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MEDICAL SUPPORT IN A CHEMICAL, BIOLOGICAL, RADIOLOGICAL, AND NUCLEAR CONTESTED ENVIRONMENT

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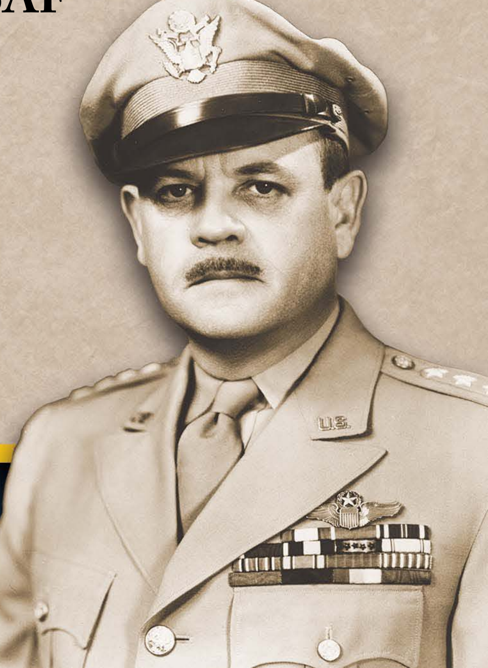

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Medical Support in a Chemical, Biological, Radiological, and Nuclear Contested Environment

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Dedicated to

Muir S. Fairchild (1894–1950), the first commander of Air University and the university's conceptual father. General Fairchild was part visionary, part keen taskmaster, and "Air Force to the core." His legacy is one of confidence about the future of the Air Force and the central role of Air University in that future.

Introduction

On a daily basis America's Warfighters rely on our Total Force Warrior Medics, which include Air Force Active, Guard and Reserve medical professionals, to deliver on the promise of "Trusted Care." In close coordination with our partners in Army, Navy, the Defense Health Agency, and civilian medicine, we deliver the medical capability to ensure we win our nation's wars while caring for American heroes. As the 24th Surgeon General of the United States Air Force and 2nd Surgeon General of the Space Force, I could not be prouder of the men and women that make up our Air Force Medical Service.

Together we have deployed the world's finest contingency trauma care system to battlefields and communities in crisis around the world. We have improved our warfighter's personal and collective protection, and we have developed new techniques—and revisited some old ones, to improve casualty care at the point of injury. Ready medics are on the battlefield and begin resuscitation immediately before assisting in rapid evacuation. Small, highly-skilled surgical teams apply damage control surgery and resuscitation techniques in austere, contested locations and within the "golden hour." Our most severely wounded patients travel in flying intensive care units as part of our en route care system, moving through a series of well-choreographed movements to receive definitive care.

In many ways and many cases we have learned to cheat death. Over the past twenty years of war there are thousands of American heroes who are alive today because of this work. These were men and women who would have died in any other war, fought by any other nation, at any other time.

This is a stunning success story. Each warrior medic who has been a part of this team and this system-of-systems should be proud. However, we must remember we will never fight yesterday's war tomorrow. If we only look back at our current and prior accomplishments, we will fail the American people, especially if we fight against a determined peer or near-peer competitor. We must anticipate the need to adapt to change because tomorrow will not be forgiving of a stagnant approach. That is the key to success for both the profession of arms and the profession of medicine.

It is our sacred obligation to maintain our competence on the cutting edge of trauma care. However, we must simultaneously learn the lessons from past wars and understand how to apply them to future problems. We must learn to look at the problems of today as opportunities to think in new ways so that we position our team to win our nation's wars tomorrow. We must nurture the habits of mind to question existing assumptions and current doctrine to *lead change—and win.*

As the Air Force and Space Force Surgeon General, I consider the relationship between the Air University and the Air Force Medical Service one of my more strategic and enduring partnerships. Whether officer, enlisted, or civilian, each Air Force warrior medic is touched by the new ideas generated from the Air University. Similar to our Line Air Force partners, nearly every member of the Air Force Medical Service are either currently enrolled in or have completed educational programs through the Air University, whether in residence or through distance learning modalities.

This volume is an important collection of thought about the future of medical care provided in the Chemical, Biological, Radiological, and Nuclear contested environment. It is a small representation of a commitment of medical officers challenged to think differently at Air University with a goal of creating the future. This student and faculty led partnership bring together analysts, academics, operators, and medical practitioners to challenge the nature of how we provide medical support for the future of combat operations.

Today, in the middle of a global pandemic, many of the concepts contained in this monograph are relevant not only to our military but to our civilian healthcare workers. Over the past many months we have served together on the front lines against Coronavirus, a defining moment in our nation's history. It has served as a stark reminder of our collective responsibility as medical professionals to our nation, regardless of the uniform we wear.

When we send America's sons and daughters into harm's way, they deserve the very best our nation can deliver. Each of them is a son, daughter, father, mother, brother, or sister. As the Air Force Medical Service, we are responsible to support those young men and women when they answer our nation's call. Ensuring military medicine is ready to care for these remarkable warriors in the future must be our work today.

ROBERT I. MILLER, LIEUTENANT
GENERAL, USAF, MC, SFS
Department of the Air Force
Surgeon General

Preface

Medical professionals in today's Military Health System do not have the required joint training to fully meet the demands of a contest environment during a Chemical, Biological, Radiological, and Nuclear (CBRN) event. Combat operations will require resilient and adaptable medical support. The future warfighting environment could include antiaccess, area denial, and CBRN operations that will threaten our ability to reinforce medical units, stabilize and evacuate patients, and circulate medical supplies.

The agile combat support necessary for high acuity care and theater patient regulation will be degraded and operationally limited in this contested environment. This new reality will require senior medical leaders to lead change in the development, employment, and sustainment of medical capabilities. Because of these challenges, a post-cold war strategy must lay the foundation for transformational organizational change to prepare for these threats or risk enemies using CBRN to contest and deny our access to the operational and tactical battlespace.

Integrating training at the joint service level within the Military Health System will require focus in the areas of patient care and movement, operational treatment approach, machine learning, and psychological application. A centralized joint platform will provide effective communication and interdependency within all branches and will subsequently save lives.

This collection of essays discusses different aspects of conducting medical care during a CBRN event, as well as in contested or denied environments. The authors are all Air Force medical providers and medical planners, and discuss the current realities of the MHS, and the issues that they will face in future conflicts if the service fails to quickly address training needs. The authors contend that sweeping changes will be difficult to coordinate without following prescribed planning measures, notably those outlined by John Kotter in his book, *Leading Change*.

Joint Training: The Solution to Medical Support in a Chemical, Biological, Radiological, And Nuclear Contested Environment

Lt Col Jennifer Garrison

Introduction

Leading change in the Military Health System (MHS) can be extremely difficult, especially when considering a Chemical, Biological, Radiological, and Nuclear (CBRN) contested environment. China, Iran, North Korea, and Russia have adapted to the changing battlespace by modernizing their technology, equipment, and utilizing decentralization of execution to create a forceful balance of power. The rapidly changing abilities of our adversaries is discussed in the National Defense Strategy, which states that, "in this environment, there can be no complacency, we must make difficult choices and prioritize what is most important to field a lethal, resilient, and rapidly adapting joint force. America's military has no preordained right to victory on the battlefield."[1] The MHS must establish a joint training platform to synchronize training efforts among the services to support those fighting our adversaries.

The MHS is currently ill-prepared to deliver integrated combat support in a contested environment where CBRN weapons are employed. Medical professionals are narrowly trained to deliver expeditionary medicine during low-intensity warfare, and few receive any training for joint operations. Considering the strategic implications of the CBRN environment for expeditionary medical operations, MHS must require joint training and planning solutions before medical forces are sent into a contested theater with degraded communication, limited evacuation and resupply, and more high acuity casualties than our system has managed in decades. If no action is taken, the forecasted operational tempo will likely drive our joint theater capabilities to failure and supported units to ineffectiveness. To mitigate these current deficiencies, recommendations and methodology must be developed that focuses on requirements necessary to conduct joint medical operations training between the services in a contested CBRN environment. The use of John Kotter's "8-Stage Process of Creating Major Change" is an effective way to develop these methodologies.

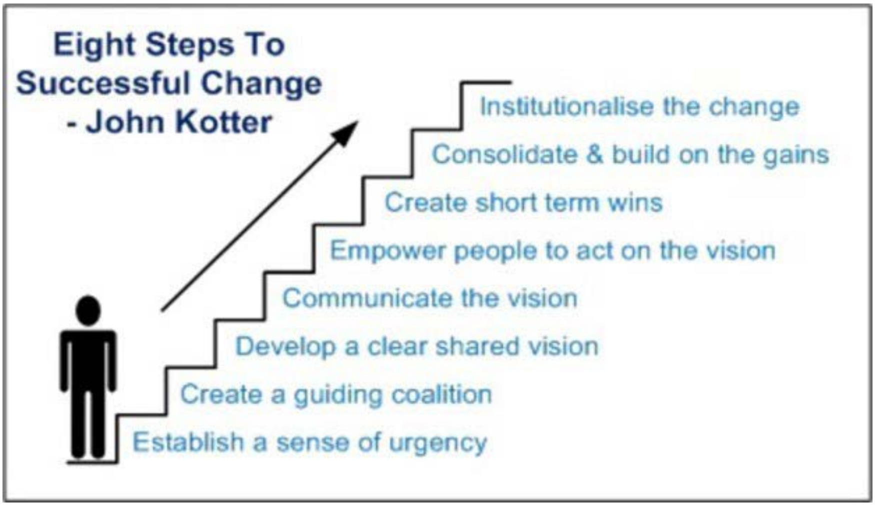

Figure 1.1 Kotter's Eight Steps to Major Change

Step 1: Create a Sense of Urgency

According to John Kotter, "establishing [a] sense of urgency is crucial to gaining needed cooperation throughout the organization."[2] Senior leadership in the MHS should take bold risks to create opportunities that focus on aligning people around common goals. Creating this strong sense of urgency demands bold and risky actions through senior leadership.[3] Because they have the power, senior leaders in the MHS are the key players in reducing the force of inertia.[4] Middle managers are at risk of being part of the status quo and are stuck in the "frozen middle." This frozen middle is defined as "those middle managers who are the gateway between junior to mid-level employees and leaders in the corporation."[5] The frozen middle sees new ways of doing business as a threat and will only change when an organizational crisis becomes real.[6] They eventually roll into a crisis life cycle model as labeled in Figure 1.2.[7]

The crisis life cycle is defined over both time and disequilibrium. The vertical disequilibrium axis illustrates the amount of stress or chaos felt by the members of the organization and is divided into the comfort, learning, and danger zones.[8] The comfort zone is the status quo and is where most organizations are in the state of equilibrium or stagnation. The frozen middle helps the organization remain in the status quo.

The MHS has been stagnating in this comfort zone for many years. To break this cycle, Congress created a sense of urgency by establishing the Defense Health Agency (DHA) to focus on innovation and enhance communi-

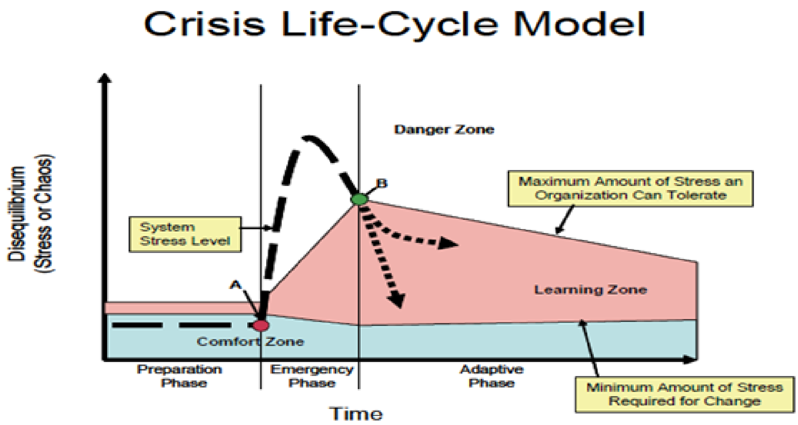

Figure 1.2 Crisis Life Cycle Model

cation between the services. The DHA is a "joint, integrated Combat Support Agency that enables the Army, Navy, and Air Force Medical Service (AFMS) to provide a medically ready force and ready medical force to Combatant Commands in both peacetime and wartime."[9] DHA has established the Education and Training Department (J7) to provide these objectives:

9. Establish an enterprise-wide eLearning tool that meets the requirements of each service to better coordinate medical education services and resources.
10. Consolidate and streamline administrative and oversight functions for medical education and training programs, initiatives, and schools.
11. Coordinate professional development and sustainment programs.
12. Facilitate centralized training review process to ensure medical education and training is coordinated across the MHS.

To meet these new objectives, DHA has created the Defense Medical Readiness Training Institute (DMRTI) in San Antonio, Texas to ensure this sense of urgency and create an organizational culture for joint training to allow for full spectrum readiness among all services.

The focus on joint training is needed from the MHS primarily for two reasons: to instill confidence from all services in the event of an attack and to provide an understanding of the implications of the operational treatment approach. Integrating joint partners in training and operations provides different perspectives and potential options which would not have been otherwise realized. While the MHS trains personnel to current battlespace standards, they must focus on training in a CBRN environment. The next conflict will likely include the challenge of prioritizing mission continuation over medical needs. Training must not only focus on how to penetrate a CBRN contested environment but how to identify the support operations to make it happen. With the increased focus on joint force operations, medical professionals from all branches will be working together. Integrating joint partners in training and operations provides different perspectives and expertise. The MHS will need a guiding coalition to move from the comfort zone to the learning zone to adapt to a coalition or joint force domain.

Step 2: Creating a Guiding Coalition

A strong guiding coalition is needed to demonstrate trust while eliminating key obstacles and generates short-term wins and anchors new approaches to the organizational culture.[10] This coalition will need to convince people change is necessary. This often takes strong leadership and visible support from key people within an organization. This usually is difficult as leadership is trying to convince people to go from the comfort zone and into the learning zone as in the crisis leadership cycle shown in Figure 2.[11]

Once the coalition is formed, they should identify leaders and stakeholders within the MHS, and involve them in the entire change process. Together, they should identify weak areas within the coalition teams and fill them with people from different cross functional departments across the services.[12] The ability to move an organization from where it feels comfortable, without the urgency of crisis, is extremely difficult. Change means threatening stable relationships, balances of power, standard operating procedures, and current distribution of resources. Beyond the comfort zone is the critical area between equilibrium and organizational danger called the learning zone. The line between the comfort and learning zone is described as the minimum amount of stress needed for an organization to change.[13] Moving into this zone causes organizational stress and conflict. People are often afraid of change and its accompanying pain in setting up a guiding coalition.[14]

Dr. Paul Nelson, then Surgeon General's Chair to Air University, set up a research taskforce at the Air War College to help form this guiding coalition to assist the MHS in identifying solutions for integrating CBRN contested scenarios into a joint training platform. This task force was called the "Medical Support Combat Operations in a CBRN Contested Environment" (MSCOCE). It was led by students, four of whom are Air Force medical providers, and two Air Force medical planners.

This team was tasked to help change and transform the MHS in the areas of patient care, patient movement, machine learning, operational treatment approach, and psychological impact. Developing joint training platforms based on these areas will ensure the MHS is successful in a CBRN environment.

Step 3: Develop a Clear Vision

According to Kotter, developing a clear vision can help employees understand the "why" behind the reason for change.[15] When people can see for themselves what an organization is trying to achieve, the directives they are given tend to make more sense.

From 25–27 September 2018, the MS-COCE Research Task Force asked the AFMS leadership to send experts to Air War College to discuss how to implement CBRN training into a joint training platform. The working group consisted of people from Headquarters AFMS (Air Staff), United States Air Force School of Aerospace Medicine, Manpower and Equipment Force Packaging System (MEFPAK) representatives from Air Combat Command (ACC), Air Mobility Command (AMC), Air Force Special Operations Command, Air Education and Training Command (AETC), Pacific Air Force, and DMRTI's J-7 Education and Training Department. This working group's purpose was to build a collective vision and provide guidance and recommendations on inserting CBRN contested scenarios into a joint training platform.

The short summary for this collective vision was to identify the shortfalls in CBRN training in the AFMS and plan for recommendations on how build training modules of the CBRN training packages the AFMS already has to enable utilizing existing equipment as much as possible. The AFMS needs to be trained on their own CBRN equipment and trained on all operational procedures during the training sessions that are Air Force Specialty Code (AFSC) specific. This makes the training better targeted to the particular skill set and the trainees will get appropriate preparedness to use the CBRN equipment and procedures during a crisis. Then, after the shortfalls are identified with the CBRN training; this team should develop a joint operational course process for the services to train together at a joint training platform so the MHS can be ready for this catastrophe. The next step will analyze how to take a clear vision and utilize communication to adapt to change.

One reason for this urgent CBRN training is North Korea. North Korea, with its long history of testing missiles, has now come closer to reaching the United States and North America. In 2017, they launched a few missiles, and fired one ballistic missile that brought Alaska within range. According to the Pentagon, "North Korea probably has a long-standing chemical weapons program with the capability to produce nerve, blister, blood, and choking agents and likely possesses a chemical weapons stockpile that could be used with artillery and ballistic missiles."[16]

Step 4: Communicating the Change Vision

John Kotter stated that "a clear vision can help employees understand the 'why' behind the reason for change."[17] The MS-COCE Research Task Force identified what the Department of Defense (DOD) senior leaders expect of the Air Force to be ready for adversaries in a joint environment. Gen Joseph F. Dunford, former Chairman of the Joint Chiefs of Staff said, "One of my priorities is joint readiness . . . to provide timely and viable military options that, in the event of a crisis or contingency, are responsive to the desired policy end state . . . Underlining the principles of responsiveness, flexibility, and resiliency is ensuring that our men and women never enter a fair fight."[18] Former Secretary of the Air Force, Heather Wilson shared these views: "I would say the services are on the cusp of becoming integrated; not just interdependent, not just joint, but integrated in our operations; if we can gather information faster, decide faster and act faster, then we are going to prevail in twenty-first century conflict."[19] The senior leadership of the Air Force expects to integrate its capabilities with the rest of the DOD to be able to fight in multiple domains.

Joint doctrine that integrates all medical capabilities has been published but has yet to be adopted. According to the Joint Concept of Health Services, "joint interoperable medical capabilities are the key to providing medical support to joint operations, especially in contested environments. Providing health services in contested environments will necessitate delivery of medical care that is not dependent upon existing facilities or new infrastructure."[20] This requires solutions across DOD, agency, coalition, and international lines to share capabilities to increase efficiency, share resources, and break down language barriers in a CBRN contested environment.

Joint Publication 4-02, *Joint Health Services* states that, "in an operationally constrained or contested environment, transportation options may be limited and therefore a constant evacuation flow, patient movement (PM) must be a synchronized effort to ensure timely, responsive, and effective support is provided to the tactical commander."[21] Joint medical capabilities are the key to providing medical support, especially in contested environments.

The MHS is a global health system of the DOD with the principal mission of integrating a "combat-ready system in support of battlefield medical requirements that includes deployable hospitals, shipboard medical capabilities, an aeromedical evacuation system, and global medical surveillance services."[22] Over the past 15 years, the AFMS has worked together with the Army, Navy, and Marines to create the Joint Trauma System (JTS). During this time, the JTS has served members in combat situations in Iraq, Afghanistan, North Africa, and other areas of the Middle East. Through collaboration, the JTS developed new battlefield trauma practices which are being used to save lives. Many of these advances have been adopted internationally and continue to advance the art and science of trauma medicine around the world through incorporating the innovation and integration of the best practices in medical centers into the operational environment in field hospitals, and in aircraft during aeromedical evacuation (AE). The DHA was instructed through Section 707 of the 2017 National Defense Authorization Act to enact substantial reforms to the current MHS. Section 707 focuses on the "provision and improvement of trauma care delivery to injured Service Members, their dependents, and others eligible for care through the establishment of a Joint Trauma System" within the DHA.[23]

The Air Force Surgeon General's Full Spectrum Readiness Priorities are to "enhance forward surgical and enroute care capabilities, currency/competency training, and future requirements supporting contested operations."[24] Using these concepts, the AFMS plans to support the MHS to support the JTS.

Adversaries will target those who are opposed to their ideologies and political aims and target the destruction of their opponent's military to ensure the survival of their country, region, or group. They will also adapt their fighting tactics to suit different situations. This security dilemma has been seen in World War I and World War II. North Korea has already threatened the United States with nuclear power. A 2017 assessment by US and East Asian intelligence officials stated that "North Korea will be capable of launching a nuclear-capable, intercontinental ballistic missile as early as next year."[25] North Korea's "blueprint appears to be derived from the playbooks of other countries who developed nuclear weapons, including Pakistan" and that Kim Jong Un would "hope to have enough nuclear firepower to repel a conventional attack from South Korea while deterring a game-ending nuclear retaliation by the United States."[26]

The MHS is used to a 98% survivability rate for patient care in a deployed setting because of the ability to get patients to the next echelon of care within hours. This will not be the case in the CBRN contested environment, unless the AFMS starts incorporating CBRN contested environment scenarios in its Unit Type Code (UTC) training platforms.

