	2013	Israeli trauma registry*	8.8	89%
Morrison[17]	2013	U.S./U.K. helicopter evacuation teams	20.3	NR
Blackburn[10]	2018	Combat prehospital	16.9	NR
Maddry[18]	2018	NCTH + Amputation	58	NR

MTF, Military Treatment Facility; NR, not reported; NCTH, noncompressible torso hemorrhage. *51% of dataset derived from military operations.

to supplement the Department of Defense Trauma Registry (DoDTR), which captures data from casualties evacuated to and treated at a Role 3 facility. Recent studies using this newly available dataset have examined patient types and injuries treated at Role 2 facilities,[19] evacuation modalities between Role 1 and Role 2,[20] the en-route treatment and transport between Role 2 and Role 3,[21] factors determining length of stay at Role 2,[22] and the characteristics of casualties based on if and where they died.[23]

Examinations of airway intervention patterns in the military prehospital space could improve research, training, and treatment algorithms. As yet, no study has done a comprehensive analysis of airway management performed before arrival at Role 2 facilities using the R2D, which contains much higher patient numbers than the previously used Prehospital Trauma Registry. Therefore, the goal of this study was to characterize airway management patients in the prehospital setting under combat conditions in Afghanistan. Our primary hypothesis was that a relationship between airway intervention and mortality could be found, but without a priori commitment as to whether airway intervention should predispose to harm or protection. Given the conflicting literature on the role and benefit of civilian prehospital airway intervention, we sought to examine the R2D prehospital data for evidence of a direct relationship between airway intervention and mortality.

METHODS

R2D Description

The R2D used for this study was consolidated and maintained by the Department of Defense Joint Trauma System (JTS) but remains unlinked to the DoDTR. Data from the R2D were collected and entered by Role 2 facility members following casualty events. Role 2 personnel received basic training on the database once deployed and entered data on a voluntary basis; the data represent a convenience sample of patients cared for by Role 2 teams. Patients included in this study received treatment at a Role 2 medical treatment facility, were 18 years or older, and sustained traumatic injury in Afghanistan from February 2008 to September 2014; patients with isolated disease or psychiatric/mental illness concerns were excluded from analysis. When available, source documentation was used to validate and complete the Role 2 data by JTS; however, only a small percentage was linked at the time of analysis (roughly 6.7%). Approval was obtained from the U.S. Army Institute of Surgical Research institutional regulatory department; the study was determined to be exempt.

The R2D includes prehospital data: mechanism and type of injury, mode and time of transport, prehospital interventions, and vital signs. Role 2-related data elements include patient status, time, admission vital signs, and some laboratory results. Diagnoses, interventions, blood administrations, and some complications are also included. Patient affiliation identified a casualty as U.S. military (all branches), non-U.S. military (Afghanistan police or military, NATO and non-NATO allied coalition forces, enemy combatants) and civilian or unknown (Afghan civilian, civilian contractor, other non-U.S. and U.S. civilians).

Study Methods

In place of injury severity scores (ISS) or abbreviated injury scores (AIS), which were not available in this dataset, Combat Mortality Index (CMI) Prehospital (PH), a measure developed by Le and colleagues, was used to adjust for injury severity among battlefield casualties; preliminary efforts and comparisons demonstrate that CMI is a better predictor of mortality than the existing revised trauma score, field triage score, and shock index score.[24] The CMI scoring system uses clinical variables of heart rate (HR), systolic blood pressure (SBP), and Glasgow coma score (GCS) to develop a CMI-PH score ranging from 0 to 4 (0/mild, 1/moderate, 2/severe, 3–4/critical); a point is assigned for HR <60 or >100, another if SBP <100, and 1 or 2 points for GCS <14 or <8, respectively.

Airway procedures were categorized as INT, cricothyrotomy (CRIC), or airway not otherwise specified (AWNOS). Airway not otherwise specified represents the aggregate of patients who were documented positive in the R2D for having undergone a "prehospital airway" or

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"definitive airway adjunct" without concurrent confirmation of INT or CRIC. Because "definitive airway adjunct" could refer to oropharyngeal airway, nasopharyngeal airway, bag-valve-mask (BVM) ventilation, a supraglottic airway (SGA), or potentially INT, it was therefore interpreted as general prehospital airway manipulation. The two patients who underwent a prehospital tracheotomy were statistically combined with the patients who underwent CRIC.

If a casualty received hemostatic dressings (eg, QuikClot, Combat Gauze), tourniquet, or fluid resuscitation (crystalloid, whole blood, or blood product), they were globally regarded as having received hemodynamic intervention; for the purposes of this airway investigation, attention paid to hemostasis and hemodynamic resuscitation efforts as equivalent and dichotomous (subsequent analysis following logistic regression model development demonstrated negligible impact of separating bandage interventions and fluid resuscitation into separate variables). Other variables included age, sex, mechanism of injury (vehicle crash, explosion, fall, gunshot, other), type of injury (penetrating, blunt, burn), admission vital signs (selected over prehospital vital signs for low missing proportion), evacuation/transport time to Role 2 (minutes), class of injury (battle, non-battle), and medications.

Statistical Analysis

To evaluate the primary hypothesis of a relationship between airway intervention and mortality, airway interventions were regarded as equivalent to maximize power, and mortality was dichotomized as those who survived to Role 2 discharge vs. those who did not; those with unknown mortality status represented 0.3% of total casualties in the dataset and were excluded from analysis. Clinically valid covariates were identified using the following model selection process to identify the best fit logistic regression model: First, we constructed a full model, where the outcome variable was mortality and the exposure variable was airway intervention (dichotomous), including all covariates (CMI-PH, hemodynamic intervention, mechanism of injury, class of injury, type of injury, age, gender, patient affiliation; time of transport was not included due to 6203 patients missing data, 48.5%), and identified those which were statistically significantly (ie, $p < 0.05$) associated with the outcome (ie, CMI-PH, hemodynamic intervention, class of injury, type of injury). These covariates were then included in a reduced model. Finally, every possible combination of the previously nonsignificant variables (ie, patient affiliation, mechanism, age, and gender) was added to the reduced model, but inclusion of nonsignificant variables did not generate a compelling change in reduced model effect estimates and no combination of those variables was found to be statistically significant (Supplemental Table SI). A sensitivity analysis was then performed by including elapsed transport time to evaluate the robustness of effect estimates in this subset; no model variable odds ratio changed significantly.

Observing significant discrepancy among airway intervention proportions between patient affiliation groups, an exploratory analysis was performed against the possibility of systematic differences in injury severity accounting for the difference; groups were paired and stratified by CMI-PH, with pooled estimates of the odds ratio generated by Cochran-Mantel-Haenszel testing. Other statistical tests included: chi-square, Fisher's exact, Kruskal-Wallis, or Cochran-Armitage, as appropriate. Analysis was performed using SAS 9.4 (SAS Institute, Cary, NC).

RESULTS

From February 2008 to September 2014, there were records for 12,780 casualties in the R2D that met the inclusion/exclusion criteria. Of those, 890 (7.0%) underwent some type of documented prehospital airway intervention. Patient affiliation included 36.5% U.S. Military, 38.6% non-U.S. Military, and 24.9% civilian or unknown (Table II). A higher proportion of airway patients died (25.3% vs. 5.8%) than nonairway patients; however, the relationship between airway intervention and mortality lost significance in a model adjusting for CMI-PH, hemodynamic intervention, type of injury, and battle/nonbattle injury classification (OR 1.28, 95% CI 0.98–1.68; Fig. 1); mechanism of injury and gender lowered Akaike information criterion but did not introduce any meaningful change in the remaining effect estimates and was therefore excluded for the sake of parsimonious model.

Compared with U.S. military personnel, other military patients were twice as probable to receive an airway intervention (OR 2.05, 95% CI 1.72–2.43); this moderated but remained significant after adjusting for CMI-PH (OR 1.33, 95% CI 1.07–1.64; Fig. 2). A similar relationship was found when comparing U.S. military with civilian/other patients (OR 1.32, 95% CI 1.05–1.66; Fig. 3), while no difference was found when comparing non-U.S. military against civilian/other patients (OR 0.99, 95% CI 0.82–1.19).

Most patients were categorized as battle injury (76.2%). The most common mechanisms of injury were explosion (45.6%) and gunshot wound (24.0%); gunshot wound patients had a higher proportion of documented airway intervention (8.6%) vs. fall (2.7%). The most common injury types were penetrating (51.6%) and blunt (31.3%). Proportion of airway intervention increased with increasing CMI-PH (1.9% with mild CMI to 45.8% with critical CMI, p for trend < 0.001). Among those with available data, time of transport was faster for patients with airway intervention vs. those without (median 65 minutes, interquartile range [IQR] 41–133 vs. 76 minutes, IQR 43–161.5, $p < 0.023$), though a two-way ANOVA including CMI-PH resulted in airway intervention not significantly associated with transport time ($p < 0.262$) after the main effect of CMI-PH ($p < 0.027$).

Also more common in airway patients were needle decompression (3.6% vs. 0.5% in non-airway patients), hemodynamic interventions (48.5% vs. 32.1% in non-airway),

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TABLE II. Patient Demographics in Casualties That Did vs. Did Not Undergo an Airway Procedure

	Total	(+) Airway	(−) Airway	*p*-Value
Number of patients, *n* (%)	12,780 (100)	890 (7.0)	11,890 (93.0)	
Gender, *n* (% male)	12,350 (96.6)	862 (7.0)	11,488 (93.0)	0.64
Age (years), median [IQR]	25 [21–30]	25 [21–30]	25 [21–30]	0.09
Patient affiliation, *n* (%)				
Non-U.S. military	4,933 (38.6)	419 (8.5)	4,514 (91.5)	
U.S. military	4,667 (36.5)	202 (4.3)	4,465 (95.7)	<0.0001*
Civilian/other	3,180 (24.9)	269 (8.5)	2,911 (91.5)	
Class of injury, *n* (%)				<0.0001
Battle injury	9,733 (76.2)	754 (7.7)	8,979 (92.3)	
Nonbattle injury	3,047 (23.8)	136 (4.4)	2,911 (95.6)	
Mechanism of injury, *n* (%)				<0.0001
Explosion	5,938 (46.5)	433 (7.3)	5,505 (92.7)	
Gunshot wound	3,082 (24.1)	265 (8.6)	2,817 (91.4)	
Motor vehicle crash	1,237 (9.7)	74 (6.0)	1,163 (94.0)	
Other	1,202 (9.4)	44 (3.7)	1,158 (96.3)	
Unknown	798 (6.2)	60 (7.5)	738 (92.5)	
Fall	523 (4.1)	14 (2.7)	509 (92.3)	
Injury type, *n* (%)				<0.0001
Penetrating	6,598 (51.6)	571 (8.7)	6,027 (91.3)	
Blunt	3,997 (31.3)	140 (3.5)	3,857 (96.5)	
Penetrating & blunt	921 (7.2)	94 (10.2)	827 (89.8)	
Burn	235 (1.8)	35 (14.9)	200 (85.1)	
Unknown	1029 (8.1)	50 (4.9)	979 (95.1)	
Prehospital CMI *n*, (%)				<0.0001
0 Mild	7,003 (54.8)	135 (1.9)	6,868 (98.1)	
1 Moderate	2,941 (23.0)	167 (5.7)	2,774 (94.3)	
2 Severe	747 (5.9)	203 (27.2)	544 (82.8)	
3–4 Critical	537 (4.2)	246 (45.8)	291 (54.2)	
Unknown	1552 (12.1)	139 (9.0)	1,413 (91.0)	
Elapsed time from being wounded to arrival at Role 2				
Patients with available time information, *n* (%)	6,548 (51.2)	335 (5.1)	6,213 (94.9)	<0.023†
Elapsed minutes, median [IQR]	77 [45–165]	65 [41–135]	78 [45–168]	0.01
Patients with arrival time <60 minutes, *n* (%)	2716 (21.3)	161 (5.9)	2,555 (94.1)	0.01
Outcome *n* (%)				<0.0001
Alive-RTD	4,498 (35.2)	78 (1.7)	4,420 (98.3)	
Alive-transported	7,321 (57.3)	585 (8.0)	6,736 (92.0)	
Dead	920 (7.2)	225 (24.4)	695 (75.6)	
Unknown	41 (0.3)	2 (4.9)	39 (95.1)	

n, number; IQR, interquartile range; CMI, Combat Mortality Index; RTD, returned to duty.
*U.S. military was statistically different from Non-U.S. military and civilian/other, while the latter two were not different from each other ($p < 0.956$).
†Not significant after accounting for main effect of CMI-PH.

and medications generally (41.3% vs. 14.1% in non-airway; Table III). Airway patients received higher proportions of analgesia (18.2% vs. 11.0% in non-airway), notably ketamine (3.0% vs. 1.0% in non-airway) and fentanyl (4.7% vs. 2.8% in non-airway). Airway patients exhibited consistently higher proportions of vital sign derangements on arrival to Role 2 facilities; they were more frequently documented as hypotensive (SBP< 90mmHg, 20.9% vs. 3.3% in non-airway patients), bradycardia (HR < 60 beats per minute, 12.4% vs. 4.1% in non-airway), tachycardia (HR ≥100 beats per minute, 54.4% vs. 29.5% in non-airway), hypoxic (9.5% vs. 4.3% in non-airway), and demonstrating depressed GCS (48.4% vs. 4.1% in non-airway).

Among patients who received airway intervention, they were generally male (96.9%) with a median age of 25 years (IQR 21–30; Table IV). Proportions of airway interventions were not uniformly distributed among patient affiliation groups ($p = 0.001$). Proportions of CRIC and INT rose significantly with increasing CMI-PH ($p < .0001$), and proportions of airway procedures were not uniformly distributed across mortality outcomes ($p < .0001$); patients who died at or before Role 2 had higher proportions of prehospital intubations (20.0%) and cricothyrotomies (16.0%) than those who were eventually transferred to higher levels of care (13.4 and 7.7%, respectively). While median admission temperature (97.6 °F, IQR 96.5–98.5) and SBP (120 mmHg, IQR 95–137) were

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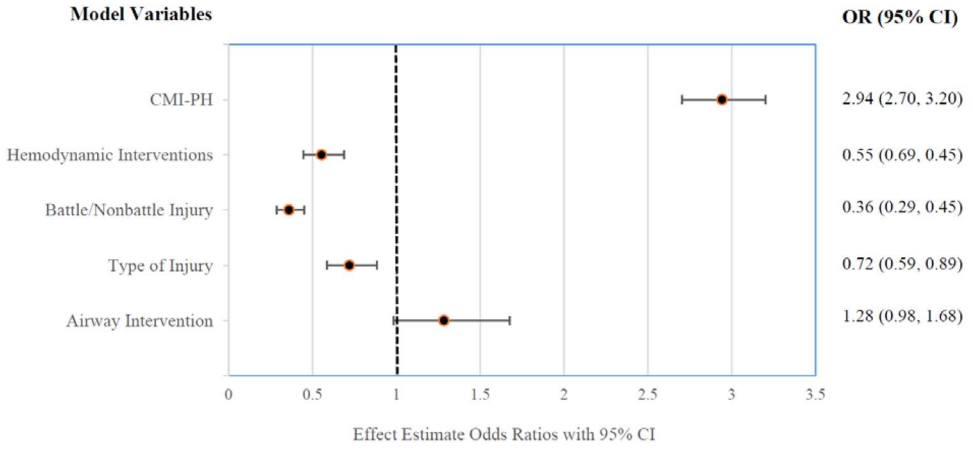

FIGURE 1. Multivariable logistic regression model effect estimate odds ratios representing statistical associations with mortality. Type of injury (Penetrating, Blunt, Burn).

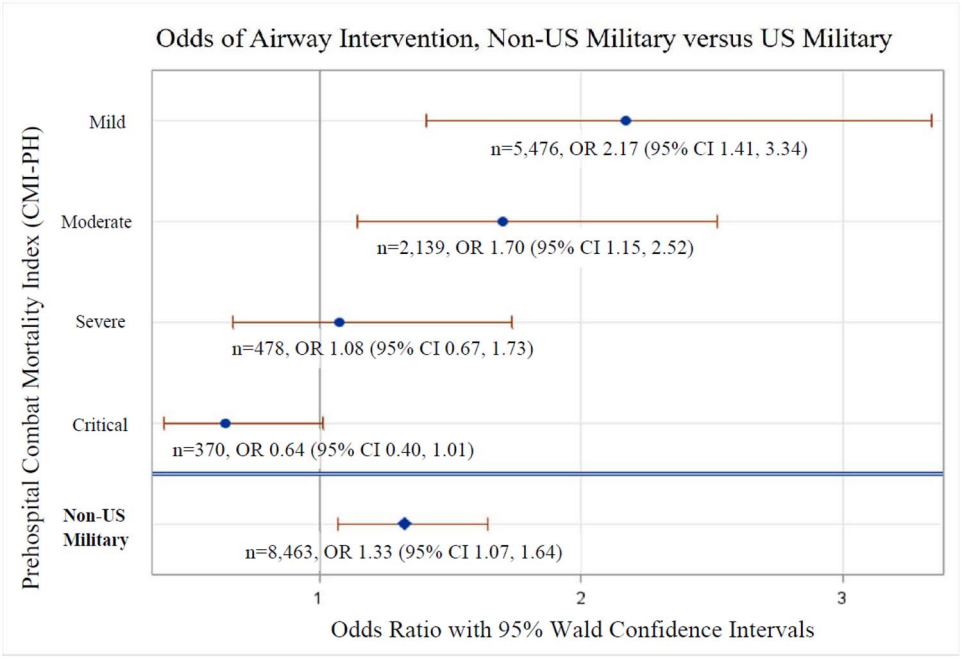

FIGURE 2. Cochran-Mantel-Haenszel pooled odds ratio demonstrating odds of non-U.S. military casualty receiving airway management at different levels of prehospital injury severity and overall; U.S. military is referent group with OR of 1.

not significantly different between airway intervention types, median unassisted respiratory rate (respirations per minute, CRIC 12, IQR 0–19 vs. INT 15, IQR 10–20 vs. AWNOS 20, IQR 16–27), pulse (beats per minute, CRIC 87.5, IQR 62.5–116.5 vs. INT 100, IQR 70.5–119 vs. AWNOS 98, IQR 94–100), and oxygen saturation (percent, CRIC 94.5, IQR 84.5–99.5 vs. INT 99, IQR 94–100 vs. AWNOS 98, IQR 94–100) were statistically different.

DISCUSSION

Airway intervention on the battlefield remains a daunting task in the management of combat casualties. While approaches are variable and meet with inconsistent success, casualties have been identified whose deaths may have been prevented had the airways been managed.[9] Proficient airway management will remain a challenging prospect; it is regarded as a perishable skill, and military prehospital providers may not perform enough repetitions to retain skill, much as in the civilian world.[25] Without appropriate technique, the potential exists to generate excess harm through wasted time or the dreaded cannot-intubate-cannot-oxygenate scenario after sedation or airway trauma; a subset of patients may not require airway intervention at all.[26]

Our primary hypothesis supposed a relationship between receiving airway intervention and mortality. In that regard,

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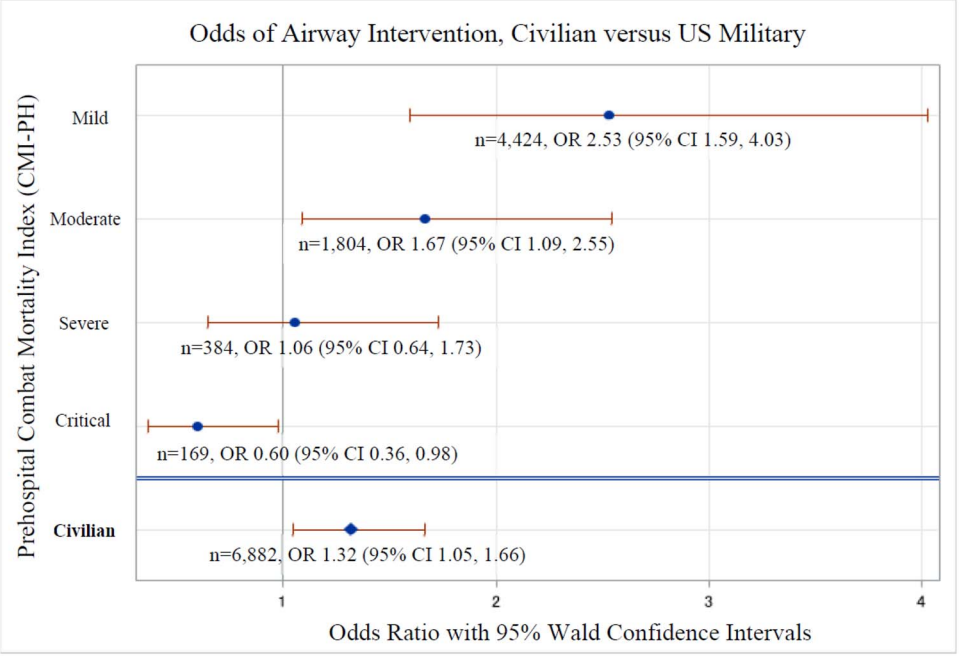

FIGURE 3. Cochran-Mantel-Haenszel pooled odds ratio demonstrating odds of civilian/other casualty receiving airway management at different levels of prehospital injury severity and overall; U.S. military is referent group with OR of 1.

TABLE III. Additional interventions and vital signs in casualties that did vs did not undergo an airway procedure

	Total Casualties	(+) Airway	(-) Airway	p-value
Number of Patients, n (%)	12,780 (100)	890 (7.0)	11,890 (93.0)	
Other Life-Saving Interventions Received Prior to Arrival to Role 2 Facility, n (%)				
Needle Decompression	91 (0.7)	29 (3.3)	62 (0.5)	0.26
Hemodynamics (hemostatic dressings, TQ, IV fluid/blood administration)	4,243 (33.2)	432 (48.5)	3,811 (32.1)	<.0001
Medications	2,048 (16.0)	368 (41.3)	1,680 (14.1)	<.0001
Analgesia, n (%)				
Patients with recorded analgesia, n (%)	1,475 (11.5)	162 (18.2)	1,313 (11.0)	<.0001
Ketamine	140 (1.1)	27 (3.0)	113 (1.0)	.0001
Morphine	622 (4.9)	23 (2.6)	599 (5.0)	<.0001
Fentanyl	377 (2.9)	42 (4.7)	335 (2.8)	.001
Others	336 (2.6)	70 (7.9)	266 (2.2)	<.0001
Patients with recorded sedative, n (%)	114 (0.9)	56 (6.3)	58 (0.5)	<.0001
Patients with recorded paralytic, n (%)	61 (0.4)	47 (5.3)	14 (0.1)	<.0001
Physiological Status on Arrival to Role 2 Facility, n (%)				
Patients with recorded arrival vital signs, n (%)	11,975 (93.7)	800 (90.0)	11,175 (94.0)	<.0001
Hypotensive (SBP < 90 mmHg)	538 (4.5)	167 (20.9)	371 (3.3)	<.0001
Bradycardia (BPM < 60)	552 (4.6)	99 (12.4)	453 (4.1)	<.0001
Tachycardia (BPM ≥ 100)	3,736 (31.2)	435 (54.4)	3,301 (29.5)	<.0001
Hypoxic (O2 < 94%)	555 (4.6)	76 (9.5)	479 (4.3)	<.0001
Glasgow Coma Scale (≤ 8)	848 (7.1)	387 (48.4)	461 (0.6)	<.0001

n, number ; TQ, tourniquet ; SBP, Systolic blood pressure ; BPM, Beats per minute ; O2, oxygen saturation by pulse oximeter

having accounted for several potentially confounding factors, in the R2D we did not identify any statistical association between airway intervention and mortality in our model; while it is axiomatic that certain patients will die rapidly without emergency airway management, we also found evidence that airway management may not be consistently applied. Although not statistically significant, the possibility of airway intervention associated with increased odds of mortality is concerning, and findings of excess mortality associated with prehospital airway management in trauma patients have been previously published.[27,28] It is possible that certain patients underwent unnecessary airway procedures resulting

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TABLE IV. Patient Demographics of Casualties That Underwent a Prehospital Airway or Definitive Airway Adjunct (Airway NOS), Endotracheal Intubation, or Cricothyrotomy/Tracheotomy

	Total	Airway NOS	Intubation	Cricothyrotomy/Tracheotomy	*p* Value
Number of patients, *n* (%)	890	677 (75.3)	128 (14.2)	85 (9.6)	
Gender, *n* (% male)	862 (96.9)	655 (97.9)	124 (96.9)	83 (97.6)	0.2886
Age, median [IQR]	25 [21–30]	25 [21–30]	25 [22–30]	25 [23–30]	0.20
Patient affiliation, *n* (%)					0.0013
U.S. forces	202 (22.7)	165 (24.4)	17 (13.3)	20 (23.5)	
Non-U.S. mil	419 (47.1)	295 (43.6)	75 (58.6)	49 (57.6)	
Civilian/other	269 (30.2)	217 (32.1)	36 (28.1)	16 (18.8)	
Prehospital CMI, *n* (%)					<0.0001
0 Mild	135 (15.2)	132 (19.5)	2 (1.6)	1 (1.2)	
1 Moderate	167 (18.8)	155 (22.9)	6 (4.7)	6 (7.1)	
2 Severe	203 (22.8)	145 (21.4)	39 (30.5)	19 (22.4)	
3–4 Critical	246 (27.6)	159 (23.5)	54 (42.2)	33 (12.0)	
Unknown	139 (15.6)	86 (9.8)	27 (21.9)	26 (30.6)	
Outcome, *n* (%)					<0.0001
Alive-RTD	78 (8.8)	71 (10.5)	4 (3.1)	3 (3.5)	
Alive-transported	585 (65.7)	461 (68.1)	79 (61.7)	45 (52.9)	
Dead	225 (25.3)	144 (21.3)	45 (35.2)	36 (42.4)	
Vital signs, median [IQR]					
SBP (mmHg)	120 [95–137]	121 (96–137)	119 (95–139)	110 (69–134)	0.17
Unassisted respiratory rate (RPM)	20 [14–26]	20 (16–27)	15 (10–20)	12 (0–19)	<0.001
Pulse (BPM)	102 [79–124]	104 (81–126)	100 (71–119)	87.5 (62.5–116.5)	0.007
O_2 saturation (%)	98 [93–100]	98 (94–100)	99 (94–100)	94.5 (84.5–99.5)	0.002
Temperature (°F)	97.6 [96.5–98.5]	97.7 (96.6–98.6)	97.3 (95.8–98.3)	97.2 (96.8–98.0)	0.250

BPM, beats per minute; O_2, oxygen saturation by pulse oximeter; RPM, respirations per minute; RTD, returned to duty.

in excess risk or that undue time was spent on the management of the airway that may have been better spent addressing hemorrhage control and hemodynamic resuscitation. The potential harms associated with positive-pressure ventilation in a patient already suffering from hemorrhagic shock have also been discussed.[29,30]

Time of transport was faster for patients with airway interventions, which further analysis suggested to be largely a reflection of their overall more severe clinical status. The median transport time in our dataset was much longer than that reported by Kotwal et al. (77 minutes vs. 46 minutes), but that study included only U.S. military personnel.[11] In an attempt to curb unnecessary prehospital interventions such as airway management, the civilian sector considers what is termed a "scoop-and-run" policy, which prioritizes rapid delivery of patients to a higher level of care without delays for field interventions not absolutely indicated; this is opposed to a "stay-and-play" approach, which emphasizes on-scene care.[31] Among blunt and penetrating trauma, the closest civilian parallel to combat trauma, the verdict is unclear but seems to favor rapid delivery to higher care.[31–34] Unfortunately, given the unique circumstances of battlefield medicine in terms of the involved pathologies as well as the evacuation logistics to higher levels of care out of or through denied areas, the "scoop-and-run" may not always be applicable.[35] While we recognize the benefit of immediate transport, and a retrospective study of the impact of the "Golden Hour" mandate suggested a significant improvement in outcomes,[11] these times are unlikely to be replicated in future shifting, nonlinear, immature battlespaces against near-peer adversaries. If evacuation will not solve the problem of airway management in the military context, military prehospital caregivers must receive optimal equipment and training in how to perform airway interventions and also have understanding of when to simply observe a patent airway in the prolonged field care setting. It has been suggested that at times the correct answer is to do nothing with airway in hemorrhage, rather than inflict iatrogenic harms by positive pressure ventilation or unnecessary care delay.[30] For shorter management times, BVM ventilation could be chosen over the technically challenging CRIC; a recent study found them equivalent in mortality to one another and superior to SGAs in terms of morbidity, while others have advocated for SGA as rescue devices for failed intubation.[36,37]

Of interest are the systematic differences in the application of airway interventions between affiliation groups having equivalent CMI-PH. This may be attributable to language barrier; a prior retrospective civilian study found that primarily Spanish-speaking trauma patients were intubated in excess of otherwise similar English-speaking patients.[38] Front-line caregivers may have had challenges assessing the mental status of foreign personnel and therefore moved to protect the airway of neurologically questionable individuals or rather defaulted to sedation and airway intervention over general

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security concerns in the case of local civilians and enemy personnel. It is possible that the injuries were systematically different while still arriving at similar severity of CMI-PH, but further post-hoc evaluation is not possible without ISS/AIS and more detailed intervention information.

Our observed proportion of 7.0% receiving airway intervention is consistent with Lairet et al. and falls within the range of previously published combat/prehospital data.[16] Cloonan suggested that increasing prevalence of body armor use might reduce the number of immediately fatal injuries and therefore add to the number of surviving, airway-injured casualties.[39] It should be noted that the 7.0% proportion of casualties receiving airway intervention is much lower than our previous finding of 16.9% using the prehospital trauma registry, a high proportion which the authors noted may be a reflection of the low number of patients, systematic bias in reporting, or increased training and emphasis of TCCC guidelines.[10] The discrepancy may also be accounted for by the casualties who did not present to Role 2, by either overflying to a Role 3 facility or being declared dead at a Role 1 station.

Limitations

This is a retrospective study examining inconsistently entered data. Role 2 data throughout the time period in question were entered on a voluntary basis by local healthcare personnel. While there was training on the data entry system, significant variation was found in the thoroughness of documentation. The original design of the dataset included a variable called "definitive airway adjunct," which represented a significant source of ambiguity; what this category could include was unclear. Given the deidentified nature of the dataset, it was not feasible to assess the relevance of this category beyond confidence that the airway had been managed. One might infer that airways were instrumented in similar proportions to what had been reported elsewhere, which would indicate that "AWNOS" is made up of predominantly endotracheal tubes.[5,8,10] But due to lack of granularity, it was not possible to group many of the casualties by actual procedure received.

With regard to the differences observed between national groups in terms of odds of receiving airway manipulation, specifics are not available regarding their injury patterns and whether those patterns were systematically different in a way which would compel point-of-injury caregivers toward consistently different decisions in airway management (whether that be contrasts in body armor, differences in transportation or mission parameters, or as a function initial care given by nation-specific medical personnel at point of injury). And though the large majority of airway patients for whom we have details of their transportation were evacuated by U.S. forces (roughly greater than 90%), it is not impossible that their point-of-care injury was performed by foreign caregivers with different practice patterns; indeed, the database contains no data on the credentials or training of the airway management operator. Ultimately, however, there is evidence of systematic differences, and the possible causes merit further exploration.

Inability to ascertain long-term outcome data for the sake of within-groups analysis, or enjoy a higher proportion of available point-of-injury/prehospital vital signs (vital signs on arrival such as those reported above are the inseparable aggregate of initial clinical status and resuscitative efforts en route), hampers the ability to build more robust models of association. However, this dataset is presently the best statistical window into wartime point-of-injury, prehospital interventions that exist.

CONCLUSION

Airway management is a challenging aspect of trauma resuscitation, as the patient can rapidly die if an airway is required but not established, while excess harm can result through complications of a procedure that was not indicated. In our analysis of the R2D focusing on patients who underwent airway procedures, we find no clear statistical association between airway intervention and mortality when adjusting for other significant confounding factors in a multivariable logistic regression model. Airway patients tend to undergo more interventions, be more critically injured, and ultimately have a higher proportion of deaths; the ability to rapidly and consistently manage the airway when indicated, or spend time on other resuscitative needs when airway management is not indicated, could lead to improved outcomes.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *MILMED* online.

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Forward Surgical Team Procedural Burden and Non-operative Interventions by the U.S. Military Trauma System in Afghanistan, 2008–2014

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ABSTRACT

Introduction

No published study has reported non-surgical interventions performed by forward surgical teams, and there are no current surgical benchmarks for forward surgical teams. The objective of the study was to describe operative procedures and non-operative interventions received by battlefield casualties and determine the operative procedural burden on the trauma system.

Methods

This was a retrospective analysis of data from the Joint Trauma System Forward Surgical Team Database using battle and non-battle injured casualties treated in Afghanistan from 2008–2014. Overall procedure frequency, mortality outcome, and survivor morbidity outcome were calculated using operating room procedure codes grouped by the Healthcare Cost and Utilization Project classification. Cumulative attributable burden of procedures was calculated by frequency, mortality, and morbidity. Morbidity and mortality burden were used to rank procedures.

Results

The study population was comprised of 10,992 casualties, primarily male (97.8%), with a median age interquartile range of 25.0 (22.0–30.0). Affiliations were non-U.S. military (40.0%), U.S. military (35.1%), and others (25.0%). Injuries were penetrating (65.2%), blunt (32.8), and burns (2.0%). Casualties included 4.4% who died and 14.9% who lived but had notable morbidity findings. After ranking by contribution to trauma system morbidity and mortality burden, the top 10 of 32 procedure groups accounted for 74.4% of operative care, 77.9% of mortality, and 73.1% of unexpected morbidity findings. These procedure groups included laparotomy, vascular procedures, thoracotomy, debridement, lower and upper gastrointestinal procedures, amputation, and therapeutic procedures on muscles and upper and lower extremity bones. Most common non-operative interventions included X-ray, ultrasound, wound care, catheterization, and intubation.

Conclusions

Forward surgical team training and performance improvement metrics should focus on optimizing commonly performed operative procedures and non-operative interventions. Operative procedures that were commonly performed, and those associated with higher rates of morbidity and mortality, can set surgical benchmarks and outline training and skillsets needed by forward surgical teams.

INTRODUCTION

More than 20,000 U.S. battle injured casualties have been treated by military medical providers during the past 17 years of conflict in Afghanistan.[1] In addition to U.S. casualties, these providers have also treated tens of thousands of non-battle injured and non-U.S. casualties.[2–4] The use of technology on the battlefield, and throughout the military health system, has advanced information capture on combat casualties.[5] However, the exact number of non-U.S. casualties treated in the combat zone by U.S. military medical providers is unknown due to difficulties of data collection on the battlefield.[6–8] In part, this is due to challenges associated with combat operations, movement of patients through multiple roles of care, and an environment particular to Afghanistan, which includes harsh and austere conditions with hazardous terrain, weather extremes, and limited resources.

