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TITLE: Implementation of the AWARE System to Support Virtual Critical Care in a MEDCEN and CSH

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CONTRACTING ORGANIZATION: The Geneva Foundation, Tacoma, WA

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14. ABSTRACT
In combat casualty care environments, decisions about triage, treatment, and evacuation are commonly made quickly, using limited and fragmented data. These decisions are difficult for novice clinicians to make due to lack of situational experience. Enabling critical care experts to be easily and immediately available to inexperienced clinicians using virtual critical care technologies could significantly improve their medical decision making and patient care by increasing process adherence, reducing errors, and improving outcomes. This study aims to determine if implementing a virtual critical care service that utilizes novel clinical decision support software (CDSS) to facilitate daily key quality indicators, process, and outcome metrics will improve patient safety, process adherence, and patient outcomes in a military intensive care unit and thus validate similar findings in civilian medical centers for the military. The study also aims to demonstrate that we can deploy similar technologies and virtual critical care support services to a combat support hospital during a simulated patient care exercise.

15. SUBJECT TERMS
Tele-critical care, combat casualty care, tele-medicine, intensive care unit

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TABLE OF CONTENTS

1. INTRODUCTION:

In this project we intend to determine if using teleconsultation technologies and specialized software will improve patient safety, adherence to best medical practices, and improve patient outcomes in a military intensive care unit. These findings will validate civilian research findings in a military setting. We also intend to demonstrate that we can use similar technologies to facilitate critical care support during simulated patient care in a combat support hospital during a field training exercise.

2. KEYWORDS:

Tele-Critical Care, Combat Casualty Care, Tele-Medicine, Intensive Care Unit

3. ACCOMPLISHMENTS:

What were the major goals of the project?

Timelines and progress are reported based on the most up to date SOW that had been approved. The tasks and the percentage of completion is as of 20 October 2020:

1. Task 1.1: Obtain Risk Management Framework (RMF) approval for the AWARE software package. (**Not Started**). Due to policy, AWARE software cannot interoperate with MHS Genesis.
2. Task 1.2: MAMC establishes a remote workstation for monitoring ICU beds. (**Complete**)
3. Task 1.3: Install VTC hardware in MAMC ICU rooms and establishes servers to host all necessary software. (**Initial install Complete, additional 5 rooms pending**)
4. Task 1.4: Purchase low cost, mobile devices and Omnicure Software for monitoring non-ICU patients from the TeleICU workstation. Test their function. (**Complete**)
5. Task 1.5: Develop remote physiologic monitoring solution that is usable on the DoD network (**75% Complete**)
6. Task 2.1: NMCSD Develops Clinical Practice Guidelines that include clinically meaningful process and outcomes metrics. (**80% Complete**: 2 protocols completed, 2 still in development)
7. Task 2.2: NMCSD and Mayo write and submit research protocol to submit to the IRB. (**Complete**)
8. Task 2.3: NMCSD clinicians monitor patients at the remote work station and audit metrics, complete reports, and provide real-time feedback to bedside clinicians on performance (**Not Started**)
9. Task 2.4: Analyze impact of these structural and process changes on clinician performance and patient outcome. (**Not Started**)
10. Task 3.1: Mayo creates and implements research protocol to evaluate military clinician use of AWARE CDSS (**75% Complete**)
11. Task 3.2: Establish connection with JOMIS (or a remote client of CERNER if JOMIS is not yet available). (**Not Started**)
12. Task 4.1: Determine software and network solution(s) to connect combat support hospital to garrison clinical workstations (**Complete**)
13. Task 4.2: Scale project to support minimum bandwidth data transfer. This may involve reduced real-time physiologic monitoring, reduced frequency of data refresh rates, or other methods to diminish network demand and optimize remote clinician recommendations/monitoring. (**Complete**)
14. Task 4.3: Provide remote clinician support during a CSH or FST FTX. (**Complete**)
15. Task 5.1: Determine software and network solution(s) to connect role 2 and MEDEVAC platform(s) to garrison clinical workstations (**90% Complete**)
16. Task 5.2: MAMC support a multi-role FTX demonstrating proof of concept for TeleCritical Service support during multi-casualty scenario from Role 2 to Role 3 (90% **Complete**)

What was accomplished under these goals?

1. **Task 1.1: Obtain Risk Management Framework (RMF) approval for the AWARE software package. (Not Started)**
    - *Subtask 1.1.1: Complete*
        - Software and documentation were provided to MAMC by Mayo on 15 December 2017.
    - *Subtask 1.1.2: MAMC Submits RMF Application*
        - MAMC completed the paperwork portion of the RMF process in the fall of 2017, but was required to re-submit/start over due to changes in the RMF process. The software validation testing and cybersecurity scanning were completed as part of the original submission and should be usable in the re-submission. The new packet was delayed for submission pending challenges with connecting AWARE to MHS GENESIS through an approved governance process and API.
        - Due to current policy, AWARE software cannot interoperate with MHS Genesis.
2. **Task 1.2: MAMC establishes a remote workstation for monitoring ICU beds. (Original SOW Complete; pending implementation of DocBox ICU platform)**
    - *Subtask 1.3.1: Complete*
        - Equipment and hardware for the MAMC remote workstation has been obtained. This includes two single tier adjustable ergonomic desks, workstation monitors, Jabber cameras, and computers. Funding for this effort was a mixture of MTF and Grant.
    - *Subtask 1.3.2: Complete*
        - Remote workstation space at MAMC was renovated in anticipation of installation.
        - All equipment has been installed in this location.
        - Software components for the workstations to function completely include:
            - Remote Electronic Medical Record Access: tested and functional with MHS GENESIS.
            - Remote VTC: tested and functional with Cisco Jabber and VNC VTC.
            - Remote Imaging: tested and functional with PACS system.
            - Remote Vital Signs Monitoring: tested and functional using the SpaceLabs virtual application hosted on AVHE called CareAware. This interface will be updated after DocBox ICE platform completes RMF and can be used to virtualize remote visualization of bedside physiologic monitors).
3. **Task 1.3: Install VTC hardware in MAMC ICU rooms and establishes servers to host all necessary software. (Original SOW Complete, additional 5 rooms pending)**
    - *Subtask 1.3.1: GENEVA Purchases Equipment for MAMC*
        - Equipment installation has been completed 7 rooms according to the original SOW.
        - 5 additional rooms will be allocated to ICU East at MAMC for future Telehealth training and monitoring
        - Collaboration between MAMC and NMCSD is underway for allocation of 5 additional rooms to ICU east with Bernoulli
            - Implementation of additional rooms will take place next fiscal year
4. **Task 1.4: Purchase low cost, mobile devices and Omnicure Software for monitoring non-ICU patients from the TeleICU workstation. Test their function. (Complete)**
        - OmniCure has completed integration SensoScan vital signs monitoring into their data display.
        - OmniCure has provided requirements for mobile device platform and Geneva has purchased tablets as the mobile device solution to host the OmniCure application.
        - OmniCure software application is complete and publically available on the Android, and iPhone, if needed, platforms.
        - The workflow between SensoScan continuous vitals data, bedside applications, and physician/provider monitoring via Omnicure has been successfully demonstrated

