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14. ABSTRACT Annual report reviewing progress on the "Connected and Autonomous Procedure Support Tools for Combat Trauma and Mass Casualty Management" project. This report covers work to date and reviews the current collaborators, participants, and overall accomplishments during year two. This report describes a process to develop an offline decisional support tool for facilitation of trauma resuscitative care. This application will leverage procedural video datasets, machine learning, and feedback from subject matter experts to provide guidance to medical personnel attempting advanced critical care procedures.					
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TABLE OF CONTENTS

	Page
1. Introduction	4
2. Keywords	4
3. Accomplishments	4
4. Impact	14
5. Changes/Problems	15
6. Products	17
7. Participants & Other Collaborating Organizations	22
8. Special Reporting Requirements	26
9. Appendices	27

1. INTRODUCTION: *Narrative that briefly (one paragraph) describes the subject, purpose and scope of the research.*

U.S. military units are increasingly organized into smaller elements and operate in remote areas leading to longer evacuation times. This requires increased medical care by inexperienced clinical providers beyond doctrinal timelines, called "prolonged casualty care" (PCC). However, rapid deployment of clinicians who do not regularly work with trauma or critically ill patients to austere locations often results in limited knowledge, skills, and experience to optimally care for critically ill and injured casualties beyond initial Tactical Combat Casualty Care (TCCC). Consequently, it may result in worse patient outcomes for combat support hospitals during the early deployment portion. By implementing advanced telemedicine tools with audio-visual capabilities during PCC, we can enhance inexperienced clinicians' decision-making and, therefore, casualty care. We are collaboratively developing a phone-based application with AR/VR-guided intervention systems to be utilized as a clinical decision-support tool. We hypothesize that the use of this application by equipped medical professionals in simulated trauma scenarios will result in improved performance of medical interventions compared to equally-equipped unassisted professionals.

Our goal is to create an evidence-based interface based on connected clinical decision support systems. We seek to comprehensively evaluate procedural performance to establish a phone-based application with AR/VR guided intervention systems efficacy and explore the benefits it may offer within deployed environments. Management of critically ill patients prior to evacuation to higher echelons of care requires clinical expertise to make judgment-weighted decisions that successfully manage these nuances. Advanced telecommunication devices that enhance communication and situational awareness may provide essential critical care expertise in real-time, decrease mental task load, and comfort clinicians when faced with unfamiliar, challenging problems. In addition, the development of virtual health technology is rapidly increasing in the private sector.

This prospective study aims to facilitate focus group collaboration to achieve a consensus amongst SMEs regarding best practices, scripting strategies, and specific steps to develop a decisional support tool. We also aim to measure clinician performance related to simulated critical care interventions of complex casualties with one of the following groups; comprehensive guided decisional support or no support. The objective is to determine the "best" subject performance.

2. KEYWORDS: *Provide a brief list of keywords (limit to 20 words).*

Artificial Intelligence, Machine Learning, Procedural Video Data Registry, Decisional Support tool, Prolonged Casualty Care, Task Training, Military Medicine

3. ACCOMPLISHMENTS: *The PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction.*

What were the major goals of the project?

List the major goals of the project as stated in the approved SOW. If the application listed milestones/target dates for important activities or phases of the project, identify these dates and show actual completion dates or the percentage of completion.

Specific Aim 1: Test the hypothesis that Scripting is a feasible/efficacious approach to fill capability/resource gaps in prolonged field care	Timeline	% Complete
Major Task 1: Develop and optimize scripts for mentors to guide operators to perform TCCC procedures	Months	
Subtask 1.1: Review Scripts already developed for efficacy		
Subtask 1.1.1 Submit overall project to IRB for determination and HRPO for review	1-3	95%
Subtask 1.2: Collect focus group input for at least 3 levels of end users from non-medical to credentialed provider (e.g. non-medical first responder, combat medic, Special Operations Medic nurse, physician)	1-3	65%
Subtask 1.3: Develop prototype mentoring scripts for end users from non-medical credentialed provider		
1.3.1 at least 2 procedure scripts	3-6	95%
1.3.2 at least two reference CPG selected		
Subject 1.4 Optimize script based on pilot testing of end user performance with script type and success at TCCC procedures	6-12	50%
Will require IRB determination and HPRO review		
Subtask 1.5: Develop Mentor Training knowledge product with the goal to train a mentor to effectively guide a remote provide using the scripts	12-18	70%
Milestone(s) Achieved: 1) ≥ 2 scripts for ≥ 2 training level of operator created for procedure mentoring of TCCC procedure 2) training knowledge product for mentor to present script created		Pending
Milestone(s) Achieved: 1) Submit project to IRB for exemption 2) Submit IRB protocols for project aims deemed HSR	3	Pending
Milestone(s) Achieved: Receive IRB determination and HRPO review	6	Pending
Major Task 2: Develop prototype automated script management software		
Subtask 2.1: Select high yield Clinical Practice Guidelines for initial use by prototype software	1-3	95%
Subtask 2.2: Focus group with intended end users (at least 3 levels of aforementioned		

non-medical to credentialed provider) to determine human use/user interface capabilities/requirements	1-3	65%
Subtask 2.3: Develop prototype of audio assistant	3-12	95%
Subtask 2.4: Test prototype assistant with end user community for feedback and optimization	9-27	70%
Milestone(s) Achieved: 1) Offline capable version of audio assistant prototype created 2) Audio assistant capable of utilizing procedure script 3) Audio assistant capable of utilizing CPG or other reference material		Pending
Specific Aim 2: Demonstrate proof of concept that audio assistance can be utilized by operators in non-connected environments		
Major Task 3: Integrate CPG and mentor script into automated assistant		
Subtask 3.1: Select multiple reference CPGs for incorporation into digital audio assistant	9-27	60%
Subtask 3.2: Select mentor scripts to incorporate into digital audio assistant	9-27	45%
Subtask 3.3: Present prototype assistant references and scripts to end user community for feedback and optimization	12-30	40%
Milestone(s) Achieved: 1) Automated assistant can replay audio of multiple CPG and procedure scripts while disconnected from a network 2) Successful use of automated assistant to assist in procedure completion in simulation lab		Pending
Major Task 4: Demonstrate proof of concept of the effectiveness of mentoring scripts via connected and autonomous delivery		
Subtask 4.1: Test scripts with multiple audience levels via autonomous and connected delivery to establish feasibility to perform procedures and solve clinical problems.	12-36	0%
Subtask 4.2: Perform initial proof of concept of utilizing scripts with augmented reality for procedural mentoring	12-36	20%
Subtask 4.3: Perform initial proof of concept to Integrate Automated Assistant with Augmented Reality and Machine learning capability	12-36	80%
Milestone(s) Achieved: Automated digital assistant demonstrated in field environment during simulated exercise		Pending
Milestone(s) Achieved: 1) Randomized comparative study of automated assistant vs remote connect mentor for procedure completion by local provider complete 2) Pilot demonstrations of AR/VR script utilization (using a mentor) 3) Pilot demonstration of		Pending

AR/VR integration with automated assistant 4) Manuscript developed and submitted for publication for completed milestones		
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What was accomplished under these goals?