The military trauma system consists of three roles of care in the combat zone with each role having increased resources and personnel than the previous. Role 1 consists of prehospital

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care. Role 2 forward surgical teams (FSTs) provide emergency damage control resuscitation and surgical care using limited surgical and hospital resources with the goal of rapid casualty stabilization and transport to a higher role of care.[9] Role 3 provides robust surgical and hospital care.[9] In order to increase capability of clinical data collection at Role 2 facilities and other forward battlefield locations, the Department of Defense Joint Trauma System (JTS) implemented standalone software programs to overcome issues with remote and intermittent connectivity. This software has facilitated capture and study of casualty data from Role 2 facilities in Afghanistan.[10–15]

Previously, Mann-Salinas et al. conducted a general analysis of casualties treated by Role 2 FSTs in Afghanistan.[10] This was followed by an analysis of surgical procedures performed at Role 2 and 3 military treatment facilities in Afghanistan and Iraq by Turner et al.[11] However, neither of these studies nor any other study has included information on non-surgical interventions performed by FSTs. Additionally, surgical benchmarks for FSTs have not been previously described in the literature. This differs from the civilian sector where Scott et al. identified emergency general surgery procedures that represented the greatest clinical burden for facilities in the United States in terms of frequency, morbidity, mortality, and cost.[16] Identification of operative procedures and non-operative interventions performed by FSTs can inform future staffing and equipping models. Additionally, to optimize preparation and medical training of FSTs for combat deployments and other contingency operations, it is important to focus on tasks, procedures, and interventions that could potentially have the greatest impact on casualty care. Thus, the objectives of this study were to describe operative procedures and non-operative interventions received by battle and non-battle injured casualties treated by FSTs in Afghanistan and to determine the operative procedural burden on the battlefield trauma system.

METHODS

A retrospective, secondary data analysis was conducted using the JTS Role 2 database.[10] This standalone database contains information on casualties treated by U.S. military Role 2 providers who collected and gathered the information. This database differs from the more well-known Department of Defense Trauma Registry (DoDTR), which, prior to 2014, did not capture patients who died before arrival or were not transferred to a Role 3 facility.[10] Patients eligible for study were adult, battle or non-battle injured casualties, treated at Role 2 facilities in Afghanistan from February 2008 to September 2014, an important timeframe for this population given the initial data capture of the DoDTR. Patients with a documented injury or intervention were included. This study was reviewed and approved by the U.S. Army Institute of Surgical Research institutional regulatory department and determined to be exempt by the institutional review board.

Fluids, blood products, operative procedures, and non-operative interventions were included in the dataset. Fluids and blood products included those received during the first 24 hours at the Role 2 facility. Fluids (L) included crystalloids and colloids. Blood products (units) included fresh whole blood, red blood cells (RBCs), platelets, cryoprecipitate, and fresh frozen plasma. For procedural data, the dataset included up to 33 recorded operating and non-operating room procedures per patient encounter. Procedures were described using International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) codes, which is a uniform, standardized coding system capable of classifying over 3900 procedure codes.

To aid statistical reporting, ICD-9-CM procedure codes were grouped into 231 procedure groups, which were smaller and more clinically meaningfully classifications, using the Healthcare Cost and Utilization Project (HCUP) Clinical Classifications Software categorization scheme.[17] The HCUP's clinical classification efforts began in 1993 and through an iterative process has resulted in a standardized, publically available lexicon for categorizing ICD-9-CM codes. The categorization scheme is based on clinical homogeneity (evaluated by trained personnel) and inpatient discharge data. Procedure groups were assigned into one of four categories: non-operating room diagnostic, non-operating room therapeutic, operating room diagnostic, and operating room therapeutic. Only operating room procedures were included in burden rank calculations, where burden was defined as procedural volume, morbidity, and mortality, to account for frequency and procedures with low survival or increased subsequent morbidity.

Patient outcomes included mortality at Role 2 discharge and morbidity. Morbidity was determined by notable morbidity findings among survivors, which were diagnoses preselected by the JTS for capture in the Role 2 database. There were 22 of these findings, and definitions for each were determined by the JTS. Furthermore, individual patients could have multiple findings.

Statistical Analysis

Using a previously published process by Scott et al.,[16] procedure burden rank calculations were performed. Procedure, mortality, and morbidity counts were calculated for each procedure group. To protect patient identity, all counts less than five were not presented. Therapeutic exploratory laparotomies were excluded as to not double count the same operation. For each procedure group, a score for mortality was calculated using the product of mortality proportion and procedure frequency, while morbidity score was the product of the notable morbidity finding proportion and procedure frequency. After ranking mortality and morbidity scores by procedure groups, the mortality and morbidity ranks were summed to generate a combined burden score by procedure group. The procedure groups were ranked by combined burden score, and in the event of an equivalent combined burden score, the procedure group was ranked according to procedure count. A lower rank indicates a higher procedural burden.

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TABLE I. Demographics, Characteristics, Outcomes, and Interventions of Study Patients ($s = 10{,}992$)

	n	%
Male	10,679	97.8
Age, median (IQR)	10,992	25.0 (22.0–30.0)
Patient affiliation		
U.S. military	3856	35.1
non-U.S. military	4392	40.0
Other	2744	25.0
Injury classification		
Any penetrating	6664	65.2
Blunt	3351	32.8
Burn	202	2.0
Injury severity score, median (IQR)	6053	2 (1, 5)
Mortality	471	4.4
Morbidity (notable morbidity findings among survivors)	1632	14.9
Hypothermia	866	35.4
Anemia/blood loss or hypovolemia	762	31.1
Shock	208	8.5
Cardiopulmonary resuscitation	157	6.4
Progression of original neurologic insult	121	4.9
Compartment syndrome extremity	86	3.5
Hemothorax	57	2.3
Respiratory failure	55	2.2
Organ/nerve/vessel perforation or injury	36	1.5
Major arrhythmia	29	1.2
Compartment syndrome abdominal	13	0.5
Seizures	13	0.5
Acute respiratory distress syndrome	11	0.4
Acute renal failure	9	0.4
Myocardial infarction	8	0.3
Pleural effusion	8	0.3
Pulmonary embolus	8	0.3
In-hospital 1st 24-hour fluid, median (IQR), L		
Crystalloids	9187	1.1 (1.0, 2.1)
Colloids	531	0.5 (0.5, 1.0)
In-hospital 1st 24-hour blood product, median (IQR), units		
Whole blood	366	4.0 (2.0, 7.0)
Red blood cells	1971	4.0 (2.0, 8.0)
Platelets	249	2.0 (1.0, 3.0)
Cryoprecipitate	262	3.0 (2.0, 7.0)
Fresh frozen plasma	1617	4.0 (2.0, 7.0)

Abbreviations: IQR, interquartile range

After sorting by procedure burden rank, to determine the bulk of operative procedural burden by FSTs, the cumulative attributable burden of procedures was calculated for frequency, mortality, and morbidity. For each of these three measures, the cumulative attributable burden was calculated by rank (i.e., 1–32) as the summation of count for each procedure group (rank 1 through x) divided by the total count. This calculation is similar to the derivation of a percentile value for each ranked procedure. All analyses were completed using SAS version 9.4 (SAS Institute Inc).

RESULTS

Of 15,310 patients in the Role 2 dataset, 12,780 patients were eligible for study.[12] An additional 1788 (14.0%) patients were excluded due to undocumented interventions or injury diagnoses, leaving 10,992 patients in the final analytic sample. The study population was comprised primarily of young (median [interquartile range (IQR)] age = 25.0 [22.0–30.0]) men (97.8%) with penetrating injuries (65.2%) and a low injury severity score (median [IQR] = 2 [1, 5]) (Table I). Approximately a third (35.1%) of the population was U.S. military, 40.0% were non-U.S. military, and 25.0% had another affiliation (e.g., civilians). A total of 2630 notable morbidity findings were reported among 14.9% of the population. The top four of these findings were hypothermia (32.9%), anemia/blood loss (26.0%), hypovolemia (9.9%), and shock (7.9%). Most patients received crystalloid fluids (83.6%; median [IQR] = 1.1 [1.0–2.1] liters). A smaller fraction of the population received any type of blood product (18.9%; median [IQR] = 8.0[4.0–16.0] units) or RBC-containing product (RBCs and whole blood) (18.5%; median [IQR] = 4.0[2.0–9.0] units). More patients received RBCs (17.9%) and fresh frozen plasma (14.7%) compared to whole blood (3.3%), platelets (2.3%), and cryoprecipitate (2.4%).

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TABLE II. Diagnostic and Therapeutic Non-operative Procedures

Procedure description	Count	Percent
Diagnostic	13,672	
Other diagnostic radiology and related techniques (i.e., X-ray)	10,133	74.1
Diagnostic ultrasound of abdomen or retroperitoneum	2801	20.5
Psychological and psychiatric evaluation and therapy	498	3.6
Electrocardiogram	160	1.2
Other[a]	31	0.2
Proctoscopy and anorectal biopsy	24	0.2
Diagnostic bronchoscopy and biopsy of bronchus	14	0.1
Tracheoscopy and laryngoscopy with biopsy	11	0.1
Therapeutic	9828	
Other therapeutic procedures	2631	26.8
Wound care	1537	58.4
Vaccination, tetanus immune globulin	762	29.0
Nonmechanical resuscitation	109	4.1
Infusion, hypertonic saline	99	3.8
Acupuncture	28	1.1
Washout, abdominal	28	1.1
Infusion, Dilantin, or fosphentoin sodium (Cerebyx)	27	1.0
Infusion, mannitol	21	0.8
Other[b]	20	0.8
Other vascular catheterization; not heart	1926	19.6
Traction, splints, and other wound care	1370	13.9
Respiratory intubation and mechanical ventilation	1037	10.6
Suture of skin and subcutaneous tissue	625	6.4
Incision of pleura, thoracentesis, chest drainage	472	4.8
Physical therapy exercises, manipulation, and other procedures	396	4.0
Nasogastric tube	374	3.8
Other non-OR therapeutic procedures of urinary tract	227	2.3
Conversion of cardiac rhythm	138	1.4
Ophthalmologic and otologic diagnosis and treatment	95	1.0
Other fracture and dislocation procedure	85	0.9
Other[c]	76	0.8
Other therapeutic procedures on eyelids; conjunctiva; cornea	71	0.7
Other non-OR therapeutic procedures on skin and breast	51	0.5
Treatment; fracture or dislocation of lower extremity (other than hip or femur)	43	0.4
Tracheostomy; temporary and permanent	41	0.4
Other non-OR or closed therapeutic nervous system procedures	36	0.4
Enteral and parenteral nutrition	36	0.4
Treatment; fracture or dislocation of the radius and ulna	28	0.3
Non-operative removal of foreign body	20	0.2
Other OR therapeutic procedures on bone	13	0.1
Debridement of wound; infection or burn	11	0.1
Other therapeutic ear procedures	10	0.1
Other non-OR therapeutic procedures; male genital	9	0.1
Treatment; fracture or dislocation of hip and femur	7	0.1

[a]Ultrasound, ophthalmologic and otologic diagnosis and treatment, contrast arteriogram of femoral and lower extremity arteries, upper gastrointestinal endoscopy, biopsy, arterio- or venogram (not heart and head), monitoring, A-line

[b]Tranexamic acid and antibiotic bead placement

[c]Plastic procedures on nose, facial fracture/dislocation treatment, arthrocentesis, respiratory system procedures, gastrostomy, blood transfusion, gastrointestinal therapeutic procedures, nose, mouth and pharynx procedures, hemic and lymphatic system procedures, or prophylactic vaccinations and inoculations

A total of 27,251 procedures were identified. Of these procedures, 13,672 were non-operating room diagnostic procedures, and 9828 were non-operating room therapeutic procedures (Table II). Most non-operating room diagnostic procedures were X-rays (74.1%). Otherwise, the distribution of non-operating room therapeutic procedures was widely dispersed. Of the remaining 3751 operating room procedures, there were 23 procedures with a count of 5 or fewer and 155 therapeutic exploratory laparotomies excluded. The final analytic sample of 3573 procedures included 128 unique 4-digit ICD-9-CM procedure codes, which were mapped into 32 distinct HCUP procedure groups.

When sorted by burden rank, the cumulative attributable burden of procedures for frequency, mortality, and morbidity increased sharply from procedure 1–10; gradually increased through procedure 20; and then gradually flattened thereafter

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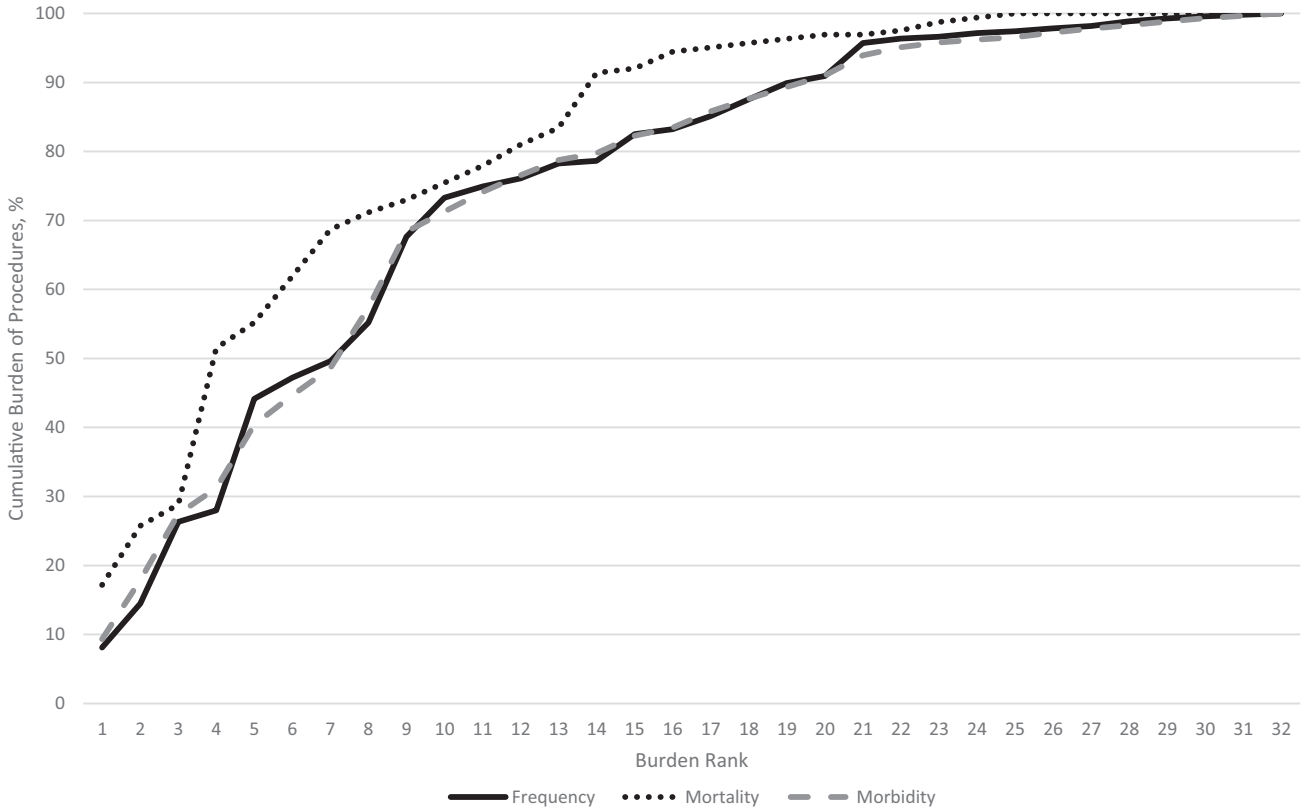

FIGURE 1. Cumulative Burden of Procedures by Burden Rank.

(Fig. 1). The top 10 procedures included (1) non-therapeutic exploratory laparotomy; (2) vascular procedures other than head and neck; (3) external fixator; (4) thoracotomy; (5) debridement; (6) resection, repair, suture, or incision of large or small intestine, duodenum, or colon; (7) suture of liver, abdominal wall, pancreas, or omentum/laparotomy NEC/pancreatectomy/groin exploration; (8) amputation of lower extremity; (9) therapeutic procedures on muscles and tendons; and (10) debridement of open fracture, internal fixation, or reduction to lower extremity (other than hip or femur). These procedures accounted for 74.4% of all procedures, 77.9% of mortality, and 73.1% of morbidity. Table III shows a complete list of procedure groups by burden rank, procedure frequency, mortality percent, and morbidity percent. Non-therapeutic exploratory laparotomy had the greatest burden rank with 9.7% mortality and 38.4% morbidity. Cardiopulmonary resuscitation and pericardial window procedures (burden rank = 14) appeared to be a high risk (100% mortality), low volume ($x = 13$) procedure group. Supplemental Table SI breaks down the specific procedures and ICD-9-CM codes within each procedure group.

DISCUSSION

This study of Role 2 FSTs in Afghanistan identified interventions that were performed by these teams and describes the operative procedures that were commonly performed, associated with higher mortality, and associated with higher morbidity in survivors. Our study demonstrated that (1) the most common diagnostic non-operative procedures were X-ray and ultrasound; (2) the most therapeutic non-operative procedures were for wound care, catheterization, and intubation; and (3) the highest operative procedural burden was from non-therapeutic exploratory laparotomy and vascular procedures. The procedure groups with the greatest mortality percentage included cardiopulmonary resuscitation/pericardial window (#14), thoracotomy (#5), lung lobectomy/resection (#23), and skull and brain procedures (#16).

In 2017, Turner and colleagues detailed combat surgical workload and procedures at both Role 2 and Role 3 facilities in Afghanistan and Iraq.[11] They found the most common surgical procedures performed at Role 2 facilities were soft tissue, abdominal, orthopedic, and vascular. Their study was more comprehensive than previous studies that analyzed only individual Role 2 or Role 3 facilities for limited time periods.[18–32] However, their analysis excluded non-operative procedures and did not account for patient morbidity or mortality in procedure burden calculations. Additionally, their study's broad procedural groups, based largely on body region, were determined using an iterative process by combat surgeons, but, at the time of this analysis, the procedure categorization scheme was not publically available, making this work unre-

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TABLE III. All Operating Room Procedure Groups by Burden Rank

Burden Rank	Procedure Group	Procedure Count[a], 2008–2014	Percent		Rank		Combined Burden Score
			Mortality	Morbidity	Mortality	Morbidity	
1	Non-therapeutic exploratory laparotomy	289	9.7	38.4	2	3	5
2	Vascular procedures other than head and neck	228	6.1	44.7	3	6	9
3	External fixator	423	1.2	27.0	8	2	10
4	Thoracotomy	60	61.7	75.0	1	9	10
5	Debridement	577	1.0	18.9	7	4	11
6	Resection, repair, suture, or incision of large or small intestine, duodenum, or colon	110	10.0	46.4	5	7	12
7	Suture of liver, abdominal wall, pancreas, or omentum; laparotomy NEC; pancreatectomy; groin exploration	86	12.8	54.7	5	8	13
8	Amputation of lower extremity	199	2.0	52.3	10	5	15
9	Therapeutic procedures on muscles and tendons	445	0.7	29.4	15	1	16
10	Debridement of open fracture, internal fixation, or reduction to lower extremity (other than hip or femur)	202	2.0	17.3	10	10	20
11	Resection of large intestine	58	6.9	58.6	10	12	22
12	Splenectomy	42	11.9	69.0	8	14	22
13	Debridement of open fracture, internal fixation, or reduction to hip and femur	78	5.1	33.3	10	16	26
14	Cardiopulmonary resuscitation, pericardial window	13	100.0	92.3	4	22	26
15	Debridement of open fracture, internal fixation, or reduction to the radius and ulna	139	0.7	21.6	17	13	30
16	Skull and brain procedures	25	16.0	56.0	10	20	30
17	Amputation, disarticulation of upper extremity, or unspecified	68	1.5	41.2	17	15	32
18	Arthrotomy	86	1.2	25.6	17	17	34
19	Exploration, neck	85	1.2	23.5	17	18	35
20	Suture of diaphragm or lung, trachea repair	36	2.8	55.6	17	18	35

Continued

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TABLE III. Continued

Burden Rank	Procedure Group	Procedure Count[a], 2008–2014	Percent		Rank		Combined Burden Score
			Mortality	Morbidity	Mortality	Morbidity	
21	Debridement of open fracture, internal fixation, or reduction to the humerus, hand, or unspecified	171	0.0	20.5	25	11	36
22	Nephrectomy	23	4.3	60.9	17	20	37
23	Lung lobectomy, lung resection	10	20.0	80.0	16	23	39
24	Exam of eye under anesthesia	19	5.3	26.3	17	29	46
25	Canthotomy, canthoplasty	9	11.1	44.4	17	30	47
26	Arterial bypass	15	0.0	53.3	25	23	48
27	Stomach suture	12	0.0	58.3	25	25	50
28	Debridement of open facial fracture	24	0.0	25.0	25	26	51
29	Orchiectomy, penis suture, scrotum repair	15	0.0	40.0	25	26	51
30	Colostomy	12	0.0	50.0	25	26	51
31	Suture of bladder, ureter, or kidney	8	0.0	50.0	25	30	55
32	Small intestine resection	6	0.0	66.7	25	30	55

[a]23 procedures, with a count of five or fewer, were excluded from the calculation of burden rank; the excluded procedure groups were: Other extraocular muscle and orbit, therapeutic procedures, other intraocular therapeutic procedures, decompression peripheral nerve, treatment; facial fracture or dislocation, procedures on the urethra, other OR therapeutic procedures on skin and breast, embolectomy and endarterectomy of lower limbs, laminectomy, excision intervertebral disc, and other OR therapeutic nervous system procedures.

producible. In contrast, the classification scheme developed by the HCUP, as used in this study, is publically available and was developed over the course of multiple years using both clinical homogeneity and inpatient discharge data.[17]

By ranking the cross-product of procedure count through both morbidity and mortality, our study identified 10 procedure groups that accounted for approximately 75% of FST operative case burden, where burden was comprised of commonality, morbidity, and mortality. Four of the top 10 procedure groups identified in this study were treatments for limb-threatening injuries. This study also identified infrequently conducted high-risk procedures, the most commonly encountered morbidity findings in survivors, and the overall volume of fluids and blood products provided to casualties. Cumulatively, this information will prove helpful in establishing surgical benchmarks for care provided in environments and combat trauma systems similar to that found in Afghanistan, guide investigators toward the most clinically relevant areas for research, assist with the allocation of resources and medical assets on the battlefield, direct educators on the content of pre-deployment training, and help implement policy directives on the type of providers or skillsets needed to optimize staffing of FSTs.

During recent conflicts in Afghanistan and Iraq, traumatic hemorrhage and associated complications have been shown to be the leading mechanism of death.[33–35] Hemorrhage can be accompanied by acidosis, coagulopathy, and hypothermia as the lethal triad of trauma. Hypovolemia following hemorrhage can cause hypoperfusion, which can subsequently result in acidosis, hypothermia, tissue hypoxia, and end-organ damage. Additionally, pathologic hyperfibrinolysis and coagulopathy are maladaptive physiologic changes that can also occur with hemorrhage and hemorrhagic shock.[36] Commensurate with the known common complications of hemorrhage, our study also noted that hypothermia, anemia/blood loss, hypovolemia, and shock were the most frequent morbidity findings. Although prehospital and hospital guidelines have been optimized and published to guide efforts that would prevent and mitigate such morbidity findings on the battlefield,[37] continuous performance improvement measures are required to reinforce and refine the timely and appropriate provision of ideal care.

Important limitations of this study were that our dataset did not include information on medical provider skill level and experience as well as the number and type of injuries that were not treated due to limited resources or personnel. This may limit the generalizability of our findings to other conflicts or combat theaters. Future studies are warranted to prospectively monitor patients and gather data to assess if patients are appropriately stabilized upon transfer to the next role of care. Role 2 database is currently a non-validated, voluntary data collection tool. Consequently, we are unsure of the proportion of patients not accounted for by this database. In addition, over 10% of patients in the database did not have

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a documented injury or diagnosis. Given the large sample size in this study, the authors posit that what was reported in the database provides the best representation of Role 2 FST care during this timeframe, but documentation and data collection at these facilities must improve to support and enhance future performance improvement efforts.

This study described operative procedures and non-operative interventions administered by FSTs in Afghanistan. FST training and performance improvement metrics should focus on optimizing commonly performed operative procedures and non-operative interventions. Operative procedures that were commonly performed, and those associated with higher rates of morbidity and mortality, can set surgical benchmarks and outline training and skillsets needed by FSTs. Department of Defense policy, research, and training programs should focus on these common FST procedures to optimize and improve readiness of providers, effectively resource Role 2 facilities, and ultimately mitigate morbidity and mortality of those wounded on the battlefield.

SUPPLEMENTARY DATA

Supplementary data are available at *MILMED* online.

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Anatomic injury patterns in combat casualties treated by forward surgical teams

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BACKGROUND: Role 2 forward surgical teams provide damage-control resuscitation and surgery for life- and limb-threatening injuries. These teams have limited resources and personnel, so understanding the anatomic injury patterns seen by these teams is vital for providing adequate training and preparation prior to deployment. The objective of this study was to describe the spectrum of injuries treated at Role 2 facilities in Afghanistan.

METHODS: Using Department of Defense Trauma Registry data, a retrospective, secondary data analysis was conducted. Eligible patients were all battle or non–battle-injured casualties treated by Role 2 forward surgical teams in Afghanistan from October 2005 to June 2018. Abbreviated Injury Scale (AIS) 2005 codes were used to classify each injury and Injury Severity Score (ISS) was calculated for each patient. Patients with multiple trauma were defined as patients with an AIS severity code >2 in at least two ISS body regions.

RESULTS: The data set included 10,383 eligible patients with 45,225 diagnosis entries (range, 1–27 diagnoses per patient). The largest number of injuries occurred in the lower extremity/pelvis/buttocks (23.9%). Most injuries were categorized as minor (39.4%) or moderate (38.8%) in AIS severity, while the largest number of injuries categorized as severe or worse occurred in the head (13.5%). Among head injuries, 1,872 injuries were associated with a cerebral concussion or diffuse axonal injury, including 50.6% of those injuries being associated with a loss of consciousness. There were 1,224 patients with multiple trauma, and the majority had an injury to the extremities/pelvic girdle (58.2%). Additionally, 3.7% of all eligible patients and 10.5% of all patients with multiple trauma did not survive to Role 2 discharge.

CONCLUSION: The injury patterns seen in recent conflicts and demonstrated by this study may assist military medical leaders and planners to optimize forward surgical care in future environments, on a larger scale, and utilizing less resources. (*J Trauma Acute Care Surg.* 2020;89: S231–S236. Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiological, Level III.

KEY WORDS: Role 2; forward surgical care; military health system; injury pattern; Abbreviated Injury Scale.

The military trauma system consists of three levels of care in the combat zone, with each level having increased resources and personnel than the previous level. Role 1 consists of prehospital care at point of injury and during transport.[1] Role 2 forward surgical teams (FSTs) bridge the gap between wounding and definitive battlefield care by providing damage-control resuscitative and surgical care with the goal of rapid stabilization and transport to definitive care at Role 3 medical treatment facilities.[2,3] Mann-Salinas et al.[4] performed a comprehensive analysis of casualties treated by Role 2 FSTs, which was a descriptive study of casualties injured in Afghanistan between February 2008 and September 2014. Subsequent studies of this population have examined casualties transported to Role 2 FSTs[5] and their length of stay,[6] casualties transferred by Role 2 FSTs to higher levels of care,[7] fatalities at the Role 2 level of care,[8] and the procedures performed by Role 2 FSTs.[9] As Role 2 FSTs may be positioned at far-forward locations on the battlefield with limited resources and personnel,[10] a representation of the overall patient population and their injuries is vital to guide team preparation and training. The objective of this study was to describe the spectrum of injuries treated at Role 2 facilities in Afghanistan.

METHODS

Using Department of Defense Trauma Registry (DoDTR) data, a retrospective, secondary data analysis was conducted.[11] The DoDTR contains data abstracted by trained and certified medical abstractors of the Defense Health Agency Joint Trauma System and includes patient demographic, injury treatment, and outcome data. Eligible patients for this study were battle or non–battle-injured trauma casualties treated at Role 2 facilities in Afghanistan from October 2005 to June 2018. This study was reviewed and approved by the US Army Medical Research and Development Command institutional review board under expedited review.

Abbreviated Injury Scale (AIS) 2005 codes were used to classify each injury within four categories: (1) body region (head; face; neck; thorax; abdomen; spine; upper extremity; lower extremity, pelvis, and buttocks; external, thermal, and

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other injuries), (2) anatomic structure (not further specified [NFS], whole area, vessels, nerves, organs, skeletal), (3) injury type for whole area injuries (tear/rupture, crush, inhalation injury, degloving, NFS, avulsion, burn/compartment syndrome, amputation, contusion, skin abrasion, laceration, penetrating), and (4) severity (minor, 1; moderate, 2; serious, 3; severe, 4; critical, 5; maximum, 6).[12] Whole-area injuries included an injury to more than one anatomical structure: vessels, nerves, organs, or skeletal in the same body region. For some head injuries, anatomic structure was not listed, and only loss of consciousness was described. In the AIS classification system, anatomic structure does not apply to the spine. Thus, the spine was classified by anatomical region (lumbar, thoracic, and cervical). The cervical anatomical region included the brachial plexus.

Injury Severity Score (ISS) was calculated as the sum of squares for the highest AIS severity code in each of the three most severely injured ISS body regions.[13] The ISS body regions include head or neck, face, chest, abdominal or pelvic contents, extremities or pelvic girdle, and external.[12] Patients with multiple injuries were defined as patients with an AIS severity code >2 in at least two ISS body regions.[14] The injury pattern of patients with multiple trauma was shown for body regions with AIS score greater than 2, comprised of 33 possible combinations of injuries to a primary and secondary body regions; these included 13 combinations with a tertiary, and eight combinations with a quaternary body region injury. Patient outcomes included mortality. Descriptive statistics were used to report the findings. Data are presented as a percentage of injuries for nonmissing data. All analyses were completed using SAS version 9.4 (SAS Institute Inc).

RESULTS

There were 10,383 patients in the DoDTR treated at Role 2 facilities between November 1, 2005, and June 10, 2018, with Role 2 facilities treating the most patients between 2009 and 2012 (Table 1). The study population consisted of mainly men (95.9%) with battle injuries (77.7%) caused by an explosive mechanism (52.5%). The median (interquartile range [IQR]) age of the study population was 25 years (21–30 years), and the median (IQR) of the ISS was 9 (4–16). Mortality was reported in 3.7% of the study population.

The data set included 45,225 diagnoses entries. The study population sustained up to 27 recorded injury diagnoses per patient encounter. The largest number of injuries occurred in the lower extremity, pelvis, buttocks (23.3%), followed by face (16.0%), upper extremity (14.6%), and head (14.4%) (Fig. 1). Most injuries were categorized as minor (39.4%) or moderate (38.8%) in severity. The largest number of injuries categorized as severe or worse occurred in the head (13.5%).

There were 1,872 head injuries listed without further specified anatomic structure (meaning the injury was associated with a cerebral concussion or diffuse axonal injury), with 50.6% of those injuries being associated with a loss of consciousness. The remaining 4,651 head injuries were classified by anatomic structure. Figure 2 graphically depicts body region by anatomic structure for all nonspinal injuries ($x = 40,598$). Of the 2,755 spinal injuries, the anatomical region varied: 47.3% lumbar, 31.8% thoracic, and 20.9% cervical. Of all patients who died (n = 383), the most severe injuries (AIS severity code >2) affected internal organs (54.5% of which 67.6% were head, 18.5% were thorax, and 13.5% were abdomen) or the skeletal system (22.7%) (Fig. 3). Over a quarter of all injuries were whole-area injuries (28.6%). Among whole-area injuries, the majority were penetrating (37.9%) or laceration injury (19.0%) (Fig. 4).

This study included 1,224 patients with multiple trauma: 990 (80.9%) patients with two, 194 (15.8%) patients with three, 38 (3.1%) patients with four, and 2 (0.2%) patients with five AIS serious to maximal injuries (i.e., scores of 3 to 6). The majority of patients with multiple trauma had an injury to the extremities and pelvic girdle (58.2%), followed by chest (49.7%), head or

TABLE 1. Demographics, Characteristics, Outcomes, and Interventions of Study Patients (N = 10,383)

	n	%
Sex		
No. patients with nonmissing data	10,380	
Male	9,957	95.9
Age		
No. patients with nonmissing data	10,378	
Median (IQR)	25	(21–30)
Patient affiliation		
No. patients with nonmissing data	10,147	
US military	3,902	38.5
Non-US military	3,112	30.7
Other	3,133	30.9
Mechanism of injury		
Explosive	5,448	52.5
Gunshot wound	2,673	25.7
Motor vehicle crash	948	9.1
Fall	457	4.4
Other	857	8.3
Classification of injury		
No. patients with nonmissing data	10,297	
Battle injury	8,002	77.7
Nonbattle injury	2,295	22.3
ISS		
No. patients with nonmissing data	10,381	
Median (IQR)	9	(4–16)
Year of injury		
2005	82	0.8
2006	637	6.1
2007	752	7.2
2008	772	7.4
2009	1,498	14.4
2010	1,845	17.8
2011	1,889	18.2
2012	1,224	11.8
2013	577	5.6
2014	381	3.7
2015	128	1.2
2016	224	2.2
2017	340	3.3
2018	34	0.3
Mortality		
No. patients with nonmissing data	10,381	
Death	383	3.7

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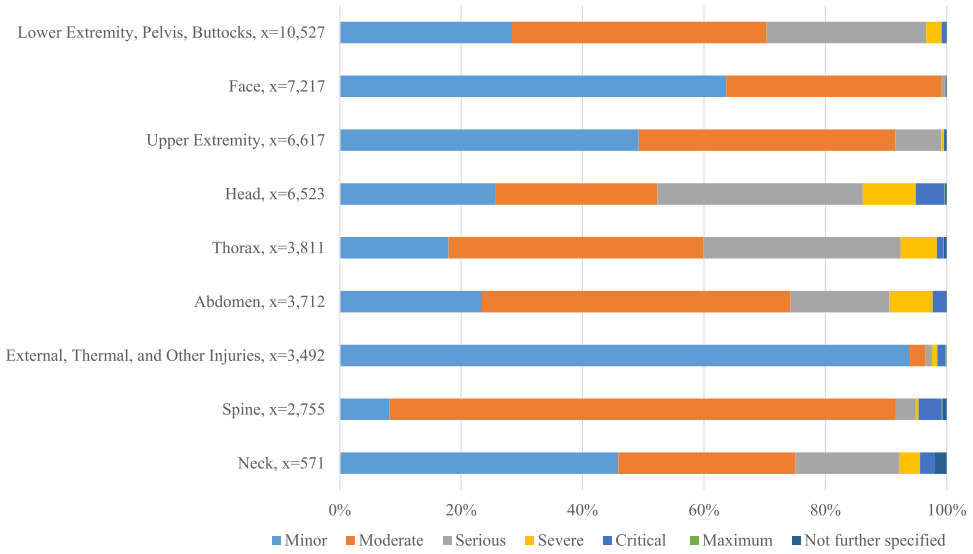

Figure 1. Body region by severity ($x = 45,225$).

neck (42.9%), abdomen and pelvic contents (39.9%), external (7.2%), and face (2.2%) (Table 2). Of the 1,224 patients with multiple trauma, their median (IQR) ISS was 27 (22–34), and 10.5% did not survive to discharge. No mechanism of death data were specified in DoDTR.