during a simulated MASCAL event during the Navy's Fleet Week exercise in San Francisco (https://www.navy.mil/submit/display.asp?story_id=107325). This demonstration utilized the integrated OmniCure/Sensoscan platform to monitor and interact with 4 simulated and 20 synthesized patients through a web portal visible at Madigan Army Medical Center and Naval Medical Center San Diego.

5. **Task 1.5: Develop remote physiological monitoring solution that is usable on the DoD Network. (75% Complete)**
    - *Subtask 1.5.1: Obtain RMF for DocBox software and device*
        - PIA for DocBox is completed and approved. RMF for DocBox is with DHA: prioritization discussion is happening on 29 Sep to see if CyberLog will prioritize this effort. We are still waiting for a decision.
        - Subtask 1.5.2: Develop visualization software solution for real-time dataDocBox and Omnicure have begun integration to provide visualization software for real time data at the bedside and in remote environments
        - The current capabilities are two-way video/audio, two-way messaging, remote vital signs monitoring, file sharing, SOS alerts, and patient self-registration
6. **Task 2.1: Develop Clinical Practice Guidelines that include clinically meaningful process and outcomes metrics. (80% Complete)**
    - *Subtask 2.1.1: NMCSD develops SOPs to integrate virtual critical care into daily patient care.*
        - Draft version of this SOP has been completed. Final SOP is still undergoing revision pending additional nursing engagement.
    - *Subtask 2.1.2: NMCSD develops CPGs with local SME's, clinical champions, and critical care leadership*
        - The Blood Transfusion and Sepsis CPGs are complete. The ARDS CPG is 50% complete. Given the challenges with adopting and modifying the AWARE software, the AKI CPG may not be possible to implement.
        - Replacement of clinical data personnel has taken place and Task 2.3.1 is underway
7. **Task 2.2: NMCSD and Mayo write and submit research protocol to submit to the IRB to evaluate impact of providing data to clinicians regarding quality metrics (Complete)**
        - Protocol has been approved at NMCSD
8. **Task 2.3: NMCSD clinicians monitor patients at the remote workstation and audit metrics, complete reports, and provide real-time feedback to bedside clinicians on performance. (Not Started)**
    - *Subtask 2.3.1: NMCSD monitors pre-TeleAWARE Process and Outcomes Metrics (retrospective and 3 months prospective) (25% Complete)*
        - The 3 month of prospective data collection has begun
    - *Subtask 2.3.2: Run-in period. No data collection. Virtual presence established. (Not Started)*
    - *Subtask 2.3.3: NMCSD monitors post- clinical data collection Process and Outcomes Metrics (3-6 months) (Not Started)*
9. **Task 2.4: Analyze impact of these structural and process changes on clinician performance and patient outcome. (Not Started)**
    - *Subtask 2.4.1 MAMC analyzes data with Mayo for final report and demonstrates improved process adherence and patient outcomes post-implementation of virtual critical care service established compared to pre-implementation, and evaluates feasibility of CDSS on military clinician efficacy.*
10. **Task 3.1: Mayo creates and implements research protocol to evaluate military clinician use of AWARE CDSS (75% Complete)**
    - *Subtask 3.1.1: Mayo creates synthetic environment consisting of actual critical care patient data evolving over simulated time and remotely viewable via AWARE CDSS (75% Complete)*

- *Subtask 3.1.2: Mayo writes and gets approved IRB protocol to test clinician response in remote synthetic environment (50% Complete)*
    - Mayo protocol has been received and must be adjusted for the MAMC environment before being submitted and approved by MAMC IRB
    - Dr Colombo has reviewed the MAYO protocol and is currently reviewing the data sharing agreement to submit both to the IRB
    - Will be implementing remotely due to Covid-19
- *Subtask 3.1.3: NMCSD recruits clinician subjects to participate in protocol (Not Started)*
- *Subtask 3.1.4: Mayo and MAMC analyze data (Not Started)*