For this reporting period describe: 1) major activities; 2) specific objectives; 3) significant results or key outcomes, including major findings, developments, or conclusions (both positive and negative); and/or 4) other achievements. Include a discussion of stated goals not met. Description shall include pertinent data and graphs in sufficient detail to explain any significant results achieved. A succinct description of the methodology used shall be provided. As the project progresses to completion, the emphasis in reporting in this section should shift from reporting activities to reporting accomplishments.

Specific Aim 1: Test the hypothesis that Scripting is a feasible/efficacious approach to fill capability/resource gaps in prolonged field care

Major Task 1: Develop and optimize scripts for mentors to guide operators to perform TCCC procedures

- Subtask 1.1: Review Scripts already developed for efficacy
 - Subtask 1.1.1 Submit overall project to IRB for determination and HRPO for review (**95% complete**)
 - Three IRB protocols are anticipated for this research effort. The first (regarding the formation of focus groups to establish best practices for application development) was approved by local MAMC IRB and OHRO/HRPO review. CRADA is currently pending final signatures. The second protocol (regarding video data collection of simulated procedures) was submitted for regulatory review, however minor stipulations were requested. These stipulations were addressed and the protocol is currently under review following resubmission. The third protocol (to evaluate the efficacy of the decisional support tool) is 70% drafted. **Please see supplemental documents S1, S2, and S3..**
 - Subtask 1.2: Collect focus group input for at least 3 levels of end-users from non-medical to credentialed providers (e.g. non-medical first responder, combat medic, Special Operations Medic nurse, physician) (**65% Complete**)
 - Zotero library group is created with more than 15 articles related to the chatbot and intelligence studies.
 - The Geneva Research Team met with potential collaborators from the Telemedicine and Advanced Technology Research Center (TATRC) to discuss a collaborative video data repository.
 - Formal focus group protocol was approved by local MAMC IRB and HRPO/OHRO with data collection tentatively scheduled for November and December 2023.
 - Subtask 1.3: Develop prototype mentoring scripts for end-users from non-medical to credentialed providers (**95% complete**)
 - 1.3.1 at least 2 procedure scripts
 - The mobile application and desktop host page have undergone continuing review to add procedure sections and refine usability, audio navigation, video upload of various file types (video/mp4, audio/mp3, pdf, docs, PPT, etc.), and procedure creation. **Please see products P4, P5, and P6.**
 - Conducted weekly meetings with Mission First/Zulucare to discuss the overall user experience and functionality of the decisional support application. Mission First/Zulucare has continued to develop mobile wireframes, and also conducted a preliminary internal release of the website for review by their quality assurance team.
 - Additional drafts of prototype mentoring scripts have been developed and integrated into the desktop and mobile-based application platform by the Mission First/Zulucare team. This allows the end user to access and/or download mentoring scripts as: 1) A comprehensive PowerPoint with procedure instructions, audio, and visuals; 2) A step-by-step verb/noun instructional PowerPoint with pictures; and 3) A Text-only document). These documents now encompass all five procedures (tourniquet, needle decompression, chest tube, intraosseous access, and cricothyroidotomy) highlighted in this study effort. These documents have undergone continuing review by physician collaborators. **Please see supplemental documents S4, S5, and S6.**
 - 1.3.2 at least two references CPG selected
 - Subtask 1.4: Optimize script based on pilot testing of end-user performance with script type and success at TCCC procedures (**50% complete**)
 - Research staff and SMEs have conducted ongoing pilot testing with the mobile application while completing simulated procedures to identify areas for improvement in usability and content. **Please see product P10.**
 - Subtask 1.5: Develop Mentor Training knowledge product with the goal to train a mentor to effectively guide a remote provider using the scripts (**70% complete**)
 - Physician collaborators made ongoing contributions to best practices documentation surrounding execution and grading criteria for the five trauma resuscitative procedures. These materials were used to refine mentor scripts (comprehensive

procedure guidance and step-by step instructions) for each of the five procedures, and scripts were uploaded to the application. **Please see supplemental document S7.**

Major Task 2: Develop prototype automated script management software

- Subtask 2.1: Select high yield Clinical Practice Guidelines for initial use by prototype software **(95% Complete)**
 - The video data collection protocol has been resubmitted for MAMC IRB review following completion of requested minor stipulations. The protocol is currently pending further regulatory review. This protocol will gather video data of simulated procedures, which will be annotated for task analysis. Annotations and video content will be sent to our collaborators at Purdue University where they will undergo machine learning analysis for task recognition, to facilitate the development of a software that will manage scripts and procedural guidance. Physician collaborators reviewed current airway management CPG documentation for integration into the application. **Please see supplemental document S8.**
- Subtask 2.2: Focus group with intended end-users (at least 3 levels of aforementioned non-medical to credentialed provider) to determine human use/user interface capabilities/requirements **(65% Complete)**
 - A formal focus group protocol was approved by MAMC IRB and OHRO/HRPO review. Recruitment under this protocol is currently pending completion of the CRADA between the Geneva Foundation and MAMC IRB. This protocol will identify additional priorities in trauma resuscitative care for integration into the CDSS. **Please see supplemental attachment S1.**
- Subtask 2.3: Develop prototype of audio assistant **(95% complete)**
 - The Zulucare/Mission First team has continued to manage and revise the overall application, which is currently compatible with hands-free audio navigation for procedural guidance and now includes various scripts for each procedure to guide the end user. Select research staff have obtained upload authority for integration of additional mentor scripts. **Please see products P4, P5, and P6.**
 - Research staff are currently working with the Geneva contracting team and Mission First to obtain a 12-month, 100 user bundle Picca Voice license. This voice license will be used for future usability testing and our efficacy evaluation protocol, enabling multiple devices to use Trauma THOMPSON's voice navigation feature.
- Subtask 2.4: Test prototype assistant with the end-user community for feedback and optimization **(70% complete)**
 - The Geneva/MAMC team and collaborating SMEs have continued prototype testing of audio assistant, procedure creation, video upload capabilities, and have reviewed new procedural guidance formats to provide feedback for optimization.