The study population contained 16 patients with injuries that were deemed maximal (i.e., AIS = 6), and these injuries included: massive burns, spinal injuries, heart lacerations, penetrating brain injuries, and head crush injuries. Six of the 16 patients with maximal injury severity survived to discharge from the highest role of care where they were treated and where DoDTR collected patient data: one was a documented long-term survivor, one discharged home, one discharged to civilian facility with minimal chance of meaningful recovery, one transferred to civilian hospital in home country, one presumed dead, and one confirmed dead. Of these six patients who survived to discharge, the body region with the maximal AIS included: head/neck (n = 3), chest (n = 1), and external (n = 2).

DISCUSSION

This is a detailed description of battlefield injury patterns at Role 2 FSTs in Afghanistan. Previous studies have examined several aspects of casualties treated by Role 2 FSTs, including length of stay and the procedures performed by these teams, as well as the fatalities at this level of care. Our goal with the present study was to more specifically describe the anatomic injury diagnoses, patterns, and severity in casualties treated at Role 2. Accordingly, this study yielded several important findings. The median ISS was 9, and nearly 80% of the eligible patients had injuries classified as minor or moderate. Our findings may be a result of widespread use of body and vehicle armor, which has helped to reduce the risk of devastating injuries to core body regions.[15] Injury analysis also contributed to educational efforts utilized during the study period to encourage the use of personal protective equipment in body regions where injuries are associated with high morbidity, such as hand and eye injuries.[16,17] On the contrary, our findings may be representative of the flaws associated with the AIS scoring system. Meaning, ISS may underrepresent military injuries which frequently have multiple injuries to the same body region,[18] while AIS may inadequately describe combat injuries, as it was designed to describe civilian automobile crashes.[19] We used ISS and AIS in this study because they are the most commonly used scoring systems to quantify injury severity in trauma, but future studies should describe injury pattern using other scoring systems to determine the impact on the study results.

The region of the body most frequently injured was the lower extremities/pelvis/buttocks. Explosions were the most common mechanism of injury in both Afghanistan and Iraq.[20]

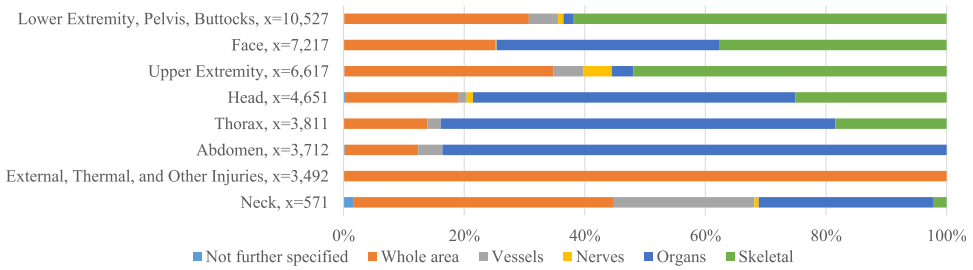

Figure 2. Body region by anatomic structure for all injuries ($x = 40,598$). Note: This does not include loss of consciousness ($x = 1,872$) and spinal injuries ($x = 2,755$).

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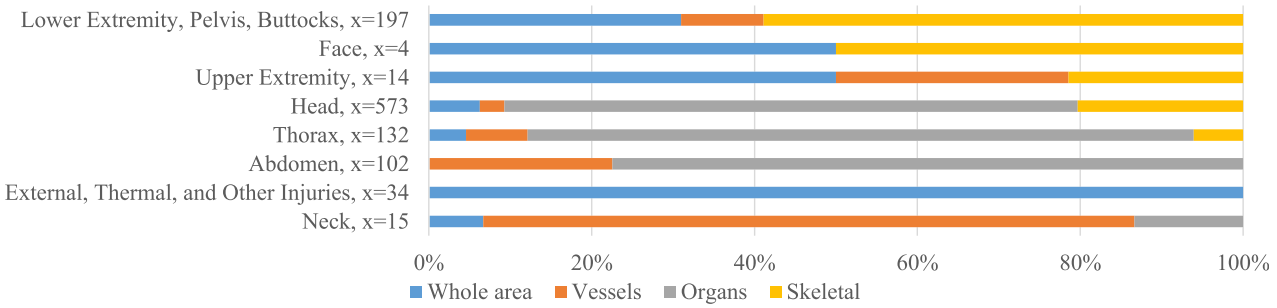

Figure 3. Body region by anatomic structure for injuries with a severity >2 among deceased patients (x = 1,071). Note: This does not include loss of consciousness (x = 12) and spinal injuries (x = 9).

Although more sophisticated pelvic protective gear was utilized by troops and shown to be effective in reducing the odds of sustaining a genitourinary injury,[21] explosives could still penetrate this armor and cause severe trauma,[22] and it is no longer frequently worn as it may reduce the agility of the warfighter. Moreover, injuries to this region could have occurred from both traditional munitions or improvised explosive devices (IEDs) during mounted or dismounted operations. The IEDs were a major cause of casualties in Afghanistan and Iraq, and these devices ranged from being primitive, hand-made bombs to powerful explosives that could destroy armored vehicles and severely injure the occupants.[23] These weapons frequently caused complex blast injuries in casualties on foot (i.e., dismounted complex blast injuries [DCBI]), and Fleming et al.[24] found that 96% of the patients in their study cohort with multiple traumatic extremity amputations suffered DCBIs from IEDs. The DCBI injury pattern includes lower-extremity injury associated with colorectal, genitourinary, and musculoskeletal trauma and profound wound contamination.[25]

Over 10% of the casualties in our study had multiple injuries. Similar findings have been reported in several other studies, including those that have examined extremity wounds,[26] fractures,[20] and burns[27] largely resulting from explosives.[28] The powerful blast waves that are generated by these explosions cause significant shear, stress, and overpressure injuries upon contact with the body.[29] These waves also turn fragmented munitions and nearby debris into ballistic projectiles that further increase the lethality of these weapons.[29] Moreover, the surrounding air can be heated to extremely high temperatures and combust, causing fires and toxic gases to be generated that result in thermal and inhalation injuries.[30] As a result, the explosives used in Afghanistan and Iraq evolved into powerful, versatile weapons capable of routinely causing multiple trauma by blunt, penetrating, or thermal mechanisms of injury.

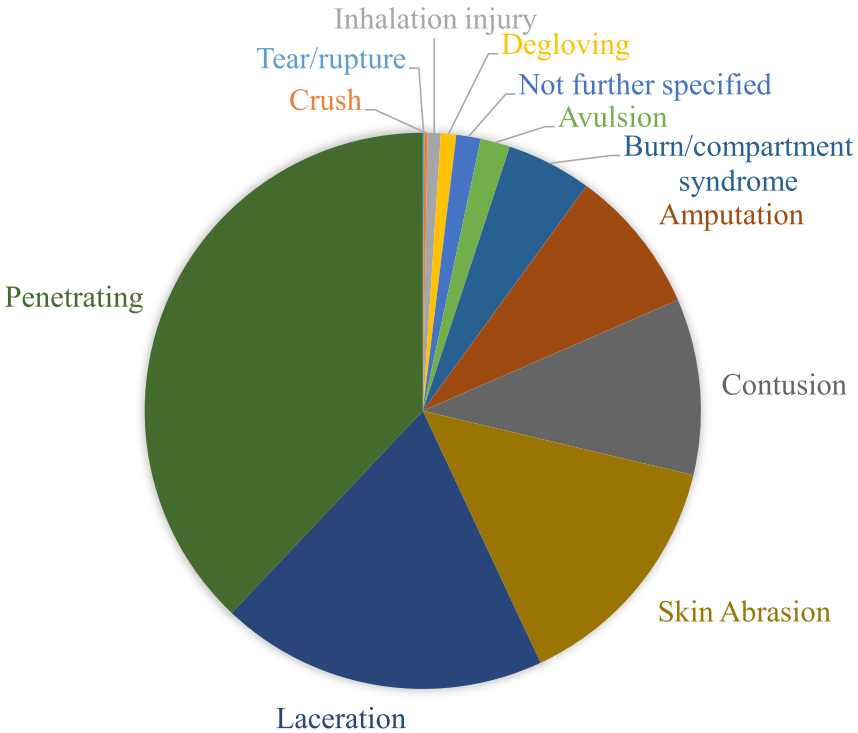

Figure 4. Injury type among all whole body injuries (x = 12,917).

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TABLE 2. Injury Pattern in Patients With Multiple Trauma (N = 1,224)

	Secondary Body Region					
	Head or Neck	Face	Chest	Abdomen and Pelvic Contents	Extremities and Pelvic Girdle	External
Primary body region						
Head or neck		26	275*,**	28	184†	12
Face					1	
Chest				135‡	168§	30
Abdomen and pelvic contents					319¶,‖	6
Extremities and pelvic girdle						40
External						

*Including 89 patients with a tertiary injury to the face ($x = 5$), abdomen and pelvic contents ($x = 28$), or extremities and pelvic girdle ($x = 56$) body regions.

**Including four patients with a tertiary or quaternary body regions injured.

†Including seven patients with a tertiary injury to the face ($x = 4$) or external ($x = 3$) body regions.

‡Including four patients with a tertiary injury to the face ($x = 1$) or external ($x = 3$) body regions.

§Including seven patients with a tertiary injury to the face ($x = 1$) or external ($x = 6$) body regions.

¶Including 87 patients with a tertiary injury to the head or neck ($x = 30$), face ($x = 2$), chest ($x = 52$), or external ($x = 3$) body regions.

‖Including 36 patients with a tertiary, quaternary, or quinary body regions injured.

We recently described the operative and nonoperative procedures performed by Role 2 FSTs in Afghanistan.[9] Combining the findings from that investigation with the results from this study provides a detailed description of the injury and procedure burden that was seen by these teams. From a systems perspective, understanding the injury patterns and their accompanying interventions can inform resource planning and allocation to ensure that FSTs have the necessary equipment, supplies, and training. Benchmarks can be established to optimize the quality of care by these teams and facilitate performance improvement. Prior to deployment, training can be developed and updated to reflect these findings such that teams are better prepared to diagnose and treat specific injuries. However, it is important to recognize that surgical team training must focus on rare but critical injuries, as well as common injuries. At a team level, staffing can be optimized so that FSTs have the most appropriate providers with the skill sets needed to handle the variety of the injuries that will be encountered and the appropriate procedures to be performed. Optimizing training is paramount to ensure that military clinical providers are prepared to execute their patient care missions with the highest quality at any time or place. Consequently, the military has formed partnerships with civilian institutions to develop and maintain clinical competency with training programs and rotations at these institutions.[31]

Recent literature has described the need for ongoing research to better understand the optimal staffing of FSTs and assessments of their capabilities and outcomes. This follows trends and changes that have emerged in forward surgical care, including the use of smaller "austere surgical teams" and the addition of emergency medicine physicians into Role 2 teams while simultaneously reducing the number of general surgeons on these teams.[32] Moreover, future conflicts are expected to occur in situations and settings that may involve peer or near-peer adversaries. While characteristics of such conflicts may include scenarios with massive numbers of casualties, delayed evacuations or prolonged transport durations for casualties, and more lethal and expanded battlefields, it is likely that overall wounding patterns of blast and penetrating trauma with survivable injuries will remain fairly similar. These and other projected features of future conflicts have led to the development of multidomain operations as the strategy for engaging potential enemies.[33] Consequently, military medical leaders have recognized the importance of making changes to the combat casualty care paradigm to align with multidomain operation.[34] The results from this study may assist leaders and planners to address the injury patterns seen in recent conflicts in future environments, on a larger scale, and utilizing less resources.

There are limitations with this study. This was a secondary analysis of retrospective data. Therefore, the accuracy of the results is dependent on the quality and completeness of the data capture, which is difficult in a combat theater. However, quality improvement initiatives were regularly performed by the Joint Trauma System over the course of the conflicts in Afghanistan and Iraq to optimize the quality of data capture as much as possible.[35] Additionally, casualties were not included in DoDTR, unless they were admitted to the Role 3 level of care prior to 2014. In subsequent years, casualties who were treated at the Role 2 level of care and did not continue their care at the Role 3 were included in DoDTR. Although the DoDTR has incomplete data collection of Role 2 patients, DoDTR is the largest source of validated Role 2 data available and, therefore, the most representative source of data to describe injury pattern at Role 2 facilities. In addition to incomplete Role 2 patient capture, the DoDTR may be missing injury data for patients treated only at Role 2 facilities; these facilities do not have advanced imaging and may not have laboratory capability when teams are split, thereby limiting the ability to identify latent injuries that might be found if the patients were treated in a Role 3 facility. This Role 2 capability limitation also may have influence on the injury data collected about these patients. Second, this study only examined casualties from the Afghanistan conflict; therefore, generalizing these results to future conflicts may be limited if the injury patterns, weaponry, or pace of combat operations are different. Finally, given the complexity of combat injuries, NFS codes were sometimes used when it was not possible to identify an AIS code that fit the injury description. However, only a small proportion of injuries were assigned NFS (<1%), so any potential for information bias would be limited.

This study provides a large-scale and systematic description of injuries in casualties treated at Role 2 facilities in Afghanistan. Many casualties had minor or moderate injuries, while the spectrum of injuries was broad. The most frequently injured body region was the lower extremities/pelvis/buttocks, while the largest number of injuries categorized as severe or worse occurred in the head. Over 10% of casualties had multiple trauma injuries. Combined findings from the recently published procedural burden investigation[9] and the results from this study provide a detailed description of the injury and procedure burden

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seen by Role 2 FSTs. Ongoing work is focused on optimizing FST staffing and training, and these results should guide military medical leaders and planners to optimize forward surgical care.

AUTHORSHIP

M.S., K.V.D., S.S., and A.S. participated in the literature search. A.S. participated in the study design. M.S., K.V.D., C.V., J.T., E.M.S., and A.S. participated in the data collection. A.S. participated in the data analysis. M.S., K.V.D., C.V., S.S., and A.S. participated in the data interpretation. M.S., K.V.D., A.S. participated in the writing. M.S., K.V.D., C.V., J.T., E.M.S., S.S., and A.S. participated in the critical revision.

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DISCLOSURE

The authors declare no conflicts of interest.

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Whole blood at the tip of the spear: A retrospective cohort analysis of warm fresh whole blood resuscitation versus component therapy in severely injured combat casualties

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ABSTRACT

Background: Death from uncontrolled hemorrhage occurs rapidly, particularly among combat casualties. The US military has used warm fresh whole blood during combat operations owing to clinical and operational exigencies, but published outcomes data are limited. We compared early mortality between casualties who received warm fresh whole blood versus no warm fresh whole blood.

Methods: Casualties injured in Afghanistan from 2008 to 2014 who received ≥2 red blood cell containing units were reviewed using records from the Joint Trauma System Role 2 Database. The primary outcome was 6-hour mortality. Patients who received red blood cells solely from component therapy were categorized as the non−warm fresh whole blood group. Non− warm fresh whole blood patients were frequency-matched to warm fresh whole blood patients on identical strata by injury type, patient affiliation, tourniquet use, prehospital transfusion, and average hourly unit red blood cell transfusion rates, creating clinically unique strata. Multilevel mixed effects logistic regression adjusted for the matching, immortal time bias, and other covariates.

Results: The 1,105 study patients (221 warm fresh whole blood, 884 non−warm fresh whole blood) were classified into 29 unique clinical strata. The adjusted odds ratio of 6-hour mortality was 0.27 (95% confidence interval 0.13−0.58) for the warm fresh whole blood versus non−warm fresh whole blood group. The reduction in mortality increased in magnitude (odds ratio = 0.15, $P = .024$) among the subgroup of 422 patients with complete data allowing adjustment for seven additional covariates. There was a dose-dependent effect of warm fresh whole blood, with patients receiving higher warm fresh whole blood dose (>33% of red blood cell−containing units) having significantly lower mortality versus the non−warm fresh whole blood group.

Conclusion: Warm fresh whole blood resuscitation was associated with a significant reduction in 6-hour mortality versus non−warm fresh whole blood in combat casualties, with a dose-dependent effect. These findings support warm fresh whole blood use for hemorrhage control as well as expanded study in military and civilian trauma settings.

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Background

Hemorrhage remains the leading cause of preventable death due to trauma in both the military and civilian settings.[1] Death from hemorrhage usually occurs within 6 hours, with the median time ranging from 2 to 2.6 hours in prospective resuscitation trauma studies.[2–4] In severely wounded military casualties, minutes

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matter; prehospital transfusion initiated within 30 minutes of injury was associated with improved 24-hour and 30-day survival. At present, the focus of research initiatives in combat casualty care is to explore optimal approaches to reduce the number of deaths due to hemorrhage, and the recent conflicts in the Middle East underscore the importance of the "damage control" approach to early cessation of hemorrhage.[5,6] Damage control strategies are fundamental to the US military's battlefield trauma system and include: (1) point of injury hemorrhage control with tourniquets and hemostatic dressings; (2) antifibrinolytics; (3) early use of blood products as close to the point of injury as possible; (4) rapid transport to surgical care; (5) advanced en route care with transfusion capability; (6) hemostatic (balanced) resuscitation (including whole blood); (7) avoidance of crystalloid; (8) rapid surgical hemorrhage control, and (9) abbreviated surgical interventions for unstable casualties.[2,7–11] Observational studies, as well as a randomized clinical trial, have indicated that hemostatic resuscitation (balanced ratio/whole blood based transfusion strategy) for traumatic hemorrhage improves early survival.[2,12–14]

Whole blood is integral to the damage control concept. Whole blood can be transfused either immediately after collection at or above room temperature (warm fresh whole blood [WFWB]), or after cold storage at 2°C to 6°C in preservative solutions for up to 35 days.[15] From a historical and military perspective, during World War II, survival differences were observed in patients who received whole blood compared to freeze-dried plasma or albumin.[16] Owing to factors such as the clinical, technologic, and economic challenge of blood banking, regulatory frameworks, and enthusiasm for crystalloid-based resuscitation, transfusion medicine transitioned from whole blood to component blood products. This transition in clinical practice was not evidence-based or supported by clinical research.[17,18]

Over 10,000 units of WFWB have been transfused to approximately 1,800 casualties at US military treatment facilities (MTF) in the Middle East between 2001 and 2018.[19] The findings among previous observational studies comparing WFWB to conventional component therapy in patients with traumatic hemorrhage may reflect bias due to inadequate adjustment for the time-dependency of blood transfusion (a potential source of immortal time bias) and for the variability of injury and hemorrhage severity.[12,14,20,21] This is a secondary analysis of a data set and prior publication that found WFWB had improved survival in patients who had a higher combat mortality index.[22] In this study we sought to comprehensively address the shortfalls of our previous analyses with the addition of more detailed individual injury data, as well as advanced additional statistical methodology and adjustment for both immortal time bias and bleeding/injury severity. This additional analysis is intended to better estimate the association between survival and resuscitation strategies that use whole blood. The primary objective of the study was to compare early mortality in combat casualties who either had WFWB included in their resuscitation regimen or received only component blood product transfusions including red blood cells (RBCs).

Methods

Study design

This was a retrospective cohort study.

Setting

Patients included in this study were treated at 1 of 24 Role 2 MTFs in Afghanistan from February 2008 to September 2014. The study period was the first 6 hours after admission to the Role 2 MTF. Role 2 MTFs are strategically positioned on the battlefield to provide damage control resuscitation and surgery. This somewhat limited capability bridges the gap between point of injury and definitive care at the Role 3 (Combat Support Hospital), which is the highest level of care on the battlefield. Role 2 surgical teams range between 6 and 20 personnel—usually 10 personnel. Due to resource constraints, these MTFs frequently rely on a "walking blood bank" (WBB) to obtain units of WFWB for bleeding casualties requiring resuscitation and emergency surgery. Typically, the WBB requires approximately 15 to 45 minutes to provide WFWB for transfusion. The Joint Trauma System's Clinical Practice Guideline outlines clinical indications for WFWB transfusion and the tactical and logistical considerations in providing this capability.[23] Although stored whole blood is now a Federal Drug Administration (FDA)—approved product, WFWB is not FDA approved; during combat operations overseas, FDA regulations do not apply. Additionally, during the time of this study, cold stored whole blood had not yet been FDA approved.

Participants

To identify a valid comparison group of patients who had similar indications, but did not receive WFWB, study eligibility was restricted to patients who received at least 2 units of RBC-containing blood product (from either WFWB, component therapy, or both); this was done to account for the time of the WBB in patients who only received component therapy. In addition, patients with >20% total body surface burn and missing values for key variables (ie, the 5 matching factors and covariates as defined later) were excluded from this study.

To further balance the study groups based on injury/hemorrhage severity and other considerations that could affect outcomes, patients in the exposure group were frequency-matched to non-exposure group recipients identically on 5 matching factors: injury type (penetrating, nonpenetrating), patient affiliation (US military, other), tourniquet use, prehospital blood transfusion, and quartiles of the average hourly rate of RBC-containing transfusions estimated as the sum of RBC-containing transfusions divided by the patient's length of stay up to 6 hours (Supplemental Table S1). The average hourly rate of RBC-containing transfusions served as a surrogate metric to adjust for differences in bleeding severity and further reduce immortal time bias.

The 5 matching factors classified the patients into 29 unique clinical strata, each containing from 1 to 24 patients (median, 6 patients) and 1 to 320 patients (median, 8 patients), respectively (see Supplemental Table S1). The ratio of matched non-WFWB group to the WFWB group per stratum ranged from 0.3 to 21.5 (median, 2 patients). There were 221 patients in the exposed group and 884 frequency-matched non-exposed group patients.

Variables

In the primary analyses, both study groups may have also received plasma, RBCs, cryoprecipitate, or apheresis-collected platelets. Exposure was defined as 1 or more units of WFWB included in the initial resuscitation (exposure denoted as WFWB group). Non-exposure was defined as no receipt of WFWB and receipt of component therapy that included at least 1 RBC containing product (non-exposure denoted as non-WFWB group) (Table I). The primary outcome was mortality by hour 6 after Role 2 arrival, as this had been identified as the highest-risk period for mortality due to hemorrhage in military cohorts.[24,25] Severity of head injury was included as an additional covariate for adjustment in the analyses. Severe head injury was defined by the maximum head abbreviated injury scale (AIS) score (severe ≥3, moderate <3,

Table I
Definitions of exposure and non-exposure study groups

Type	Name	Receipt of warm fresh whole blood?	Receipt of plasma, cryoprecipitate, or apheresis-collected platelets?	Receipt of red blood cells?
Exposure	WFWB group	Yes	Possibly*	Possibly*
Non-exposure	Non-WFWB group	No	Possibly	Yes

* Thirteen of 221 WFWB group recipients received only WFWB and no plasma, cryoprecipitate, apheresis-collected platelets, or red blood cells.

none) or admission Glasgow Coma Scale <8 if the head AIS score was missing.

In a secondary analysis, exposure was defined as the ratio of unit WFWB transfusions to the sum of all RBC-containing units transfused by hour 6, while the primary outcome remained 6-hour mortality. For all other secondary analyses, the exposure and outcome remained the same as the primary analysis, but these secondary analyses included other covariates, tested for interaction, or were limited to a specific subgroup. Additional details on these analyses are given in the statistical methods section.

Data sources/measurement

Records were drawn from the Joint Trauma System Role 2 Database on adult patients injured in Afghanistan.[26] The Role 2 Database includes data collected and entered by Role 2 providers, and this database contains the largest number of patients treated at Role 2 MTFs by surgical teams working in austere environments.

Bias

To maximize the validity of this analysis, propensity score-matching (or using the "nearest neighbor") was avoided because it can (1) fail to adequately balance exposure groups on individual covariates, and (2) preclude valid assessment of effect modification (interactions between the WFWB group with important covariates).[27,28] Instead, this study used frequency matching, which means exposed patients were matched to non-exposed patients, who were identical to them in regard to the matching factors.

Study size

After identifying all eligible patients, patients who were unable to be identically matched for the analysis were excluded.

Quantitative variables

The ratio of WFWB transfusion was calculated as units of WFWB divided by the total sum of WFWB and other RBC units received, and then categorized as low (ie, <0.33) or high (ie, ≥0.33).[14] The cutoff of 33% was selected by quantile splitting of the data set and analysis of each tertile for direction and magnitude of effect sizes. This analysis demonstrated that the 2 upper tertiles showed highly similar distributions and were thus combined for comparison to the first tertile. This was also in agreement with previous published combat data showing an average ratio of approximately 30% for WFWB versus component products.

Statistical methods

For the primary analysis, multilevel mixed-effects logistic regression adjusted for the matching by incorporating the variable containing each of the identification numbers for the 29 unique strata into the multilevel mixed-effects logistic models as a random intercept. The severity of head injury was included in the logistic models along with the independent variable for WFWB versus non-WFWB assuming they had fixed effects. Stratum constituted the second level of the multilevel model. Logistic regression results were presented as odds ratio (OR) and 95% confidence intervals (CI) and can be interpreted as the relative odds of 6-hour mortality.

To determine the robustness of the logistic regression findings from the primary analysis, 4 prespecified secondary analyses were conducted also using logistic regression:

1. To increase the stringency of the covariate adjustment, seven additional fixed-effect covariates were included in an analysis of the subset of study patients with non-missing values: injury severity score, maximum AIS score, admission base deficit, age, gender, high shock risk, and elapsed time from injury to Role 2 MTF arrival. High shock risk was defined as admission systolic blood pressure ≤90, admission pulse ≥120, or shock index ≥0.9.
2. To determine if the ratio of WFWB received was associated with mortality, exposure was defined by the ratio of WFWB transfusion. The Wald test was used to determine a linear trend of a ratio-dependent effect.
3. Logistic modeling also tested for the interaction between the severity of head injury with WFWB group exposure.
4. A separate analysis was performed to evaluate whether the association between survival and WFWB group exposure was independent of platelet transfusion; the logistic model was restricted to include only the subset of matching non-WFWB group patients who had received 1 or more units of platelet concentrate (apheresis platelets).

An additional set of analyses using Cox proportional hazards modeling evaluated the sensitivity of the association between survival and WFWB group exposure to different assumptions about the start time of the initial unit of WFWB. The first of these sensitivity analyses assumed the initial WFWB unit did not start until WFWB group recipients were 25% of the way through their Role 2 length of stay (up to the 6-hour maximum), and subsequent analyses increased the assumed WFWB start time in 1% increments. The "assumed" WFWB start time was modeled as a time-dependent covariate in Cox proportional hazards models. This approach tested the association between survival and WFWB group exposure assuming progressively longer delays until the first WFWB transfusion was initiated. The Cox models were stratified by the 29 matched groups and adjusted also for severity of head injury (as previously described) and the average hourly transfusion rate of RBC-containing units modeled as a continuous covariate for each patient. For the Cox models, the proportional-hazards assumption was tested using Schoenfeld residuals and log-log plots. Cox regression results were presented as hazards ratio and 95% confidence intervals (CI) and can be interpreted as the relative risk of 6-hour mortality.

In an exploratory analysis to estimate the effect of WFWB transfusion on the total sum of blood products transfused, survivor-average causal effect (SACE) modeling was implemented to adjust for early deaths that precluded further transfusions needed for hemorrhage control.[29,30] The SACE modeling tested whether WFWB group exposure was associated with the 6-hour sum total of either (1) RBC-containing (WFWB or RBCs) transfusions or (2) all blood

Table II
Unadjusted characteristics[*] of study patients treated at Role 2 MTFs in the Afghanistan combat theater

	WFWB group (n = 221)	Non-WFWB group (n = 884)
Injury type,[†] n (%)		
Penetrating	205 (92.8)	797 (90.2)
Nonpenetrating	16 (7.2)	87 (9.8)
Patient affiliation,[†] n (%)		
US military	84 (38.0)	151 (17.1)
Other	137 (62.0)	733 (82.9)
Tourniquet use,[†] n (%)		
Yes	103 (46.6)	314 (35.5)
No	118 (53.4)	570 (64.5)
Prehospital blood,[†] n (%)		
Yes	7 (3.2)	27 (3.1)
No	214 (96.8)	857 (96.9)
Hourly rate of unit RBC/WFWB transfusion,[†,‡] n (%)		
Low (0.33 to <1.71)	59 (26.7)	647 (73.2)
Medium-Low (1.71 to <2.88)	62 (28.1)	133 (15.0)
Medium-High (2.88 to <4.91)	55 (24.9)	59 (6.7)
High (4.91 to 34.29)	45 (20.4)	45 (5.1)
Head injury,[§] n (%)		
Severe	13 (5.9)	61 (6.9)
Moderate	6 (2.7)	16 (1.8)
No	202 (91.4)	807 (91.3)
Ratio of WFWB,[‖] n(%)		
Low (3% to <33%)	66 (29.9)	n/a
High (≥33 to 100%)	155 (70.1)	n/a
Gender,[¶] n(%)		
No. of patients without missing data	220 (99.5)	879 (99.4)
Male	217 (98.2)	851 (96.3)
Age, median (IQR)[¶]	26 (22,30)	25 (22, 30)
High shock risk[¶,#]		
Yes	143 (64.7)	507 (57.4)
No	78 (35.3)	377 (42.6)
Admission base deficit, median (IQR)[¶]	-7 (-13, -4)	-5 (-8, -3)
MAIS score[¶]		
No. of patients without missing data	132	608
Value, median (IQR)	3 (2,3)	3 (2, 3)
Injury severity score[¶]		
No. of patients without missing data	132	608
Value, median (IQR)	9 (5, 14)	9 (5, 11)
Time from point of injury to Role 2 MTF[¶]		
No. of patients without missing data	113	459
Value, median (IQR)	60 (35, 117)	65 (37, 130)
% of blood products used, n (%)		
Plasma	187 (84.6)	709 (80.2)
Platelets	20 (9.0)	119 (13.5)
Blood products, units, median (IQR)[**]		
WFWB	4 (2, 8)	n/a
RBC	7 (4, 11)	4 (2, 7)
Plasma	5 (2, 8)	3 (2, 6)
Platelets[††]	0 (0, 0)	0 (0, 0)
Total	17 (11, 27)	8 (4, 12)

WFWB group, exposure of interest defined by the addition of 1 or more units of fresh whole blood to the resuscitation, which could potentially also include plasma, additional red blood cells, cryoprecipitate, or apheresis-collected platelets; *non-WFWB group*, non-exposure was defined by the receipt of red blood cells from component therapy (plasma, additional red blood cells, cryoprecipitate, or apheresis-collected platelets) alone; *IQR*, interquartile range; *RBCs*, red blood cells; maximum abbreviated injury scale, *MAIS*; *WFWB*, warm fresh whole blood; *MTF*, military treatment facility.

[*] Unadjusted between-group differences are due to varying non-WFWB group:WFWB group matching ratios across the 29 unique strata into which study patients were frequency matched (not propensity-score matched); thus, simple statistical tests such as χ^2 cannot be used to compare study groups in this table. Advanced multilevel mixed-effects logistic modeling adjusted for the matching ratios to ensure their balance (with no between-group differences) in the estimation of the final models.

[†] One of 5 matching factors that classified WFWB group patients into 29 unique strata and enabled the selection of comparable non-WFWB group patients by frequency matching.

[‡] Hourly rate of unit RBC/WFWB transfusion was calculated as units of WFWB or RBCs divided by patient Role 2 length of stay with a maximum length of stay of 6 hours. For the frequency matching, the hourly rates were categorized into quartiles.

[§] The head injury covariate, included in all modeling, was defined by maximum head abbreviated injury scale score or, if missing, by Glasgow coma scale.

[‖] Ratio was calculated as units of WFWB divided by the total units of WFWB and RBCs. Patients categorized as low ratio received WFWB in <33% of all RBC-containing units, minimum = 3%, while high ratio patients received WFWB in ≥33% of all RBC-containing units, maximum = 100%.

[¶] One of 7 additional covariates simultaneously adjusted in pre-specified secondary analyses using multilevel mixed-effects logistic modeling.

[#] High shock risk was defined as admission systolic blood pressure ≤90, admission pulse ≥120 or shock index ≥0.9.

[**] See Table IV for blood product results appropriately adjusted for the competing risk of early mortality by survivor-average causal effect modeling as well as for the matching and head injury covariate.

[††] 20 WFWB group and 119 non-WFWB group patients received platelets.

product transfusions. These analyses were similarly adjusted by multilevel mixed-effects logistic regression for matching and the head injury severity covariate. SACE results were presented as *P* values, where *P* values <.05 were considered statistically significant. All analyses were conducted using SAS version 9.4 (SAS Institute, Inc 2013, SAS/ACCESS 9.4, Cary, NC) and Stata version 15.1 (StataCorp LLC, 2017, Stata Statistical Software: Release 15, College Station, TX).

Results

During the study period, 1,131 patients met the study eligibility criteria. There were 26 patients unable to be identically matched for the analysis, leaving a final study population of 1,105 patients: 221 WFWB group recipients and 884 frequency-matched non-WFWB group recipients. Thirteen of 221 WFWB group recipients (5.8%) received only WFWB and no component therapy. Table II summarizes the injury and clinical characteristic univariately for the WFWB and non-WFWB groups.

In the adjusted logistic regression, receipt of WFWB was associated with significantly lower 6-hour mortality relative to the non-WFWB group (OR 0.27, 95% CI 0.13 to 0.58, $P = .001$) (Table III [primary analysis] and Fig 1). The results of the 4 prespecified secondary analyses are as follows:

1. In the subset of 422 matched study patients with complete data on additional covariates, the association of reduced mortality in the WFWB group was even stronger and remained significant despite sample size reduction (adjusted OR = 0.15, 95% CI 0.03−0.78, $P = .024$) (Table III [secondary analysis 1] and Fig 1). Compared to the 683 patients missing the additional covariate data, the 422 patients with complete data did not differ significantly on mortality (adjusted OR = 0.72, 95% CI 0.38−1.38, $P = .324$) and were thus reasonably representative of the source population of 1,105 study patients.
2. Overall, the adjusted association of WFWB transfusion with reduced mortality was significantly ratio-dependent as WFWB increased from <33% to ≥33% of RBC-containing transfusions (Wald trend test, $P < .001$). Among the 1,105 matched study patients, only the higher ratio of WFWB transfusion (≥33% or "high ratio WFWB") was associated with significantly reduced mortality compared to <33% WFWB transfusion ratio or none (Table III [secondary analysis 2] and Fig 1).
3. In the subgroup with the most severe head injuries, patients in the WFWB group were associated with a greater mortality reduction (OR 0.07 95% CI 0.004 to 1.26 $P = .072$) (Table III [secondary analysis 3] and Fig 1). However, the difference between subgroups was not significant (interaction term $P = .129$) possibly secondary to subgroup size.