11. **Task 4.1: Determine software and network solution(s) to connect combat support hospital to garrison clinical workstations (Complete)**
    - *Subtask 4.1.1: MAMC/NMCSD coordinates efforts with health IT principles (Complete)*
        - Multiple software and network solutions (TES, Omnicure software, Athena WVSM) have been integrated and tested for theoretical use to connect a combat support hospital to garrison clinical workstations.
12. **Task 4.2: Scale project to support minimum bandwidth data transfer. This may involve reduced real-time physiologic monitoring, reduced frequency of data refresh rates, or other methods to diminish network demand and optimize remote clinician recommendations/monitoring. (Complete)**
    - *Subtask 4.2.1: MAMC works with CSH and tests IT support in preparation for FTX.(Complete)*
        - Transportable Exam Station has been purchased and utilized due to low network requirements. Bandwidth reading have been captured during FTX when possible.
13. **Task 4.3: Provide remote clinician support during a live and/or field training exercise. (Complete)**
    - *Subtask 4.3.1: MAMC provides remote continuous critical care support to hospital (Complete)*
        - MAMC has provided remote continuous care during 4 field training exercises (Joint Warfighter Assessment, San Francisco Fleet Week exercise, and a Forward Surgical Team exercise, and Army Best Medic Competition)
    - *Subtask 4.*3.2: *MAMC and hospital write after action review (AAR) of the event for inclusion in the final report. (Complete)*
        - A lessons learned/after action report that contains a review of each exercise will be included as an appendix.
14. **Task 5.1: Determine software and network solution(s) to connect role 2 and MEDEVAC platform(s) to garrison clinical workstations. (90% Complete)**
    - *Subtask 5.1.1: MAMC coordinate efforts with IT principles at MB (75% Complete)*
    - *Subtask 5.1.2: MAMC coordinate with DocBox and Omnicure or other suitable vendor for software product that delivers VTC, real-time physiologic vital signs, and simple documentation solution. (Complete)*
        - DocBox and Omnicure have created a software product that delivers VTC, real-time physiologic vital signs, and a simple documentation solution.
    - *Subtask 5.1.3: TGF Purchases hardware (android mobile devices and TeleHealth carts to support proof of concept demonstration (Complete)*
15. **Task 5.2: MAMC/ISR support a multi-role FTX demonstrating proof of concept for TeleCritical Service support during multi-casualty scenario from Role 2 to Role 3 (90% Complete)**
    - *Subtask 5.2.1: Develop casualty simulation scenarios (Complete)*
    - *Subtask 5.2.2: Conduct multi-casualty simulation FTX (75% Complete)*
        - A multi-casualty simulation is scheduled for 30 October 2020

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

Telecritical care offers a new scope of practice for military critical care nurses, physicians, and medics. While none of the clinical decision making is new, the manner in which clinicians review data and communicate with local caregiver is a *skillset* that may be developed and trained. MAMC and clinical partners at NMCSD and BAMC are working to develop these training programs.

How were the results disseminated to communities of interest?

Thus far, we have three CPGs that will help standardize clinical practices across the Joint Tele-Critical Care Network after this project completes, a Telecritical Care SOP at MAMC that has been drafted and continues to undergo interactive development with other clinical partners, and training media/SOPs that are also undergoing development jointly with other clinical partners. These will all be made available to the Sponsor once the products are more fully developed and validated.

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

Associated Task	
Major Task 1.5	• Obtain RMF for Docbox and Omnicure
Major Task 2.3	• Continue to gather data on quality metrics
Major Task 2.4	• We will begin analysis in the next quarter
Major Task 3.1	• Task 3.1 will be completed virtually due to Covid-19
Major Task 5.1.1	• MAMC will continue to coordinate efforts with IT principles at MB to finalize possible network and software solutions

4. IMPACT:

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

Clinical Impact:

- The installation of remote monitoring workstation equipment at MAMC has allowed the site to be a leader in the creation of the Joint Tele-Critical Care Network (JTCCN). The active JTCCN network includes MAMC, BAMC, and Naval Medical Center San Diego. The remote monitoring capabilities amongst these sites allow personnel burdens and responsibilities to be divided amongst all sites. This in turn has resulted in more active patient care with increased access to experienced providers. The JTCCN network has also been able to provide support for the established ADVISOR system.
- The increased momentum and visibility brought to virtual care has in part lead to tele-critical care being investigated by the MHS Tele-Health workgroup for program objective memorandum (POM) funding.
- The Virtual Critical Care Center (VC3) at MAMC has also provided proof of concept operations during a Joint Warfighter event in Yakima, WA.

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.

NOTHING TO REPORT

What was the impact on technology transfer?

- Tele-Critical Care (TCC) is a core component of the ADvanced VIrtual Support for OpeRational (ADVISOR) system that has now provided support for over 30 real world and over 100 training scenarios. TCC resources (i.e. the workstation and clinical support) offers a novel method to provide high fidelity, continuous consultation to operational forces during prolonged field care.

What was the impact on society beyond science and technology? *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.*

The proof of concept MASCAL demonstration at Fleet Week is a potential model for supporting a large scale (i.e. nation or multi-national) response to natural or man-made disasters that create 100s-1000s of casualties over short time periods. This model workflow could be combined with other technologies (like drone delivery of supplies and mobile ad hoc networking) to offer a highly flexible and scalable technology solution for humanitarian aid.

5. CHANGES/PROBLEMS:

Changes in approach and reasons for change

NMCSD has been added to the SOW in order to utilize their Clinical Practice Guidelines that include clinically meaningful process and outcomes metrics. Moreover, NMCSD clinicians will monitor patients at the remote workstation and audit metrics, complete reports, and provide real-time feedback to bedside clinicians on performance. Moving these tasks to NMCSD will expedite the process of analyzing data and collecting information; efficiently utilizing time and resources.
Please see updated GANTT chart (Appendix I).

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.

The VTC hardware for the 5 additional rooms will be utilized by installing them into the MAMC ICU East rooms. This will depend on how ICU East is being utilized for the future. Once the equipment is installed into ICU East rooms, it will be used for Telehealth monitoring and training.

The DocBox PIA has been received by DHA and is being processed. The ATO will be discussed by CyberLog on 29 Sep to determine if it will be added to the prioritization list. We are still waiting for their final decision. Future work with Omnicure will be devoted to using their software platform for two-way Communications between a rapid response nurse and a floor nurse. This proved to be successful for providing communications during a simulated physical therapy patient interaction.

Covid-19 has delayed all non-Covid research heavily. Efforts and deliverables have been coordinated between the NETCCN project and the AWARE project to complete tasks effected by the heavy delays. A no cost extension is expected to be required and will be requested in Q4.

Changes that had a significant impact on expenditures

Due to the delays mentioned above, spending on the project has been slower than anticipated. However, this will allow the team to finish the deliverables during an extension period (if approved).

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

Significant changes in use or care of human subjects

NOTHING TO REPORT

Significant changes in use or care of vertebrate animals

N/A

Significant changes in use of biohazards and/or select agents

N/A

6. PRODUCTS:

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

Journal publications.