Specific Aim 2: Demonstrate proof of concept that audio assistance can be utilized by operators in non-connected environments

Major Task 3: Integrate CPG and mentor script into automated assistant

- Subtask 3.1: Select multiple reference CPGs for incorporation into digital audio assistant **(65% complete)**
 - Research team has continued to review multiple reference CPGs for integration into the digital audio assistant. Airway Management CPG documentation from the Joint Trauma System (JTS) was integrated, however further CPG inclusion will be dependent on the priorities identified through the formal focus group protocol.
- Subtask 3.2: Select mentor scripts to incorporate into digital audio assistant **(45% complete)**
 - Mentor scripts were developed for each procedure based on established best practice task lists/ guidance for each procedure. These materials are currently available for user review in three formats 1) A comprehensive PowerPoint with procedure instructions, audio, and visuals; 2) A step-by-step verb/noun instructional PowerPoint with pictures; and 3) A Text-only document). Additional feedback from the Subject Matter Experts will be collected on the scripts once receiving the IRB and HRPO approval. **Please see supplemental attachment S4, S5, and S6.**
- Subtask 3.3: Present prototype assistant references and scripts to the end-user community for feedback and optimization **(40% complete)**
 - Procedural scripts/guidelines have undergone continuing development based on ongoing literature reviews and machine learning analysis of procedural video data. These guidelines have undergone continuing review by collaborating SMEs in the field of trauma resuscitative care to optimize scripts. The feedback generated from the formal focus group protocol will also be used to guide further review of scripts and guidelines.

Major Task 4: Demonstrate proof of concept of the effectiveness of mentoring scripts via connected and autonomous delivery

- This project was presented at an IPR meeting with the sponsor on April 28th, 2023. **Please see Supplemental Attachment S9.**
- This project has been accepted for the following presentations/manuscripts:
 - 2022 Uniformed Services University of Health Sciences (USUHS) Research Day
 - Presenter: Kyle Couperus, MD
 - Location: Virtual Presentation on 7 December 2022
 - 2022 MHSRS Supplement to Military Medicine
 - 2023 Trauma Association of Canada (TAC)
 - Presenter: Andrew Kirkpatrick, MD
 - Location: Edmonton, Alberta, CA on 20 April 2023

- 2023 Government Services Symposium (GSACEP)
- Presenter: Christina Kim, PY1 EM Intern
- Location: Austin, TX on 14-16 April 2023
- 2023 Military Health System Research Symposium
- Presenter: Jonah Beck, BS
- Location: Kissimmee, FL on 15 August 2023
- 2023 Medical Image Computing and Computer Assisted Intervention (MICCAI) Challenge
- Presenter: Nina Jiang, PhD Candidate from Purdue University
- Location: Vancouver, BC, CAN on 8-12 October, 2023
- 2023 Medical Image Computing and Computer Assisted Intervention (MICCAI) Challenge Publication
- 1. Wachs, J, Jiang, N., Zhuo, Y., Couperus, K., Colombo, C., Birch, E., Gorbalkin., C, Tran, O., Beck, J., DeVane, D., Kirkpatrick, A., McKee. J., (2023). The Trauma THOMPSON Challenge Proposal. International Conference on Medical Image Computing and Computer Assisted Intervention (MICCAI) 2023 (MICCAI 2023). Zenodo.
<https://doi.org/10.5281/zenodo.7835347>

Please see supplemental attachments S10, S11, S12, S13, S14, and S15.

- Subtask 4.1: Test Scripts with multiple audience levels via autonomous and connected delivery to establish feasibility to perform procedures and solve a clinical problem. **(20% Complete)**
 - The procedural scripts have undergone preliminary testing by the research staff to ensure the feasibility of procedural guidance. Additional testing with the end user will be conducted following completion of our efficacy evaluation protocol.

Please see product P10.

- Subtask 4.2: Perform initial proof of concept of utilizing scripts with augmented reality for procedural mentoring **(20% Complete)**
 - Research team conducted preliminary beta-testing of HoloLens augmented reality device with a focus on user interface and user experience. Scripts are currently under development and will be finalized pending completion of focus group protocol.
- Subtask 4.3: Perform initial proof of concept to Integrate Automated Assistant with Augmented Reality and Machine learning capability **(80% complete)**
 - Purdue collaborators continue to refine their machine learning algorithm using additional GoPro video content which was recorded by the research staff at various sites. Further development of this algorithm will occur once the video data collection protocol has been approved by local IRB and HRPO/OHRO. This protocol will expand the procedural video dataset, which will be tagged and analyzed to enhance the machine learning elements of task recognition and action anticipation.
 - The research team continued to record additional procedural videos, expanding the dataset to 212 videos of simulated procedures (chest tube, intraosseous access, tourniquet placement, needle decompression, and cricothyroidotomy). All videos underwent annotation for task analysis. Videos and annotations were utilized by Purdue collaborators to further train the machine learning network and to develop a Visual Question Answering (VQA) system, allowing the machine learning algorithm to analyze images of video data to answer questions such as “is there bleeding present?”. **Please see products P20, P21, P22 and supplemental attachment S16..**
 - The Purdue team has continued to utilize procedural video annotations (using the annotator software and manual transcription) to facilitate landmark identification, task recognition, and action anticipation on a wide range of manikins. The recorded procedures were conducted on a variety of diverse manikins to enable functionality of the machine learning algorithm for a diverse set of patients. Thus far, video content has been provided only by the study's primary investigators. The videos are actively being used to 'train' a computer program on landmark identification and predictive analytics to identify 'next steps' for each procedure. These videos do not include identifiable features, including only the upper extremities of the user and the area of interest on the manikin/simulated patient. These videos will not be used in 'research' but rather for the development of the 'computer program'. The Purdue team is currently working to address challenges with the manikin regarding action recognition and anticipation
 - MICCAI Challenge Website is active to collaboratively enhance task recognition and action anticipation. **Please see Product P24.**

Describe the Regulatory Protocol and Activity Status (if applicable).

