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Enhancing Military Readiness Through Technology Convergence: Why Military Medicine is Behind and How We Move Forward

by

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16 June 2020

A paper submitted to the Faculty of the United States Naval War College Newport, RI in partial satisfaction of the requirements for the Ethics and Emerging Military Technology Graduate Certificate Program.

The contents of this paper reflect my own personal views and are not necessarily endorsed by the Naval War College, the Bureau of Medicine and Surgery, or the Department of the Navy.

Abstract

Despite first-rate medical providers, superb casualty survivability and seven percent of the $686 billion-dollar Department of Defense budget, the military health system has been unable to successfully affect medical readiness of the Joint Force. The Department of Defense is making great strides to provide combat-credible military forces, yet its health service support organizations are still using concepts from the 1950s. This lag in health services adding value to the Joint Force, in part, led to the creation of the Defense Health Agency. This agency claims to have a renewed focus on operational readiness, yet it does not have the authority nor experience to truly execute this assertion. In order to aid the Joint Force's competitive stance, civilian and military health leaders must reevaluate the implementation of emerging medical technologies across the range of military operations. Addressing underlying ethical concerns of employing emergent technologies, this paper examines the issues through the lenses of the military health system, warfighter, and societal impact.

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TABLE OF CONTENTS

Scope of Discussion

This paper examines the issues of implementing emerging medical technologies as well as ethical issues of employment delays for the warfighter. While several emerging technologies would benefit warfighters, this paper will focus on wearables, telemedicine, additive manufacturing, and virtual reality. Military medical leaders should capitalize on these technologies to improve readiness of the force. Ethics and morality are deeply intertwined in the fabric of healthcare, so dilemmas are legitimate, profound, and should continually be discussed. What this paper will deliberate is the convergence of technologies that are readily available or in advanced stages of development. Technological advancements are no longer exclusive to the government or the military-industrial complex, so the immediacy of availability will be a prerequisite to capitalize on first-mover advantage in the era of Great Power Competition.

Although the most recent National Defense Strategy (NDS) does not explicitly address medical readiness issues, a reasoned approach can be distilled from its message. Former Secretary Mattis states, "Without sustained and predictable investment to restore readiness and modernize our military to make it fit for our time, we will rapidly lose our military advantage, resulting in a Joint Force that has legacy systems irrelevant to the defense of our people."[1] The basis of revamping military medical readiness should be conceived through this perspective. As such, this paper will span the full range of military operations to discuss the current status, applicability, and appropriateness of some emergent technologies. Finally, recommendations for implementation of programs across the spectrum are put forth.

[1] Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America* (Washington, DC: Department of Defense, 2018), https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

Ethics and Technology

As ethical leaders, we must engage and remain involved in the development of technology and continue to be reminded of Kranzberg's first law: "Technology is neither good nor bad; nor is it neutral."[2] At the cross-section of implementing technology and pursuance of ethics, it is imperative for leaders to examine potential biases and fallacies. An example might be why some of the technologies discussed further in this paper have not been implemented. These technologies are already in the mainstream of society; perhaps, medical leaders have fallen victim to the "slippery slope" logical fallacy.[3] Additive manufacturing might already be more prolific in operational medicine; however, leaders at every level do not seem to have a full understanding of the functionality or benefits, so they draw on a pessimistic bias.[4] Servicemembers must be confident that medical technology will be used in an ethical manner and trust that it adds to the overall success of military operations. To foster this level of trust, it is paramount that all fully comprehend ways in which the technology will be used so that it will create "buy in."[5]

In his book *Technopoly*, Neil Postman states that "Every technology is both a burden and a blessing."[6] Innovations in medical technology have provided medical professionals with dynamic capabilities but also brought about ethical challenges. For instance, the implementation of electronic health records (EHR) brought about the ease of providing more efficient and coordinated care; however, providers must guard against data breaches and privacy concerns.

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[2] Melvin Kranzberg, "Technology and History: "Kranzberg's Laws"," *Technology and Culture* 27, no. 3 (July 1986): 545.

[3] The Slippery Slope fallacy asserts that if we allow A to happen then Z will consequently happen too, therefore A should not happen.

[4] Pessimism bias overestimates the likelihood of negative outcomes.

[5] Ida Joiner, "Editorial Board Thoughts Column Getting to Yes: Stakeholder Buy-in for Implementing Emerging Technologies in Your Library," *Information Technology and Libraries* 37, no. 3 (2018): 5-7.

[6] Neil Postman,*Technopoly: The Surrender of Culture to Technology,*(New York: Random House , 2011)

The benefits of EHR far outweigh any drawbacks, so to think of a health system or provider not utilizing an EHR due to privacy concerns would be unethical in and of itself. Leaders must continuously keep abreast of technological advances and the benefits it provides regardless of personal biases. This approach will foster a heightened level of trust between medical leaders and the types of technology that are required for productive use in garrison and operationally. Military healthcare professionals must have an open and honest discussion around our explicit or implicit values, including why we are behind in understanding and implementation of emerging technologies as well as develop strategies to excel.

Philosopher Hans Jonas discusses the traits of modern technology in *Toward a Philosophy of Technology*. These traits can be summarized by four main points; first, that every new step creates multi-directional steps; second, technological innovation will spread quickly; third, the technology relationship is circular; and finally, technology is a driving force.[7] Military leaders must acknowledge and understand how modern technology will, directly and indirectly, impact the strategic, operational, and tactical environments. A recent example is the Commandant of the Marine Corps', General Robert Neller, decision to employ commercial off-the-shelf quadcopters by individual rifle squads.[8] The creation of the "drone" was one of intrigue and military necessity—the technology spread to commercial institutions who created other uses and further developed the technology. Due to the success of larger drones in providing situational awareness in Iraq and Afghanistan but the strategic nature of employment, the Marine Corps attempted to solve the problem that the knowledge of drone technology

[7] Hans Jonas, "Towards a Philosophy of Technology" in *Technology and Values: Essential Readings,* ed. Craig Hanks, (Hoboken, NY: Willey-Blackwell, 2010), 5.

[8] Gidget Fuentes, *"*Pentagon Grounds Marines' 'Eyes in the Sky' Drones Over Cyber Security Concerns," *USNI News*, June 18, 2028, https://news.usni.org/2018/06/18/pentagon-grounds-marines-eyes-sky-drones-cyber-security-concerns

created. In 2018, then Deputy Secretary of Defense, Patrick Shanahan, halted the employment of the commercial product due to cybersecurity risks.[9] Although this is a somewhat easy issue to resolve, a question of ethics arises. Does the presence of a cybersecurity risk outweigh the risk of losing life, limb, or eyesight? Senior leaders in the Marine Corps are looking to increase the survivability of the force. Is it unethical to have a technology that could save a life but not employ it because of an unknown or potential risk?