NOTHING TO REPORT

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)**

NOTHING TO REPORT

- **Technologies or techniques**

NOTHING TO REPORT

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

NOTHING TO REPORT

- **Other Products**

Three Abstracts submitted and accepted for presentation:

- Abstract accepted and presented at the 2019 Military Health Systems Research Symposium (MHSRS) Conference. Ieronimakis, et. Al., "The Trifecta of Tele-Critical Care: Intra-hospital, Operational and Mass Casualty Applications" (Appendix II)
    - Also submitted and accepted as a manuscript to a supplement to Military Medicine (Journal)
- Abstract presented at the Society of Critical Care Medicine. Colombo, et. Al., "Virtual Health in a Graduate Medical Education Prolonged Field Care Exercise" (Appendix III)
- Abstract presented at the Society of Critical Care Medicine. Ieronimakis, et. Al., "Military Tele-Critical Care: Intra-hospital, Operational and Mass Casualty Applications" (Appendix IV)

7. PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS

What individuals have worked on the project?

NAME	LTC Christopher Colombo (no change)
NAME	COL Jeremy Pamplin (no change)
NAME	Mary McCarthy (no change)
NAME	LTC Cristin Mount (no change)

NAME	Brian Pickering (no change)
NAME	Vitaly Herasevich (no change)
NAME	Kevin Ross (no change)
NAME	Justin Valovich (no change)
NAME	Stacie Barczak (no change)
NAME	Drew Thomas (no change)
NAME	CAPT Konrad Davis
PROJECT ROLE	Co-Investigator
NEAREST PERSON MONTH WORKED	0.6 calendar months
CONTRIBUTION TO PROJECT	He is responsible for assisting the Principal Investigator in guiding the protocol through IRB, HRPO, and other regulatory approval processes, coordinating activities from across participating study sites, and facilitating necessary data analysis and reporting requirements.
NAME	Jakob Kerns
PROJECT ROLE	Clinical Data Specialist
NEAREST PERSON MONTH WORKED	12 calendar months
CONTRIBUTION TO PROJECT	He is responsible for data analysis and management, quality control assurance, report generation, and operations of the day to day study responsibilities.

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

None.

What other organizations were involved as partners?

Organization Name: Mayo Clinic
Location of Organization: Rochester, MN
Partner's contribution to project: Collaboration (Mayo staff worked with the research team to initiate the RMF process for incorporating the AWARE system with MHS Genesis)

8. SPECIAL REPORTING REQUIREMENTS

QUAD CHARTS: *Attached*

9. APPENDICES

Appendix I

Updated GANTT Chart

		2017	2018				2019				2020			
		Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Aims & Tasks	**Months after award**	3	6	9	12	15	18	21	24	27	30	33	36	39
1	Install hardware and software for virtual monitoring in the adult intensive care unit and non-ICU patients at Madigan Army Medical Center.													
1.1	Obtain a RMF for the AWARE software package.							1						
1.2	MAMC establishes a remote workstation for monitoring ICU beds.		2											
1.3	Install VTC hardware in MAMC ICU rooms and establish servers to host all necessary software.		3											
1.4	Purchase low cost mobile devices and Omnicure Software for monitoring non-ICU patients from the TeleICU workstation. Test their function.													
1.5	Develop remote physiologic monitoring solution that is usable on the DoD network.							4						
2	To test the hypothesis that implementing a virtual critical care service in a military adult intensive care unit that utilizes novel decision support software (CDSS) to audit quality indicators, process, and outcome metrics on a daily basis and to review that data with bedside clinicians, we can improve patient safety, process adherence, and patient outcomes.													
2.1	Develop Clinical Practice Guidelines that include clinically meaningful process and outcomes metrics.					5,6								
2.2	NMCSD and Mayo write and submit research protocol to submit to the IRB.					7,8								
2.3	Mayo incorporates process and outcomes metrics into context based checklist, alerts, and reports available in AWARE.													
2.4	NMCSD clinicians monitor ICU patients at the remote workstation and audit metrics, complete reports, and provide real-time feedback to bedside clinicians on performance.													
2.5	Analyze impact of these structural and process changes on clinician performance and patient outcome.													
3	To test the hypothesis that military clinicians can utilize a novel clinical decision support software (CDSS) to facilitate recognition of decompensating patients and speed intervention.													
3.1	Mayo creates and implements research protocol to evaluate military clinician use of AWARE CDSS.													
4	Demonstrate proof of concept that this virtual service can be deployed during live and/or field training exercise.													
4.1	Determine software and network solution(s) to connect corresponding hospital to garrison clinical workstations													
4.2	Scale project to support minimum bandwidth data transfer. This may involve reduced real-time physiologic monitoring, reduced frequency of data refresh rates, or other methods of diminishing network demand and optimize remote clinician recommendations/monitoring.										10			
4.3	Provide remote clinician support during a live and/or field training exercise.													
5	Demonstrate proof of concept that this virtual service can support combat casualty care evacuation and monitoring from a role 2 to, and in a role 3 facility.													
5.1	Determine software and network solution(s) to connect role 2 and MEDEVAC platform(s) to garrison clinical workstations													
5.2	MAMC/ISR support a multi-role FTX demonstrating proof of concept for TekeCritical Service support during multi-casualty scenario from Role 2 to Role 3												12	

	Milestones and Events		
1	**Approved RMF and GENESIS Connection for AWARE Software**	9	**Pre-Post Implementation Data**
2	**Functioning Workstation**	10	**AWARE Integrates with JOMIS if available**
3	**Functioning ICU Monitoring Equipment in 10 ICU Beds**	11	**AAR of virtually supported FTX**
4	**Advanced Monitoring Solutions for ICU Beds**	12	**Multi-casualty FTX Simulation Scenario**
5	**SOPs for Virtual Critical Care**	13	**Proof of concept software and network solution outlined**
6	**CPGs for clinical practice that Virtual Critical Care Supports**		

7	Research Protocol Approved by IRB(clinical data)		
8	Research Protocol Approved by MAYO and MAMC IRB (synthetic clinical environment)		
	Quarterly Status Report		Final Report

Appendix II

The Trifecta of Tele-Critical Care: Intra-hospital, Operational and Mass Casualty Applications

Kristina M. Ieronimakis, BSN, RN; CCRN, TNCC; Mark Griffith RN, BSN, CCRN, MCPO, USN, Ret.;Christopher J. Colombo MD, MA, FACP, FCCM; Konrad L. Davis, MD FCCP FCCM, Jeremy C. Pamplin, MD FCCM, FACP TATRC, USUHS

Background: Tele-Critical Care (TCC) has the capacity to simultaneously improve patient outcomes in military treatment facilities, in deployed environments and mass casualty events. TCC leverages technology to extend the reach of critical care physicians and nurses beyond geographic boundaries. Tele-consultative services (TCS) are not limited to traditional hospital settings; the military leverages telemedicine in operational environments to provide expert consultative support to deployed providers. TCC reduces patient mortality by enhancing quality of care, patient safety, process adherence, and reduce costs. Madigan Army Medical Center's (MAMC) new Virtual Critical Care Center (VC3) has been integrated into the military's Joint Tele-Critical Care Network (JTCCN) and is designed to support both hospital and field based TCC. The varied and unpredictable census of garrison ICU's, operational patient needs and mass casualty events lends itself to overwatch being provided for all of these applications by a single intervention (TCC), ideally by a networked solution that provided the TCC system resiliency and redundancy.