Describe the Protocol and Activity Status for sections a-c, as applicable, using the format described for each section. If there is nothing significant to report during this reporting period, state “Nothing to Report.”

(a) Human Use Regulatory Protocols

TOTAL PROTOCOLS: State the total number of human use protocols required to complete this project (e.g., “5 human subject research protocols will be required to complete the Statement of Work”). If not

applicable, write “No human subjects research will be performed to complete the Statement of Work”

TOTAL PROTOCOLS:

3 human subject research protocols will be required to complete the Statement of Work

PROTOCOL (1 of 3 total):

Protocol [HRPO Assigned Number]: 223046

Title: Trauma Alexa: Developing Scripted Autonomous Decisional Support Applications for Medical Intervention During Prolonged Casualty Care.

Target required for clinical significance: 15-30

Target approved for clinical significance: 15-30

SUBMITTED TO AND APPROVED BY:

- The first protocol was approved by local MAMC IRB and OHRO/HRPO review. CRADA is currently pending final signatures from staff at the Geneva Foundation and the MAMC IRB office.

STATUS:

- (i) Number of subjects recruited/original planned target: Planned Target = 15-30
Number of subjects screened/original planned target: Planned Target = 15-30
Number of patients enrolled/original planned target: Planned Target = 15-30
Number of patients completed/original planned target: Planned Target = 15-30

- (ii) Report amendments submitted to the IRB and USAMRMC HRPO for review:

- Nothing to report for this quarter

- (iii) Adverse event/unanticipated problems involving risks to subjects or others and actions or plans for mitigation:

- Nothing to report for this quarter

PROTOCOL (2 of 3 total):

Protocol [HRPO Assigned Number]: Pending

Title: Trauma Alexa: Procedural Video Data Collection for Task Analysis and Machine Learning Review

Target required for clinical significance: 30

Target approved for clinical significance: 30

SUBMITTED TO AND APPROVED BY:

- The second protocol is completely drafted and has undergone multiple rounds of regulatory review and revision with the local MAMC IRB. Most recently, requested minor protocol revisions were submitted on 9/13/23 and are currently under regulatory review.

STATUS:

- (i) Number of subjects recruited/original planned target: Planned Target = 30
Number of subjects screened/original planned target: Planned Target = 30
Number of patients enrolled/original planned target: Planned Target = 30
Number of patients completed/original planned target: Planned Target = 30

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

- Nothing to report for this quarter

(iii) Adverse event/unanticipated problems involving risks to subjects or others and actions or plans for mitigation:

- Nothing to report for this quarter

PROTOCOL (3 of 3 total):

Protocol [HRPO Assigned Number]: Pending

Title: TBD

Target required for clinical significance: 36

Target approved for clinical significance: 36

SUBMITTED TO AND APPROVED BY:

- The third protocol is approximately 70% drafted. Additional content is dependent upon the information yielded by the first and second protocols.

STATUS:

- (i) Number of subjects recruited/original planned target: 36
Number of subjects screened/original planned target: 36
Number of patients enrolled/original planned target: 36
Number of patients completed/original planned target: 36

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

- Nothing to report for this quarter

(iii) Adverse event/unanticipated problems involving risks to subjects or others and actions or plans for mitigation:

- Nothing to report for this quarter

Include & update enrollment chart, showing projected, actual, and cumulative enrollment.

Example			<u>Enter information regarding number of subjects</u>				
<u>HRPO Protocol Number</u>	<u>Protocol PI Name</u>	<u>Organization (Site)</u>	<u># Target</u>	<u># Screened</u>	<u># Enrolled</u>	<u># Completed</u>	<u>Other</u>
223046	Chad Gorbatkin,	Madigan Army Medical	15-30	0	0	0	

	MD	Center					
Pending	Chad Gorbatkin, MD	Madigan Army Medical Center	30	0	0	0	
Pending	Chad Gorbatkin, MD	Madigan Army Medical Center	36	0	0	0	

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

No RDT&E, education or training activities involving human cadavers will be performed to complete the Statement of Work (SOW)

(c) Animal Use Regulatory Protocols

No animal use research will be performed to complete the Statement of Work.

What opportunities for training and professional development has the project provided?

If the project was not intended to provide training and professional development opportunities or there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe opportunities for training and professional development provided to anyone who worked on the project or anyone who was involved in the activities supported by the project. “Training” activities are those in which individuals with advanced professional skills and experience assist others in attaining greater proficiency. Training activities may include, for example, courses or one-on-one work with a mentor. “Professional development” activities result in increased knowledge or skill in one’s area of expertise and may include workshops, conferences, seminars, study groups, and individual study. Include participation in conferences, workshops, and seminars not listed under major activities.

- Dr. Christina Kim (DEM Resident Y1) attended and presented this study at GSACEP 2023.
- Dr. Eleanor Birch (DEM Resident Y2) collaborated with the research team to author the 2022 MHSRS Supplement to Military Medicine

How were the results disseminated to communities of interest?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how the results were disseminated to communities of interest. Include any outreach activities that were undertaken to reach members of communities who are not usually aware of these project activities, for the purpose of enhancing public understanding and increasing interest in learning and careers in science, technology, and the humanities.

Within the last year (currently 2 years into this effort), a manuscript was submitted and accepted

to Military Medicine: Warfighters 2022 Supplement and is currently in press for publication. Posters for the project have also been presented at the 2023 Government Services Symposium (GSACEP) and the 2023 Medical Health System Research Symposium. The study was also accepted for presentation at the 2023 Medical Image Computing and Computer Assisted Intervention (MICCAI) Challenge, for which we have an active website to encourage collaboration and further development of the machine learning algorithm. **Please see supplemental documents S11, S12, S13, S14, and S15.**

Collaborative meetings with other partners (such as TATRC and USHUS) took place to discuss potential future collaboration on this effort.

What do you plan to do during the next reporting period to accomplish the goals?

If this is the final report, state "Nothing to Report."

Describe briefly what you plan to do during the next reporting period to accomplish the goals and objectives.