Step 5: Empowering Employees for Broad-Based Action

John Kotter defines the fifth step as "removing obstacles to change structures that undermines the vision while encouraging risk-taking using nontraditional ideas are needed for innovation transformation."[27] The MS-COCE Research Task Force, along with AFMS experts sent from major commands, identified six topics with recommendations which could be used to integrate into the UTC based capability training to get deployed members ready for a CBRN contested environment.

The first topic is how to provide patient care in this setting. Currently, medical personnel are not adequately prepared to provide care in a CBRN environment. This is in large part because current doctrine, mandates, and guidance manuals apply to today's environment but do not consider the future battlespace. The recommendation from the MS-COCE working group is to update doctrine and training for clinical teams to conduct operations in a resource-contested CBRN environment. However, these long-term solutions must be worked in the course training plan, which takes time. An interim solution would be to create an expert AFMS CBRN team to partner with the Army at the Army Medical Research Institute of Infectious Diseases to adapt these skills and develop these concepts to train our deployed teams.

The working group's second topic focused on the guidance needed for the clinical teams to provide an operational treatment approach in the CBRN contested environment. Current formal readiness training requirements and military exercises will need substantial revision to allow medics to execute the operational treatment approach. Education of the military medical professional should emphasize the "why" behind the theory.

Medical professionals must often operate in a gray zone, where there is often no easy or perfect solution to situations. They must be educated to rapidly develop and execute the best possible solution in a dynamic and challenging environment. It is imperative that military exercises, readiness training, and education integrate line assets such as wing commanders, crisis action team members, and other vested stakeholders into the decision-making process. The recommendations are to collect data from previous CBRN medical cases, public health responses, and medical war records to collaborate with civil medical ethics team and partner with the Judge Advocate General Corps to develop and steer the medicolegal policies and standards of care to better guide ethical operational decision-making in the training and exercises. Training for the operational treatment approach will enable clinical teams to be ready for psychological impacts that may occur during a crisis.

The third topic identified dealt with the psychological implications and complications of providing medical support in a CBRN contested environment. The CBRN contested environment has yet to be fully realized because training constraints limit identification of and preparation for those stressors. Time limitations along with other resource constraints have prohibited current training platforms from truly mirroring the operational stress present with a CBRN attack. There would be needless casualties among medical personnel because they cannot don appropriate Mission Oriented Protective Posture (MOPP) gear proficiently, use said gear when performing basic functions (e.g., drinking water), or perform job related tasks. The loss of even one medical professional decreases the amount of medical support available for injured personnel. In light of this, small numbers of CBRN casualties will be difficult enough to treat, but in the face of mass casualties, medical resources will be overwhelmed and prevent any meaningful reconstitution of forces.

Proper investment in training and execution of preventative actions on the part of nonmedical personnel will help thwart enemy objectives, sustain line resources, and enable medics to save more lives and potentially return more people to the fight. This objective will prepare medics to transport patients using multimodal assets in this complex environment.

The fourth topic identified from the working group is PM in a CBRN contested environment. PM and guidance must be flexible and adaptable to support unregulated, long distance enroute care. Recommendations include building patient hold scenarios into UTC based capability training, building plans for nonairlift PM and consider multimodal methods to transport patients. The plans need to address things like litter stanchions to modify for train cars, AE crews and medical teams to be utilized for alternative movement capability, modification of equipment sets to allow for more multi-use items versus single use or disposable items, and incorporation of CBRN patient pick up scenarios into AE crew training. The training should help medics to be ready to absorb an enormous influx of patients and cope with information overload.

The fifth topic identified from the working group is developing the concept of teaming medics with machines in operational medicine. The CBRN contested environment presents the challenge of increased casualties, decreased AE capacity, and deployed provider overload. To save lives in situations where time is critical, machine learning will help casualty care practitioners do their jobs more efficiently. Recommendations included telehealth, hand-held applications, and chatbots to use for predictive analysis. The inclusion of this technology should be incorporated into a training platform for all DOD medical professionals so they can learn to adapt to patient overload situations.

The previous five topics gave rise to the sixth topic: the solution for the AFMS to adapt to a joint training platform for all DOD medical capabilities to incorporate CBRN contested environment scenarios. The working group discussed why joint training and partnership with other DOD medical teams is necessary. The DOD has invested heavily in the JTS, which has reduced combat casualties to unprecedented levels. Evacuation times from the point of injury to a Role 3 or Role 4 facility, which may be located thousands of miles away, is measured in hours.[28] Service members have come to trust that the medical system will save lives. The moment a patient feels expectations are violated, trust in the system is lost forever. With the increased focus on the joint force and joint operations, medical personnel from other branches could be working alongside Air Force personnel on a base affected by an attack. Therefore, there are two major points that must be highlighted. First, it is important that commanders be confident that AFMS personnel will provide high quality care to all patients from all services in the event of an attack. Second, and more importantly, the commanders must understand the implications of the operational treatment approach. Integrating joint partners in training and operations provides different perspectives and potential options which would not have been otherwise realized. For the MHS to have joint training, a process for a joint operational course must be established.

Step 6: Generating Short-Term Wins

John Kotter stated that "a good short-term win is visible, unambiguous and clearly related to the change effort at hand."[29] In the development of a joint training initiative, focusing on a CBRN course that bridges the gap between the AFMS to the DHA is a good first step. Once complete, other services can use the same processes to conduct training or develop service specific courses.

This process was developed by the author, a member of the DHA, and a cadre member from AETC. Together, they developed a process that allows each service to organize a process to integrate joint operational courses.

The service begins by identifying a training requirement. For example, in 2018, the AFMS needed all clinical CBRN UTC based capabilities to be able to accept and treat patients exposed to a biological or chemical agent. Instead of asking the other services for a joint training solution, the AFMS reached out to the US Army Medical Research Institute of Infectious Diseases (USAMRIID) to conduct their training.

This training included the history and current threat of chemical and biological agent use, the characteristics of threat agents, the pathophysiology and treatment of agent exposure, and the principles of field management of threat agent casualties. The training also identified clinical gaps in the AFMS UTC based training platforms. If all services were jointly operated and collocated in one location, the Army could have trained all the services for this capability.

After training requirements have been identified, military branches submit training requests to DHA via the DHA Requirements Portal. The MHS Triage Team will triage and assign to the appropriate DHA directorate for review and validation. Once validated, DHA will contact all services to determine if any of the DOD medical teams want to coordinate and train together on the identified training requirement. This is where the branches can say yes or no for the coordination. If the answer is no, that branch can continue with their specific course training plan process. If the answer is yes, and the branch would like to train with the other branches on the new training identified, the request goes to the DHA Developmental Analysis Group to see how the training can be merged and coordinated among the services.

The DHA Developmental Analysis Group will then send new training requirements to the Curriculum Review Board, a working group established of Subject Matter Experts (SMEs) throughout the DOD, to review new course training requirements and identify how the requirements can be merged with each service curriculum for coordination.

The DHA Curriculum Review Board will forward the requirement directly to the Requirement Resource Analysis Board to determine how much money is needed for supplies and equipment and identify the number of personnel needed based on Air Force Specialty Code skill set for the training requirement.

If more funding and manpower are needed to support the new training requirement, then the bill is sent through each individual service-specific resourcing process to get the money and manpower needed for the course.

If that branch can provide the money and resources needed for the course, the requirement goes back into the resourcing process for the service-specific course training plan to be certified. If the service has the funding, but not the manpower to put on the new training requirement for the course, the process goes all the way back to the DHA, which will determine if that service can join training that is being conducted by other branches.

For example, the AFMS has identified a need for 17 additional personnel for the Ground Surgical Team. The AFMS has the funding but contracting the people with the necessary skillsets is difficult. The solution is, if UTC-based capabilities throughout the DOD medical system were centralized on one campus, each service might be able to provide the manpower needed to support the Ground Surgical Team requirements in a CBRN environment.

The solution for conducting CBRN contested environment training would be to have all MHS medical capability collocated into one centralized training platform. This will standardize training requirements and remove resource barriers for all services. DMRTI has established an area at Camp Bullis, Texas as a potential location for a joint CBRN medical training and integration site. This opportunity, facilitated by DHA-J7, was created so cadre and student collaboration across the DOD could be collocated on one campus. For this to work, each service must identify service specific course requirements as well as commonalities across all courses and branches. Doing so will help consolidate resources, promote efficiency, and limit course redundancies.

In the future, the Combat Army Surgical Hospital course, the Navy's Forward Resuscitative System course, and the Air Force's Expeditionary Medical Support/Ground Surgical Team, Decontamination, and Aeromedical Evacuation Patient Staging courses could be merged to cross train each branch and standardize medical care and procedures in a CBRN environment. Merging courses and training also better simulates what happens during real-world deployments.

Step 7: Consolidating Gains and Producing More Change

The seventh step, John Kotter notes, is that "all highly successful transformation efforts combine good leadership with good management."[30] At this point in Kotter's eight steps, the organization should be working toward eliminating processes that do not fit in with the change initiative—moving beyond the frozen middle and the comfort zone—and moving toward the learning zone. The AFMS exemplified this when they coordinated with the USAMRIID for CBRN training. Medical readiness needs to stay in the learning phase, as the battlefield is always evolving, and tactics are always changing.

Step 8: Anchoring New Approaches in the Culture

Of the final step to leading change, John Kotter states, "for any change to be sustained, it needs to become embedded in the new way we do things around here."[31] After the culture has been shifted, the rest of the change effort becomes more feasible and easier to put into effect. The MHS, in conjunction with the DHA J7, should outline joint training requirements and implement them into the Joint Medical Readiness Doctrine. These training requirements need to fully and rapidly educate medical professionals to evaluate and execute the best possible solutions in CBRN situations where there may not be clear right or wrong answers. For future integration into joint force development plans, this guidance should also be outlined in a Chairman of the Joint Chiefs of Staff Instruction.

Conclusion

The MHS should consider the strategic implications of the CBRN environment for expeditionary medical operations and require joint training and planning solutions before medical forces are sent into a contested theater. If no action is taken, the forecasted operational tempo will likely drive our joint theater capabilities to failure and supported units to ineffectiveness. To mitigate these current deficiencies, doctrine concerning medical operations in a contested, CBRN environment must be developed. The recommendations of the MS-COCE working group, developed by using John Kotter's "8-Stage Process of Creating Major Change," provides a road map for the DOD and the MHS to use when creating doctrine for joint training. The use of the Joint Training Platform at Camp Bullis will provide the centralized location necessary for all branches. Finally, this solution will place all military medical professionals in Kotter's learning zone phase to better adapt to the constantly changing, complex, CBRN environment.

Notes

(All notes appear in shortened form. For full details, see the appropriate entry in the bibliography.)

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28. There are five roles, or levels, of facilities for medical care. Role 3 facilities are those that provide the highest care available within the combat zone. Role 4 facilities are those outside of the combat zone, but still within the theater of operations. —Ed.

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Medical Readiness to Treat Nonconventional Exposures as a Strategic Threat

Lt Col Christopher Backus

"The danger from hostile state and nonstate actors who are trying to acquire nuclear, chemical, radiological, and biological weapons is increasing."

2018 National Security Strategy

Introduction

Improvements in trauma care have allowed the US military to achieve unprecedented casualty survival rates, suggesting the MHS is a system that is effective under stress.[1] Specialization and resulting efficiency over the past 50 years has led to exceptional medical response in a conventional combat environment. From the time of injury and administration of self-aid/buddy care, to arrival at full Role 3 medical capabilities at major military treatment facilities (MTF), the US has achieved unmatched response rates and ability to save lives.

Over the past two decades, however, as operations in Iraq and Afghanistan have stabilized, the Air Force, in response to the perceived lowered CBRN threat in the world, has reduced the amount and type of CBRN training it conducts. Although some overseas military installations continue to regularly train and exercise, the time and resources to train most Airmen for this threat have been directed elsewhere. The AFMS has also reduced CBRN training, and the full impact of this decision has been felt as US military forces recently refocused on preparing for the threat as enemies have begun to focus on asymmetric means to contest US power across the globe.[2] Because of the relatively short duration of military service among many physicians, this reduction in training has led to an alarming lack of preparation for CBRN medical care.

With these factors in mind, this chapter begins with an analysis of the current state of CBRN readiness within the AFMS. Because of the technical nature of this problem, analysis of each CBRN threat will allow for current limitations to be described and initial solutions to be considered. Recommendations to close strategic gaps between the current state and a fully prepared end state will be presented. Ultimately, prioritization of resources throughout a decade of conventional low-intensity conflict and inadequate preparation to treat CBRN patients has created avenues for enemy exploitation. By using John Kotter's change model, these weaknesses can be overcome.

Current Threats Drive a Sense of Urgency

CBRN attacks are rare, and so it can be difficult to weigh the benefits of spending time and resources training for them. The potential impact of these decisions can be seen in real world incidents.

On 4 March 2018, a man and his daughter, Sergei and Yulia Skripal, were found foaming at the mouth, unconscious, and having lost control of bodily functions on a park bench in Salisbury, England.[3] A witness thought they must have been "taking something quite strong," and dismissed it as recreational drug use. Investigation showed Sergei Skripal had previously been a Russian spy, imprisoned for providing information to the United Kingdom. This prompted authorities to expand their search for a cause of the Skripal's symptoms. Analysis of the doorknob of the Skripal home revealed the presence of a Novichok variant, one of a family of nerve agents developed by the Soviet Union, and more advanced than VX.

Examination of travel records and camera footage revealed agents of the Russian Intelligence Service likely placed the nerve agent. A police officer became contaminated and required hospitalization after investigating the home despite wearing forensic protective gear. Additionally, two other British citizens were poisoned, one of whom died, when they encountered a modified perfume bottle, in the nearby town of Amesbury. It is not believed that this couple was targeted.[4] Both Skripals were in critical care for over a month on life support and Yulia had a clear tracheostomy scar in videos afterward, suggesting she required mechanical assistance to breathe.[5] Russia's involvement raised as many questions as it answered. Were Russians unable to strike Skripal without leaving a clear trail or was there a deliberate choice to leave links to this attack? If purposeful, what message was it meant to send? Some answers were clear: this case revealed nerve agents as a current, deadly threat.

While preparations are underway for potential conflict in Asia, this attack was in the UK, one of our closest allies. One might question whether this event has helped establish a sense of urgency within the AFMS and MHS in regard to CBRN threats. Kotter's *Leading Change* emphasizes complacency as a barrier to leading change in established organizations and notes crises as an opportunity to establish urgency to overcome complacency.[6]

Strategic Context

American military power in conventional military engagements overmatched most potential enemies after World War II. Those enemies realized this and devised alternative strategies to avoid conventional warfare against the US. The tactics used by the North Vietnamese military during the Vietnam War, and other military actions against the US from that point on have been characterized by insurgency or terrorism.

Clausewitz said, "one must keep the dominant characteristics of both belligerents in mind. Out of these characteristics, a certain center of gravity develops." Enemies of the US understand that unconventional warfare is their most effective strategy against a country that places the highest value on human life and has an aversion to military losses. McNerney et al. said, "when stakes are questionable, strong democracies' will to fight is more fragile—and increasingly so if casualties are high and conflict duration grows." To this point, Saddam Hussein said before Desert Storm in 1991 that five hundred casualties would defeat the US. More recently, Rear Adm Lou Yuan from China said this in a speech at the 2018 Military Industry List summit, "what the United States fears the most is taking casualties." He later said that 5,000 service members could be killed if one carrier is sunk.[7]

Our enemies believe inflicting casualties is a strategy to pit their human courage and will against our military power and technological might. This perception of the US leads to the identification of a serious strategic weakness—lack of readiness to treat CBRN casualties—that threatens failure for the military instrument of power, undermines the credibility of the US military, and harms US interests.

Overview of the Current State of Readiness

Preparation of medical professionals to survive and deliver care in a deployed CBRN environment is vital. After comments like those made by Rear Adm Yuan, heightened tension in the Asia theater prompted the AFMS to consider their readiness in responding to CBRN attacks and found shortcomings. Collective Protection (CP) only existed in a few facilities, such as an Expeditionary Medical Support System (EMEDS) and the hardened facilities of some MTFs.[8]

As a readiness tool, exercises are a necessity to assess preparedness. Most medical exercises start at a defined time when exercise participants are already gathered for work with equipment readily available. Exercises focus on donning MOPP gear in a timely fashion, wearing it correctly, and occasionally demonstrating some nonmedical skills like drinking from a canteen or carrying a litter. Practice of specialized medical skills, like decontamination of small numbers of patients, is practiced by predetermined teams and does not reflect the more realistic scenario of working with any available personnel. At the Aerospace Medicine Primary course, required only of flight surgeons, CBRN training has been updated to include intubation and advanced physician skills performed on highly realistic simulators. A recent graduate of the course noted while they initially trained while wearing chemical defense ensembles, they quickly removed them because of discomfort and inconvenience to focus on the precise delivery of the medical procedures and skills. The physicians found the training procedures inordinately difficult to perform while wearing the equipment. Across the AFMS, experienced physicians agree existing exercises fall short both as a tool to achieve confidence in protective gear and in competence in delivery of contingency medical care. Most also agree on one of the fundamental causes of these problems: a focus on patient access metrics to the detriment of readiness.

Dynamic Tension Between Access and Readiness

Providers within the AFMS experience tension between access and readiness. Access is the provision of everyday medical care to Airmen, dependents, and retires, while readiness prepares medical professionals for deployment so that they perform competently while deployed and ensure all Airmen are similarly medically ready.

Often, this tension is obscured because the two requirements overlap and blend together. AFMS previously highlighted care that provided experience to build medical competence for deployment. The degree to which this happens varies. For example, intensive care, requiring invasive lines, monitoring, and intravenous (IV) fluids prepares medical professionals for deployed intensive care. Routine care, such as diagnosing and treating colds in otherwise healthy adults, provides fewer training opportunities. As the AFMS has transitioned to largely outpatient clinics, clinicians provide a substantially less diverse slate of routine medical care. Other procedural specialists like trauma surgeons or anesthesiologists may suffer from inadequate workload or mismatch between in-garrison case types and deployed skills needed. For outpatient primary care, access and readiness seem to be distinct, competing demands.

This divergence from the historical role access played in preparing physicians for deployment was noted in a publication from the Institute for Defense Analyses that stated, "The concept of dual missions for the medical force . . . arose in a period of time when medicine wasn't as specialized and theater medical care included significantly longer-term care than is currently practiced. The dual missions have diverged in nature, and thus aren't as complementary today than in previous eras."[9] Access has come to be more a measure of productivity than a metric of patient needs met, or especially patient outcomes achieved. As a result, outpatient clinicians lack time to invest into experiences that yield true readiness demands during conflict, particularly, readiness to respond to the CBRN threat. Readiness training requires time and mental investment.

Most metrics in use by the AFMS measure access and readiness metrics focus on personal health care requirements, training accomplished, and computer-based training accomplished, often "checkboxes" measuring attendance rather than competence. Consistent with the focus in the civilian world on metrics and access to care, providers in the Air Force have been pressed to improve efficiency and exceed the limits imposed by limited resources.

As the DHA assumes control over MTFs, the emphasis on access metrics increases. Readiness is the stated priority so distinguishing routine medical care that is less relevant to deployment preparation is vital to ensure adequate time for readiness preparation. Inadequate preparation time decreases the utility of thorough TTP because preparation will be rushed. Actual competence in readiness skills needs to be considered, tested, and trained to high levels of demonstrable application. Achieving observable competence among the entirety of medical providers in the face of dynamic tensions requires a vision.

John Kotter notes that leading change in an organization requires a clear vision of the desired end state.[10] The AFMS has lacked skills to treat CBRN emergencies not out of laziness nor lack of awareness of the threat, but because the problem is complex and occurs in a larger system with competing priorities, unpredictable risks, and a resource constrained environment. US troops have not suffered from CBRN attacks since World War I. Since then, world leaders have avoided widespread use of CBRN. Perhaps in a resource-constrained environment, a high-consequence, low-likelihood event does not require expensive preparation.

One assumption is that preparation for a CBRN event will not reliably achieve patient outcomes consistent with expectations unless a significant cadre of medical professionals are fully trained and prepared to care for CBRN exposures from the point of injury until resolution or transfer of care. The first course of action considered is to stop all preparation and use these resources to pursue other priorities. A second course of action involves maintaining the current level of preparation with no changes. The most costly, but effective course of action is to fully prepare to a high reliability standard, but preparation would be complicated by the technical nature of the threat.