Methods: The VC3, staffed by a critical care trained physician and nurse, offers TCS to ICU bedside nurses at MAMC and consultative support to field medical personnel. Two recent exercises demonstrate this flexibility. The first was a pilot introduction of TCC nursing for the monitoring of six patients in the MAMC ICU over the course of a week. The VC3 physician teamed with the TCC nurse to provide multidisciplinary care via virtual means. Additionally, the physician was scheduled to be available for operational telementoring for prolonged field care (PFC). In the second instance, the VC3 supported a military medical exercise by concurrently monitoring the MAMC ICU and a mass casualty exercise in a remote location. The VC3 physician closely monitored a recently extubated high risk ICU patient while the VC3 nurse provided over-watch on vital signs of 24 simulated casualties. This supported multiple parallel goals: intervention by the critical care physician to prevent hypoxia and reintubation in the ICU, unburdening of the teaching attending in the ICU to facilitate training of housestaff in critical care, and augmenting the mass casualty response allowing a separate group of remote physicians to focus on procedural tele-mentorship.

Results: VC3 support in the ICU resulted in anecdotal improvement in clinical practice guideline adherence by allowing for real-time education and guidance to bedside nurses. The VC3 nurse was a critical member of the bedside healthcare team, improving patient outcomes by clarifying physician orders, coordinating and communicating with ancillary services and documenting bedside interventions, thus freeing the task saturated bedside nurse to complete vital direct patient care. All the while, the VC3 physician was able to provide TCC guidance to a field medic in a complex prolonged field care medical simulation scenario, including procedural and cognitive tele-mentoring. The VC3 physician and nurse continued to collaborate with each event occurring simultaneously, thus enriching the quality of care and interventions being provided to all recipients of the TCS. Throughout the mass casualty exercise while the VC3 nurse successfully maintained remote overwatch on the vital signs trends of 24 simulated casualties, the VC3 physician was able to directly observe hypoxia in the recently extubated patient, and quickly intervene,

successfully treating the hypoxia and lowering the risk of reintubation. Overall, informal feedback was positive and enthusiastic during this pilot phase of VC3 implementation. Participants commented that the VC3 enhanced the quality and safety of bedside care. Families expressed deep appreciation for the “second set of eyes” watching their loved one. Responses from the military exercise were positive and indicated the application of TCS can expand multi-patient monitoring during a mass casualty event.

Conclusion: Monitoring capabilities of the VC3 continue to evolve with technological improvements. Currently, TCS are offered in traditional hospital settings. However, the opportunity to support the ICU-without-walls (i.e. “critical care anywhere”) concept and participate in pre-hospital care has military and civilian relevance in the acute management of natural disaster and mass casualty events. Fully leveraging capacity in the VC3 to simultaneously support ICU and operational patient scenarios can lead to improvements in safety, outcome, maintenance of critical war time medical skills and continuity of care for military casualties. Future directions include formal measure of efficacy and processes adherence metrics, simultaneous monitoring of garrison ICU patients at multiple sites, leveraging TCC in the assistance of triage and treatment for operational field exercises beginning at point of injury thru evacuation. Additionally, there is a focus on interoperability and rapid expandability given the possible overwhelm of a single TCC provider covering multiple responsibilities. TCC has the potential to expand the capacity and capability of pre-hospital caregivers to increase their ability to optimize care for one or many patients. This capability should be further developed as a possible solution for managing the large volume of casualties anticipated in future peer/near-peer conflicts or MASCAL events, civilian or military.

Appendix III

Virtual Health in a Graduate Medical Education Prolonged Field Care Exercise: A Pilot Intervention

Authors: Christopher Colombo, Lindsay Grubish, Jillian Phelps, Deanna Musfeldt, Mohammed Haque

Introduction/Hypothesis:
Military, mass casualty and disaster medicine may require less expert providers to care for critically ill patients in austere environments for extended time. Virtual Health (VH) capability brings remote expertise to these prolonged field care (PFC) providers. Graduate medical education (GME) provides minimal experience with VH, but it is a vital skill for austere PFC providers. We utilized an existing VH capability in concert with a planned military GME field exercise to determine attitudes and gain feedback about VH in PFC.

Methods:
An initial baseline survey measured 70 graduating military resident's VH experience and perception of value of VH in PFC. All participants attended a brief didactic session on utilizing the synchronous voice VH service. During the field exercise, participants in a critically ill trauma PFC simulation scenario were provided a cellular phone to utilize VH. Critical care physician staffed the VH line and provided advice. Post exercise anonymous surveys measured VH experience, perception of value of VH, and impact of VH on knowledge, stress and confidence in PFC. Free text observations were also solicited anonymously.

Results:
67 pre and 59 post surveys were returned (88%). Pre-exercise, likert scale ratings of perception of VH experience was low (mean 1.8/5, SD 0.9) and perception of value was just above neutral (mean 3.7/5 SD 0.8). Post- exercise perception of VH experience (mean 3.0/5 SD 1.05) and value of VH in PFC (Mean 4.12/5 SD 0.65) showed a statistically significant increase (student's T-test, $p < 0.05$). Perceived impact on knowledge (4.08/5), confidence (4.33/5) and stress (4.17/5) were positive. 11% of subjects rated all impacts non-positive (< or = 3/5), citing connectivity issues preventing effective VH utilization. Comments focused on connectivity; many suggesting a more complicated/challenging simulation scenario to provide more opportunity to use VH.