Table III
Adjusted odds of mortality in WFWB group patients versus matched* non-WFWB group patients

Question	n (WFWB group)	Deaths (WFWB group)	Exposure group	Odds ratio	95% Confidence interval		*P* value
Primary analysis: Is WFWB group associated with reduced 6 hour mortality relative to Non-WFWB group?	1,105 (221)	71 (15)	WFWB vs non-WFWB	**0.27**	0.13	0.58	.001
Secondary analysis 1: Does the association of WFWB group with 6 hour mortality remain consistent after adjustment for additional covariates (injury severity score, maximum abbreviated injury scale, admission base deficit, age, gender, shock, and time from injury to Role 2 facility) in the subgroup of patients with non-missing values?	422 (68)	29 (3)	WFWB vs non-WFWB	**0.15**	0.03	0.78	.024
Secondary analysis 2: Does WFWB exhibit a ratio-response effect in association with 6 hour mortality relative to Non-WFWB group?	1,105 (221)	71 (15)	Low Ratio† WFWB vs Non-WFWB	**0.54**	0.22	1.34	.184
			High Ratio† WFWB vs Non-WFWB	**0.12**	0.04	0.38	<.001
Secondary analysis 3: Does severe head injury modify the association of WFWB group with mortality relative to Non-WFWB group?	74 (13)	19 (2)	WFWB with severe head injury vs Non-WFWB	**0.07**	0.004	1.26	.072
	1,009 (202)	47 (12)	WFWB without severe head injury vs Non-WFWB	**0.35**	0.15	0.79	.011
Secondary analysis 4: Is the association between survival and WFWB group exposure independent of platelet transfusion?	313 (194)‡	24 (14)	WFWB vs Non-WFWB with platelet receipt	**0.55**	0.19	1.59	.265

WFWB group, exposure of interest defined by the addition of one or more units of fresh whole blood to the resuscitation, which could potentially also include plasma, additional red blood cells, cryoprecipitate, or apheresis-collected platelets; *non-WFWB group*, non-exposure was defined by the receipt of red blood cells from component therapy (plasma, additional red blood cells, cryoprecipitate, or apheresis-collected platelets) alone; *WFWB*, warm fresh whole blood.

* Multilevel mixed-effects logistic regression adjusted simultaneously for frequency-matching on injury type, patient affiliation, tourniquet use, prehospital blood, and hourly rate of unit RBC/WFWB transfusion and the covariate, head injury severity assessed by maximum head abbreviated injury scale score or Glasgow coma scale when abbreviated injury scale missing.

† Ratio was calculated as units of WFWB divided by the total units of WFWB and RBCs. Patients categorized as low ratio received WFWB in <33% of all RBC-containing units, minimum = 3%, n = 66, while high ratio patients received WFWB in ≥33% of all RBC-containing units, maximum = 100%, *n* = 155). Non-WFWB group was referent.

‡ 27 WFWB group patients did not have a non-WFWB group counterpart match and were not included in the model.

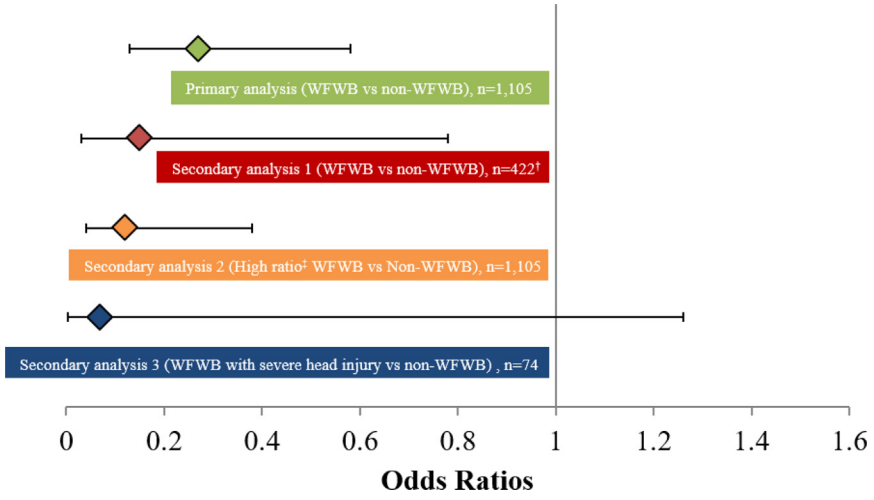

Fig 1. Adjusted odds of mortality in warm fresh whole blood (WFWB) patients versus matched *non-WFWB patients for all patients and select subgroups of high-ratio WFWB, those with non-missing data, and those with severe traumatic brain injury.
*Multilevel mixed-effects logistic regression adjusted simultaneously for frequency-matching on injury type, patient affiliation, tourniquet use, prehospital blood, and hourly rate of unit RBC/WFWB transfusion and the covariate, head injury severity.
†Adjustment for additional covariates (injury severity score, maximum abbreviated injury scale, admission base deficit, age, gender, shock, and time from injury to Role 2 MTF) in the subgroup of patients with non-missing values.
‡Ratio was calculated as units of WFWB divided by the total units of WFWB and RBCs. Patients categorized as low ratio received WFWB in <33% of all RBC-containing units, minimum = 3%, *n* = 66, while high ratio patients received WFWB in ≥33% of all RBC-containing units, maximum = 100%, *n* = 155). Non-WFWB group was referent.

4. In the adjusted analysis of the restricted subset of 119 non-WFWB group counterparts who received platelet concentrate and 194 WFWB group patients with a non-WFWB group counterpart match, 6-hour mortality was still decreased in the WFWB group, though not statistically significant given the smaller sample size (OR = 0.55, 95% CI = 0.19–1.59), *P* = .265) (Table III [secondary analysis 4] and Fig 1).

In the sensitivity analysis, the association between reduced 6-hour mortality and the WFWB group remained significant (hazards ratio = 0.21, 95% CI 0.10–0.46, *P* < .001) in the adjusted Cox regression model that assumed the start of WFWB transfusion was delayed until WFWB group patients had completed 25% of their maximum 6-hour Role 2 stay. Supplementary Figure S1 shows the adjusted 6-hour mortality curve estimated by time-dependent Cox proportional hazards modeling at the mean value of each covariate. Both the statistical significance of the association and its consistency with the proportional-hazards assumption remained until the assumed WFWB delay was increased to 44% of WFWB group patients' Role 2 stay (up to the 6-hour maximum).

Table IV
Results of survivor-average causal effect modeling for total sum of blood products received in WFWB group patients versus matched* non-WFWB group patients

Question	n	WFWB group median, units	Non-WFWB group median, units	*P* value
Is WFWB group associated with the sum total of RBC-containing transfusions among patients predicted to survive >6 hours, regardless of WFWB group or Non-WFWB group?	465	13	11	.426
Is WFWB associated with the sum total of blood product transfusions among patients predicted to survive >6 hours, regardless of WFWB group or Non-WFWB group?	465	21	19	.685

WFWB group, exposure of interest defined by the addition of one or more units of fresh whole blood to the resuscitation, which could potentially also include plasma, additional red blood cells, cryoprecipitate, or apheresis-collected platelets; *non-WFWB group*, non-exposure was defined by the receipt of red blood cells from component therapy (plasma, additional red blood cells, cryoprecipitate, or apheresis-collected platelets) alone; *WFWB*, warm fresh whole blood.

* Logistic regression adjusted simultaneously for the covariates injury type, patient affiliation, tourniquet use, prehospital blood, hourly rate of unit RBC/WFWB transfusion, and head injury severity assessed by maximum head abbreviated injury scale score or Glasgow coma scale when abbreviated injury scale missing.

Supplementary Figure S2 shows the adjusted 6-hour mortality curve estimated by time-dependent Cox proportional hazards modeling at the mean value of each covariate. The median length of Role 2 stay (up to the 6-hour maximum) for WFWB group patients was 5.5 hours (IQR = 3.5–6.0).

In the exploratory analysis to compare the 2 study groups on the sum of RBC-containing transfusions by hour 6 after admission, the SACE modeling (Table IV) showed no significant between-group difference. Additionally, there were no significant between-group difference in the sum total of all blood products transfused. In summary, after appropriate adjustment for early deaths that precluded sufficient hemorrhage control, study patients predicted to survive 6 hours regardless of transfusion protocol had no significant between-group (WFWB versus non-WFWB) difference in total blood product consumption.

Discussion

This report comprises the largest and most robust analysis of the impact of fresh whole blood as a primary resuscitative fluid for severely injured trauma patients in a military setting. Recent research has clearly demonstrated that minutes matter when initiating blood product transfusion for traumatic hemorrhage.[31,32] This study suggests that what is being transfused may be as important as when to transfuse. The comprehensive analysis of a database from military operations in Afghanistan reveals that WFWB added to a resuscitation strategy was associated with a significant decrease in early deaths among severely injured battlefield casualties. This study was a secondary analysis of previously published data from the Joint Trauma System Role 2 Database.[22] The robust Role 2 Database allowed us to perform a significantly more stringent and comprehensive analysis, and to address some of the shortcomings associated with prior publications from our group and others.[12,14,22,33] Findings from this study are concordant with 2 smaller studies involving WFWB use in combat casualties but provide significantly more robust and adequately powered analyses to examine this question.[12,14] Contrary to our observations, Perkins et al reported no difference in 300day survival for 85 WFWB patients compared to 284 component therapy patients.[33] Our results may differ because Perkins et al excluded the highest-risk hemorrhaging patients who died before receiving a massive transfusion, analyzed significantly fewer patients, and lost a large proportion of patients to follow-up before the primary outcome.[20,34]

The strengths of this study include its large, high-risk study population, unique military data resources, and systematic approach to adjust for the immortal time bias and between-group differences in injury and bleeding severity that have plagued previous trauma transfusion studies.[31,35] Applying time-dependent Cox proportional hazards regression revealed that receipt of WFWB was consistently associated with significantly reduced early mortality.

To ensure that severe head injury neither confounded nor modified the effect of WFWB exposure, logistic modeling included the term “severity of head injury” as a covariate in all analyses and assessed its potential interaction (as an effect modifier) with WFWB group exposure. Findings from the model that included the interaction term suggest that although the WFWB group was significantly associated with reduced mortality for trauma patients without severe head injury (adjusted OR = 0.35), a resuscitation regimen including WFWB may or may not also have the potential to benefit trauma patients with severe head injury (adjusted OR = 0.07, 95% CI 0.004–1.26). In our analyses, the subgroup with severe head injury also included polytrauma patients. Thus, one possibility is that the severe head injury subgroup was the most seriously injured and was therefore at the highest risk of hemorrhage-related mortality. This strong association, albeit not statistically significant, requires additional investigation and represents research and clinical opportunities to evaluate the effect of whole blood transfusion on the blood brain barrier, platelet function, mitigation of coagulopathy, or other factors that may impact outcomes.[36,37] The strong association we reported is in agreement with previous studies, which have shown increased transfusion of plasma or platelets is associated with improved outcomes in traumatic brain injury patients.[38,39] Our study supports the concept that hemostatic resuscitation may also improve outcomes in traumatic brain injury patients—not just systemic bleeding. To this end, further investigation is needed in terms of mechanisms of biologic plausibility and transfusion cohort studies controlling for severe head injury.

Our primary endpoint of 6-hour mortality is supported by data from multiple high-quality trauma studies that indicate differences in interventions occur between 3 and 6 hours after initiation and that a large proportion of hemorrhagic deaths occur during this timeframe.[2,32,40] In a recently published article that sought to identify more clinically relevant outcomes for hemorrhage control, an international panel of experts in trauma resuscitation concluded that death at 3 to 6 hours after an intervention is an appropriate primary outcome in randomized controlled trials of hemostatic agents in patients with traumatic bleeding.[41]

Among 1,105 matched study patients, the adjusted odds ratio of 6-hour mortality was 0.27 for the WFWB group compared to the non-WFWB group. For the subgroup of 422 patients (who were found to be comparable to the rest of the study population) with non-missing values on 7 additional covariates (injury severity score, maximum AIS, admission base deficit, age, gender, risk factors for shock, and elapsed time from injury to arrival), the adjusted OR suggested an even greater reduction in mortality when compared to the entire study population of 1,105 matched study patients (0.15 vs 0.27). The lower OR for this subgroup suggests an even stronger association with reduced mortality given that more

potentially important confounders were included in this subgroup analysis.

This study identified a decrease in the odds of mortality for the receipt of WFWB relative to receiving solely component therapy. The increased number of survivors in the WFWB group, who may have died if they did not receive WFWB, may explain why these patients received more blood products compared to their counterparts prior to adjustment analysis. Using SACE modeling to adjust for early deaths that precluded sufficient hemorrhage control, especially in the non-WFWB group, revealed no significant between-group difference in blood product consumption.

Our results imply that the addition of WFWB to resuscitation represents a superior resuscitation strategy by reducing early death from hemorrhage. Moreover, there are significant logistical advantages in using whole blood, particularly in the military setting.[42,43] In the deployed setting at a MTF, a well-trained and rehearsed WBB typically results in WFWB available to transfusion in 15 to 20 minutes; FFP on the other hand, can take up to 45 minutes to thaw if the Role 2 hospital did not carry thawed FFP, which may not have been feasible depending on the trauma volume and resource/resupply limitations. WFWB has a high activity of clotting factors, minimal additive solutions, and delivers a product close to physiologic temperature; moreover, WFWB improves the logistics and challenges of transfusion of blood components in a 1:1:1 ratio. Future studies should address the comparative effectiveness of WFWB transfusion relative to a 1:1:1 balanced ratio of plasma:-platelets:RBCs. Additionally, since November 2016 the military began fielding low titer Group-O whole blood (LTWOB).[44] Future studies will need to assess differential effects between these products.

One potential mechanism that could account for WFWB being associated with decreased mortality could be platelets. Platelet concentrate contains, on average, the equivalent of 6 single-donor units of platelets, and a unit of WFWB contains platelets from one donor; thereby this may potentially affect the response to transfusion. Although the OR in the analysis was not statistically significant (given the smaller sample size), our secondary analysis that included only the restricted subset of 119 matched non-WFWB group patients who had received platelet concentrate raises the hypothesis that the receipt of WFWB may reduce mortality independently of the influence of platelets. Future investigation is needed to confirm or refute these findings.

Several limitations must be taken into consideration when interpreting the results of the current study. First, the Role 2 database was maintained on a voluntary basis among all Role 2 MTFs, and the total number of study-eligible patients treated at Role 2 MTFs during the study period is likely close to this number, but the exact number is not known. Given that the majority of patients were host national patients and did not receive long term care in the US trauma system, the 6-hour outcome was used to optimize the number of patients that could be included in this study. Previous work from this group has used 24-hour outcomes, but some of the host nation patients are repatriated into their local trauma system. Six hours is a clinically relevant outcome when considering death from hemorrhage. Most studies demonstrate that the time to death from trauma hemorrhage is under 3 hours; therefore, if a patient survives 6 hours, they are likely to have continued survival.[2,32,40] Despite efforts to adjust for potentially important confounding, residual or unmeasured confounding may still exist. For instance, the Role 2 Database does not include exact information on transfusion timing from the time of injury. To reduce immortal time bias, we restricted eligibility to patients who were transfused at least 2 units, matched the cohorts on their average hourly rate of RBC-containing transfusions (including any prehospital transfusions), and assumed, in sensitivity analyses, that WFWB group did not receive their first unit of WFWB until completing a range from 24% to 44% of their Role 2 stay (up to the 6-hour maximum). These strategies served as surrogate metrics to adjust for between-group differences in bleeding severity as well as the timing and sequence of transfusions. There is a potential for the existence of additional significant confounders that were not included in the analysis, such as tranexamic acid administration. As there were very few patients with tranexamic acid administration administration recorded, this was not considered reliable enough to report or include in the statistical modeling. Although we modeled several different realistic scenarios for the timing and order of administration of blood products based on the authors' experience and published combat data, the data set lacked exact timestamp information for injury occurrence and each administered unit of blood products that could have impacted the study results. The analyses limited to the subgroup of patients with non-missing data obviously relies on a significantly smaller sample size, which results in potential bias and less power to detect small but significant associations. However, the subgroup with complete data on the additional covariates was reasonably representative of the entire study cohort. Given that our analyses adjusted for the known major potential confounders and evaluated alternative assumptions to reduce any residual bias using sensitivity analysis, our cumulative and extensive experience with Role 2 data leads us to believe the following: the findings are reasonably valid, precise, generalizable to the casualty population at risk of early hemorrhagic death, and reproducible.

In conclusion, to our knowledge, this is the largest study to date assessing the effect of receiving WFWB on early outcomes after traumatic injury requiring transfusion. Despite limitations of the data collection from the austere combat zone, statistical analyses including: frequency matching study patients by average hourly transfusion rate; SACE modeling; and time-dependent covariate survival analysis were implemented to decrease immortal time bias, and thereby increase validity. In our study, the addition of WFWB to the resuscitation of combat casualties was associated with a significantly reduced odds of 6-hour mortality compared to standard component blood product resuscitation. These results support the potential benefit of WFWB transfusion in military environments as well as whole blood use in certain civilian scenarios, although further research is needed to confirm these findings and identify subgroups that may have the greatest benefit.

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Conflict of interest/Disclosure

The authors have no financial or other conflicts of interest related to this submission to report.

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Supplementary materials

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An Assessment of Pre-deployment Training for Army Nurses and Medics

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ABSTRACT

Introduction:

Although military nurses and medics have important roles in caring for combat casualties, no standardized pre-deployment training curriculum exists for those in the Army. A large-scale, survey-based evaluation of pre-deployment training would help to understand its current state and identify areas for improvement. The purpose of this study was to survey Army nurses and medics to describe their pre-deployment training.

Materials and Methods:

Using the Intelink.gov platform, a web-based survey was sent by e-mail to Army nurses and medics from the active and reserve components who deployed since 2001. The survey consisted of questions asking about pre-deployment training from their most recent deployment experience. Descriptive statistics were used to analyze the results, and free text comments were also captured.

Results:

There were 682 respondents: 246 (36.1%) nurses and 436 (63.9%) medics. Most of the nurses (n = 132, 53.7%) and medics (n = 298, 68.3%) reported that they were evaluated for clinical competency before deployment. Common courses and topics included Tactical Combat Casualty Care, Advanced Cardiac Life Support, cultural awareness, and trauma care. When asked about the quality of their pre-deployment training, most nurses (n = 186; 75.6%) and medics (n = 359; 82.3%) indicated that their training was adequate or better. Nearly all nurses and medics reported being moderately confident or better (nurses n = 225; 91.5% and medics n = 399; 91.5%) and moderately prepared or better (nurses n = 223; 90.7% and medics n = 404; 92.7%) in their ability to provide combat casualty care. When asked if they participated in a team-based evaluation of clinical competence, many nurses (n = 121, 49.2%) and medics (n = 180, 41.3%) reported not attending a team training program.

Conclusions:

Most nurse and medic respondents were evaluated for clinical competency before deployment, and they attended a variety of courses that covered many topics. Importantly, most nurses and medics were satisfied with the quality of their training, and they felt confident and prepared to provide care. Although these are encouraging findings, they must be interpreted within the context of self-report, survey-based assessments, and the low response rate. Although these limitations and weaknesses of our study limit the generalizability of our results, this study attempts to address a critical knowledge gap regarding pre-deployment training of military nurses and medics. Our results may be used as a basis for conducting additional studies to gather more information on the state of pre-deployment training for nurses and medics. These studies will hopefully have a higher response rate and better quantify how many individuals received any form of pre-deployment training. Additionally, our recommendations regarding pre-deployment training that we derived from the study results may be helpful to military leadership.

INTRODUCTION

Army nurses and medics are important assets to the military medical force. The lessons learned in Afghanistan and Iraq have led to the development of numerous clinical practice guidelines for deployed medical personnel caring for trauma patients at the various echelons or roles of care.[1] Each role of care has different capabilities and responsibilities,[2] so medical personnel need to be proficient with a broad skill set that allows them to function effectively at any role of care. On the battlefield, care begins at the point of injury (POI), which frequently consists of self-aid, buddy-aid, or care from medics.[3] From the POI, casualties may be brought to small facilities (Role 1) such as battalion aid stations (BAS), which may be staffed by physicians, advanced practice providers,

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or additional medics. At the BAS and other similar facilities, the primary goal is to provide life-saving interventions such as tourniquet application or airway management.[4] Following evacuation from the POI or Role 1, forward surgical teams (Role 2) are typically next to care for these casualties, as they provide damage control resuscitation and surgery.[5] The next role of care (Role 3) consists of comprehensive hospital and surgical care before casualties are evacuated out of the combat theater[6] or discharged to local facilities.

Developing the ideal pre-deployment training paradigm for Army nurses and medics in the future will require understanding the experiences of recently deployed individuals. For these nurses and medics, caring for trauma victims on the battlefield may have been challenging. Treatment settings may have rugged terrain or extreme temperatures, and care may be provided in sub-optimal conditions, including in darkness or while under gunfire.[7] Additionally, medical teams assigned to far-forward locations on the battlefield may have had limited resources. To prepare for these conditions, optimal preparation for these nurses and medics includes exposing them to as many combat trauma situations as possible before deployment.[8,9] A large-scale evaluation of the pre-deployment training of Army nurses and medics would help with understanding its current state. Consequently, the purpose of this study was to survey Army nurses and medics with deployment experience to describe the quality and type of pre-deployment training they experienced. This information will inform Army nursing and medic leaders charged with developing, standardizing, and updating future pre-deployment training curricula, with the underlying goal of ensuring force readiness. Clinical readiness for Army medical personnel refers to the ability to provide competent and high-quality care when deployed.[10] The results from this study will assist Army leaders in ensuring readiness among nurses and medics by providing guidance on training courses, pre-deployment training quality, confidence levels, and areas for improvement.

METHODS

This descriptive, cross-sectional study was conducted after review and approval by the U.S. Army Institute of Surgical Research (USAISR), and this study was determined to be exempt from institutional review board consideration. This study used an online survey that was approved by the U.S. Army Research Institute for Behavioral and Social Sciences (ARI) in accordance with Army and Department of Defense (DoD) policies for conducting surveys or interviews of 10 or more individuals (ARI control number DAPE-ARI-AO-18-01). Eligible individuals met the following inclusion criteria: 1) age 18 years or older, 2) currently serve or served in the U.S. Army, 3) were a nurse or medic when deployed, 4) were not a prisoner of war or detainee, 5) deployed to a combat zone on or after 2001, and 6) willing and able to complete a survey about their most recent deployment experience. The target population for this study included Army nurses (medical/surgical, emergency, critical care, nurse anesthetist, or licensed vocational nurse [LVN]) and medics (combat medic/emergency medical technician-basic [EMT-B], flight medic, or special operations combat medic [SOCM]) from the Active and Reserve components who had deployed to a combat theater since 2001.

The survey instrument was modeled after a previously unpublished survey conducted among DoD surgeons regarding their perceived readiness to deploy.[11] We designed our survey questions based on this previous survey, feedback from nurse and medic subject matter experts, as well as guidance from ARI. We then tested the online platform selected for administration of the survey (Intelink.gov) and adjusted the survey questions and delivery method for clarity and platform usability. Question format consisted of multiple choice, Likert-type scales, and free text answers. Topics asked of participants included: demographic information, deployment history, pre-deployment competency evaluation and training, perceived ability to provide combat casualty care before deployment, and training shortfalls. Some individuals completed the survey multiple times; only the initial submission was used.

The survey was disseminated by sending a standardized recruitment e-mail to the military e-mail accounts of all personnel identified by Army Human Resources Command (AHRC) as being either an Army nurse or medic; AHRC provided this list of individuals and their e-mail addresses to the research team. The survey platform did not provide a user-friendly means of sending anonymous e-mails to potential participants. As such, we used an "honest broker" to manage all correspondence with potential participants and de-identify (anonymize) the responses before the results were analyzed. The recruitment e-mail indicated that participation in the survey was voluntary, described the purpose of the study, and provided directions for accessing the survey along with a direct link. To maximize participation, the e-mail message was sent to all potential participants once a month for three consecutive months. Descriptive statistics (count, percent) were used to analyze responses, and free text comments provided important and insightful contextual understanding of some of the quantitative data from this survey.

RESULTS

The survey was sent to 22,337 individuals, and there were 1,181 respondents (5.3% response rate) with 682 (57.7%) meeting the inclusion criteria. Individuals not meeting the inclusion criteria were excluded, with the most common reasons for why individuals were excluded being they did not deploy to a combat zone on or after 2001, they were not willing or able to complete the survey, or they did not answer these questions. Background and demographic information about the respondents is provided in Table I. Of the 682 respondents, there were 246 (36.1%) nurses and 436 (63.9%) medics. Most respondents were male (n = 504; 73.9%), Active duty (n = 627; 91.9%), and between 25 and

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TABLE I. Background and Demographic Characteristics of the Respondents

	Total		Specialty			
			Nurse (n = 246)		Medic (n = 436)	
	n	**%**	**n**	**%**	**n**	**%**
Gender						
Female	178	26.1	114	46.3	64	14.7
Male	504	73.9	132	53.7	372	85.3
Component						
U.S. Army (active duty)	627	91.9	192	78.0	435	99.8
U.S. Army reserves	55	8.1	54	22.0	1	0.2
Age						
18 to 24 years	95	13.9	9	3.7	86	19.7
25 to 34 years	324	47.5	86	35.0	238	54.6
35 to 44 years	201	29.5	94	38.2	107	24.5
45 to 54 years	58	8.5	53	21.5	5	1.1
55 to 64 years	4	0.6	4	1.6	0	0.0
Years in specialty						
<3 years	156	22.9	66	26.8	90	20.6
3 to 5 years	136	19.9	48	19.5	88	20.2
5 to 10 years	190	27.9	50	20.3	140	32.1
10 to 15 years	141	20.7	51	20.7	90	20.6
≥15 years	59	8.7	31	12.6	28	6.4
Number of deployments						
1	259	38.0	119	48.4	140	32.1
2	210	30.8	72	29.3	138	31.7
3	115	16.9	30	12.2	85	19.5
4	56	8.2	17	6.9	39	8.9
5 +	42	6.2	8	3.3	34	7.8
Location						
Afghanistan	358	52.5	111	45.1	247	56.7
Africa	13	1.9	6	2.4	7	1.6
Iraq	188	27.6	77	31.3	111	25.5
Kosovo	7	1.0	5	2.0	2	0.5
Kuwait	57	8.4	22	8.9	35	8.0
Syria	17	2.5	12	4.9	5	1.1
Other area (Middle East)	20	2.9	7	2.8	13	3.0
Other area (global)	22	3.2	6	2.4	16	3.7
Role of care assigned						
Respondents with missing data	1	0.1	0	0.0	1	0.2
Medical evacuation	31	4.5	8	3.3	23	5.3
Other	33	4.8	8	3.3	25	5.7
POI[a]	53	7.8	0	0.0	53	12.2
POI and Role 1	35	5.1	0	0.0	35	8.0
POI and medical evacuation	2	0.3	0	0.0	2	0.5
Role 1	102	15.0	1	0.4	101	23.2
Role 1 and Role 2	14	2.1	3	1.2	11	2.5
Role 1 and Role 3	4	0.6	1	0.4	3	0.7
Role 1 and medical evacuation	2	0.3	0	0.0	2	0.5
Role 1, Role 2, and Role 3	1	0.1	0	0.0	1	0.2
Role 2	210	30.8	97	39.4	113	25.9
Role 2 and Role 3	58	8.5	24	9.8	34	7.8
Role 3	124	18.2	103	41.9	21	4.8
Role 4	1	0.1	1	0.4	0	0.0
Special forces	11	1.6	0	0.0	11	2.5

[a]Point of injury

44 years old during their deployments (n = 525; 77.0%). Most respondents (n = 526; 77.1%) reported at least three years of experience in their specialty at the beginning of their deployment. Respondents varied in their number of deployments, from one (n = 259; 38.0%) to more than five (n = 42; 6.2%). The respondents (Table II) included 383 combat medics, 66 medical/surgical nurses, 62 critical care nurses, 55 nurse anesthetists, 37 emergency nurses, 33 flight medics, 26 LVNs, and 20 SOCMs. The most common deployment locations were Afghanistan (n = 358; 52.5%) and Iraq (n = 188; 27.6%). The respondents were assigned to several different roles of care, with the most common assignments being Role

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TABLE II. Breakdown of Nurse and Medic Specialties of the Respondents

Nurses (n = 246)		
	n	**%**
Medical/Surgical Nurse	66	26.8
Critical Care Nurse	62	25.2
Nurse Anesthetist	55	22.4
Emergency Nurse	37	15.0
Licensed Vocational Nurse	26	10.6
Medics (n = 436)		
	n	**%**
Combat Medic	383	87.8
Flight Medic	33	7.6
Special Operations Combat Medic	20	4.6

2 only (n = 210; 30.8%), Role 3 only (n = 124; 18.2%), and Role 1 only (n = 102; 15.0%).

The most common pre-deployment training courses and topics, most critical combat casualty care skills used, and most common core trauma competencies or skill capabilities lacking from team members during the most recent deployment are shown in Table III. The table shows the top five selections for each question. The most common course attended by nurses was Advanced Cardiac Life Support (ACLS; n = 176; 71.5%) and by medics was Tactical Combat Casualty Care (TCCC; n = 324; 74.3%). Other trauma-oriented courses attended by the respondents included Trauma Nursing Core Course (TNCC; nurses n = 132; 53.7% and medics n = 4; 0.9%) and Advanced Trauma Care for Nurses (ATCN; nurses n = 16; 6.5% and medics n = 2; 0.5%). The most common topics covered during training among both nurses and medics were cultural awareness (nurses n = 172; 69.9% and medics n = 339; 77.8%), basic trauma care (nurses n = 141; 57.3% and medics n = 321; 73.6%), and hemorrhage control (nurses n = 123; 50.0% and medics n = 319; 73.2%). Nurses reported airway management as the most critical combat casualty care skill (n = 187; 76.0%), whereas medics reported achieving hemostasis (n = 291; 66.7%). The skill that would have benefitted most from additional training was managing a mass casualty event according to nurses (n = 85; 34.6%) and providing prolonged field care according to medics (n = 191; 43.8%). Importantly, most nurses (n = 86; 35.0%) and medics (n = 176; 40.4%) felt that core trauma competencies or skill capabilities were not lacking from their team members.

Table III also contains information on the respondents' assessments of their most recent deployment for all nurses and medics. When asked about evaluations of clinical competency, 114 (46.3%) nurses and 137 (31.4%) medics reported that their clinical competency was not evaluated. For respondents that did not receive individual pre-deployment training, the primary reason for both nurses (n = 114, 46.3%) and medics (n = 237, 54.4%) was unknown, with the next most common reason for both being time constraints (nurses n = 50; 20.3% and medics n = 72; 16.5%). Regarding the quality of their pre-deployment training, most nurses (n = 186; 75.6%) and medics (n = 359; 82.3%) indicated that their training was adequate, good, or excellent. Nearly all nurses and medics reported being moderately confident or better (nurses n = 225; 91.5% and medics n = 399; 91.5%) and moderately prepared or better (nurses n = 223; 90.7% and medics n = 404; 92.7%) in their ability to provide combat casualty care. When asked if they participated in a team-based evaluation of clinical competence, many nurses (n = 121, 49.2%) and medics (n = 180, 41.3%) reported not attending a team training program. The respondents provided many comments within the survey. Broadly, several of the most common "messages" among all of the comments were related to scheduling and time constraints, assessment and instructional methodologies, training prioritization, and suggestions for more critical care, emergency care, and trauma experiences. Supplemental Table 1 provides a breakdown of nurse and medic responses by their various specialties.

DISCUSSION

This study is important because it is a systematic and large-scale analysis of Army nurse and medic pre-deployment training. The first step to improving pre-deployment training for nurses and medics requires understanding its current state. There was some variation with the completion of clinical competency evaluations before deployment when comparing the various nurse and medic specialties: 95.0% SOCMs, 75.8% flight medics, 66.3% combat medics, 61.5% LVNs, 61.3% critical care nurses, 56.8% emergency nurses, 50.0% medical/surgical nurses, and 43.6% nurse anesthetists. In the Army, operational units rely on medical personnel to be adequately trained. If these individuals are not formally assessed for individual clinical competence, then operational unit commanders must rely solely on the attestation of medical leaders that individuals are prepared to execute their patient care mission. Just as individual infantry personnel are formally assessed on their combat readiness (e.g., marksmanship, parachuting, etc.) before deployment using objective metrics, nurses and medics also should be formally assessed before deployment. This is often completed with individual critical task lists (ICTLs) or mission essential task lists (METLs).