Technical Assessment of the CBRN Threat

Among nonconventional threats to the US military, chemical agents are the most substantial threat as evidenced by the recent UK attack, Syrian chemical weapon attacks, and Japanese domestic terrorist attack in the mid-

1990's. There are five traditional categories of chemical weapons: choking, nerve, blood, blister, and incapacitating.[11] Of those, nerve, blood, and blister are of grave concern due to their lethality.

Nerve Agents

Nerve agents are highly toxic compounds. They can be divided into two categories, persistent and nonpersistent. Persistent agents are those that can "cause casualties for more than 24 hours to several days or weeks." Nonpersistent agents dissipate quickly, or otherwise lose their ability to cause casualties after 10–15 minutes. The addition of thickeners may be added to nonpersistent agents to increase the amount of time they can cause damage.[12] Nerve agents have different physical qualities. They are liquid and range from colorless to light brown. They can be tasteless and odorless, or they might have a fruity scent.

The mechanism of action for nerve agents is by inhibiting acetylcholinesterase enzymes, which causes excess of a neurotransmitter acetylcholine and activates of all the nerves. In layman's terms, nerve agents work by attacking all nerves of the body, causing symptoms that range from increased sweating, to nausea, to death. Symptoms vary in onset and course depending on dose, depending on whether a patient is poisoned via vapor or liquid.[13]

There are different dispersal methods used to deploy these agents, and each affects how the agent is absorbed. Sprays and aerosols are absorbed through the skin, through breathing, or through accidental consumption. Vapors are primarily absorbed through respiration, which is the most efficient means of absorption. Onset of symptoms occurs in seconds to minutes. Absorption stops once patient is removed from vapor. Because of time required to absorb through skin, enter the bloodstream, and travel to target organs, onset occurs within minutes up to 18 hours later for low doses, and faster onset of poisoning with higher doses. Even once decontamination is performed, effects can worsen as the absorbed dose travels through skin, to the bloodstream, and to organs.[14]

The best defense against nerve agents is to prevent exposure, but chemical attacks are frequently unexpected, so rapid decontamination with older M291 skin decontamination kits (powder) or current reactive skin decontamination lotion is advised to prevent absorption. At any sign of symptoms, the first antidote autoinjector should be given.

Toxicity of nerve agents has increased over time. Until recently, VX nerve agent has been the most toxic of all. A droplet of VX, the size of Lincoln's head as seen in the memorial on the back of a penny, is enough to kill a person. Novichok agents are said to be five to eight times more toxic than VX. Little is known about this class of agents, but Novichok remains deadly when dispersed outside for 24 hours or more, and its persistence is described as extreme, potentially lasting months to years.[15]

There are three antidotes to nerve agent poisoning. The first, atropine, eases muscle tightness and stops excess secretions to allow the patient to breathe. Pralidoxime, often called 2-PAM, blocks the nerve agent by removing the agent bindings. Finally, the administration of diazepam, commercially known as Valium, is administered as an anticonvulsant in the event of seizure activity in the patient. Each of these medications is issued in autoinjector kits. Pyridostigmine Bromide, also known as Soman Nerve Agent Pretreatment Pyridostigmine, is sometimes used as a prophylaxis against organophosphate nerve agents. While it does not prevent exposure, it does provide additional protection until other antidotes can be administered.[16]

Blood (Cyanide) Agents

The second class of chemical agents is called blood (cyanide) agents. In the past, blood and blister (vesicant) agents were one category, because each of these agents is absorbed into the bloodstream. Blood (cyanide) agents, however, interfere with the cellular use of oxygen in energy production, hence the need for a separate category. There are two major types of agents in this category, hydrogen cyanide, and cyanogen chloride.[17]

Blood (cyanide) agents are not persistent and dissipate quickly from the environment. These agents, in high concentrations, can cause unconsciousness and death within minutes. Treatment options for blood (cyanide) poisoning include ventilation, IV administration of sodium nitrite and sodium thiosulfate, and amyl nitrite to open airways.[18]

Blister (Vesicant) Agents

A third class of agents, vesicants, refers to the tendency of this class to cause blisters.[19] Mustard, Lewisite, and Phosgene all belong to this class. Treatment consists largely of prevention through proper wear of MOPP gear, the patient should be decontaminated and treated for burns. In the event of ingestion or inhalation, treatment options will be dictated by the type of blister agent used and the amount of exposure.[20]

Biological Agents

Biological agents are concerning, but immunization and countermeasures exist for most known agents.[21] The largest preparation gap may be the existence of novel agents. Our experience with the minor threat posed by Ebola in late 2014 illustrates novel illnesses with high potential mortality pose a larger threat than anticipated. The ability to travel freely in the US could be a risk factor for bringing similar illnesses into the country. Gene editing is becoming increasingly routine, leading to consideration whether operationally useful agents, such as anthrax, could be engineered to circumvent the immunity developed by existing vaccines. The best approach to this threat is ongoing research.

Radiological and Nuclear Agents

Because of their limited scope, these threats are not addressed. The introduction of nuclear weapons changes the strategic landscape sufficiently that medical readiness is no longer a primary concern. Discussion of technical aspects of the threats provides a foundation for analyzing the current limitations in the system.

Current Limitations in CBRN Preparation

All medical professionals must be SMEs in CBRN mitigation practices. The most critical areas of improvement are in the ability to survive and the delivery of medical care in the CBRN environment.

Before medical care can be administered, all medical professionals must first be able to survive in a contested environment. Current deployment structure does not guarantee trained personnel will be present at the location of a CBRN attack. Planning for life support functions such as food, water, and elimination of human waste cannot be overlooked in preparation for a CBRN event. If individuals are unable to obtain food and water, particularly while in a contaminated area, physiologic decreases in efficiency can be expected.

Transitions between trained skills, like donning MOPP gear and then traveling to the point of care or mission execution is a constant gap in preparation identified in mobility exercises. Without training in the proper actions for these transitions, isolated medical personnel may be unaware of whether to shelter in place, proceed to the workplace, or proceed to a designated shelter. Most exercises use radios or speaker systems, but personnel may not reliably hear such guidance if indoors and wearing protective equipment.

Provision of Medical Care

Existing models of deployed health care rely on permissive air traffic flow. This is important to move patients on to larger facilities and to resupply. If movement is contested, this model may fail as patients accumulate at forward locations and supplies are exhausted. Therefore, to deliver medical care in a contested CBRN environment, intelligence, medical, civil engineering, and mobility experts need to determine how long medical care in isolation may be expected and develop new processes designed to handle patient accumulation and supply exhaustion.

When medical personnel or patients enter a CP area, like an EMEDS, the area cannot be opened without contamination. Medical professionals are not normally trained how to perform their lifesaving mission without opening the protected area. Consequently, they are either trapped in the EMEDS without access to patients and unable to perform the mission or open the door, leading to contamination of the EMEDS, obstructing safe patient care.

Medically specific skills are expected to be performed while in protective equipment, but the processes are never taught or exercised. Technical skills like IV placement are difficult to impossible while medical personnel are wearing thick butyl gloves in MOPP.[22] Ideal TTPs must consider whether medics should remove butyl gloves and cotton under gloves to enable IV access. Similar impeded skills include pneumothorax decompression, tourniquet placement, listening to heart or lung sounds, palpation for trauma, and even bandage placement. Any medical treatment beyond the use of an autoinjector requires decontamination of the patient and a protected environment, but the only documented CP environment, EMEDS, is sealed to prevent contamination. This conflict at best slows medical treatment and at worst motivates unsafe exposures resulting in medical personnel as casualties. While this research could not confirm these gaps are universal throughout the MHS, they are widespread enough throughout the AFMS to pose a threat and require correction.

TTPs also place a large amount of faith in prophylactic efficacy, leading to the unrealistic assumption few patients will need respirators. Given the effects of nerve agents on central and peripheral respiration, the low volume of respirators and medics competent in both intubation and management of respirators is more of a risk than expressed in TTPs. The gap between the supply of ventilators and trained medical personnel when compared to potential demands presents a grave risk, especially as severe cases of nerve agent poisoning typically require ventilator support.[23]

Additionally, it is not known if issued chemical detection kits will register the newest agents like Novichok because little is known about this class of nerve agents. Discussion of current limitations naturally takes us to possible solutions.

Solutions to General CBRN Gaps

Sustenance for medical personnel is a high priority. Hydration is one of the most important considerations for Airmen who are conducting operations in MOPP gear. Water must be stored in canteens or in an area where there are no contaminants. Leaders need to be aware of the weather conditions, as work/rest and hydration requirements change depending on temperature, humidity, and MOPP level.[24] Although not as time-sensitive, leaders who understand physiological needs and ensure Airmen have a chance to eat in the safest relative environment within the first 12 hours will maximize human performance. This may seem trivial, but symptoms of hypoglycemia duplicate some nonspecific symptoms of chemical agents. The resulting confusion and decrement in human performance is significant and deserves leadership consideration.

Equally important is the elimination of waste while in MOPP gear. Fluids, either from waste inside the equipment, or outside sources, degrade the protective capabilities of the MOPP gear. This forces a risk-benefit analysis between the dangers of opening the suit to urinate vs degrading the suit by urinating within it. Training Airmen to visually inspect their suit for contaminants, inspect with detection paper, and then decontaminate prophylactically after opening the suit and urinating outside will empower them to resolve this conflict.

Leaders also need to consider accountability of troops outside of work hours. Lt Col Sean McCarthy, a physician who served as Wing Inspection Team medical lead at Yokota Air Base, Japan, described an unannounced accountability exercise outside of work hours. Despite most Airmen living on base, the exercise took an extended time. Among the issues encountered, initial alerts to Airmen outside the workplace, transition to the workplace, and accountability surfaced as initial considerations in notification. Commanders need to consider the distribution of their Airman by time. As an example, a rough estimate assuming 12-hour shifts results in half the assigned Airmen present pending accountability and half dispersed as unavailable for mission and expected to lag in accountability. A more complicated scenario exists at locations near enough to a threat to be at risk, but far enough away not to be in a deployed posture.

Osan Air Base is a model of this complicated scenario. Some Airmen live off base, many have dependents, and most spend time in town. If each Airman takes one month leave per year, that means approximately ten percent are on leave at any given time, but 75–90 percent are likely in the area. An alert outside of duty hours means close to 100 percent of Airmen will be at home or at unknown social locations. If they are not required to carry MOPP gear with them, many will be casualties or will be unable to return to the workplace without becoming casualties because of difficulty transiting chemically contaminated areas safely without equipment. Commanders need to plan, because a mass casualty event, manageable with a full complement of medical personnel might become overwhelming with a significant manpower decrement. Airmen also need contingency plans if an alert happens outside the workplace. Designated intermediate locations to gather would allow commanders to send fewer runners to gather more Airmen. Fewer designated locations increase convenience but incur greater risk as more Airmen gather together.

Once units perform initial accountability, preplanned multi-unit teams should conduct sweeps to collect those who missed initial alerts. Many TTPs assume advanced medical capabilities are located outside the contaminated area.[25] This assumption invalidates these TTPs in any case where this is not true, so further planning is required in the event medical facilities are struck.

Provision of Medical Care

Most modern nerve agents are designed to be persistent and most TTPs assume medical care, particularly at higher roles, happens outside the contaminated area. In a more mobile MHS of the future or in current forward deployed medical units, this is not the case. If an EMEDS is sprayed with a persistent agent, operations would be stopped. Those inside are protected by the internal seal, but entry in and out is strongly affected. If an Airman breaches the CP seal in a hot zone, contamination will occur and is unlikely to be decontaminated. Persistence of a nerve agent also contests movement into and out of a hot zone. Contamination of a flight line, runway, and vehicle marshaling area poses a threat of cross contamination with other areas and effectively isolates the medical unit from receiving patients or delivering them to a higher level of care. Once "split-MOPP" is achieved in an area, the EMEDS remains one of the only CP facilities.[26] Medic reluctance to leave EMEDS can interfere with ongoing high tempo medical operations, as some medics may try to sleep in the EMEDS instead of in unprotected tents.

Medical care during MOPP operations is complicated by the gear itself, both on the medical personnel, and the patients. Medics are urged to protect themselves first.[27] Medical personnel in MOPP will experience detriments to provision of care. The JTS Clinical Practice Guideline (CPG) for CBRN Injury Part I is the most comprehensive attempt to address trauma care in a setting of nonconventional threat. The CPG attempts to reconcile the conflicts between CBRN care and conventional trauma care.

The guide breaks down the threat into hot, warm, and cold zones. Each zone has its own sets of mnemonics to help personnel react and render aid.

The hot zone is the immediate contact with the CBRN agent. The associated mnemonic is (MAR)2. For medical treatment, this stands for Massive Hemorrhage, Airway, and Respiration. On the CBRN side, it means Mask, Antidotes, and Rapid Spot Decon. For both, extraction is the immediate concern after initial processes have been conducted.[28]

The warm zone is the tactical field care location. This is where decontamination and further treatment takes place. The mnemonic (MARCHE)2 is applied here. The initial (MAR)2 is the same as in the hot zone, but adds Circulation/Countermeasures, Hypothermia, Head Wounds, and Evacuation to the process. Treatment in the warm zone should only be conducted on those whose lives are threatened.[29]

Even skilled providers will encounter obstacles in this environment, while working in MOPP-4. Applying tourniquets or pressure bandages to treat massive hemorrhages can require selective exposure of the patient and require spot decontamination. Clearing the airway of a patient presents potentially insurmountable challenges, especially in an active zone. If the patient will die without airway intervention, the medical professional must decide how best to triage that patient, as well as decide how to demask the individual. Like airways, respiration has its own difficulties, though medical personnel can check for breathing and skin color visually, as well as listen for heartbeat through a stethoscope.

For each of these situations, the medical professional must overcome the obstacles dealt by wearing MOPP-4. Visual acuity is decreased with masks. Tactile sensation is greatly diminished with the double layer of cloth and butyl gloves. The hood also lessens noise, making it difficult to hear.

The use of technology will be necessary. Small portable oxygen monitors placed on a finger as an additional resource for the medic struggling to assess respiratory status might help, although it requires an exposed finger and might raise the risk of potential cross contamination. A large quantity of small, durable, reliable monitors would be most useful. The CPG stresses egress to a warm zone at this point in care, where decontamination and further treatment is planned.[30] The CPG noted obstacles here, too, requiring solution either by improvement of TTPs or by on-site medical professionals. TTP refinement is vital, because future training ideally incorporates solutions to these questions with optimal plans for simultaneous CBRN and injury treatment. Providers are essential to this process, because they have the technical knowledge to highlight conflicts between CBRN needs and trauma needs.

Recommendations

The AFMS is restructuring as part of the DHA assumption of control. In this process, readiness is stated to be the explicit priority. CBRN readiness is a subset of overall readiness. Therefore, the goal must be to train all personnel to a level of demonstrated competence in the ability to survive in CBRN environment, medical diagnosis of CBRN, and medical treatment of CBRN while in and out of MOPP.

To better align TTPs with current needs, large scale exercises should be created on the scale of EMEDS. Participants should be trained to a competency level equal to current CBRN TTPs. Afterward, a highly realistic exercise that combines conventional wounds and CBRN exposure on as many patients possible should be conducted. If possible, the ratio of observers/evaluators should be 1:1 for each provider.

The after action report (AAR) should note equipment and medicine changes and shortages, difficulties in diagnoses and treatment processes, and medical individuals who removed MOPP gear to do their jobs. The working group should then evaluate and improve TTP and supply lists. Ideally, the exercise should be repeated until the desired outcomes are reached.

Some medical equipment and processes are incompatible with current MOPP gear. Tactile agility necessary for IV placement or wound palpitation is nonexistent while wearing butyl gloves. Sound is diminished under the hood on the gas mask.

Proposed solutions to these problems included electronic stethoscopes with visual displays, or stethoscopes with Bluetooth connections to in-ear devices. Thinner gloves to be worn in low-risk contamination situations were also recommended. These solutions need to be implemented simultaneously with TTP refinement, as they are interrelated processes.

Once TTPs, equipment, and supply lists are validated, the entire medical force should be trained to the new standards. After initial force training happens, retention needs to be a focus. Experienced personnel are important to force protection.

Much of the progress made in conventional battlefield trauma care stems from training frontline Soldiers.[31] Medical professionals must remind nonmedical leaders, health is an operational priority and improvements in individual Ability to Survive and Operate (ATSO) training, buddy care, and decontamination may improve survival more than MHS preparation, no matter how thorough.

Conclusion

With the changes required to eliminate this strategic weakness and a vision for a desired end state articulated, a strategy is essential for success. Recommendations to close the strategic gap between the current state and a fully prepared end state show we must use realistic exercises to fix and validate our TTPs, bring our technology and equipment up to current standards, and fully train our medical community. We must also focus on retaining the best of our professionals to ensure tactical advantage.

Lack of resources, largely time and manpower, requires difficult decisions because fixing this gap is not possible while continuing to perform routine operations as usual. Dynamic tension between access and readiness represents the prime example of the types of conflicts dictating prioritization within a resource-constrained environment. While the MHS overall has improved its performance in the face of high levels of average stress from recent conflicts, as shown by record low died-of-wounds rates, the same cannot be said concerning readiness to treat CBRN patients. Enemies of the US learned from our military dominance and have adopted asymmetric means to address it, making nonconventional attacks like CBRN attractive. Analysis of the current state clearly shows a shortfall within the AFMS. Prominent chemical attacks globally highlight the sense of urgency that drives this effort. A gap in MHS readiness to treat CBRN patients creates a weakness that adversaries will exploit, but MHS leaders can address this limitation, resulting in increased CBRN readiness.

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Operational Treatment Decision-Making in a Chemical, Biological, Radiological, and Nuclear Contested Environment

Lt Col Melissa Dooley

"Medical ethics in times of armed conflicts is identical to medical ethics in times of peace."

Introduction

The current military climate calls for action in response to the increase of CBRN threats around the world. With that increase comes a shift in the security environment, and future battlespaces will be contested. Technological and economic development has also changed this landscape.[1] For the military medical professionals, the past 25 years of working within the paradigm of permissive domains, air superiority, and relatively unlimited medical resources has bred a generation of military medical teams unfamiliar with the dilemma of prioritizing between military necessity and medical needs. To remedy this situation, two steps of Kotter's eight-stage change process—establishing a sense of urgency and creating the guiding coalition—can be used within the enterprise to develop processes and supporting structures to promote operational treatment decisions in conditions such as a contested CBRN environment.[2]

Basic Principles of War and Medicine

To begin the discussion, it is useful to provide a simple framework of the ethical guidelines for how warfare is conducted by the US military. Military necessity as defined by the DOD is, "the use of all measures needed to defeat the enemy as quickly and efficiently as possible that are not prohibited by the law of war."[3] The profession of arms justifies war through legal constructs (the government) and morally by meeting criteria for the how and why of war.

Under the rule of *Jus in Bello* (law of war), two principles, proportionality of force and discrimination of target, limit how war will be prosecuted, to mitigate unnecessary death and destruction.[4] Additionally, the how and why of war is further examined using principles under *Jus ad Bello* (right to war), including: proper authority to execute, just cause, just intention, last resort, outcome better than the current or likely state should no action be taken, and probability of success.[5]

These ethical principles of *Jus ad Bello* are the foundation of the United Nations Charter and its mission to maintain international peace and security. 193 other countries purport these principles by virtue of their membership.[6]

The legitimacy of the use of armed conflict occurs best when applied with the concurrence and support of national, regional, and international institutions. For example, during the 1991 Gulf War, a US led, 34-country coalition was largely supported by the American public, Congress, regional leaders in the Middle East, and the UN Security Council. Contrast this with the 2003 Iraq War, which was hotly contested internationally and lacked support by regional countries as well as leading Western states. For better or worse, the reality is that the global community defines international norms, and when states take actions poorly supported by peers and do not meet political or social norms, this can lead to doubts of legitimacy or scrutiny of a state's decisions and actions.

Medicine is similar, standards of care are defined by how a "reasonably prudent physician [with the same qualifications] would act in the same or similar circumstances," considering the resources available.[7] These expected norms are used to judge medical providers' actions as legal and or legitimate. Consequently, providers are encouraged to consult peers, use professional guidelines from evidenced-based research and have support from within their organizations when making controversial or difficult ethical decisions.