Conclusions:
A simple, synchronous voice VH service was successfully utilized by graduating physicians with little prior VH experience. Brief exposure to the service increased perception of the value of VH to PFC in military providers. Many felt the value would extend to a more complex clinical scenario. The feedback will aid in improving VH training and implementation in military GME.

Appendix IV

Military Tele-Critical Care: Intra-hospital, Operational and Mass Casualty Applications

Kristina M. Ieronimakis, BSN, RN; CCRN, TNCC; Mark Griffith RN, BSN, CCRN, MCPO, USN, Ret.;Christopher J. Colombo MD, MA, FACP, FCCM; Konrad L. Davis, MD FCCP FCCM, Jeremy C. Pamplin, MD FCCM, FACP TATRC, USUHS

Background: Military Tele-Critical Care (MTCC) has the potential to fulfill unique roles in addition to those fulfilled by civilian TCC, to include support for deployed medical providers. Full development of this capability may simultaneously improve patient outcomes in military treatment facilities, in deployed environments and mass casualty events. In order to fully optimize limited human clinical resources (ICU physicians and nurses), military MTCC needs to be flexible and adaptable to rapid changes in demand. The varied and unpredictable census of garrison ICU's, operational patient needs and mass casualty events lends itself to overwatch being provided for all of these applications by a single intervention (TCC), ideally by a networked solution that provided the TCC system resiliency and redundancy.

Methods: We performed three pilot feasibility exercises in which a MTCC center was simultaneously utilized to monitor hospital based ICU patients, and support a field training exercise. First was a pilot introduction of TCC nursing for a hospital ICU over the course of a week with a physician and ICU nurse teamed to provide multidisciplinary TCC. Additionally, the physician was providing cognitive and procedural telementoring for a military medic performing prolonged field care (PFC). Second, MTCC concurrently monitored ICU and a disaster mass casualty exercise in a remote location. The MTCC physician monitored a recently extubated high risk ICU patient while the nurse provided over-watch on vital signs of 24 simulated casualties. Third, the MTCC nurse simultaneously monitored the hospital ICU while providing reachback support to nurses training in a simulation scenario of a deployed field hospital ICU.

Results: We were able to demonstrate the feasibility of multiple iterations of simultaneous multi role MTCC, including the physician and nurse alternating operational and hospital support roles, and the ICU nurse managing both simultaneously. Informal feedback obtained from ICU staff commented that MTCC enhanced the quality and safety of bedside care. Families expressed deep appreciation for the "second set of eyes" watching their loved one. Positive responses from the field exercise participants indicated the application of MTCC can expand multi-patient monitoring during a mass casualty event and enhance training via expert reachback availability.

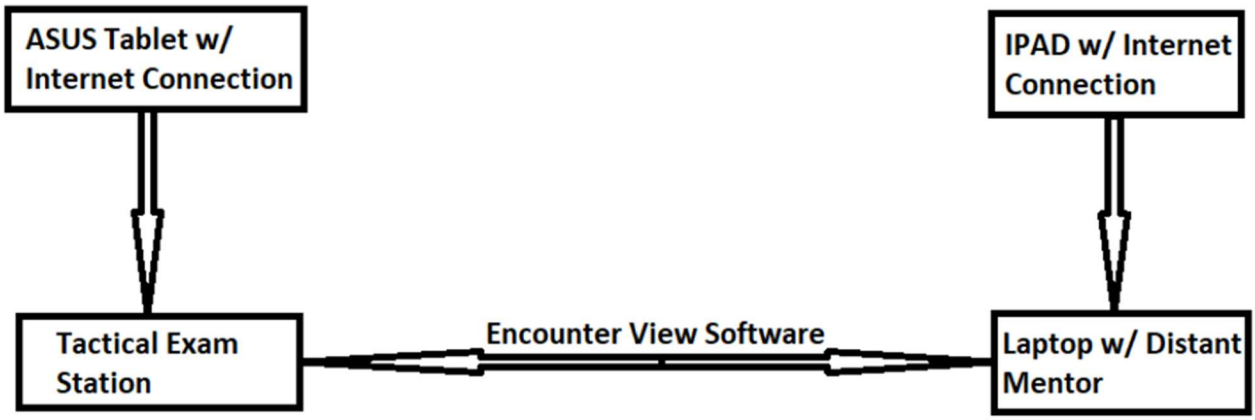
Conclusion: MTCC is unique in the opportunities to extend the ICU-without-walls concept to field, disaster and mass casualty settings, while simultaneously performing tradition tele critical roles. Interoperable and rapidly expandable systems must be developed given the possible overwhelm of a single MTCC provider covering multiple responsibilities.. Lessons learned from the development of this capability should have applicability for managing mass casualty events whether deriving from military (war) or civilian (disaster) events.

Appendix V

Lessons Learned

Surgical Exercise @ Madigan 24-26 July 19

Network Diagram



Requirements

Stationary Mbps:	1.8	2.2	1.9	2.3	1.9	2	1.8	2.5	2.2	1.7
	2.1	1.7	1.4	1.9	2.3	2.4	1.6	1.8	2	2.7
		Mean:	**2.01**	**Median:**	**1.95**	**Mode:**	**1.8,**	**1.9**		
W/ Audio Mbps:	1.9	3.7	2.8	2	2.8	3	4.1	2.7	2.9	3.8
	3.3	3.5	3.3	4	3.1	3.4	3.8	2.8	4.5	2.7
		Mean:	**3.21**	**Median:**	**3.2**	**Mode:**	**2.8**			

*****Upload and download are equals due to the nature of a two way call*****

Lessons Learned

Encounter View to Encounter Capabilities (Software)

- Video and audio calling w/ screen sharing and drawing capabilities that show on both ends.
  - Cannot expand shared screen using Encounter
- Capable of using associated devices and monitored reading from devices on both ends
- End User(Mentor) can move/adjust camera from the distant end

Encounter View to Encounter View Capabilities (Software)