The lack of formal evaluation may be the result of several factors based on the survey questions and free text responses. One reason is if respondents did not take part in any pre-deployment training, then there would be no evaluation. Another reason provided by some respondents was other responsibilities (such as their direct patient care mission in a hospital) were prioritized over their pre-deployment training, making it difficult to participate in formal evaluation exercises. Other respondents indicated that formal evaluation did not occur because of scheduling and time constraints; that is, some respondents indicated that they were notified of their

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TABLE III. Most Common Pre-deployment Training Courses and Topics, Most Critical Combat Casualty Care Skills Used, Most Common Core Trauma Competencies, or Skill Capabilities That Were Lacking From Team Members, and Respondents' Assessments of Their Most Recent Deployment

	Total		Specialty			
			Nurse (n = 246)		Medic (n = 436)	
	n	**%**	**n**	**%**	**n**	**%**
Individual pre-deployment training courses[a]						
TCCC[b]	393	57.6	69	28.0	324	74.3
ACLS[c]	284	41.6	176	71.5	108	24.8
Other[d]	226	33.1	72	29.3	154	35.3
PALS[e]	213	31.2	134	54.5	79	18.1
TNCC[f]	136	19.9	132	53.7	4	0.9
Individual pre-deployment training topics[a]						
Cultural awareness	511	74.9	172	69.9	339	77.8
Trauma	462	67.7	141	57.3	321	73.6
Hemorrhage	442	64.8	123	50.0	319	73.2
AOC- or MOS specific skills[g]	414	60.7	107	43.5	307	70.4
Resuscitation	394	57.8	124	50.4	270	61.9
Most critical combat casualty care skills used[a]						
Intravenous (IV) access	468	68.6	185	75.2	283	64.9
Achieving hemostasis (stop bleeding)	458	67.2	167	67.9	291	66.7
Preparing the patient for evacuation/casualty movement	443	65.0	186	75.6	257	58.9
Airway management	438	64.2	187	76.0	251	57.6
Medication administration	426	62.5	164	66.7	262	60.1
Skills that may have benefitted from additional individual pre-deployment training[a]						
Providing prolonged field care	257	37.7	66	26.8	191	43.8
Managing a mass casualty event	255	37.4	85	34.6	170	39.0
Other[d]	179	26.2	63	25.6	116	26.6
Medication administration	215	31.5	30	12.2	185	42.4
Managing burns	190	27.9	69	28.0	121	27.8
Core trauma competences or skill capabilities that were lacking from your team members[a]						
None	262	38.4	86	35.0	176	40.4
Providing prolonged field care	164	24.0	49	19.9	115	26.4
Managing a mass casualty event	161	23.6	61	24.8	100	22.9
Medication administration	161	23.6	43	17.5	118	27.1
Communicating/documenting care	147	21.6	52	21.1	95	21.8
Evaluated for clinical competency						
Respondents with missing data	1	0.1	0	0	1	0.0
Yes	430	63.0	132	53.7	298	68.3
No	251	36.8	114	46.3	137	31.4
Primary reason for not receiving individualized pre-deployment training						
No available resource	71	10.4	25	10.2	46	10.6
Time constraints	122	17.9	50	20.3	72	16.5
Scheduling	29	4.3	9	3.7	20	4.6
Unknown	351	51.5	114	46.3	237	54.4
Other	107	15.7	47	19.1	60	13.8

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TABLE III. (Continued)

	Total		Specialty			
			Nurse (n = 246)		Medic (n = 436)	
	n	**%**	**n**	**%**	**n**	**%**
Quality of pre-deployment training						
Respondents with missing data	1	0.1	0	0.0	1	0.2
Excellent	123	18.0	39	15.9	84	19.3
Good	211	30.9	65	26.4	146	33.5
Adequate	211	30.9	82	33.3	129	29.6
Poor	102	15.0	45	18.3	57	13.1
Extremely poor	34	5.0	15	6.1	19	4.4
Confidence in providing combat casualty care						
Respondents with missing data	1	0.1	0	0.0	1	0.2
Fully prepared	219	32.1	65	26.4	154	35.3
Very prepared	228	33.4	75	30.5	153	35.1
Moderately prepared	177	26.0	85	34.6	92	21.1
Slightly prepared	49	7.2	18	7.3	31	7.1
Not at all prepared	8	1.2	3	1.2	5	1.1
Preparedness in providing combat casualty care						
Respondents with missing data	1	0.1	0	0.0	1	0.2
Fully prepared	205	30.1	63	25.6	142	32.6
Very prepared	245	35.9	81	32.9	164	37.6
Moderately prepared	177	26.0	79	32.1	98	22.5
Slightly prepared	49	7.2	21	8.5	28	6.4
Not at all prepared	5	0.7	2	0.8	3	0.7
Team-based pre-deployment training[a]						
None	301	44.1	121	49.2	180	41.3
Other	165	24.2	59	24.0	106	24.3
JRTC[h]	177	26.0	28	11.4	149	34.2
ATTD[i]	78	11.4	48	19.5	30	6.9
BCT3[j]	21	3.1	0	0.0	21	4.8

[a]Only the top five selections of the total study population displayed here.
[b]Tactical Combat Casualty Care.
[c]Advanced Cardiac Life Support.
[d]For this question in the survey, "Other" was selected for answers that were not included in the answer choices for the questions.
[e]Pediatric Advanced Life Support.
[f]Trauma Nursing Core Course.
[g]AOC (area of concentration)—or MOS (military occupational specialty) specific skills refers to skills specific to nurses and medics in general.
[h]Joint Readiness Training Center.
[i]Army Trauma Training Detachment.
[j]Brigade Combat Team Trauma Training.

deployment very near the departure date, so they did not have time to participate in ICTL or METL verification, or any other evaluation process. Beyond making it difficult to allow formal evaluations to occur, short intervals between deployment notification and departure date may not allow nurses and medics to have adequate time to prepare for their deployment with training in the unfamiliar clinical or operational skills (e.g., weaponry, generator maintenance, etc.) that are unique to their particular mission. In particular, learning these operational skills may be challenging given that they likely may not be practiced or taught in clinic or hospital settings. Although our dataset lacked the information to tell us exactly how many individuals did not have enough time to get adequate training in these skills, we suspect that this may have been a sizable number.

Our findings revealed that Army nurses and medics completed a variety of training courses that covered a multitude of topics. This may be reflective of the broad skill sets needed in order to adapt to the dynamic nature of combat where weaponry and injury mechanisms can change over time.[12] Most of the free text responses discussing specific training courses were positive, as the respondents typically found the courses that they took to be helpful. Among the medic respondents, the most commonly attended course was TCCC, which was not surprising given that these individuals frequently treat patients in prehospital settings such as far-forward locations

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on the battlefield or near the POI. However, ACLS was more common among nurses. This course is more practical for hospital-like settings, where supplies to treat patients in cardiac arrest are readily available. Accordingly, our findings revealed that most nurses were assigned to the Role 2 level of care or higher. It was noteworthy that nurses completed other courses focused on the care of trauma patients. One common course was TNCC. This course provides foundational training in the rapid assessment and management of patients in the acute stages following traumatic injuries. Some nurse respondents also completed ATCN (not shown in Table II since this was not one of the top five most common courses among all of the respondents). This course provides more advanced training in care after the acute stages. As trauma patients require extensive care, directing nurses and medics to pursue courses that provide instruction across the entire trauma care spectrum is important.

Regardless of the courses taken or topics covered, most respondents indicated that the quality of their pre-deployment training was adequate or better. The favorable quality of training responses may explain the respondents' feelings of confidence and preparedness in providing combat casualty care before deployment, as nearly all of the respondents felt moderately confident or better and moderately prepared or better, and the respondents' selection of "None" as the most common answer when asked about core trauma competencies or skill capabilities that were lacking from team members. Of those respondents who rated the quality of their training as "Poor" or "Extremely poor," the free text responses provided some insights into why they felt that their pre-deployment training was inadequate. Some individuals indicated that they did not get enough experience in trauma, critical care, and emergency medicine, and accordingly wanted more. Others felt that they did not receive enough training in prolonged field care, managing a mass casualty event, and medication administration. These topics were also some of the core competencies and skills lacking from team members, according to survey respondents. Other reasons given by respondents to describe the inadequacies of their training were related to not enough opportunities to work with actual patients, hands-on training, and realistic simulation exercises (e.g., cadavers or live tissue training). Providing prolonged field care will be a particularly important skill in future conflicts that may be characterized by more lethal battlefields with large numbers of casualties and delayed evacuation capabilities.[13] Interestingly, this was the most common skill selected by medics as having benefitted from additional training, whereas it was only the third most common skill for nurses. This may be related to the assigned roles of care, as many medics (n = 208, 47.7%) treated casualties at the POI or Role 1 facilities, but most nurses (n = 225; 91.5%) were assigned to facilities at the Role 2 level of care or higher. At lower levels of care (e.g., POI, Role 1), the settings may be more austere, and personnel and resources are fewer, which may potentially explain the feeling of wanting more training in prolonged field care among many of the medic respondents. Additionally, prolonged field care situations are likely to require advanced patient care skills, which includes nursing skills, so these would be skills many nurses may already be trained in and therefore not likely to require further training.[14]

With the respondents that reported feeling not at all, slightly, or moderately confident or prepared to provide combat casualty care, some of the free text comments provided the reasons, several of which were similar to the reasons provided by respondents who felt the quality of their training was poor or extremely poor: not enough experience in trauma, critical care, and emergency medicine; not enough training in prolonged field care, managing mass casualty events, and medication administration; and not enough opportunities to work with actual patients, hands-on training, and realistic simulation exercises. Other reasons provided by the free text comments included a desire for more team-based training courses and more experience working with their deploying units before arriving in the combat theater.

When examining Supplemental Table 1, some differences can be seen among and within the nurse and medic specialties. With pre-deployment courses, all of the nursing specialties except LVNs had more than 50% of the respondents complete ACLS. Likewise, only a small percentage of nurse anesthetists and LVNs completed TNCC, but more than 70% of respondents from the other nursing specialties completed this course. For medics, TCCC was completed by at least 70% of respondents from all specialties. With all other courses, combat medic respondents reported no more than 50% completion. In contrast, flight medic and SOCM respondents had at least 50% completion of ACLS and PALS. There was some variation with the completion of clinical competency evaluations before deployment, with 46.3% to 61.5% among the nursing specialties and 66.3% to 95.0% among the medic specialties. For the questions regarding quality of pre-deployment training, "Adequate" was the most common response among medical/surgical nurses and nurse anesthetists, whereas it was "Good" for the rest of the nursing specialties. For medics, "Good" was the most common response among the combat medics and flight medics, but it was "Excellent" for the SOCMs. For confidence and preparedness in providing combat casualty care, either "Fully prepared," "Very prepared," or "Moderately prepared" were the most common responses among the nursing specialties. For medics, "Fully prepared" was the most common response for flight medics and SOCMs, but it was "Very prepared" for the combat medics. Altogether, the results from Supplemental Table 1 suggest that combining all of the nursing and medic specialties into two groups of "nurses" and "medics," and subsequently making comparisons may limit the conclusions that can be drawn. Based on the results from Supplemental Table 1, immediate next steps for future work include more detailed and in-depth analyses of these results with the nurses and medics separated by their specialties.

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Among the respondents, the generally high levels of satisfaction with the quality of their pre-deployment training, the feelings of confidence and preparedness in providing care to traumatically injured patients, and the feelings that most often, team members were not lacking in any of the core trauma competencies and skills were encouraging findings. But, interpretations of these high perceptions of abilities and confidence must be done while also considering the limitations. One of these limitations is the Dunning-Kruger effect, which posits that individuals with low levels of competence at baseline may be more likely to overestimate their competence, and individuals with high levels of competence at baseline tend to more accurately assess their competence. Likewise, individuals with low levels of competence may be less likely to accurately assess the competence of others compared to individuals with high levels of competence.[15]

There are other limitations that need to be considered. One limitation is that our survey did not query the respondents about their individual workload or assigned duties while deployed. We suspect that this "experience" during deployment likely would have influenced the responses, so this information would be important to gather in future studies. Another limitation is that our assessment of pre-deployment training in this study is reliant upon the subjective opinions of the respondents. Ideally, adequacy of pre-deployment training would be assessed using objective measures, and this is the strategy that we would have preferred to use over nurse and medic perceptions in assessing the adequacy of pre-deployment training. However, we relied on self-report as this was ultimately the most practical and feasible strategy for our study. With nearly all (91.9%) of the respondents coming from the Active component, our results may not be generalizable to National Guard and Reserve component members. Other limitations include recall bias, the low response rate and small study sample size, and survey accessibility issues because of Army firewall restrictions. Finally, there are two limitations where we plan to focus our efforts with regards to subsequent analyses with our results. First, we do not know why many respondents did not receive pre-deployment training, as "Unknown" was the most selected answer for this question. Second, most analyses thus far were completed with all of the respondents in two groups—nurses and medics—but as described, some differences can be seen among and within the nurse and medic specialties that may limit the conclusions that can be drawn.

Based on our findings, we have several recommendations regarding future pre-deployment training of nurses and medics that military leaders may find helpful. Indicators of clinical competence should be objective, validated against patient outcomes, and used to assess all nurses and medics before deployment. Additionally, nurses and medics should receive deployment notifications with enough time to participate in pre-deployment training and be evaluated for competency. Following deployment notifications, arrangements should be made to allow nurses and medics to attend pre-deployment training courses, and individuals that do not meet predefined readiness benchmarks should be remediated accordingly. We recommend that nurses and medics obtain as much training in trauma, critical care, and emergency medicine as possible; additional topics should be included based on mission requirements. Ideally, didactic instruction should be complemented by actual patients, hands-on training, and realistic simulation exercises. Broad skill sets are needed to care for trauma patients, particularly in prolonged field care scenarios, so we recommend nurses and medics participate in courses that cover the entire spectrum of trauma care. The small sample size of our survey means that future studies with more respondents are needed to gather more information on the state of pre-deployment training. In designing these future studies, strategies to improve the response rate and better determine how many individuals received training of any kind should be employed, which may include attempting to contact individuals by other methods (e.g., work phone, work mailing address, in-person using on-site research coordinators, etc.). Additionally, special consideration should be given to the survey platform; the platform should be the easiest possible to use for potential respondents. Training leaders should initiate coordinated efforts to capture informative and comprehensive data through other organizations within the military. An example of one of these organizations is the Joint Trauma System. In particular, our recommendations for goals and objectives of future studies align with one of the missions of the Education and Training Branch of the Joint Trauma System, which is to optimize pre-deployment readiness and training programs.

CONCLUSIONS

We conducted a study that assessed the pre-deployment training of Army nurses and medics. The respondents completed a variety of courses that covered many topics, including critical care, trauma, and cultural awareness. However, only 132 (53.7%) nurses and 298 (68.3%) medics reported having their clinical competency evaluated before deployment. Most of the respondents were satisfied with the quality of their training and felt confident and prepared to care for combat casualties. These are encouraging findings, but they must be interpreted within the context of the limitations associated with self-report, survey-based assessments. Furthermore, the low response rate limits the generalizability of our findings. Nonetheless, our results attempt to address an important knowledge gap in the pre-deployment training paradigm of military nurses and medics which may inform future data collection efforts related to nurse and medic pre-deployment training. Based on our findings, our recommendations regarding future pre-deployment training of nurses and medics may be helpful to military leadership.

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CONFLICTS OF INTEREST STATEMENT

None declared.

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Characteristics of burn casualties treated at role 2 in Afghanistan

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BACKGROUND: Role 2 medical treatment facilities (MTFs) are frequently located in austere settings and have limited resources. A dedicated assessment of burn casualties treated at this level of care has not been performed. Therefore, the objective of this study was to characterize burn casualties presenting to role 2 MTFs in Afghanistan, along with the procedures they required, complications, and mortality to begin understanding the resources consumed by their care.

METHODS: We identified burn casualties from the Department of Defense Trauma Registry (DODTR). The inclusion criteria were (1) experienced burn injuries in Afghanistan between October 2005 and April 2018 and (2) had documentation of treatment at role 2 in the DODTR. We excluded casualties with only first-degree burns, not otherwise specified burns, or only corneal burns. Casualty demographics, injury characteristics, procedures, and outcomes were reported.

RESULTS: We identified 453 burn casualties with a median (interquartile range) Injury Severity Score of 10 (4–22) and percent total body surface area burned of 11 (5–30). There were 123 casualties (27.2%) with inhalation injury, and the casualties experienced 3,343 additional traumatic injuries and needed 2,530 procedures. Casualties with documentation of resuscitation information received a median (interquartile range) of 1.9 (0.7–3.7) L of crystalloid fluids. Complications were documented in 53 casualties (11.7%). Final mortality was reported in 36 casualties (8.0%), and mortality at role 2 MTFs was reported in 7 casualties (1.5%).

CONCLUSION: Burn casualties had many injuries and needed many procedures, including those related to airway management, resuscitation, and wound care. Given the urgency of these procedures, ensuring that there is enough equipment and supplies will be important in the future. Although infrequent, some casualties experienced complications. Factors that may influence resuscitation include injury severity, concomitant traumatic injuries, and available supplies. Obtaining more contextual information on the patient care environment will be useful going forward. (*J Trauma Acute Care Surg.* 2021;91: S233–S240. Copyright © 2021 Wolters Kluwer Health, Inc. All rights reserved.)

LEVEL OF EVIDENCE: Epidemiological, level III

KEY WORDS: Role 2; burn casualties; Afghanistan.

In the combat theater, role 2 medical treatment facilities (MTFs) provide damage control resuscitation and surgery for critically injured casualties.[1] Our group previously analyzed several aspects of the role 2 level of care, including the injury[2] and procedure[3] burdens, the fatalities,[4] and specific interventions such as fresh whole blood resuscitation[5] and prehospital airway management.[6] However, a dedicated assessment of burn casualties treated at this level of care has not been performed to date. This assessment is important, as thermal injuries account for 5% to 20% of casualties during combat.[7] Importantly, explosions have been the defining mechanism of injury during the conflict in Afghanistan,[8] and United States (US) service members with severe burns were most commonly injured by blasts or explosive weapons.[9] Role 2 MTFs are frequently responsible for the initial management of burn casualties, and delays in resuscitation are associated with worse outcomes.[10] However, the austere nature of these MTFs can make caring for burn casualties challenging because of the large amount of resources they require.[11,12] Therefore, the objective of this study was to characterize burn casualties presenting to role 2 MTFs in Afghanistan, along with the procedures they required, complications, and mortality to begin understanding the resources consumed by their care.

PATIENTS AND METHODS

After obtaining regulatory approval, we performed a retrospective data analysis of burn casualties identified from the Department of Defense Trauma Registry (DoDTR), which includes combat casualty care data throughout the continuum of care from the point of injury to the last US treatment facility. These data were cleaned and validated by the Joint Trauma System. All US military, non-US military, and civilians were eligible for the study. The inclusion criteria were (1) experienced burn injuries in Afghanistan between October 2005 and April 2018 and (2) had documentation of treatment at role 2 in the DoDTR. We excluded casualties with only first-degree burns, not otherwise specified burns, or only corneal burns.

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This study was presented at the 33rd Annual Southern Region Burn Conference of the Southern Medical Association, December 7, 2020, in Lubbock, Texas.

Some of the results were described in an abstract that was accepted for the 28th Annual Meeting of the Military Health System, August 24–27, 2020, in Kissimmee, Florida (which was cancelled because of the COVID-19 pandemic).

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Casualty demographics, injury characteristics, and discharge information were captured. Children were identified as casualties who were younger than 18 years. Burn and injury parameters included percent total body surface area (%TBSA) burned, presence of inhalation injury, and Injury Severity Score (ISS). Discharge information included time spent at surgical role 2 MTFs and disposition. For casualties with documentation of the amount of crystalloid fluids received, we calculated the amount received during the first 24 hours after arrival at the role 2 MTF. Captured outcomes included final mortality and mortality at role 2 MTFs, complications, and the need for mechanical ventilation. Final mortality was determined based on status upon discharge from the final US MTF. Mortality at role 2 MTFs was determined based on identifying casualties who were discharged to the morgue. All complications documented in DoDTR were included, and, unless specified, could have occurred at any time between the point of injury and the last US treatment facility. Specific complications related to overresuscitation (overresuscitation morbidities) were as follows: abdominal compartment syndrome (ACS), acute respiratory distress syndrome (ARDS), and extremity compartment syndrome (ECS) (not present on admission).

Burns not meeting the inclusion criteria and traumatic nonburn injuries in the casualties were identified using *International Classification of Diseases, Ninth and Tenth Revisions, Clinical Modification* (*ICD-9-CM* and *ICD-10-CM*) codes. These codes were then categorized into groups based on the body region injured and injury type. Codes that described more than one body region or injury type were categorized into more than one body region or injury type groups. When the body region or injury type was not clear from the *ICD-9-CM* and *ICD-10-CM* codes, patient records in the data set were reviewed for clarification. Likewise, the procedures that casualties received were also identified using *ICD-9-CM* and *ICD-10-CM* codes, and they were then categorized into procedure groups using the Healthcare Cost and Utilization Project (HCUP) Clinical Classifications Software categorization scheme, which is a standardized, publically available classification scheme that can be used for categorizing *ICD-9-CM* and *ICD-10-CM* codes. We further assigned the procedure groups to the following broader groups using the HCUP definitions: nonoperating room diagnostic or therapeutic and operating room diagnostic or therapeutic. All of the procedures were performed at the role 2 level of care. We used this methodology previously to characterize the burden of procedures on role 2 surgical teams.[3] Categorization of the injuries and procedures into the previously described groups was done to make them smaller and more clinically meaningful.

Descriptive statistics were used to report the findings. For all casualties with a %TBSA burned value, we graphed crystalloid fluids received by %TBSA burned using a scatterplot with casualties color coded by their maximum Abbreviated Injury Scale (AIS) score and with a penalized b-spline curve. All analyses were completed using SAS version 9.4 (SAS Institute Inc., Cary, NC).

TABLE1. Demographics, Characteristics, and Outcomes of Burn Casualties (n = 453)

Sex		
No. casualties with nonmissing data, n (%)	453	(100.0)
Male, n (%)	415	(91.6)
Age		
No. casualties with nonmissing data, n (%)	453	(100.0)
Median (IQR), y	24	(19–30)
Casualty affiliation		
No. casualties with nonmissing data, n (%)	446	(98.5)
Non-US civilian, n (%)	144	(32.3)
Army, n (%)	141	(31.6)
Afghanistan army or police, n (%)	66	(14.8)
Other non-US armed forces, n (%)	53	(11.9)
Other US military, n (%)	19	(4.3)
US civilian, n (%)	13	(2.9)
Other, n (%)	10	(2.2)
Time spent at role 2 MTFs		
No. casualties with nonmissing data, n (%)	185	(40.8)
Hours, median (IQR)	4.5	(2.1–15.9)
Disposition from role 2 MTFs for survivors		
No. casualties with nonmissing data, n (%)	452	(99.8)
Transferred to another military MTF (no additional information provided), n (%)	193	(42.7)
Transferred to Bagram/Camp Lacy, n (%)	140	(31.0)
Discharged to home, n (%)	31	(6.9)
Transferred to Kandahar, n (%)	30	(6.6)
Returned to duty, n (%)	16	(3.5)
Transferred to Bastion, n (%)	11	(2.2)
Discharged to a civilian facility, n (%)	10	(2.4)
Transferred to Dwyer, n (%)	9	(2.0)
Unspecified, n (%)	5	(1.1)
Classification of injury		
No. casualties with nonmissing data, n (%)	451	(99.6)
Battle injury, n (%)	304	(67.4)
ISS		
No. casualties with nonmissing data, n (%)	453	(100.0)
Score, median (IQR)	10	(4–22)
Total body surface area, %		
No. casualties with nonzero value, n (%)	256	(56.5)
Value, median (IQR)	11	(5–30)
Inhalation injury		
No. casualties with nonmissing data, n (%)	453	(100.0)
Present, n (%)	123	(27.2)
Mechanical ventilation		
No. casualties with nonmissing data, n (%)	256	(56.5)
No. casualties recorded as having one or more ventilator days, n (%)	142	(55.5)
Final mortality		
No. casualties with nonmissing data, n (%)	452	(99.8)
Death, n (%)	36	(8.0)
Mortality at role 2 MTFs		
No. casualties with nonmissing data, n (%)	452	(99.8)
Death, n (%)	7	(1.5)

RESULTS

We identified 453 casualties who met the inclusion criteria (Table 1). Most were male (n = 415, 91.6%) with a median (interquartile range [IQR] age of 24 (19–30) years. The affiliation of the largest number of casualties was non-US civilians (n = 144, 32.3%). Median (IQR) time spent at role 2 MTFs was 4.5 (2.1–15.9) hours. Most casualties were transferred to

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another military MTF (no additional information provided) (n = 193, 42.7%) and were injured during battle (n = 304; 67.4%). Median (IQR) ISS and %TBSA burned were 10 (4–22) and 11 (5–30)%, respectively. There were 123 casualties (27.2%) with inhalation injury, and 142 casualties (55.5%) were recorded as having one or more ventilator days. Final mortality was reported in 36 casualties (8.0%), and mortality at role 2 MTFs was reported in 7 casualties (1.5%).

Table 2 describes the casualties who were children (n = 96, 21.2%). There were 30 children (31.9%) injured during battle. The median (IQR) ISS and %TBSA burned were 10 (4.5–25) and 24 (10–35)%, respectively. There were 6 children (6.3%) with inhalation injury, and 28 children (53.8%) were recorded as having one or more ventilator days. Final mortality was reported in 13 children (13.5%), and mortality at role 2 MTFs was reported in 1 child (1.0%).

The casualties experienced 3,343 additional injuries (burns not meeting the inclusion criteria and traumatic nonburn injuries) that were described by 490 unique *ICD-9-CM* and *ICD-10-CM* injury codes (Tables 3 and 4). Most injuries occurred in the head/face/neck (x = 1,097, 32.8%), and the most common injury type was wound/injury (unspecified injury type) (x = 1,110, 33.2%). There were 2,530 procedures performed on the casualties, which included 272 unique *ICD-9-CM* and *ICD-10-CM* procedure codes that mapped into 94 distinct HCUP procedure groups. Table 5 shows the five most common procedures in each category, with all of the procedures shown in Supplementary Table 1 (http://links.lww.com/TA/B935). Most procedures were nonoperating room therapeutic (x = 1,246, 49.2%), followed by nonoperating room diagnostic (x = 835, 33.0%), and operating room diagnostic or therapeutic (x = 449, 17.7%). In the nonoperating room therapeutic procedures group, the most common procedure was respiratory intubation and mechanical ventilation (n = 235, 18.9%). In the nonoperating room diagnostic procedures group, the most common defined procedure was diagnostic ultrasound of abdomen or retroperitoneum (x = 144, 17.2%), which likely represented the focused abdominal sonogram for trauma examination. In the operating room diagnostic or therapeutic procedures groups, the most common procedure was debridement of wound, infection, or burn (n = 98, 21.8%).

There were 222 casualties (49.0%) with documentation of having received crystalloid fluids. For these casualties, the median (IQR) liters of crystalloid fluids received was 1.9 (0.7–3.7) L. The relationship between %TBSA burned and crystalloid fluids is shown in Figures 1*A* and *B*. Figure 1*A* shows the casualties color coded by their maximum AIS score, and from this figure, casualties with higher AIS scores appear to have higher %TBSA burned and crystalloid fluids received. In Figure 1*B*,

TABLE 2. Demographics, Characteristics, and Outcomes of Burn Casualties Who Were Children (n = 96)

Sex		
No. casualties with nonmissing data, n (%)	96	(100.0)
Male, n (%)	72	(75.0)
Age		
No. casualties with nonmissing data, n (%)	96	(100.0)
Median (IQR), y	7.5	(3–11)
Classification of injury		
No. casualties with nonmissing data, n (%)	94	(97.9)
Battle injury, n (%)	30	(31.9)
ISS		
No. casualties with nonmissing data, n (%)	96	(100.0)
Score, median (IQR)	10	(4.5–25)
Total body surface area, %		
No. casualties with nonzero value, n (%)	59	(61.5)
Value, median (IQR)	24	(10–35
Inhalation injury		
No. casualties with nonmissing data, n (%)	96	(100.0)
Present, n (%)	6	(6.3)
Mechanical ventilation		
No. casualties with nonmissing data, n (%)	52	(54.2)
No. casualties recorded as having one or more ventilator days, n (%)	28	(53.8)
Final mortality		
No. casualties with nonmissing data, n (%)	96	(100.0)
Death, n (%)	13	(13.5)
Mortality at role 2 MTFs		
No. casualties with nonmissing data, n (%)	96	(100.0)
Death, n (%)	1	(1.0)

TABLE 3. Burns Not Meeting the Inclusion Criteria and Traumatic Nonburn Injuries in Casualties by Body Region (x = 3,343)

	n	%
Head/face/neck	1,097	32.8
Lower extremity	726	21.7
External/thermal/other (unspecified body region)	551	16.5
Upper extremity	506	15.1
Abdomen/pelvis	218	6.5
Chest	189	5.7
Back/spine	91	2.7

Injury entries that described more than one body region were categorized into more than one body region.

TABLE 4. Burns Not Meeting the Inclusion Criteria and Traumatic Nonburn Injuries in Casualties by Injury Type (x = 3,343)

	n	%
Wound/injury (unspecified injury type)	1,110	33.2
Dislocation/fracture/sprain/strain	1,076	32.2
Burn*	433	13.0
Laceration	174	5.2
Contusion	168	5.0
Amputation	112	3.4
Abrasion	96	2.9
Concussion	77	2.3
Vascular injury	74	2.2
Nerve injury	18	0.5
Avulsion	10	0.3

Injury entries that described more than one injury type were categorized into more than one injury type.

*Burns that did not meet the inclusion criteria, which were first-degree burns, not otherwise specified burns, or only corneal burns.

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TABLE 5. Five Most Common Procedures on Burn Casualties in Each Category

	x	%
Nonoperating room therapeutic	1,246	49.2
Respiratory intubation and mechanical ventilation	235	18.9
Traction, splints, and other wound care	188	15.1
Other vascular catheterization; not heart	168	13.5
Physical therapy exercises, manipulation, and other procedures	132	10.6
Debridement of wound, infection, or burn	116	9.3
Other	407	32.7
Nonoperating room diagnostic	835	33.0
Other diagnostic radiology and related techniques	517	61.9
Diagnostic ultrasound of abdomen or retroperitoneum	144	17.2
Other minor diagnostic procedures	27	3.2
Other CT scan	25	3.0
Computerized axial tomography scan head	22	2.6
Other	100	12.0
Operating room diagnostic or therapeutic	449	17.7
Debridement of wound; infection or burn	98	21.8
Other therapeutic procedures on muscles and tendons	51	11.4
Other OR therapeutic procedures on bone	34	7.6
Other OR procedures on vessels other than head and neck	30	6.7
Amputation of lower extremity	27	6.0
Other	209	46.5

CT, computerized tomography; OR, operating room.

the penalized b-spline curve shows a slight increase in crystalloid fluids received as %TBSA burned increases to 40%, and then the slope of the curve subsequently remains flat until % TBSA burned increases to approximately 80%, at which point the curve begins to decrease slightly.

Complications were recorded in 53 casualties (11.7%) (Table 6). The most common complication was wound infection and cellulitis, which occurred in 14 casualties (3.1%). Complications potentially associated with overresuscitation occurred in 10 casualties (2.2%): 3 casualties (0.7%) with ACS, 3 casualties (0.7%) with ARDS, 3 casualties (0.7%) with ECS, and 1 casualty (0.2%) with both ACS and ARDS.

DISCUSSION

This study examined casualties with burn injuries treated at role 2 MTFs in Afghanistan. Burns were frequently caused by explosions,[9] which have become the defining mechanism of injury during the conflict in Afghanistan.[8] In addition, more than one quarter of the study population had inhalation injury, and 76 of these casualties were US service members. This is important because military affiliation is a predictor of mortality in individuals with inhalation injury,[13] highlighting the need for early airway stabilization. Casualties generally did not spend a lot of time at role 2 MTFs, as the median length of stay was only 4.5 hours. Prolonged critical care capabilities are limited at role 2 MTFs, and casualties requiring ongoing treatment need to be transferred to another facility.[14] Accordingly, the most common disposition plans for casualties were transfer to another location for ongoing medical care. From Table 1, many casualties were transferred to locations that operated at the role 3 level of care for at least some portion of the

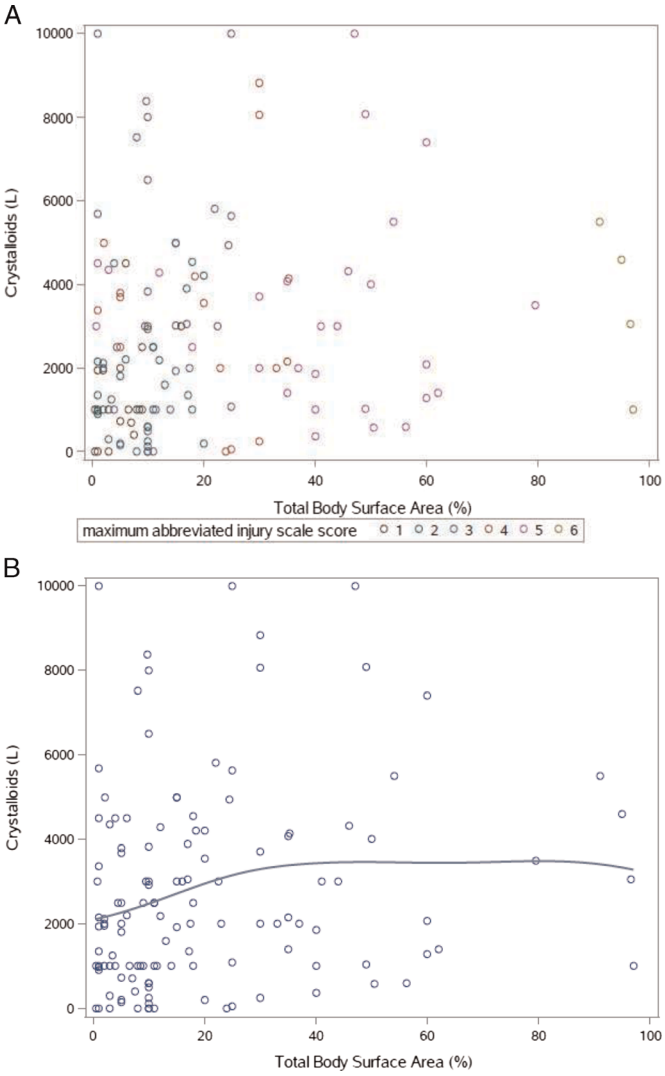

Figure 1. (*A*), Percent total body surface area burned versus crystalloid fluids received by burn casualties (n = 127), with casualties color coded by their maximum AIS score. (*B*), Percent total body surface area burned versus crystalloid fluids received by burn casualties (n = 127), with penalized b-spline curve.

TABLE 6. Complications in Study Patients (n = 453)

	n	%
Any complication	53	11.7
Wound infection and cellulitis	14	3.1
Acute respiratory failure	11	2.4
Overresuscitation morbidities	10	2.2
Bacteremia	9	2.0
Sepsis	8	1.8
Hypothermia	6	1.3
Ventilator-associated pneumonia	6	1.3
Acute renal failure	3	0.7
Cardiopulmonary arrest (unexpected, not resulting in death)	3	0.7
Burn graft loss	1	0.2
Delay in burn donor site healing	1	0.2

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study period (i.e., Bagram/Camp Lacy, Kandahar, Bastion, and Dwyer). Casualties were most commonly transferred to another military MTF (no additional information provided), and we suspect that many casualties with this disposition were transferred to the role 3 level of care; future studies should collect more detailed location information on discharge disposition for casualties treated at role 2 MTFs.