The profession of medicine, like the profession of arms, conducts itself within a set standard of common beliefs and ethics. Military medical professionals must operate under the same professional values and ethics as all other service members and are also held to the ethical guidelines of their medical professional organizations. The profession of medicine recognizes four broad principles of medicine, codified over 30 years ago: autonomy, nonmaleficence, beneficence, and justice.[8] Autonomy demands respect for human dignity and honesty, nonmaleficence is commonly referred to and understood as "first, do no harm," beneficence is the requirement that actions should support and lead to the benefit of the patient, and finally, justice obligates providers to treat patients fairly, equally, and impartially.[9] These medical ethical principles are consistent across most medical specialties and professional organizations and are used to inform and guide international law and policies. These core principles are reflected in Geneva Convention, Article 12, which states that, "members of the armed forces . . . who are wounded or sick, shall be respected and protected . . . treated humanely and cared for . . . without any adverse distinction. . . . Only urgent medical reasons will authorize priority in the order of treatment to be administered."[10] The DOD *Law of War Manual* and JP 4-02 *Joint Health Services* publication reiterate Geneva Conventions Article 12 with similar language and clarify that the wounded and sick can be any person, whether friend or foe.[11]

Despite a broad consensus of these guidelines in the theoretical realm, when faced with real situations in combat, medical professionals may find themselves conflicted when grappling with decisions about the patient versus the greater good for the greatest number. There are tensions within the ethical principles of warfare and medicine respectively, which become further complicated when applied together in a situation appearing to prioritize the mission over the individual, where a military medical professional owes loyalty to both.

There are limitations in the application of these ethical principles, as seen when applied in resource-constrained environments, like emergency departments, where the health care system is attempting to allocate resources fairly through a process called triage.[12] Triage, the process of sorting, has been attributed to Napoleon's surgeon, Baron Dominique-Jean Larrey, and is the concept of organizing patients into categories based on clinical severity.[13] Unfortunately, the four basic principles discussed above do not take into account the reality of limited resources, time, and space, nor do they take into account the level of need required by a patient. These principles also do not adjust for the relationship of the provider to the patient, provider to the population, and patient to the population. Triage systems that use a principle of equality by applying a first-come, first-serve policy use resources inefficiently or ineffectively.[14] An example would be a patient arriving and receiving nonurgent imaging to rule out appendicitis. This may require about 15–20 minutes of preparing the patient and performing the study, while another patient who arrives moments later with an intracranial bleed also needs imaging and several other resources, including the medical team's full attention. Based on a first-come, first-served policy, the provider cannot abandon care to the first patient (i.e., stop the imaging mid-sequence) to assume care of the second. This policy could only work in an environment where resources and personnel were far greater than patient demand.

Another proposed method applied in triage is the worst-first priority. Elements of this process are seen in many US hospital-based emergency departments—this is why a 26-year-old patient with a sprained ankle may wait two hours to be seen and treated and a 56-year-old patient with chest pain is immediately whisked to an examination room. Theoretically, this works well, until demand surpasses resources. Often, depending on how busy they are, emergency departments operate along a spectrum of first-come, first-served, to worst-first, to finally, what is often referred to as greatest good for greatest number policy, a utilitarian principle.[15]

In some contexts, such as a contested CBRN environment, there may be no obvious right or wrong answers, despite current well-developed triage processes. The decisions health professionals must make regarding who to collect from the incident scene and decontaminate first (who to operate on and who should be evacuated versus who might be able to rejoin the fight) may all be answered differently by different providers. The mission priorities of organizational commanders can further complicate the decision-making process.

The basic ethical principles dictating both the profession of arms and medicine help justify the military medic's mission and purpose. Medical professionals in the US armed forces focus their efforts toward three components of the MHS mission: ensuring 1.7 million uniformed personnel are fit to fight in support of national security interests, training and maintaining capability and skills to care for operational personnel, and providing health care to 9.4 million beneficiaries.[16] Military medicine, from its infancy as a poorly organized, decentralized medical department in the Civil War with approximately 100 physicians has evolved into a DOD health care system, with over 12,000 physicians and an additional 100,000 medical professionals. The MHS has grown into a complex health care structure including medical departments from all branches and boasts unprecedented survival rates.[17] Army Surgeon General Lt Gen Nadja Y. West noted in 2016, American forces had a survived-of-wounds rate of 92 percent, the highest in US history.[18] Achievements like this, however, can lead to complacency, decreased motivation (success has already been obtained), or inability to recognize the need for change. As military medicine celebrates worthy accomplishments it must simultaneously analyze the next threat, look for gaps, and fixate on failure to avoid or minimize the consequences of not looking forward and anticipating the next obstacle to mission success. The world is moving fast, and what we know now may not apply tomorrow. Military medicine's triumph today is not by accident, but through the sacrifice of many lives and professionals deliberately applying the lessons learned from the past. As war and technology keep evolving, so must military medicine and the organizations responsible for delivering operational medical treatment. Military medicine will be a victim of its own success if it continues its current strategy of slow evolutionary changes in response to external pressures from each conflict. The over-dependency on current technology, the fast pace of operations, and lack of medical familiarity in a contested CBRN environment will not be forgiving, nor will the court of public opinion should the MHS fail to anticipate and prepare today.

What Is the Urgency

Research conducted by students from the Air Command and Staff College and the Air War College shows that the MHS is not prepared to provide medical support in a denied environment, much less one contested by CBRN.

These concerns have been further validated during exercises, such as Exercise Southern Hope, conducted in the Republic of Korea in 2018. In addition to identifying areas of improvement, they discussed the ethical decisions that medical professionals may have to make during each stage of triage.[19]

The CBRN threat is not new and it is not going away. Syria continues to violate the international ban on the use of chemical weapons despite ratifying the Chemical Weapons Coalition agreement in 2013.[20] Of note, North Korea, South Sudan, and Egypt have not signed or ratified the Chemical Weapons Coalition.[21] Furthermore, North Korea's successful nuclear testing in the fall of 2017 proves that the CBRN threat around the global community is increasing as more international actors, with ideologies different from the US, obtain chemical, biological, and nuclear capabilities.

Military medicine built its legacy of success in the context of historical battlespace dominance, and the current training and policies are forged on the premise of continued theater superiority. The MHS must aggressively address vulnerabilities in its system and analyze the best way forward to meet new challenges as well as old threats in a potentially contested environment complicated by CBRN contamination.

The argument military medicine must prepare for the future battlespace by having medical professionals capable of prioritizing the mission above medical needs of the individual patient is not meant to dismiss the ethical issues. On the contrary, military medical personnel have been and continue to be put in positions where they are faced with making an ethical decision as they consider the legalities of the orders given them from the line, the moral obligations they have to their patients, and the core values associated with their service commitment. The concern is how to transform the MHS and build the structures and develop the policy and guidance needed to better support medical professionals as they make challenging ethical decisions daily. Providing those resources, tools, and training, across the whole spectrum of military medicine, will allow medics to become familiar with how to address ethically charged decision-making, and then apply in a novel environment contested by CBRN.

In October 2017, the LeMay Center at Air University hosted wargames that were developed by Lt Col Karey Dufour, a student at the Air War College. Some of the recurring themes in the AAR were the lack of training and concerns regarding the ethics of clinical decision-making in an unfamiliar operational environment. Medical professionals expressed discomfort at making ethical decisions they had never had to consider and had no frame of reference for making those decisions. Teams often misunderstood commander's intent and defaulted to what they considered important. As a result, their decision-making efforts were ineffective at best and ran counter to mission success at worst. Medical personnel who had familiarity and recent training felt more comfortable when confronted with difficult decisions.[22] The MHS must invest future efforts toward training and guidelines in operational treatment decisions to better support military necessity, as this will help prioritize, deconflict, and clarify existing doctrine.

Arguably, while in garrison, both time and resources favor the provider faced with a novel situation or an ethical decision. Short of the patient presenting in extremis, the medical team has the time and option to request assistance from peers, specialty colleagues, the medical director, or the Chief of Medical Staff. For ethical or legal concerns, the medical legal consultant is a phone call away and convening an ethics board is always a consideration for the decisions that seem to have no morally right answer. When medical teams deploy, the resources available shrink and the time available to make decisions compresses. Fortunately, for the past couple of decades, the deployment situation has not changed much from year to year and the ethical decisions are not overwhelming in number or nature. This relatively stable environment and well-established medical facilities built up over the two decades in Iraq and Afghanistan have resulted in theater-prescribed medical rules of engagement (ROE) and a local standard of care based on the host nation's local capabilities. As medical teams redeploy and deploy again, from their perspective, the execution of their mission has not drastically changed.

Beyond the introduction to the Law of Armed Conflict/Geneva Conventions, a few prescriptive ROEs, and CPGs, little more has been done to prepare military medics for the challenging life and death ethical decisions relative to tomorrow's battle. Medical personnel are left to their own interpretation of the Geneva Convention framed in the limited context of their own experience. Applying what they know and understand of Article 12 while obeying an order from the theater or local commander, to whom they are subordinate, may create doubts and counterproductive or delayed actions. In war, this may result in administrative and medicolegal complications. More concerning is the impact it can have on human lives, trust (between patient and provider, between officer and commander, between state and military) and mission effectiveness.

While ethical arguments are not the principal focus of exercises, the tension seen in the LeMay Center wargames is also seen in real world conflicts. The consequences of these tensions are unavoidable but can be mitigated. The question is how the MHS can assuage concerns or doubt about whether medical professionals will make operational treatment decisions that prioritize and support the mission and thus ultimately serve the good of the nation. Military medicine, disaster medicine, public health, and services meant to address a population or community can be argued as justifiable under the ethical principle of utilitarianism. The principle of utility considers how an action impacts the population and so long as the outcome is better or results in happiness overall for the group, then the decision is good and ethical.[23] In this theory is a trade-off, an understanding that some individuals may not receive a beneficial outcome, and that their benefit may be sacrificed for the good of the larger group. The military can find some confidence in knowing medical professionals have prioritized mission in the past, they do it now, and if they are to continue to do so in tomorrow's unknown battlespaces, the MHS and the line must work and train together to ensure this. More importantly, organizational and process changes must occur to support medical professionals who come to ethical resolutions that could prioritize a mission-first endeavor.

However novel a contested CBRN environment may seem today, military medicine need only look back to the early 20th century. World War I (WWI) illustrates military medicine prioritizing the operational mission above the medical needs of the individual. Military medics provided large scale medical support in a contested CBRN environment in the trenches, where chemical weapons were cited to be responsible for 1.3 million casualties and 90,000 deaths.[24] They were confronted with an overwhelming number of casualties in a contested CBRN environment and forced to develop triage processes and clinical decision-making protocols for clearing the battlefield and hospital beds to return as many capable fighters as possible to the front-lines. This war saw unprecedented numbers of injured as the fighting escalated both geographically and technologically, with a growing number of participating soldiers and the introduction of increasingly destructive weapons along with the use of chemical gases. By 1915, all belligerents were using chemical warfare and, by 1917, a third of all artillery contained poisonous gas.[25] In 1918 Maj William Keen, an innovative general surgeon in the Army Medical Reserve Corps, instructed in his manual, *The Treatment of War Wounds*, "a hospital with 300 or 400 beds may suddenly be overwhelmed by 1,000 or more cases. . . . A single case, even if it urgently requires attention . . . may have to wait, for in that same time a dozen others, almost equally exigent, but requiring less time, might be cared for. The greatest good of the greatest number must be the rule."[26] Another medical handbook from WWI identified two priorities of triage: "the conservation of manpower, and the conservation of the interests of the sick and wounded."[27] These manuals provided very little guidance but justify the rationale and provide a priority list for future medics to at least understand the reasoning behind decisions that seem on the surface to be heartless and unethical. It is difficult for contemporary US military medics to comprehend hundreds to thousands of patients presenting at once for treatment, but that is exactly what occurred during the sarin gas attacks in Tokyo and the chemical accident in Bhopal; both should serve as reasons to not only imagine, but prepare for the potential reality.[28] The MHS must consider the possibility and have in place well-developed protocols and guidelines medics can resort to when considering the mission objectives while overrun by hundreds of contaminated patients seeking care.

Even without the extreme pressure of a contested CBRN environment, military operations have been ranked above medical needs. Consider, for example, that in 1942, limited penicillin supplies were given to healthy Soldiers with sexually transmitted infections as opposed to war-wounded Soldiers based on preservation of the fighting force.[29] The military justified these actions through military necessity. To obtain and maintain the advantage, limited resources such as antibiotics had to be reserved for those able to contribute to winning the fight, because the sooner the war was won, the fewer lives would be sacrificed overall. Many find it challenging to come to terms with this sort of rationalizing. Beyond the justification of military necessity, this case simultaneously highlights the medical principle of utilitarianism, where the outcome of greater good led to prioritization of returning Soldiers to duty. The underlying message is not that wartime operations are taking priority over the medical needs of patients, but that the utility of serving the greater good justifies the sacrifice of a few in war and medicine.

A similar line of reasoning is extended into the public health realm inside and outside of the military. The overall purpose of public health is underpinned by the interests of the population, where the battle is not at the front, drawn along lines of longitude or latitude, but along populations at risk versus those who are contaminated or infected. Public health policy and guidelines must balance the individual's rights and interests with those of the population at large.[30] During an outbreak or pandemic or immunization shortage, the public health officer has authority to mandate quarantine or isolation, establish immunization prioritization, and require testing for identifying potential disease status in individuals, all in the interest of the health and welfare of the greater good.[31] Like processes established in triage, there is a process public health officials apply to make decisions based on ethical principles, clinical criteria, risk prediction, and so forth. There is forethought and development of standing public health policies that involve ethical considerations and balance individual rights with those of the populace.

Probably a less recognized illustration of how the AFMS organizational structure prioritizes operational mission over medical needs is the Flight Medicine Clinic construct. Flight medicine as a subspecialty of primary care consists of medical professionals who have had additional training in aerospace medicine physiology and provide care solely to the flying community. The important role of flight doctors is to know and enforce the strict physical and medical requirements all aircrew members must meet to continue flying duties. Providing this subspecialty medical care to aircrew members decreases risk of catastrophic loss of aircraft and crew because of the flight doctor's understanding of the relationships between the weapon system, operator, and environment. This prioritization ensures preservation of the force. This explanation of flight medicine as a specialty does not seem particularly controversial but the reality of its execution highlights the ethical tension and argues precedent has been set regarding mission over medicine.

The ratio of patients to provider is strictly dictated by Air Force Instruction (AFI) for primary care specialties like family health, where the bulk of active duty Airman are seen. Current ratios are approximately 1,300 patients assigned to one medical provider. The provider will make at least 90 appointments available weekly to those 1,300 patients. On the other hand, flight medicine is assigned only rated Airman (flyers) and will never have thousands of flyers assigned to each provider, there aren't enough rated Airman for this to occur. Additionally, the AFI states appointment availability standards and requirements will not be applied to flight medicine clinics. The resulting implications of these AFIs are that flyers have practically unfettered access to care and any nonacute issue can be seen immediately as a same day appointment. The average nonflyer is assigned to a different clinic, and can wait a week to four weeks for a nonacute medical appointment.[32] The health system and military enterprise have established a structure and culture to ensure mission support and primacy, and leaders must continue to project a similar spirit across the full spectrum of military medical operations. For an operational medicine culture and construct as seen in the flight medicine realm to translate to all medical professionals in a contested CBRN threat, there must be deliberate effort from multiple disciplines in medicine, ethics, and law.

Creating the Guiding Coalition

Finally, the MHS must address the challenges of the ethical balance of mission and operational treatment decisions. This requires building a guiding coalition. Step two of John Kotter's *Leading Change*, creating the guiding coalition, is necessary to catalyze the change and sustain it. Kotter identifies four critical characteristics of an effective team: having enough key players in power roles, including members with expertise, having enough credibility on the team, and proven leaders that can drive the new processes.[33] He also notes that trust and common goals are necessary to build a team to successfully move an organization.[34] For the MHS this is particularly important, yet difficult, because military medicine straddles two professions and the range of medical practice is regulated by state, federal, and international organizations. The purpose is not to argue the moral or ethical merits of prioritizing military necessity over medical needs, but to highlight the need for an organization to support medical teams in making ethically sound decisions resulting in consideration of the overall common goal, mission, or objective.

Military medical personnel are highly skilled professionals who are unlikely to blindly accept legal orders that appear to violate their understanding of ethics in medicine. When faced with questionable orders, medical staff may challenge the commanding authority or policy that conflicts with their current interpretation of the legal and ethical limits they work in or they simply may not comply. The consequences from this dissension could range from commanders accusing medical professionals of dereliction of duty or disobeying a direct order. Medical personnel may lose faith in leadership or military members may lose confidence in the reliability of military medicine, and worse, the public may come to distrust the military.

Ultimately, the goal is to facilitate or enable operationally sound and ethically consistent decision-making that falls within the standards and norms as judged by Western medicine. A guiding coalition of leaders and SMEs must work toward common goals for both general military operations and military medicine. Getting both sides to better understand the mission and ethical dilemmas that medical professionals face will improve the support that is given and received during today's operations.

For organizations to change or transform, there needs to be a meaningful effort from key leaders, and others with power and authority. The belief that the organization must adapt needs to start from the top, then through authority, influence, and relationships established on trust, build the remaining pieces of the coalition. When considering the whole of the coalition, the MHS should identify consequences that may not be readily apparent when considering readiness gaps for operating in a CBRN environment. Operational leaders responsible for executing missions in the interest of national security, theater commanders in regions of higher risk based on proximity to threats, and military medical leaders who are responsible for a ready medical force should also be brought into the group. These individuals add perspective and experience necessary to the success of the coalition and the organization as a whole.

The coalition should also include an ethics panel formed by leaders from within the military and civilian medical communities to focus on common and potentially distinct ethical and clinical decision models relevant to disaster medicine, covering incidents like hurricanes, earthquakes, and CBRN accidents or attacks. Ethicists and medicolegal consultants brought into the coalition can assist in the development of policy that can help guide decision-making across medical teams, helping achieve consistency in interpretation across several medical disciplines in various contexts. In a contested CBRN battle, the principles do not change, but the relationships, responsibilities, and consequences may look so drastically different that a military commander or military health professional may be paralyzed by the dilemma. The real value will be the legitimacy of the products produced by a well-constructed coalition involving SMEs as they bring the credibility needed for the input toward new doctrine and guidance. In turn, new policy and better guidelines with clarification and tools for decision-making can help drive training and education platforms to build and sustain a ready medical force sensitive to the mission and how ethical decisions in medicine can support the operational side.

The MHS provides medical professionals with numerous guidelines, policies, and instructions regarding operational medicine, but given the concerns that arose during the exercise at the LeMay Center, there is doubt as to whether these products aid in operational treatment decisions in the context of a contested CBRN environment.

In 2013, the Defense Health Board (DHB) was tasked by the Assistant Secretary of Defense for Health Affairs (ASD(HA)) to perform an independent review of military medical professional practices, policies, and guidelines. The ASD(HA)'s specific question regarding medical professionals' ability to balance obligations between patient and military service speaks to the acknowledgment of the duality of the medical profession and the impact on mission readiness.[35] After more than two years of investigation by the DHB Medical Ethics Subcommittee, they concluded that the plethora of ethical guidance and materials available across professional societies were "remarkably consistent" and that military policies and instruction manuals "implicitly operationalize[d]" the ethical guidance from the aforementioned material.[36] This may be the case, but it does not adequately ensure the ability of medical teams to understand and apply these guidelines in the fog of a contested battlespace, where communication may be compromised, time constrained, and personnel have no means to reach out or up for assistance to determine a better way forward.

Studies suggest that military and civilian medical students receive little instruction in military medical ethics; some students claim as little as one hour.[37] This leads to physicians who lack the training to navigate challenging ethical dilemmas on the battlefield and civilian physicians potentially handicapped in a civilian disaster response situation which may look eerily like their military counterpart in warfare. Domestic and international terrorism has touched the US numerous times in just the past two decades, and civilian and medical professionals must create a common framework to aid in the thought process of clinical ethics and treatment, especially against a potential CBRN threat. Working toward a shared tool for application against a mutual threat decreases the level of scrutiny toward a military medical professional's decisions or actions in a contested CBRN environment so long as their actions are in line with the same tools their civilian counterparts are using and developed jointly with civilian partners.

Many ethical decision-making models currently exist in the clinical realm, focusing mostly on the patient-provider relationship, but they do seek to balance or prioritize various principles like beneficence with autonomy.[38] These models are limited because they fail to address the broader context of the relationship between military medical professionals and unit commanders and consequently fall short for direct application to the operational environment.

Recently, Riverside County in California acknowledged their vulnerability to respond effectively with medical assets to any community-wide disaster and began developing a response plan including both the operation and ethical components.[39] By looking at how civilian organizations and multiple disciplines address ethical and operational decision-making, the MHS can develop a foundational framework for decision-making and can continue to evolve to better meet the mission and medical needs.