The following annual report will complete:

The research team will secure approved documentation for video data collection protocol from both IRB and HRPO. Upon HRPO approval, the recruitment and enrollment of study subjects for the video data collection protocols will commence.

In order to finalize the mentor scripts, we plan to enlist 15-30 Subject Matter Experts (SMEs) between November and January 2024 for focus group interviews. Concurrently, as testing and feedback collection from the end user community progresses, we will contact SMEs for video data collection related to five distinct procedures: chest tube insertion, intraosseous access, tourniquet placement, needle decompression, and cricothyroidotomy. The interviews with SMEs will be crucial for identifying priorities in medical intervention and establishing best practices for each procedure. Simultaneously, the research team will continue the development of prototype mentoring scripts and will proceed to test and validate the mobile and web-based applications.

Once the mentor scripts are finalized and based on performance feedback gathered during pilot testing with the end user community, as well as the success of Tactical Combat Casualty Care (TCCC) procedures, the research team will draft the efficacy protocol and submit it to the IRB for approval.

Subsequent to the IRB and HRPO approval of the efficacy protocol, the research team will initiate the recruitment of study subjects for efficacy evaluation and proceed with an initial proof of concept utilizing the scripts for procedural mentoring.

Furthermore, our objective is to submit the manuscript to an alternative journal for publication, incorporating the collected data. Simultaneously, we will pursue additional grants to sustain the momentum of this project and drive further advancements in the development of Trauma THOMSON

4. IMPACT: *Describe distinctive contributions, major accomplishments, innovations, successes, or any change in practice or behavior that has come about as a result of the project relative to:*

What was the impact on the development of the principal discipline(s) of the project?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research in the principal disciplinary field(s) of the project. Summarize using language that an intelligent lay audience can understand (Scientific American style).

This project supports developing a decisional support tool to guide medical personnel in complex critical care procedures. We hypothesize that this will improve the care provided to individuals injured through traumatic mechanisms (military and civilian), particularly when the advanced critical care procedures are outside of the traditional scope of practice for the medical personnel providing care. Extensive progress has been made to provide a strong foundation for application development. The collective expertise of collaborating SMEs on this project has yielded documentation outlining best practices, application content, and videos of investigators completing these critical care procedures.

Please see supplemental documents S4, S5, S6, and S7 as well as products P10 and P20.

Collaborators at Purdue University are utilizing this video data to refine a machine learning system on procedural task recognition and subsequent task prediction. This machine learning system will play an integral role in the decisional support application by offering guidance in real-time, depending on the specific actions being completed. **Please see products P21 and P22.** Additionally, Mission First and Zulucare have continued to develop web and mobile interfaces for the application with continued collaboration by the research team. **Please see products P4 and P5.** The focus group protocol has been approved by local Madigan IRB and HRPO/OHRO. The video data collection protocol is under review by Madigan IRB following completion of additional requested stipulations.

What was the impact on other disciplines?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

While this study primarily focuses on the end product (a decisional support tool), the process of refining the machine learning algorithm will provide additional benefits to the field of artificial intelligence. Using the collected video data and annotations, the Purdue team will develop a system capable of recognizing a large number of medical instruments and identifying hand-tracking patterns associated with each action. This could prove beneficial if the dataset is expanded to include other procedures and could provide a foundation for subsequent unrelated studies involving complex task recognition and predictive analytics.

In addition, our team has identified potential data registries where we could upload the collected procedural video data. This would ideally prove mutually beneficial. The data registry would provide our team with a secure storage platform, and we would contribute valuable video data that could aid in their support of prolonged casualty care.

What was the impact on technology transfer?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use, including:

- *transfer of results to entities in government or industry;*
- *instances where the research has led to the initiation of a start-up company; or*
- *adoption of new practices.*

Through participation in the 2023 Medical Image Computing and Computer Assisted Intervention (MICCAI) Challenge, we have requested that outside collaborators use the data to create an optimal algorithm for action prediction. Collaborators benefit from access to a unique dataset, and our team benefits from their collective expertise regarding machine learning/predictive analytics. This effort aims to enhance the accuracy of the machine learning algorithm in task recognition and action anticipation.

What was the impact on society beyond science and technology?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world on areas such as:

- *improving public knowledge, attitudes, skills, and abilities;*
- *changing behavior, practices, decision making, policies (including regulatory policies), or social actions; or*
- *improving social, economic, civic, or environmental conditions.*

Through the decisional support application, we aim to improve education and the practice of critical care medicine, particularly in deployed environments and prolonged casualty care scenarios. Procedural video data is also crucial for developing a machine learning algorithm capable of complex task recognition and predictive analytics. This could substantially impact subsequent and unrelated projects using task recognition.

5. CHANGES/PROBLEMS: *The PD/PI is reminded that the recipient organization is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction. If not previously reported in writing, provide the following additional information or state, “Nothing to Report,” if applicable:*

Nothing to report.

Actual or anticipated problems or delays and actions or plans to resolve them

Describe problems or delays encountered during the reporting period and actions or plans to resolve them.

No anticipated problems at this time.

Changes that had a significant impact on expenditures

Describe changes during the reporting period that may have had a significant impact on expenditures, for example, delays in hiring staff or favorable developments that enable meeting objectives at less cost than anticipated.

Nothing to report.

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

Describe significant deviations, unexpected outcomes, or changes in approved protocols for the use or care of human subjects, vertebrate animals, biohazards, and/or select agents during the reporting period. If required, were these changes approved by the applicable institution committee (or equivalent) and reported to the agency? Also specify the applicable Institutional Review Board/Institutional Animal Care and Use Committee approval dates.

Significant changes in use or care of human subjects

Nothing to report.

Significant changes in use or care of vertebrate animals

Nothing to report.

Significant changes in use of biohazards and/or select agents

Nothing to report.

6. PRODUCTS: *List any products resulting from the project during the reporting period. If there is nothing to report under a particular item, state “Nothing to Report.”*

- **Publications, conference papers, and presentations**

Report only the major publication(s) resulting from the work under this award.