Regarding medical readiness, the Military Health System (MHS) has largely failed the Soldiers, Sailors, Airmen, and Marines it is charged to protect. For decades, the MHS focused on garrison care geared towards military dependents, provided at the military treatment facilities (MTF). This selective focus led to cognitive inhibition in understanding the austere operational environment. Providers can spend years at United States-based garrison MTFs, utterly unaware of their role in the MHS, challenges of military operations, or the role that medics and Corpsmen have in sustaining medical readiness. This highlights the disconnect among those who rise to leadership positions because they are close to the proverbial "flagpole," vice those who spend careers working in and understanding the ever-changing operational environment. Medical readiness has been negatively affected across the Range of Military Operations (ROMO) because leaders in the military medical community seem not to consistently understand readiness or operations. This highlights the need for a greater understanding of complex systems and their dynamics. As the use and impact of emerging technologies become more pervasive, military medical leaders must champion and harness its use in order to support the Joint Force. These

[9] Gidget Fuentes,Pentagon Grounds Marines*' "Eyes in the Sky" Drones Over Cyber Security Concerns, USNI News, June 18, 2018,* https://news.usni.org/2018/06/18/pentagon-grounds-marines-eyes-sky-drones-cyber-security-concerns.

emerging technologies must be incorporated and further developed in a way that increases medical readiness and eventually leads to a potent and ready medical force.

Careerism poses a constant threat in any professional organization, and in the military a careerist tendency to preserve the status quo may limit the implementation of technologies that would increase the readiness of the force. Using the *Ethics & National Defense* explanation, careerism is not a particular moral defect but rather a collection of transgressions united only in the context in which they occur.[10] The prevalence of careerists and the Department of Defense's (DoD) overreliance on "readiness percentages" failed to appreciate how a complex medical readiness system would defy simplistic reductionism. Service members are not more resilient simply because they are green in the Army's Medical Protection System (MEDPROS) or Navy's Medical Readiness Reporting System (MRRS). Healthcare providers are not ready just because they have conducted a Periodic Health Assessment (PHA). Emerging technologies must be explored that can fill the gaps between medical readiness and ready medical forces.

Military leaders tend to be predisposed and hampered by the tyranny of averages, the tendency for averages to convey little practical information about data.[11] Every higher headquarters from the most tactical unit to the strategic relies on percentages to validate success or failure. Leaders became over-reliant on the numbers reported via the various medical readiness tracking systems because it is a familiar tool. These averages, numbers, and percentages never truly scoped to the full picture of readiness, but it was the program of record, so it was not challenged.

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[10], James C. Gaston and Janis Bren Hietala, *Ethics and National Defense* (Washington, D.C: National Defense University Press, 1993)< p. 38-40

[11] John Spacey, "What is the Tyranny of Averages?" Simplicable, November 21, 2016, https://simplicable.com/new/tyranny-of-averages.

Genuine readiness of the force has been eroded by an unethical standard of creeping normality.[12] The 2018 Health of the DoD Force reported an average of 17.4 percent across the entire DoD that meets the definition of obesity, a steady increase in the overall rate.[13] While the U.S. Marine Corps (USMC) had the lowest rate of obesity at 8.3 percent, they had a higher rate of back and knee injuries, the types of injuries that led to productivity loss, and medical separation.[14] This report highlights how even with the expansion of the MHS and significant advances in technology, little has been done to produce a healthier and fit force. At some point, medical leaders neglected the greater good of the Department and overlooked the needs of subordinates, patients, and the greater public.

Issues

Another phenomenon in the medical departments of all services is the challenge to remain relevant in the civilian sector as well as progress in the Profession of Arms. Doctors, nurses, administrators, and medical scientists walk a fine line when interacting with senior military and civilian leaders. They usually lack the same contextual understanding of warfighting and similar leadership roles in the progression to general or flag officer. This absence of parity makes it easy to identify officers who spend their time checking with superiors or peers concerning whether to act or not. This engrained lack of professional candor is so pervasive that readiness has suffered, and the collective medical arms of the services are debilitated.

[12] Creeping normality is a process by which a major change can be accepted as normal and acceptable if it happens slowly through small, often unnoticeable, increments of change. The change could otherwise be regarded as objectionable if it took place in a single step or short period.
[13] 2018 DOD Health of the Force Report.
[14] 2018 DOD Health of the Force Report.

The formation of the Defense Health Agency (DHA) is the culmination of the fractured trust in the MHS and its military and civilian leadership. For too long, the services have been unable to balance the benefit and readiness missions correctly. This lack of discernible operational value, in part, led to the creation of the DHA. The readiness mission strives to provide the commander with ready forces (including ready medical forces), while the benefit mission executes the service that generates medically ready forces. Examples of the benefits mission include audiograms, vaccinations, medical homeport, dental exams, and PHAs. For decades, the MHS has given priority to the benefit mission, which provided insignificant value to senior civilian and military leaders.

Understanding of the PHA, in its current state, is irrelevant to the wars we fight, has done very little if anything to improve medical readiness, and does not justify the cost – in time nor money. The general idea was that the five-year physical was too long of a gap for service members to go without seeing a doctor in an MTF. The PHA was designed to be a screening tool to gather readiness data quickly. Each service eventually created electronic medical readiness tracking systems, Army's MEDPROS, Navy's MRRS, and Air Force's Aeromedical Services Information Management System (ASIMS). These systems, coupled with the shift to conducting yearly face-to-face meetings with a healthcare provider, encompassed the new medical readiness program. While the DoD would be the ultimate beneficiary, the service member would receive the residual effects.

Unfortunately, neither party has received the promised benefit of this new readiness program because service members are not necessarily healthier, and the DoD is unable to decipher collected data to inform operational decision making. A 2015 RAND study highlights this point. Service members are at increased risk for misuse of energy drinks, have an elevated

level of binge drinking, and get less sleep than required, which is associated with several adverse health outcomes such as being overweight and obese as well as a discernable prevalence of depression, anxiety, and post-traumatic stress disorder.[15] The PHA policy calls for screening for these health risks and developing a health plan to improve health outcomes.[16] An issue presents because the medical provider screens the servicemember for adverse health behaviors but lacks a readily available avenue to identify how these behaviors affect mission readiness. The PHA system should be making the connection between individual readiness and readiness of the force. If artificial intelligence were better integrated into the readiness system, issues would be flagged to medical leaders and commanders in order to make informed decisions.

Looking to the past in order to understand the current military system will avoid a future of solipsistic justificatory patterns and behaviors. During the U.S. Civil War in 1862, long before high-reliability organizations, the fascination with the "Golden Hour," (a battlefield standard of reducing the time from injury to reaching a field hospital in 60 minutes or less) and the allure of managed care, Major Jonathan Letterman, a Union Soldier, was busy designing the Military Health System.[17] Major Letterman identified four priority areas that would benefit the soldiers in his care. The priority was to preserve the fighting strength by reducing infectious diseases.[18] The second unresolved problem was the inability to specifically direct soldiers to the appropriate surgeon and hospital.[19] A third issue was the disorganized logistics and chaotic

[15] Sarah O.Meadows, et al., Charles C. Engel, Rebecca L. Collins, Robin L. Beckman, Matthew Cefalu, Jennifer Hawes-Dawson, Molly Waymouth, Amii M. Kress, Lisa Sontag-Padilla, Rajeev Ramchand, and Kayla M. Williams, *2015 Department of Defense Health Related Behaviors Survey* (HRBS)(Santa Monica, CA: RAND Corporation, 2018), p. 86-122 https://www.rand.org/pubs/research_reports/RR1695.html.
[16] HA Policy 06-006, Periodic Health Assessment.
[17] Jonathan Letterman, *Medical Recollections of the Army of the Potomac* (New York: Applewood Books, 2008), 94-165.
[18] Letterman, Medical, p. 98
[19] Letterman, p. 65-66

process of casualty transport that did not fully support the surgical teams.[20] The final challenge identified by Letterman was the quality of care in treatment areas. This objectivity in his decision making and the adaptations he recommended could be construed as destructive change.[21]