- Video and audio calling w/ screen sharing and drawing capabilities that show on both ends.
  - Can expand shared screen to make drawing and markings beneficial for provider performing operation
- Not capable of using associated devices and monitoring reading on both ends(Exam camera, ultra sound, temp)
- End user (Mentor) can move/adjust camera from the distant end

Notes/Lessons Learned for TES (W/i1000 Camera):

- W/ out screen sharing: < 1Mbps
- Increased motion in camera view = increased degradation in picture quality due to camera trying to constantly auto focus
- Camera quality was extremely clear with a still picture enabling it to focus, even when zoomed in
- Camera would randomly swing completely up or to the side.
    - Possibly due to poor connection causing a lag in command to action
- Audio quality increased greatly when telementor used a headset
    - High noise floor on operational side increased difficulty in hearing mentor w/ clear audio

Feedback from Mentors:

- Wireless headset with boom mic for medic/doctor performing medical operation to mitigate background noise
    - Bluetooth operations within 10-15FT for security purposes
- Camera with mic, speaker, and light for an all-in-one solution
- Different mounting options that take up less room or space within operation area
- Possibly a manual focus option to mitigate a constant auto focus
- Connection status window within encounter/encounter view software to expedite connection troubleshooting on either end
- Active style camera that doesn't have to focus, ex. GoPro style on a functional mount with distant end control capabilities
- Encounter/Encounter view software w/ TES equipment is very user friendly for setting up calls and drawing capabilities

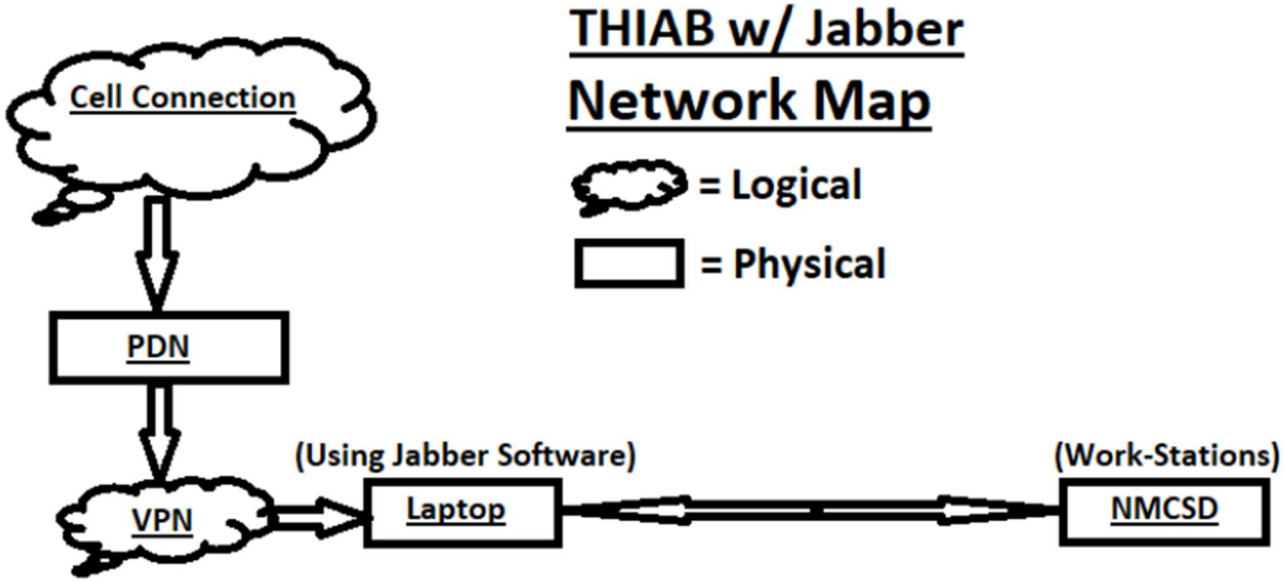
Way Forward for data connection:

- PDN connection fell through, need to contact PDN POC for equipment discussion
    - Continue to use data enables tablets until PDN issue is resolved
- Possibly explore alternate options for repeaters that enhance internet connections