Journal publications. *List peer-reviewed articles or papers appearing in scientific, technical, or professional journals. Identify for each publication: Author(s); title; journal; volume: year; page numbers; status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

A manuscript was submitted to the 2022 MHSRS Supplement to Military Medicine, also known as the Warfighters 2022 Supplement, and is currently pending publication. This manuscript focused on research methodologies used for this project. **Please see supplemental document S11.**

Books or other non-periodical, one-time publications. *Report any book, monograph, dissertation, abstract, or the like published as or in a separate publication, rather than a periodical or series. Include any significant publication in the proceedings of a one-time conference or in the report of a one-time study, commission, or the like. Identify for each one-time publication: author(s); title; editor; title of collection, if applicable; bibliographic information; year; type of publication (e.g., book, thesis or dissertation); status of publication (published; accepted, awaiting publication; submitted, under review; other); acknowledgement of federal support (yes/no).*

Nothing to report.

Other publications, conference papers and presentations. *Identify any other publications, conference papers and/or presentations not reported above. Specify the status of the publication as noted above. List presentations made during the last year (international, national, local societies, military meetings, etc.). Use an asterisk (*) if presentation produced a manuscript.*

No additional publications, papers, or presentations to report aside from those reflected above. **Please see supplemental documents S9, S10, S11, S12, S13, S14, and S15.**

- **Website(s) or other Internet site(s)**

List the URL for any Internet site(s) that disseminates the results of the research activities. A short description of each site should be provided. It is not necessary to include the publications already specified above in this section.

- [Trauma THOMPSON Website](#) - This site provides an overview of the study efforts and collaborative teams involved in the project.
 - [Trauma THOMPSON MICCAI Challenge Website](#) - This website hosts the video dataset that has been used to develop the machine learning algorithm so far. We have invited other subject matter experts in machine learning to develop additional algorithms for action recognition and anticipation using the data.
 - [Trauma THOMPSON Trailer](#) - This trailer provides a brief video overview of the efforts captured under the Trauma THOMPSON study.

- **Technologies or techniques**

Identify technologies or techniques that resulted from the research activities. Describe the technologies or techniques were shared.

The research team has continued to refine the machine-learning algorithm using expanded procedural video datasets with the end goal of producing an algorithm capable of recognizing a specific task being performed in any of 5 procedures (chest tube, IO insertion, tourniquet, needle decompression, or cricothyroidotomy). Additionally, this algorithm will use the recognized task to predict the following steps. This is accomplished by collecting a large volume of procedural video data, annotating each task in the procedure, and presenting this data to the algorithm for “learning”. A small subsection of the data will be presented to the algorithm for “testing” to establish the accuracy of task recognition and prediction. While the accuracy has continually improved as the size of the dataset increases, this piece of technology is not final and we anticipate further data collection as proposed in Trauma THOMPSON Protocol #3 (currently under regulatory review) is needed to yield a fully functioning machine learning algorithm.

- **Inventions, patent applications, and/or licenses**

Identify inventions, patent applications with date, and/or licenses that have resulted from the research. Submission of this information as part of an interim research performance progress report is not a substitute for any other invention reporting required under the terms and conditions of an award.

Nothing to report.

- **Other Products**

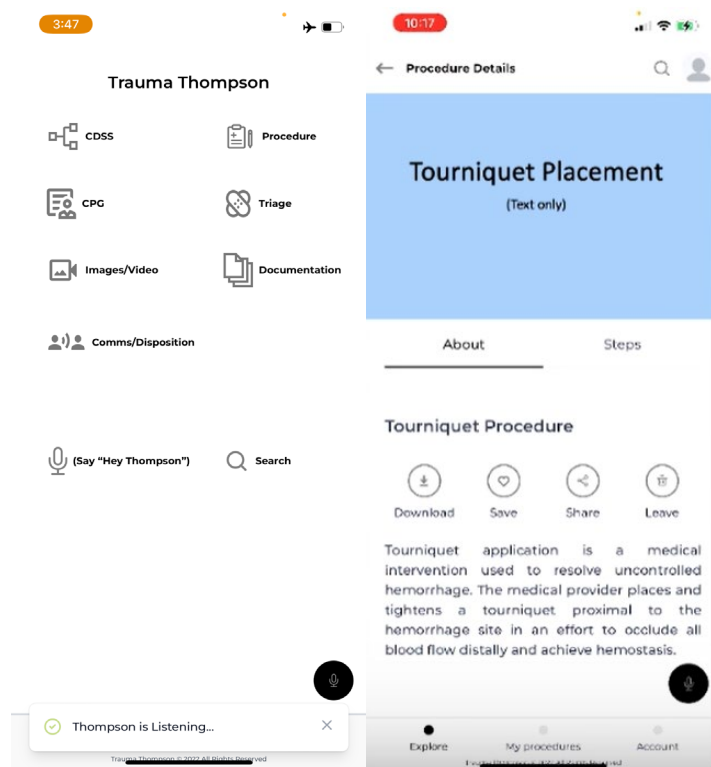
Identify any other reportable outcomes that were developed under this project. Reportable outcomes are defined as a research result that is or relates to a product, scientific advance, or research tool that makes a meaningful contribution toward the understanding, prevention, diagnosis, prognosis, treatment and /or rehabilitation of a disease, injury or condition, or to improve the quality of life. Examples include:

- data or databases;
- physical collections;
- audio or video products ;
- software;
- models;
- educational aids or curricula;
- instruments or equipment;
- research material (e.g., Germplasm; cell lines, DNA probes, animal models);
- clinical interventions;
- new business creation; and
- other.

P1: Approved Focus Group Protocol - Please see supplemental attachment [S1].

P2: Video protocol (under review) - Please see supplemental attachment [S2].

P3: (DRAFT) Efficacy Evaluation Protocol - Please see supplemental attachment [S3].



P4: Trauma THOMPSON application landing page displaying THOMPSON listening for voice commands while the mobile device is in airplane mode displaying offline voice navigation capabilities (left). Title page of tourniquet placement text only content displaying a cover page, options to download, save, and share content with a brief description of what the intervention is and why it is performed (right).

P5: Content uploading page on the Trauma THOMPSON application. Content will be uploaded via the desktop platform and the uploader will be able to include the name of the procedure, their profession, medical category, institution they are associated with, the contents status (draft, review, or published), and a brief summary of the content being uploaded.

P6: [Voice Navigation Demonstration of the Trauma THOMPSON Application](#)

P7: Needle Decompression Text Only - Please see supplemental attachment [S4]

P8: Needle D step-by-step slides (with audio) - Please see supplemental attachment [S5]

P9: Needle D Comprehensive Slides (with audio) - Please see supplemental attachment [S6]



P10: Egocentric video footage of Dr. Couperus applying a tourniquet on a simulated amputated leg under guidance of Trauma THOMPSON mobile application. In this setting, the application provided step-by-step instructions accompanied by images of that step in the procedure. These materials were accessed via hands-free voice navigation.