In Major Letterman's case, he challenged the idea that only the Quartermaster should manage carriages, that troops should regularly bathe or that physicians could be task-organized from home station.[22] By looking uniquely at the problem, Letterman brought about the change required to propel the military health system forward. In his article on leading change, John Kotter summarizes the results of his research.[23] The most general lesson learned from the successful cases is that the change process goes through a series of phases that, in total, usually require a considerable length of time.[24] He also notes that skipping steps creates only the illusion of speed and never produces a satisfying result.[25] Another general lesson was that critical mistakes in any of the phases could have a devastating impact, slowing momentum and negating hard-won gains.[26]

Readiness

Readiness is a term widely used to describe various states of status across a variety of organizations. Major Letterman may have delineated it best for military medicine. When describing what he did for the MHS he stated, "…it is a popular delusion that the highest duties of medical officers are performed in prescribing a drug or amputating a limb. The true function

[20] Letterman, p. 125
[21] Letterman, p. 148
[22] Letterman, p. 178
[23] John P. Kotter, "Leading Change Why Transformation Efforts Fail," *Accountancy SA*09 (September 2017): 19-29.
[24] Kotter, "Leading Change," 19-29.
[25] Kotter, p. 26
[26] Kotter, p. 26

is to strengthen the hand of the Commanding General by keeping his army in the most vigorous health, thus rendering it in the highest degree efficient for enduring fatigue and privation, and for fighting."[27] The fundamentals initiated by Letterman, amplified over decades, illustrate the importance of this sentiment. The integration of medical administrators, which foreshadow a Medical Service Corps, medical specialization, detailed record-keeping, standardized logistical processes, coherent and expeditious process for evacuation and resuscitative care, and outcomes measurements, all spawned out of necessity. In essence, any actions that provide the commander with a medically ready force are tied to readiness.

Issues in medical readiness stem from a misunderstanding of the unique requirement. The MHS has two separate and distinct missions, readiness and benefit. The readiness mission strives to provide the commander with medically ready forces (including ready medical forces), while the benefit mission executes the service that generates medically ready forces. Most service members are only exposed to the benefit mission such as PHAs, vaccinations, fitness for duty assessments, and Personnel Reliability Program (PRP) exams. Operational commanders rarely understand how the two missions draw upon overlapping resources, inevitably creating a system of competition. For its part, the MHS focused heavily upon the reduction of beneficiary health care costs. While cost reductions temporarily satisfice senior leaders, very little appreciable value is provided to operational and tactical commanders.

Military forces are overly burdened with excessive tasks lending to medical readiness becoming a nuisance. A 2002 U.S Army War College study found the days required to complete all mandatory training directives "literally exceeds the number of training days available to company commanders. Company commanders somehow have to fit 297 days of mandatory

[27] Jonathan Letterman, *Medical Recollections of the Army of the Potomac* (New York: Applewood Books, 2008), p.100.

requirements into 256 available training days."[28] After the tragic 2017 deaths of ten Sailors aboard the USS *McCain* and seven aboard the USS *Fitzgerald,* then Navy Secretary Richard Spencer also addressed issues facing an overworked force. He identified the fundamental problem as a collision between a shrinking fleet, growing operational demands, and erratic funding for training and maintenance.[29] The Navy has been operating according to "false math… robbing Peter to pay Paul to get our missions done, and now the bills are coming home."[30] These examples exemplify the enormous pressure Soldiers, Sailors, Airmen, and Marines are under to be "administratively ready." Excessive medical readiness requirements that take time away from the limited training days reduce the very readiness it is meant to improve.

Suicides and attempted suicide are a debilitating readiness issue that continues to plague the force. This affects the member as well as their family and friends. A 2011 RAND report indicates that suicides disproportionately concentrate among lower ranks, but occur among all ranks.[31] It also identified that a substantial proportion of suicides in the Army and Marine Corps occur in theater, stressing the need for suicide prevention for deployed personnel.[32] Continuous analysis of risk factors and trends is essential to identify and address vulnerable military members. While the services have made considerable strides in trying to purge negative stigmas surrounding mental health treatment, emerging technologies can also be used.

Medical readiness spans all aspects of a service member's life. Consider the RAND study which identified issues with high energy drinks consumption. This information is not reported to

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[28] Leonard Wong and Stephen J. Gerras, *Lying to Ourselves: Dishonesty in the Army Profession (Carlisle Barracks, PA: United States Army War College Press, 2015),* p. 4

[29] *Sydney Freedberg JR., "*Overburdened Navy must just Say 'No': Spencer*, "Breaking Defense*, September 20, 2017, https://breakingdefense.com/2017/09/overburdened-navy-must-just-say-no-spencer/.

[30] Freedberg JR. "Overburden."

[31] Rajeev Ramchand, et al. T*he War Within: Preventing Suicide in the U.S. Military* (Santa Monica: CA, 2011), p.27 RAND Corporation. Accessed May 8, 2020. https://www.rand.org/pubs/monographs/MG953.html.

[32] Ramchand, et al, The War Within, p.27

the command; nevertheless, it affects operational readiness. Imagine the effectiveness of the medical provider if they noticed this trend, understood the link to depression and anxiety, and had a meaningful method to communicate this in readiness terms. The commander could then focus on educating the unit on the adverse effects of energy drinks as well as highlight the availability of mental health resources.

Creating ready medical forces is a complex issue for operational leaders as well as being problematic for medical leaders. A ready medical force represents personnel that are fully trained, experienced, and prepared to deploy in support of their wartime mission. The challenge for operational and medical leaders is that the language and ideas for medical readiness training almost exclusively belong in or are the result of institutional instruction. While addressing restructuring service medical treatment facilities to the DHA, Tom McCaffery, Assistant Secretary of Defense for Health Affairs said, "Military readiness includes making sure MTFs are operated to ensure service members are medically ready to train and deploy."[33] He went on to say, "It also means MTFs are effectively utilized as platforms that enable our military medical personnel to acquire and maintain the clinical skills and experience that prepares them for deployment in support of combat operations around the world."[34] Maintaining clinical skills in the MTF is valuable for the clinician, but cannot duplicate the operational experience. Operational commanders lack control over the MTF and, therefore, the training requirements which are integral to support of the wartime mission.

This is not to say that the DHA should not retain command and control of the MTFs or benefits mission. This author contends that emerging technology can close the gap between the

[33] "DoD to Restructure 50 Hospitals, Clinics to Improve Readiness, " Health.mil, February 19, 2020, http://health.mil/News/Articles/2020/02/19/DoD-to-restructure-50-hospitals-clinics-to-improve-readiness.
[34] "DoD to Restructure."

operational imperatives. Wearables like smartwatches, hearing aids, and skin patches could be used to increase the understanding of medical readiness while reducing the burden on the force. Telemedicine, particularly when used at the appropriate care level, could be the difference between medical evacuation and light duty. Additive manufacturing innovation and proficiency directly impact the readiness of the medical logistics chain, while virtual reality and simulation offer opportunities to simulate the clinical, operational environment.