There appeared to be some differences when comparing the injury characteristics of children to the overall study population. One difference was children appeared to be injured less during a battle, and this finding aligns with previous work demonstrating more noncombat-related admissions to US military hospitals in Afghanistan.[15] The reason for this may be due to children being less likely to participate in combat operations than adults. In addition, with adults (which would include coalition soldiers) being more likely to participate in combat operations, they would have better access to body armor, and this may explain the smaller burn size in the overall study population compared with children. Interestingly, despite the number of children with inhalation injury being small (n = 6, 6.3%), a fairly large percentage of children were recorded as having one or more ventilator days (n = 28, 53.8%), and as noted in Borgman et al.,[16] this may reflect some of the other reasons why children may require intubation, such as ARDS, pneumonia, or to facilitate procedures. Lastly, final mortality appeared to be slightly higher in children compared with the overall study population, and there may be several reasons for this. Coalition soldiers will have body armor, and those with severe injuries may be expediently evacuated to higher levels of care. In addition, children with minor injuries may be triaged to civilian medical facilities, leaving children with severe injuries to be treated at US and coalition MTFs. Finally, medical teams are primarily equipped and trained to care for adult casualties, and these teams frequently do not have providers with extensive experience caring for children.[17]

Besides their thermal injuries, the casualties had many other traumatic injuries that contributed to their ISS (Tables 3 and 4). In addition to causing burns, explosions frequently result in polytraumatic injuries. As seen with our results, head/face/neck wounds and musculoskeletal extremity injuries were common, and this is likely related to the configuration of body armor, which typically protects the torso, but leaves the craniomaxillofacial region and the extremities exposed.[18,19] Accordingly, accounting for these traumatic nonburn injuries is important, as previous studies have shown that the mortality rate of individuals with both burns and nonburn injuries is higher than in individuals with burns alone.[20,21]

Burn casualties also needed many procedures at role 2 MTFs. The large majority of procedures were nonoperating room diagnostic and therapeutic procedures. Within the nonoperating room diagnostic procedures group, most of the procedures were radiological studies, which likely included focused abdominal sonogram for trauma (FAST) examinations looking for associated trauma. Within the nonoperating room therapeutic procedures group, the most common procedure was respiratory intubation and mechanical ventilation. As a primary function of role 2 MTFs is lifesaving procedures, a large number of airway-related procedures are not surprising. Other common nonoperating room therapeutic procedures included those related to wound care and management, and vascular catheterization. Given the importance of wound care and intravenous fluid resuscitation when managing burn injuries, these procedures would be common.

Figure 1*A* shows the casualties color coded by their maximum AIS score, and casualties with higher maximum AIS scores generally received more crystalloid fluids. There were some casualties who received large volumes of crystalloid fluids, but had lower %TBSA burned; these casualties likely also experienced traumatic nonburn injuries requiring resuscitation with blood products. The penalized b-spline curve of Figure 1*B* further explains the relationship between %TBSA burned and crystalloid volume received. As %TBSA burned increased, there initially was an increase in the amount of crystalloid fluids received by casualties, and there are several factors that may explain this relationship. Burn size is used to calculate the initial fluid resuscitation rate, and urine output is one of the primary endpoints for adjusting this rate.[22] Another factor is the presence of any concomitant traumatic injuries. Although crystalloid fluids are recommended for burn casualties, blood product–based resuscitation is recommended for hemorrhaging casualties. For casualties with both burns and nonburn injuries, they likely received blood products and crystalloid fluids. Near 40% TBSA burned, the curve in Figure 1*B* begins to flatten and continues with this trajectory until approximately 80% TBSA burned, when the curve begins to decrease slightly. In casualties with large burns, there are some additional factors that may affect the trajectory of the curve. When treating casualties with large burns or severe injuries, the burn care clinical practice guideline describes triaging host nation casualties with large burns (>50% TBSA full thickness burns) to an "expectant" category if local clinics and hospitals will not have the ability to provide ongoing care and rehabilitation.[22] Finally, the supply of intravenous fluids at role 2 MTFs will influence resuscitation volumes. Casualties with large burns have significant fluid requirements, but they may not be able to receive the ideal amount of fluid if their treating facility has limited supplies.

Although relatively rare, some casualties did experience complications. The finding of four casualties with ACS is important given the clear association between ACS and overresuscitation,[23] and in US military burn casualties, ACS can be a highly lethal complication.[24] Another important resuscitation-related morbidity is ARDS, which occurred in four casualties. Park et al.[25] demonstrated that in US combat casualties, increased crystalloid volumes were an independent risk factor for ARDS. In burn patients, ARDS can occur quickly, sometimes within days after the initial injury.[26] Finally, there were three casualties with ECS, which can occur from a primary injury or from secondary causes such as fluid resuscitation.[27] Casualties with burns and concomitant traumatic injuries may develop early ECS that may be related to their resuscitation.[28] Given the findings of these studies, providers initiating early resuscitation at role 2 MTFs for burn casualties must be aware of these complications. Although our data set did not specify which level of care the complications and their treatment occurred, given the relatively short median length of stay at role 2 MTFs, many of these complications likely occurred at higher levels of care. However, providers at role 2 MTFs must still be aware of these complications and their treatment, as some overresuscitation morbidities can occur early after the initial injury. Moreover, for casualties who developed complications shortly after transfer from role 2 MTFs, actions by the medical teams at this level of care may facilitate the

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development of these complications, and additional data and further investigation will be needed to make this determination.

Other important complications are infectious complications, which included wound infection and cellulitis, bacteremia, sepsis, and ventilator-associated pneumonia. Similar to the overresuscitation morbidities, although we suspect that many of the infectious complications were diagnosed at higher levels of care rather than at role 2 MTFs, the concern for infection and their sequelae should be present at all levels of care. From Table 5, wound debridement was a fairly common procedure, so role 2 providers were likely intervening early to prevent or treat infection that could manifest at higher levels of care by removing nonviable or grossly contaminated tissue. Moreover, clinical practice guidelines from the Joint Trauma System provide information and guidance to providers on wound care, infection prevention, and ventilator-associated pneumonia in the combat theater.[22,29,30]

Because of the fidelity of the data set, determining supply usage for burn casualty care at role 2 MTFs was not possible. However, our results may provide a general sense of resource consumption. Severely burned casualties require large amounts of intravenous fluids, so adequate supplies of this resource are essential. From Figure 1*B*, the penalized b-spline curve began to flatten and remain constant at approximately 3.4 L over a large range of %TBSA burned values starting at approximately 40%. Although this would be less than the fluid requirement for the first 24 hours using the modified Brooke formula (5.6 L, assuming a 70 kg male with 40% TBSA burns), 3.4 L may serve as a starting point when planning for individual fluid needs for burn casualties at role 2 MTFs, with the understanding that casualties may need more fluids, as seen in Figure 1*B* by the many casualties who received more than 3.4 L of fluid. Equally important, the equipment to deliver large amounts of intravenous fluids will also be needed, which includes catheters, tubing, and pumps.[11] For burn wound care, the median %TBSA burned (11%) may serve as a benchmark when estimating antimicrobial supplies (topical agents, impregnated dressings, etc.) and dressings (gauze, sponges, etc.) needed by casualties. Moreover, dressings are commonly applied in multiple layers to maintain wound moisture and frequently need to be changed, sometimes more than once per day.[12] Finally, casualties with inhalation injury need early airway stabilization and benefit from inhaled bronchotherapies, which will require airway supplies (endotracheal tube, laryngoscope and sterilization equipment, etc.), mechanical ventilators, ventilator tubing, and oxygen, often administered at 100% FiO_2 after inhalation injury. Because approximately one third of the burn casualties were recorded as having one or more ventilator days in this study, estimating that one third of the burn casualties treated at role 2 MTFs will need airway supplies and ventilators may be a reasonable starting point when planning.

There are limitations with our study. We did not have data from Iraq or other countries in the Middle East, so we cannot freely extrapolate our findings to casualties injured in these regions. Another limitation regards the complications data captured in the DoDTR, as unless specified, the complications could have occurred at any time between the point of injury and the last US treatment facility. Specific details regarding which level of care they occurred usually were not available in the DoDTR, but given the short length of stay at role 2 MTFs, many of these complications likely occurred at higher levels of care. In addition, many of the "complications" may not actually be consequences of actions by the surgical team, but unavoidable sequelae of the underlying injuries; unfortunately, there was not enough fidelity in DoDTR to make this delineation. Nonetheless, providers at role 2 MTFs need to be aware of these complications and their treatment, as some can occur soon after burn injuries, and the interventions performed at this level of care may predispose or prevent complications from occurring at higher levels of care. Finally, clinical decisions in austere environments are not made in a vacuum, but are made using contextual knowledge (e.g., How many casualties present simultaneously? How long before casualties can be evacuated? What are resource and supply inventories? What are the current medical rules of engagement and their impact on complications and outcomes?). Unfortunately, the DoDTR contains limited detailed information on patient care, resource utilization, and the medical rules of engagement at the time of injury. Consequently, more contextual data about the patient care environment represent an important knowledge gap that should be addressed in the future. Despite these limitations, the DoDTR is the largest registry of validated role 2 data, so these data are the most representative of the care provided at role 2 MTFs during the study period.

Based on our results, specific changes with regards to resource allocation for role 2 MTFs include ensuring that there are enough equipment and supplies to treat the most common injuries and perform the procedures needed by burn casualties, which include radiologic studies, airway and respiratory interventions, fluid resuscitation, and wound care. In particular, these recommended changes for adequate resource allocation must also consider the growing importance of prolonged field care.[31] Other recommended changes are more experience and training in burn care before deployment for all providers assigned to role 2 MTFs. In a recent survey of the predeployment training of nurses and medics, we found that 28.0% of nurses and 27.8% of medics felt that "managing burns" was a skill that may have benefitted from additional training.[32] Although many individual providers do receive some basic burn care training or opportunities to work in our burn center before deploying, one recommendation would be to have entire units complete a rotation in the burn center, as the results from another survey of providers (including, but not limited to, surgeons/physicians/advanced care providers, registered nurses/licensed practical nurses, medics, and others) conducted by our group described increases in self-reported readiness ranging from approximately 4% to 16% in several combat casualty care competencies following a 1- to 3-week rotation in the burn center.[33] Of course, even for providers with some burn care experience, early consultation with burn center personnel is encouraged when deployed to facilitate care coordination and management.[22]

CONCLUSION

In this study, we examined the injury characteristics and outcomes of casualties with burn injuries treated at role 2 MTFs in Afghanistan. Casualties included both adults and children, and in addition to their thermal injuries, they experienced many traumatic nonburn injuries that required many procedures. Using a penalized b-spline curve to describe the relationship

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between %TBSA burned and crystalloid volume received demonstrated that there was a slight increase in crystalloid volume received as %TBSA burned increased to approximately 40%. Subsequently, the curve flattened, suggesting that the amount of fluid received changed minimally as %TBSA burned increased beyond 40% until approximately 80%, when the curve started to decrease slightly. Some casualties experienced complications, and 2.2% of the study population had complications associated with overresuscitation such as ACS, ARDS, and ECS. Planning for future combat operations should ensure that there are enough equipment and supplies to treat the most common injuries and perform the most common procedures at this level of care, including radiologic studies, airway and respiratory interventions, fluid resuscitation, and wound care. In addition, more experience and training in burn care before deployment for all team members will likely be helpful. An important focus of future studies should be to obtain more detailed contextual information on the patient care environment, the equipment used, and the supplies consumed by role 2 surgical teams.

AUTHORSHIP

M.R.S., A.M.S., J.D.T., K.K.V.-D., C.A.V., and J.A.R. contributed in the literature search, study design, data collection/analysis/interpretation, writing, and critical revision of the article.

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DISCLOSURE

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The views expressed in this article are those of the authors and do not reflect the official policy or position of the US Army Medical Department, Department of the Army, Department of Defense, or the US Government.
This study was conducted under a protocol reviewed and approved by the US Army Medical Research and Development Command Institutional Review Board and in accordance with the approved protocol.

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Pre-deployment training of Army medics assigned to prehospital settings

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Prior Presentation: Some of the results were described in an abstract that was accepted for the 28th Annual Meeting of the Military Health System, August 24-27, 2020 in Kissimmee, FL (which was cancelled due to the COVID-19 pandemic)

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Abstract:

Background:

Medics have numerous responsibilities in the combat theater, which include performing life-saving interventions, providing basic medical and nursing care, and caring for casualties in a variety of scenarios unique to the battlefield. An evaluation of the medic pre-deployment training paradigm is important and will help to understand its current state and identify areas for improvement. Therefore, the purpose of this paper is to perform a focused assessment of Army medic pre-deployment training to identify patterns that might inform future medic training.

Methods:

A web-based survey was created using the Intelink.gov platform and sent by e-mail to Army medics who deployed since 2001. Medics were asked to reflect upon the pre-deployment training from their most recent deployment experience. There were multiple choice, Likert-type scale, and free-text response questions. Descriptive statistics were used to analyze the results.

Results:

There were 254 respondents who met the study inclusion criteria. Most of the respondents had their clinical competency evaluated (68.5%, n=174). Respondents reported several acute trauma, basic nursing, and battlefield medicine skills as being critical, but also felt that many of these same skills would have benefited from additional pre-deployment training. Most of the respondents felt very or fully confident and prepared to provide combat casualty care (74.8%, n=190 and 74.8%, n=190). There were 64 (25.2%) respondents that reported feeling not at all,

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slightly, or moderately confident, and 54 (84.4%) of these respondents described in a free-text question wanting additional training prior to deployment.

Conclusions:

Respondents reported many skills as being critical to combat casualty care, but several of these skills would have benefited from additional pre-deployment training. Respondents with more deployment experience or completion of more pre-deployment training reported feeling more confident and prepared to provide combat casualty care. A common sentiment was the desire for more training of any form prior to deployment.

Level of Evidence, Study Type: Level IV, epidemiological

Key words: Army, medic, pre-deployment training

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Background:

A medic's proficiency in combat casualty care skills can vary depending on their initial training and opportunities to practice these skills afterward. Unlike licensed medical providers whose daily duties include providing care to patients consistent with their deployment duties, non-deployed Army medics may not function in their pre-hospital, emergency medical technician role, and their non-medical duties may prevent them from obtaining the patient care experiences necessary to sustain their combat casualty care-related skills.[1] These are important skills because medics are frequently responsible for initiating first aid and point-of-injury care to casualties. This stabilizing and time-sensitive care may be life-saving before casualties are able to be evacuated to higher levels of care.[2] Many of the critical patient care skills needed by medics are taught and practiced during the Tactical Combat Casualty Care (TCCC) course.[3] This course covers the TCCC Guidelines, which serve as the standard of care for treating traumatically injured casualties in the prehospital environment on the battlefield. Broadly, the TCCC Guidelines are organized into the following phases of care: care under fire/threat, tactical field care, and tactical evacuation care. Accordingly, this course teaches evidence-based interventions and treatment strategies during these phases of care, with the important goal of eliminating preventable deaths associated with exsanguination and airway or breathing compromise.[4] Importantly, the TCCC course is now mandatory for all deployed personnel and offered as four "tiers" to support the spectrum of first responders and medical specialties.[5] Outside of the TCCC course, the only standardized medic pre-deployment training in the Army is the annual validation of Individual Critical Task List (ICTL) skills.

We recently published the results of a large-scale survey describing the pre-deployment

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training experiences of Army medics and nurses.[6] The survey was aimed at assessing the pre-deployment training of Army medics and nurses who deployed to a combat zone, assess their feelings of confidence and preparedness to provide combat casualty care, and identify areas for improvement to the pre-deployment training paradigm. In this survey, we identified differences between medics and nurses related to pre-deployment training and deployment experiences that warranted further investigation. Therefore, the purpose of this paper is to perform a focused assessment of Army medic pre-deployment training to identify patterns that might inform future medic training.

Methods:

This was a descriptive, cross-sectional study reviewed and approved by the United States Army Institute of Surgical Research regulatory office and the Army Research Institute. The study utilized a Department of Defense survey platform, www.intelink.gov, to collect data electronically. The survey consisted of multiple choice questions, Likert-type scale questions, and free-text responses. Eligible individuals met the following inclusion criteria: 1) age 18 years or older, 2) currently serve or served in the United States Army, 3) were a medic when deployed, 4) assigned role of care was only point-of-injury, medical evacuation, or Role 1, 5) not a prisoner of war or detainee, 6) deployed to a combat zone on or after 2001, and 7) willing and able to complete a survey about their most recent deployment experience.

Details of the survey platform and dissemination methodology were discussed in a previous publication.[4] The questions covered a variety of topics, including combat casualty care skills, confidence, preparedness, and pre-deployment training courses. With the survey

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questions, we wanted to 1) identify the most critical combat casualty care skills used, 2) identify skills which may have benefited from additional individual pre-deployment training, 3) determine some of the reasons for why medics did not feel confident to provide combat casualty care, and 4) see how confidence and preparedness in providing combat casualty care during the most recent deployment varied based on the number of deployments and completion of TCCC, additional/other, or no pre-deployment training. To organize and understand the data, we grouped the most critical combat casualty care skills used and skills which may have benefited from additional individual pre-deployment training into the following sub-categories: tactical combat casualty care skills, basic nursing skills, providing care in various locations, managing various patient types, and other topics. Demographic information, pre-deployment training, and deployment history were collected. Rank information (E-1 to E-9) was also captured. Platoon medics are generally lower enlisted soldiers, E-1 to E-4, but may include some E-5 soldiers. The senior medics in a company may be E-5 or E-6 soldiers, and the senior medics in a battalion or brigade will be E-7 or E-8 soldiers. Finally, the E-9 soldier is a Sergeant Major, and these soldiers are often senior medics in the division or higher level units. The results were analyzed by categorizing the respondents based on their specialty (combat medic, flight medic, special operations combat medic), number of deployments, and whether they had completed TCCC, additional/other, or no pre-deployment training. Descriptive statistics (count, percent) were used to analyze responses. The free-text comments provided contextual understanding of some of the quantitative results from this survey.

Results:

The survey link was e-mailed to 22,337 military e-mail addresses, and 1,181 individuals

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responded (5.3% response rate). Of the 1,181 respondents, 254 (21.5%) met the inclusion criteria for this study (Figure 1 and Table 1). Of the respondents, 91.7% (n=233) were male, nearly all (99.6%, n=253) were active duty, and more than half (57.5%, n=146) were between the ages of 25 to 34 years at the beginning of their most recent deployment. Most held the rank of E-5 to E-6 (61.8%, n=157), with the most common military occupational specialty (MOS) being combat medic (83.5%, n=212), followed by flight medic (9.1%, n=23) and special operations combat medic (7.5%, n=19). The median (interquartile range, IQR) years between completion of the survey and when the respondents left for their most recent deployment was 6 (3-8) years. Including their most recent deployment, most respondents had deployed more than once to a combat zone (70.9%, n=180), and the most common deployment locations were Afghanistan (59.4%, n=151) and Iraq (23.6%, n=60). Most of the respondents had their clinical competency evaluated prior to their most recent deployment (68.5%, n=174).

The most critical combat casualty care skills used during their most recent deployment according to MOS are described in Table 2. Respondents indicated that the most critical combat casualty care skills within each sub-category were achieving hemostasis (67.7%, n=172), medication administration (62.2%, n=158), providing care under fire (43.3%, n=110), managing burn patients (38.2%, n=97), and managing a mass casualty event (49.6%, n=126), respectively. For the skills which may have benefitted from additional individual pre-deployment training during their most recent deployment, the most common responses within each sub-category were airway management (35.4%, n=90), medication administration (45.3%, n=115), providing care in a prolonged field care scenario (50.0%, n=127), managing burn patients (26.8%, n=68), and managing a mass casualty event (40.2%, n=102), respectively.

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Table 3 describes the respondents by the number of deployments. Most of the respondents felt very or fully confident and prepared to provide combat casualty care (74.8%, n=190 and 74.8%, n=190). By the number of deployments, 84 respondents (86.6%) with 3+ deployments felt fully or very confident to provide combat casualty care compared to 64 (77.1%) respondents with 2 deployments and 42 (56.8%) respondents with 1 deployment. In contrast, there were a total of 64 (25.2%) respondents that reported feeling not at all, slightly, or moderately confident to provide combat casualty care. Of these 64 respondents, 54 (84.4%) respondents described in a free-text question wanting additional training of some form prior to deployment. Table 4 provides a summary of these responses categorized by the type of additional training desired. In terms of preparedness to provide combat casualty care (Table 3), 85 (87.6%) respondents with 3+ deployments felt fully or very prepared compared to 63 (75.9%) respondents with 2 deployments and 42 (56.8%) respondents with 1 deployment.

Table 5 describes the respondents by whether they had completed TCCC or any other pre-deployment training. Over 80% of respondents attended a TCCC course (TCCC and additional training 48.4%, n=123; TCCC only 32.7%, n=83), while 5.1% (n=13) had other training and 13.8% (n=35) had no training. In terms of confidence to provide combat casualty care, 102 (82.9%) respondents who completed TCCC and additional training felt fully or very confident compared to 58 (69.9%) respondents who completed TCCC only, 10 (76.9%) respondents who completed other training, and 20 (57.1%) respondents who completed no training. Likewise, in terms of preparedness to provide combat casualty care, 101 (82.1%) respondents who completed TCCC and additional training felt fully or very prepared compared

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to 58 (69.9%) respondents who completed TCCC only, 10 (76.9%) respondents who completed other training, and 21 (60.0%) respondents who completed no training.

Discussion:

We explored several aspects of the current pre-deployment training paradigm in this detailed analysis after asking Army medics to reflect upon their most recent deployment. These providers are frequently the first medical providers to encounter casualties after their injuries, so their ability to provide combat casualty care is critical to the survival of injured service members. Accordingly, it was encouraging to see that most of the respondents had their clinical competency evaluated prior to deployment. We suspect that for many of these respondents, these evaluations occurred with their ICTL skills assessments. Although many medics may complete regular assessments and evaluations because of their civilian certifications (e.g., emergency medical technician-basic or EMT-B, etc.), there are some competencies and skills related to combat casualty care that may not be addressed by these civilian certification programs.[7] This includes skills directly related to combat, such as battlefield tactics, logistics, and weaponry,[8] and medics need to be proficient in these skills in addition to their medical skills.

Examining the results with the respondents grouped by the number of deployments and by the completion of TCCC, additional/other, or no pre-deployment training suggests some important findings (Tables 3 and 5). As the number of deployments increased, there was a trend towards more respondents feeling fully or very confident and prepared to provide combat casualty care during their most recent deployment. For respondents that completed the 'most' training (TCCC plus additional training), there was a trend towards more respondents feeling

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fully or very confident and prepared to provide combat casualty care. All together, these findings suggest that feelings of confidence and preparedness may be more likely in respondents that had more real world experience (e.g., deployed multiple times) and more pre-deployment training. Based on these findings, one idea for future study would include performing univariate and multivariate analyses to determine the variables associated with confidence and preparedness. This will require a larger sample size such that important questions can be answered. Are certain pre-deployment courses independently associated with greater confidence and preparedness in performing combat casualty care skills? Is more recent completion of pre-deployment training courses associated with greater confidence and preparedness to treat combat casualties? Are certain real-world training experiences or programs (e.g., hospital rotations, EMT ride-along shifts, working with emergency medicine and trauma surgery personnel from civilian trauma centers, etc.) associated with greater confidence and preparedness to provide combat casualty care? Answering these and other questions should be a focus of future research regarding combat medic pre-deployment preparation.

Among the respondents that felt not at all, slightly, or moderately confident to provide combat casualty care, Table 4 summarizes their free-text responses when asked what would have helped to increase their efficiency or effectiveness during their most recent deployment. Not surprisingly, most of these respondents wanted a variety of different experiences, forms, and types of additional training. In the free-text responses from several other respondents, the need for opportunities to sustain skills between deployments was frequently expressed. Once training is obtained, unless it is sustained with practice and regular performance, then those skills may not be retained. Having a variety of training platforms is useful, but unless they are combined in

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a mutually reinforcing manner with frequent practice and execution in clinical settings, then this training may not produce the needed capability to care for casualties during combat operations and protect the health of the force.[9] For several of the training opportunities and programs listed in Table 4, the number of medics that described these experiences as being beneficial was lower than one might expect (e.g., 9.4% for "Clinical rotations/EMT ride-along opportunities"). However, this table describes the free-text responses of the respondents. If a specific training opportunity or program was not described in the free-text comments, then it would not have been captured in this table. Accordingly, we suspect that if the survey had a multiple-choice question that listed all of the training opportunities and programs in Table 4, many more medics would have selected "Clinical rotations/EMT ride-along opportunities" along with the other training opportunities and programs.

From Table 5, there was a group of respondents that reported receiving no pre-deployment training. With these respondents, or those that received minimal pre-deployment training, their free-text responses provided some reasons to explain this lack of training. Some of the respondents did not have time to participate in pre-deployment training due to limited time between being notified of their deployment and their departure date. Other individuals did not have enough time for pre-deployment training due to the competing demands of their other responsibilities and workload of their jobs immediately prior to deployment. One sentiment that was expressed by some respondents was the desire for additional support from leadership to facilitate or ensure that medics have adequate time and opportunities to complete pre-deployment training. Medics need the opportunity to participate in "live fire" medical exercises, similar to infantry soldiers, in order to prepare them for their real world mission.[10] Having leadership

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support is critical to optimizing combat casualty care, particularly in the pre-hospital environment where medics frequently operate.[11] If training is not prioritized by leadership, then it may be prone to being overlooked or incorrectly assumed to have been completed, and this false assumption may have dire consequences for the unit. This also includes ensuring that the senior officers responsible for conducting training have adequate time to teach and evaluate medics prior to deployment, which is an ongoing challenge that continues to be present given their numerous responsibilities.[12] Importantly, the TCCC course is now mandatory for all deployed personnel.[5] This is one of the important changes to the pre-deployment training paradigm since 2001, as early implementation of the TCCC Guidelines on the battlefield is now the foundation for combat casualty care. Other important changes include the successive revisions and standardization of the TCCC course over the years; examples include the now uniform recommendations for using tourniquets, which are associated with improved hemorrhage control[13] and survival,[14] and emphasis on resuscitation using whole blood or a balanced ratio of components when possible, as this is also linked to improved survival.[15,16]

The most critical combat casualty care skills used during their most recent deployment from the perspective of the three medic specialty groups are shown in Table 2. The respondents selected several combat casualty care skills that may be life-saving depending on the clinical context, including achieving hemostasis (stop the bleeding), airway management, and intravenous access (presumably for resuscitation).[2] These findings are not surprising given that medics may be the first medical providers that casualties will encounter on the battlefield. More importantly, many medics also reported that additional pre-deployment training would have been beneficial prior to performing these life-saving skills, and these findings from Table 2 underscore

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the need for medics to have sufficient opportunities to practice and sustain these life-saving skills with simulation, live-tissue models, and real-life practice on actual patients. However, medics also need to have broad and diverse skill sets in order to perform all of their duties, and this is reflected in our results. Besides acute trauma care skills, medics need to be proficient in basic medical and nursing skills.[8] These skills – such as intravenous access, medication administration, documentation, gathering vital signs, etc. - are important because during deployments, medics will likely also care for many individuals with non-traumatic diseases or illnesses.[17] Moreover, proficiency in caring for patients with non-traumatic diseases or illnesses is critical for medical force protection.[8] Many medics selected evacuation platforms (e.g., ground evacuation, air evacuation), and these results can be explained by another important responsibility of medics: caring for casualties during transport. Medics frequently serve as the primary caregivers for casualties during transport, so having well-trained medics during the evacuation phase of the combat casualty care continuum can reduce mortality.[18] Finally, in the "Other Topics" sub-category, "Managing a mass casualty event" was selected by nearly 50% or more of the respondents in each of the MOS groups as being a critical combat casualty care skill. This may be because of the unique circumstances of war, where mass casualty events may occur frequently, but also because of the challenges associated with caring for overwhelming numbers of casualties that present with serious injuries simultaneously.[19] Accordingly, over 40% of the respondents reported additional pre-deployment training in this skill would have been beneficial. This will be an important deficiency to address going forward, as future conflicts are expected to be characterized by multi-domain battlefields with large-scale combat operations.[20] Consequently, mass casualty events may need to be managed frequently at medical facilities, particularly those with limited evacuation capabilities.

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As previously noted, many medics reported additional pre-deployment training would have been beneficial prior to performing several life-saving skills. Likewise, Table 2 shows that there were many medics reporting additional training in basic medical and nursing skills, patient care during evacuation, and battlefield medicine topics (e.g., mass casualty event, prolonged field care, etc.) would also have been beneficial prior to deploying. Accordingly, more training in these skills and topics represents one area for improvement in the pre-deployment training paradigm for medics. Another sentiment expressed in several of the free-text comments was the desire for more training that induces stress, which may be another area for improvement. Caring for casualties in the pre-hospital environment can be difficult due to the hostile nature of this treatment setting on the battlefield.[7] However, this is where simulation can be helpful, as realistic exercises can create stress in medics during training.[21] Most importantly, this induction of stress may assist with learning and performance.[22] To facilitate this realistic training, it is important to have experienced instructors who are proficient in the concepts and skills of TCCC. Equally important, these instructors also need to be aware and knowledgeable of the latest updates to the TCCC curriculum.

There were some limitations with this study. As with any study where the subjects are asked to remember events from the past, recall bias likely affects our results, as the median (IQR) length of time between survey completion and most recent deployment was 6 (3-8) years, and respondents that had pre-deployment training closer to when they completed the survey may have better recollection of their experiences. An important limitation is the low response rate, and the relatively small sample size may limit the ability to generalize our results to all medics in

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the Army. We did not have access to civilian e-mail addresses, but this could be helpful in the future, as sending survey links to both civilian and military e-mail addresses may lead to a better response rate. Some respondents had difficulty accessing the survey due to Army firewall restrictions, and this likely contributed to the low response rate. Our survey did not ask the medics about the number of casualties they treated, their assigned duties, or the tempo of combat operations during their deployment, and we suspect these factors would have influenced their responses to several of the survey questions. Consequently, this is information that will need to be gathered in future studies. Another limitation is related to the Dunning-Kruger effect, as highly competent individuals may be more likely to accurately estimate their personal competence level compared to individuals with low competence.[23] That is, more experienced medics may recognize their limited knowledge, skills, and abilities, and therefore moderate their confidence ratings compared to less experienced medics. Finally, all but one of the respondents was from the Active component, so our results may not be generalizable to National Guard or Reserve component members. Furthermore, our findings may be even less generalizable to civilian paramedics. However, with the growing interest in incorporating the TCCC Guidelines into their own practices by civilian Tactical Emergency Medical Support units,[4] determining if civilian prehospital providers would benefit from more opportunities to participate in courses that cover the principles of TCCC or providing trauma care in tactical settings would be important.

In terms of the relevance of this study going forward, our findings allow us to make several recommendations with regards to medic pre-deployment training. Medics should receive as much training in critical care, emergency medicine, and trauma care as possible. Specific

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emphasis and focus should be placed on learning the life-saving interventions within these specialties, as medics may need to perform these emergent procedures in the pre-hospital setting. Medics should also be comfortable with basic medical and nursing skills, and caring for casualties in situations specific to the combat theater, including evacuation, mass casualty incidents, and prolonged field care scenarios. In particular, with future conflicts expected to be characterized by a more lethal, complex, and logistically challenging environment, proficiency in the skill sets needed for casualty care during evacuation, mass casualty incidents, and prolonged field care scenarios will be imperative. During simulations and hands-on training experiences, they should be as realistic as possible so that medics can experience the challenges, difficulties, and stress that comes with caring for severely injured casualties during active combat operations. Leadership support is important to ensuring medics have adequate access to pre-deployment training courses and instructors so that they can stay abreast of the latest changes and updates to the TCCC curriculum. Most importantly, with sufficient opportunities to partake in pre-deployment training opportunities – including courses, live-tissue laboratories, simulations, hands-on training, and direct patient care experience in clinical settings – medics can develop the knowledge, skills, and abilities commensurate with their combat casualty care mission requirements. As their number of real world experiences increases, we suspect that their feelings of confidence and preparedness will also improve. These recommendations are based on our results, and we hope that they contribute to the current data and understanding of medic pre-deployment training by suggesting opportunities for improvement in the future.

Conclusion:

We conducted a survey of Army medics who deployed to a prehospital setting to assess

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their pre-deployment training for combat casualty care. The respondents reported many skills relevant to critical care, emergency medicine, and trauma as being important. Moreover, basic medical and nursing skills, along with several battlefield medicine competencies were also felt to be critical when treating combat casualties. Accordingly, many respondents felt additional pre-deployment training in several of these skills would have been beneficial. Moreover, respondents with more deployment experience or completion of more pre-deployment training reported feeling more confident and prepared to provide combat casualty care. Importantly, there are some aspects of the pre-deployment training paradigm that need improvement. A frequent sentiment among the respondents was the desire for more training of any form prior to deployment, with examples including, but not limited to, classes, hands-on training, live-tissue/cadaver/simulations, medical skills, and clinical rotations. Moreover, it is also important to ensure that medics have protected time and resources devoted to pre-deployment training, and between deployments, have ongoing opportunities for sustainment and improvement of their clinical skills, along with access to qualified instructors who are proficient in combat casualty care. As medics frequently are the first medical providers who casualties encounter on the battlefield, their contributions to the care team should be valued, and ensuring that they feel confident and prepared to provide combat casualty care is critical to protecting the health of the force. There are important limitations to this study, such as the low response rate and recall bias due to when the TCCC course was taken relative to completion of the survey, but the findings set the stage for future work. Given the self-report limitations related to the Dunning-Kruger effect, actual competence using patient-centered outcomes based on completion of pre-deployment training courses (e.g., TCCC) and confidence in performing combat casualty care skills should be assessed.