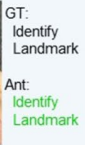
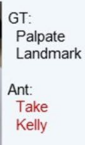
- P11: Procedural Task List Consensus - Please see supplemental attachment [S7]**
- P12: Airway Management CPG - Please see supplemental attachment [S8]**
- P13: Trauma THOMPSON IPR - Please see supplemental attachment [S9]**
- P14: USUHS Research Day 2022 - Please see supplemental attachment [S10]**
- P15: Trauma Thompson MHSRS Manuscript - Please see supplemental attachment [S11]**
- P16: TAC 2023 - Please see supplemental attachment [S12]**
- P17: GSACEP Poster 2023 - Please see supplemental attachment [S13]**
- P18: TT MHSRS Poster 2023 - Please see supplemental attachment [S14]**
- P19: MICCAI TT Challenge Proposal - Please see supplemental attachment [S15]**

	Tourniquet	IO Access	Cricothyroidotomy	Tube Thoracostomy	Needle Decompression	Total Videos
Number of Videos on Human Subjects (using moulage/simulation)	12	12	12	0	0	36
Number of Videos on non-human Manikins/Simulators	35	40	39	35	27	176
Total Videos:	47	52	51	35	27	212

P20: Current videos collected by research staff to develop a foundation for the machine learning algorithm.



P21: Images of the current video dataset, which captures first-person (egocentric) video of providers completing one of the five procedures (tube thoracostomy, cricothyroidotomy, tourniquet application, intraosseous infusion, and needle thoracostomy).

Action Recognition		Action Anticipation		Action Recognition		Action Anticipation		Action Recognition		Action Anticipation	
GT: Evaluate Lungs		GT: Identify Landmark		GT: Take Windlass		GT: Twist Windlass		GT: Insert Kelly		GT: Expand Kelly	
Rec: Evaluate Lungs		Ant: Identify Landmark		Rec: Take Strap		Ant: Take Windlass		Rec: Insert Kelly		Ant: Take Kelly	
GT: Attach Needle		GT: Palpate Landmark		GT: Position Catheter		GT: Insert Catheter		GT: Position Tourniquet		GT: Tighten Strap	
Rec: Take Needle		Ant: Take Kelly		Rec: Position Needle		Ant: Remove Catheter		Rec: Take Strap		Ant: Take Windlass	

P22: This graphic shows accuracy testing of the machine learning algorithm for action recognition (what task is being performed) and action anticipation (what step comes next). The GT is the “ground truth” or “correct” step, and Rec./Ant. represent the “best guess” of the machine learning algorithm.

P23: Tourniquet VQA - Please see supplemental attachment [S16]

P24: [MICCAI Challenge Website](#)

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

Provide the following information for: (1) PDs/PIs; and (2) each person who has worked at least one person month per year on the project during the reporting period, regardless of the source of compensation (a person month equals approximately 160 hours of effort). If information is unchanged from a previous submission, provide the name only and indicate “no change”.

Example:

Name: Mary Smith
Project Role: Graduate Student
Researcher Identifier (e.g. ORCID ID): 1234567
Nearest person month worked: 5

Contribution to Project: Ms. Smith has performed work in the area of combined error-control and constrained coding.

Funding Support: The Ford Foundation (Complete only if the funding support is provided from other than this award.)

Name: Christopher J. Colombo, MD, FACP, FCCM
Project Role: Program Director/ Co-Principal Investigator
Researcher Identifier: ORCID ID 0000-0001-5499-3368
Nearest person month worked: 5.7

Contribution to Project: Dr. Colombo began the project as a Staff Intensivist and Director of Virtual Health and Telecritical Care at Madigan Army Medical Center, and following his

retirement is now employed by the Geneva foundation specifically to work on projects like these. He will serve as the Principal Investigator and will dedicate 10% effort to this project. As the PI for this study, he will be responsible for the overall conduct and oversight of the study at MAMC. Specifically, Dr. Colombo will meet with the research team on a regular basis to review the planning and execution of the proposed project and support coordination and access to the user community for testing and validation. Dr. Colombo will also be responsible for the submission of technical reports and manuscripts generated by this study.

Name: Kyle Couperus, BSN, MD

Project Role: Co-Investigator

Researcher Identifier: N/A

Nearest person month worked: 4.2

Contribution to Project: Dr. Couperus began the project as Research Director in the Department of Emergency Medicine at Madigan Army Medical Center (MAMC) and following his leave from being active duty is now being employed by the Geneva Foundation and reservist at 75th Innovation Command. He serves as a Co-Investigator and will dedicate 3% effort to this project. He will support Dr. Colombo with the overall conduct and oversight of the study at Madigan. Specifically, Dr. Couperus will oversee the execution of simulation scenarios and scripts. He will also meet with the research team on a regular basis to review the experimental design and statistical analysis, as well as support the submission of technical reports and manuscripts generated by this study.

Name: Chad Gorbalkin, MD

Project Role: Co-Investigator/MAMC Site PI

Researcher Identifier: N/A

Nearest person month worked this quarter: 0.12

Contribution to Project: Dr. Gorbalkin began study project as Assistant Program Director of the Emergency Residency Program in the Department of Emergency Medicine (DEM) at Madigan Army Medical Center (MAMC) and is now Attending physician at DEM, MAMC. He serves as a Co-Investigator and will dedicate 1% effort to this project. Dr. Gorbalkin also serves as Principal Investigator on the IRB Research protocols at MAMC. He supports Dr. Colombo with the overall conduct and oversight of the study at Madigan. Specifically, Dr. Gorbalkin oversees the execution of simulation scenarios and scripts. He also meets with the research team on a regular basis to review the experimental design and statistical analysis, as well as support the submission of technical reports and manuscripts generated by this study.