Emerging Technology Potential Use

It is unimaginable to envision a future battle scenario where technology will not be integral. Philosopher Hans Jonas stated, "Modern technology touches on almost everything vital to man's existence – material, mental, and spiritual."[35] He went on to explain how an individual, institution, or society uses technology that determines how vital any technology becomes.[36] In the fall of 2017, President Trump announced his decision to accept Defense Secretary James Mattis' recommendation to elevate United States Cyber Command to a Unified Combatant Command in recognition of the growing centrality of cyberspace to U.S. national security and an acknowledgment of the changing nature of warfare.[37] Following the historical and current trends, medical leaders must embrace emerging technology and apply ethics throughout the development process rather than at the end-user.

Military operations present moral problems for the military medical professional that are not realized by their civilian counterparts. Military health leaders must reach for a higher moral standard, which can be described by what J. Carl Ficarrotta calls "*role-based*."[38] This *role,* as

[35] Hans Jonas, "Towards a Philosophy of Technology" in *Technology and Values: Essential Readings*, ed. Craig Hanks (Hoboken, NY: Willey-Blackwell, 2010), 5.
[36]Jonas, "Towards," 5.
[37] https://www.cybercom.mil/About/History/
[38] J. Carl Ficarrotta, *Kantian Thinking about Military Ethics,* (London: Routledge, 2010), p. 10

described by Ficarrotta, is voluntarily assumed and carries moral baggage.[39] While he concludes that there is little to no basis for requiring military members to be more morally insistent than others, this author believes that it is the standard. As leaders progress to the highest ranks, they must shoulder the added moral responsibility of their role, billet, or command. Technology cannot and will not solve every problem, and just because it is available it may not be the best solution in every situation. Therefore, it is the leader, not the technology, that must determine its ethical use.

Artificial Intelligence

Artificial intelligence (AI) is no longer on the horizon; it is intertwined with daily life. Email spellcheck, predictive Google searches, and virtual-assisted smartphone directions are improving the world around us. The layperson relies almost solely on the designers of these complex algorithms to incorporate ethics based on the lens of their knowledge and experiences. Technology users readily accept the terms and conditions without fully understanding them, assuming that the engineers, developers, and companies are looking out for their best interest. Military medical leadership cannot passively allow the engineers, coders, and programmers free rein because their scope of knowledge rarely encompasses the physiological, social, or ethical aspects of military care. As the MHS delves into uses of AI across the DoD, ethical guidelines should be developed and practiced.

As a function of medical readiness, the MHS must understand the technology-based ethical questions revolving around normative issues with the collection of massive amounts of data and the use of AI. Leaders are obligated to address the concerns that technology is biased and, creates or increases inequalities, which erodes the trust between the warfighter and the

[39] Ficarrotta, *Kantian Thinking, p.10*

health system.[40] Leaders within the MHS are being tasked to increase readiness while reducing cost through congressional mandates and service prerogatives. Developers of emerging technologies promise to solve whatever problem there is, making it more enticing for medical leaders to incorporate a commercial off the shelf solution. The problem is that these solutions do not account for uncertainty. The DoD is designed to anticipate an uncertain world, so its technology should be developed in the same manner.

Future development of AI for operational medical readiness must anticipate uncertain operating environments. In his study on nanoethics, Philip Brey uses the concept of *anticipatory technology ethics* (ATE).[41] He describes this as ethically anticipating possible future devices, applications, and consequences at the Research and Development and introduction stage of technology development.[42] In order to anticipate future ethical issues, the MHS must develop principles for development. Embracing the recently adopted Joint Artificial Intelligence Center's "*Ethical Principles for Artificial Intelligence*," the MHS specific principles should be:[43]

1. **Oversight** – AI augments the medical professional's knowledge, skills, and abilities. It is a decision support tool that requires human oversight.

2. **Transparency** - AI-enabled solutions must be developed in partnership with the warfighter. Through honest and informed dialogue between clinicians, administrators, policymakers, and service members, the MHS will address the various needs and concerns in the interest of national security.

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[40] Will Knight, "AI is Biased. Here's how Scientists are Trying to Fix It," *Wired, December* 19, 2019, https://www.wired.com/story/ai-biased-how-scientists-trying-fix/.
[41] Philip A. Brey, "Anticipatory Ethics for Emerging Technologies," *Nanoethics* 6, no. 1 (2012), 1-13.
[42] Brey, "Anticipatory," p.1
[43] "DOD Adopts Ethical Principles for Artificial Intelligence," U.S. Department of Defense, last modified February 24, 2020, https://www.defense.gov/Newsroom/Releases/Release/Article/2091996/dod-adopts-ethical-principles-for-artificial-intelligence/.

3. **Autonomy** - AI solutions will not impede service members ability to decide treatment rendered and care provided.

4. **Proactive** – AI capabilities will enable the MHS to anticipate health solutions that increase readiness across the force.

Wearable Technologies

Wearable devices have become synonymous with fitness and health due to their prevalence in recent years. Devices such as smartphones, activity trackers, and smartwatches have been widely embraced and have become almost inseparable from the human body.[44] These devices span the more common application of smartwatches and fitness trackers to smart clothing and electronic glasses. Military members have embraced this technology, almost ad nauseum. In late 2017, Strava, a social-fitness network, posted a global heat map that inadvertently identified classified military bases prompting the Pentagon to set guidelines for the force.[45] Wearables have incredible potential, while also presenting significant risks and privacy concerns.

The DoD should invest in the development of military-specific wearables that improve the readiness of the force while implementing operational security fundamentals. Wearables produced by Apple, Fitbit, and Garmin are examples of devices that are already in use, monitor aspects of health-related to readiness, and conduct constant monitoring. These devices collect vital information such as heart rate, number of daily steps, hours of sleep, and length and type of exercises. All of these are beneficial in determining the medical readiness of an individual. A

[44] Paul Lamkin, "Smartwatch Popularity Booms with Fitness Trackers on the Slide, " Forbes, February 22, 2018,https://www.forbes.com/sites/paullamkin/2018/02/22/smartwatch-popularity-booms-with-fitness-trackers-on-the-slide/.

[45] Liz Sly, "Military Stealth Undone by Fitbit," *National Post,* January 30, 2018. .

military-specific device would also hold individuals, unit leaders, and military medical professionals accountable in creating positive health-related outcomes.

Wearables can also have positive impacts on the battlefield and post-deployment. Imagine having the ability to simultaneously monitor a specific unit's vital statistics prior to, during, and after a military operation. Medical leaders could potentially identify service members who may have experienced or are experiencing post-traumatic stress and advise commanders accordingly. According to recent studies, higher heart rate and cortisol sensitivity in individuals who experience trauma, measured immediately after exposure, predict subsequent Post Traumatic Stress Disorder (PTSD) development.[46] There is also data that suggests that sleep impairment is a biomarker for PTSD. Sleep involves the attainment of a restorative state of diminished arousal in contrast with reacting to provocative stimuli with increased arousal as when in a firefight.[47] Early identification of troops dealing with PTSD directly impacts operational readiness.