Conclusion

The MHS must ensure their medical professionals have the tools necessary to consider the balance of military necessity with medical needs, to ensure operational treatment decisions meet the needs of the mission. Kotter's first step toward organizational change uses the energy of a crisis or urgency of need to catalyze and create momentum. Using the threats identified in the National Security Strategy as impetus, the MHS can create change before the threat comes to fruition and an unforgivable crisis results in unnecessary morbidity and mortality. The successes up to this point should not be dismissed, but a continued metric to maintain or work toward unknown future environments including contested CBRN conflicts. Building a multidisciplinary team of experts across the military and civilian sectors of the legal, ethical, and medical professions provides multiple perspectives and widespread acceptance of an ethics program for operational treatment, with tools for guidance and ethical decision-making models. Ethical decision-making must be supported by a well-developed process or system for the dilemmas medical teams may face. More importantly, the program should provide a process that guides not the actions, but the thought-processes that will result in decisions that better balance the interest of the mission, the medic, and the patient. Efforts should be invested toward incorporating joint service medico-legal consultants, cross-agency ethical committees, civilian and military bioethicists, multidisciplinary health specialists, and CBRN experts to mature a military medical ethics program.

This program should further clarify military medical ethics along a spectrum of conflict, including contested CBRN environments. It should also improve training programs to introduce medical ethics and decision-making in the context of disaster medicine. Doing so will universalize application and understanding of common ethical principles across military and civilian domains. Decision-making models based on a common understanding of complex relationships between service commitment, medical ethics, and personal morals also need to be developed and implemented.

A coalition of civilian and military professionals to develop an ethics program for military medicine legitimizes ethical decision-making tools and ethical thinking frameworks by involving all stakeholders and provides transparency in how the program develops, matures, and evolves for all key players. Finally, once an ethical decision-making framework or model is developed, the MHS must introduce its use through various teaching methods, such as case reports, vignettes, simulation, and workshops methods. Training should be introduced to the imminently deployable medical teams or those assigned to operational tasking until the joint service program could target the medical professional pipeline. Ultimately, the goal should be to cover ethics and decision-making during clinical training and then sustainment throughout a medical professional's clinical career, as the operational component is just one end of the medical ethics spectrum for military medicine.

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Patient Movement Limitations in a Chemical, Biological, Radiological, and Nuclear Contested Environment

Lt Col Lea Ann Calderwood

Introduction

The 2018 National Defense Strategy predicts our ability to rapidly obtain US dominance across land, air, maritime, space, and cyberspace domains is unsustainable because "Today every domain is contested—air, land, sea, space, and cyberspace."[1] Our ability to achieve air superiority over the past 20 years, specifically in Operations Enduring Freedom (OEF) and Iraqi Freedom (OIF), permitted the rapid transport of injured Soldiers, Sailors, Airmen and Marines to higher levels of care, increasing survival rates to unprecedented levels. Unfortunately, this success stripped the MHS adaptability and left it ill-prepared to provide PM in a CBRN contested environment.

John P. Kotter created an eight-step process to create major change, providing a methodology organizations can follow to transform their operations for future success. If the AFMS applies Kotter's steps to establish a sense of urgency, create a guiding coalition, and create a strategic vision it can adapt to the new threat environment by mitigating current challenges of "evacuate and replace" assumptions, doctrine transformations dependent upon air superiority, as well as modifications to equipment and supply sets reliant on rapid resupply for patient evacuation.[2]

Before discussing our past 20 years of successful operations, it is important to define the key terms related to PM. PM is the process of "moving wounded, ill, injured, or other persons (including contaminated, contagious, and potentially exposed patients) to obtain medical, surgical, and dental care or treatment. . . . PM occurs across the continuum of care, from point of injury, wounding, or illness or infectious agent exposure (suspected or known) through successive roles of medical care to final destination."[3] In turn, regulated PM is outlined by comprehensive, coordinated activities under authorized command and control entities designated by operational commanders, in theater and out.[4] Intertheater evacuation is the movement of patients between theaters where intratheater is the transfer between points within theater.[5]

Other important key terms are related to modal methodologies for PM. AE is movement of patients under medical supervision to and between medical treatment facilities by air transportation.[6] The AE system as a whole provides for control of PM by air transport, specialized medical teams for inflight care as well as ground facilities on or near air strips (or bases), and communications systems across the treatment locations.[7] The Air Force AE system provides the movement via fixed-wing aircraft.[8] Casualty evacuation is unregulated movement of casualties aboard vehicles or aircraft. Medical evacuation is traditionally movement by US Army, Navy, Marine Corps, or Coast Guard utilizing tactical or logistic aircraft equipped and staffed for care.[9]

Twenty Years of Success

To understand how ill-prepared the AFMS is to respond in a CBRN contested environment, it is important to understand how PM evolved and we got to the remarkable success of AE over the past 20 years. PM, or clearing the battlefield, is not a new concept. The need to move the injured or dead from the battlefield was identified during the Second Punic War when Publius Cornelius Scipio Africanus took the time to clear the battlefield because it impeded his formation's advance in the Battle of Zama.[10] During that time, the movement was not to streamline or provide care, but to enable continuation of the battle. Centuries later, movement transitioned to provide better care to the wounded. In the Italian Campaign of 1797, Dominique-Jean Larrey evacuated sick and wounded in horse-drawn vehicles referred to as the *ambulance volante*. PM in other battles changed little until the advent of the aircraft and armies incorporated its use in patient evacuation. In fact, aircraft were used in World War I, but not with the dedicated, equipped, and trained medical staff utilized now. By the end of 1942, US military medics forecasted the role AE could play and developed the first processes to enable transatlantic evacuation.[11] Since then, advances in equipment and training transformed AE to the point where flying Intensive Care Units exist. This new system proved extremely successful in our most recent conflicts primarily because the Air Force flew in relatively uncontested environments.

These uncontested environments allowed for rapid trauma and surgical capabilities available to deployed members within one hour from injury. Former Secretary of Defense Robert Gates mandated one hour evacuation in Afghanistan, since the died-of-wounds rate was lower in Iraq where the "Golden Hour" ring was in place.[12] The new timeline of days versus months for a wounded member to make it all the way back to the US is remarkable when compared to movement during World War II.

During World War II, my grandfather was injured in Cherbourg, France in June 1944. He was on the battlefield for over a week before being moved to a medical facility. Infection set in while he waited for treatment, leading to the loss of his left leg. Eventually he was evacuated to a field hospital outside of London where he stayed for more than a year before being transported to Fort

Hood, Texas. Contrary to this scenario, the illustrations below depict the phenomenal success AE has achieved in recent conflicts in uncontested skies.

Figure 4.1 captures both the mortality rate decline from 30 percent in World War II to less than 10 percent for Operations Iraqi Freedom and Enduring Freedom and shows the advancement of AE and casualty care during each of those engagements. Furthermore, the ratio of wounded to killed dropped significantly. During Vietnam, approximately three service members were injured for every one member killed, and this plummeted to ten injured for every one killed in Iraq and Afghanistan.[13] Table 4.1 depicts the total number of medical evacuations for OIF and OEF. All casualties from OIF and OEF were returned to the continental United States (CONUS) by air whereas by the end of World War II, only 10 percent returned by air and the rest were transported by ship.[14]

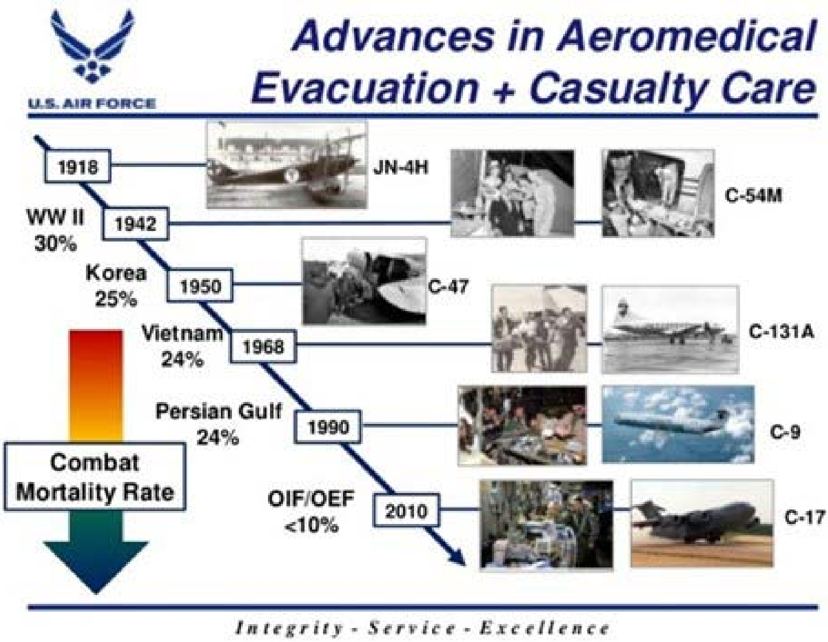

Figure 4.1 Mortality Rate

Unfortunately, air superiority and the ability to set up scheduled rotations to keep beds clear as well as redirect missions for urgent PM requests set the system up for failure. While there may be the expectation that the one golden hour standard can always be maintained, in practice, it cannot. Because of this expectation, the MHS moved away from planning for redundancy and multimodal transport. By the end of World War II, even with air transport available, it was not enough to transport the large the number of casualties. Even then planners recognized air operations could be hindered by other factors, like weather, darkness, or enemy denial.[15]

Table 4.1 OIF/OND Medical Evacuation

OIF / OND Medical Evacuations (as of 2013)		
	Number	**Percentage**
OIF / OND Battle Injuries	9,042	16.9
OIF / OND Diesease / Non-Battle Injuries	11,607	83.1
Total	20,649	100
OEF Medical Evacuations (as of 2013)		
	Number	**Percentage**
OEF Battle Injuries	5,746	23.7
OEF Cisease / Non-Battle Injuires	18,463	76.3
Total	24,209	100

Source: CRS correspondence with Dr. Michael J. Carino, Army Office of the Surgeon General, 13 December 2012. Data from Transportation Command, TRAC2ES.

What is more concerning is that there have been recent examples where AE was not available or was limited by other factors. In 1982, during the Falkland Islands conflict, the British had to plan for alternate transport due to lack of airfield availability and distance of the battlefields to care.[16]

Another example is the 2010 Iceland volcano eruption. The eruption halted air travel across Europe, making it the worst disruption to transport since the terror attacks on 11 September 2001 in the US.[17] Ash from the volcano was a threat for airplane engines, so, for safety reasons, aircraft were prohibited from flying through the impacted areas. Not only did this disrupt civilian aircraft at the cost of $1.7 billion,[18] it also impacted the movement of patients from both OEF and OIF to Landstuhl Regional Medical Center (LRMC) in Germany. LRMC is the designated stopping point for almost all patients from the Central Command Area of Responsibility before travel back to the US. The military had to come up with contingency plans. Its initial solution implemented long medical flights, requiring multiple in air refuelings, being flown directly from Iraq and Afghanistan back to the US.[19] Ultimately, Balad, Iraq, although not as robust as LRMC, became a theater collection point and then patients were moved to Rota, Spain before routing them back to the continental US. This route added another eight hours of flight time for LRMC stops.[20] Additionally, bases in England and Germany were forced to cancel all flight operations.[21] These examples illustrate how forces, outside of our control led to the denial of air transport.

In turn, they also highlight the consequences for the AFMS in an environment of restricted movement. DOD has already established the military is in a crisis with regards to its ability to respond to threats. The AFMS needs to follow suit and create a sense of urgency within the medical community.

A sense of urgency is the beginning step of the eight stages, as Kotter outlines in his book *Leading Change*. Establishing this sense of urgency is done by examining the market and competitive realities to identify crisis and potential crisis. For example, North Korea has been ramping up nuclear testing and missile capabilities. In both 2014 and 2015, North Korea did not conduct any nuclear or missile tests. In 2016 and 2017 they conducted ten tests.[22]

Kotter states "establishing a sense of urgency is crucial to gaining needed cooperation."[23] He further asserts when complacency is high, few will be interested in change. Consequently, because of the recent AE successes, there is not a sense of urgency or driving momentum to change current processes. In 2017, the AFMS reacted to the North Korea nuclear testing, but only with short-term CBRN treatment training for a few medics and added in less than one hour of chemical gear training to formal UTC training. The AMC is looking at chemical protective liners for enroute patient staging facilities, but this does not adequately address the current crisis. AFMS leadership needs to establish a sense of urgency, mimicking national security senior leaders. Driving joint training can help capitalize on expertise of other services as well as incorporate new scenarios to respond to CBRN events.

Doctrine and Instructions

Even with these recent reminders of denied air transport, our doctrine for PM relies on assumptions we will not be denied AE. By focusing on recent success, these documents (even ones updated within the past few years with the rise of new threats and fears of increased casualties and area denial) reflect PM must, and will, continue with rapid transportation times.

In fact, several strategic-level documents highlight the need to plan for contested environment operations. Joint Operations Environment 2035 says, "the near-uncontested freedom to operate on the seas, through the air, in orbit and over the electromagnetic spectrum has provided the United States with a high degree of freedom of maneuver and the ability to securely trade with partners around the world . . . however, it is very unlikely future adversaries will allow US forces to move through the commons to forward positions and await a set-piece US onslaught as, for example, the Serbs or Iraqis did in the past."[24] This forecasting of a contested environment requires the MHS to update its doctrine to overcome the gap created from the success of current operations.

Joint Operations Environment 2035 states the joint force must be prepared to address and respond to the uncontrolled spread of weapons of mass destruction (WMD). It proposes WMD may be obtained by terrorist operations either by making them themselves or by seizing them from fragile states lacking the capability to adequately secure them.[25] Unfortunately, this document was published in 2016 and operational level doctrine has not been updated to maintain or close the gap of providing PM during WMD events.

Former Congressman Jim Saxton said, "Airlift is a precious lifeline that keeps [troops] fed and equipped, brings the wounded home, and eventually, brings our forces home,"[26] highlighting not only the importance of air mobility to the entire military, but how AE is vital in supporting transport of wounded troops. AFTTP 3-42.5 states, "the highly lethal potential of today's battlefield, the reduced medical footprint, and the 'evacuate and replace' philosophy, have made the AE mission even more critical than in the past."[27] The result of this is our successes have made the MHS reliant on AE for PM and our doctrine reflects this belief.

In addition to operating in contested environment, current documents call for maintaining support during CBRN contested events. Department of Defense Instruction (DODI) 6000.11 requires the MHS to "provide qualified medical personnel to deliver the appropriate level of enroute care to wounded, ill, and injured patients (including contaminated, contagious, and potentially exposed patients) during patient movement."[28] This instruction is contrary to identified obstacles to enroute care capability found in after action reports from the Air University MS-CODE war game as well as from exercises conducted in South Korea.

The current expected timelines for moving patients assumes unlimited access to medical facilities will be available. The evacuation standards and priorities are categorized as urgent, priority, and routine. Urgent patients require movement within 12 hours of request to save life, limb, eyesight, or to prevent serious complications. Priority patients need movement within 24 hours if required treatment is not available and patients cannot wait for routine transport. Routine patients are all others who need medical evacuation but are not expected to get worse. These timelines fail to consider we will be limited in our air operations in a CBRN environment. DODI 4500.57, *Transportation and Traffic Management*, which is based upon the National Defense Strategy, states the DOD has a "strong Defense Transportation System... that is fully responsive and globally capable of meeting personnel and materiel movement requirements across the range of military operations."[29] This is yet another example of conflicting guidance, stating we must be responsive, but planning efforts do not reflect contested environment scenarios.

On top of the rapid timelines, Joint Publication 3-17 requires AE planners to develop plans to address requirements for the movement of CBRN contaminated patients, thus assuming there will be access to a contaminated environment.[30] Moreover, DODI 5154.06, assigns responsibility to the ASD(HA), along with the services and the Commander of the US Transportation Command to develop and provide guidance for moving contaminated patients.[31] This conflict of doctrine and instruction, is not in line with current practices and training further necessitating the AFMS's need to apply Kotter's principal to recognize we have a gap and create a sense of urgency to overcome it.

In addition to the joint documents, AFI 48-307, *Enroute Care and Aeromedical Evacuation Medical Operations*, says the enroute patient staging system is designed for short-term inpatient medical-surgical care and limited emergent intervention.[32] In turn, it says staging facilities will ensure patients have all approved equipment, supplies, and medications to support transport.[33] Unfortunately, exercises and discussions among the MEFPAK commanders have demonstrated facilities are not prepared to hold patients for long periods of time in a contested environment. Getting the medical resupply to the facilities will also be an issue. During the 2018 MS-CODE wargames at Air University, "participants viewed the AE system as cumbersome, inflexible and did not meet the needs of the end-user." Users then had to think through alternatives and eventually decided to put patients on aircraft with no medical support.[34]

The AFMS must create a sense of urgency to propel members to act. Once the sense of urgency is established, it is pivotal for the AFMS leadership to apply Kotter's second principal by creating a guiding coalition, which would include the MEFPAKS and US TRANSCOM. The MEFPAKS are the executors for establishing both the training and equipment requirements for deployable packages. By establishing joint training platforms and incorporating patient holding scenarios, potential new best practices could be identified as members who attend training respond to contested environment scenarios. US TRANSCOM has already identified the need to go back to multimodal methods for moving patients, but since these other areas are not service specific, a joint training site could provide proof of concept and training for members to consider additional transport options.

By creating a guiding coalition of the MEFPAKS and US TRANSCOM, training requirements reflecting the need for multimodal transport and incorporating these needs into CBRN contested scenarios could be accomplished. Collaboration for a joint training site and development of training scenarios across the services can further identify gaps in current assumptions. Recognizing these gaps exist and creating coalitions to develop new solutions will contribute to future PM success in CBRN contested environments.

Equipment and Supplies

Recent patient movement success in operations and current doctrine have driven training, techniques, and procedures which are dependent on rapid PM and unchallenged airspace. In fact, mission capability statements for patient holding and AE depend upon rapid airlift. As air traffic corridors increase, more patients can be supported within a conflict with fewer deployed assets. If airspace is challenged, staging capabilities will have to be much larger, better equipped, and members will need to be trained on holding patients for greater than 72 hours.

Because of recent operations and doctrine, our equipment and supply processes are built on the assumption that there is available and unlimited airflow. Further compounding this deficiency is the process for establishing the initial UTC equipment sets and the process for resupply through the Theater Lead Agent for Medical Materiel (TLAMM). In fact, our successes have greatly impacted our current equipment sets and inventory levels.

Initial deployment equipment sets are established by the MEFPAKs. Management is broken down into ground UTCs which are set by ACC. Air UTCs and Patient Movement Items (PMI) are established by AMC. The MEFPAKS rely on pilot units, experts, and after action reports to make changes and update UTCs. Over the years, equipment sets have gotten lighter and leaner.

Because of the input for equipment sets from users and after action reports and lack of CBRN threats in the past 20 years, current sets and deployment sites have limited to no CBRN capability or protection equipment. AMC staff have indicated they are working on including chemically protected liners into the sets, but the capability will not be available for approximately two years. Additionally, they are planning for only one liner per set, limiting continued operations in a CBRN contested environment without rapid replacement.

Current AE crew sets do not support CBRN contested environment response capability. Even though doctrine argues AE must continue and contaminated patients may be required to be transported, AE crew sets do not currently include training or protective equipment for the crews or replacement protective equipment for patients.

In addition to the initial UTC equipment set's limited ability to support CBRN events, the resupply system is dependent upon rapid air response. The

TLAMM's inventory is based on current requirements and historical use. If items are not frequently ordered and ordered at minimum established quantities, they will not be added to the inventory. Additionally, PMI at forward locations is based on historical use. The setting of stock levels based on historical use is an efficient usage of funds for maintaining an inventory without waste, but it does not allow for rapid resupply in the event of a CBRN mass casualty event. Consequently, increased holding and treatment sustainment will be required for contested environments.

Air Force Tactics, Techniques and Procedures 3-42.8, *Expeditionary Medical Logistics* establishes the resupply procedures for deployed operations. This document states UTCs are made up of "tailored and rapidly deployable forces" requiring a synchronized flow for expeditionary medical logistics.[35] This system was tested during OEF and was successfully executed because of the great work of the logistics community and use of focused logistics. Focused logistics is reliant upon "rapid, reliable, and time-definite transportation systems to reduce the need for maintaining excessive on-hand stock."[36] This reinforces the current concern—that operations will fail in a CBRN contested environment.

To be rapidly deployable, initial setup requires that resupply be rapidly achieved to sustain operations. A ten bed enroute patient staging facility requires resupply to begin seven days after initial setup.[37] After this, resupply is then established based on usage. To further complicate the issue, new item requirements (items not on the allowance standard) must be extensively justified and will take longer to receive if they are not on the established TLAMM inventory.