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Figure Legend:

Figure 1. Flow diagram identifying included and excluded respondents

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Figure 1

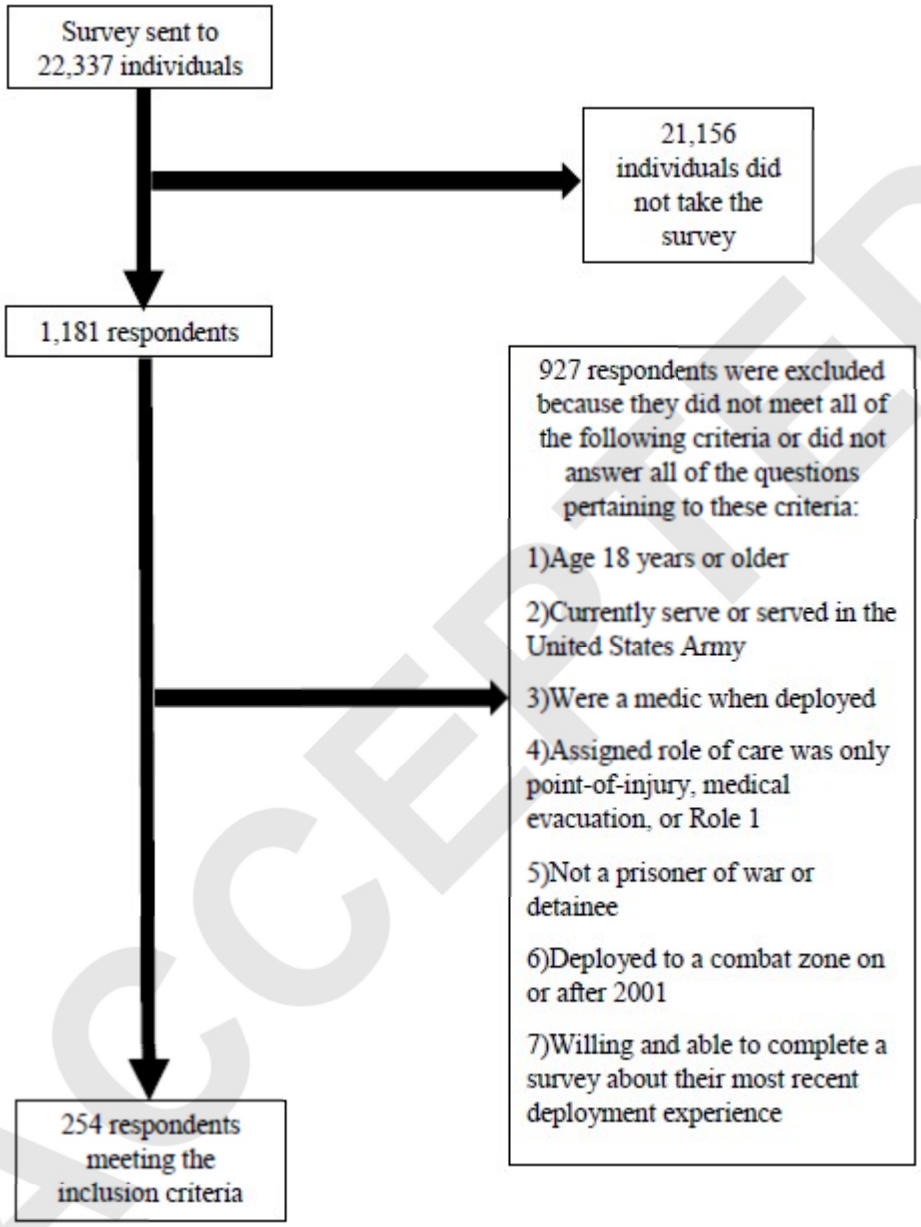

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Table 1. Demographics and deployment details of study respondents (n=254)

Gender, n (%)		
Female	21	(8.3)
Male	233	(91.7)
Affiliation, n (%)		
US Army- Active duty	253	(99.6)
US Army- Reserves	1	(0.4)
Age at beginning of most recent deployment, n (%)		
18 to 24 years	54	(21.3)
25 to 34 years	146	(57.5)
35 to 44 years	52	(20.5)
45 to 54 years	2	(0.8)
Rank at beginning of most recent deployment, n (%)		
E-1 to E-4	71	(28.0)
E-5 to E-6	157	(61.8)
E-7 to E-9	26	(10.2)
Military occupational specialty at beginning of most recent deployment, n (%)		
Combat medic	212	(83.5)
Flight medic	23	(9.1)
Special operations combat medic	19	(7.5)
Time interval between completion of survey and most recent deployment		
Respondents in which this information could be determined, n (%)	237	(93.3)
Median (IQR), years	6	3-8
Number of deployments to a combat zone (including most recent deployment), n (%)		
1	74	(29.1)
2	83	(32.7)
3+	97	(38.2)
Most recent deployment location, n (%)		
Afghanistan	151	(59.4)
Iraq	60	(23.6)
Kuwait	14	(5.5)
Other	13	(5.1)
Other area in the Middle East	10	(3.9)
Africa	6	(2.4)
Years of experience at beginning of most recent deployment, n (%)		
<3 years	45	(17.7)
≥3 years to <5 years	57	(22.4)
≥5 years to <10 years	90	(35.4)
≥10 years to <15 years	51	(20.1)
≥15 years	11	(4.3)
Years of military service prior to most recent deployment, n (%)		

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<3 years	42	(16.5)
≥3 years to <5 years	51	(20.1)
≥5 years to <10 years	92	(36.2)
≥10 years to <15 years	56	(22.0)
≥15 years	13	(5.1)
Evaluated for individual clinical competency prior to most recent deployment, n (%)		
Yes	174	(68.5)
No	80	(31.5)

Abbreviations: US-United States, IQR-interquartile range

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Table 2. The most critical combat casualty care skills used and skills which may have benefited from additional individual pre-deployment training during most recent deployment (n=254)

	Total		Combat Medic		Flight Medic		Special Operations Combat Medic	
	n	%	n	%	n	%	n	%
Total	254	100.0	212	83.5	23	9.1	19	7.5
Most critical combat casualty care skills used								
Tactical Combat Casualty Care Skills								
Preparing the casualty for evacuation/movement	254	100.0	130	61.3	11	47.8	12	63.2
Achieving hemostasis (stop the bleeding)	172	67.7	145	68.4	15	65.2	12	63.2
Intravenous fluid therapy	149	58.7	124	58.5	14	60.9	11	57.9
Airway management	144	56.7	119	56.1	14	60.9	11	57.9
Preventing hypothermia	109	42.9	90	42.5	9	39.1	10	52.6
Breathing support	95	37.4	76	35.8	10	43.5	9	47.4
Blood management	3	1.2	2	0.9	0	0.0	1	5.3
Basic Nursing Skills								
Medication administration	158	62.2	130	61.3	13	56.5	15	78.9
Intravenous access	154	60.6	128	60.4	14	60.9	12	63.2
Communicating/documenting care	145	57.1	125	59.0	10	43.5	10	52.6
Monitoring vital signs (manually)	141	55.5	121	57.1	10	43.5	10	52.6
Monitoring vital signs (electronically)	82	32.3	64	30.2	12	52.2	6	31.6
Providing Care In Various Locations								
Under fire	110	43.3	98	46.2	6	26.1	6	31.6
Ground evacuation	80	31.5	71	33.5	2	8.7	7	36.8
Prolonged field care scenario	76	29.9	59	27.8	6	26.1	11	57.9
Air evacuation	64	25.2	38	17.9	15	65.2	11	57.9
Managing Various Patient Types								
Burns	97	38.2	84	39.6	7	30.4	6	31.6
Fractures	83	32.7	74	34.9	4	17.4	5	26.3
Penetrating eye injuries	33	13.0	28	13.2	4	17.4	1	5.3
CBNRE	15	5.9	12	5.7	1	4.3	2	10.5
Cardiac	3	1.2	1	0.5	1	4.3	1	5.3
Amputations	1	0.4	1	0.5	0	0.0	0	0.0
Other Topics								
Managing a mass casualty event	126	49.6	103	48.6	13	56.5	10	52.6
Other	35	13.8	30	14.2	2	8.7	3	15.8
None/no trauma care used	16	6.3	14	6.6	1	4.3	1	5.3
Disease and non-battle injuries	5	2.0	4	1.9	0	0.0	1	5.3
Skills which may have benefited from additional individual pre-deployment training								
Tactical Combat Casualty Care Skills								

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Airway management	90	35.4	76	35.8	10	43.5	4	21.1
Breathing support	72	28.3	58	27.4	9	39.1	5	26.3
Intravenous fluid therapy	72	28.3	62	29.2	9	39.1	1	5.3
Preparing casualty for evacuation/movement	71	28.0	62	29.2	6	26.1	3	15.8
Achieving hemostasis (stop the bleeding)	70	27.6	61	28.8	7	30.4	2	10.5
Preventing hypothermia	57	22.4	49	23.1	8	34.8	0	0.0
Basic Nursing Skills								
Medication administration	115	45.3	97	45.8	14	60.9	4	21.1
Communicating/documenting care	81	31.9	66	31.1	9	39.1	6	31.6
Intravenous access	61	24.0	53	25.0	7	30.4	1	5.3
Monitoring vital signs (manually)	47	18.5	41	19.3	5	21.7	1	5.3
Monitoring vital signs (electronically)	42	16.5	35	16.5	7	30.4	0	0.0
Providing Care In Various Locations								
Prolonged field care scenario	127	50.0	111	52.4	11	47.8	5	26.3
Ground evacuation	69	27.2	57	26.9	7	30.4	5	26.3
Air evacuation	56	22.0	46	21.7	8	34.8	2	10.5
Under fire	53	20.9	48	22.6	4	17.4	1	5.3
Managing Various Patient Types								
Burns	68	26.8	58	27.4	6	26.1	4	21.1
CBNRE	53	20.9	44	20.8	4	17.4	5	26.3
Fractures	51	20.1	44	20.8	5	21.7	2	10.5
Penetrating eye injuries	46	18.1	39	18.4	4	17.4	3	15.8
Other Topics								
Managing a mass casualty event	102	40.2	91	42.9	9	39.1	2	10.5
Other	73	28.7	60	28.3	5	21.7	8	42.1
None	58	22.8	47	22.2	4	17.4	7	36.8
All Of The Above	2	0.8	1	0.5	0	0.0	1	5.3

Abbreviations: CBRNE-Chemical, biological, radiological, nuclear, explosive

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Table 3. Confidence and preparedness during most recent deployment with respondents grouped by the number of deployments (n=254)

	Total		1 deployment		2 deployment		3+ deployments	
	n	%	n	%	n	%	n	%
Total	254	100.0	74	29.1	83	32.7	97	38.2
Confidence in providing combat casualty care during most recent deployment								
Not At All Prepared	1	0.4	0	0.0	1	1.2	0	0.0
Slightly Prepared	14	5.5	6	8.1	5	6.0	3	3.1
Moderately Prepared	49	19.3	26	35.1	13	15.7	10	10.3
Very Prepared	91	35.8	28	37.8	34	41.0	29	29.9
Fully Prepared	99	39.0	14	18.9	30	36.1	55	56.7
Preparedness during most recent deployment								
Not At All Prepared	0	0.0	0	0.0	0	0.0	0	0.0
Slightly Prepared	11	4.3	2	2.7	5	6.0	4	4.1
Moderately Prepared	53	20.9	30	40.5	15	18.1	8	8.2
Very Prepared	102	40.2	28	37.8	39	47.0	35	36.1
Fully Prepared	88	34.6	14	18.9	24	28.9	50	51.5

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Table 4. Comments about wanting more pre-deployment training from respondents that reported feeling not at all, slightly, or moderately confident to provide combat casualty care (n=64) when asked about what would have increased their efficiency or effectiveness during their most recent deployment[a]

	n	%
Courses, skills, training, etc. particularly related to battlefield medicine/combat casualty care (TCCC, BCT3, prolonged field care, etc.)	22	34.4
Hands-on, live-tissue, cadaver, medical skills (sutures, lines, tubes, IVs, RSI, etc.)	14	21.9
Did not directly specify wanting more training based on comments	9	14.1
ATLS/ACLS/EMT courses, etc. (including any courses not otherwise specified)	8	12.5
Realistic/Stress/MOS specific training	8	12.5
Clinical rotations/EMT ride-along opportunities	6	9.4
Sick call	2	3.1
Sustainment	1	1.6
No response	1	1.6

[a]The comments from some respondents described wanting more than one training experience, opportunity, or program

Abbreviations: TCCC-Tactical Combat Casualty Care, BCT3-Brigade Combat Team Trauma Training, IV-intravenous, RSI-rapid sequence intubation, ATLS-Advanced Trauma Life Support, ACLS-Advanced Cardiac Life Support, EMT-emergency medical technician, MOS-military occupational specialty

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Table 5. Confidence and preparedness during most recent deployment with respondents grouped by the completion of TCCC, additional/other, or no pre-deployment training (n=254)

	Total		TCCC and additional training		TCCC only		Other training		No Training	
	n	%	n	%	n	%	n	%	n	%
Total	254	100.0	123	48.4	83	32.7	13	5.1	35	13.8
Confidence in providing combat casualty care during most recent deployment										
Not At All Prepared	1	0.4	1	0.8	0	0.0	0	0.0	0	0.0
Slightly Prepared	14	5.5	7	5.7	2	2.4	0	0.0	5	14.3
Moderately Prepared	49	19.3	13	10.6	23	27.7	3	23.1	10	28.6
Very Prepared	91	35.8	43	35.0	31	37.3	6	46.2	11	31.4
Fully Prepared	99	39.0	59	48.0	27	32.5	4	30.8	9	25.7
Preparedness during most recent deployment										
Not At All Prepared	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Slightly Prepared	11	4.3	5	4.1	2	2.4	1	7.7	3	8.6
Moderately Prepared	53	20.9	17	13.8	23	27.7	2	15.4	11	31.4
Very Prepared	102	40.2	51	41.5	32	38.6	6	46.2	13	37.1
Fully Prepared	88	34.6	50	40.7	26	31.3	4	30.8	8	22.9

Abbreviations: TCCC-Tactical Combat Casualty Care

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Suresh, M. R., Valdez-Delgado, K. K., VanFosson, C. A., Trevino, J. D., Mann-Salinas, E. A., Shackelford, S. A., & Staudt, A. M. (2020). Anatomic injury patterns in combat casualties treated by forward surgical teams. *Journal of trauma and acute care surgery, 89*(2S), S231-S236. doi:10.1097/ta.0000000000002720

Gurney, J. M., Staudt, A. M., del Junco, D. J., Shackelford, S. A., Mann-Salinas, E. A., Cap, A. P., . . . Martin, M. J. (2021). Whole blood at the tip of the spear: A retrospective cohort analysis of warm fresh whole blood resuscitation versus component therapy in severely injured combat casualties. *Surgery*.

Suresh, M. R., Valdez-Delgado, K. K., Staudt, A. M., Trevino, J. D., Mann-Salinas, E. A., & VanFosson, C. A. (2021). An Assessment of Pre-deployment Training for Army Nurses and Medics. *Military Medicine, 186*(1-2), 203-211.

Suresh, M. R., Staudt, A. M., Trevino, J. D., Valdez-Delgado, K. K., VanFosson, C. A., & Rizzo, J. A. (2021). Characteristics of burn casualties treated at Role 2 in Afghanistan. *Journal of trauma and acute care surgery, Publish Ahead of Print*. doi:10.1097/ta.0000000000003161

Suresh, M. R., Valdez-Delgado, K. K., Staudt, A. M., Trevino, J. D., Papalski, W. N., Greydanus, D. J., . . . VanFosson, C. A. (2021). Pre-deployment training of Army medics assigned to prehospital settings. *Journal of Trauma and Acute Care Surgery*.

From:	Galin, Chaya L CIV USARMY MEDCOM AISR (USA)
To:	VanFosson, Christopher A (Chris) LTC USARMY MEDCOM AISR (USA)
Cc:	Trevino, Jennifer D CTR USARMY MEDCOM AISR (USA); Staudt, Amanda M CTR USARMY MEDCOM AISR (USA); USARMY JB San Antonio MEDCOM AISR Mailbox RCD-HUMAN
Subject:	RE: Closure of H-15-010
Date:	Wednesday, November 18, 2020 8:54:10 AM

LTC VanFosson,

RRCD will close out all activities on our end for the project " Evaluation of Role 2 (R2) Medical Resources in the Afghanistan Combat Theater: Past, Present and Future (H-15-010)"

If this project has HRPO approval, please let them know of this closure.

V/R
Chaya

From: VanFosson, Christopher A (Chris) LTC USARMY MEDCOM AISR (USA) <christopher.a.vanfosson.mil@mail.mil>
Sent: Tuesday, November 17, 2020 3:59 PM
To: USARMY JB San Antonio MEDCOM AISR Mailbox RCD-HUMAN <usarmy.jbsa.medcom-aisr.mbx.rcd-human@mail.mil>
Cc: Trevino, Jennifer D CTR USARMY MEDCOM AISR (USA) <jennifer.d.trevino3.ctr@mail.mil>; Staudt, Amanda M CTR USARMY MEDCOM AISR (USA) <amanda.m.staudt2.ctr@mail.mil>
Subject: Closure of H-15-010

RRCD Team,

The research team has completed work on protocol H-15-010. As such, I would like to close the protocol and formally end all activities related to it.

My understanding from the e-mail attached, this e-mail is all that is needed to close this protocol. If anything further is need, please let me know.

Respectfully,

cvf

Christopher A. (Chris) VanFosson, PhD, MHA, RN, NEA-BC
Lieutenant Colonel, Army Nurse

Chief, Clinical Research Support Group
US Army Institute of Surgical Research
Joint Base San Antonio - Fort Sam Houston, Texas

Chair, Institutional Review Board
Headquarters, US Army Medical Research and Development Command
Fort Detrick, Maryland

O: 210-916-6379
C: 210-771-1089

NIPR: christopher.a.vanfosson.mil@mail.mil
SIPR: christopher.a.vanfosson.mil@mail.smil.mil (please send heads up email to NIPR)

MAXIMUS AD MILEM ("World-Class for the Soldier")

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CLASSIFICATION: UNCLASSIFIED

From:	Rodriguez, Marissa A CIV USARMY FUTURES COMMAND (USA)
To:	VanFosson, Christopher A (Chris) LTC USARMY FUTURES COMMAND (USA)
Cc:	Trevino, Jennifer D CTR USARMY MEDCOM AISR (USA); USARMY JB San Antonio MEDCOM AISR Mailbox RCD-HUMAN
Subject:	Closure acknowledgement for H-16-022x (PI: LTC VanFosson)
Date:	Friday, December 4, 2020 1:56:03 PM

LTC VanFosson:

SUBJECT: Closure acknowledgement: "**Evaluation of Healthcare Systems Training for Combat Casualty Care (CCC) Skills**", US Army Institute of Surgical Research, JBSA Fort Sam Houston, TX 78234-7767, Log # H-16-022x, PI, LTC Christopher VanFosson, PhD, MHA, RN

The RRCD received a final report on 18 November 2020 and reviewed with some correspondence with PI.

Please consider this email the acknowledgement and approval of the above referenced protocol on 04 December 2020.

There are no further human subjects protections issues to be addressed. The RRCD file will be closed and archived.

Further information regarding this review, contact Marissa Rodriguez at marissa.a.rodriguez18.civ@mail.mil or 210-539-4431/210-379-4842.

V/R,
Marissa

Marissa A. Rodriguez, M.S.
Chief, Research Regulatory Compliance Division
Human Protections Director
United States Army Institute of Surgical Research
BHT1 (Bldg. 3611)
3698 Chambers Pass
JBSA Fort Sam Houston, TX 78234-7767
210-539-4431 (office)
210-379-4842 (personal cell phone)-please try this number first during public emergency COVID-19
210-413-9082 (office cell phone)
210-539-3387 (fax)
marissa.a.rodriguez18.civ@mail.mil

From:	Galin, Chaya L CIV USARMY USAISR (USA)
To:	VanFosson, Christopher A (Chris) LTC USARMY MEDCOM BAMC (USA); Rodriguez, Marissa A CIV USARMY FUTURES COMMAND (USA); Voelker, Amber N CIV USARMY USAISR (USA)
Cc:	Trevino, Jennifer D CTR USARMY FUTURES COMMAND (USA); Staudt, Amanda M CTR USARMY USAISR (USA)
Subject:	RE: H-16-023 (Surgeon Case Log) (UNCLASSIFIED)
Date:	Tuesday, October 19, 2021 8:07:02 AM

CLASSIFICATION: UNCLASSIFIED

LTC VanFosson,

RRCD has closed out the project H-16-023x. Please ensure de-identification and retention of any data is as listed in the protocol.

V/R
Chaya

Chaya Galin, MS, BSN, RN, CCRC
210-539-1246
Cell 210-739-4903

From: VanFosson, Christopher A (Chris) LTC USARMY MEDCOM BAMC (USA) <christopher.a.vanfosson.mil@mail.mil>
Sent: Monday, October 18, 2021 4:49 PM
To: Galin, Chaya L CIV USARMY USAISR (USA) <chaya.l.galin.civ@mail.mil>; Rodriguez, Marissa A CIV USARMY FUTURES COMMAND (USA) <marissa.a.rodriguez18.civ@mail.mil>; Voelker, Amber N CIV USARMY USAISR (USA) <amber.n.voelker.civ@mail.mil>
Cc: Trevino, Jennifer D CTR USARMY FUTURES COMMAND (USA) <jennifer.d.trevino3.ctr@mail.mil>; Staudt, Amanda M CTR USARMY USAISR (USA) <amanda.m.staudt2.ctr@mail.mil>
Subject: H-16-023 (Surgeon Case Log)

RRCD Team,

We would like to close the H-16-023 (Surgeon Case Log) protocol. Funding for this project has lapsed and we will not move forward with any further protocol-related procedures.

If you have any questions/concerns, please let me know.

Respectfully,

cvf

Christopher A. (Chris) VanFosson, PhD, MHA, RN, NEA-BC
Lieutenant Colonel (Promotable), Army Nurse

Chief, Center for Nursing Science & Clinical Inquiry

Deputy Consultant to The Surgeon General for Nursing Research
Brooke Army Medical Center
Joint Base San Antonio - Fort Sam Houston, Texas

Chair, Institutional Review Board
Headquarters, US Army Medical Research and Development Command
Fort Detrick, Maryland

O: 210-916-8619
C: 210-380-9536

NIPR: christopher.a.vanfosson.mil@mail.mil

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DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY MEDICAL RESEARCH AND DEVELOPMENT COMMAND
810 SCHREIDER STREET
FORT DETRICK, MARYLAND 21702-5000

FCMR-RPI 5 November 2021

MEMORANDUM FOR THE RECORD

SUBJECT: Final Report Acceptance and Closure of the Protocol, "A Comprehensive Evaluation of Patients Treated at Role 2 Surgical Units in Afghanistan," Principal Investigator: LTC Christopher VanFosson, USAISR, San Antonio, TX, USAISR Protocol Log H-18-00, IRB Protocol Number M-10723

1. The HQ USAMRDC IRB received a final report and request to close the protocol on 22 October 2021. A review of the submitted closure documents finds them in compliance with Federal, Department of Defense, and U.S. Army human subjects protection requirements. The report is accepted.

2. There are no further human subjects protection issues to be addressed. The IRB approval for the protocol is ended and no further review of the protocol will be conducted by the HQ USAMRDC IRB. The IRB Office protocol file will be closed.

3. Please note any further activities must be in accordance with local institutional policy.

4. The IRB Office point of contact for this action is Marizel S. Davila-Figueroa, Ph.D., General Dynamics Information Technology, at marizel.s.davila-figueroa.ctr@mail.mil. .

11/5/2021

X Amanda Kelley

Signed by: USA
AMANDA M. KELLEY, PhD
Designated IRB Member
Headquarters, U.S. Army Medical Research and Development Command Institutional Review Board

From:	DHA NCR J-6 Mailbox DSA MAIL
To:	Trevino, Jennifer D CTR USARMY FUTURES COMMAND (USA)
Cc:	DHA NCR J-6 Mailbox DSA MAIL; VanFosson, Christopher A (Chris) LTC USARMY MEDCOM BAMC (USA)
Subject:	Executed DHA DSA #21-2708
Date:	Wednesday, October 13, 2021 7:08:52 AM
Attachments:	DSAA 21-2708 Approved DRT for Genl Extractions_OtherThanMDR_9.2.2021.pdf DSAA #21-2708 Approved.pdf DHA DUA #21-2708 for LDS Executed.pdf

---

Dear Ms. Trevino,

The fully executed DHA DSA #21-2708 with the incorporated DHA DSAA and Approved DRT are attached for your records. For questions or additional assistance, please contact the DHA Privacy Office's Data Sharing Support Team at DHA.DataSharing@mail.mil.

**** RENEWAL/CHANGE NOTICE ****:
The DSA will expire on 01/30/20Y22 and will then need to be renewed. The DHA Privacy and Civil Liberties Office (Privacy Office) automatically grants a 60-day grace period ending on 04/01/2022.
* All DSA templates can be downloaded from the DSAA website at:
Caution- https://www.health.mil/Military-Health-Topics/Privacy-and-Civil-Liberties/Submit-a-Data-Sharing-Application/Templates
* To modify the DSA, complete a *DSA Modification Request* template. In order to process request(s) in a timely manner, please complete and digitally sign all applicable fields.
* To renew the DSA, complete a *DSA Renewal Request* template. In order to process request(s) in a timely manner, please complete and digitally sign all applicable fields.
* If the DSA is for DoD operations support, include updated ATO details (as applicable) and any other applicable supporting documentation with the DSA Renewal Request.
* If this DSA has one or more DHA HIPAA Safeguard Review of Non-Federal Systems (HSRs) on file, a * HSR * template for each company, Updated ATO details (as applicable) and any other applicable supporting documentation must be submitted with the DSA Renewal Request.
* If this DSA is for research, a copy of most recent IRB and/or HRPP Continuing Review Approvals (if applicable), Updated ATO details (as applicable) and any other applicable supporting documentation must be submitted with the DSA Renewal Request.
* If the DSA needs to be closed (i.e., the project is complete, the contract ended, or the data is no longer needed), please complete the *Certification of Data Disposition (CDD)*. Once received, the Privacy Office will add the CDD to the file and close your DSA.

Send all DSA submissions to the DHA Privacy Office's Support Team at DHA.DataSharing@mail.mil. Please allow a minimum of (10) business days for processing.

V/r,
Data Sharing Support Team
DHA.DataSharing@mail.mil

Deloitte Consulting, Contractor
In Support of the Defense Health Agency
Administration and Management (J-1)

Privacy and Civil Liberties Office
7700 Arlington Boulevard, Suite 5101
Falls Church, VA 22042-5101

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DHA Privacy and Civil Liberties Website:
https://health.mil/Military-Health-Topics/Privacy-and-Civil-Liberties

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Defense Health Agency
Data Sharing Agreement Application

Table of Contents

Click a heading below to advance directly to the desired DSAA section:

PROJECT TITLE	SECTION 1, Page 2
CONTACT INFORMATION	SECTION 2, Page 2
SUPPORT / CONTRACT ARRANGEMENTS	SECTION 3, Page 3
PROJECT DESCRIPTION / JUSTIFICATION FOR DATA USE	SECTION 4, Page 3
DATA DE-IDENTIFICATION, PUBLISHING AND REPORTING	SECTION 5, Page 4
DATA FLOW, USE AND MANAGEMENT	SECTION 6, Page 5
RESEARCH REQUESTS	SECTION 7, Page 6
SOURCE AND TYPE OF DATA	SECTION 8, Page 7
ADDITIONAL INFORMATION	SECTION 9, Page 8
SYSTEM SECURITY INFORMATION	SECTION 10, Page 8
APPLICABLE SUPPORTING DOCUMENTATION	SECTION 11, Page 8
CERTIFICATIONS	SECTION 12, Page 9
RESPONSIBILITIES	APPENDIX A, Page 10
DE-IDENTIFIED, SENSITIVE AND PROPRIETARY DATA	APPENDIX B, Page 11
EXAMPLE DATA FLOW	APPENDIX C, Page 12
BUSINESS ASSOCIATE FUNCTIONS AND SERVICES	APPENDIX D, Page 13
DEFINITIONS, ACRONYMS AND REGULATORY REQUIREMENTS	APPENDIX E, Page 14

Privacy Office Use
DSAA # 21-2708

Defense Health Agency
Data Sharing Agreement Application

The Data Sharing Agreement Application (DSAA) is designed to assist the Defense Health Agency (DHA) Privacy and Civil Liberties Office (Privacy Office) with its consideration of prospective data uses involving DHA data. Each application is reviewed to confirm that the potential data use, described therein, complies with the applicable privacy and security regulatory requirements.

Both the Applicant and the Government Sponsor, defined below, must complete this application. As the DSAA is project or contract-specific, not individual data user-specific, only the names of the Applicant and Government Sponsor should be specifically referenced. Upon approval, this application will be incorporated into a Data Sharing Agreement (DSA).

The Privacy Office neither grants system access, nor provides data extractions; however, prior to gaining access to, or an extraction of the data, the appropriate program office may require an executed DSA.

See Appendices A - E for applicable requirements, responsibilities, definitions, acronyms, and examples.

1. PROJECT TITLE

Comprehensive analysis of humanitarian care in combat zones

2. CONTACT INFORMATION

a. **Applicant:** *See Appendix A for a full description of responsibilities*
If contractors will access the data, the Applicant must be from the **primary contracting organization**.

(i) Indicate the type of Applicant:

☑ Contractor ☐ Government Employee or Service member ☐ Researcher in DoD-Supported Study
☐ Academic Researcher ☐ Other *(Describe):*

(ii) Enter Applicant's Professional Contact Information:

Applicant Name		Title or Rank	
Jennifer Trevino		CTR	
Company or Organization		Street Address	
The Geneva Foundation at USAISR		3698 Chambers Pass	
City	State	Zip	Country
JBSA Fort Sam Houston	TX	78234	USA
Phone Number		E-mail Address	
210-539-8729		jennifer.d.trevino3.ctr@mail.mil	

b. **Government Sponsor :***See Appendix A for a full description of responsibilities*

(i) Enter Government Sponsor's Professional Contact Information:

Government Sponsor Name		Title or Rank	
Christopher A. VanFosson		LTC (P)	
Office or Agency		Street Address	
Brooke Army Medical Center (BAMC)		3551 Roger Brooke Drive	
City	State	Zip	Country
JBSA Fort Sam Houston	TX	78234	USA
Phone Number		E-mail Address	
(210) 916-8619		christopher.a.vanfosson.mil@mail.mil	

3. SUPPORT / CONTRACT ARRANGEMENTS

a. Select the type of arrangement under which this project was awarded, and provide the arrangement number:

☐ Contract ☑ Grant ☐ Cooperative Research and Development Agreement (CRADA)

☐ Other: *Describe any other type of arrangement, or if support arrangement is not applicable (i.e. government only)*

b. Support Arrangement Number, *if applicable:* W81XWH-15-2-0085

c. Current Option Year Period of Performance (PoP) Dates:
(*Not supported by contract? List expected start and completion dates.)*

PoP Start: 30 SEP 2015 PoP End: 30 JAN 2022

d. Other Primary Contractors: (*Each primary contracting organization using the data is required to submit a separate DSAA)*

NA

e. Subcontracting Organizations

(i) List each subcontracting organization that will have access to or use of the data:

NA

(ii) Briefly describe how subcontractor(s) will use the data:

NA

f. The support arrangement referenced above includes business associate agreement language: ☐ Yes ☑ No
If this data use involves PHI, a modification to incorporate business associate language into the support arrangement may be required before the DSAA is approved. Language may be found on the Privacy Office website

4. PROJECT DESCRIPTION / JUSTIFICATION FOR DATA USE

Describe the intended data use, including a justification of why the data are needed.
If this response exceeds the space available, attach additional pages.

The research team proposes to undertake a descriptive analysis of humanitarian care provided to local nationals and non-coalition personnel by the US military from 2005 to present. In addition, the team will compare this information to like cohort data from Médecins Sans Frontières (MSF) conflict missions operating in the same time frame. The primary goal of this study is to gain greater insight into the types of injuries suffered by civilians and the care provided to them in modern conflict settings. The intent of this study is to gain a further understanding of workload, types of patients and similarities to the humanitarian care system for local national/civilian care. In the future operating environment, civilian care may be integrated into the trauma system; having a better understanding of the epidemiology of injury as well as similarities and differences to care provisioned by humanitarian organizations will help with planning, training and refinement of the deployed trauma system in a combat zone. This analysis will be descriptive in order to elucidate the epidemiology of humanitarian needs in the target population. The team will assess patient records to extract information on demographics, diagnosis, injury specifics where applicable, relevant clinical data, and outcomes. This study has the potential to contribute significantly to improvements in humanitarian response in conflict zones as well as coordination between actors operating in the humanitarian space. Additionally, this study will inform planners about the training and logistical needs of military missions to support humanitarian responses in conflict zones.

5. DATA DE-IDENTIFICATION, PUBLISHING AND REPORTING

a. If the use or storage of data involves variables that have been de-identified according to DoDM 6025.18, complete this section; otherwise, skip to section 5b. (*See Appendix B for more information)*

(i) Indicate the intended de-identification method:

☐ Expert Determination ☐ Safe Harbor ☑ Combination (Expert Determination & Safe Harbor)

(ii) Describe data de-identification steps (i.e., encryption, redaction, small cell size eradication):

The study team will request DoDTR data (see DRT) from the Joint Trauma System (JTS), in the form of an excel spreadsheet, using the standard JTS process. JTS will provide the study team with the most up-to-date data available. Once obtained, the Research Nurse will convert procedure and admission dates to a "days post injury" format. Injury month and day will then be deleted, leaving only the year of injury. The research database will then be shared with other research team members listed on the protocol for analysis.

Please see attached De-Identification Plan on the next page for additional details.

(iii) Indicate the parties who intend to de-identify the data, and their role(s) for this project:

The Research Nurse, Nicole Caldwell, de-identified the data from JTS as described above.

(iv) Justify any use of proprietary and sensitive data (e.g., pharmacy dispensing/ingredient cost):

NA

(v) If applicable, list any remaining identifiers associated with the 18 HIPAA categories of PHI:

Injury, procedure and admission dates will be included in the data received from JTS, However, these dates will be converted to days since injury. Only the injury year will remain.

b. Publishing, Reporting or Other Data Release

(i) Describe the audience to whom the data will be reported

Intended audiences include the broader healthcare community, DoD and Department of State leaders, non-governmental organization personnel, and the international humanitarian community.

(ii) Indicate the type of information that will be published, reported, or otherwise released

Aggregate data will be published and/or reported at DoD and academic conferences IAW DoD guidance including USAISR OPSEC/PAO approval. None of the HIPAA 18 identifiers, including dates, will be published or reported outside of the research team.

Below is a sample de-identification plan. Please use the template below to provide the de-identification process to be used for your project. The plan should show how MHS sensitive data elements (or quasi-identifiers) will be de-identified as well as how the 18 HIPAA identifiers will be handled (e.g., dropped, collapsed, etc.). Please email DHA.DataSharing@mail.mil if you have any questions.