Another readiness impact for wearables is in patient movement and tracking. Currently, the DoD's single patient tracking management system is Transportation Command Regulating and Command and Control Evacuation System (TRAC2ES). This system relies on several personnel conducting data input, usually in a chaotic operational environment. A wearable device worn by a service member such as a watch, band or another piece of uniform gear could collect data like oxygen levels, pulse, and blood pressure. This could then be linked to Radio

[46] Amit Shah, and Viola Vaccarino, "Heart Rate Variability in the Prediction of Risk for Posttraumatic Stress Disorder." *JAMA Psychiatry* 72, no. 10 (October 2015): 964-965. doi:10.1001/jamapsychiatry.2015.1394.
[47] Thomas Alan Mellman, "Reduced Heart Rate Variability during Sleep: A Candidate PTSD Biomarker with Implications for Health Risk: Commentary on Ulmer Et Al., "Posttraumatic Stress Disorder Diagnosis is Associated with Reduced Parasympathetic Activity during Sleep in US Veterans and Military Service Members of the Iraq and Afghanistan Wars,"" *Sleep* 41, no. 12 (December 1, 2018), p. 1-2 doi:10.1093/sleep/zsy249.

frequency identification (RFID) technology, already in use by the DoD for medical equipment, to globally track ill and injured patients.

Inevitably, there are ethical concerns about privacy, safety, and data management of any military-specific wearable devices. These concerns invoke questions such as where the service members' information is being stored, does the data belong to the member or the service, and are members tracked during liberty and leave and does it follow the member upon discharge. And while a goal of such a device or devices would be to influence health, there is also a question whether the collected data could influence a member's leadership billets, promotion, and geographic assignment potential. This veers into the ethics principle of equity. This principle involves providing people with the means to attain equal opportunities based on their circumstances. In this context, a staff officer at an operational level command may not get near as much activity, exercise, or steps as another officer attending duty under instruction, such as a war college, but it should not equate to which officer would make a better leader. However, the use of collected data in determining promotions or geographic assignment does not automatically equate to inequities. Inequity refers to variances, which are unnecessarily avoidable, but also are considered unfair and unjust.[48] It remains crucial that leaders continue to examine the context of use and engage in the ethical development of any military-specific wearable to avoid any inequities and minimize issues with data management.

An inherently more significant ethical concern revolves around the capacity for a Soldier, Sailor, Airman, or Marine to give bona fide informed consent. The importance of informed consent in medical ethics is a core issue for any emerging technology development, yet a hierarchical military structure truly impacts the service member's capacity to consent. For

[48] Margaret Whitehead, "The Concepts and Principles of Equity and Health," *International Journal of Health Services* 22, no. 3 (January 1, 1992): 429-445, doi:10.2190/986L-LHQ6-2VTE-YRRN.

example, the DoD's aviation community has identified a military requirement to keep pilots, particularly those flying single-seat aircraft, awake and focused during missions.[49] Unlike a standard command operations center, pilots do not have ready access to a coffee percolator. The solution is in a medically modified amphetamine known as "go pills."[50] The policy outlines a set of tenets with one of them being, "Prior to using dextroamphetamine, each pilot must read and sign a detailed informed-consent agreement to ensure sufficient knowledge about both the positive and potentially negative effects of the medication. Failure to obtain documented informed consent precludes the operational use of the drug for that individual."[51] What happens if a pilot does not consent to take the drug? It can be assumed that command pressure, whether overt or inadvertent, informs the pilot's consent; if they are unable to fly, they may be ranked below their peers.

Military specific wearables will challenge the peripherals of consent. The enlistment contract states, "I understand that many laws, regulations, and military customs will govern my conduct and require me to do things under this agreement that a civilian does not have to do."[52] This statement implies that consent may not be required because the signer is giving agency away.[53] Highlighting this conflict is the military's controversial anthrax policy. Although litigation has altered the current program, the policy's original statement mandated inoculation.[54] Shortly after the implementation of the program, troops experienced debilitating side effects,

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[49] John A. Caldwell, "Go Pills in Combat: Prejudice, Propriety, and Practicality," *Air & Space Power Journal* 22, no. 3 (2008): 97-104,127.
[50] Caldwell, "Go Pills," p. 97
[51] Caldwell, "Go Pills," p. 102
[52] DD FORM 4/1, OCT 2007.
[53] Stanford Encyclopedia of Philosophy describes Agency in the following terms: an agent is a being with the capacity to act, and 'agency' denotes the exercise or manifestation of this capacity.
[54] Lee Black, "Informed Consent in the Military: The Anthrax Vaccination Case," *The Virtual Mentor:VM* 9, no. 10 (October 1, 2007): 698-702, doi:10.1001/virtualmentor.2007.9.10.hlaw1-0710.

causing some to refuse the vaccination.[55] This led to discharges and punishments that negatively affected careers.[56] We must learn from these past missteps and ensure that ethics are embedded in the future.

United States Food and Drug Administration (FDA) approval will likely influence the implementation of wearables in the future. The FDA currently has a broad scope of digital health technologies that include wearable devices, telehealth, and telemedicine.[57] The FDA's Center for Devices and Radiological Health is focusing on the convergence of medical devices with connectivity and consumer technology.[58] Dexcom, a glucose monitor device maker, is the biggest name in FDA-regulated wearables. Despite not producing a wearable, they are partnering up with companies like Apple and Fitbit to provide data.[59] Military wearables would also need to connect with the MHS in order to affect medical readiness. This is where telehealth will support the operational readiness mission.

Telehealth

Telemedicine in and of itself is not necessarily emerging technology as much as the artificial intelligence that influences it. Telemedicine's first use can be traced to the late 1950s when a closed-circuit television link was established between the Nebraska Psychiatric Institute and Norfolk State Hospital for psychiatric consultations.[60] This technology has successfully been used to improve patient access to care while reducing healthcare costs by replacing the

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[55] Black, "Informed Consent," p. 699
[56] Black, "Informed Consent," p. 701
[57] "Digital Health," U.S. Food & Drug Administration, accessed May 6, 2020, https://www.fda.gov/medical-devices/digital-health.
[58] "Digital Health."
[59] Husain Sumra, "How FDA Approval Affects Your Wearables, and how it's Going to Change," Wearable, January 17, 2018, https://www.wareable.com/wearable-tech/fda-wearables-state-of-play-239.
[60] Services, Board on Health Care and Institute of Medicine, *The Evolution of Telehealth: Where have we been and Where are we Going?* (Washington, D.C.: National Academies Press, 2012), https://www.ncbi.nlm.nih.gov/books/NBK207141/.

traditional face-to-face way of providing medical care (e.g., face-to-face consultations or examinations between provider and patient).[61] In 2016, an estimated 61 percent of U.S. healthcare institutions and 40 to 50 percent of U.S. hospitals used telemedicine.[62] The MHS must evaluate how to integrate the use of telehealth into medical readiness effectively.

Telemedicine is only a subset of telehealth, the latter having more implications in operational readiness. According to the World Health Organization, telehealth includes "Surveillance, health promotion, and public health functions."[63] Telemedicine and telehealth are sometimes used interchangeably and synonymously; however, for this paper, we will use telehealth since it refers to a broader scope of remote healthcare services than telemedicine. Telemedicine also has connotations of service delivery by physicians only, while operational readiness cannot continue to be constrained by garrison concerns.[64] This technology must be developed to include all health professionals engaged in medical readiness, including Hospital Corpsmen, medics, Environment Service Officers, psychologists, and others.