In addition to supplies for use at the deployed facilities, PMI is maintained based on projected casualty flow to support the patient movement through the deployed theater back to CONUS care. PMI resupply is critical to management of the inventory and the AE mission. A mass casualty event can easily use up an inventory requiring rapid replacement. Consequently, hubs are designated to maintain large supplies of PMI, but uncontested air movement is required to move items from the hub back to the forward locations. For example, Ramstein Air Base, Germany is the hub for US European Command, US Africa Command, and US Central Command. In November 2016, a suicide bomber on Bagram Air Base killed four and wounded 16 people.[38] Rapid transport was provided to move the patients to Landstuhl Regional Air Base in Germany, but this depleted Bagram's PMI levels. Ramstein Air Base had to provide an emergency resupply, with an opportune aircraft to restore their equipment capability for ongoing enroute care support. Without air capability, resupply to the far reaches of these operational theaters will be drastically delayed.

Another complication to the resupply is medical classification. The DOD classifies supplies and materials to assign shipment priority values. Medical supply is classified as a Class VIII material. Class VIII is not the highest supply level and cargo can be delayed for resupply when items of higher values (rations, ammunition, or petroleum) require movement. For operations in fiscal year 2009, the average shipment timeline from US Army Medical Materiel Center-Southwest Asia (USAMMC-SWA) to a medical customer averaged ten days.[39] If air traffic is restricted, timelines will be severely lengthened as compared to having routine flight routes in place for uncontested environments. For example, in OIF, medical supplies initially arrived late or in unserviceable condition. The Defense Logistics Agency concluded one of the main factors was not enough aircraft to support the supply chain.[40] Similarly, during the 2004 Theater War Reserve Materiel in Garrison Conference, it highlighted "constrained airlift" as an issue with medical supply delays.[41] During build up to operations, higher priority equipment, supplies, and people compete with medical supplies for transport space. This will be the same in contested environments where air transport will be limited.

Limited supplies aren't an issue just for the US military. Major Frank Strange, a British nurse deployed to a field hospital in Iraq said, "in war the winner is often the side with personnel and equipment remaining at the end of the conflict. To fulfill its task a field hospital requires a mass of sophisticated equipment."[42] Having equipment in place is key to ensure the success of any Air Force.

To further show how the current AE system is defined as successful and not in need of improvement or change, in 2003, then Air Force Surgeon General George Peach Taylor said, "there is little to change about the aeromedical evacuation system . . . at Army hospitals in Afghanistan and Iraq, you don't find a large number of Army casualties because the aeromedical system is so good (at moving) people."[43] This assessment reaffirms the AFMS does not see current operations as a crisis so it must first create a sense of urgency so that Kotter's additional step of creating a vision can be enacted.

It is important to note that US TRANSCOM created a vision of going back to multimodal transportation options. Unfortunately, no other service was assigned responsibility for PM in our current conflicts to test and become proficient in other modal capabilities. The AFMS needs to work within DHA to develop a plan of action to incorporate these other modes. In turn, training must be provided across all services to account for the additional options and techniques for medical personnel moving patients on other modes.

The AFMS must communicate this vision and relay expectations to the commands for moving in new direction. During a September 2018 working visit to Air University, members of the MEFPAKs agreed PM will be impacted in a CBRN contested environment, but plans or other options are not actively being sought out or addressed. Because there is no sense of urgency, the AFMS is not moving fast enough to develop a way ahead to bridge the current gaps. Training scenarios should include increased holding times and seek alternate modes of transport. Waiting until the event occurs to prep our teams is too late. As it says in the 2018 National Defense Strategy Commission report, "America's ability to defend its allies, its partners, and its own vital interests is increasingly in doubt. If the nation does not act promptly to remedy these circumstances, the consequences will be grave and lasting."[44] If the AFMS creates a vision for a joint training platform, this training would provide another method to share resources and gain efficiencies to mitigate current challenges.

Conclusion

By using Kotter's steps to create a sense of urgency, build a guiding coalition, and create a vision to build a joint training platform, the AFMS could mitigate current obstacles of the "evacuate and replace" policy, doctrine dependent upon air superiority, and rapid resupply requirements to save lives in a CBRN contested environment. If the AFMS does not create major change, readiness will suffer, and more lives will be lost. The National Defense Strategy Commission report cautioned the readiness of US forces has suffered because there is a gap of qualified individuals.[45] Importantly, the report stated "for over a decade, and with good reason, training for much of our conventional and special operations forces emphasized the specific challenges of operations in Afghanistan and Iraq . . . and a greater share of training and readiness efforts must be devoted to the full range of potential missions our forces face."[46] US TRANSCOM and others have identified the need to return to multimodal platforms. By embracing John Kotter's steps and mitigating the current obstacles, the AFMS can transform the future of PM.

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Cognitive, Psychological, and Behavioral Implications of Providing Medical Support in a Contested Environment

Lt Col Catherine Callender

"Success is not final, failure is not fatal: it is the courage to continue that counts."

Winston Churchill

Introduction

The US military is widely revered as the best in the world, but even the best organizations are susceptible to the impact of stress. On 17 June 2017, a United States Navy destroyer, the USS *Fitzgerald*, collided with another vessel off the coast of Japan, killing seven Sailors.[1] Two months later, in August 2017, another Naval destroyer, the USS *John S. McCain*, collided with a ship in the Straits of Singapore, resulting in the deaths of 10 Sailors.[2] Then, on 6 September 2017, an event most people think is unfathomable given today's advanced technology occurred. Two USAF A-10C aircraft collided in midair forcing both pilots to eject. While the pilots sustained only minor injuries, the cost of the loss of two aircraft and the environmental cleanup related to the crash was over $30.5 million.[3] In fiscal year 2018, the Army continued to see an increase in Class A–C mishaps involving their rotary aircraft. Of the seven ground mishaps, four were Class A, and just two of those Class A mishaps alone resulted in $6.6 million worth of damage.[4]

Those accidents are just a few of the many that have transpired throughout the Air Force, Army, and Navy between 2017 and 2018. Investigations of each one of them determined human factors, such as lack of adherence to standard procedures, fatigue, delayed response, loss of situational awareness, inadequate training, misperception of changing environment, failure to appropriately assess risk, and distraction, contributed to the mishaps.[5]

These tragic events are not recounted to find fault with the military or the dedicated professionals charged with the nation's safety. Rather, they are provided to illustrate that more needs to be done to prepare and equip service members to competently fulfill the incredible level of responsibility they are given. The fact that none of these accidents occurred under the pressure of combat operations illustrates how susceptible human performance is to even low to moderate stress. In noncombat military operations, stress taxes cognitive and psychological functioning and can lead to catastrophic mistakes. It is not difficult to imagine how the uncertainty of providing medical support in a contested environment will present extraordinary challenges the MHS has not faced in decades, and some it has never faced before.

Since the initiation of OEF in October 2001 in Afghanistan and OIF in Iraq in March 2003, medical personnel within the Air Force, Army, and Navy have demonstrated unprecedented success in preserving the lives of American and allied forces fighting in those conflicts. Providing medical support in those environments has been challenging, but the operational complexity of those missions pales in comparison to what will be required to provide medical support in a contested environment, especially one contaminated by CBRN weapons. It should never be for lack of preparation the MHS fails in its endeavor to save lives and fortify the broader combat mission. Given the challenges of providing medical support in a contested environment and the implications of those challenges for cognitive, psychological, and behavioral functioning, the MHS must strengthen those functional domains through more rigorous and regularly occurring training. However, developing and applying the requisite training can only be accomplished by shifting priorities and mitigating resource constraints via the employment of empirically supported methods of organizational change.

Challenges of Providing Medical Support in a Contested Environment

Providing medical support in a contested environment, especially one in which CBRN is an issue, presents significant challenges in terms of the complexity of medical care rendered, as well as the stressors medical personnel will face themselves. Communication can be a challenge in any environment, but in a conflict, typical means of communication will be severely impeded if not eliminated altogether. As threats from the adversary become more imminent, anxiety levels of even the most well-prepared military service members will naturally increase as an adaptive function of the sympathetic nervous system. However, in the shadow of a credible CBRN threat and in the face of limited communication, anxiety symptoms mirroring many of the symptoms of nerve agent contamination may result in medical personnel being overrun by the "worried well," who are not likely to be easily convinced their symptoms are a function of anxiety versus a chemical agent.

An actual CBRN attack will necessitate treatment of not only CBRN casualties but also injuries sustained by traditional weapons. Providing basic lifesaving measures will be hindered by the functional restrictions of wearing MOPP gear, not to mention the complexity of attempting to triage such a wide variety of casualties while simultaneously trying to discern what agent-specific decontamination and treatment protocols are needed. Unlike OEF and OIF, medical resources and personnel will be extremely limited due to the sheer volume of casualties, and medics will be faced with the agonizing decision of determining who can be saved and who cannot. Conflict with an adversary could result in an overwhelming number of casualties requiring rapid medical reconstitution of personnel at an unprecedented rate. In such a case, rules governing triage may have to be expanded requiring medical personnel to consider unorthodox, but mission essential, parameters dictated by line commanders. The moral and ethical aspects of those decisions will have far-reaching personal, professional, and systemic implications for military medical professionals for years to come.

In the event of a CBRN attack, personnel may be required to function continuously in MOPP gear for days, weeks, and possibly longer. Protracted use of individual protective equipment (IPE) will inevitably elevate the risk of deterioration in performance and increase the likelihood of heat casualties.[6] Wearing full IPE obscures basic senses such as vision and hearing, making it extraordinarily difficult to communicate effectively and even evoking a sense of isolation. Anxiety and fear already present simply by virtue of the nature of combat may be compounded by diminished psychological tolerance arising from the challenges produced by restriction in mobility and physical dexterity related to wearing full MOPP gear. Additionally, it is not uncommon for personnel to experience symptoms of claustrophobia and even a sense of panic.[7] As the challenges of navigating basic health-related needs as simple as eating and drinking become increasingly more apparent, a sense of helplessness may also arise. The functional costs associated with those stressors will be significant.

Implications of Stress on Cognitive, Psychological, and Behavioral Functioning

Attention, memory, reaction time, and reasoning are vital aspects of cognitive functioning, but they tend to be highly vulnerable to deterioration because of factors such as sleep deprivation, fatigue, extreme temperatures, moral and ethical turmoil, and acute stress, which are commonly experienced in combat. There is substantial research providing evidence of the functional impairment caused by those variables. Given the need to be as prepared as possible for the incredible complexity of war, it is important to understand the cognitive, psychological, and behavioral implications of those stressors for functioning.

During combat, medical personnel will inevitably experience sleep deprivation. They are also likely to be fatigued because of the significant volume of medical care they will be responsible for and the chronic stress they will be under. Sleepiness is characterized as a heightened need, almost to the point of pressure, to sleep,[8] while fatigue has been described as "an overwhelming sense of tiredness, lack of energy, and feeling of exhaustion, associated with impaired physical and/or cognitive functioning."[9] Research shows both sleepiness and fatigue have detrimental effects on functioning. One study examined the effects of sleep deprivation on participants' ability to remember procedural steps after being interrupted. Both pre and posttest task completion involved interrupting participants at random intervals as they accomplished the required tasks using the designated procedures. The post-interruption errors made by the sleep deprived participants were more frequent than those of participants who were not sleep deprived, even though error rates between the two groups had been similar before the sleep intervention.[10] Medical personnel are routinely interrupted when providing medical care, and interruptions are likely to increase considerably in a contested environment. The study's findings have noteworthy implications for providing effective medical support in a contested environment.

Sleep deprivation also has the potential to create lapses in attention, thereby precluding the encoding of critical information a medic may need to recall to provide safe, effective medical care. One study examined the way in which lapses in attention, induced by sleep deprivation, impaired short-term memory. The results suggested sleep deprivation impedes memory functions as basic as recognition.[11] During the course of even routine aspects of medical care, lapses in attention on the part of any medical professional could have catastrophic consequences, but in a combat environment where resources are severely constrained and the vast majority of personnel are likely to be sleep deprived and fatigued, the threat posed by inattention to the provision of competent medical support increases exponentially.

Fatigue can be caused by physical exertion, sleep deprivation, and contending with chronic stress.[12] All those factors are common issues experienced by military personnel in combat. Research demonstrates fatigue has the potential to cause numerous impairments to cognitive functioning, such as processing speed, attention, and short-term memory.[13] Those types of cognitive impediments are often identified as significant contributory factors in aircraft mishaps. In fact, an informal analysis of Navy Safety Center data from 1997–2002 revealed fatigue to be the second most frequent contributing factor in aeromedical mishaps, ranking just behind spatial disorientation.[14] Sleep deprivation and fatigue are common problems in combat environments, and the research provides clear evidence of the deleterious effects of those issues on a wide variety of performance variables.[15]

Sleep deprivation and fatigue will not be the only challenges with which medical personnel will have to contend. In a CBRN contested environment, becoming overheated because of protracted wear of IPE is a significant concern. Research demonstrating how extreme temperatures impair human function validates these specific concerns. In one study, Soldiers' cognitive and motor functioning were assessed before and after being subjected to an exertional heat stress test (EHST). Two groups of participants received ten days of acclimatization, while two other experimental groups received no such treatment. Ninety percent of the troops who did not complete the EHST did so because of intolerable discomfort or because they reached the predetermined cutoff for elevated core temperature. This finding has implications for medical personnel and their ability to tolerate heat much less function effectively in it. The data collected on the neuropsychological functioning of the unacclimatized troops provided evidence of mild impediments to attention after induced heat stress, and it also yielded statistically significant deficits in troops' performance on more complex tasks of visual information processing and reaction time. Conversely, all the acclimatized Soldiers in the study did not demonstrate any decline in neuropsychological performance before being subjected to exertional heat stress.[16]

Results of this study provide rudimentary insight into the effect of heat stress that medical professionals are likely to experience during protracted wear of MOPP gear. If troops who are more accustomed to operating in extreme temperatures experienced neurocognitive impairment resulting from heat stress, then medical professionals whose duties typically do not involve being subjected to extreme temperatures are likely to experience more significant impairments than the military service members in the study.

In addition to having to cope with sleep deprivation, fatigue, and extreme temperatures, medical professionals will likely have to manage complicated moral and ethical issues. Conflict within a CBRN contested environment or with a competitor who has nearly achieved parity in military capability with the US will result in massive numbers of personnel being wounded or killed. The manning deficits created by those events are likely to impair operations and significantly jeopardize the success of the US. Under those circumstances, typical triage guidelines that suggest the highest acuity injuries are treated first may become secondary to the need to rapidly attend to mass numbers of personnel with lower acuity injuries in order of operational necessity. It is one thing for military medical professionals to experience the death of a patient after they have done everything they can to save the person's life, but it is quite a different experience to be forced to allocate lifesaving interventions and resources based on operational needs versus medical acuity, while recognizing people who might have otherwise been saved will die. Those issues are likely to cause significant cognitive dissonance, emotional turmoil, and become yet another impediment to functioning. In fact, morally injurious experiences have been linked to the development of maladaptive psychological symptoms.[17] Additionally, if alignment of professional medical ethics and the concept of operational necessity is not achieved before a large scale conflict takes place, the issues are also likely to have professional implications for licensed providers and could create systemic upheaval within the MHS.

Acute stressors are characterized as "sudden, novel, unexpected, and of short duration" and include elements such as time limitations, uncertainty, task saturation, and threat.[18] While research on the effects of those types of acute stressors on military populations is strongly needed, it is still relatively limited. However, one study examined the performance of Army Rangers during a training exercise and a group of Navy Sea Air and Land (SEAL) candidates as they endured "Hell Week" as part of the SEAL selection process.[19] Both situations required participants to function in a state of fatigue, exposed to extreme temperatures, and faced with acute stressors, such as time constraints, task overload, and uncertainty. Invariably, military service members will be faced with those same types of stressors during combat. This study provides the most comprehensive insight into the way in which the cognitive, psychological, and behavioral functioning of medical personnel may be impacted while providing support in a contested environment.

Before the start of the exercise, as well as during the exercise and at its conclusion, the Army Rangers completed instruments designed to measure reaction time, vigilance, working memory, attention, short-term memory, logical reasoning, and indicators of mental status. The Navy SEAL candidates completed the measures before the start of Hell Week and after 73 hours of training had elapsed. Virtually the same battery of tests used with the Rangers were also used with the SEAL candidates, however, due to time constraints, the SEAL candidates did not complete the instrument designed to assess logical reasoning.[20]

Midpoint and posttest results of the Army Ranger testing showed statistically significant depreciation in each area of cognitive functioning assessed by testing. Reaction time slowed, sustained vigilance decreased, and attention, memory, and reasoning ability were impeded. Additionally, caliber of mental status was threatened by decreased vigor and increased anger, depression, tension, fatigue, and confusion. The deficits in cognitive processing and decline in mental status exhibited by the SEAL candidates was even greater than the decline exhibited in the Rangers, but the difference may have been a function of the higher acuity of stress the SEAL candidates were subjected to in comparison to the Army Rangers.[21] Nevertheless, the key point is in contexts characterized by combat stressors similar to those military medical professionals are also likely to experience while providing support in a contested environment, the cognitive, psychological, and behavioral functioning of service members was impaired.

It is important to recognize those service members were Army Rangers and Navy SEAL candidates, who are generally considered to be among the best trained and equipped to contend with acute combat stress. Given their statistically significant decline in cognitive performance in the face of those stressors, the implications for military medical personnel providing support in a contested environment are even more grave. Military medical professionals are also highly skilled and trained, but they are not accustomed to the levels of combat stress endured by Army Rangers and Navy SEAL candidates. It is not unreasonable to expect acute combat stress may impair the performance of medics to an even greater degree than the degree of impairment the Rangers and SEALs in the study experienced.

Recommendations for Readiness Training

Although research and real world combat experiences offer some degree of insight regarding the cognitive and psychological challenges medical professionals will incur in a contested environment, the existing rate of change demands multifaceted training based on goals identified through wargaming and grounded in exceptionally close approximations of the actual experience of rendering medical support during conflict. Additionally, given the incredible degree of stress medical personnel will have to endure in a contested environment, skills training alone will not prove sufficient. Rather, it is critical for skills training be integrated with stress inoculation training (SIT) as well. Finally, although urgent issues often interfere with training plans, it is imperative readiness preparation become the norm rather than an intrusion into standard operations.

In 2017, a wargaming initiative, MS-CODE Spiral II,[22] which was based on research from MS-CODE Spiral I,[23] was conducted. The research within Spiral I and the wargaming results of Spiral II revealed little known challenges MHS personnel will experience supporting combat operations in a contested environment. Both Spiral I and Spiral II highlighted complications providers will inevitably face if they are compelled to triage based on operational necessity versus standard triage protocols.[24] Additionally, other challenges, such as greater threat of medical facilities being destroyed during the course of combat, decrease in safe areas in which to stabilize and stage patients, degradation of options for casualty evacuation, diminished ability to communicate effectively, and significant risk to the well-being and safety of medical professionals themselves were also identified and proved invaluable in defining initial training goals to best prepare medical personnel for conflict.[25]

Although the benefits to wargaming are readily apparent, the practice does not expose service members to the rigors of combat to the extent exercises do. This distinction limits the depth of knowledge and experience gained from wargaming and attenuates the degree of preparation it can provide. During MS-CODE Spiral II, "it became very clear early in the wargame that participants were determined to make what they knew from past education and training fit the current situation."[26] In a wargame where the cost of decision-making is envisaged versus experienced, as it would be during an exercise, it can be more difficult for people to see the merit and even the necessity of adopting a position or taking an approach which differs from their typical training. Research also suggests there is an optimal degree of stress at which point, performance may be enhanced, but most wargaming scenarios are less likely than experiential training to evoke the level of stress needed to amplify creativity and enhance performance.[27] Although wargaming is an essential tool for defining initial readiness priorities and reevaluating those priorities in the face of new information, the stress, urgency, and sense of crisis evoked by experiential training is even more important in the endeavor to thoroughly prepare medical personnel for providing support in a contested environment.

The value of experience for long-term learning cannot be understated. According to Rosenzweig, Breedlove, and Leiman, "measurable changes can be induced in the brain by experience."[28] Studies also suggest the ability to remember knowledge and skills varies based on degree of experience employing those skills.[29] The experience of simulating medical care in a contested environment during an exercise results in training that is more likely to be retained. Additionally, the experiential nature of an exercise fosters significant depth of understanding regarding the implications of combat stress-related impairment of cognitive, psychological, and behavioral functioning. From the standpoint of strategic, operational, and tactical planning, the dynamic nature of exercises provides greater clarity pertinent to second- and third-order effects of proposed strategies and tactics, and they increase the likelihood problems will be identified and resolved before the eruption of a real-world conflict. There is little debate that MHS professionals will benefit from experiential training in a context that mimics the chaos and uncertainty characterizing medical operations in a contested environment. Given the evidence substantiating the likely deterioration of functioning because of combat stressors, readiness training must also incorporate empirically supported methods of fostering functional resilience.

