

Military-Civilian Exchange of Knowledge & Practices in Trauma Care

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The following manuscript is presented with profound admiration for the sacrifices made by the men and women of the Armed Forces and in recognition of their commitment to excellence in serving the United States of America.

Commissioned by the National Academies of Sciences, Engineering, and Medicine Committee on Military Trauma Care's Learning Health System and Its Translation to the Civilian Sector

The responsibility for the content of this article rests with the author and does not necessarily represent the views of the National Academies of Sciences, Engineering, and Medicine or its committees and convening bodies.

COMMISSION

- *Describe the major mechanisms by which military and civilian sectors exchange knowledge and best practices in trauma care, including but not limited to dedicated military committees within professional societies, consultation programs, special edition journal supplements, and joint military-civilian training programs. This should include explicit consideration of mechanisms for translation from the military to the civilian sector and from the civilian to the military sector.*
- *Discuss strengths and challenges of the identified mechanisms for cross-sector exchange of trauma care knowledge and practices. This should include an analysis of the extent to which exchange mechanisms extend beyond the trauma surgeons to include other surgical and medical specialties (e.g., anesthesiology), nursing and allied health care providers.*

PREMISES

- We have an all-volunteer, professional military highly trained in conducting combat operations. In contrast, our military medical corps is largely untrained in combat casualty care and does not maintain a high level of readiness in this area at baseline.
- The military medical system—as it currently exists—does not afford an adequate experience in trauma care for the vast majority of military medical personnel.
- A short course in pre-deployment training does not create expertise in trauma or the care of severely wounded combat casualties.
- There is sufficient overlap in civilian and military trauma care to warrant ongoing collaboration. Combat casualties and civilian trauma patients will all benefit if lessons learned are adapted to the particular patient and clinical situation.

War is a laboratory of nightmares, but...more than any other recorded events in history, war has advanced the care of the injured.

C. William Schwab, MD

All military medicine insofar as civilians are concerned, is a discontinuous specialty, consequently, in every new war the same stupid mistakes are made again and soldiers lose their lives and limbs, because the doctor was ignorant of past experience.

Edward Churchill, MD

The traditional civil-military relationship is frayed and ill-defined. Our military and defense structures are increasingly remote from the society they protect, and each must be brought back into harmony with the other.

Gary Hart/James Fallows, The Atlantic

Introduction

With every major conflict in U.S. history, the care of injured patients—both military and civilian alike—has improved substantially (1). However, during the inter-war period, lessons learned are forgotten and expertise in military trauma erodes. This erosion then costs the lives of soldiers early in the next conflict (see Figure 1). This cycle has been repeated for centuries (2). The Institute of Medicine has theorized that implementing a learning military health system will break this long-standing historic pattern.

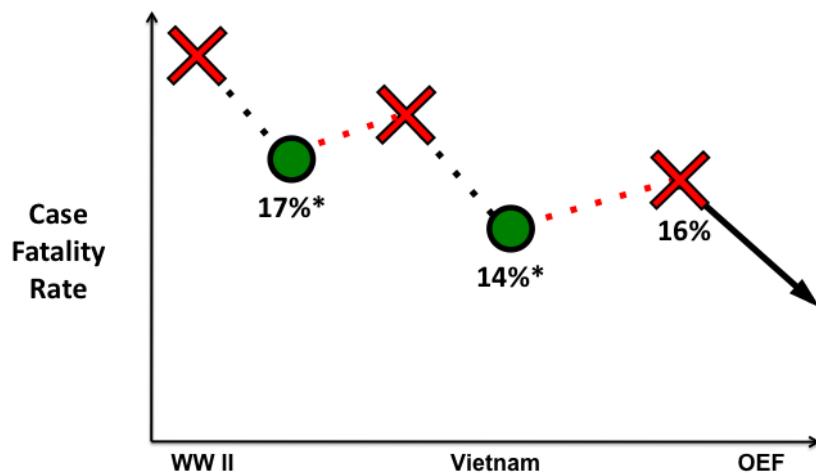


Figure 1 The well-recognized historic cycle of combat casualty outcomes. During times of conflict, outcomes improve with time. However, the quality of care erodes during the inter-war period resulting in worse outcomes at the beginning of the next conflict (3,4). *Estimates of the Case Fatality Rates (CFR) at the end of WW II and Vietnam are estimated assuming a 2% reduction over the mean CFR for the entire conflict. OEF, Operation Enduring Freedom, Afghanistan; WW II, World War II

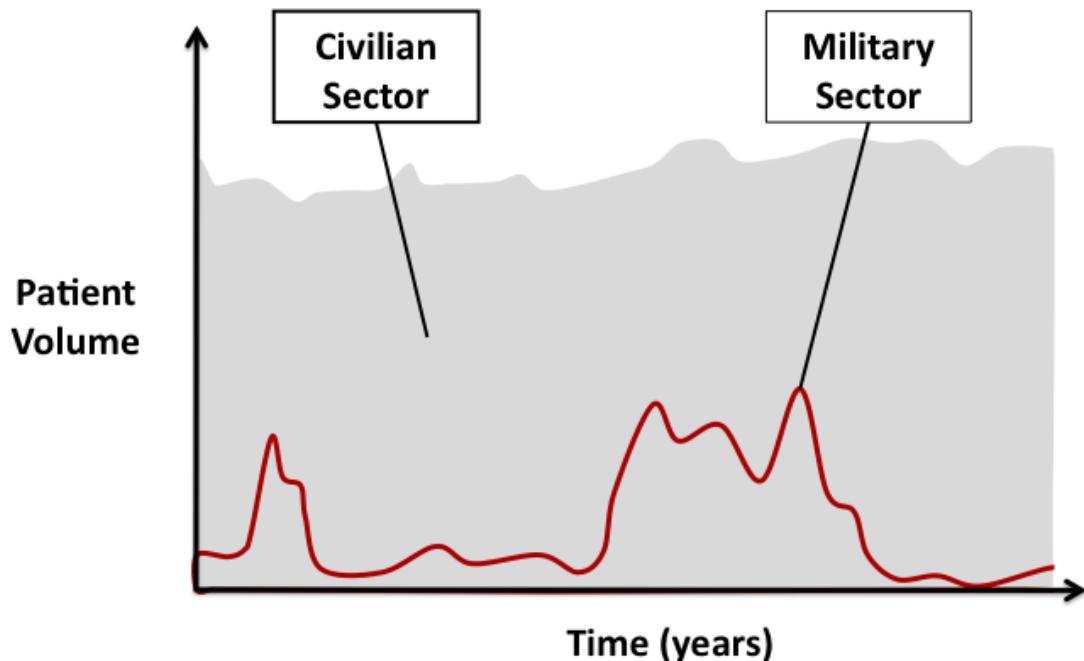


Figure 2 Episodic nature of trauma care in the military sector as compared to the civilian sector.

Military trauma care is, by nature, episodic (see Figure 2) (2). Consequently, to ensure a robust and sustained learning health system for combat casualty care, exchange with the civilian trauma sector is imperative. The following paper describes the major mechanisms for cross-sector exchange of trauma care knowledge and practices across all disciplines involved in the care of critically injured patients. Strengths and weaknesses of these current mechanisms are enumerated and methods for optimizing such exchanges in the future are proposed.

Historic Perspective

Over the centuries, the military has drawn staff from civilian medical facilities to provide care to the combat wounded (5–7). Following combat operations, these personnel—physicians, nurses, and medics—returned to civilian life carrying with them lessons from the battlefield. Through individual practice, word of mouth, oral and written histories of combat medical care, and publications in the medical literature, these lessons seeped into civilian practice (8). Although this historic pattern is well known, it raises a number of questions which merit further exploration (see Table 1).

Table 1. The historic practice of filling military medical ranks with civilian staff raises a number of issues.

- 1) What was the prior experience of these civilian personnel in caring for severely injured patients?
- 2) What knowledge and training specific to combat trauma care were they provided prior to deployment?
- 3) To what extent was on-the-job or just-in-time training employed?
- 4) How well did their prior experiences translate into the care of large numbers of severely wounded combat casualties?
- 5) How applicable were their battlefield experiences to the management of civilian patients?
- 6) In subsequent conflicts, how well was this knowledge and experience preserved?

Civilian Surgeons Activated for War—Instructive Examples from World War II

Dr. Edward Churchill's experiences during World War II provide some insights on the issues raised by this practice (5). At the outset of combat operations in Europe, Dr. Churchill was a Professor of Surgery at Harvard Medical School and the Chairman of Surgery at Massachusetts General Hospital (MGH). Although he was an eminent thoracic surgeon with exceptional technical skill, he did not have any significant military experience. Churchill had been a medical student during World War I and was not drafted (9). Furthermore, over the ensuing decades after World War I, the medical history and lessons learned were haphazardly collected and difficult to access; so very few civilian surgeons, including Churchill, were knowledgeable in this area.

Churchill also was not widely experienced in trauma surgery. During his surgical career prior to World War II, only significant experience in managing large numbers of significantly injured patients was after the Coconut Grove fire (9). Although many of the MGH interns, residents, and staff were activated or drafted, Churchill was exempted due to his leadership position. However, he petitioned the surgeon general for a position that would allow him to serve in a senior advisory role for the many junior staff that were deploying. He was granted a consultant position for the new North African/Mediterranean Theater, equivalent to the position held by Dr. Elliott Cutler (Surgeon-in-Chief at the Peter Bent Brigham Hospital in Boston) for the European Theater.

Prior to his deployment, Churchill received no additional training in combat casualty care. In his words, "...on departure for overseas I received no instructions in the management of the wounded and there was no guide to the buried periodical literature of 1918. The Surgeon General's History of World War I was inadequate as far as casualty care was concerned. In fact, the History was not even included in the library list available to overseas hospitals" (9).

Notwithstanding, during his multi-year service in the North African and Mediterranean Theater, Churchill made many important contributions to combat casualty care. He advocated for staged management of severe wounds. He clarified “wound shock” as being caused by hemorrhage. He proposed that freeze dried plasma alone was not sufficient for hemorrhage resuscitation and that use of whole blood was a superior strategy. Finally, he established a research presence in the combat zone that collected data for future analysis.

Following his return to civilian life, Churchill contributed to the Surgeon General’s compendium on combat casualty care in which he observed, “Cobwebs of theory and hypothesis were swept away by simple observations and precise definitions” (10). However, the degree to which his specific insights and observations impacted civilian trauma care or the care of combat casualties in future wars is less clear. Also, there is little, if any, documentation of similar experiences of nurses and medics deployed during World War II.