Of benefit to mission readiness is the freedom that telehealth provides to affect health outcomes globally. This is particularly vital in the operational environment where access to a specialist or diagnostic capabilities is limited yet could be the difference between light-duty and medical evacuation or life and death. The armed services have had an interest and involvement in both mobile health and telemedicine services for some time. Advanced telecommunications technology was used in conjunction with mobile health units during the operations in the Middle East, demonstrating that these two technologies can be integrated, even under difficult

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[61] https://www.medicaid.gov/medicaid/benefits/telemedicine/index.html
[62] Jamal H. Mahar, James Gregory Rosencrance, and Peter A. Rasmussen, "The Future of Telemedicine (and What's in the Way),"ConsultQD, accessed April 28, 2020, https://consultqd.clevelandclinic.org/the-future-of-telemedicine-and-whats-in-the-way/.
[63] WHO Global Observatory for eHealth, *Telemedicine: Opportunities and Developments in Member States: Report on the Second Global Survey on eHealth (*Geneva: World Health Organization, 2010).
[64] WHO, *Telemedicine.":*

geographic and climatologic circumstances, with beneficial effects.[65,66] In 2011, the Service Members Telemedicine and eHealth Portability (STEP) Act, removed the federal requirement that healthcare is delivered in a military facility.[67] Since then, the MHS has expanded telehealth options to include patient portal messaging, nurse advice lines, and telephone consults. However, these programs are garrison-care centered and often underutilized by the Joint Force. Designing a better graphical user interface as well as pushing this to the operational Corpsmen and medics should be a priority since these are the health providers that best understand challenges to individual and unit medical readiness.

Implementation of telehealth to help manage readiness at the unit level can extend to health management in combat environments. A study on aeromedical evacuations during Operation Iraqi Freedom (OIF) underscores this. Over one month in 2003, 6.9 percent of aeromedical evacuations were for psychiatric reasons, while historically psychiatric patients are usually less than 10 percent of all patients evacuated.[68] This study goes on to suggest that healthcare providers and commanders had to make decisions on evacuation with incomplete information. Providers, commanders, and service members would benefit from telehealth technology in these environments because at-risk personnel might quickly be identified using wearables, and appropriate treatment modalities could be started through telemedicine. A service like this could keep a soldier with his or her unit while also decreasing the number of deployed non-combat personnel.

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[65] MichaelCawthon, et al., "Preliminary Assessment of Computed Tomography and Satellite Teleradiology from Operation Desert Storm," *Investigative Radiology* 26, no. 10 (October 1991): 854-857, doi:10.1097/00004424-199110000-00002.

[66] R E Spiller, Jr,, J. W. Hellstein, and P. J. Basquill, "Radiographic Support in Highly Mobile Operations," *Military Medicine* 155, no. 10 (October 1990): 486-489, doi:10.1093/milmed/155.10.486.

[67] Eric Wicklund, "DoD Expands Telemedicine Access for Military, Families," mHealth Intelligence, February 5, 2016, https://mhealthintelligence.com/news/dod-expands-telemedicine-access-for-military-families.

[68] William W. Hurd and William Beninati, (ed.) *Aeromedical Evacuation: Management of Acute and Stabilized Patients* 2nd ed.(New York: Springer, 2019)..p. 391

Operational readiness extends beyond the Joint Force, and telehealth can bridge gaps with the civilian health system, interagency organizations like the Department of Veteran's Affairs and Department of State, as well as with foreign allies and other partners. The future of military operations will not only involve the United States, as former Secretary Mattis stated, "Our allies and partners came to our aid after the terrorist attacks on 9/11, and have contributed to every major U.S.-led military engagement since."[69] Usually, the deployed MTF is the only healthcare available or the best option for care in the operating area, yet there is not a system in place for medical staff to review pertinent medical records or contact relevant non-trauma specialists (i.e., cardiologist, internal medicine, etc.). The use of telehealth could greatly benefit this effort. In addition, it could also foster a better deployment screening process for non-military members that will provide the military care team and the commander with pertinent information. This leads to better decision making across the spectrum of operations.

Physicians believe that ethical concerns about telehealth center on the patient-physician relationship. The American Medical Association's Code of Medical Ethics states that "A patient-physician relationship exists when a physician serves a patient's medical needs."[70] Doctors have been taught to lean on this guideline to require encounters tacitly. Despite a presumptive value of face-to-face encounters, the benefit of telehealth is to improve access to care for the warfighter, provide a knowledge resource for the collective medical community, and aid in the commander's decision-making process. The military community cannot be held hostage to outdated ideas and policies that impede modalities which improve the quality of care.

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[69] Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America* (Washington, DC: Department of Defense, 2018), https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

[70] American Medical Association,"Patient-Physician Relationships," accessed May 8, 2020, https://www.ama-assn.org/delivering-care/ethics/patient-physician-relationships.

Another ethical concern is patient privacy. Telemedicine should not create greater concerns about risks to privacy because it is subject to the Health Insurance Portability and Accountability Act (HIPAA) regulations.[71] Furthermore, telemedicine is increasingly being seen as a means to facilitate the Patient-Centered Medical Home (PCMH) model, which is integral to the MHS vision of medical readiness.[72] However, the privacy of patients and their data should remain a priority as the MHS expands telehealth in the operational domain and maintain the same security measures as in-patient visits. Security issues are more operational than ethical, in as much as new encryption and security tools to protect information continue to proliferate.

Additive Manufacturing

Additive manufacturing, also known as 3-D printing, might not immediately seem to have importance in the medical readiness discussion, yet if developed appropriately, its benefits will be actualized. Currently, in the health care setting, additive manufacturing is broken down into four major applications:

1. Replacing human organs
2. Increasing the speed of surgical procedures
3. Production of inexpensive surgical tools
4. Improving the lives of those reliant on prosthetic limbs.[73]

[71] Timothy M. Hale and Joseph C. Kvedar, "Privacy and Security Concerns in Telehealth," *AMA Journal of Ethics* 16, no. 12 (December 2014): 981-985,doi:10.1001/virtualmentor.2014.16.12.jdsc1-1412.
[72] , Cynthia LeRouge and Monica J. Garfield, "Crossing the Telemedicine Chasm: Have the U.S. Barriers to Widespread Adoption of Telemedicine been significantly Reduced?, " *International Journal of Environmental Research and Public Health* 10, no. 12 (12, 2013): 6472-84.
[73] Allie Nawrat, "3D Printing in the Medical Field: Four Major Applications Revolutionizing the Industry" Verdict Medical Devices, August 7, 2018, https://www.medicaldevice-network.com/features/3d-printing-in-the-medical-field-applications/.

In the operational medical environment, leaders have countless possibilities for additive manufacturing. Using comparable categories, operational medicine can create significant application areas. An example might be:

1. Medical Logistics
2. Printing of blood and blood products
3. Medical Training

Additive manufacturing can provide the capability to deliver task-oriented, tailored operational readiness solutions for the Joint Force.

Military medical logistics is critical in any operational environment. The current system is biased to the provider's requests and operational leadership demands. A recent report on lessons from Operations Enduring Freedom and Iraqi Freedom indicated that medical material had low transportation priority, medical supplies were left behind in order not to affect movement of other resources, and providers lacked knowledge of military procedures.[74] During those operations, provider preference added more considerable strain on the medical logistics system by continually increasing the weight requirements of forward resuscitative capabilities.[75] For example, the Forward Resuscitative Surgical System increased from 1,040 pounds and 128 cubic feet in 2002 to 8,511 pounds and 957.11 cubic feet in 2012.[76] Additive manufacturing can mitigate issues with ordering, storage, and transportation of medical materiel.