Functional resilience is best achieved through a combination of skills training and strategies designed to essentially inoculate individuals against the negative effects of stress. Skills training focuses specifically on increasing the automaticity of behavior.[30] When skills are more automatic, they require less attention, are less susceptible to the damaging effects of stress, and have the potential to increase an individual's sense of control, which can help mitigate anxiety.[31] Although skill acquisition has some anxiety-mitigating potential, training designed primarily to instill knowledge and skills will not be sufficient to ensure personnel can withstand extreme stress and perform proficiently.[32] Comprehensive readiness training to prepare personnel for providing medical support in a contested environment also needs to emphasize stress inoculation techniques.

Research suggests training in stress reduction techniques mitigates anxiety and has the associated benefit of improving performance.[33] Results of one study examining the effectiveness of stress management strategies on flight training suggested the techniques not only allayed physiological responses to stress but also decreased participants' appraisals of acuity of stress and enhanced performance in comparison to participants who did not receive instruction in managing stress.[34] Similarly, a group of jumpmasters, who had been trained in techniques to mitigate stress, performed better on skills tests than members of the control group, who had not been trained on the same techniques. Furthermore, physiological measures of stress were lower in the experimental group than the control group during high-risk jumps.[35] Comparable effects of stress management training were also observed in a study examining the effectiveness of combining stress inoculation training with cardiopulmonary resuscitation (CPR) training in medical personnel.[36] Students' CPR skills were reevaluated without warning six to 12 months after training. Individuals who received SIT in conjunction with their typical CPR training performed more rapidly and accurately than students who had not received the SIT component.[37] Additionally, the success the Army and Navy have reported from incorporating SIT into some of their training protocols further validates that it can be effective for enhancing performance in stressful situations.[38] Ultimately, there is convincing evidence to suggest skills training combined with stress inoculation strategies can help instill functional resilience in MHS personnel.

Providing skills training and SIT for MHS personnel has clear benefits. However, if those skills are not practiced in a realistic setting, their utility will be limited. While most people assume they will function proficiently when under extreme stress, the reality is individuals and their leadership really cannot know how they will react in the face of extreme combat stress until it arises. Training which occurs in the absence of stress does not necessarily mitigate the harmful effects of stress when skills are applied in an arduous and demanding context.[39] Short of the actual combat environment, realistic exercises characterized by the stress of uncertainty, urgency, and a sense of crisis are the best option for preparing medics and circumventing panic and degradation of functioning.

While training needs to be realistic, it also needs to occur regularly. Research has shown medical training is highly susceptible to decay. One study detected deterioration in knowledge in as little as two weeks after training. Furthermore, the research also suggests "well-learned tasks are most resistant to negative effects of stress."[40] Many other studies draw similar conclusions.

Part of the challenge of learning something well is that it takes time. Within the AFMS, active duty medical officers and technicians are provided with training when they are preparing for deployment. Training is limited and not well suited to providing support in a contested environment. Beyond those training opportunities, AFMS medical groups generally devote either a full day or a half day to training once per month. Assuming a full ten-hour day is devoted to training, then in the span of one year, medical groups allocate a total of 120 hours, or approximately five percent of their time to training. Given the multitude of competing priorities within medical groups, the limited time for training is understandable. However, the current limitations to time and resources devoted to training and readiness are likely to impede endeavors to ensure medical professionals are fully prepared to render medical support in a contested environment. Fundamental organizational change may be needed to reprioritize core responsibilities within the MHS.

Recommendations for Organizational Change

Individual human behavior is probably one of the most complicated phenomena to deconstruct, analyze, and formulate principles which can be applied to promote change. Additionally, an infinite number of biological, psychological, and sociological variables play a role in behavior, and when change is needed from more than just a single person, as is the case within organizations, the challenge becomes exponentially more complex. Current models of organizational change tend to navigate the process of change from the standpoint of a large group, effectively ignoring the change which must occur within individuals to cultivate an organizational shift. Ultimately, a more comprehensive model, integrating the organizational and individual processes of change, is needed.

Toward a More Comprehensive Model of Organizational Change

John Kotter's macro approach for leading organizational change (Figure 1.1) is invaluable at a time when the speed of change has increased exponentially.

The relevance of Kotter's principles to change needed within the MHS is evident. However, two specific limitations must be addressed to ensure the applicability of the model to readiness challenges within the medical services.

Kotter's model does not adequately address the needs of an organization as diverse, as large, and as geographically diffuse as the MHS. For example, Kotter conceptualizes communication as a discrete stage, limited exclusively to conveying and reinforcing the organization's newly established vision. However, the size, diversity, and geographical dispersion of the MHS requires clear, concise, repetitive communication about not only the vision, but about every key aspect of the organizational change process. Deficiencies in communication have the potential to dramatically undermine the change process within MHS.

The success of any change initiative within the MHS requires the application of strategic communication throughout the entire model, versus being relegated to one discrete step. Additionally, the creation of a single guiding coalition, as suggested by Kotter, will not be powerful enough in an organization like the MHS to effect change the way the model intended. The power of guiding coalitions relies heavily on the expertise, credibility, and degree of influence of coalition members.[41] The size, diversity, and geographical dispersion of the MHS warrant the establishment of a primary guiding coalition as well as satellite guiding coalitions as low as the MTF level to ensure consistent concentration of influence at every organizational level. Otherwise, critical messages become attenuated as they progress through the layers of the organization.

The second limitation of Kotter's model is that it does not account for the way in which change, or lack thereof, within individual members of the organization impacts the organization's overall progress toward change. According to Conner and Patterson, "The most prevalent factor contributing to failed change projects is a lack of commitment by the people."[42] Even a few vocal, influential skeptics can foster wide scale resistance to change. During the course of the organizational change process, the individual level of change cannot be ignored.[43] Prochaska, Norcross, and DiClemente's transtheoretical model of change (TTM) has proven to have significant applicability not only to the course of individual change but also to organizational change.[44] Integrating Kotter's eight-stage model of organizational change with TTM and tailoring the stages to address the diversity, size, and geographical dispersion of the MHS provides an approach that addresses both the macro and micro levels of change and mitigates the limitations of the model in its original form.

The integration of Kotter's eight-stage model of organizational change with Prochaska, Norcross, and DiClemente's TTM entails reconceptualizing the guiding coalition, the vision, and communication more as tools to be incorporated into each stage of change, rather than as discrete stages as Kotter proposed. The integrated model encompasses the steps outlined below as well as the application of the stage matched interventions found in the Integrated Model of Organizational Change chart (Appendix A).

Step 1: Establish the primary guiding coalition. The power of Kotter's guiding coalition plays a significant role in the overall efficacy of the organizational change process. Because the guiding coalition is designed and structured to be highly persuasive,[45] it should be established as early in the process as feasible. Additionally, the dynamics and influence of the guiding coalition should be carefully evaluated and adjustments to the composition should be made, if necessary, to maximize its leverage.

Step 2: Initiate and finalize the vision. Starting and completing the development of the vision early is important for two reasons. An initial lack of vision will slow the pace of the change process. Because war could take place at any time, the MHS needs to change as rapidly as possible and cannot afford the delays caused by the lack of a clear vision. Kotter suggests that devising an effective vision can take several hundred hours.[46] The initiation of the development of the vision needs to take place as early as possible in the process to allow enough time to formulate a compelling view of the future.

Step 3: Construct a strategic communication plan. According to some researchers, communication is the true impetus for change,[47] which suggests lack of communication or poor communication can be debilitating to any organizational initiative. Clear, concise, and consistent messaging about important aspects of the organization's transformation is essential at all stages of change, which is why the establishment of a comprehensive, strategic communication plan early in the process is so vital.

Step 4: Form the satellite guiding coalitions. Kotter stipulates that to produce significant change, approximately 15 percent of the entire population of the organization will need to "go far beyond the call of duty."[48] A single guiding coalition within the MHS will not carry the influence needed throughout all levels of the organization to generate the active motivation of 15 percent of the population, but multiple guiding coalitions do have the potential to accomplish that goal. Using the structure of the AFMS as an example, satellite coalitions will be established at the Major Command and medical group levels, and although they will emulate the work of the primary guiding coalition, they also have the flexibility to modify strategies to make them more effective for their organizational population. Finally, the satellite coalitions will help ensure the necessary breadth and depth of communication throughout the transformation.

Step 5: Assess the organizational stage of change. The size and geographical dispersion of the MHS might make it seem impractical to try to identify the stage of change of everyone in the organization. However, that type of issue is one of the many reasons why the satellite guiding coalitions are established. Each satellite guiding coalition will administer a survey, which takes less than one minute to complete, in a group format to all members of their organization (See Appendices B and C). The stage of change which characterizes the majority of their organization's members is the current stage of change of the organization.

Step 6: Apply stage matched interventions based on the organizational stage of change (e.g., the stage of change in which most individuals fall). For each stage of change, there are certain techniques effective at moving individuals from one stage of change to the next stage. Studies have demonstrated stage matched interventions are more effective than programs which employ uniform strategies with everyone at the same time.[49] Additionally, certain interventions designed for earlier stages of change are beneficial for sustaining motivation to change. The application of those interventions even at intermediate stages of change also helps facilitate the process of change for individuals who have already progressed beyond the stage of change of most members of the organization. That adaptability ensures the process is applicable to everyone. The Integrated Change Model chart (Appendix A) delineates the types of actions organizational leaders and the guiding coalitions need to take to facilitate progression through the stages of change. It also shows how the remaining stages of Kotter's model of organizational change are integrated with Prochaska, Norcross, and DiClemente's transtheoretical model of change.

Step 7: Repeat steps five and six until most of the organization is in the maintenance stage of change. Because change is so complicated, there may be times when the preponderance of the organization's population has not progressed to the next stage of change. That phenomenon exists in all organizational change initiatives, but it goes undetected because the stage of change of individual members of the organization is not typically assessed. Continuing to apply interventions matched to the stage of change of most of the population, versus ignoring the data and jumping to the next stage, is the best way to ensure true organizational change is achieved and prevent superficial change susceptible to reverting to previous processes and habits.

Conclusion

Given the challenges of providing medical support in a contested environment and the implications of those challenges for cognitive, psychological, and behavioral functioning, the MHS cannot afford to allow the limited probability of conflict with a near-peer competitor to lull it into complacency. The impact of known variables such as sleep deprivation and fatigue, extreme temperatures, moral and ethical turmoil, and acute stress can be devastating to the functioning of medical personnel, but the character of future conflict is likely to present the military services with additional, yet unidentified, significant issues. Preparing personnel to provide medical support in an environment contested by conventional and unconventional means is vital to negating the effects of known stressors to be better prepared for the inevitable presentation of new and more challenging problems. Regularly occurring, experiential training based on lessons from wargaming and combining skills acquisition with stress inoculation is essential for instilling functional resilience in medics and ensuring they will be able to fulfill the tremendous responsibilities they will be tasked to accomplish during conflict.

Despite the realities of combat, there are still significant obstacles to facilitating the preparedness of military medical personnel. The MHS is faced with competing priorities which force training and readiness into positions of secondary or tertiary responsibility. Years of highly effective medical support rendered in other conflicts may have created a sense the MHS is ready, or can potentially be ready on short notice, regardless of the nature of the combat environment medics must support. The evidence suggests anything less than rigorous and regular readiness training will not produce the medical preparedness necessary to meet the demands of conducting medical operations in a contested environment. In an age of significant resource constraints and competing priorities, it is difficult for organizations like the MHS to devote the requisite time, money, and manpower to the training needed to be ready for combat in a CBRN environment. Applying effective organizational change strategies and reprioritizing readiness will enable the MHS to fulfill its obligations to the nation, the mission, and the military members it serves.

Notes

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3. Munger, "Aircraft Accident Investigation," 2.
4. Dickinson, "Ground Taxi Mishap Trends," 1.
5. Office of the Chief of Naval Operations, "Report on the Collision," 4, 21, 22, 44; Munger, "Aircraft Accident Investigation," 2.
6. Kelly et al., "The Effects of 12 Hours of MOPP IV," 18; AFMAN 10-2503, *Operations in a Chemical, Biological, Nuclear, and High-Yield Explosive Environment*, 170. This manual no longer includes "high-yield explosive" in the title and is an out-of-date publication. —Ed.
7. AFMAN 10-2503, *Operations in a Chemical, Biological, Nuclear, and High-Yield Explosive Environment*, 172.
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10. Stepan, Fenn, and Altmann, "Effects of Sleep Deprivation," 1–3.
11. Polzella, "Effects of Sleep Deprivation on Short-Term," 194, 199.
12. Weeks et al., "Physiological and Psychological Fatigue," 438; McEwen, "Physiology and Neurobiology of Stress and Adaptation," 891.
13. Caldwell, "Crew Schedules, Sleep Deprivation, and Aviation Performance," 86.
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15. Weeks et al., "Physiological and Psychological Fatigue," 439.
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17. Battles et al., "Moral Injury and PTSD as Mediators," 9372.
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23. Parsons, "MS-CODE: Considerations for Immediate and Future Operations."

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25. Parsons, "MS-CODE: Considerations for Immediate and Future Operations," 12–3.

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32. LeBlanc, "The Effects of Acute Stress on Performance," S30.

33. Saunders et al., "The Effect of Stress Inoculation Training," 27.

34. McClernon, "Stress Effects on Transfer," 114.

35. Burke, "An Experimental Evaluation of Stress-Management Training," 20, 22.

36. Starr, "Training for Safety in Automated Person-Machine Systems," 1029.

37. Quoted in Orasanu and Backer, "Stress and Military Performance," 107.

38. Robson and Manacapilli, *Enhancing Performance Under Stress*, 23.

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40. Su et al., "A Randomized Controlled Trial," 784; Staal et al., "Cognitive Performance and Resilience to Stress," 280.

41. Kotter, *Leading Change*, 57.

42. Conner and Patterson, "Building Commitment to Organizational Change," 18.

43. Jimmieson, Terry, and Callan, "A Longitudinal Study," 11.

44. Levesque, Prochaska, and Prochaska, "Stages of Change," 227.

45. Kotter, *Leading Change*, 51–2, 65–6.

46. Kotter, 87.

47. Cone, "Hold that Thought!" 5.

48. Kotter, *Leading Change*, 35.

49. Levesque, Prochaska, and Prochaska, "Stages of Change," 229.

APPENDIX A

Integrated Model of Organizational Change

	Establishing a sense of urgency	**Empowering broad-based action**	**Generating short-term wins**	**Consolidating gains and producing more change**	**Anchoring the new approaches in the culture**
Precontemplation Does not see need for change; no intent to change; resistant to change	-Communicate supporting data for change -Clarify rationale for change -Identify concerns -Communicate risks and benefits				
Contemplation Recognize need to change but have no sense of urgency to do so	-Reinforce change rationale -Emphasize benefits and risks -Increase performance accountability -Communicate widely	-Identify and address obstacles and concerns			
Preparation Motivated and making plans to initiate change within one month	-Continue reinforcing urgent information -Continue emphasizing benefits of change	-Emphasize benefits of change for individuals and the organization -Ensure positive aspects outweigh negative -Align organizational structure, evaluation, and resources to vision -Ensure change process for organization and individuals is clear			

	Establishing a sense of urgency	**Empowering broad-based action**	**Generating short-term wins**	**Consolidating gains and producing more change**	**Anchoring the new approaches in the culture**
Action Execute tangible changes	-Continue reinforcing information that drives urgency	-Continue emphasizing benefits of change for individuals and the organization -Reexamine organizational structure, systems, and resource allocation for consistency with vision	-Identify short-term performance goals -Ensure "wins" are apparent, unambiguous, and related to change effort -Communicate data and information to dispel skepticism -Highlight individual commitment to change -Employ visible reminders to keep vision and action at forefront -Use rewards to reinforce behavior	-Ensure momentum is sustained -Use short-term goal attainment to propel further change -Streamline organizational processes and structures to facilitate further change	
Maintenance Consolidate gains made in prior stages, avert reversion to previous practices			-Communicate data and information to dispel skepticism -Keep vision at forefront of people's minds	-Continue rewarding behavior consistent with change goals -Remain vigilant for signs of regression	-Remind personnel of benefits of change -Ensure hiring and promotion systems consider change related performance -Use data to dispute skepticism -Ensure support to address problems -Sustain alignment of resources and structure -Remain vigilant for signs of regression

Information adapted from John P. Kotter, *Leading Change*; James O. Prochaska, John C. Norcross, and Carlo C. Diclemente, *Changing for Good*; Deborah A. Lefescque, Janice M. Prochaska, and James O. Prochaska, "Stages of Change and Integrated Service Delivery" in *Consulting Psychology Journal: Practice and Research*.

APPENDIX B

Stage of Change Assessment

Please circle the most appropriate response in relation to your role in preparing your organization to provide medical support in a CBRN contaminated, contested environment.

1	I resolved the aspect of the readiness issue for which I am responsible over six months ago. (If yes, please stop here.)	Yes	No
2	I have taken action within my area of responsibility for the readiness issue within the past six months. (If yes, please stop here.)	Yes	No
3	I intend to take action within my area of responsibility for the readiness issue in the next month. (If yes, please stop here.)	Yes	No
4	I intend to take action within my area of responsibility for the readiness issue in the next six months.	Yes	No

Adapted from Prochaska, James O., John C. Norcross, and Carlo C. DiClemente, *Changing for Good*.

APPENDIX C

Stage of Change Assessment Scoring

		Precontemplation	Contemplation	Preparation	Action	Maintenance
1	I resolved the aspect of the readiness issue for which I am responsible over six months ago.	No	No	No	No	Yes
2	I have taken action on my area of responsibility for the readiness issue within the past six months.	No	No	No	Yes	Yes
3	I intend to take action on my area of responsibility for the readiness issue in the next month.	No	No	Yes	Yes	Yes
4	I intend to take action on my area of responsibility for the readiness issue in the next six months.	No	Yes	Yes	Yes	Yes

Adapted from Prochaska, James O., John C. Norcross, and Carlo C. DiClemente, *Changing for Good*.

The pattern of yes or no responses defines a person's stage of change. The stage of change in which the majority of the members of the organization fall should be considered the organization's stage of change, and interventions should be matched to that stage.

The Application of Artificial Intelligence Methods to Monitor Mass Casualties, Assess Casualty Care, and Adapt Medical Operations in the Contested Environment

Col Matthew Hanson

Introduction

American military medics have transformed casualty care with data. During Operation Enduring Freedom and Operation Iraqi Freedom, the JTS leveraged data to achieve unprecedented survival rates. Two separate JTS capabilities contributed to the success. First, the centralized DOD Trauma Registry (DODTR) allowed trauma experts in the US to analyze data and develop military-unique CPG for use in the operational theater. Second, deployable teams collected data and implemented the CPGs at theater MTFs. The DODTR and JTS teams contributed to innovations in hemorrhage control, critical care, and trauma surgery. For over a decade casualty care continued to improve along the "chain of survival" from the point of injury to definitive care in the US.[1] To sustain high survival rates in the next conflict, military medicine will require a strategy to harness data and adapt casualty care.

The next conflict threatens to challenge theater medical systems in different ways. The National Security Strategy describes the competitive global security environment and highlights the threats imposed by North Korea's pursuit of WMD and advanced missile systems.[2] The medical impact of a theater contested by CBRN weapons is significant. The DOD has assessed a potential conflict in Korea could "produce 200,000–300,000 South Korean and US military casualties within the first 90 days."[3] Additionally, CBRN and conventional attacks on allied airfields will prevent casualties from being evacuated to a higher level of care.[4] The threats to casualty survival demand a new strategy.

The National Defense Strategy addresses international competition and describes the modernization requirements for success in the next fight. The strategy promotes investment in artificial intelligence (AI) with a focus on emerging commercial applications.[5] The Joint Concept for Health Services offers a potential framework for AI investments and the application of commercial breakthroughs. One of the required capabilities for expeditionary medicine is a joint medical information system with the ability to "monitor patient outcomes, assess clinical effects, and adapt operations."[6] AI methods could adapt the contemporary medical information system to the new, competitive environment.

AI science involves the use of computers and algorithms to perform tasks typically associated with human cognition.[7] A recent review of 152 commercial AI projects found the most common applications involved process automation, pattern detection in large datasets, and human engagement.[8] In civilian health care AI algorithms are being developed to automate health care administration functions, identify skin and eye conditions, manage diagnostic results, and schedule patients for care.[9] In military medicine, AI investment is limited. A meeting of medical SMEs was held at Air War College in September 2018 to discuss casualty care problems associated with CBRN weapons. Medical leaders representing the combat, mobility, and special forces communities were not aware of any medical modernization efforts involving AI.[10] The integration of AI methods into theater MTF modernization projects will sustain casualty survival in the contested CBRN environment.