Name: Ross Candelore, DO

Project Role: Co-Principal Investigator

Researcher Identifier: N/A

Nearest person month worked this quarter: 0.36

Contribution to Project: Dr. Candelore began the project as a Resident Simulation Director in the Department of Emergency Medicine at Madigan Army Medical Center (MAMC) and is

now an attending physician at Brooke Army Medical Center (BAMC). He serves as a Co-Investigator and will dedicate 3% effort to this project. He supports Dr. Colombo with the overall conduct and oversight of the study. Specifically, Dr. Candelore oversees the execution of simulation scenarios and scripts. He also meets with the research team on a regular basis to review the experimental design and statistical analysis, as well as support the submission of technical reports and manuscripts generated by this study

Name: Jonah Beck

Project Role: Research Assistant III

Researcher Identifier: N/A

Nearest person month worked: 5.35

Contribution to project: Mr. Beck has assisted with network and system administration including but not limited to the installation of equipment and software, training of other staff, and other technical requirements in support of the scope of work at Madigan Army Medical Center. He also works closely with Madigan IT and the study team to ensure the system's smooth operation and resolve problems as needed.

Name: DeAnna DeVane

Project Role: Research Assistant II

Researcher Identifier: N/A

Nearest person month worked: 3.1

Contribution to project: Ms. DeVane has assisted with network and system administration including but not limited to the installation of equipment and software, training of other staff, and other technical requirements in support of the scope of work at Madigan Army Medical Center. She also works closely with Madigan IT and the study team to ensure the system's smooth operation and resolve problems as needed.

Name: Oanh Tran

Project Role: Program Manager

Researcher Identifier: N/A

Nearest person month worked: 3.0

Contribution to project: Ms. Tran has assisted Dr. Colombo and other investigators in serving as the direct interface with Madigan Army Medical Center for all study collaborators. Additionally, she is also responsible for oversight of all staff supporting the project

Name: Justin Valovich

Project Role: Project Manager

Researcher Identifier: N/A

Nearest person month worked: 1.1

Contribution to project: Mr. Valovich has assisted in coordination of study activities and organizational structure of work to be performed.

Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

If the active support has changed for the PD/PI(s) or senior/key personnel, then describe what the change has been. Changes may occur, for example, if a previously active grant has closed and/or if a previously pending grant is now active. Annotate this information so it is clear what has changed from the previous submission. Submission of other support information is not necessary for pending changes or for changes in the level of effort for active support reported previously. The awarding agency may require prior written approval if a change in active other support significantly impacts the effort on the project that is the subject of the project report.

N/A

What other organizations were involved as partners?

If there is nothing significant to report during this reporting period, state “Nothing to Report.”

Describe partner organizations – academic institutions, other nonprofits, industrial or commercial firms, state or local governments, schools or school systems, or other organizations (foreign or domestic) – that were involved with the project. Partner organizations may have provided financial or in-kind support, supplied facilities or equipment, collaborated in the research, exchanged personnel, or otherwise contributed.

Provide the following information for each partnership:

Organization Name:

Location of Organization: (if foreign location list country)

Partner’s contribution to the project (identify one or more)

- Financial support;
- In-kind support (e.g., partner makes software, computers, equipment, etc., available to project staff);
- Facilities (e.g., project staff use the partner’s facilities for project activities);
- Collaboration (e.g., partner’s staff work with project staff on the project);
- Personnel exchanges (e.g., project staff and/or partner’s staff use each other’s facilities, work at each other’s site); and
- Other.

Organization Name	The Geneva Foundation
Location of Organization	917 Pacific Ave Suite 600, Tacoma, WA 98402
Contribution to the Project	Financial support. The Geneva Foundation provided Research Assistant II-III and program manager contract services.

Organization Name	Purdue University
Location of Organization	610 Purdue Mall, West Lafayette, IN 47907

Contribution to the Project	Financial support and in-kind support. Purdue University team works with the research team on annotation and Machine Learning (ML) analysis.
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Organization Name	University of Calgary
Location of Organization	Unit 32, 1359-69 Street SW, Calgary, Alberta, T3H 3W8
Contribution to the Project	Collaboration support. Worked with the research team to develop procedural guidelines and prototype mentoring scripts for end users from non-medical to credentialed providers.

Organization Name	Brooke Army Medical Center (BAMC)
Location of Organization	3551 Roger Brooke Dr, San Antonio, TX 78219
Contribution to the Project	Collaboration support. Worked with the research team to develop procedural guidelines and prototype mentoring scripts for end users from non-medical to credentialed providers.

Organization Name	Zulu Care Inc.
Location of Organization	1055 Stewart Ave, Suite 15, Bethpage, NY 11714
Contribution to the Project	Collaboration support and In-kind support. Work with the research team to develop a fully functional Android/Apple agnostic mobile application with core content areas.

Organization Name	Mission First Inc.
Location of Organization	8830 Stanford Boulevard, Suite 415, Columbia, MD 21045
Contribution to the Project	Collaboration support and In-kind support. Work with the research team to develop a fully functional Android/Apple agnostic mobile application with core content areas.

8. SPECIAL REPORTING REQUIREMENTS

COLLABORATIVE AWARDS: *For collaborative awards, independent reports are required from BOTH the Initiating Principal Investigator (PI) and the Collaborating/Partnering PI. A duplicative report is acceptable; however, tasks shall be clearly marked with the responsible PI and research site. A report shall be submitted to <https://ebrap.org/eBRAP/public/index.htm> for each unique award.*

QUAD CHARTS: *If applicable, the Quad Chart (available on <https://www.usamraa.army.mil/Pages/Resources.aspx>) should be updated and submitted with attachments.*

9. APPENDICES: *Attach all appendices that contain information that supplements, clarifies or supports the text. Examples include original copies of journal articles, reprints of manuscripts and abstracts, a curriculum vitae, patent applications, study questionnaires, and surveys, etc.*

- [S1] Approved Focus Group Protocol**
- [S2] Video protocol (under review)**
- [S3] (DRAFT) Efficacy Evaluation Protocol**
- [S4] Needle Decompression Text Only**
- [S5] Needle D step-by-step slides (with audio)**
- [S6] Needle D Comprehensive Slides (with audio)**
- [S7] Procedural Task List Consensus**
- [S8] Airway Management CPG**
- [S9] Trauma THOMPSON IPR**
- [S10] USUHS Research Day 2022**
- [S11] Trauma Thompson MHSRS Manuscript**
- [S12] TAC 2023**
- [S13] GSACEP Poster 2023**
- [S14] TT MHSRS Poster 2023**
- [S15] MICCAI TT Challenge Proposal**
- [S16] Tourniquet VQA**