Additive manufacturing can also mitigate issues with biomedical repair. In austere operational environments, it is not feasible to have several replacement parts for critical

[74] Mark J. Dole and Jonathan M. Kissane, "Medical Logistics Lessons Observed during Operations Enduring Freedom and Iraqi Freedom," *U.S. Army Medical Department Journal*, no. 2-16 (Apr, 2016): 119,. https://www.ncbi.nlm.nih.gov/pubmed/27215878.
[75] Dole and Kissane, "Medical Logistics," 199.
[76] Christian Miller, "Forward Resuscitative Surgical System AMAL 645 Review." Quantico, VA, January 12, 2012

equipment. This could be due to high cost, abated shelf-life, or complications in supply chain management. Using additive manufacturing technology, medical leaders can provide the commander with options and decision space. Parts for medical equipment that would typically take days or weeks can be replaced in hours at a fraction of the cost.

Plastic and metal are not the only material that can be shaped through additive manufacturing. Printing with human mesenchymal stem/stromal cells (hMSCs) is already being tested.[77] Blood and blood products are critical to saving lives in the operational environment. During Operation Iraqi Freedom, the austere environment combined with a relatively short 12-day shelf life of blood products stressed the blood distribution chain.[78] Bioprinting living tissue on the battlefield will revolutionize blood distribution.[79] Printing during military operations will benefit the warfighter, but the benefit extends to the training environment in preparing medical professionals for operations.

Additionally, additive manufacturing can increase ready medical forces through live tissue training. An integral part of readiness is training, so it would be unethical to limit the use of bioprinting to the battlefield. Corpsmen and medics are the first medically trained responders in military operations. Many times, Corpsmen and medics have not seen the scope of traumatic injuries that are seen on the battlefield. To better train these frontline responders, the DoD created "Goat Labs" which spurred controversy because goats, pigs, cats, and other animals were

[77] Kim Hyerim et al., "Mesenchymal Stem Cell 3D Encapsulation Technologies for Biomimetic Microenvironment in Tissue Regeneration," *Stem Cell Research & Therapy* 10, no. 1 (Feb 7, 2019): 51, doi:10.1186/s13287-018-1130-8.
[78] Maria F. Johnson,"Combat Blood Operations in Iraq: Army Logistician," *Army Logistician* 37, no. 6 (2005): 26-27.
[79] David B. Kolesky et al., "Three-Dimensional Bioprinting of Thick Vascularized Tissues," *Proceedings of the National Academy of Sciences of the United States of America* 113, no. 12 (Mar 22, 2016): 3179-84, doi:10.1073/pnas.1521342113.

injured and killed in order to prepare for war.[80] Due to the ethics of this program and congressional pressure, the Department effectively ended live tissue training for the force.[81] Additive manufacturing provides an avenue to enable realistic training by bioprinting living cells with trauma wounds. The ready medical force can use this in combination with other technologies to be better equipped in dealing with the range of traumatic injuries they will encounter, therefore increasing operational readiness.

Simulation, Virtual and Augmented Reality

Almost all MHS initial training programs incorporate some level of simulation. This includes the U.S. Army's Combat Medic (68W) and the U.S. Navy's Fleet Marine Force Corpsmen to the Graduate Medical Education programs at the Uniformed Services University. Simulation in medicine can be traced back to the aviation industry, which utilized simulation-based learning to train pilots after World War One.[82] Other areas where we find simulation in the MHS is in Basic Life Support and Advanced Cardiovascular Life Support training with manikins in addition to patient evacuation and infectious disease modeling. Medical simulation not only allows for safe training and experiential learning, but it also permits personnel to engage in actions deemed too dangerous to practice yet may be required in real-world scenarios (e.g., corpsman in prolonged field care conducting a decompressive craniectomy or Endoscopic Third Ventriculostomy). As the MHS continues to pursue a culture shift towards being a high-reliability organization (HRO), leaders must not only mimic other HROs but incorporate ethics specifically into healthcare.

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[80] Adam Linehan, "A Goat Helped Me Save My Buddy, and Others, on the Battlefield," *New York Times* July 6, 2016.

[81] *Use of Animals in DOD Conducted and Supported Research and Training* Office of the Under Secretary of Defense for Research and Engineering, 2019).

[82] Kathleen R. Rosen, "The History of Medical Simulation." *Journal of Critical Care* 23, no. 2 (2008): 157-166, doi:10.1016/j.jcrc.2007.12.004.

High-reliability organizations require high-reliability leaders. The MHS organizational structure complicated its readiness mission. Exacerbated by unclear governance, inconsistent protocols and multiple chains of command also weakened operational medical leaders' authority and reliability. Dissimilar to well-known HROs like the aviation industry, aircraft carriers, and electrical power grids, the MHS is currently not focused on the basis of its organization – the executors. While improved access, patient safety, and patient engagement are supremely essential and required in HROs, it does not impact operational readiness in the generation of ready medical and medically ready forces.[83] The MHS's understanding of HRO is focused on a Joint Commission approach, a nonprofit organization that accredits healthcare organizations yet does not regulate the operational environment. Operational medical leaders will indeed face complex ethical decisions, decisions that should be experienced before having to make them. These experiences can be simulated using virtual and augmented reality software.

The terms "virtual reality" (VR) and "augmented reality" (AR) are becoming common phrases because of the proliferation of gaming headsets and smartphone applications like the international phenomenon "Pokemon Go." While the terms are used interchangeably, they are not the same. Therefore, before use in operational medicine environments, they will require ethical review. The Franklin Institute classifies VR as a complete immersion experience that shuts out the physical world.[84] In contrast, AR simply uses a device's camera to add digital elements to a live view.[85] Military medical leaders must evaluate and implement both aspects of the technology appropriately to increase force readiness.

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[83] "Advancement Toward High Reliability in Healthcare Awards Program," Health.mil, accessed May 17, 2020, https://armymedicine.health.mil/MHSHome/Military-Health-Topics/Access-Cost-Quality-and-Safety/Quality-And-Safety-of-Healthcare/Patient-Safety/Quality-Patient-Safety-Awards.
[84] Nancy Gupton, "What's the Difference between AR, VR, and MR?," The Franklin Institute, accessed May 19, 2020, https://www.fi.edu/difference-between-ar-vr-and-mr.
[85] Gupton, "What's the Difference."

Virtual reality and augmented reality technology are a requirement for ethical medical leaders. Over two decades ago, the General Accounting Office reported, "Military medical personnel has almost no chance during peacetime to practice battlefield trauma care skills."[86] In late 2019, a nine-month-long investigation by *U.S. News* revealed that surgeons and surgical teams lack skills required for the battlefield.[87] The basic concept for VR is to create a realistic pseudo-environment providing the user with visual, auditory, and haptic feedback.[88] This means that VR completely takes over your vision to give you the impression that you are somewhere else. Augmented reality simulates the surrounding environment by overlaying stimulation to induce the user to act.[89] Medical leaders must understand the range of ethical dilemmas presented on the battlefield and harness the capabilities of VR and AR to develop medical professionals. Healthcare professionals must be introduced to these ethical dilemmas in peacetime in order to be better prepared in war. VR and AR are the bridge to close the readiness gap of the medical force.