Other prominent surgeons who served on active duty during World War II included Elliot Cutler from Boston, Loyal Davis from Chicago, Michael DeBakey from Houston, Evarts Graham from St. Louis, and I. S. Ravdin from Philadelphia. Each of these remarkable surgeons made invaluable contributions to combat casualty care in their time. However, tracing the translation of these advances into civilian practice and estimating the sustained impact of each surgeon’s contribution in future wars is difficult. It appears that as these individuals and the many other deployed personnel returned to practice, the advances they effected during the war were dutifully archived and then quickly forgotten (2).

Staffing the Military Medical Corps without a draft

Following World War II, there was growing discontent in the civilian medical community with the draft and the impact of this staffing model on our state-side medical centers. At the recommendation of Drs. DeBakey, Churchill and others, the Army and Navy initiated independent residency programs within several Military Treatment Facilities in the late 1940’s with the Air Force following suit in the 1960’s (11). To further bolster the military medical ranks for wartime demand and to address mounting pressure to eliminate the draft for medical personnel, the Assistant Secretary of Defense (Health and Medical), Dr. Frank B. Berry proposed a model which allowed medical students to sign up for two years of military medical service in lieu of being subject to the draft (12).

Thus, from 1945 to the mid-1970's, deploying physicians consisted of either career military members or "obligate volunteers" who joined the military ranks through the Berry Plan or, in some cases, the regular draft (13,14). During the Korean War, these physicians placed of surgical assets close to the front lines (i.e. MASH units), offered dialysis to patients with acute renal failure, and repaired injured vessels against the conventional surgical wisdom of the time (1). As a result, by the end of combat operations, the case fatality rate was significantly lower than it had been in World War II, thus validating this new staffing model (11).

In Vietnam, deployed surgeons suffered under the scourge of public disillusionment. Even still, important advances in combat casualty care were made and these advances were translated into civilian practice. Examples include the rapid helicopter transport of casualties, creation of dedicated trauma centers (e.g. Cook County Hospital and Maryland Shock Trauma), minimization of post-trauma renal failure through crystalloid resuscitation, and the use of mechanical ventilators to support patients with acute respiratory distress syndrome (15).

Refinements to Military Staffing After Vietnam

In the early 1970's a number of refinements to the military staffing model were made in response to growing dissatisfaction with the draft and the Berry Plan. The Uniformed Services Health Professions Revitalization Act of 1972 led to the establishment of a military medical school, the Uniformed Services University of the Health Sciences (USUHS). It also authorized the Armed Forces Health Professions Scholarship Program (AFHPSP) which funded medical school tuition and living expenses in exchange for 3 to 4 years of active duty medical service. At the same time, the draft (including the physician draft) ended in 1973. Residency training continued as it had in years past with some military physicians receiving training in MTFs and others in civilian residency programs. Thus, with these changes, the military medical ranks were now filled with some physicians who may have been educated and trained exclusively in the military, some who had been educated and trained exclusively in the civilian sector, and still others with a combination of military and civilian experience (see Figure 3).

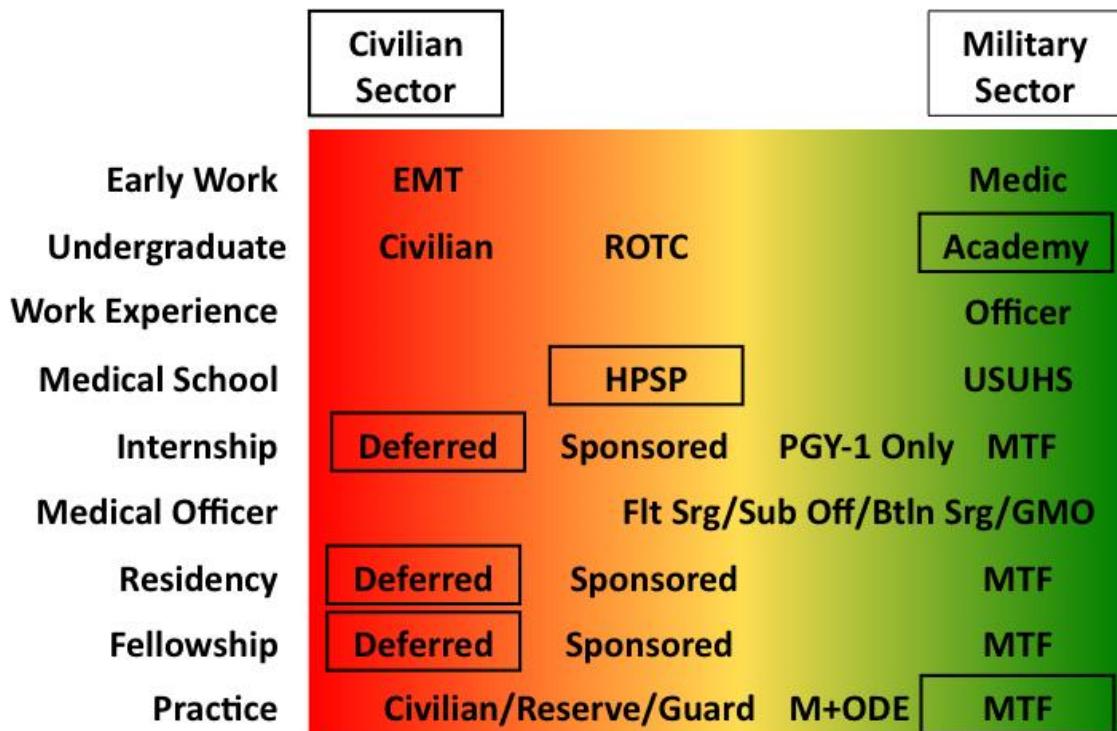


Figure 3 Training pipeline and sources for military physicians. A number of possible combinations of military and civilian experiences are now possible. The boxes indicate the training pathway of the author. Experiences exclusively in the civilian sector are shown in red while those conducted entirely in the military sector are shown in green. Elements that are conducted in the civilian sector with a military obligation or sponsorship are shown in orange. Candidates for military service typically enter the medical training pipeline during undergraduate or medical school. A small minority of physicians enter military service directly from civilian clinical practice (i.e. direct accession). Btl Srg, battalion surgeon; EMT, Emergency Medical Technician; Flt Srg, flight surgeon; GMO, general medical officer; MTF, military treatment facility; ODE, off-duty employment (i.e. “moonlighting”); PGY, post-graduate year; ROTC, Reserve Officer Training Corps; Sub Off, Submarine Officer; USUHS, Uniformed Services University of the Health Sciences

This staffing model is present still today resulting in a wide variety of backgrounds and experiences represented in the military medical faculty assigned to MTFs (5,13,16). This variability is further increased during combat operations when these full-time active duty medical personnel are augmented by National Guard and Reserve staff. These latter individuals have a wide range of military experience from recent military separates to those with no prior military experience (so-called direct acquisitions). This variability in backgrounds and experience can represent either an asset or a liability to combat casualty patient care. In general, however, a physician with no prior military experience, little or no exposure to critically injured patients, and no knowledge of military medical history will be challenged to provide high-quality care in an austere combat environment. Furthermore, this sequestering of mostly young surgeons

in our MTFs with little civilian contact and few opportunities to maintain trauma management skills is suboptimal.

Lapses in Readiness

Unfortunately, in the years after Vietnam, despite (or perhaps in part due to) the changes in military staffing noted above, the medical system lapsed into a state of disrepair. This ultimately culminated in a number of inexcusable deficiencies and substandard care during Desert Storm (17). In the years leading up to Desert Storm, the medical ranks became severely depleted leading to significant understaffing. Then, during the mobilization, medical teams were sent into theater with incomplete supplies with the expectation that these could be obtained in the combat theater. Furthermore, there was no integrated trauma system to guide patient evacuation. Finally, the non-medical command forbade data collection for research. In subsequent conflicts, some of these deficiencies have been rectified (18–20). However, even in the current military medical system, relevant military medical history is not taught to medical students outside of USUHS, readiness for trauma care is not specifically measured or rewarded, and there are few opportunities for robustly maintaining trauma management skills once physicians enter active service and are assigned to an MTF (see Table 2) (21). Unless these deficiencies are addressed and a state of constant trauma readiness is maintained in the military, we risk repeating mistakes of the past.

Table 2 Potential surgeon assignments and opportunities for civilian patient care and regular interaction with civilian counterparts.

Branch of Service	Surgeon Assignment	Opportunities for Routine Civilian Interaction
Air Force	MTF Level 1 Trauma Center—SAMMC	Civilian Patients, STRAC, ODE at civilian centers
	MTF Level 2 Trauma Center—Walter Reed NMC	ODE
	AF MTF Non-Trauma Center	ODE (CONUS Only)
	CSTARS—Baltimore, Cincinnati, St. Louis	N/A
Army	MTF Level 2 Trauma Center—Walter Reed NMC	ODE
	Army MTF Non-Trauma Center	ODE (CONUS Only)

	ATTC—Miami	N/A
Navy	MTF Level 2 Trauma Center— Walter Reed NMC	ODE
	Navy MTF Non-Trauma Center	ODE (CONUS Only)
	NTTC—LA County	N/A

ATTC, Army Trauma Training Center; CONUS, continental United States; MTF, military treatment facility; NMC, National Medical Center; NTTC, Navy Trauma Training Center; ODE, off-duty employment (i.e. “moonlighting”)

Current State of Military-Civilian Interactions

Military medicine is best characterized as an enclave of the healthcare sector separate from the civilian world. Civilian interaction with members of the military community is largely by invitation only. However, the military system can, and often does, function independent of civilian medical influence. It is only through active engagement—often at the grass roots level—that civilian-military interactions occur (22–24). In the area of trauma care, these cross-sector interactions are highly mutually beneficial and represent the mechanism whereby trauma advances are disseminated (25). Numerous recent examples can be cited including the adoption of an organized trauma systems approach to care by the military (26) and the widespread use of damage control resuscitation by civilian trauma surgeons (27). Unfortunately, recent experience has demonstrated that these vital interactions are tenuous and can be quickly threatened or even truncated at the hands of short-sighted military policy (28). The following paragraphs seek to describe the principal mechanisms for such exchanges within the current system of military healthcare.

The Training Pipeline: Undergraduate Medical Education through Residency/Fellowship

As described above, medical students with military commitments are currently trained either at USUHS or under a military medical scholarship similar to ROTC, termed the HPSP Scholarship. The faculty at USUHS include a mix of military and civilians with many of the civilians coming from prior military service. The curriculum includes an emphasis on military medical history and incorporates a number of military-specific training modules. However, these benefits are offset by the long service commitment incurred by USUHS students and frequent

deployments during military service, making USUHS attendance less appealing for many medical school applicants (29).

In contrast, HPSP students are trained almost entirely by civilians except for the relatively few faculty at civilian medical schools with prior military experience or reserve commissions. There is no requirement for coursework on military medical history. Although HPSP students are required to complete four months of active duty service during medical school, these rotations can be on any elective subject ranging from dermatology to pediatric surgery, so long as they are conducted at an MTF. Thus, there is no programmed exposure of HPSP students to either the rich history of combat casualty care advances or to the current practice of trauma care in the military. Furthermore, accessing these students to provide military-relevant educational materials has historically proven impossible in the author's experience.

In recent years, however, the National Board of Medical Examiners (NBME) has recognized the importance of a general knowledge of military medical topics among graduates of US medical schools. To encourage education on these topics, the NBME has partnered with military physicians to provide content for all steps in the USMLE board examinations through the Joining Forces Initiative (30).

As students near graduation, they apply to the Joint Services Graduate Medical Education Selection Board (JSGMESB) for post-graduate training. This Board, chaired by the Surgeons General, meets annually in late November to match military applicants into designated training positions. In surgery, applicants are selected for training in one of the 13 military residency programs or for civilian training through deferment (with no additional commitment) or military sponsorship (with additional commitment in exchange for a military officer's salary during training) (11). The vast majority of Army and Navy surgical trainees are selected for military residency while the Air Force often trains up to half of its surgeons in the civilian sector. Neurosurgery has one military training program at WRNMC which has trained both Army and Air Force members. All other neurosurgeons are civilian trained. Specific military/civilian distribution in other combat-relevant specialties including Orthopaedics, Otolaryngology (ENT), Anesthesia, and Emergency Medicine can be obtained from subject matter experts in these areas, upon request. This board historically met in Washington DC where civilian students with military commitments could meet board members during a pre-planned student open house.

However, recent budget cuts have resulted in this meeting being held virtually thus eliminating this important opportunity to interact, even if briefly, with obligated students.

During residency training, again, those in military residencies experience vastly more exposure to military-specific experiences than obligated civilian residents (see Figure 3). MTFs are staffed predominately by active duty military surgeons with recent deployment experience. Most military residents fulfill their formal trauma requirements during training by rotating at civilian trauma centers, with San Antonio Military Medical Center representing the one notable exception. Residents in civilian programs have little to no contact with military trauma faculty. The results of these different experiences on perceptions of combat readiness were recently evaluated by Tyler, et al (31). These authors surveyed 137 military surgeons with recent deployment experience. Of these, 94 (69%) trained in the military while 43 (31%) trained in a civilian program. A total of 114 (83%) felt well or very well trained for deployment although gaps in training identified included vascular trauma, neurosurgery, and orthopaedics. Six (4%) respondents felt poorly or very poorly prepared, suggesting that simply rotating at a trauma center as a visiting military resident may not provide optimal training. Of these, five trained in military programs. Similar results have been reported by orthopaedic surgeons most of whom trained in the military (32).

In this light, it is important to note that the training experience in MTF-based programs does not offer the same volume and patient complexity compared to civilian residency (and fellowship) programs, with some limited exceptions (11). Following the approval of TRICARE in 1993, patients over 65 (i.e. those with more co-morbidities and complex medical conditions) were moved to the civilian sector for both primary and specialty care. Consequently, residency programs in many MTFs suffered significantly and have struggled to meet their minimum patient encounter requirements. Some have partnered with civilian residency programs to meet volume and case mix requirements although this solution alone does not necessarily provide adequate experiences to train military surgeons in the complex cases they face during deployment (33).

During residency, opportunities for military-civilian exchange aside from day-to-day training activities include attendance of national meetings and interaction with visiting professors. For military residents, these represent important opportunities to interact with civilian surgeons. For obligated civilian residents, in contrast, once again, interaction with military physicians generally does not occur in these venues, either. For example, in my experience in a

civilian training program, I only attended one national meeting (combined SAGES/AHPBA meeting) which did not feature any military speakers. Also, none of the visiting professors during my entire eight years of postgraduate training had any military experience. The only military-specific lecture I attended during my training was a lecture given at another Harvard hospital by Dr. William Cioffi on his experiences at Rhode Island Hospital following the Station Nightclub fire. In the absence of any military-specific training or educational requirements, even those who are on a pathway for deployment soon after graduation do not seek or are not afforded relevant military educational opportunities in the current military medical training pipeline.

Finally, US surgical residents are no longer able to deploy in support of combat operations, which clearly represents the best possible combat training experience. In times past, both active duty and drafted residents and interns deployed (7). Although these generally unplanned contingency experiences proved disruptive to military and civilian hospital staffing, the clinical experience was considered invaluable by many who served during their surgical training (7). The ACGME generally opposes resident deployments, and the services have established policies prohibiting such educational activities, even when planned out with detailed supervision and mentorship as well as clear educational objectives. The value of these deployed experiences for resident training have been recognized by numerous other countries, including the UK (34), which now routinely sends surgical residents on rotations into a combat zone, a practice which has been reviewed very favorably by the trainees (35).

Specialty training in trauma and surgical critical care bears special mention. Within the military, the full spectrum of surgical specialties are represented including transplant and pediatric surgery. Among these surgical specialists include a small number of surgeons who undertake specific training in Surgical Critical Care (1 year) with or without an additional year of training in trauma (1 year). There is one military Trauma + Surgical Critical Care fellowship at SAMMC (Army and/or Air Force). All other training in these specialties is conducted in civilian trauma centers. These specialists in Surgical Critical Care or Trauma + Surgical Critical Care often serve as the lead surgeon in a deployed hospital setting (i.e. the so-called Trauma Czar) or as the theater-wide trauma consultant. Of note, those surgeons who are typically identified as establishing the in-theater trauma systems in Iraq and Afghanistan all pursued specialty training in Trauma+Surgical Critical Care in civilian trauma centers where the benefits of a systems-based approach to trauma care was demonstrated among many other invaluable medical lessons.

Allied Professions—Educating Military Nurses and Medics

Military nurses enter active duty following graduation from nursing school. There is no military program for undergraduate nursing education; so all entry-level training for military nurses is conducted in the civilian sector (36). The ROTC scholarship can be used to pursue a nursing degree. In addition, military branches often offer loan repayment programs wherein undergraduate student loans can be paid off in exchange for service commitment time. ROTC students do receive some fundamental military training; however, in general, there is little to no exposure to military nursing mentors during the undergraduate nursing experience. USUHS does offer graduate nursing degrees to military nurses through the Daniel K. Inouye Graduate School of Nursing. These now include a Master of Science in Nursing, a Doctor of Nurse Practice, or a PhD in Nursing Science.

Medical personnel in the enlisted corps can serve as medics (Army), medical technicians (Air Force), hospital corpsmen (Navy), Independent Duty Medical Technicians (IDMT, Air Force), or Licensed Practical Nurses (LPN, Army). These individuals have graduated from high school or have the equivalent of a high school diploma and have completed basic military training. Basic medic training is completed over 16 weeks (37), and medics must subsequently maintain certification as an EMT-Basic and BLS provider. These individuals have no contact with civilian personnel throughout their training and do not commonly interact with civilian pre-hospital providers or civilian medical technicians in their career fields. In some fields, military medics are *not* required to maintain certification by a civilian specialty board in the course of their clinical practice (e.g. respiratory therapy).

Advanced training as a Special Forces Medic (18D designator in the Army) requires over a year of total training which includes both medical and trauma training as well as exposure to veterinary medicine and dentistry. These highly trained and skilled individuals have a broad scope of practice when on a deployed mission. Between deployed missions, they typically maintain their skills through training agreements with civilian trauma centers (e.g. University of Alabama).

Faculty Experiences—Non-Trauma Center MTFs

Graduates of PGY-1 only programs may go on to train in a medical specialty if they were pre-selected by the JSGMESSB, or they enter the active duty workforce as primary care general medical officers (GMOs), flight physicians (i.e. Flight Surgeons), submarine officers, or battalion surgeons. On active duty, these physicians are fully immersed in the military healthcare realm and have few if any interactions with civilian patients or civilian counterparts. Many of these individuals also deploy with their units, or in some cases, are assigned to a larger combat medical facility to staff the outpatient clinic or to work on the inpatient ward. Some of these PGY-1 only individuals go on to re-enter residency programs after several years of service or they separate and then find work or further specialty training in the civilian world.

Following residency or fellowship training, graduates are assigned either to an MTF which may or may not have a trauma program or to a civilian center with an embedded unit of military cadre who oversee pre-deployment training (see Table 2) (38). The former are discussed in detail in this section while the latter are discussed further in the next. There are also a few isolated examples of active duty staff being assigned to a civilian center outside of one of these embedded military units (e.g. Col Alan Murdock assigned to UPMC and Maj Joe Love assigned to UT Houston). Some graduates are also assigned to units in largely administrative roles as commanders or administrators.

As noted above, 13 of the MTFs have surgical residency programs. Additionally, there are a number of assignments in and out of the continental US (CONUS and O-CONUS, respectively) which are not affiliated with a residency program. Examples include Mountain Home, ID, and Aviano Air Base, Italy. In general, MTFs care for a young, healthy patient population. The most common medical encounters are for obstetrical care, and most of the surgical care is provided on an elective basis for patients with low-acuity and low-complexity problems (21). As described above, for patients over 65, most care is provided outside the military system which has significantly reduced the number of cases available to military surgeons except where the command has actively sought to re-capture these patients under specific “right of first refusal” provisions for specialty care. Thus, there is little similarity between the care provided in most MTFs outside the combat zone and those designed to support combat operations, a phenomenon that has been recognized for decades (see Figure 4) (21,39). Similarly, the surgical cases most active duty surgeons manage in regular practice have little

resemblance to those faced during deployment. Finally, and perhaps most tragically, following deployments, these surgeons are stovepiped within MTFs with few opportunities to exchange ideas and lessons learned with civilian trauma surgeons and no opportunity to put their lessons learned into practice. Thus, these invaluable experiences and lessons learned may lie fallow for months to years unless the surgeon participates in off-duty employment (ODE) in a civilian trauma center.

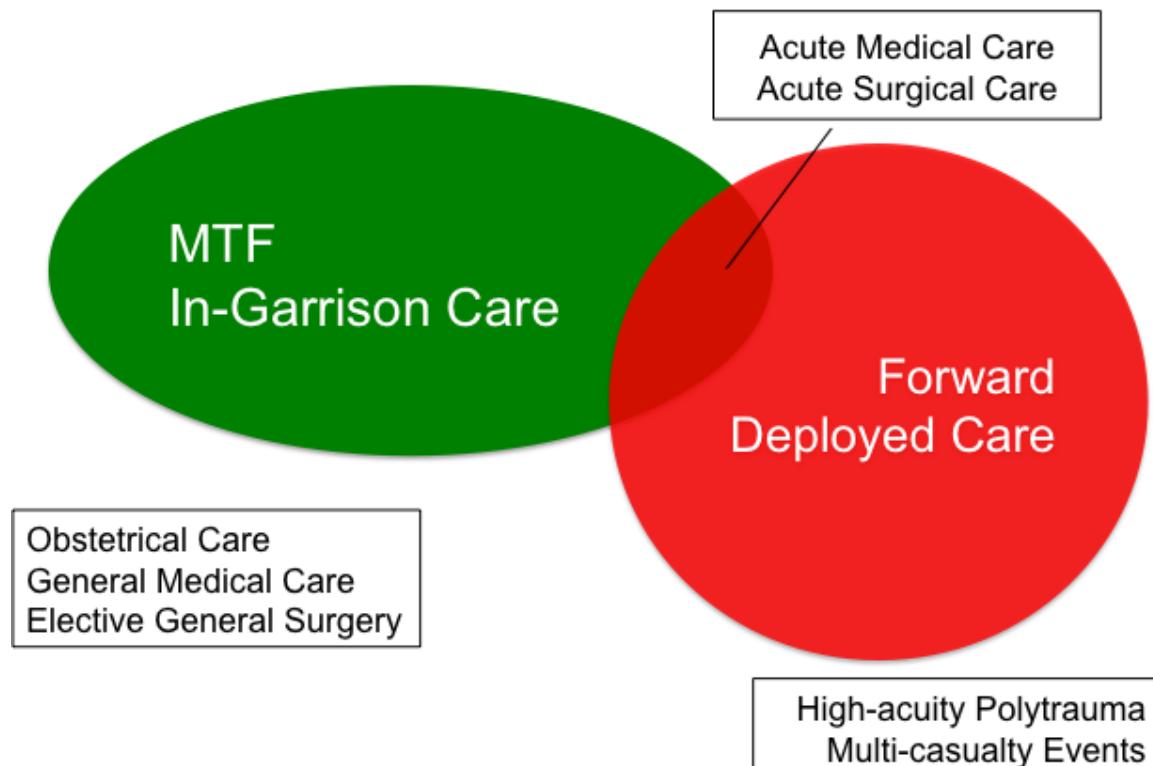


Figure 4 There is very little overlap in the types of patients managed in Medical Treatment Facilities (MTFs) outside of the combat zone and those managed during forward combat operations.

Military nurses in these centers also do not routinely care for trauma patients, yet they must achieve and then maintain these competencies (40). Recognition of this necessity has led to the establishment of defined readiness skills and a process for skill validation. In the Air Force, these skills are tiered (personal communication, Col Elizabeth Bridges, PhD, 1 Dec 2015). Basic skills are fundamental to all nurses and can be readily achieved and maintained by all nurses. The next tier are more advanced competencies but they can be achieved in routine clinical practice. The final set are readiness specific and focus on advanced trauma nursing skills. These are emphasized only when a nurse is on the verge of deployment. The challenge is grooming exceptional nurses who achieve and maintain all three skill tiers on a routine basis. Currently, the

military health system is not equipped to support this full scope of practice; so the emphasis has been on just-in-time training for individuals and teams to train or refresh the most advanced skills only intermittently through partnerships with civilian institutions (discussed below).

Additional challenges arise for nurses and medics who are expected to have a broad scope of practice during deployment (36,37). These personnel face regulatory hurdles in obtaining training commensurate with their anticipated scope of practice when downrange and then are forced to regress into a narrower scope of practice upon return to their home station. One example for medics involves the administration of pain medications (e.g. trans-oral fentanyl) or pain-control adjuncts (e.g. ketamine). These medications are routinely administered by medics in the pre-hospital environment to minimize pain and avoid post-traumatic stress disorder (PTSD). However, providing these medications in a military or civilian hospital in the US, even under physician guidance, is considered outside their scope of practice and is thus not permitted, even for training purposes.

Military Trauma Centers: SAMMC, WRNMC, and LRMC

A small number of MTFs do provide acute trauma care on a regular basis and thus, have more overlap between the care provided In-garrison and in a forward setting. Three MTFs are currently verified as trauma centers by the American College of Surgeons: San Antonio Military Medical Center (SAMMC, Level 1), Walter Reed National Medical Center (WRNMC, Level 2), and Landstuhl Regional Medical Center (LRMC, Level 2). However, only SAMMC is approved to care for acutely injured civilian patients under a special Secretary of the Army Designee Program. This program is critical for maintaining the volume and acuity needed to support a Level 1 center; however, for financial reasons, it is under near-constant threat of termination. The other trauma centers only care for injured military personnel and civilian beneficiaries within the Department of Defense.

The achievement of verification status as a trauma center and maintaining this status affords military physicians, nurses, and medics at all of these centers numerous opportunities to attain and sustain expertise in trauma care and to interface with civilian trauma leaders. Furthermore, the trauma infrastructure within the MTF is often maintained by civilians with significant experience in civilian trauma program administration. The military physicians in leadership positions in these centers also have a unique opportunity to participate in the civilian

trauma system and interact with local, regional, and national civilian trauma leaders. These physicians then have the knowledge and administrative skills necessary to provide trauma organizational leadership in combat zones. This held true in both Iraq and Afghanistan where leaders from the DoD's Trauma Centers recognized the need for establishing a trauma system in-theater and then formalized this trauma system resulting in more timely patient care and near real-time data collection for both performance improvement and research (41–43).

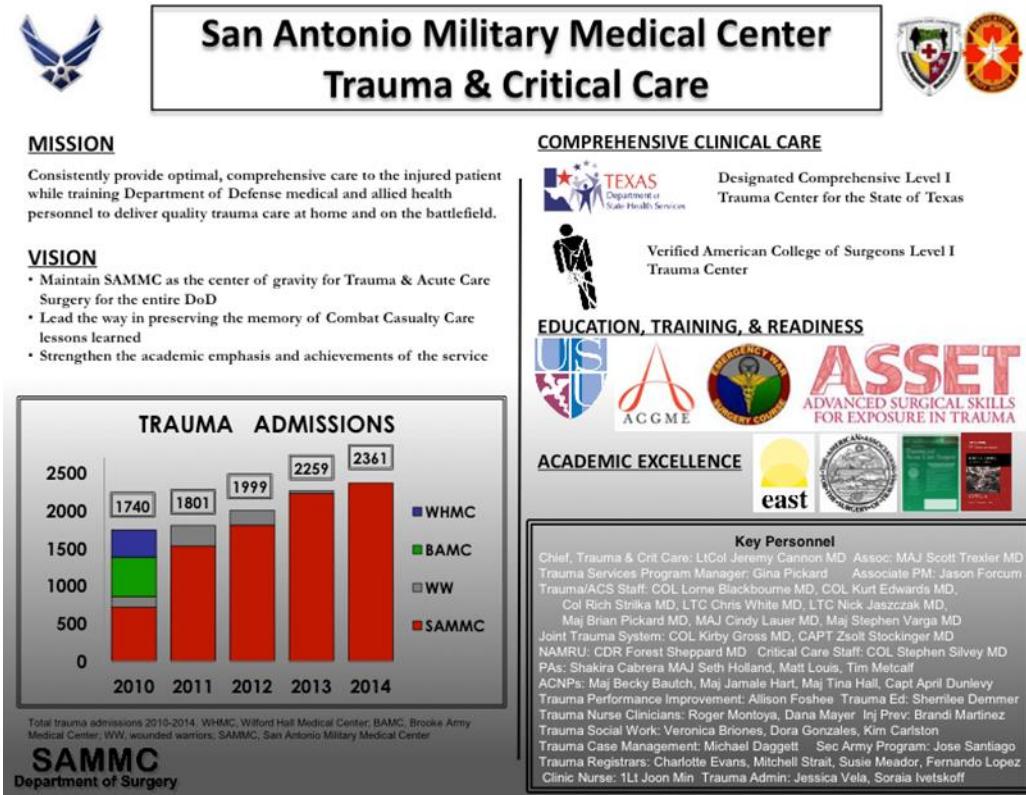


Figure 5 Details of clinical, research, and training activities performed at San Antonio Military Medical Center.

SAMMC currently evaluates nearly 3,500 acutely injured trauma and burn patients per year and admits over 2,300 trauma and 300 burn patients, thus representing a high-volume experience (see Figure 5). Residents in General Surgery, Orthopaedics, ENT, Oral and Maxillo-facial Surgery (OMFS), Ophthalmology, Neurosurgery, Urology, Anesthesia, Radiology, and Emergency Medicine as well as fellows in Surgical Critical Care, Trauma, and Burn all participate in the care of these patients. Similarly, faculty from all of these departments and divisions maintain a high-volume trauma practice in addition to their elective practices.

Importantly, these civilian patients often have injuries like those seen in combat, thus providing a high-fidelity training environment for military staff, fellows, and residents.

The Trauma Medical Directors of the SAMMC program and its predecessors (Wilford Hall Medical Center and Brooke Army Medical Center) represent a *Who's Who* in both military and civilian trauma: Lorne Blackbourne, Brian Eastridge, Steve Flaherty, Don Jenkins, and Tim Nunez. Interactions with civilian experts in trauma occur on a regular basis through the Southwest Texas Regional Advisory Council (STRAC) (24) and through the ACS which sends teams of 2 Trauma Surgeons, 1 Emergency Medicine physician, and 1 Trauma Nurse every 3 years to review the care provided. Furthermore, visiting professors graciously share their experiences and expertise approximately every 4 months now under the auspices of the Basil Pruitt Visiting Professor in Trauma and Burns. Recent examples include Chip Baker, Mitchell Cohen, William Cioffi, Peggy Knudson, Paula Shireman, and Bill Schwab. When visiting professors come to the University of Texas Health Sciences Center at San Antonio (UTHSCSA), SAMMC physicians (many of whom hold joint appointments at UTHSCSA) are always invited to attend. Recent speakers at UTHSCSA have included Kenji Inaba and Lenworth Jacobs. All of these professors have emphasized recent advances in civilian trauma with relevance to military trauma care, and many have also taken military lessons learned back to their home institutions following their visit to San Antonio.

The SAMMC trauma center has also been an important proving ground and test-bed for many of the advances in trauma care inspired by combat experience. In recent years, SAMMC has participated in the Prospective, Observational, Multicenter, Major Trauma Transfusion (PROMMTT) Study (44), re-introduced the concept of balloon aortic occlusion for trauma resuscitation (45,46), promoted the pre-hospital use of purposed tourniquets based on combat data (47), and has been a leader in promoting advanced extracorporeal care for trauma patients with severe acute respiratory distress syndrome (48–50). Through the Multidisciplinary Trauma Committee (MDTC, mandated by the ACS for trauma center verification), SAMMC maintains an active roster of regularly updated clinical practice guidelines (CPGs) based on the most current trauma literature—both military and civilian. SAMMC faculty regularly participate in monthly Grand Rounds sponsored by the American Association for the Surgery of Trauma (AAST), and in some cases actually give these distinguished lectures which are viewed

internationally (e.g. Cannon & Baer on Freeze Dried Plasma; Rasmussen on Resuscitative Balloon Aortic Occlusion).

SAMMC is also geographically co-located with the DoD's Joint Trauma System (JTS) (42) and the US Army Institute of Surgical Research (USAISR), which affords unique opportunities for synergy in both trauma care and research to physicians with assignments to any of these three entities. Thus, SAMMC represents a unique environment for high-volume trauma care within the DoD and an important location where both pre-clinical and clinical research in trauma can be conducted all while maintaining close ties to civilian trauma experts.

Unfortunately, although the physicians, nurses, and medics assigned to SAMMC and the other DoD trauma centers provide exceptional clinical care and trauma leadership when deployed, they cannot support the entire pre-deployment training mission alone. Furthermore, these centers do not have the capacity to train all DoD physicians, nurses, and medics who are about to deploy. Thus, in order to assure a sustained high level of trauma readiness in the military, the number of verified trauma centers within the DoD caring for acutely injured military *and* civilian patients needs to increase *or* the number of military personnel permanently assigned to high-volume trauma centers must increase, or both (25).

The USAISR Burn Center at SAMMC

The US Army Institute of Surgical Research (USAISR) is tasked with both a research mission and with supporting the DoD's only burn center (51). For many decades, this burn center has provided exceptional clinical care for burned military and civilian patients and has also provided long-range transport for severely burned and critically injured patients (52,53). Numerous important advances in burn care have come out of this burn center as have many of the current leaders in burn care across the country (54).

However, in 2004, the high operational tempo and frequent staff turnover threatened the historically high quality of care provided in this burn center. To mitigate these risks, a civilian burn surgeon—Dr. Steve Wolf—was assigned as the Burn Center Director to personally supervise and lead the clinical care provided. In this capacity, Dr. Wolf led many new efforts in clinical research and ensured a continued sense of pride in the care provided at this world-class center. As a result of his efforts in the context of excellent military directors before and after his tenure, recent reviews by the American Burn Association (ABA) site visitors have been glowing.

Thus, this is an important example of how a timely interchange between the military and civilian sectors can preserve and even elevate the quality of care provided to our military members and combat casualties.

Off-Duty Employment for Active Duty Physicians at MTFs

Physicians assigned to MTFs are permitted to participate in ODE in order to maintain critical wartime skills. Local commanders review requests for ODE and can approve (or disapprove) such requests if they are appropriately justified and the requested ODE does not interfere with the primary duty of the physician. Physicians assigned to trauma and non-trauma MTFs participate in ODE, often in Level II trauma centers and community hospitals but may in some cases work at Level I trauma centers. In this capacity, surgeons and other physicians in critical wartime specialties are exposed to trauma care and civilian colleagues. However, this exposure is not structured, systematic, or in any way programmed to fill experience or knowledge gaps. Furthermore, ODE is subject to local command approval which may not be granted for various reasons. It is also dependent on the physician to initiate the ODE opportunity—to find a position and seek the approval to participate. Some military physicians with little or no trauma experience may not be hired by civilian centers. Consequently, this ad-hoc approach does not represent a robust and fail-safe approach to assuring adequate physician trauma experience.

Physicians, Nurses and Medics in the Reserves and National Guard

Those physicians, nurses, and medics who deploy through the Reserves and National Guard are immersed in the civilian medical sector (see Figure 3). In many cases, physicians in these positions participate in high-volume, high-acuity clinical care in their civilian practices which readily translate into a high level of deployment readiness. Examples include LTC David King, MD, who is a full-time trauma surgeon at Massachusetts General Hospital and an Army Reservist and COL Martin Schreiber, MD who is the Chief of Trauma, Critical Care, and Acute Care Surgery at Oregon Health & Sciences University and the late MAJ John Pryor, MD who was on faculty at the University of Pennsylvania.

These personnel bring incredible expertise to their deployed team (33) which may include some members with trauma experience but generally consists of young and inexperienced

personnel (5). Then, following deployment, they bring this knowledge and expertise back to their civilian centers where they can readily apply the lessons learned that make sense for civilian care. Also, these individuals are well suited to leading research efforts to address identified knowledge gaps during deployment such as the management of non-compressible torso hemorrhage (55). Guard and Reserve surgeons and those involved in the SVS program (discussed later) have been invaluable in providing both clinical care and after-action reviews in recent civilian mass casualties including the Boston Marathon Bombing, the Sandy Hook School Shooting, and the Asiana Airlines crash in San Francisco.

National Guard and Reserve units also deploy nurses and medics who typically bring a high level of quality and significant expertise. In at least one case, a deployed National Guard unit raised the standard of care for deployed units. Standard Army MEDEVAC transport helicopters are staffed by a single medic who is trained as an EMT-Basic. In contrast, some deploying medics from the National Guard are certified Critical Care Flight Paramedics (CCFPs). In a study comparing outcomes in patients transported by MEDEVAC vs. a CCFP, 48-hour mortality was decreased from 8% to 15%, and transport by a CCFP was independently associated with a 66% estimated mortality (56). The authors appropriately recommend this disparity in outcomes be aggressively reviewed with a plan to implement higher training requirements for pre-hospital military medics, alternative staffing models, and expert medical direction for MEDEVAC transports going forward.

However, these expert providers often serve *in spite of* significant bureaucratic red tape and dysfunctionality in the National Guard and Reserve systems. For example, the author has spent nearly an entire year pursuing a position in the Air Force reserves and is only now being offered such a position despite being able to offer significant deployment trauma expertise to the Air Force Reserve Medical System. Others have resigned their commissions early or have participated at the minimal possible level as a result of these and other related issues. Also, pre-deployment training requirements are not standardized in the Guard and Reserve, and poorly qualified individuals who do not maintain an active and relevant clinical practice have been intermittently deployed to the combat theater (38). Nonetheless, the Guard and Reserve systems represent potentially important avenues for promoting meaningful, reliable, and sustained exchange between the military and civilian trauma sectors if the administrative shortcomings are addressed.

Pre-Deployment Training

Just-in-Time Training for Military Surgeons, Nurses, and Medics in Civilian Centers

After the scathing reviews of care provided during Desert Storm (17), the DoD developed a number of trauma training centers in high-volume civilian facilities (57–61). These centers are designed to provide so-called just-in-time training for individuals and even entire units immediately prior to deployment through a 2-4 week course. The current training centers include the Army Trauma Training Center (ATTC) in Miami, the Navy Trauma Training Center (NTTC) in Los Angeles, and three Air Force Center for Sustainment of Trauma and Readiness Skills (C-STARS) sites in Baltimore, Cincinnati, and St. Louis. The cadre for these sites are active duty (and in one case National Guard) military surgeons, anesthesiologists, emergency medicine physicians, nurse anesthetists, nurses, and technicians (see Table 3). The physician cadre are fully credentialed by the host hospital (with the exception of the ATTC) and are integrated into the academic medical staff. In contrast, the students come from a wide range of backgrounds—some with no prior trauma experience—and through the training course have variable contact with the civilian faculty. Alternatively, some training sites are staffed entirely by civilian cadre including Rush University Medical Center (Emergency Medicine) (62), the University of Washington (63), Scottsdale Healthcare, and University of Alabama (Air Force Special Operations Medics).

Table 3 Military cadre assigned to representative civilian training sites.

Training Site	Assigned Personnel	Notes
ATTC, Ryder Trauma Center, Miami, FL	Physician Director (General or Trauma Surgeon), CRNA, ED RN x2, ICU RN x2, OR RN, LPN, Research RN (ED or CC), EMT, Surgical Tech	2-year assignment with optional 3 rd year. Classes are 2 weeks long. Cadre typically take 1-2 clinical shifts during non-rotation weeks
C-STARS, R. Adams Cowley Shock Trauma Center at the University of Maryland, Baltimore, MD	Trauma Surgeon x3, Orthopaedic Trauma Surgeon, ED/CC, CRNA, ICU RN x3, OR RN, RT, Surgical Tech, ED Tech, ICU Tech, IDMT x2	Physicians, nurses, and some technicians function as hospital staff when not training students
NTTC, USC+LAC Medical Center, Los Angeles, CA	Physician Director (Trauma Surgeon), Orthopaedic surgeon, anesthesiologist, ED RN, ICU RN, Peri-Op RN, ED Corpsman, Surgical Tech Corpsman	Nurses and corpsmen have no clinical responsibilities

ATTC, Army Trauma Training Center; C-STARS, Center for Sustainment of Trauma and Readiness Skills; CRNA, Clinical Registered Nurse Anesthetist; ED, Emergency Department; ED/CC, Emergency Medical/Critical Care Physician; EMT, Emergency Medical Technician; ICU, Intensive Care Unit; IDMT, Independent Duty Medical Technician; NTTC, Navy Trauma Training Center; RN, Registered Nurse; USC+LAC, University of Southern California + Los Angeles County

These training sites and the courses they offer represent a tremendous advance in pre-deployment preparation. However, there are several limitations to this model for readiness and sustainment. First, a short course in trauma care, no matter how exceptional it may be, cannot possibly transform a novice into an expert physician, nurse, or technician in this complex field. Thus, the principal benefit of these sites appears to be for the permanent faculty who are fully integrated into the staff of the medical center (except in the ATTC where the physician director is credentialed as a trauma fellow) over a 2-3 year assignment (59). If these faculty were to be expanded and could deploy during their assignment, they would offer immense value to the forward care of critically injured patients.

Second, despite pre-deployment training being required for physicians, relatively few deploying physicians report undergoing this training, which is often waived for various reasons. One recent survey of military surgeons reported that only 32 of 137 (23%) attended a C-STARS, NTTC, or ATTC course (31). Furthermore, 58 of 137 (42%) respondents did not attend any pre-deployment training course prior to their first deployment. Many surgeons felt the training was valuable but many felt additional training was needed in many areas of combat-relevant patient care including extremity vascular repairs (46%), neurosurgery (30%), and orthopaedics (29%) among many others. Thus, although these sites represent important assets for pre-deployment training, modification to this training paradigm is needed to address these weaknesses.

Deployed nurses assigned to an ICU, likewise, are not all fully trained in military ICU care and may not have their critical care skills verified. One author noted that in 2006, 70% of ICU nurses “are validated with formal ICU preparation as well as with proficient skill and knowledge sets” (64). This suggests that a significant percentage may not be qualified and may require on the job training after arriving at their deployed location which degrades the quality of the entire team and detracts from the primary mission focus.

Lastly, military medics are not required to have any actual patient contact prior to deployment. Thus, paradoxically, those individuals with the *least* clinical experience and hands-on training are expected to function at a high level in the *most* stressful situations (i.e. tactical care under fire) as expert first responders.

ACS-Sponsored Training Courses with Readiness Applications

A number of trauma courses sponsored by the American College of Surgeons (ACS) are relevant to deploying physicians, nurses, and medics. However, the requirements for maintaining currency in these courses is highly variable across services and specialties. Advanced Trauma Life Support (ATLS) covers the basics of trauma care and is designed primarily for civilian safety net and community hospital providers. This course provides an excellent introduction to trauma care; however, some deploying providers may have never taken it or may have taken the course many years prior. Furthermore, the scenarios covered in ATLS incompletely addresses many injuries seen in a deployed environment.

To address these shortcomings, the Joint Trauma System and the Defense Medical Readiness Training Institute (DMRTI) recently developed some deployment-specific operational modules for the ATLS course, which have been approved by the ACS-COT. This course has been termed ATLS-Operational Emphasis (ATLS-OE) and is now being offered as the principal entry-level trauma course for military physicians. The next challenge is to ensure currency in this course is required for deploying medical and surgical specialists. Furthermore, the content of the course needs to be kept current with input from both military and civilian experts to ensure relevance to the environment into which military members will deploy.

The Advanced Trauma Care for Nurses (ATCN) is a partner course with ATLS designed for nurses. This course is now being taught to some deploying nurses although military-specific content likely needs to be added to ensure optimal relevance for deploying nurses. In contrast, the Prehospital Trauma Life Support Course (PHTLS) has been fully converted into a military version and is integral to the Tactical Combat Casualty Care (TCCC) training provided to pre-hospital combat medics.

More advanced courses sponsored by the ACS which have been offered to pre-deploying physicians include Advanced Trauma Operative Management (ATOM) and Advanced Surgical Skills for Exposure in Trauma (ASSET). ATOM is a live tissue (anesthetized pigs) course focused on repairing penetrating injuries. In this respect, ATOM is very relevant to deploying general and trauma surgeons. However, it requires a ratio of one instructor to one student to one animal, which makes it cost prohibitive for many military centers to offer to all deploying surgeons. Furthermore, some critical skills like vascular shunt insertion are missing from the standard curriculum.

ASSET is a vascular exposures cadaver course developed by a deployment-experienced surgeon assigned to USUHS (Col [ret] Mark Bowyer, MD). This course provides a comprehensive experience in operative vascular dissection and fascial compartment releases. These procedures represent some of the most infrequently performed but highest stakes procedures in all of trauma surgery. Thus, practicing these potentially life and limb saving techniques prior to deployment is invaluable, even for experienced trauma surgeons. One drawback to the course is the lack of vascular perfusion, which makes the dissections somewhat unrealistic (the vessels are often difficult to distinguish from nerves and do not bleed if you cut them, even in fresh cadavers). Also, cadaver costs vary widely from state to state. In some cases, cadaver costs have made hosting the course cost-prohibitive for some MTFs.

In summary, these courses represent civilian courses which have been adopted by the military or military-inspired courses which are now being used by both military and civilian centers. Although these courses by no means make experts in trauma out of novices, they are critical for adding incremental knowledge and providing an assessment of essential skills for our deploying physicians and nurses who will be caring for trauma patients. Future iterations of these courses should include military-specific modules to ensure optimal relevance for the military consumers of these knowledge products.

Emergency War Surgery Course and Text

The Emergency War Surgery Course (EWSC) is the most frequently attended pre-deployment training course (31) and is the officially endorsed didactic curriculum of the Combat Trauma Surgical Committee (CTSC). This 3-day course consists of a series of deployment-relevant lectures based on the Emergency War Surgery handbook (65) and the current JTS CPGs (66), a live tissue training lab, and the ASSET course. Combat-relevant hands on modules are also added to include lateral canthotomy, external fixation of fractures, intracranial pressure monitoring, and craniotomy. EWSC does not provide any hands-on experience with tourniquet application (left to self aid-buddy care training conducted at the unit level), massive resuscitation, or multi-casualty or mass casualty events. Nurses and physicians take the didactics together while there is a parallel hands-on portion for the nurses.

EWSC has been offered in some form for over a decade, and has been well received (31). However, it faces significant challenges including limited funding, difficulty standardizing the

curriculum across all sites, and extremely limited administrative support. Furthermore, this course is best suited for advanced students with significant pre-existing knowledge and experience in trauma care, as it cannot possibly transform novices into trauma experts in three days. Finally, in its current form, it does not cover pre-hospital tactical care which is increasingly recognized as a vital link in optimizing survival from combat injuries (38,67,37,68).

Interface with Civilians through the SVS Program and Academic Societies

Inspired by the civilian consultant system of World War II, the Senior Visiting Surgeon (SVS) program was established in 2005 sponsored by the ACS, the AAST, and the Society of Vascular Surgeons to permit formal input from experienced civilian trauma and vascular surgeons to the military medical leadership on issues of trauma systems, research infrastructure, and the management of severe combat injuries (22,23). Between 2005 and 2012, 192 civilian trauma and vascular surgeons participated in the SVS program at a cost of approximately \$380,000 (23). These surgeons traveled to the Level IV combat casualty care facility at LRMC for 2-4 weeks or further downrange to Level III facilities in either Iraq or Afghanistan.

In a survey of those who participated in this program, 118 (61%) responded. Only 28 had any prior military service. Grand Rounds lectures were given by 71 (60%) while all conducted daily didactics on ICU or ward rounds. 19 (16%) conducted IRB-approved research leading to 22 publications, and 59 (50%) maintained a mentorship relationship with one or more military surgeons for a year or more after their visit. Of the 40 plus CPGs, 9 were felt by these surgeons to have relevance to civilian practice including 1) complex wound management/use of the VAC dressing, 2) venous thromboembolism prevention protocols, 3) ventilation and oxygenation strategies (including use of extracorporeal membrane oxygenation), and 4) transfusion practices. These surgeons felt there would be significant value in maintaining the SVS program in some form during peacetime and offered a number of suggestions for continued involvement by SVS participants ranging from rotating through MTFs to hosting rotating military residents. Other specialties expressed interest in establishing similar programs including orthopaedics and neurosurgery, but no such formal military-civilian exchanges have materialized in these specialties outside of research collaborations (e.g. Major Extremity Trauma Research Consortium [METRC]).

A number of professional societies have provided superb support for military surgeons throughout the recent conflicts (see Table 4). These societies have afforded military surgeons an important platform for peer review of research based on combat lessons learned and have provided opportunities for military surgeons to gain valuable leadership experience in academic medical activities. Furthermore, society meetings have facilitated exchanges between military and civilian surgeons (28). One particularly effective military-civilian collaboration has been the Trauma Hemostasis and Oxygenation Research (THOR) Network in which all panels and committees have an equal number of military and civilian representatives (69). Another example in the research domain is the National Trauma Institute (NTI) which includes both military and civilian members on its Board of Directors (70).

Table 4 Professional medical societies which have actively supported military members and military-civilian exchange.

Specialty	Society	Means of Support
Medicine	Massachusetts Medical Society	Free membership and subscription to <i>New Engl J Med</i>
	AMSUS	Military medical society with broad representation from all medical specialties and the allied health services but with limited emphasis on readiness topics
Surgery	ACS	SVS, ACS-MSH Partnership
	SMCAF	Organization of former military surgeons and physicians, now defunct
Trauma	AAST	SVS, Military Committee, Pre-meeting Military Symposium, Dedicated military session, Discounted meeting registration
	EAST	Repository of relevant articles on web site, Military Committee, Discounted meeting registration
Vascular	Society of Vascular Surgeons	SVS
Orthopaedics	AAOS/OTA/SOMOS/ORS	Extremity War Injuries and Disaster Preparedness
Neurosurgery	Congress of Neurological Surgeons	Complementary membership and meeting registration; complementary meeting housing; complimentary educational modules
Critical Care	SCCM	Military Committee
Anesthesia	ASA	USSA/AVAA Combined Pre-meeting
Nursing	STN	Offers a Military Special Interest Group for members

AAOS, American Academy of Orthopaedic Surgeons; AAST, American Association for the Surgery of Trauma; ACS, American College of Surgeons; ASA, American Society of Anesthesiologists; AMSUS, The Society of Federal Health Professionals; AVAA, Association of Veterans Affairs Anesthesiologists; EAST, Eastern Association for the Surgery of Trauma; MHS, Military Health Service; ORS, Orthopaedic

Research Society; OTA, Orthopaedic Trauma Association; SCCM, Society of Critical Care Medicine; SMCAF, Society of Medical Consultants to the Armed Forces; SOMOS, Society of Military Orthopaedic Surgeons; STN, Society of Trauma Nursing; SVS, Senior Visiting Surgeon; USSA, Uniformed Services Society of Anesthesiologists

Conversely, civilian participation in military surgical societies has been somewhat more limited. Recently, however, civilian participation appears to have increased at the annual Military Health Service Research Symposium (MHSRS, formerly ATACCC). Furthermore, the American College of Surgeons has now formally partnered with the DoD Military Health System and will be formally hosting a Tri-Service Surgical Meeting at its annual Clinical Congress. Further measures to encourage military-civilian exchanges through these societies would be to ensure civilian representation in all military societies and military representation on the governing boards of civilian surgical societies such as the American College of Surgeons and American Surgical Association.

Unfortunately, military participation in the activities of academic societies has been threatened by a policy change in June 2012, which required formal approval of all conference attendance at the level of the Secretary or Assistant Secretary of Defense. The lead-up to this policy announcement and the aftermath of the actual policy have been devastating from an academic productivity standpoint. There are now significantly fewer military abstract submissions and, as a result, fewer military papers presented at academic meetings just when we should be analyzing the full range of data available from the last 13 years of war. Furthermore, this policy has made it difficult for military members to participate in society leadership and committee activities (28).

Civilians with Combat Casualty Care Experience

Surgeons, physicians, support personnel, administrators, nurses, and medics in the military eventually retire or separate after which they generally move on to a civilian job. Retention in the military is a near-constant challenge for many of these specialties. For example, many surgeons separate after a 4-year commitment during which time they may deploy once or, at most, twice. Similarly, many military medics separate early if they are not allowed to practice in their field because they are pulled to serve in non-medical capacities (e.g. work in the “motor pool” as a mechanic). Thus, the pool of deployment-experienced individuals in a military unit is very small.

Presently, there are numerous surgeons, nurses, and medics with extensive combat casualty care experience now in the civilian medical workforce. However, no formal mechanism currently exists to leverage the experience of these individuals for the benefit of active duty, reserve, or National Guard personnel who have no deployment experience. Informal interactions occur haphazardly when, for example, military experienced surgeons volunteered to participate in the SVS program. Engaging these experienced combat casualty care providers more formally in the training of inexperienced personnel currently on active service or providing consultation to deployed units faced with complex clinical challenges clearly represents an opportunity for matching a ready capability with a current need.

Archives of Lessons Learned and Best Practice

The medical literature and military texts serve as an invaluable repository for medical lessons learned during combat and chronicle the best practice over time. These written records also permit contemporary and future civilian and military surgeons to access the current practices and recent findings of those military investigators who are publishing their work. As noted above, in prior wars, these archival sources were difficult to access and were, thus, of little use to deploying surgeons (9). However, electronic versions of these articles and texts are now readily available including references from as early as World War I and manuscripts which reference advances as far back as the Civil War (71,72) or even ancient warfare (1). In addition, several journals including the Journal of Trauma and Acute Care Surgery and Shock have dedicated entire supplemental issues to combat casualty care research resulting in the publication of many high-impact military-specific manuscripts. Thus, the challenge is not accessing the evidence but rather filtering through the documented “advances” to determine which ones apply in current practice (47,73).

The most reliable approach to maintaining consistency and assuring best practice in a complex specialty with frequent staff turnover is the use of CPGs (74,75). The current guidelines in use by the DoD are developed, maintained, and distributed by the JTS through their web site (66). Education on the content of these guidelines occurs in the military trauma centers on a regular basis, during pre-deployment training, and once teams reach their deployed location. However, ensuring all deployed personnel are both aware of the presence of the guidelines and aware of the content of the guidelines is a constant struggle. Because the CPGs do not cover all

topics relevant to deployed teams (e.g. Pediatric Care), they are often supplemented by ad hoc instructions and suggestions passed from an outgoing unit to their replacements (e.g. the BADASS Rules Of Engagement).

Although the presence of these CPGs represent a great advance in combat casualty care (26), there are some weaknesses in the current approach to guideline creation and maintenance. First, the process for selecting new CPGs and the decision to retire old CPGs is opaque. Second, the analytic methods for evaluating the quality of evidence in these CPGs are not uniform nor do they adhere to systematic review standards. Finally, aside from the informal assessments provided by the SVS and the input from select individuals, there is no direct and systematic civilian input into any of the CPGs currently in use. Thus, the current CPGs resemble those developed in an individual trauma center rather than a set of robust, systematic guidelines espoused by a large organization.

Strengths, Weaknesses, and Recommendations for Improved Military-Civilian Exchange

The exchange of knowledge and practices between the military and civilian sectors was seamless through World War II—civilian surgeons were activated for combat deployment and then returned to civilian practice with their lessons learned. Significant changes in military medical staffing over subsequent decades have led to an all-volunteer medical force with little trauma experience practicing largely in nontrauma hospitals. Because most deploying surgeons, allied medical specialists (e.g., in anesthesia, radiology, and emergency medicine), allied support specialists (e.g., blood bank, pharmacy, and administration personnel), nurses, and medics are not experts in trauma care and do not regularly practice in that field, brief predeployment training courses have minimal impact on their expertise. Postdeployment, they then return to the military sector, relatively isolated from the civilian trauma community. Furthermore, the episodic nature of military trauma care, with periods of intense action separated by many years, results in a “peacetime effect” in which the process of combat casualty care must be recreated almost from scratch every time combat operations escalate.

Because the civilian and military health systems are now largely segregated, scientific meetings and medical journals have become important venues for the exchange of knowledge and practices. However, it may be argued that although these exchanges are important and necessary, they are not sufficient. Attendance of civilian experts at military conferences is quite

limited, and military members' attendance at civilian conferences is routinely threatened by various contingencies. Furthermore, dissemination of knowledge through the medical literature is notoriously slow, taking on average up to 17 years (76).

More optimal exchange of knowledge and practices occurs in select military treatment facility (MTF) trauma centers and integrated military-civilian training sites where regular interaction with civilian counterparts takes place. Over the past decade, first-hand interactions between military surgeons and civilian trauma and vascular experts through the Senior Visiting Surgeon (SVS) Program also demonstrated significant value for both the military and civilian communities, although the future of this program or its replacement remains unclear.

At present, the challenges to maintaining consistent practice in combat casualty care, gaining knowledge on the quality of care, and exchanging that knowledge with the civilian sector and vice versa are myriad. The vast complexity of the Military Health System (25) , along with frequent turnover at all levels, creates an inherently unstable system. This reality makes consistency in routine matters difficult, much less the preservation of lessons learned across decades of practice and multiple generations of military physicians. Furthermore, an artificial division exists in who is responsible for the care of patients prehospital and once they reach medical care. The military "line" (i.e., nonmedical forces) rather than the medical corps controls all aspects of the prehospital environment. The result has been significant barriers to collecting prehospital data and understanding the causes of prehospital deaths (i.e., killed in action). Finally, significant legal and policy limitations hinder the involvement of combat-experienced civilian physicians as trainers, educators, and advisors to the military (e.g., the Committee on Tactical Combat Casualty Care). All of these factors result in a highly volatile, internally fragmented system that is stovepiped from external influences and input. It is no wonder that the same mistakes are repeated and the case fatality rate rises significantly at the beginning of each war.

The infrastructure of the Joint Trauma System (JTS) (42,77) and the pledge of partnership and collaboration between the American College of Surgeons and the Military Health System (78) represent ideal starting points for addressing the weaknesses identified above. These changes will doubtless benefit both combat casualties and injured civilians. The following table details a number of recommended courses of action for addressing the weaknesses of the current system. The underlying premise behind these recommendations is that military-civilian

exchange needs to begin at the earliest stages of medical education. Then in residency and during active practice, although civilian trauma care may be an imperfect training platform for military deployment (79), immersion in this environment is far superior to no or very limited trauma care training and experience (80–82). This same conclusion was reached years ago by many U.S. allies, which routinely house deployment-eligible military medical units entirely in the reserves or on active duty embedded within high-volume civilian trauma centers (38,83). The first step in this direction is to delineate the critical wartime specialties and the numbers needed in each specialty, and then to ensure that combat-designated military physicians, nurses, and medics are immersed in full-time trauma care either in an MTF trauma center or a high-volume, high-acuity civilian center (25). Ideally, these personnel would work together as a unit and would also deploy as a unit for optimal effectiveness (59,84). These units would then contribute lessons learned to the learning health system, which could be modeled after the Center for Army Lessons Learned (85,86). Review of these lessons learned and implementation of actionable change could then be effected through the JTS or a newly established military think tank under the auspices of Uniformed Services University of the Health Sciences or the Defense Health Agency (25,87).

Conclusion

As this manuscript has shown, maintaining a ready force of military surgeons, physicians, support personnel, nurses, and medics with expertise in combat casualty care represents a very complex challenge. However, as a nation, we owe our professional combat force the best possible trauma care. A learning health system which identifies and captures best practice so that hard-earned lessons learned are not lost as units rotate out and the operational tempo wanes represents a key step in this direction. Within this learning health system, combat casualty care will greatly benefit from formal and sustained interaction with civilian trauma experts even as the civilian sector benefits from the military experience. To achieve this aim, refinements to the military medical system must be undertaken starting with the earliest stages of military medical training and continuing through completion of active duty service. By making these changes, the military health system will move closer towards fulfilling its *raison d'être* of providing care for the combat wounded.

Focus Area	Strengths	Weaknesses	Recommendations
Undergraduate medical education—Uniformed Services University of the Health Sciences (USUHS)	<ul style="list-style-type: none"> Early exposure to military medical history 	<ul style="list-style-type: none"> Limited exposure to civilian experts, which continues into residency (most USUHS graduates are obligated to undergo military residency) 	<ul style="list-style-type: none"> Require a minimum of one civilian rotation for USUHS students in an approved specialty at approved locations
Undergraduate medical education—Health Professions Scholarship Program (HPSP)	<ul style="list-style-type: none"> Potential for exposure to national and international experts in multiple fields 	<ul style="list-style-type: none"> Students may attend any medical school regardless of the quality Little to no exposure to military medical history Required military rotations are not required to have readiness relevance 	<ul style="list-style-type: none"> Utilize the same standards as for the Yellow Ribbon undergraduate program (medical schools should actively compete for military scholarship students)¹ HPSP students should learn military medical history (e.g., USUHS course) and should perform at least one deployment-relevant clinical rotation
Undergraduate nursing education	<ul style="list-style-type: none"> Exposure to civilian thought leaders and potential mentors 	<ul style="list-style-type: none"> No military medical curriculum 	<ul style="list-style-type: none"> Develop a basic military nursing curriculum for the Reserve Officers' Training Corps (ROTC) and those seeking loan repayment
Military medic education and training	<ul style="list-style-type: none"> Heavy emphasis on prehospital trauma stabilization 	<ul style="list-style-type: none"> Disconnect between scope of practice during deployment and in garrison Little exposure to civilians in comparable positions No requirement for patient contact prior to deployment 	<ul style="list-style-type: none"> Seek special training exemptions that allow medics to prepare in skills that are within their deployment scope of practice Establish more civilian training sites for military medics Require that medics perform and maintain hands-on patient skills
Residency/fellowship—	<ul style="list-style-type: none"> Exposure to staff with 	<ul style="list-style-type: none"> No opportunity to deploy even 	<ul style="list-style-type: none"> Residents in combat-designated

¹ Information on the Yellow Ribbon Program is available from: http://www.benefits.va.gov/gibill/yellow_ribbon/yellow_ribbon_info_schools.asp (accessed May 23, 2016).

Focus Area	Strengths	Weaknesses	Recommendations
military	<ul style="list-style-type: none"> deployment experience Education in readiness-relevant topics and Joint Trauma System (JTS) Clinical Practice Guidelines (CPGs) 	<ul style="list-style-type: none"> for an elective rotation (some residents have completed Landstuhl Regional Medical Center [LRMC] rotations) Low-volume/low-acuity training with some exceptions (e.g., San Antonio Military Medical Center [SAMMC] in Trauma+Surgical Critical Care) Military regulations now limit meeting attendance 	<ul style="list-style-type: none"> specialties should perform at least one rotation as a senior resident (scheduled during an elective block) in a forward location (Level III or IV facility) or military trauma center Critically evaluate the case mix and volume in nontrauma military treatment facility (MTF) residency programs Repeal the current restrictive policy to encourage military-civilian exchange at the resident-fellow level
Residency/fellowship—civilian (sponsored or deferred)	<ul style="list-style-type: none"> Potential for exposure to national and international experts Trauma+Surgical Critical Care: exposure to critical clinical and systems-based practice concepts 	<ul style="list-style-type: none"> Little to no exposure to military physicians or military-specific topics 	<ul style="list-style-type: none"> Residents in combat-designated specialties should perform at least one rotation as a senior resident (scheduled during an elective block) in a trauma MTF and another rotation in a forward location (Level III or IV facility)
Military physicians in practice—nontrauma MTF		<ul style="list-style-type: none"> Stovepiped from civilian physicians if at an MTF (except though off-duty employment [ODE]) Little overlap between regular and deployed practice Low-volume/low-acuity practice with little exposure to trauma Lessons learned in combat are not disseminated to civilians Military regulations now limit meeting attendance Nursing readiness/trauma skills 	<ul style="list-style-type: none"> Combat-designated physicians, nurses, and medics should be assigned to trauma MTFs or to selected high-volume, high-acuity civilian trauma centers Utilize the Center for Army Lessons Learned (CALL) (or comparable system) to capture and disseminate lessons learned to other military members and to the civilian sector Repeal the current restrictive policy to encourage military-civilian exchange at the staff level

Focus Area	Strengths	Weaknesses	Recommendations
Military physicians in practice—trauma MTF	<ul style="list-style-type: none"> Diverse exposure to high-acuity military and civilian trauma patients (SAMMC) Collocated with JTS and U.S. Army Institute of Surgical Research (USAISR) (SAMMC) Collocated with Uniformed Services University of the Health Sciences (USUHS) and Walter Reed Army Institute of Research (WRAIR) (Walter Reed National Medical Center [WRNMC]) Interaction with members of the American College of Surgeons (ACS) Committee on Trauma (COT) Diverse research opportunities Frequent civilian visiting professors Emergency War Surgery Course (EWSC) and ACS-endorsed courses taught frequently 	<ul style="list-style-type: none"> Some do not permit care of civilian patients (WRNMC, LRMC) Military regulations now limit meeting attendance No incentive for combat essential specialists to remain current in trauma 	<ul style="list-style-type: none"> Expand the Secretary of Army/Navy/Air Force programs to permit care of civilian trauma patients Consider designating additional Army, Navy, and Air Force MTFs as trauma centers Repeal the current restrictive policy to encourage military-civilian exchange at the staff level Consider a “combat designated” pay incentive
Military physicians in practice—civilian training center cadre	<ul style="list-style-type: none"> Immersion in high-volume, high-acuity trauma practice with civilian experts Robust experience for multiple specialties, nurses, and medics 	<ul style="list-style-type: none"> Cadre typically does not deploy One site does not fully credential cadre (Army Trauma Training Center [ATTC]) No external validation of training consistency and quality 	<ul style="list-style-type: none"> Provide additional staffing to permit cadre to deploy All sites should fully credential qualified staff surgeons Institute reporting requirements and JTS verification reviews of training sites

Focus Area	Strengths	Weaknesses	Recommendations
National Guard/Reserves	<ul style="list-style-type: none"> • Immersed in civilian practice, which generally affords a robust and diverse clinical experience • Immediate translation of lessons learned back to the civilian sector • Deployment experience valuable for civilian disaster response 	<ul style="list-style-type: none"> • Clinical practice experience can be variable and may not be combat-relevant 	<ul style="list-style-type: none"> • Consider a “combat-designated” pay incentive • JTS should validate the practice of the Guard and Reserve combat-designated specialists • Consider a “combat designated” pay incentive
Predeployment training—civilian training sites	<ul style="list-style-type: none"> • High-quality educational offerings at all five sites • Deployment-experienced cadre 	<ul style="list-style-type: none"> • Students are expected to be experts in trauma care at the end of 2-4 weeks • Very few deploying teams and physicians pass through any of these sites despite in-place requirements 	<ul style="list-style-type: none"> • Rotators should come through for refresher training with significant prior experience and expertise in trauma • In the reorganization, only combat-designated teams should pass through for a final “check ride”
ACS-sponsored courses	<ul style="list-style-type: none"> • Many with readiness relevance • Military members have contributed modules 	<ul style="list-style-type: none"> • Some are prohibitively expensive • Combat-relevant modules needed in some courses 	<ul style="list-style-type: none"> • Liberalize staff:student ratio for experienced students (i.e., attending surgeons)—Advanced Trauma Operative Management (ATOM) • Encourage military members to develop modules
Pre-deployment training—EWSC	<ul style="list-style-type: none"> • Most frequently taken predeployment course • Compact, high-yield course • Includes ACS-endorsed course material 	<ul style="list-style-type: none"> • Challenging to maintain standardized material with multiple sites offering and little administrative support • Students are expected to be 	<ul style="list-style-type: none"> • Require that EWSC be kept current and that all sites use this version; provide additional administrative support • Students should come through for

Focus Area	Strengths	Weaknesses	Recommendations
Senior Visiting Surgeon Program	<ul style="list-style-type: none"> Operational modules add relevance Nurse education track in parallel 192 trauma and vascular surgeons spent 2-4 weeks providing expert consultation and clinical coverage at LRMC or downrange Many gave expert grand rounds lectures Research mentorship for military surgeons 	<ul style="list-style-type: none"> experts in trauma care at the end of 3 days Little to no civilian input aside from ACS-endorsed content Only selected trauma surgeons able to participate No clear plan or directive for continuing this program 	<ul style="list-style-type: none"> refresher training with significant prior experience and expertise in trauma Seek civilian consultants to contribute to EWSC content Make participation in this program a competitive application reviewed by the JTS, ACS, American Association for the Surgery of Trauma (AAST), and Society of Vascular Surgery Continue the program in some form negotiated among all stakeholders
Professional societies and conferences—civilian	<ul style="list-style-type: none"> Many have provided robust military support Some have military committees New ACS-Military Health System (MHS) partnership promising for sustained military-civilian exchange 	<ul style="list-style-type: none"> Attendance has been curtailed by military regulations Few have dedicated military sessions 	<ul style="list-style-type: none"> Repeal the current restrictive policy to encourage military-civilian exchange at the staff level Advocate for dedicated military sessions Include military members in society leadership and governance Improve conference quality to attract civilian attendees Include civilians in society leadership and governance Be more selective in abstract acceptance Add a readiness element to AMSUS
Professional societies and conferences—military	<ul style="list-style-type: none"> Important forum for dissemination of military research results to other military centers 	<ul style="list-style-type: none"> Few civilian attendees Research quality is variable The Association of Military Surgeons of the United States (AMSUS) has little relevance to deployment medicine 	
Professional journals	<ul style="list-style-type: none"> Military supplements in <i>Journal of Trauma and Acute Care Surgery</i> and <i>Shock</i> These are high-impact articles 	<ul style="list-style-type: none"> No military editors in top journals Historically difficult to access or ignored 	<ul style="list-style-type: none"> Encourage military associate editorial positions Look to CPGs for clarification

Focus Area	Strengths	Weaknesses	Recommendations
Research funding and protocols	<ul style="list-style-type: none"> • New technology makes these references readily available • Military funds significant numbers of trauma-specific research protocols (gap-driven) • USAISR and WRAIR have both military and civilian research personnel 	<ul style="list-style-type: none"> • Difficult to determine which recommendations represent standard practice • Intramural protocols typically have mostly or only military investigators • Extramural protocols typically have mostly or only civilian investigators • Imbalance between burden of disease and available funds in both the National Institutes of Health (NIH) and U.S. Department of Defense (DoD) research budgets 	<ul style="list-style-type: none"> • Require military and civilian investigators on all DoD-funded grants • Promote increased federal and private funding for injury-related research
JTS CPGs	<ul style="list-style-type: none"> • Repository of most current best practice in military trauma care • Housed and updated by JTS 	<ul style="list-style-type: none"> • Some relevant topics not covered • CPG development does not adhere to systematic review standards • Little to no external validation or civilian review/input 	<ul style="list-style-type: none"> • Conduct regular CPG reviews using the Delphi method involving both military and civilian experts • Consider adding systematic review experts to the JTS staff • Require that each CPG have at least one civilian reviewer
Recently separated or retired military physicians, nurses, and medics	<ul style="list-style-type: none"> • Wealth of knowledge and experience • Many go on to serve as civilians in MTFs or Department of Veterans Affairs Medical Centers (VAMCs) 	<ul style="list-style-type: none"> • No mechanism for formally interfacing with military personnel who are facing deployment 	<ul style="list-style-type: none"> • Establish a formal mechanism for physicians, nurses, and medics who have valuable wartime skills and experience to interface with the next generation of deploying medical professionals • Create means for deployed team members to seek advice or consultation from combat-experienced individuals who are no longer in the military

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