DHA DSAA #:

Project Title: Comprehensive analysis of humanitarian care in combat zones

In order to de-identify data, the USAISR research nurse will de-identify the 18 categories of HIPAA identifiers as follows:

18 HIPAA Identifiers	De-identification process
Name	N/A
Geographic location (zip codes)	N/A
Dates	Procedure and admission dates will be converted to a "days post injury" format. Injury month and day will then be deleted, leaving only the year of injury.
Telephone numbers	N/A
Fax numbers	N/A
Emails	N/A
SSN	N/A
MRN	N/A
Health plan beneficiary numbers	N/A
Account numbers	N/A
Certificate/license numbers	N/A
Vehicle ID numbers	N/A
Device ID numbers	N/A
URLs	N/A
IP addresses	N/A
Biometric identifiers	N/A
Full face photography	N/A
Any other unique identifying number	N/A

Demographics: Age, race, and gender will be collapsed into general categories. Below are examples of categories of demographic variables commonly provided:

Age	Race	Gender	Country of Origin
</= 12	American Indian, Alaskan Native, Hawaiian, or Pacific Islander	Male	Specify
13-19	Asian	Female	
20-29	Black		
30-39	Other: Specify		
40-49			
50-59			
60-69			
>/= 70			

Free Text Fields: N/A

Cell Size: N/A

6. DATA FLOW, USE AND MANAGEMENT

a. Describe the intended flow, use, and storage of the data (from time of receipt through the project's duration). Include diagrams and/or illustrations as separate attachments, if necessary (*See the example in Appendix C*)

The study team requested DoDTR data (see DRT) from the Joint Trauma System (JTS), in the form of an excel spreadsheet, using the standard JTS process. JTS provided the study team with the most up-to-date data available. All data was transferred from JTS to the study team via secure means, such as Secure Access File Exchange (SAFE) or encrypted email.

The dataset received from JTS contained dates of injury, pre-hospital and hospital procedures, and admission. To protect subject privacy, procedure and admission dates will be converted to number of days post injury. Injury month and day will then be deleted, leaving only the year of injury. This de-identification of data will occur as soon as possible after receipt of data and will be performed by the research nurse. Data collection and analysis will occur at the U.S. Army Institute of Surgical Research (USAISR). Comparative data will be obtained from published data and compared against like cohorts, as available.

All study investigators are affiliated with the USAISR and have proper agreements including a research grant. The dataset will not be transferred to anyone outside of the entity without proper agreements and approvals. While the study is being conducted, the data will be stored on USAISR password protected servers, shared by the PI and study personnel. The data will be stored in this manner throughout the course of this study and for at least three years following its completion. Upon closure, the Information Management Division (IMD) staff created a shared sub-folder in the USAISR archival drive for potential future study. To maintain control over the integrity of the data, the dataset will not be archived in any removable media format. Future access to this data will only be granted by the PI or IMD after a formal determination of research not involving human subjects has been approved or after IRB review/approval of a research protocol. Future access to this data will also require a new data sharing agreement.

b. Check any item(s) below that apply to the data use:

(i) ☐ Data will be accessed by login using the following access level:

(ii) ☑ Data will be received as an extraction provided by: DHA Joint Trauma System or USAISR Study Team

(iii) Equipment intended for data use is: ☑ Government Furnished Equipment (GFE)
☐ Non-Government Furnished Equipment

(iv) How often will data be obtained? ☐ Daily ☐ Monthly ☐ Yearly ☑ As needed *(explain)*
one time

7. RESEARCH REQUESTS

Complete this section if data will be used for a systematic investigation, intended for generalizable knowledge involving information about individuals. Otherwise, skip to the next section.

- The protocol must be approved by an Institutional Review Board (IRB)
- If the protocol was reviewed by a non-DoD primary IRB, the DHA Human Research Protections Program (HRPP) must review the research documentation
- The Sponsor must ensure that any publication/release complies with DoD requirements
- For more information, visit the *DHA Human Research Protection Program web page*
- If this request involves the use of PHI, the DHA Privacy Board will be advised. For more information about the DHA Privacy Board process, visit the *DHA Privacy Board web page*

a. Principal Investigator Information

PI Name	Research Organization
Christopher A. VanFosson	Brooke Army Medical Center (BAMC)
Street Address	**City**
3698 Chambers Pass	JBSA Fort Sam Houston

State	Zip	Country
Texas	78234	USA

Phone Number	E-mail Address
210-916-8619	christopher.a.vanfosson.mil@mail.mil

b. Protocol Information

(i) Title of Research Project Protocol

Comprehensive analysis of humanitarian care in combat zone

(ii) Name of Primary IRB:

US Army Institute of Surgical Research (USAISR) Institutional Review Board

(iii) If the primary IRB is outside of the DoD, provide the DHA HRPP Protocol Review Determination reference number:

NA

(iv) If this data use involves a survey of 10 more individuals, indicate the survey license information below:

Survey License Number:	Survey License Expiration Date:
NA	NA

(v) If this protocol has changed, and will modify a previously executed DSA, describe the protocol changes:

NA

8. SOURCE AND TYPE OF DATA

a. Indicate the DHA system(s) from which the data will be obtained:

- Data must be limited to the minimum necessary for accomplishing the described purpose. (*See Appendix E*)
- The type of agreement (PII excluding PHI, PHI, Limited Data Set or De-identified) is determined by the specific data elements requested, or by the type of data that may be accessed via direct login.

☐ MDR ☐ M2 ☐ DMSS ☐ AHLTA ☐ CHCS
☐ PDTS ☐ PEPR ☐ ESSENCE ☐ DMHRSi ☐ Essentris
☑ Other (specify):

Department of Defense Trauma Registry (DODTR)

b. Identify whether the data will include only a set of specific data elements, or if all the data elements from a system file are needed. Check any that apply and provide details as directed.

(i) ☑ This request includes specific data elements from the following system(s):

Department of Defense Trauma Registry (DODTR) - see attached DRT

(ii) ☐ This request includes all data in the following system(s):

NA

(iii) Provide justification for requesting the use of all data within a system:

NA

c. Specify files and data elements. Download and attach the applicable Data Request Template (DRT).
Data specification in another format is acceptable

- DRT Military Health System Data Repository (MDR) Extractions (*contact DSA Mailbox to request the latest template)*
- General Data Request Template (to list extracted data from systems other than MDR)
- DRT Access by Login (to list data intended to obtain via direct login)

ci. The Privacy Office does not confirm compliance for non-DHA systems.
Permissions to use non-DHA data should be obtained from the respective system managers

(i) If the DHA data will be merged, linked, or otherwise associated with data from any other sources outside of DHA, explain why, and by what method the DHA and non-DHA data will be associated?

NA

(ii) List the non-DHA systems:

NA

9. ADDITIONAL INFORMATION

If PII will be electronically collected, maintained, used, or disseminated, provide the following information:

a. Storage database/system name:

NA

b. System of Records Notice (SORN) number, applicable to the system in which the data will be stored, if an item, collection, or grouping of information will be created with the intent of retrieving an individual's information using a unique identifier:

NA

10. SYSTEM SECURITY INFORMATION

If data will be stored, processed, maintained or used on DoD approved equipment, include the DoD approval information below (e.g., Authority to Operate). If necessary, consult with the technical representative(s) responsible for maintaining the MTF's computing resources (e.g., *DoD Security Authorization Decision document*).

a. Provide DoD Approval Information for each network on which extracted DHA data will be transferred:

DoD Network / System Name	Authorization Decision	Authorization Termination Date
U.S. Army Institute of Surgical Research (USAISR) ISS	ATO	08/22/2022

b. List any organizations, that will store, process, maintain or use the data on equipment that is not DoD approved (e.g. contractor, academic institution equipment):

NA

If the data contain individual identifiers, a Health Insurance Portability and Accountability Act (HIPAA) Safeguard Review of Non-Federal Systems (HSR) template must be completed by each organization indicated above.
The HSR is available on the DSA templates page of the Privacy Office web site.

11. APPLICABLE SUPPORTING DOCUMENTATION

Check all documents that will be submitted in support of this DSAA

- ☐ Data Flow Diagram
- ☑ De-Identification Plan
- ☑ Other (briefly describe):
- ☑ Data Request Template(s)
- ☑ IRB Determination
- ☑ Study Protocol
- ☐ HSR Template(s)
- ☐ HRPO Determination
- ☐ Letter(s) of Support

USAISR Annual Report Humanitarian

Submit DSAA and supporting documentation to:
DHA.DataSharing@mail.mil

12. CERTIFICATIONS

The initials, provided by the Applicant and Government Sponsor, verify that the responses in this application are truthful and accurate. These representatives agree to promptly notify the Privacy Office of any project change(s) that may affect the data use reflected in this DSAA.

The parties acknowledge that after this application is approved, the Privacy Office will send the appropriate Data Sharing Agreement (DSA) to the Applicant (referenced as the Recipient on the DSA) and the Government Sponsor for signature.

After receiving the Recipient/Sponsor-signed DSA, the Privacy Office will provide final signature and forward the executed DSA, which incorporates the approved DSAA, to the Recipient and Government Sponsor.

APPLICANT	GOVERNMENT SPONSOR
By electronically initialing this application, I certify that this application is submitted with my consent	By electronically initialing this application, I certify that this application is submitted with my consent
Typed Initials: JT **Date:** 09/01/2021	**Typed Initials:** cvf **Date:** 09/02/2021

PRIVACY NOTICE

Data Sharing Agreements are project or contract-specific, not individual data user-specific. Only the names and professional contact information of the Applicant and Government Sponsor should be listed. The names and contact information for the listed individuals are maintained so information and notices can be sent to these individuals. It may be protected under the provisions of the Privacy Act of 1974 and only released as permitted by law.

PRIVACY OFFICE SIGNATURE

DSAA APPROVAL

ABRAMS.CLARENCE.ARTHUR.1069130395

Digitally signed by ABRAMS.CLARENCE.ARTHUR.1069130395
Date: 2021.10.12 13:35:42 -04'00'

Ms. Rita DeShields
Data Sharing Compliance Manager
Defense Health Agency Privacy and Civil Liberties Office
7700 Arlington Boulevard, Suite 5101
Falls Church, VA 22042-5101
Main: 703-275-6363

DEFENSE HEALTH AGENCY
DATA SHARING AGREEMENT APPLICATION

APPENDIX A

RESPONSIBILITIES

DSAA APPLICANT / DSA RECIPIENT RESPONSIBILITIES:

- Provide and maintain accurate and complete DSAA responses
- Agree to and execute a DSA after the DSAA is approved by the Privacy Office
- Ensure the project abides by the submitted protocol and the stipulations as stated in the DSA
- Assume physical or contractual liability for preserving the data integrity
- Fulfill Business Associate Agreement (BAA) requirements, if applicable
- Submit a DSA modification request template to notify the Privacy Office of any data use, storage or disclosure changes
- Follow DHA breach notification and response procedures (in the event of potential or actual loss, theft, or compromise of data) as outlined on the Privacy Office website
- Notify the Privacy Office, no later than 30 days after the completion of the project or the DSA expiration (unless requesting renewal), by submitting a Certification of Data Disposition (CDD)

GOVERNMENT SPONSOR RESPONSIBILITIES:

- Examine the intended project to avoid both duplication and unnecessary generation of DHA data
- Verify that the data are used in compliance with applicable privacy and security standards
- Confirm that publications, or any other release of data results/findings, adheres to DoD requirements
- Affirm scientific merit, feasibility and usefulness in relation to the MHS mission, goals, and objectives
- Assure that the project outcomes will benefit DoD
- Certify that accurate and complete responses are reflected in the DSAA
- Agree to and execute a DSA once the DSAA is approved by the Privacy Office
- Provide Applicant/Recipient oversight for the duration of the project reflected in the DSA
- Ensure that the BAA requirements, if applicable, are fulfilled
- Assure that DHA breach notification and response procedures are followed (in the event of potential or actual loss, theft, or compromise of data) as outlined on the Privacy Office website
- Serve as the Government (military or DHA civilian personnel) Point of Contact
- Maintain current contact information with the Privacy Office
- Sign a DSA modification request template to endorse any data use, storage or disclosure changes
- Endorse timely DSA renewal, if necessary
- Authorize the submission of a CDD no later than 30 days after DSA expiration

DEFENSE HEALTH AGENCY
DATA SHARING AGREEMENT APPLICATION

APPENDIX B

DE-IDENTIFIED, AGGREGATE, SENSITIVE AND PROPRIETARY DATA

A. The HIPAA Privacy Rule provides two methods by which health information may be de-identified
   1. Expert Determination Method:
      - This expert must have knowledge of and experience with the statistical and scientific procedures used to de-identify PHI and is competent in determining that the risk of identifying an individual from the de-identified data, when used alone or in combination with other information, is very small.
      - This expert must document the methods and results of the analysis that justify such determination.
   2. Safe Harbor Method:
      - All 18 of the HIPAA direct individual identifier categories (including those of the individual or their relatives, employers, or household members) are removed.

B. Data Aggregation is included in the Final Rule's list of business associate services
   1. Data aggregation involves grouping independent but similar information components of gathered data into summary form, generally for purposes such as statistical analysis (i.e., grouping summary information about specific groups based on definite variables such as age, profession, or income).
   2. Aggregate data is not automatically categorized as de-identified data. To ensure that aggregated health data is de-identified in compliance with HIPAA, the appropriate methods must be used to determine that the data cannot be used alone or in combination with other information to identify an individual.

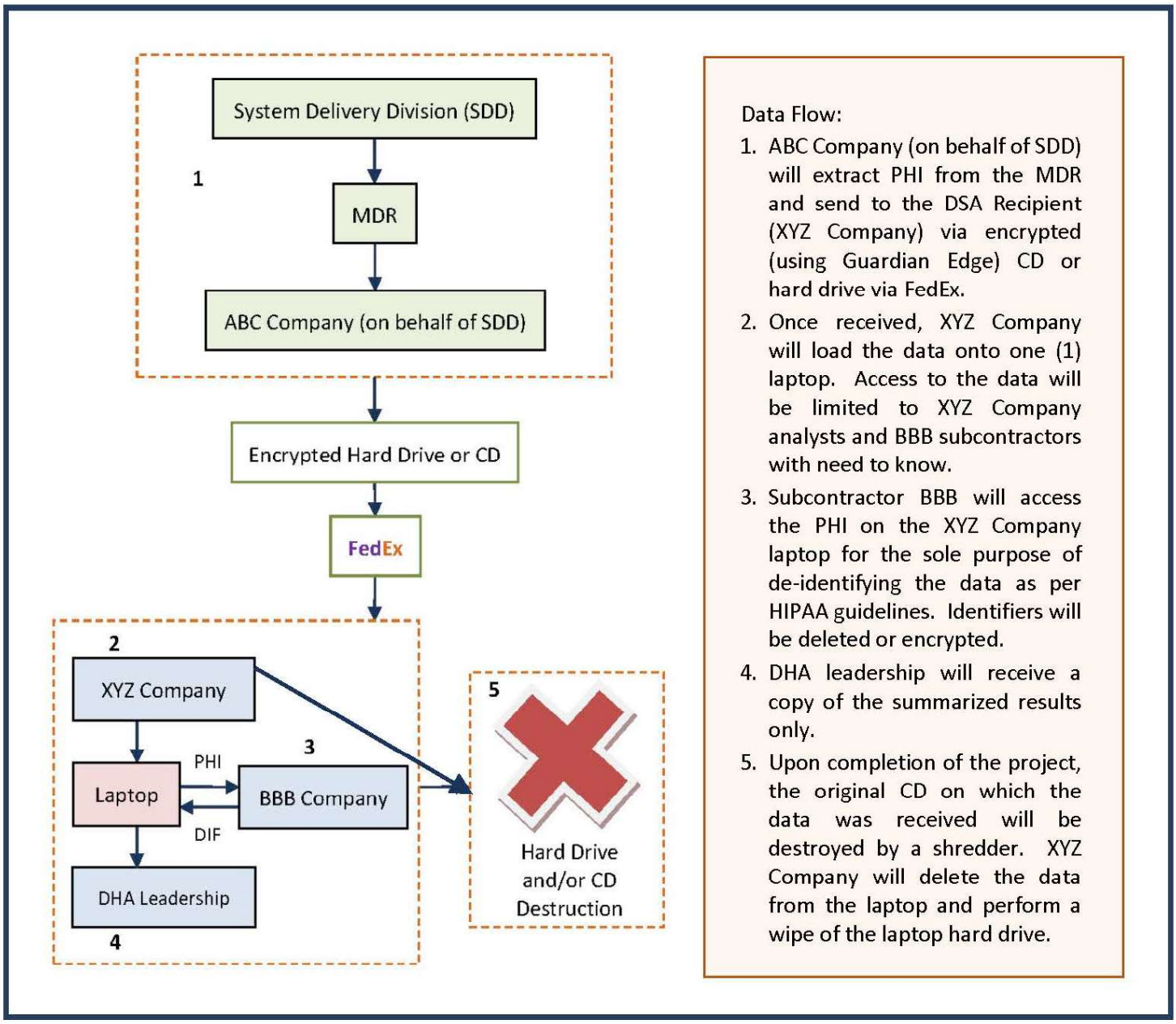
C. The potential use of or access to sensitive or proprietary business, technical, financial, and/or source selection information belonging to the Government or other contractors must be safeguarded so as not to cause adverse effects on organizational operations, organizational assets, or individuals.
   1. Protection of proprietary information prevents the compromise of property rights or economic interest, reduces risk to a contractor's commercial position, and safeguards the Government's ability to obtain access to or use of the data.
   2. Sensitive data includes cost comparisons and price quotes, Government spend plan data, contractor technical proposal data, independent Government cost estimates, negotiation strategies and contractor data presented in negotiations, contracting plans and statements of work.

D. When documenting the intended method of de-identification, keep the following questions in mind:
   1. How will the 18 categories of HIPAA identifiers be removed? (explain encryption/redaction processes)
   2. How will small cell size be determined?
   3. How will small cell sizes be eliminated? (i.e., redacted, rolled up, etc.)
   4. How will the process for ensuring minimum risk of data re-identification be explained?
   5. How will the combination of fields be reduced to ensure minimum risk of re-identification? *(In other words, how will the requestor deal with the potential ability to triangulate data to come up with data that's small enough to identify an individual?)*
      - Examples of combination fields:
        i. Cross tab of data sets
        ii. Connecting data (i.e., users with access to areas where data may be combined with information obtained from another system, potentially deducing a person's identity)

DEFENSE HEALTH AGENCY
DATA SHARING AGREEMENT APPLICATION

APPENDIX C

EXAMPLE DATA FLOW (AS INDICATED IN SECTION 5A)
Data Flow Diagram – XYZ Company for DSAA #XX-XXXX "Analysis for DHA Leadership"



Data Flow:

1. ABC Company (on behalf of SDD) will extract PHI from the MDR and send to the DSA Recipient (XYZ Company) via encrypted (using Guardian Edge) CD or hard drive via FedEx.
2. Once received, XYZ Company will load the data onto one (1) laptop. Access to the data will be limited to XYZ Company analysts and BBB subcontractors with need to know.
3. Subcontractor BBB will access the PHI on the XYZ Company laptop for the sole purpose of de-identifying the data as per HIPAA guidelines. Identifiers will be deleted or encrypted.
4. DHA leadership will receive a copy of the summarized results only.
5. Upon completion of the project, the original CD on which the data was received will be destroyed by a shredder. XYZ Company will delete the data from the laptop and perform a wipe of the laptop hard drive.

DEFENSE HEALTH AGENCY
DATA SHARING AGREEMENT APPLICATION

APPENDIX D

HIPAA DEFINED BUSINESS ASSOCIATE FUNCTIONS AND SERVICES

A. An individual or organization, that performs one or more of the following functions or services on behalf of a covered entity, may be a business associate, according to HIPAA:

1. Performs or assists in performance of one or more of the following functions or activities, involving the use or disclosure protected health information (PHI), such as:
   - Data analysis
   - Claims processing or administration
   - Utilization review
   - Quality assurance reviews
   - Any other function or activity regulated by the HIPAA Administrative Simplification Rules, including the Privacy Rule
2. Performs one or more of the following services to or for a covered entity, involving the use or disclosure of PHI, such as:
   - Legal
   - Actuarial
   - Accounting
   - Consulting
   - Data aggregation
   - Management
   - Administrative
   - Accreditation
   - Financial
3. Provides data transmission services of PHI to a covered entity (e.g., Health Information Organization, E-prescribing gateway)
4. Accesses PHI to provide a personal health record on behalf of a covered entity
5. Works for a business associate that delegated a function or service to you that the business associate agreed to provide for a covered entity or for another business associate

B. An individual or organization that fits into one of the four exceptions listed below may not meet the definition of business associate:

1. Covered entity in an organized health care arrangement, performing a covered function/service to, for, or on behalf of the arrangement
2. Government agency that receives or collects PHI to determine eligibility or enrollment in a Government health plan
3. Plan sponsors who only receive PHI from a group health plan that meets HIPAA requirements
4. Health care providers who only receive PHI from a covered entity for purposes of treating individuals

DEFENSE HEALTH AGENCY
DATA SHARING AGREEMENT APPLICATION
APPENDIX E

A. DEFINITIONS

Business Associate: A person or entity, who is not a member of the covered entity's workforce, that creates, receives, maintains, or transmits PHI on behalf of the covered entity or in providing a HIPAA-allowed service to the covered entity that involves the use or disclosure of PHI.

Covered Entity: A health plan, a health care clearinghouse, or a health care provider that conducts one or more HIPAA-covered transactions in electronic form.

DSA Recipient: The individual who initials the DSAA as "Applicant," and functions in the role of Recipient upon DSA execution.

DSAA Applicant: The individual who completes and submits a DSAA and serves as the primary point of contact during the Privacy Office approval process. This individual is generally employed by a non-DoD organization (i.e., contractor, grant recipient, research staff) that supports a Government project or research. Government personnel may meet the definition of Applicant if the data use involves only Government staff (no contractor participation).

Information System: For the purpose of this application, a set of information resources organized for the collection, storage, processing, maintenance, use, sharing, dissemination, disposition, display, or transmission of information. Includes automated information system applications, enclaves, outsourced information technology (IT)-based processes, and platform IT interconnections.

Limited Data Set: A limited set of identifiable patient information as defined in the Privacy Regulations issued under HIPAA.

Minimum Necessary: A covered entity must make reasonable efforts to limit the use, disclosure, or request of PHI to the minimum necessary for accomplishing the described purpose. HIPAA's minimum necessary rule does not apply when disclosing PHI for treatment, to a medical training program, when disclosed to the individual, pursuant to an authorization.

Personally Identifiable Information (PII): Information that can be used to distinguish or trace an individual's identity, such as his or her name, social security number, date and place of birth, mother's maiden name, biometric records, including any other personal information that is linked or linkable to a specified individual.

Protected Health Information (PHI): Individually identifiable health information that is transmitted or maintained by electronic or any other form or medium, except as otherwise contained in employment records held by DHA in its role as an employer.

B. FEDERAL LAW

Privacy Act of 1974, as amended (5 U.S.C. 552a)

HIPAA Privacy and Security Rules (45 C.F.R. 160 & 164)

C. DEPARTMENT OF DEFENSE (DOD) REGULATIONS

DoDD 5400.11, DoD Privacy Program, May 8, 2007

DoD 5400.11-R, DoD Privacy Program, May 14, 2007

DoDI 6025.18, Privacy of Individually Identifiable Health Information in DoD Health Care Programs, Dec. 2, 2009

DoDM 6025.18, Implementation of the HIPAA Privacy Rule in DoD Health Care Programs, Mar. 13, 2019

DoDI 8500.2, Information Assurance (IA) Implementation, Feb. 6, 2003

DoD 8580.02-R, DoD Health Information Security Regulation, Jul. 12, 2007

From: Trevino, Jennifer D CTR USARMY FUTURES COMMAND (USA)
To: Trevino, Jennifer D CTR USARMY FUTURES COMMAND (USA)
Subject: FW: [URL Verdict: Unknown][Non-DoD Source] 2022 ASA Abstract Notification (UNCLASSIFIED)
Date: Thursday, January 20, 2022 8:35:10 PM

CLASSIFICATION: UNCLASSIFIED

From: "Amy O'Keeffe" <AOKeeffe@prri.com < Caution-mailto:AOKeeffe@prri.com > >
Date: Tuesday, January 11, 2022 at 8:54:48 AM
To: "Gurney, Jennifer M COL USARMY MEDCOM AISR (USA)" <jennifer.m.gurney.mil@mail.mil < Caution-mailto:jennifer.m.gurney.mil@mail.mil > >
Cc: "Angela Allard" <AAllard@prri.com < Caution-mailto:AAllard@prri.com > >
Subject: [URL Verdict: Neutral][Non-DoD Source] 2022 ASA Abstract Notification

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AMERICAN SURGICAL ASSOCIATION
142nd Annual Meeting ▪ April 7-9, 2022
Marriott Magnificent Mile ▪ Chicago, IL

Abstract Reference I.D. # 3689228

January 11, 2022

Dear Dr. Gurney:

It is a pleasure to inform you that the Program Committee of the*American Surgical Association (ASA)*has selected your paper titled "**Humanitarian Trauma Care Delivered by US Military Facilities During Combat Operations in Afghanistan, Iraq, and Syria**"to be presented at the 142nd ASA Annual Meeting being held April 7-9, 2022, at the Marriott Magnificent Mile in Chicago, IL.

Please notify your co-authors that this paper has been**accepted** for presentation, as they will not be contacted individually.

To confirm your participation, please respond via reply email by Friday, January 14th

To ensure accuracy in future printed materials, please take the time to review your abstract title and author block (listed below), and include any changes/corrections to your confirmation email. In addition, please include the name of the presenting author. *No additional changes to the body of your abstract will be accepted***Please Note:** *All presenting authors are required to pre-register for theAnnual Meeting. Registration and housing will be available within the week on the*ASA Website. < Caution-Caution-https://meeting.americansurgical.org >

PUBLISHING TITLE	Humanitarian Trauma Care Delivered by US Military Facilities During Combat Operations in Afghanistan, Iraq, and Syria
AUTHOR BLOCK	Jennifer M. Gurney2, Victoria Graf3, Amanda M. Staudt3, Jennifer D. Trevino3, Christopher A. VanFosson4, Hannah Wild5, Sherry M. Wren1 1Surgery, Stanford

	University, Palo Alto, CA, United States. 2US Army Institute of Surgical Research and the DoD Joint Trauma System, San Antonio, TX, United States. 3Geneva Foundation, Fort Sam Houston, TX, United States. 4Brooke Army Medical Center, San Antonio, TX, United States. 5Surgery, University of Washington, Seattle, WA, United States.
PRESENTING AUTHOR	Jennifer Gurney

Once we have received your confirmation, detailed program information will follow (i.e. presentation date, time, time allotment, disclosure slide requirement, etc.).

Again this year, the ASA will be offering CME Credits with Self-Assessment to help attendees meet their Continuous Certification requirements. Should you accept this invitation; we ask that you submit two (2) topic-based questions to test the attendees' understanding of the main points of your presentation. For each question please provide one (1) correct answer (which will be supported by your data and presentation) and three (3) incorrect answers. One of the questions should be a case-based scenario. Note: All questions must include 4 responses, none of which are "All of the Above" or "None of the Above". Please avoid True/False responses as well.**Failure to submit your Self-Assessment Question by Monday, January 17, 2022 may result in your acceptance being revoked.**

Click Here to Submit your Questions < Caution-Caution-https://fs8.formsite.com/AoljNr/2xtsqns09e/index.html >

The ASA Program Committee will be selecting and confirming your Primary Discussant. The Primary Discussant's name and contact information will be provided to you by early March. You will then be asked to share a copy of your manuscript with them 4 weeks prior to the Annual Meeting (by Monday, March 7th).

REQUIRED MANUSCRIPT SUBMISSION: As you acknowledged when you submitted your abstract, manuscript submission is mandatory upon acceptance to present at the meeting. Your manuscript must be submitted before the start time of the Scientific Session at which you are presenting (the details of which will be provided in a follow-up email). Failure to meet this requirement may, for any or all co-authors, jeopardize future acceptance of abstracts for presentation and/or publication.

Once again, congratulations on having your work accepted! If you have any questions, please do not hesitate to contact the Association's Administrative Office at 978-927-8330.

Sincerely yours,

Yolanda Colson, M.D.
Program Committee Chair

Sent on behalf or Dr. Colson by:

Amy O'Keeffe
Meeting Manager
American Surgical Association
aokeeffe@prri.com < Caution-Caution-mailto:aokeeffe@prri.com > | americansurgical.org < Caution-Caution-http://www.americansurgical.org >

CLASSIFICATION: UNCLASSIFIED

Characterization of Humanitarian Trauma Care by US Military Facilities During Combat Operations in Afghanistan and Iraq

Jennifer M Gurney MD, Victoria Graf, Amanda M Staudt PhD, Jennifer D Trevino MBA, Christopher A VanFosson PhD, RN, Hannah Wild MD, Sherry M Wren MD

Objective: Characterize humanitarian trauma care delivered by US military treatment facilities (MTFs) in Afghanistan and Iraq.

Background: The Humanitarian Law of Armed Conflicts, which includes the Geneva Conventions, defines protections and standards of treatment to victims of armed conflicts. In 1949 these standards expanded to include injured civilians. In 2001 the Global War on Terror began in Afghanistan and expanded to Iraq in 2003. US MTFs provided care to all coalition forces as well as civilians. A thorough understanding of civilian trauma care during active combat has not been characterized in terms of injury types, resource requirements, and outcomes.

Methods: Retrospective cohort analysis of the Department of Defense Trauma Registry from 2005-2019. Inclusion criteria were traumatically injured civilians and non-NATO coalition forces (NNCF) treated at MTFs in Afghanistan and Iraq. Patient demographics, mechanism of injury, resource requirements, procedures and outcomes were categorized.

Results: A total of 29,963 casualties were included from the registry. There were 16,749 (55.9%) civilians and 13,214 (44.1%) NNCF. The overwhelming majority of patients were age >12 years [11,865 (82.4%)] and male: civilians 88.4% (14,813) and NNCF 99.8% (13,187). Most injuries were battle related: civilians 76.1% (12,740) and NNCF 84% (11,099) with penetrating trauma as the most common cause of both battle and nonbattle injuries: 74% (12,293) civilian and 76% (10,029) NNCF. Median injury severity score (ISS) was 9 in each group with ISS > 25 in 9.7% (1,624) civilians and 8.3% (1,009) NNCF. The top 3 mechanisms of injury for both cohorts were explosives (civilians 43.2%; NNCF 49.4%), gunshot wounds (civilians 33.8%; NNCF 35.8%), and motor vehicle crash (civilians 9.0%; NNCF 7.4%). Blood products were transfused to 37% of each population: 6,197 civilians were transfused 12,688 blood products, with 2,242 of them receiving >10 units; 4,916 NNCF were transfused 13,132 blood products with 1,798 receiving > 10 units. MTF mortality rates were in 7.5% (1,263) and 5.9% (776) in civilians and NNCF, respectively. Interventions, both operative and non-operative, were similar between both groups. (Table)

Conclusions: In accordance with Humanitarian Law, as well as the US military's medical rules of eligibility, civilians injured in combat zones are provided the same level of care as all other casualties. Injured civilians and NNCFs had similar mechanisms of injury, injury patters, transfusion needs, and ISS. This analysis demonstrates resource equipoise in trauma care delivery to civilians and NNCF. Hospitals in combat zones must be prepared to manage large numbers of civilian casualties with significant human and material resources to optimize survival. The provision of humanitarian trauma care is resource intensive, and these data can be used to inform planning factors for current or future humanitarian care in combat zones.

Interventions	Civilians n (%)	NNCF n (%)
Total Procedures	175,331	140,526
Non OR Procedures		
Xray Services	31,236 (17.8)	24,967 (17.8)
CT scan	24,963 (14.2)	20,226 (14.4)
Wound /Soft Tissue Management	22,972 (13.1)	18,130 (12.9)
Injection/Infusion	15,700 (9.0)	12,264 (8.7)
Ultrasound	8,714 (5.0)	7,147 (5.1)
Airway	6,947 (4.0)	5,322 (3.8)
Invasive monitoring	6,543 (3.7)	5,413 (3.9)
Closed fracture/dislocation	5,722 (3.3)	4,738 (3.4)
Endoscopy	1,376 (0.8)	1,054 (0.8)
Angiogram	1,056 (0.6%)	980 (0.7)
Neuro Monitoring	412 (0.2)	371 (0.3)
OR Procedures		
Orthopedics	10,284 (5.9)	8,062 (5.7)
Skin and Soft tissue	8,069 (4.6)	6,637 (4.7)
Hollow viscous, solid organ	5,362 (3.1)	4,277 (3.0)
Vascular	3,062 (1.7)	2,360 (1.7)
Neuro/Spine	2,273 (1.3)	1,721 (1.2)
Amputation/Reimplantation	1,712 1.0)	1,375 1.0)
Ocular	1,613 (0.9)	1,318 0.9)
ENT	1,075 (0.6)	904 (0.6)
Thoracic	768 (0.4)	590 (0.4)
GU	709 (0.4)	510 (0.4)
Endocrine	343 (0.2)	253 (0.2)
Cardiac	241 (0.1)	172 (0.1)
OB - GYN	20 (0.01)	10 (0.01)

Humanitarian Trauma Care by US Military Treatment Facilities in Global Operational Environments

Graf, Victoria[1]; Staudt, Amanda M[1]; Gurney, Jennifer M[2]; Caldwell, Nicole W[2]; Garcia-Choudary, Tricia L[2]; Trevino, Jennifer D[1]; Wren, Sherry[3]; Wild, Hannah[4]; VanFosson, Christopher[5]

[1]The Geneva Foundation, JBSA Fort Sam Houston, TX; [2]US Army Institute of Surgical Research, JBSA Fort Sam Houston, TX; [3]Stanford University; [4]University of Washington; [5]Brooke Army Medical Center, Joint Base San Antonio, Fort Sam Houston, TX

Background

In recent military conflicts, caring for the local national population, while dependent on the medical rules of engagement, was a significant part of the trauma care delivery. The objective of this analysis was to characterize humanitarian care for local national populations and non-Coalition personnel in global U.S. military medical treatment facilities.

Methods

This study was an observational, retrospective analysis of humanitarian patients in the Department of Defense Trauma Registry (DoDTR). The patients included were local national and non-coalition personnel treated at global operations Role 2 and Role 3 military treatment facilities from 2005 to 2019.

Results

The study population included 35,811 patients (93.5% male). CENTCOM made up the vast majority of patients (83.3%), and the majority of recorded injuries were battle injuries (76.1%). Injury types represented were 71.3% penetrating, 24.6% blunt, 4.0% burn, 0.1% other. Common pre-existing conditions included tobacco use (n=1,819), hypertension (n=542), and diabetes (n=370). Additionally, a total of 396,076 procedures were studied. 87.9% of procedures were done at Role 3 facilities (0.2% Role 1; 11.9% Role 2). The most common procedures were other (as opposed to routine) chest x-ray and non-excisional wound debridement.

Conclusions

In the future operating environment, local national/humanitarian care may be highly integrated into the military trauma system. Having a better concept of understanding regarding the epidemiology of injury, provision of trauma care, and outcomes of humanitarian care will inform many aspects of the combatant command trauma system during combat operations. Specifically, several of the most common pre-existing conditions in this data were not conditions seen frequently in deployed military patients, (e.g. diabetes, obesity, chronic ongoing drug abuse, and pregnancy). Future research should address the burden of humanitarian care procedures and its differences from military care.