Increased cost and political restrictions are creating insurmountable challenges to current training methods. For example, the Army conducts "*Global Medic,*" a large-scale medical exercise, twice per year.[90] This exercise was initially funded for three times per year, but has been reduced due to budgetary constraints.[91] Additionally, political pressure from special

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[86] , G.Moses, J. et al., "Military Medical Modeling and Simulation in the 21st Century," *Studies in Health Technology and Informatics* 81, (2001): 322-328.
[87] Steve Sternberg, "A Crack in the Armor: Military Health System Isn't Ready for Battlefield Injuries,"USNews,October 10, 2019https://www.usnews.com/news/national-news/articles/2019-10-10/military-health-system-isnt-ready-for-battlefield-injuries.
[88] Kenneth V. Iserson,"Ethics of Virtual Reality in Medical Education and Licensure" *Cambridge Quarterly of Healthcare Ethics* 27, no. 2 (April 2018): 326-332, doi:10.1017/S0963180117000652.
[89] Iserson, "Ethics of Virtual Reality \,"326-332.
[90] Daniel Wasserbly, "'Global Medic' Exercise Tests Wartime Medical Skills," *International Defence Review* 45, no. 7 (2012): p.1-2
[91] Office Chief of Army Reserve, "Stand-to!" Army.mil, accessed May 20, 2020, https://www.army.mil/standto/archive_2018-11-14/.

interest groups has shut down the Department's live tissue training.[92] The DoD has updated its policy to state, "In accordance with Section 718 of Public Law 115-232, medical simulation technology will be used to the maximum extent practicable, before the use of live tissue training to train medical professionals and combat medics…"[93] Combining VR, AR, and simulation will meet these challenges head-on and increase operational readiness.

Establishing joint medical simulation centers which standardize required competencies are a function of medical readiness. These centers could be engineered to provide fully immersive learning in operationally relevant healthcare settings. Amalgamating high-fidelity manikins with novel scenarios and virtual workbenches creates a risk-free learning environment. This will transform and bolster medical training from self and buddy-aid to forward trauma surgery. Field care (i.e., treatment of patients) is not the only benefit of this new training environment. Healthcare leaders should also pivot towards intangibles like medical logistics, disease and non-battle injuries, and patient movement.

To truly build ready medical forces, the whole operational medical enterprise must be trained in their specialty area. For instance, mass casualty drills/exercises are usually cost-prohibitive to conduct, yet when they are funded, most of the after-action reporting is focused on timing and triage. This leaves out the lessons that could be learned by medical logistics personnel and medical planners. Questions such as: are the authorized medical materiel adequate, how would resupply work in a prolonged care scenario, do we have the correct mix of professionals for a given mission set – are never addressed or answered. Virtual and augmented reality can get the medical support professionals operationally ready by having them engaged in

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[92] Zachary Toliver, "PETA Slams Trauma Training on Animals in Top Military Journal," last modified April 19, 2018,https://www.peta.org/blog/peta-slams-military-trauma-drills-animals/.

[93] *Use of Animals in DOD Conducted and Supported Research and Training* Office of the Under Secretary of Defense for Research and Engineering, 2019).

the scenario to practice tactics, techniques, and procedures. Historically, diseases and non-battle injures far exceed combat-related injuries, yet there is limited ability to prepare the preventive medical technicians, environmental science officers, and entomologists for military missions.[94] An AR simulated scenario could be used to practice managing and reporting diseases and non-battle injures in order to test across the specialties the operational healthcare system.

As the military develops VR and AR, leaders must continually consider the ethical complexities that this new technology presents. The ethical implications include cognitive, physiological, and behavioral effects. U.S. Army's Medical Research and Development Command is the current joint solution for coordinating emerging military simulation research.[95] Several programs will address operational readiness gaps for the MHS. Below are the relevant programs:

- **Joint Evacuation and Transport Simulation (JETS)**: S*tandardized Joint Patient Movement simulation training capabilities by replicating the chain of evacuation.*
- **Point of Injury Training System (POINTS)**: *Point of Injury (PoI) training capabilities to sustain and improve first responders and combat medical skills to support a disbursed multi-domain battlefield.*
- **Warfighter Performance, Resilience, Effectiveness, and Protection (WarPREP)**: *A future concept program to develop tools to deter skills degradation, enhance medical capabilities, and increase patient protection and pre-intervention rehearsal.*

[94] Barbara E. Wojcik et al., "Data-Driven Casualty Estimation and Disease Nonbattle Injury/Battle Injury Rates in Recent Campaigns," *U.S. Army Medical Department Journal*, no. 2-16 (Apr, 2016): 8, https://www.ncbi.nlm.nih.gov/pubmed/27215860.
[95] *Joint Program Committee-1 (JPC-1)Medical Simulation and Information Sciences (MSIS) Research Program BAA* (Washington: Federal Information & News Dispatch, LLC,[2018]).

- **Theater Hospital Operations Replication (THOR)**: *A future concept program to develop in-theater, Role 2, and Role 3 simulation training capabilities; deliver rapid deployment of prepared and skilled medical teams, task forces, and theater hospitals.*[96]

Nowhere on the website does it mention ethics or the ethical development of these capabilities. There is no indication of how the organization is thinking about "foreseeable use" versus "intended use." Trying to fix ethical issues on the back end is not sustainable.

Conclusion

The Department's health services are unique in that they are integral in every aspect of military operations. Joint Force medical professionals can be found on nearly every military platform and leadership level from submarines to infantry to aircraft. While not every military mission will necessitate the use of all warfighting functions (e.g., usually no fires in humanitarian missions), there are no missions that are executed that do not have medical considerations. These missions range from special forces reliance upon conventional medical forces for trauma management, to humanitarian assistance and disaster relief missions, which always have public health concerns, and to large-scale military campaigns that require forward resuscitative care. Even with these truths, emerging medical technologies will not be a panacea in mending the broken trust between the MHS and warfighter.

All technologies presented are dual-use and have implications across the range of military operations. The technologies brought forth in this paper can provide competitive advantages that enhance the commander's decision-making calculus by providing medically ready forces and ready medical forces. It is up to the Department to harness the depth and sophistication of its

[96] *Joint Program Committee-1 (JPC-1)Medical Simulation and Information Sciences (MSIS) Research Program BAA* (Washington: Federal Information & News Dispatch, LLC,[2018]).

established technological research programs. Organizations such as the Health Readiness Center of Excellence at Joint Base San Antonio, the U.S. Army's Medical Research and Development Command and the U.S. Army Research Institute of Environmental Medicine all are engaged in developing emerging medical technologies. Senior leaders must factor in not just how advances in technology pose security concerns but the ethical concerns that will impact the trust of the warfighter, the medical professionals, and the civilian population.

Recommendations

A review of the ethics in implementing emerging medical technologies begins with evaluating and developing ethical leaders. In order to employ emerging medical technology in the operational environment, military medical leaders should take actions to create a culture that embraces and understands ethics as well as develop and strengthen partnerships with operational leaders and civilian institutions. Ethics and technology education must be continuous across the range of military operations and from the operator to the commander in order to maintain agility in the infinitely changing technological landscape.

In addition, this report recommends further work to:

1. Develop policies that enable the ethical use of emerging medical technologies in the operational environment.

2. Request the establishment of a functional combatant commander for health services. The health service mission is too vital to national security to continue the current pick-up game. Medical readiness would be better managed and controlled by a medical operational commander that thinks globally.

3. Establish talent management strategies to train and retain personnel capable of managing technologies within the MHS. This will alleviate the medics, corpsmen, and nurses from attempting to manage technologies that they are not trained for and detract from care.

4. Bolster the operational demand for emerging medical technologies by developing applications that add value to the operational commander.

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