Theater MTF modernization efforts must enable medics to harness data and adapt to new challenges. The challenges in a contested theater include overwhelming casualties, protracted patient holding times, and CBRN injuries. AI methods will enable the theater MTFs to monitor mass casualties, assess protracted theater care, and adapt medical operations to CBRN threats. The application of AI methods will require iterative projects to automate the capture of casualty data and deploy AI algorithms. The modernization effort starts with an evaluation of a current theater MTF.

The Theater MTF

Mass casualty events occur with little notice and can quickly overwhelm a theater MTF.[11] In 2018, a large-scale military exercise in the Republic of Korea tested the readiness of an American MTF to transition to casualty care operations. The exercise medical team identified numerous inadequacies in the fielded health information system, including gaps in the ability to track patients, document care, and communication between clinical teams. The trauma team described the electronic medical record (EMR) as rudimentary, and advocated for a system capable of transmitting data through the entire trauma system. The operating room team stated the tracking mechanisms were "confusing" and could contribute to misplacing preoperative patients. The senior physician assessed the lack of automation in the outpatient record and poor interoperability between record systems could contribute to excessive staff workload and delays in casualty care.[12] AI methods can close many of the noted gaps by automating data capture, tracking patients, and integrating MTF services during a mass casualty event.

Monitoring Casualties

AI techniques are already optimizing trauma care through machine learning. Machine learning is a body of AI methods "based on computer science that use patterns in data to identify or predict an outcome."[13] The algorithms are engineered to apply a statistical model based on large volumes of data.[14] As an example, a study by the US Army Institute of Surgical Research identified patients needing lifesaving interventions with an algorithm and constant vital sign data.[15] Additionally, a trauma center in Nashville, Tennessee successfully tested an algorithm designed to predict daily trauma activity based on historical hospital admission and weather data. The Nashville algorithm allowed the trauma center to predict trauma cases per day, overall acuity, patterns of injury, and operating room cases.[16] Machine learning techniques applied to civilian casualty care can be translated to military casualty care.

Machine learning algorithms can be developed to monitor casualties, assess casualty care, and adapt operations. A casualty prediction algorithm holds the potential to recognize patterns in local trauma data, conventional and CBRN injury types, and environmental conditions. Like other algorithms, the casualty prediction algorithm will require a high volume of accurate, real-time data from multiple sources.[17] To collect the necessary data, the next theater MTF needs to be smart.

"Smart" or electronic Intensive Care Units (ICUs) leverage advances in automated patient sensors and medical informatics to improve the care of critically ill patients while decreasing information overload.[18] The translation of smart Intensive Care Unit ideas to a smart MTF will require wired and wireless networks, middleware, and servers. Each patient within a smart ICU is the center of a local network connecting the patient, patient sensors, medical equipment, medications, supplies, diagnostics, imaging, EMR, and data displays. A broader MTF network connects each patient to on site middleware programs. Concentric patient, ICU, and MTF network relationships build redundancy and resilience into the deployed medical information system. The middleware then converts medical sensors and devices into constant sources of high volume, real-time data.[19]

Potential middleware technologies for a smart MTF include alarms, device communities, real-time location systems (RTLS) and data integration. Smarter alarms are the first technology to consider. The noise from basic alarms is fatiguing in a mass casualty event because multiple patients will have physiologic issues to address simultaneously. Alarm middleware allows each alarm to be autonomously filtered and prioritized for human intervention.[20] The Boeing 777 has an alert system with a hierarchy of alarms ranging from a high priority “stick shaker” with an audible warning to a low-priority advisory with a visual warning. When the Boeing aircraft alerts the crew of an issue, a checklist linked to the issue is shown on a central console to guide the intervention. At Mayo Clinic the checklists are specific to the alarm and focus on easily missed tasks. The alarm data is also aggregated and utilized in other algorithms.[21] The alarms in a smart MTF drive timely medical interventions instead of medical staff fatigue.

The second technology in the smart MTF is the virtual device community. Device communities enable the facility to cluster and monitor patients remotely during mass casualty events. Middleware connects similar devices into a virtual community of medical equipment.[22] As an example, the medical team may want to know the vital signs of the patients awaiting operations, intravenous sedation requirements of the patients in the ward, or the ventilator settings of the patients awaiting critical care transport. An “internet of things” approach is already being utilized in civilian medicine to safely and efficiently monitor patient blood chemistries, heart rhythms, vital signs, and seizures.[23] Virtual device communities allow the smart MTF to monitor more casualties in real-time.

RTLS systems are the third potential technology for the smart MTF. RTLS middleware keeps track of the moving parts during a mass casualty event. RTLS uses identification tagging to track patient transfers, staff movement, equipment, and the supply inventory.[24] Radiofrequency identification (RFID) chips embedded in patient wristbands can accurately provide patient location and improve efficiency.[25] The reliability of RFID tracking systems has been tested in a busy civilian emergency department setting and during mass casualty exercises.[26] Device communities and RTLS will optimize productivity and safety in the smart MTF.

The fourth and final technology for the smart MTF is data integration. Data integration middleware allows the MTF to collect and display timely information to the medical decision makers.[27] Automated collection and extraction of patient histories, exams, assessments, and physician orders are becoming possible. AI methods are in development to accurately identify and scribe the medical team’s spoken word and reports directly into the EMR.[28] Considering the display of information, providers only utilize a small percentage of the available data to make decisions at any given time. Innovative displays are designed to filter and aggregate the information necessary to make decisions, thus preventing data overload.[29] Far from rudimentary, the smart MTF will deliver the right data to the right medic at the right time.

To summarize, patient alerts, virtual device communities, RTLS tracking systems, and data integration enable the smart, networked MTF to harness data for the effective monitoring of mass casualties. Next, the casualty data will be analyzed with machine learning algorithms. Predictive analytic algorithms will allow the smart MTF to assess casualty care in the contested CBRN environment.

Assessing Casualty Care

CBRN casualties will increase the demands on a theater MTF. Consider the VX nerve agent. VX attacks the nervous system to incapacitate and ultimately suffocate casualties. Patients suffer from loss of consciousness, seizures, airway obstruction, dysfunctional breathing, and apnea. The assassination of the North Korean leader's half-brother was carried out with VX and killed the victim within minutes. Survivors of exposure to VX and next-generation nerve agents have required weeks of critical care for recovery.[30] Until patient evacuation is available, the survivors in a contested environment would require constant assessment and intervention. The application of predictive analytics can enable a smart theater MTF to assess CBRN casualties.

Predictive analytic algorithms are the most common AI applications utilized in critical care. Predictive algorithms are a type of supervised ML used to predict conditions by uncovering relationships between known patient features and possible outcomes.[31] In practice, predictive analytics alert medical staff to patient decompensation and medical errors. The predictions allow the medical staff to intervene and improve patient outcomes.[32] In a contested environment with CBRN casualties, optimized medical interventions could save lives.

Predictive analytic tools are used in critical care today. For example, sepsis is a life-threatening condition associated with infection. At Emory University, the critical care staff predicted sepsis with real-time heart rate and blood pressure measurements combined with data extracted from the EMR. The Emory algorithm allowed the staff to predict sepsis in patients four hours before symptoms manifested and gave the medical staff time to prevent complications.[33] A similar project at Huntsville Hospital in Alabama combined a predictive analytic approach with alerts on mobile devices. The nursing staff received alerts for patient features associated with sepsis, advice on interventions, and reminders to complete all the tasks in the treatment plan. The Huntsville study demonstrated a 53 percent decrease in sepsis mortality.[34] Moreover, sepsis screening algorithms have decreased the nursing hours required to assess patients by up to 72 percent.[35] Predictive analytics provide the theater MTF with increased intervention lead-time, targeted alerts, and optimized automation when faced with multiple CBRN casualties.

The Mayo Clinic has taken predictive analytics a step further. Mayo implemented algorithms for sepsis and mechanical ventilator-induced lung injury at multiple hospital sites. The algorithm was integrated into the medical staff workflow, which alerted the provider when interventions are not consistent with the patient's condition and avoided data overload. The comprehensive approach at Mayo Clinic correlated with a 50 percent decrease in the mortality of critical care patients, a 50 percent decrease in ICU stay length, and a 37 percent decrease in hospital stay length.[36] Military medicine could apply the integrated predictive analytic model at Mayo to theater casualty care.

Starting with the integrated model at Mayo Clinic, the theater trauma algorithms would add known conditions associated with CBRN agents. An algorithm for predicting decompensation in VX nerve agent casualties might predict the likelihood of respiratory failure, loss of consciousness, and seizure. The JTS has developed a manual assessment system, called CRESS, which stands for consciousness/seizure, respiration, eye/pupil size, secretions, and skin.[37] Sensors in the smart MTF will capture CRESS assessment data from the patient, and language processing programs will extract additional assessment data from the EMR. The proposed CBRN algorithm would run continuously and alert the staff of potential changes in patient status, suggest interventions based on best practices, and notify staff of interventions inconsistent with the patient condition. The goals of the theater predictive analytics algorithms will include improved timeliness of intervention, decreased workload, shorter ICU stays, and increased casualty survival.

Supervised ML algorithms are used in critical care today. A smart MTF will harness data and predict conditions for early intervention. Predictive analytic algorithms will enable the medical staff to assess care effectively. Next, prognostic machine learning algorithms will enable the smart MTF to adapt operations in the contested CBRN environment.

Adapting Medical Operations

The two goals of the theater MTF are the return of treated warfighters to combat and the preservation of life, limb, and eyesight.[38] In the contested environment the return of personnel may take priority. A wargame held at Air War College in 2017 involved a theater MTF with inadequate resources to meet the concurrent demands for treated warriors and lifesaving care.[39] Trust broke down between the support commander, medical personnel, and patients. As a result, the medical professionals lost confidence and sometimes failed to make crucial operational decisions.[40] The application of prognostic analytics can enable a smart MTF to adapt medical operations in the contested CBRN environment.

Prognostic analytic algorithms are a type of machine learning designed to predict the likelihood of a specific end point. These algorithms are used to predict outcomes such as the risk of ICU transfer, prolonged ICU stay, cardiac arrest, ICU mortality, and postoperative mortality.[41] Survival can be predicted for patients with specific conditions like trauma, burns, and shock. Prognostic machine learning algorithms can enable medical staff to predict outcomes and improve trauma systems.[42] A smart MTF will need them to inform decisions and adapt medical operations.

Military medicine will benefit from the application of prognostic analytics to casualty care. Consider a smart MTF with an RTLS system to track medications, blood products, medical supplies, and medical equipment. A prognostic algorithm could combine patient sensor data with RTLS data to forecast the ICU caseload and estimate the consumption of medical resources. The combination of AI methods will enable the smart MTF leadership to determine the overall utilization of medical resources and the risk of deficits. The medical leaders will still make tough decisions, but algorithms will allow the smart MTF to anticipate medical supply deficits and adapt operations with more confidence.

Another end point for analysis is the return of treated warfighters to duty. A prognostic algorithm could analyze extracted data from the EMR and real-time data from vital sign sensors to determine the likelihood of returning a warfighter to duty after mild traumatic brain injury, orthopedic injury, or chemical weapon exposure. By forecasting the return of personnel to duty, the MTF can better balance priorities. It is a false dichotomy to state a theater MTF must "flip a switch" and stop casualty care when the mission requires additional warfighters.[43] A smart MTF using prognostic algorithms will adapt instead of flip. The decisions will still be in the hands of the medics, but they will have data to determine the best balance of mission and casualty-oriented care.

To summarize, prognostic algorithms are already used to predict specific outcomes today. A smart MTF will combine prognostic algorithms with casualty data to predict resource deficits and forecast the flow of treated warfighters. Prognostic machine-learning algorithms will enable the medical staff to adapt operation in the contested environment.

Leading Change

American medics transform casualty care with data, and the application of AI methods will enable a smart theater MTF to monitor mass casualties, assess casualty care, and adapt medical operations in the contested environment. John Kotter described a staged approach for leading organizational change, and the first steps are critical for the MTF modernization strategy. The initial steps include establishing a case for urgent change and creating a change vision. The case for change and change vision are necessary to mobilize and prepare the organization for new practices. The modernization of the theater MTF begins with the case for urgency.

The case for urgency includes examinations of the sources of complacency and the nature of the strategic crisis. Any effort to integrate AI methods into the theater MTF will compete against many sources of complacency.[44] Health care professionals may resist changes in information systems out of concern for alert fatigue or data overload.[45] Medical professionals may not understand the science of ML algorithms and the potential use cases.[46] Finally, military medical planners may be concerned about emerging threats to computer systems and networks. The concerns of health care professionals and medical planners should not prevent the application of AI methods, but the concerns deserve consideration in the theater MTF modernization strategy.

Considering the strategic crisis, the current design of the theater MTF is not optimized for the challenges of the contested environment. Medical transformation successes in Iraq and Afghanistan demonstrated the need for accurate casualty data to improve survival in future conflicts.[47] A review from the US Army Institute of Surgical Research noted "constant physiologic observations and data" could enhance the treatment of casualties.[48] China is also exploring approaches to compile and exchange health data.[49] The time for a bold vision to integrate AI methods into theater casualty care is now.

The strategic vision for theater MTF modernization must define the requirement, time frame, guiding coalition, and desired product.[50] The warfighting commander, casualties, and medics require a smart MTF enabled with AI tools today. Urgent action must be taken well before the next conflict because a smart ICU will take years to design and execute.[51] In the interim, a guiding coalition will develop the smart MTF capabilities and ML algorithms.

The guiding coalition must be carefully defined. The expansive scope of the modernization effort will require the strategic leadership of a medical flag officer. The technical design of the smart MTF and algorithms will need input from a wide range of medical specialties.[52] Steering committees have been beneficial in the development and employment of predictive analytics.[53] Additionally, the development of the integrated warning and response system across the Mayo Clinic hospitals included input from 1,500 clinician interviews.[54] Strong leadership and broad, expert participation is required to achieve the ultimate products of the modernization effort.

The final products of the smart MTF modernization effort are sustained combat missions and improved casualty survival. To achieve the mission and casualty care goals, the smart MTF will grow iteratively with ongoing upgrades to the military EMR, patient sensors, biomedical equipment, RTLS systems, middleware, and MTF networks. The theater MTF modernization can start with the introduction of vital sign sensors connected to laptop-based middleware and predictive algorithms. A simple, scalable, deployable system will be capable of alerting medical staff of targeted conditions and providing standardized casualty care guidance. Each progressive step in the development of a smart MTF should consider the role of automation, connectivity, security, and electromagnetic protection. The application of AI methods will grow as high volume, real-time data becomes available to algorithms for prediction and prognosis. Military medical leaders should work with military and civilian hospitals to develop ML algorithms until the smart MTF is ready for field exercises and theater deployment.

The medical modernization effort must begin today. A medical flag officer leading a guiding coalition of experts will require 3–5 years to field the smart MTF and machine-learning algorithms. Initially, vital sign sensors connected to deployed algorithms will enable the medics to monitor mass casualties. Ultimately, leading the changes necessary for the application of AI methods will enable the medics to sustain combat missions and casualty care in the contested, CBRN environment.

Conclusion

Military medicine must lead the change to a smart MTF capable of monitoring mass casualties, assessing casualty care, and adapting medical operations in the contested, CBRN environment. A smart theater MTF will use automated sensors to capture data for mass casualty monitoring and analysis with machine learning algorithms. The predictive algorithms will enable the medics to continuously assess casualties waiting for AE. Prognostic algorithms will enable the medical leaders to adapt medical operations to changing CBRN injuries and combat mission requirements. The integration of AI methods will take place with ongoing medical modernizations efforts. Initially, vital sign sensors connected to deployed algorithms will monitor casualties and alert the medics to decompensation. Over time, the guiding coalition will develop, test, and deploy the smart MTF and machine learning algorithms. In turn, the medics will use AI tools to transform casualty care with data.

Items for Further Research

1. DHA J-7 create a Review Analysis Board of all Service Medical Readiness Training and identify training redundancies and categorize a Service to lead and share curriculum across all services based on the best level of expertise. For example, why have 75 different types of Tactical Combat Casualty Care (TCCC) across the services. The joint force only needs one TCCC platform model where all services can train to the same course. Lead to re-conceptualize medical readiness training as Joint whenever possible and standardize.

2. AFMS Training Platforms should be centralized to train with the Army, Navy, Marines, and Coast Guard. Operations in Iraq and Afghanistan have created a level of combat-earned trust the Air Force must sustain. As current combat operations wind down, training and exercise opportunities which enhance that trust across the joint force are critical. Our battlefield Airmen have fought and died beside our sister service forces, and through that integration have developed both the enduring relationship and a perspective that is indispensable to our Air Force and the nation. As a service, the Air Force has gained significant experience and learned valuable lessons on leading people and integrating capabilities across joint operations. Our steadfast goal should be to build upon these lessons and weave them into our DNA. This will ensure a more comprehensive understanding of the synergy attained through the integration of training with our joint partners. Training alongside our sister services allows us to build partnerships that enhance deterrence, build regional stability, offset costs, increase capability and capacity, and ensure access to information to build a faster agility service to our patients and forges the bonds of trust our patients deserve. Further explore possibilities at Camp Bullis to build the first-ever MHS Joint Medical Readiness Training Site.

3. Integrating with Line to train to Multi-Domain Environments. By 2035, the meaning of integrated multi-domain operations will encompass full interoperability among air, space, and cyberspace capabilities so that the combined effect is greater than the sum of the contributed parts without being limited by rigid interdependence. By 2035, evolution in the way the service achieves readiness and required performance levels will change the organization, training, and equipping of Airmen. The Air Force will integrate appropriate teams of manned and uninhabited systems in air, space, and cyberspace to execute its five core missions. Each category of

system will include varying degrees of automation to improve decision--making and performance, enhancing, not replacing, human cognition. Performance-optimized teams will also consist of partnerships with joint, coalition, and interagency members. Greater interoperability, transparency, and dynamic command and control will facilitate effective integration and teaming. MHS will need to identify the future role of medical readiness training to train to Multi-Domain Environments with the line so medic warfighter can be resilient in all domains. Force Development and Talent Management should be explored to identify the right person at the right time for multi-domain operations.

4. Future research must consider and evaluate how the actors view and prioritize the constraints on their decision-making, i.e., standard of care versus state medical licensure versus medical specialty training versus precedence in the operational environment versus personal ethics. The military medical organization must further explore decision-making models with the deliberate purpose of incorporating the legal and ethical standards recognized by this country and many other nations. It is this marker or standard the medical community is held to across the full spectrum of cooperation, competition, and conflict. Moreover, MHS leaders must explore appropriate training techniques and platforms, and then apply tools of measure to accurately evaluate the effectiveness of the desired outcomes.

5. 5. Exploration of multimodal evacuation methods must be conducted. The AFMS must consider other modes and plan for moving patients to rail and seaports. Changes to methods may impact and require change to holding and ground transport capabilities.

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Abbreviations

AAR	After action report
ACC	Air Combat Command
AE	Aeromedical evacuation
AETC	Air Education and Training Command
AFI	Air Force Instruction
AFMS	Air Force Medical Service
AFSC	Air Force Specialty Code
AI	Artificial intelligence
AMC	Air Mobility Command
CBRN	Chemical, Biological, Radiological, and Nuclear
CONUS	Continental United States
CP	Collective Protection
CPG	Clinical Practice Guideline
CPR	cardiopulmonary resuscitation
CRESS	consciousness, respiration, eye, secretions, and skin
DHA	Defense Health Agency
DHB	Defense Health Board
DMRTI	Defense Medical Readiness Training Institute
DOD	Department of Defense
DODTR	DOD Trauma Registry
EHST	Exertional heat stress test
EMEDS	Expeditionary Medical Support System
EMR	Electronic medical record
ICU	Intensive Care Units
IPE	Individual protective equipment
JTS	Joint Trauma System
LRMC	Landstuhl Regional Medical Center
MEFPAK	Manpower and Equipment Force Packaging System
MHS	Military Health System
ML	Machine Learning

MOPP	Mission Oriented Protective Posture
MTF	Military treatment facilities
OEF	Operation Enduring Freedom
OIF	Operation Iraqi Freedom
PM	Patient movement
PMI	Patient Movement Items
RFID	Radiofrequency Identification
ROE	Rules of engagement
RTLS	Real-time location systems
SEAL	Sea, Air, and Land
SIT	Stress inoculation training
SME	Subject Matter Experts
TCCC	Tactical Combat Casualty Care
TLAMM	Theater Lead Agent for Medical Materiel
TTM	transtheoretical model of change
TTP	Tactics, Techniques, and Procedures
USAMRIID	US Army Medical Research Institute of Infectious Diseases
USS	United States Ship
UTC	Unit Type Code
WMD	Weapons of Mass Destruction

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