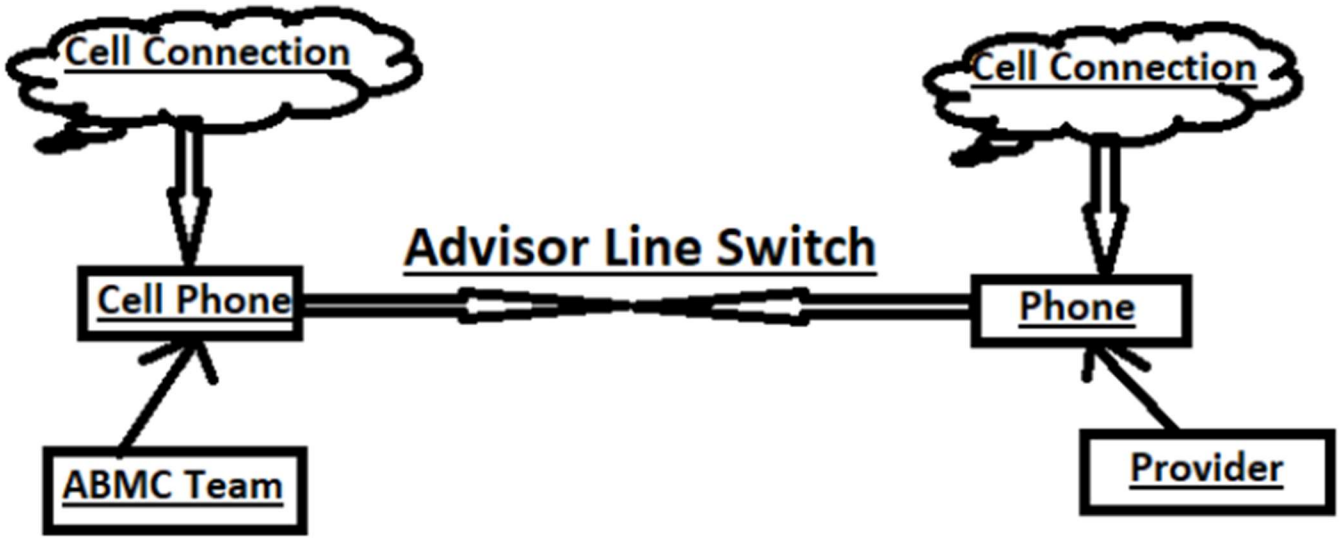
Lessons Learned JWA 2019

	Category	Topic	Project	Problem/Success	Impact	Recommendation
1	Scope Management	Capability Development	AWARE	Viewing a capability as a thing (Tempus, TES, THIAB, etc) instead of a process. This has led/contributed to overdeveloped products and underdeveloped users	High	Reframe thinking of what "capability development" actually requires. It's a place where the platform and user converge in a relationship that allow for each to be introduced, developed, and matured. A true capability is developed in that order and executed with specific outcomes in each space
2	Scope Management	Disconnect of where to implement telemedicine platforms (i.e permissive, semi-permissive, non-permissive environment)	AWARE	Pushing platforms that require connectivity to enhance PFC, either on tactical or non-tactical networks, are proving to be irrelevant in the semi-permissive/non-permissive envirtoments	High	Research community must develop a clear understanding of each domain (permissive, semi/non permissive) and its requirements in order to effectively develop and mature capabilities
3	HR Management	Physican Engagement	AWARE	Access to informed and engaged physicians at the user, proctor, and MTF allowed for a well developed training scenario that benefited unit and research team	High	The unit at JBLM (2-2) is an engaged partner and willing participant to future training objectives between both AWARE and PFC. We have all the key Stakeholders in place to begin the development phase and recommend we shift from the 44th as a training partner.
4	HR Management/Plan Management	Innovators and Enablers	AWARE	Innovation/execution are contrasting processeses that were successfully separated to achieve the stated outcome	Moderate	Sustain the establishment of a "linchpin" which designates product owners. The linchpin receives intent from PI (Innovator) and drives product owners (enablers) to meet specified outcomes.
5	Communication Management	Integration of "how to" videos for procedures	AWARE	We learned that it's more feasible/beneficial (and possible) to have preloaded videos on platform (i.e. TES) than to push them in a bandwidth constrained environment	Low	Team discussed cross-leveling videos from PFC to possibly introduce this as a future capability. Additionally, discussed this as a future research proposal.
6	HR Management	Enabler Integration	AWARE	Enablers selected at the appropriate level (rank) and possess the credibility to work in intended environment (MTF/Operational)	Moderate	Select enablers that understand how to associate the equipment/user to the operational capabilty
7	Cost Management	After-purchase support system	AWARE	Concern of implementing devices that don't encompass a long term plan for the maintenance required to operate	Moderate	Discuss options for the implementation and sustainability of devices at the unit level
8						

Lessons Learned for ABMC 25 Sep-26 Sep



- PDN Connecting to Laptop w/ VPN & Jabber Software:
  - Down Connection was between 7Mbps and 13Mbps
  - Up Connection was between 4Mbps and 6Mbps
  - Laptop failed to connect to Jabber software through the VPN (which is through military network)
    - Possibly because VPN's use more bandwidth and connection was not strong
    - Possibly because Jabber software requires a higher amount of bandwidth to operate
    - Or a combination of both
  - Possible Solution:
    - MPA may provide a strong enough (amplified) signal for VPN/Jabber to operate on
  - Recommendation:
    - Jabber is not a field viable software solution for Telehealth due to network requirements to operate
    - THIAB requires outside software (i.e. Jabber), which complicates network connection
    - However, recommend using the TES & global MED solution (or something like it) because they utilize in-house software which is ideal for connection



- ABMC Teams using cell phones w/ Advisor:
  - There was a total of 27 teams (2 ppl/Team). 39 total calls were made to the advisor line consisting of 32 Human and 7 K9 (MWD)
  - In-Field observations:
    - Advisor line was advantageous for every team in keeping their patient in the best condition (For teams that used it)
  - Lessons Learned:
    - Must make it clear that phone **could** ring for up to 3-5 minutes
    - Call order of providers does **not** change i.e. The phone system will call through the same order of providers until it reaches one that's available
  - Proved USEFUL in regards to overall Telehealth scenario

Implementation of the AWARE system to support virtual critical care in a MEDCEN and CSH.

W81XWH-17-C-0253

PI: LTC Christopher Colombo, MD **Org:** The Geneva Foundation **Award Amount:**

Study/Product Aim(s)

Using a combination of novel analytics and visualizations of electronic medical data, local workgroup-initiated process improvement projects, virtual audits of quality metrics, and daily review of process and outcomes reports by bedside and virtual clinician's, rapidly improve process adherence and patient outcomes in an adult intensive care unit. Demonstrate that this technology and approach to ensuring high quality patient care can be used in a deployed setting.

Approach

We will use the paradigm of structure, process, and outcome standardization and metric monitoring to improve care in the intensive care unit using teleICU technologies that have recently advanced to the point they are ready for supporting clinical medicine in a fixed and deployed facility.

AWARE Unit Level Interface

AWARE Patient Level Interface

Timeline and Cost

Activities CY	17	18	19	20
Install virtual monitoring capability at Madigan Army Medical Center.				
Develop CPGs, implement virtual critical care service, and measure impact on associated processes and outcomes				
Test capability with CSH during FTX				
Estimated Budget				

Updated: 10 July 2020

Goals/Milestones

CY17-18 – Installation Phase

☑ Submit AWARE/DocBox software to Risk Management Framework (RMF)
☑ Establish Telecritical Care Workstations
☑ Install VTC hardware in ICU rooms; Purchase low cost, mobile telecritical care (TCC) solution; Connect DoxBox solution to TCC workstations
☑ Develop Clinical Practice Guidelines & Submit IRB Protocol

CY18 – Operation Phase

☑ Develop CPG's to integrate VCC into daily patient care
☑ Implement research protocol to evaluate military clinician use of AWARE
☑ Work with CSH to test virtual support during FTX.

CY19 – Fielding Phase

☐ Measure impact of TCC on clinician performance & patient outcomes
☑ Test virtual presence during FTX
☐ Determine network solution to support scenario from Role 2 to Role 3

Comments/Challenges/Issues/Concerns

- DocBox RMF is being reviewed for system integration

Budget Expenditure to Date

Projected Expenditure: Actual Expenditure: