2014 MHSRS Review

Advancing Military Medicine

Table of Contents

Executive Summary

The plan stays the same—always stays the same, always has stayed the same—no matter the day or the month or the year in question. Yet it's the very execution of that plan that remains the most elusive of all variables, the most difficult construct to define across the passage of time.

Stay ahead of the curve.

Stay ahead of the curve.

It's strikingly simple, that plan, but at the same time also impossible to fully implement, as—by their very nature, of course—curves are always moving, always twisting, always deviating from the norm… whatever the norm may be at the time.

Stay ahead of the curve.

Equal parts calculated intention and simple, wide-eyed desire, that plan, in all its varying iterations, nevertheless remains the same. And yet despite the unique frustrations that seemingly only arise out of the quest for new accomplishments in the field of military medicine, nowhere else does *the plan* come together more seamlessly than at the annual Military Health System Research Symposium (MHSRS). The 2014 chapter of this signature event, held from 18-21 August 2014 in Fort Lauderdale, FL, brought together the finest minds in the military medical research field for a four-day event that highlighted just how far we've come in protecting, encouraging, and caring for the military warfighter.

The numbers alone are an accomplishment, as the 2014 MHSRS brought together more than 1,500 attendees from 16 countries, with more than 600 of those attendees acting as representatives of the U.S. federal government or, specifically, the U.S. military. Another 500-plus attendees hailed from the private sector, while 300 more arrived straight from the grounds of some of this country's most decorated academic institutions: New York University, Johns Hopkins University, The University of Minnesota. The list goes on. The bulk of the story, however, remains wrapped within the science itself, a compendium of leading-edge topics, therapies, and best practices combined with an extensive array of primary sources from both the public and private sectors: speakers, specialized breakout sessions, and more. From breakthrough studies on traumatic brain injury and neurotransplantation efforts to more field-based, utilitarian approaches to burn care and musculoskeletal overuse injuries, the 2014 MHSRS provided an academic-based venue to discuss and disseminate emerging scientific knowledge resulting from military-unique research and development. In addition, it provided a scholarly forum for the planning and development of future studies aimed at optimizing care for members of the uniformed services operating in a number of different and varying settings.

In regard to its stated educational objectives, the 2014 MHSRS allowed participants the opportunity to translate current and emerging scientific evidence into clinical practice and individualized care decisions for service members in specifically operational settings. In addition, participants were also

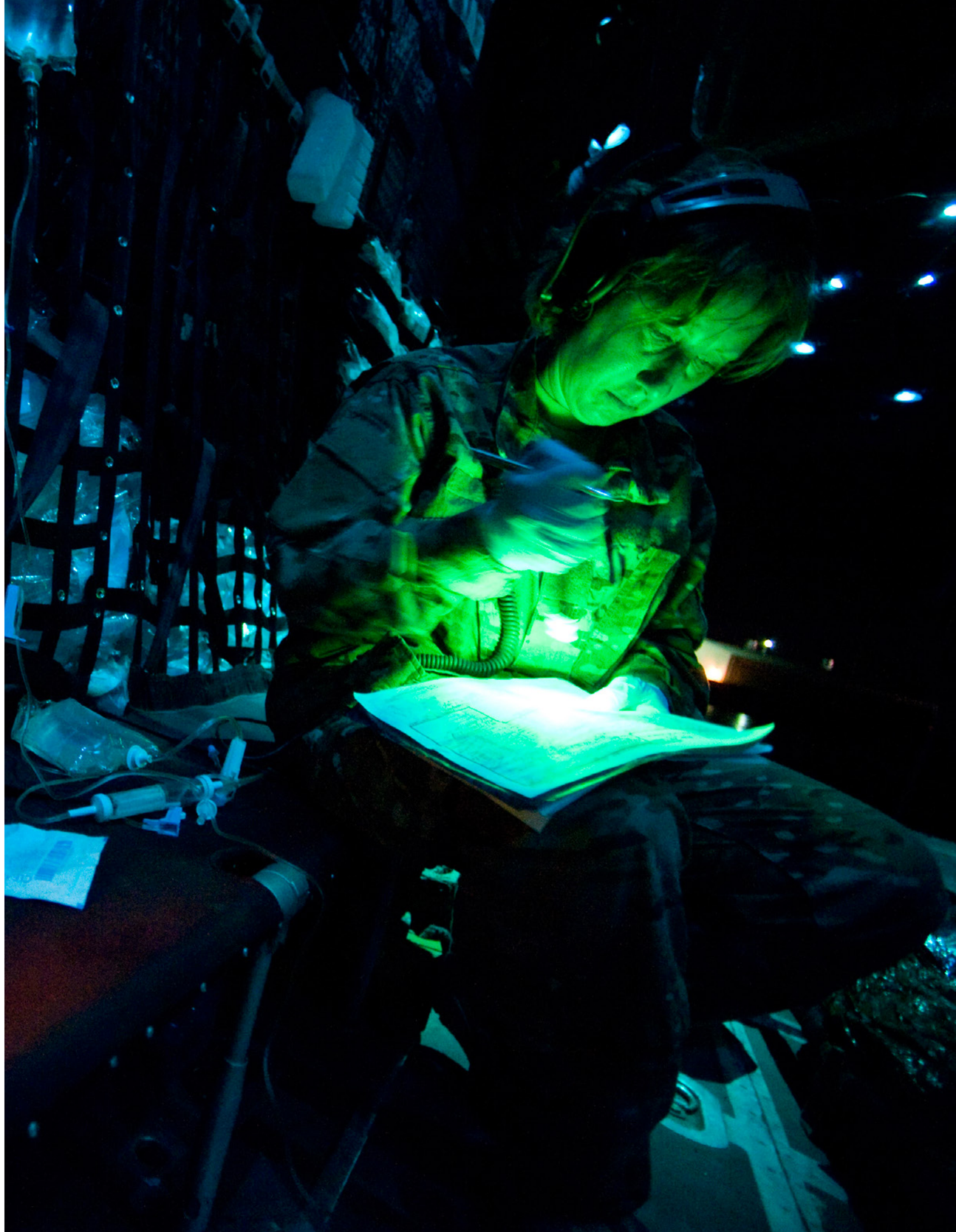
offered the opportunity to actively participate in discussions with experts, interdisciplinary team members, and colleagues regarding challenges in daily clinical practice so that new insights might later be applied to patient care. Further, key topics such as infection control, traumatic wound care, and rehabilitation care and prosthetics use were specifically spotlighted, a structural choice that allowed attendees to learn emerging best practices in the diagnosis and treatment of each.

Stay ahead of the curve.

Perhaps that might not be as difficult as we first thought.

In his remarks to this year's MHSRS attendees on 18 August 2014, U.S. Assistant Secretary of Defense (Health Affairs) Jonathan Woodson, M.D., talked at length about the notable "records" involved with the 2014 MHSRS: a record number of attendees, a record number of abstract submissions, and—sadly yet most importantly—a record number of dangers for the contemporary military warfighter. This last "record" should not be forgotten or discounted, as it is, and always will be, the reason this annual symposium is so highly attended and so desperately *needed* by the men and women of the uniformed services. In the end—and perhaps Secretary Woodson would agree with this statement, given all the information presented this year—maybe staying ahead of that mythic, constantly changing curve is a little easier when you're so well equipped to handle its unique difficulties.

So while the plan always stays the same, the process by which the plan is *executed* must constantly be subject to revision, always supplying enough skill to eliminate stated obstacles while also moving nimbly enough to focus on the most immediate threats. That, in so many words, is true forward thinking. Welcome to the 2014 Military Health System Research Symposium review.



Medical Senior Leaders and Strategic Overview

The term "military medicine" is a phrase that demands. No dormancy, no lethargy. The term "military medicine" demands of both its user and receiver via the simple act of being spoken or heard, let alone the work it takes to physically execute those words when required. It's a phrase that inherently assumes tireless effort from its front-end researchers while also oftentimes requiring immense sacrifice from its back-end users. Two bodies in motion, each one circling around the other, always. The distance between these two groups must represent the curve, then—the wavelength, the continuum—that all professionals associated with military medical research are trying to ride and, ultimately, conquer.

And yet, as we know, the term "military medicine" is also constantly evolving, forever shifting between time and date and location, half its body planted in the present, the other half standing solidly in the future, leaning forward past the horizon line. More than any other single action by the body of military medicine as a whole, it is perhaps this act of constantly straddling two different worlds that reveals the full scope of the work performed by all associated professionals: the efforts, the struggles, and the victories.

Don't mistake motion for progress, the saying goes. Change is the only true constant.

Perhaps no one person best embodies that statement than Vice Adm. Matthew L. Nathan, Surgeon General of the Navy, who, along with a slew of other luminaries, helped kick off the 2014 MHSRS on 18 August 2014 with a presentation entitled *Skating to Where the Puck Will Be*, a brief yet rousing call to arms with an underlying message that ultimately proved to be just as direct as its hockey-inspired title. Quite succinctly, Nathan implored symposium participants to stay attuned to not only what is happening in the world of trauma care right now, but also to what may happen in the future (e.g., noting emerging trends, concepts, and need-based solutions).

"I'm in the readiness business,"[1] Nathan likes to say when he's asked about his line of work, a concept which he expanded outward during his presentation to include the entire Military Health System (MHS) as a whole. "My job is to be ready for anything at any time… to put the fire out while it's small, before it gets big."[1] Boiled down, this lynchpin aspect of Nathan's speech plays out in more utilitarian terms thusly: success in military medicine—much like success in athletics—is not obtained by standing around and waiting for an event to occur; rather, it is achieved by anticipating developments within the flow of the game, and then, at the right time, intersecting the point of action with maximum effort.

And yet the question remains: how, exactly, does one anticipate the unknown? How can you predict, with any degree of certainty, the next swell along the wavelength?

The answer begins, in part, by instituting a more adaptive approach to trauma care—or, as U.S. Air Force Col. Todd Rasmussen likes to call it, a "continuously learning health system."[2] Rasmussen's presentation, also headlining the first day of the symposium, focused on the desired application of "focused empiricism" across the entirety of the Defense Health Agency (DHA). The term has its roots in the engineering world, where it implores users to observe—simply and basically observe—which particular methods are successful and which are not. Transplanted to the medical field, the term suggests that best practices should be based not upon high-level, randomized clinical trials, but rather on basic observational studies.[3] Distilled further, this concept stresses the (simple) importance of identifying which practices work best, while also encouraging the refinement of those practices as they are simultaneously integrated into a culture of continuous process improvement.

A more prudent examination of this concept can be seen—again, per Rasmussen's aforementioned presentation, entitled *Clinical Questions to Clinical Guidance: The Military's Continuously Learning System in Trauma*—in the burden of injury specifics culled from the wars in Iraq and Afghanistan.

The numbers in Figure 1, while startling in both scope and perspective, grant an extremely unique opportunity to the MHS. In examining such once-in-a-generation data, the military has been offered the opportunity to not only search for improvements in the management of severely injured personnel, but also to inventory and assess the current trauma system as a whole for various "lessons learned." It would then be the goal to apply said lessons to current practice during inter-war periods for more thorough and expedited treatment practices in the future.

The impact of the military's current learning system in cases of traumatic injury can be seen in Figure 2, which was initially presented at the 2013 MHSRS. As such, it depicts a 50 percent reduction in Case Fatality Rate among service personnel in Afghanistan via the black (or lowermost) line. This favorable trend occurred over the same period that the system was encountering a substantial increase in the injury severity of patients, which is depicted via the gray (or uppermost) line. Such nimbleness of system not only reinforces the need for focused empiricism in both concept and practice, but it also strengthens the impact of Rasmussen's overall message: for military medicine to shine its brightest, it needs to transport the right patient to the right place for the right treatment at the right time.

The Human Cost: Wars in Iraq & Afghanistan

Active Period: 2001 – Current

Total Number Wounded:	52,022
Total Number of Deaths:	6,809

Figure 1

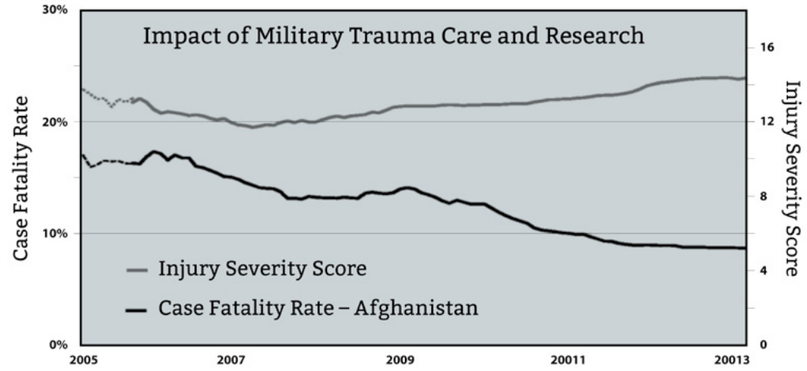


Figure 2

Far from providing the sole beneficial example of military health care system adaptability (and the need to extend and improve upon it), Rasmussen's findings were buttressed by a similar study presented by Jowan G. Penn-Barwell, Surgeon Lt. Cmdr. of the Royal Navy (U.K.). In his presentation, entitled *Injuries and Outcomes: UK Military Casualties from Iraq and Afghanistan 2003-2012*, Penn-Barwell pointed to data showing the odds ratio of a UK soldier surviving with a Trauma and Injury Severity Score (TRISS) of at least 50 percent rose by 1.349 each year4 during the test period. Further, the actual TRISS value associated with a 50 percent chance of survival dropped every year from 35.3 percent in 2003 to 0.9 percent in 2010.[4]

In many ways, those numbers prove the case for focused empiricism. Not only do they show that a health system can indeed absorb the immediate need for trauma care on a massive scale, but that it can also adapt to the type of required care quickly enough to provide near-immediate improvements in the administration of that care. The end result: more lives saved, more victories achieved.

"It's a team effort," Nathan says when he's asked about the concept of military medical research. In fact, his presentation at the 2014 MHSRS included that phrase at least half a dozen times in less than an hour. Yet while the intent of his statement is clear—that no one person can physically will the military toward any of its medical goals—perhaps, in truth, Nathan could go even further with his sentiments. After all, a team effort that is maximized and funneled toward a single, solitary goal is pointless when said goals multiply at a moment's notice and the rules of the game change on the fly. This is, of course, what happens when you live life on the curve, when you play the game alongside constantly unknowable variables.

Perhaps then Nathan might be better served in the future by using another of his favorite quotes—from a noted scientist, no less—to describe the constantly evolving state of current military medicine. It was Dr. Louis Pasteur who first said that "chance favors the prepared mind." It can be suggested then, that in the world of traumatic battlefield injury, infectious disease and traumatic brain injury, the current military medical researcher has no choice *but* to be prepared, for that is the only way to move forward.

Lynchpin Concept: Information Flow

Why military medical research? Why, exactly, military medical research?

To an outsider, that's a fair question. After all, the very concept of military medical research is, at its heart, so completely different than that which drives any other research agency, federal or otherwise. While the latter generally seeks to answer questions of importance to the scientific community as a whole, regardless of timeline, military medical research is, above all else, a requirement-driven research genre. This difference is so fundamental, so—to use a colloquial phrase here—"baked into the cake" of military medical research as a whole that it comes close to isolating the genre from other research fields. Yet, it is a concept that does not betray we know already: the term "military medicine" is one that truly demands.

That being said, the lasting gift of military medical research extends far beyond the scope of the military, as American medicine often rapidly advances when lessons learned on the battlefield are translated into civilian contexts.[5] For instance, the need for improvements in the following civilian areas all have firm roots in the military experience:

- Hemorrhage control
- Resuscitation
- Enroute care
- Damage control surgery

Such needs are, sadly, being propelled by ever-growing reports of mass violence (including shootings and stabbings), and the use of explosive devices within the civilian arena. Indeed, in the six-month span between October 2012 and March 2013, more than 170 improvised explosive devices (IEDs) were reported within the U.S. alone.[6] Furthermore, a total of 78 mass shootings have occurred within the U.S. since 1983, leading to the deaths of more than 540 people.[7] Simply put, there exists both a front-end need and a back-end utilitarian application for the various products and therapies developed via military medical research. Said efforts translate directly into improved force health, which in turn allows for increased national security, and, finally, the ancillary benefit of improved global health as well. Therefore, the answer to the question of why military medical research is needed is simple: *because it pays dividends.*

And yet, to witness the true benefit of those dividends, such freshly assembled research must first be translated into easily understandable information, inserted into the appropriate packaging (i.e., a specific product or therapy), then, finally, submitted to the end user, or, more specifically, the individuals who carry out said research. The concept we're talking about here is "information flow," or the process by which we move from information *discovery* to information *use* in a timely method to ultimately benefit the warfighter. Nothing less than a

symbiotic approach to each of these steps can be tolerated in this mission. As such, the 2014 MHSRS was constructed in such a manner to highlight this specific aspect, as well as the mission itself. To understand the science is one thing, but to understand the process by which we deliver that science to the ones who need it most is something else altogether.

Financing Science: Stakeholders & Strategic Partnerships

How much does $8.00 get you? Not much. Yet in the year 2014, it cost the average American taxpayer that same amount—those same eight dollars—to finance the entirety of the U.S. Food and Drug Administration (FDA).[8] This is a tremendous return on investment considering the breadth of services the FDA offers; everything from ensuring the safety of food products to the reliability of medical devices. Also included in the deal: more than $4 billion in FDA-approved healthcare research and innovation funding.[9]

As such, the FDA—and, to a larger extent, the U.S. Department of Health and Human Services (HHS) as a whole—is a valued partner of the MHSRS and a chief stakeholder in the research performed by its affiliated contributors. Without both the funding and the resources provided by such stakeholders, we would be unable to investigate and obtain such important and potentially life-saving information in any number of key areas. Remember, before there can be any end result, there must first be a funding mechanism in place, as well as an arena in which to perform said work. Running parallel to that line are the partnerships on which trust is built and, later, funding is allocated. The payoff, of course, arrives well down the road. Such is the process. The FDA, however, can only be used as a launching point for a conversation like this one, as the strategic partners for the MHSRS number in the dozens upon dozens, including, notably:

- The National Institutes of Health (NIH)
- The National Institute of Mental Health (NIMH)
- The Defense and Veterans Brain Injury Center (DVBIC)
- The Department of Military and Emergency Medicine
- The Defense Medical Research and Development Program (DMRDP)
- The U.S. Army Medical Research and Materiel Command (USMRMC)
- The Deployment Health Clinical Center (DHCC)
- The U.S. Department of Defense (DOD)

Speaking of the Department of Defense, one example of the type of symbiotic relationship we value so thoroughly can be seen in the recent and sizable donation from the DOD to the Mayo Clinic Department of Defense Medical Research Office. Funded with a $2.4 million grant, the Improved Training Method for Rapid Rehabilitation of Lower Extremity Amputees project teaches lower extremity amputee soldiers how to, among other things, improve their gait and practice stumble recovery strategies in everyday life.[10] Such a relationship between stakeholder and research arm leads into the discussion of another, different kind of partnership—a strategic partnership—that we use to ensure our research is performed, gathered, and then put to actual use.

Such strategic partnerships are widely used and affiliated with some of this country's premier academic institutions, places like Harvard University, Stanford University, and the University of North Carolina at Chapel Hill. But instead of simply reciting names and plaudits, perhaps it would be better to explain the necessity of such strategic partnerships, and how their jointly-produced works ultimately benefit the warfighter.

The C-STARS program is, then, the perfect place to begin. A joint venture between the U.S. Air Force and the University of Maryland School of Medicine, the Center for Sustainment of Trauma and Readiness Skills Program (or, C-STARS) provides real-life, real-time training in trauma and critical care for U.S. Air Force physicians, nurses, technicians, Special Operations medics, and chaplains prior to their respective deployments to the Middle East.[11] As a part of the program, the enrollees work across multiple Aviation Medevac Zones in coordination with state law enforcement agencies to further their understanding of the types of situations they might encounter overseas. Currently, more than a dozen U.S. Air Force personnel join the UM School of Medicine staff on a permanent basis while helping to train up to 30 service members per month from bases across the world.[12] Far from being a site-specific venture, the C-STARS program has even conducted telemedicine consultations and programs with personnel serving in field hospitals in Iraq and Afghanistan. The program therefore operates along two distinct, yet conjoined, avenues. On one hand, the program is an example of the executed concept of the strategic partnering initiative, while on the other hand it operates more importantly as a physical tool of modern research; allowing hands-on training that simply could not be obtained any other way.

Again, such an example is illustrative of the concepts we've been talking about: the constant and continuous, the parallel yet touching. Further, this example follows the "information flow" concept described earlier, in which we see the identification of valuable research, the funding of that research, the building of partnerships, and, ultimately, the translation of that funding into the development of actual products and therapies designed to benefit the warfighter.

Accessing Science: 2014 MHSRS Poster Sessions

An investment in knowledge pays the best interest. That's an old quote from Benjamin Franklin, sure, but it still rings true today, especially in the setting provided by the 2014 MHSRS Poster Sessions, held on 19 August 2014. Here specifically, more than 200 independent and federally-funded research professionals alike gathered to showcase their respective project findings in a scholarly environment, with topics ranging in scope from physical exertion and overuse injuries to battlefield burn trauma and emerging point-of-injury care techniques. The breadth of the information displayed, and the ease and thoroughness of the access, served in many ways as the key access point for funding and outreach opportunities. As such, research from the following key thematic areas was on display:

- Human Performance & Occupational Health
- Trauma Care
- Infectious Disease & Complications
- Psychological Health & Rehabilitation

The material listed above should not in any way be considered a detailed compendium of presented poster session information, yet it should remind all attendees, presenters, and officials alike of the power of the MHSRS as a venue of possibility. With the twin concepts of opportunity and ability constantly encircling any body of knowledge (or body of emerging knowledge) the possibility of additional knowledge is created and maintained. It is this possibility, of course, that is as central to the mission—the aforementioned plan—as the mission itself. The gears begin to grind… hypotheses are devised… research is conducted… numbers are processed… and conclusions are reached.

Delivering Science: 2014 MHSRS Breakout Sessions

Among its other capabilities, the 2014 MHSRS also served quite nimbly as the delivery system for the aforementioned financed, assembled, and packaged research information. Far from operating in the same capacity as the symposium's keynote presentations or plenary talks, which focused on larger and more diverse (in terms of specialization) groups of people, the breakout sessions were designed to, in a smaller setting, educate the people who are charged with carrying out the knowledge that has been gathered and established. Said sessions have proven to be a key educational node for MHSRS purposes, as the absorption rate of such concentrated information is traditionally much higher when delivered to such a receptive audience. In other words, the people attending these breakout sessions both want and need the information being delivered, and, as such, the setting for both desires has been created with these goals in mind. Additionally, such sessions are beneficial for the discussion of more complicated talking points and analyses, as well as demonstrations and first-person accounts.

The following 2014 MHSRS Breakout Sessions were among the more noteworthy:

- Traumatic brain injury
- Human performance & muscle overuse
- Burn care
- Blood & blood products
- Medical training & skills sustainment
- Continuing mental health

Overall, more than 22 individual breakout sessions were held over the course of the symposium, increasing the level of information accessibility to heights previously unknown to the MHSRS. The cycle, therefore, can now be seen as complete. After establishing the overall importance of military medical research (to both the force and the American public as a whole), we saw both the importance and the influential role of the stakeholders in such research, including their access to funding and research facilities. Partnerships, too, are key here, as we understand the use of strategic partners in a variety of capacities to cull information and build new platforms of knowledge. Finally, we see how the assembled knowledge is then delivered to the professionals—the medics, the Special Operations Command personnel—who then use the information in such a way that benefits the warfighter.

We create… We persevere… We carry on.

Key Topic Areas

So now the fruits of the labor, the meat of this compendium. Just as we've established the essential need for military medical research, the time comes now to display that research; to lift the curtain on all the various efforts, therapies and end-products that ultimately benefit not only the warfighter, but, as we've also shown, American society as a whole. Given that more than 1100 abstracts were submitted for placement and subsequent presentation across the four-day symposium, the entirety of the 2014 MHSRS has been boiled down into four richly textured topic areas, each with its own thrust of focus.

Beneath The Skin: TBI, PTSD & Beyond

If it's about anything these days, it's about Traumatic Brain Injury (TBI) and the oftentimes equally as silent Post-Traumatic Street Disorder (PTSD). While military medicine has in recent years overtly set its sights on the improved diagnosis and treatment of these twin, and occasionally invisible, health problems, unacceptable gaps still exist in processes that must be addressed and overcome. The numbers, sadly, demand nothing less.

According to the U.S. Department of Defense (DOD), the number of force-reported cases of mild Traumatic Brain Injury has spiked by more than 10,000 incidents in the past decade alone.[12] Over that same amount of time, cases classified as either "moderate" or "severe" have been reported at the same, relatively low, rate.[12] Further, The Institute of Medicine estimates that five percent of all service members in the military health network have been diagnosed with PTSD, with the prevalence at 8 percent for those who've served into Iraq and Afghanistan.[13] These two statistical themes, more than any others, show one of the chief concerns of U.S. military medical research as it moves into the future.

The 2014 MHSRS, therefore, placed a premium on research materials that addressed these topics specifically. As such, presentations such as COPTADS: Clinical Online PTSD and TBI Analysis for Decision Support (Kagan) focused on the analysis of language as a method to extract variables associated with the psychological status of PTSD and TBI.[14] By collecting materials as simple and common as patient writing samples, such a method allows for a low-cost, non-invasive window into both health issues. In that same vein, the presentation entitled A Large–scale mTBI Informatics Database: Fostering Innovation, Research, and Development for mTBI/PTSD (Caban) also focused on the low-cost collection of readily available data (e.g., audiograms, sleep tests, patient questionnaires) to augment the diagnosis of PTSD and TBI. In the latter, while the quality of data collected was, as stated by the authors, questionable at times due to the lack of data standardization, findings did show that a whopping 91.2 percent of service members experienced moderate to severe forgetfulness.[15] In regard to actual attempted treatment of TBI, results of the DOD's hyperbaric oxygen therapy (HBO2) program were presented during the symposium, but results thus far have been inconclusive as to the effectiveness of low-pressure oxygen to either TBI or PTSD patients.

Here, too, the derivation of private sector and more commercial applications from military medical research are visible. The presentation Can 'Return to Play' be Predicted from Brain Electrical Activity at the Time of Concussive Injury in Athletes? (Prichep) highlighted the application of current testing methods at the time of concussive injury in a subset of amateur student athletes; an issue which, according to the authors, often leads to a premature return to the playing field, thereby allowing for the possibility of further injury. While the pool of test subjects was admittedly small in this particular effort, recent litigation by former professional football players16 has thrust this issue firmly into the public consciousness, and additionally shows the need for larger and denser research efforts regarding the impact of concussions for the short- and long-term care of both younger and older individuals.

Right Here, Right Now: Trauma Care

The concept of trauma care is, as expected, the driving motor behind all iterations of the MHSRS, and the 2014 installment was no different. The need for adaptation and resiliency in such immediate and acute climates is a constant-yet-changing need, a moving target, and one that requires such a symposium as this one to display the various lessons learned from such environments. After all, the urgency of trauma care is not without its data collection requirements. As Rasmussen stated at the outset, the need for a "continuously learning" system of health is required to achieve excellence in both the immediate and long-term care of all service members.

Burn Care

The immediacy of burn care allows for (and, quite frankly, demands) a wide range of products and therapy solutions with respect to its unique arena. Selected 2014 MHSRS presentations falling under this theme displayed a nuanced approach to the concept of time, and how time impacts current and/or future care guidelines. The presentation entitled Full-Thickness Burn Size: More Important Than Total Burn Size in Determining Fluid Needs During Burn Resuscitation? (Salinas) investigated the impact of full thickness burns on fluid resuscitation needs. While burns covering 20 percent of Total Body Surface Area (TBSA) require continuous hourly fluid infusion during the early period after injury, it was heretofore unknown how full thickness burns would affect fluid resuscitation needs.[17] This effort found that patients with 50 percent full thickness (FT) burns required an average of 75 percent higher volume of fluid than patients with 0 percent full thickness burn with the same TBSA, data which then encouraged the authors to call for new guidelines requesting that FT burn extent be considered for fluid requirements in future burn patients.[17]

Emerging therapies in burn care were also spotlighted, an element of the symposium witnessed most specifically in The Southwest Research Institute's presentation regarding collagen-based biomasks for facial burn patients. Noting the lack of market availability of any custom-made wound-closure systems to aid in the healing following a facial burn injury, study authors used a 3-D printer to achieve that very goal, with their ultimate aim being to improve scarring, facial tone, and hair follicle growth following a burn injury.[18] With initial test results favorable, testing will begin in an animal model in the near future.

Shock

According to the National Trauma Institute, more than 21 percent of all military casualties are in shock upon admission.[19] And while statistics are merely indicators of past efforts (as opposed to predictors of future events) this number represents yet another immediate warfighter health issue that must be addressed within the system of military health.

The concept and use of medical simulation in the treatment of shock was explored in the UCLA-based study Effectiveness of Screen-Based Hemodynamics Simulator in Treatment of Shock (Laufer). Here, a screen-based simulator depicting an array of pathologic hemodynamic states was developed as a real-time teaching tool for novice trainees in the treatment of shock cases. Upon completion of the study, the authors found that a marked amount (19.2 percent) increased their treatment capabilities after using the simulator as opposed to preliminary testing scores.[20] While efficacy studies still need to be performed on the results with relation to other military medical skills training, study authors developed enough material to suggest the application of such a tool to military medic and other civilian first responder training.

Several presentations at the 2014 MHSRS focused on the concept of point-of-injury (POI) care specific to cases of shock. The study entitled Prehospital Pain Medication Use by U.S. Forces in Afghanistan (Shackelford) concluded that future efforts to improve battlefield pain control would be wise to focus on improving care delivery at the POI stage.[21] Still other presentations, like the University of Texas Health Science Center's research effort on shock-induced injury inflammation sought to determine whether systemic administration of fresh frozen plasma (FFP) or lyophilized plasma (LP) might aid in the reduction of inflammation via a mechanism in a specific heparin sulfate cell (Sdc-1).[22] Further, Brooke Army Medical Center embarked on a study to determine whether the administration of Tranexamic Acid (TXA), which is often used in trauma situations due to its ability to reduce blood loss, might increase or decrease a service member's risk of infection.[23] While preliminary research indicated the use of TXA indeed did not increase infection risk, the authors ultimately suggested more research be performed with regard to the interaction between TXA and transfusions.[23]

Blood Loss

When we talk about the benefits of military medical research, and the actual improvements to modern life made via the work performed and perfected within the military realm, we need to talk about the tourniquet. Assembly-wise, of course, it's not much to look at: a bandage, maybe some tape, a stick, possibly a tree branch if you're stuck in the wilderness somewhere. A tourniquet is, in extremely simplistic terms, a tool used to stop hemorrhagic bleeding via the use of constriction. And yet, as history shows, there was indeed a time when tourniquet use was eschewed by medical professionals due to fears of limb loss. Yet following a streamlining in both use and technique as developed by the U.S. military, the tourniquet is now regarded as an essential tool in saving lives without enduring secondary limb loss.[24] Military personnel now recommend the use of tourniquets for civilian EMS crews, where they—albeit operating in an arena where mass casualty situations occur far less—still may benefit greatly from its use due to the time-sensitive nature of their jobs.[25]

But this is just an example. It's an example that encompasses all the thematic elements we've discussed so far, but it's still an example nonetheless. And yet it applies to this section because blood—the internal flow, the prevention of its loss—is of such chief concern to the modern warfighter. This is an obvious statement of course, but yet it is always best to begin with the obvious in discussions like these, for that is where we begin our search for the complex. The one always folds into the other. The subject of blood loss and any associated products, research and therapies, therefore, continues to be of key importance to every iteration of the MHSRS.

Many presentations, therefore, dealt specifically with plasma both as a product to be improved upon and a commodity to safeguard in a variety of settings. Topics ranging from the proper usage of plasma-rich solutions in-theater were broached, as well as the application of plasma-based biomaterials (PBMs) on service members suffering from various extremity fractures.

The effectiveness of freeze-dried plasma (FDP) products were put to the test in a notable presentation from the Keck Graduate Institute's Rajesh Pareta, Ph.D.,[26] who attempted to develop and characterize an improved FDP alternative to platelet storage with great success. In a comparison between their novel FDP alternative and a current French FDP technique, the Keck team found that their approach resulted in an estimated 100 percent longer shelf life of the plasma product.[26] In addition, the resuspension time of their FDP alternative was found to take less than half the resuspension time of the French FDP method.[26] The next step for this product is to obtain usage approval from the U.S. Food and Drug Administration (FDA).

Following that same theme, a number of therapies were also presented in regard to stemming hemorrhagic blood loss in a number of specific types of patients (A Prospective Observational Study of Changes in Coagulation During Tissue Excisions Causing Significant Bleeding: A Model for Severe Bleeding in the Prehospital Setting?), specific types of wound locations (Junctional Hemorrhage Control: Update on Out-of-Hospital Interventions), and specific theater locations (Prehospital Blood Products After Battlefield Trauma: Benefit Unclear) as well.

Recovering The Future: Neurotransplantation & Muscle Regeneration

Perhaps the most noteworthy research effort falling under this topic umbrella came from Ericka M. Bueno, Ph.D., and her compelling presentation entitled Face Transplantation in a Highly Sensitized Recipient, which set out to examine whether a highly sensitized patient could, in turn, be desensitized in order to improve facial transplant outcomes.[27] This highly detailed presentation recounted the study patient's development of antibodies against a large portion of the available donor population (following multiple prior skin graft procedures), and subsequent 14-month wait for a donor.[27] While the surgery itself was ruled a success, the presentation noted the eventual increase, over three weeks, of large-scale cellular rejection of the transplanted face by the patient. In an attempt to save the transplant surgery, the patient was treated with an aggressive immunosuppressive protocol to address both humoral and cell-mediated rejection. In the end, a significant decrease in cellular rejection and donor-specific antibodies was observed little more than a few days later, culminating with the patient ultimately being discharged at the seven-week mark.[27] Four months after transplant, the patient was observed to have no evidence of rejection. Moving forward, the study author points out that additional work will be needed to determine whether the procedure can be expanded to other sensitized patients.

In this area also, work with the musculoskeletal system comes into play as a major theme in the 2014 MHSRS discussion. In particular, the work performed by the U.S. Army Institute of Surgical Research in the area of volumetric muscle loss (VML) found that regenerative factors—or, building blocks of form and function replenishment—can often be found at or near the site of such an injury when minced muscle and microvascular fragments (MVFs) are applied to said injuries.[28] According to study authors, the process activates and then dispatches satellite cells to the injured area to repair myonuclei. Minced muscle treatments from VML-injured animals transplanted to the site of injury resulted in a 50 percent increase of myogensis and muscle function, as well as a reduction in fibrosis.[28] While the study sample is small and more research on this topic is required, this specific treatment looks promising given the current data collected.

Assessment & Continuing Education: The End User Connection

We wrap up this section with a nod, once again, to the concept of translating our assembled knowledge into actual practice. After all, to obtain true success, to constantly evolve under our objective of becoming a "learning health system," there must be a mechanism of delivery, a method by which to educate the people who will eventually turn data into action. By focusing on this core concept as a theme (a theme to later be physically delivered during the MHSRS breakout sessions), we can provide a focus on the end user just as much as we've provided a focus on the previous key topic areas.

"Our clinical care has never been so sophisticated," noted Brig. Tim Hodgetts, CBE, Medical Director at the Joint Medical Command in the United Kingdom during his presentation on 19 August 2014.[29] "So how do we protect this standard of care for future unplanned operations?"[29] For Hodgetts, that protection begins with continuous innovation on all available medical platforms, meaning, as a standing edict, a focus on exploring the previously uncharted capabilities of conceptual, technological, and curricula-based design.

It is indeed this focus that Hodgetts calls his "roadmap for innovation";29 one that pays special attention to the human factors in not only the changing nature of medicine, but also the changing nature of war (which begets the need for warfighter care). The factors he identified as integral to innovation are the following:

- The desire to improve
- The belief that your improvements can make a difference
- The understanding that a series of small improvements can lead to a substantial impact

Collaboration, too, is key here. And it's worth noting that Hodgetts made a point of highlighting the positive diplomatic relationship between the U.S. and the United Kingdom as a gateway for future and continued military medical innovation.

Another hot topic among presenters at the symposium was the subject of "human knowledge" databases and their ultimate compilation for the purposes of future end user missions and deployments. A living and breathing and learning military health system—one operating in many ways as a sentient organism—must not only be able to learn via the front end (the application of new information and techniques), but also via the back end (the application of lessons learned and other cognitive changes). The presentation entitled The Lessons of War: Turning Medical Data into Clinical Decisions (Elster) paid special attention to the need for additional studies on the immunological complications that occur after complex injuries for the benefit of helping medics and other surgical staff better accelerate care and inform decision making.[30]

Along the same lines, the concept of simulation as a teaching tool was broached as well, with the presentation led by the U.S. Army Institute of Surgical Research Bridging Combat Casualty Burn Care Education with High Fidelity Human Patient Simulation (Hayes, et al.) pointing out that objective-driven and heavily scripted evidence-based clinical simulation scenarios continue to prove to be beneficial for nurse educators in prehospital and trauma settings.[31] Still other symposium presentations noted the quality of the data now available via the Military Orthopaedic Trauma Registry (regarding specialty patient care), while the presentation Early In-Theatre Management of Combat Related Traumatic Brain Injury: A Prospective, Observational Study to Identify Opportunities for Performance Improvement (Fang) highlighted the increasing need to focus on prehospital care and the continuous training of medical personnel to sustain their skills.[32]

With the intended information flow of the MHSRS already established in previous pages, we have, here, also established the material that is delivered via that pipeline; a constantly evolving series of efforts at all stages of medical innovation (research, product and therapy creation, knowledge delivery) being independently processed inside the same living and learning entity of military medicine. As we continue to reverse-engineer the system, our last step moves toward understanding the individual people who drive that innovation for the Defense Medical Research and Development Program: the six separate Joint Program Committees.

JPC Involvement

It is here, in this section, where we talk about the people behind the science—the actual decision-makers—because it is here where they truly matter most. It is only here amongst the various Joint Program Committees (JPCs) of the Research, Development and Acquisition Directorate (RDA), that we finally begin to identify more fully with the people who drive each individual research component of warfighter care. Likewise, it is here where we finally witness their true roles within the system, for they act as the tip of the medical research spear, the edge of the knife. The people who run the JPCs truly ride the wave—that mythic curve of innovation—that we've been targeting so squarely since the beginning of this report. The six incumbent JPC Directors are, quite simply, the leading edge of the DHA, as they ultimately make the decisions that both build and shape the MHSRS.

"We have a unique opportunity here,"[33] says U.S. Navy Rear Adm. Bruce Doll, RDA Director, of those very decisions. "We have an opportunity to become the world leader in coordinating military medical research, and that focus is captured in the latitude we give our Joint Program Committees."[33] Specifically, Doll refers to the placement of the JPCs in a position whereby they can make both flexible and immediate decisions for the good of their respective research portfolios and, ultimately, the warfighter. Such freedom was initiated with the creation of the RDA in the early months of 2014, a move designed to both streamline and improve collaboration and coordination between the services in all medical research matters.

"It starts very early on,"[34] says U.S. Navy Capt. Douglas Forcino of the process used to stack the bricks—the method employed to assemble the most prime knowledge from within the Military Operational Medicine Research Program (JPC 5), of which he serves as director. Presentations concerning posttraumatic stress disorder (PTSD) and overuse injuries—subjects which both have extreme crossover appeal to the commercial world—were among the notable contributions from JPC 5 to the 2014 MHSRS. "We had great success with those," says Forcino. "Some very lively sessions."[34] Appropriate for a JPC whose main thrust is Force Health Protection, Forcino says he's eager to display updated research on topics such as heat and cold stress injuries, nutrition, and environmental psychology at the coming year's event. "We're looking for more sessions than last year," says Forcino of the 2015 effort. "And we'll be ready."

No doubt U.S. Army Lt. Col. Teresa Brininger can be heard excitedly saying "me, too!" in response to Forcino's statement. Brininger serves as the director of the Clinical and Rehabilitative Research Program (JPC 8); she targeted key nuero-musculoskeletal research efforts (such as the aforementioned facial transplantation presentation) for inclusion in the 2014 MHSRS, as well as other in-garrison-based efforts concerning pain management and regenerative medicine (the latter including various emerging bone grafting and muscle repair techniques). Yet next year has even more to offer. What are the most important research areas for 2015, according to Brininger? "All of them," she says, succinctly.[35] "It's impossible for me to separate what's this or what's that—everything we do helps our cause, and I can't wait to show more of it."[35]

And yet it goes further, deeper. The heavily structured, thickly layered contributions of the Medical Simulation Training and Informatics Research Program (JPC 1) concentrates on various support models with a driving interest in health information technology. The similarly rangy force health protection efforts of the Medical Radiological Defense Research Program (JPC 7) focuses on the far more dense, overtly internal sides of warfighter care with its efforts in heavy metal toxicity, radiation injury, and radiation biology modeling. Combine all these efforts and the full picture comes into view, not only of the minds that perform the work, but of the minds that must also steer their respective ship's course from very open waters through very narrow gaps—to convert such wide-open possibilities into tools that can help U.S. service members in any place and at any time. You get the picture now, and perhaps you also feel the expectations—the pressure of performance.

And yet, as we've already proven, military medical research delivers every time.

In its first year of involvement with the MHSRS, the Military Infectious Disease Research Program (JPC 2) received more than 120 abstract submissions (and hosted more than 20 invited speakers) for just two initial breakout sessions, according to U.S. Navy Cdr. Gail Chapman.[36] Chapman noted that two additional such sessions were added to the agenda in order to accommodate demand. Presentation topics falling under the JPC 2 umbrella included, among others, the assessment and treatment of acute and chronic wound infections (and accompanying new product reveals), plasma-based solutions for bone fractures, and the whole of respiratory pathogens.[36] According to Chapman and her staff, upcoming research efforts to be spotlighted at the 2015 MHSRS include gains made in wound infection prevention and management, as well as next-generation diagnostic systems (NGDS) to diagnose naturally occurring infectious disease threats.[36]

"It's this whole concept of getting the right person to the right place for the right treatment at the right time,"[37] says U.S. Air Force Col. Todd Rasmussen, echoing a similar statement he made earlier in this very compendium. Rasmussen serves as the Director of the Combat Casualty Care Research Program (JPC 6), the program responsible for stocking the 2014 MHSRS with a slew of in-depth presentations on trauma care and hemorrhage topics, as well as a broad spectrum of sessions specifically devoted to the topic of en route care. "It's this concept of the golden hour," Rasmussen says, rather emphatically, of the work that still needs to be done within JPC 6. "It's this concept of doing what we need to do while also being mindful of that key principal."[37] Moving forward, as the United States phases out combat operations in Iraq and Afghanistan, Rasmussen will look to remind key partners and contributors of the work his program is performing in the areas of acute trauma and point-of-injury (POI) care. In other words, the gradual decline in actual warfighting should not mean the abandonment of funding for military trauma research. "This is what we're struggling with now," says U.S. Army Major Ian Dews, Military Deputy Director for the Combat Casualty Care Research Program. "This will be the big issue going forward."[38]

But that's the thing about going forward, isn't it? The fear of the unknown. An insatiable appetite for the next challenge tempered with a constant search for reason and solid footing. This is the dynamic. This is normal here amongst the JPCs. *Tip of the spear. Edge of the knife.* This ever-evolving process of adjusting on-the-fly, of mapping a gradual, long-term steering effort while also paying attention to short-term goals—this is how missions are accomplished.

Conclusion/Wrap

Have we finally reached the end, you ask? Have we come to the final page? That's a tough question. For now, maybe. For this particular effort. But over the long haul? For the mission as a whole? Have we completed the work which we were asked to perform in the first place?

Never.

And that must be the answer—the *only* answer, really—when the mission is as clear (yet inherently challenging) as the one we've been assigned: to always stay ahead of the curve. And so now, hopefully, you can see the true nature of the work displayed in the previous pages, the work embarked upon by the JPCs, the work funded by our partners and bred via our close professional relationships: the products and therapies so desperately needed by the men and women who wear the uniform of the United States of America on battlefields across the globe.

The work we do cannot ever be completed.

If it were, then such finality would cut to the very beating heart of military medical research. *There can always be better. We can always do more.* Whether you're systematically staying ahead of the curve or continually skating to where the puck will be, you are always existing within the current moment, yet always moving toward the very next. Do you see the continuity? You are never at rest because you simply cannot afford to be. *A body in motion tends to stay in motion.* It was another scientist—Sir Isaac Newton—who first taught us that; further proof that the work performed beneath the umbrella of military medical research is, and always will be, uniquely and fundamentally aligned with our core subject matter. We evolve as the science evolves, each body rotating around the other in perpetuity.

In his presentation entitled *Thoughts for the Future of Military Medicine*, delivered during the last day of the 2014 MHSRS, retired U.S. Air Force Lt. Gen. Paul Carlton Jr. delivered his three tenets for aligning oneself with constant change:

- You must face reality
- You must understand that improvement never stops
- You must have thick skin

In other words, Carlton's message was this: in whatever you do, look at where you stand right now and realize that there is—and always will be—more work to be done, and understand that as you push forward, doubters will always exist among those you're trying to educate. His ultimate point? *The mission never ends.* It can't end. Too many lives depend on it. And so as much as we learned this year, perhaps next year the data will read differently. Perhaps it will force us to ask new questions and lead us in different directions. And perhaps, with a little luck, it will lead us to the answers we've been searching for all along. Wherever we must go, we'll be ready.

References

1. Nathan, M. "The George P. Schultz Lecture Series." Marines' Memorial Association. Marines' Memorial Club & Hotel, San Francisco, CA. 19 Feb. 2013. Keynote speech.
2. Rasmussen Todd. "Clinical Questions to Clinical Guidance: The Military's Continuously Learning System in Trauma." Military Health System Research Symposium, 2014. Presentation.
3. Grossmann C, W. Goolsby, L. Olsen, and J. McGinnis. *Engineering A Learning Healthcare System: A Look at the Future.* Washington, DC: The National Academies Press. Print.
4. Penn-Barwell, J. "Injuries and Outcomes: UK Military Casualties from Iraq and Afghanistan 2003-2012." *Orthopaedic Proceedings* 95-B (2013): n. pag. Web. 27 Oct. 2014.
5. Rasmussen, Todd. "Why Military Medical Research?" *Military Medicine* 8.1 (2014): 1-2. Print.
6. Schofield, M., and E. Bolstad. "Bombs frequent in U.S.; 172 'IED' incidents in last 6 months, by one count." McClatchy. 16 April 2013. Web. 07 Nov. 2014.
7. Bjelopra, J., E. Bagalman, S. Caldwell, K. Finklea, and G. McCallion. "Public Mass Shootings in the United States: Selected Implications for Federal Public Health and Safety Policy." *Journalists Resource*, n.d. Web. 21 Nov. 2014.
8. "Department of Health and Human Services: Fiscal Year 2014 Justification of Estimates for Appropriations Committees." *FDA.gov.* U.S. Food and Drug Administration, n.d. Web. 21 Nov. 2014.
9. "FDA Budget by Strategic Goal." *FDA.gov.* U.S. Food and Drug Administration, n.d. Web. 21 Nov. 2014.
10. "Department of Defense Medical Research Office: Current Initiatives." *Mayo Clinic*. Mayo Clinic, n.d. Web. 21 Nov. 2014.
11. "C-STARS (Center for the Sustainment of Trauma and Readiness Skills)." *Program in Trauma.* University of Maryland School of Medicine, n.d. Web. 20 Nov. 2014.
12. "DoD Worldwide Numbers for TBI." *Defense and Veteran's Brain Injury Center*. Defense Centers of Excellence for Psychological Health and Traumatic Brain Injury. 2013. Web. 20 Nov. 2014.
13. Walsh, J., and C. Dickson. "Effectiveness of PTSD Treatment Provided by Defense Department and VA Unknown; Tracking of Outcomes Needed to Manage Growing Burden." *National Research Council.* The National Academies, 20 June 2014. Web. 20 Nov. 2014.
14. Kagan, V. "Clinical Online Posttraumatic Stress Disorder and Traumatic Brain Injury Analysis Detection System." Military Health System Research Symposium, 2014. Presentation.
15. Caban, J. "A Large-Scale Mild Traumatic Brain Injury Informatics Database: Fostering Innovation, Research, and Development for Mild Traumatic Brain Injury/ Posttraumatic Stress Disorder." Military Health System Research Symposium, 2014. Presentation.
16. "Federal judge approves NFL concussion settlement." *NFL.com*. The National Football League, 7 July 2014. Web. 19 Nov. 2014.
17. Salinas, J. "Full Thickness Burn Size: More Important Than Total Burn Size in Determining Fluid Needs During Burn Resuscitation?" Military Health System Research Symposium, 2014. Presentation.
18. Cheng, X. "Collagen-Based Biomask as a Promising Skin Graft for Facial Burn." Military Health System Research Symposium, 2014. Presentation.
19. Eastridge, B. (2009) Joint Theater Trauma Registry Data. June 2006-November 2008. 8. MacLeod, J.B., Lynn, M., McKenney, M.G., Cohn, S.M., and Murtha, M. (2003) Early coagulopathy predicts mortality in trauma. *J Trauma* 55, 39-44.
20. Laufer, D. "Effectiveness of Screen-Based Hemodynamics Simulator in Treatments of Shock." Military Health System Research Symposium, 2014. Presentation.
21. Shackelford, S. "Prehospital Pain Medication Use by U.S. Forces in Afghanistan." Military Health System Research Symposium, 2014. Presentation.
22. Kozar, R. "Could the Systemic Administration Fresh Frozen Plasma or Lyophilized Plasma and Hypertonic Saline Lessen Injury and Inflammation by Syndecan-1 Mediated Gut Protection by and after Hemorrhagic Shock." Military Health System Research Symposium, 2014. Presentation.
23. Lewis, C. "Tranexamic Acid Administration and Infection Risk in Combat Casualties." Military Health System Research Symposium, 2014. Presentation.
24. Elster, E., E. Schoomaker, and C. Rice. "The Laboratory Of War: How Military Trauma Care Advances Are Benefiting Soldiers And Civilians." *Health Affairs Blog.* 18 December 2013. Web. 17 Nov. 2014.
25. Risk, Gregory and Augustine James. "Civilian EMS Should Consider Tourniquets." *Journal of Emergency Medical Services.* March 2012: n. pag. Web. 19 Nov. 2014.
26. Pareta, R. "A Freeze-Dried Plasma Alternative to Fresh Frozen Plasma with Improved Handling to Enable Point-of-Injury Care." Military Health System Research Symposium, 2014. Presentation.
27. Bueno, E. "Face Transplantation In A Highly Sensitized Recipient." Military Health System Research Symposium, 2014. Presentation.

28. Rathbone, C. "Translational Autologous Approaches for Regeneration of Skeletal Muscle." Military Health System Research Symposium, 2014. Presentation.

29. Hodgetts. T. "Sustaining Innovation and Excellence in Military Medicine—The Challenge of Contingency." Military Health System Research Symposium, 2014. Presentation.

30. Elster, E. "The Lessons of War: Turning Medical Data into Clinical Decisions." Military Health System Research Symposium, 2014. Presentation.

31. Serio-Melvin, M. "Bridging Combat Causality Burn Care Education with High Fidelity Human Patient Simulation." Military Health System Research Symposium, 2014. Prese;ntation.

32. Fang, R. "Early In-Theatre Management of Combat Related Traumatic Brain Injury: A Prospective, Observational Study to Identify Opportunities for Performance Improvement." Military Health System Research Symposium, 2014. Print.

33. Doll, Bruce. Personal Interview. 10 Nov. 2014.

34. Forcino, Douglas. Personal Interview. 01 Dec. 2014.

35. Brininger, Teresa. Personal Interview. 28 Oct. 2014.

36. Chapman, Gail. Personal Interview. 01 Dec. 2014.

37. Rasmussen, Todd. Personal Interview. 17 Sep. 2014.

38. Dews, Ian. Personal Interview. 24 Nov. 2014.

Illustrations

The Human Cost: Wars in Iraq & Afghanistan

Active Period: 2001 – Current

Total Number Wounded:	52,022
Total Number of Deaths:	6,809

Figure 1

Rasmussen, Todd. "Clinical Questions to Clinical Guidance: The Military's Continuously Learning System in Trauma." Military Health System Research Symposium, 2014. Presentation.

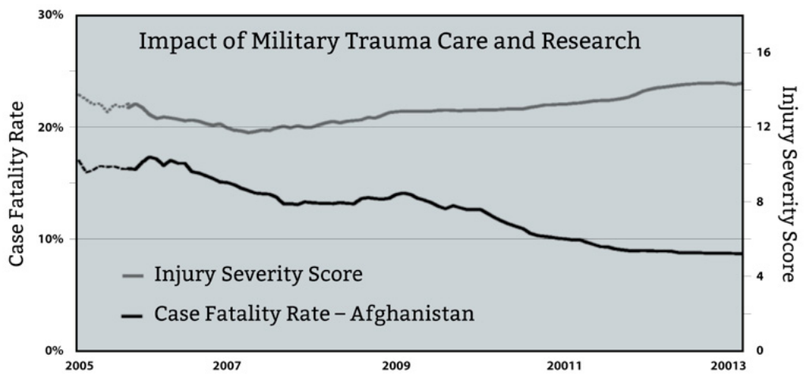


Figure 2

Rasmussen Todd. "Clinical Questions to Clinical Guidance: The Military's Continuously Learning System in Trauma." Military Health System Research Symposium, 2014. Presentation.

Prepared by

IGS

Isom Global Strategies