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Review article

DIGITAL TRANSFORMATION IN MILITARY MEDICINE AND PHARMACY - KEY ASPECTS AND CHALLENGES

Antonio Ivanov[1,2], Evgeni Grigorov[1,3], Ivan Popivanov[1]

1) Department of Military Medicine, Military Medical Academy, Sofia, Bulgaria.
2) Department of Organization and Economics of Pharmacy, Faculty of Pharmacy, Medical University Sofia, Bulgaria.
3) Department of Organization and Economics of Pharmacy, Faculty of Pharmacy, Medical University - Varna, Bulgaria.

ABSTRACT

Purpose: Digital transformation, as a modern phenomenon, encompasses almost all areas of life, including military medicine and pharmacy. This study aims at reviewing the historical development and key aspects and challenges in the modern process of applying digitalization technologies in the structures of the armed forces.

Material/Methods: Review of the Google Scholar database and websites of governmental institutions was performed to identify the most prominent areas where digital transformation is utilized.

Results: We have identified that the use of such technologies can take place in the theatre of war itself, mainly through telemedicine, contributing to reduced costs, enhancing medical evacuations and lowering mortality. On the other hand, the other main implementation is in peacetime where trends are aimed at providing more efficient health and pharmaceutical care to servicemembers and veterans, as well as conducting in-depth analyses of military medical supply and crisis response preparedness. While an appropriate population due to its centralized management and hierarchy, there are several challenges to digital technology implementation in the military. These include administrative hurdles, policies, and the need for specific digital products that meet stringent cybersecurity and secrecy requirements.

Conclusions: Despite military medicine and pharmacy being pioneers in implementing digital technologies starting in the 60s, there are signs of delayed digital transformation relative to the civilian population, need to address challenges more effectively, and a need of military-customized digital solutions.

Keywords: military medicine, military pharmacy, digital transformation, telemedicine, medical supply, e-learning,

BACKGROUND

Due to the rise in computing power and their compact sizes modern computers and digital technologies are becoming essential elements in every aspect of life. In parallel to this scientists and engineers develop interconnected computer networks which are the foundations of the Internet. [1] The modern state of these includes smartphones and various wearables which can track various body parameters as well as Web 2.0 which describes the higher interoperability and transformation to more user-generated content. With that much of the information flow becomes digitalized. The advantages of these technologies are enormous – the ability to access and share the information remotely and even worldwide, easier and faster data processing and analysis, and many others. On the other hand, there are challenges as well – difficulties to operate without proper education, risks for cybersecurity and data protection rules. [2]

One of the key elements in the future of digitalization is the use of artificial intelligence (AI). This is a rapidly evolving field of computer science that aims to create machines that can perform tasks that typically require human intelligence. Developed in 1951 mainly as an academic research topic, modern AI includes various techniques such as machine learning (ML), deep learning (DL), and natural language processing (NLP) which help machines to overperform. [3] The Internet of Things (IoT) is another emerging paradigm which encompasses a system of wireless, interrelated, and connected digital devices that can collect, send, and store data over a network without requiring human-to-human or human-to-computer interaction. These developments provide a great opportunity for health care systems to proactively predict health issues and diagnose, treat, and monitor patients both in and out of the hospital. [4]

The military science has always been a pioneer in the creation and use of digital technologies. The Cold War was a prominent driver for implementation of the idea for connected computers by Paul Baran (RAND Corporation) and further developed by the Advanced Research Projects Agency (ARPA) within the Department of Defense (DoD).

In 1972 the latter created ARPANET - the first wide-area packet-switched network with distributed control and one of the first computer networks to implement the TCP/IP protocol suite. [5] The first occurrence of telehealth services in the army was in the 1960s when the Massachusetts General Hospital (MGH) implemented a telecommunication connection with the Veterans Administration Hospital in Bedford, Massachusetts. This was established via interactive television microwave link and provided telepsychiatry services that continued to operate until the mid-1980s. Later, the U.S. Public Health Service and the Department of Defense sponsored a series of teleradiology projects in the 1970s and 1980s. These projects led to the collaborative Digital Imaging Network Project to promote the development and implementation of civilian and military teleradiology. [6]

Nowadays, the digital transformation in military healthcare is continuously evolving which can be seen from strategies and procedures like the Military Health System's Digital Transformation Strategy (MHS DTS). Its mission is to achieve digitally enabled ready medical force together with infrastructure that maximises automation, augmentation and amplification of digital assets and capabilities through AI integration and development of digital care and self-care models. [7]

Our review aims at determining key areas of healthcare in military operations both in war and peacetime settings where digital transformation can play part and the challenges that this process can have.

We have performed a review of Google Scholar database using the following criteria:

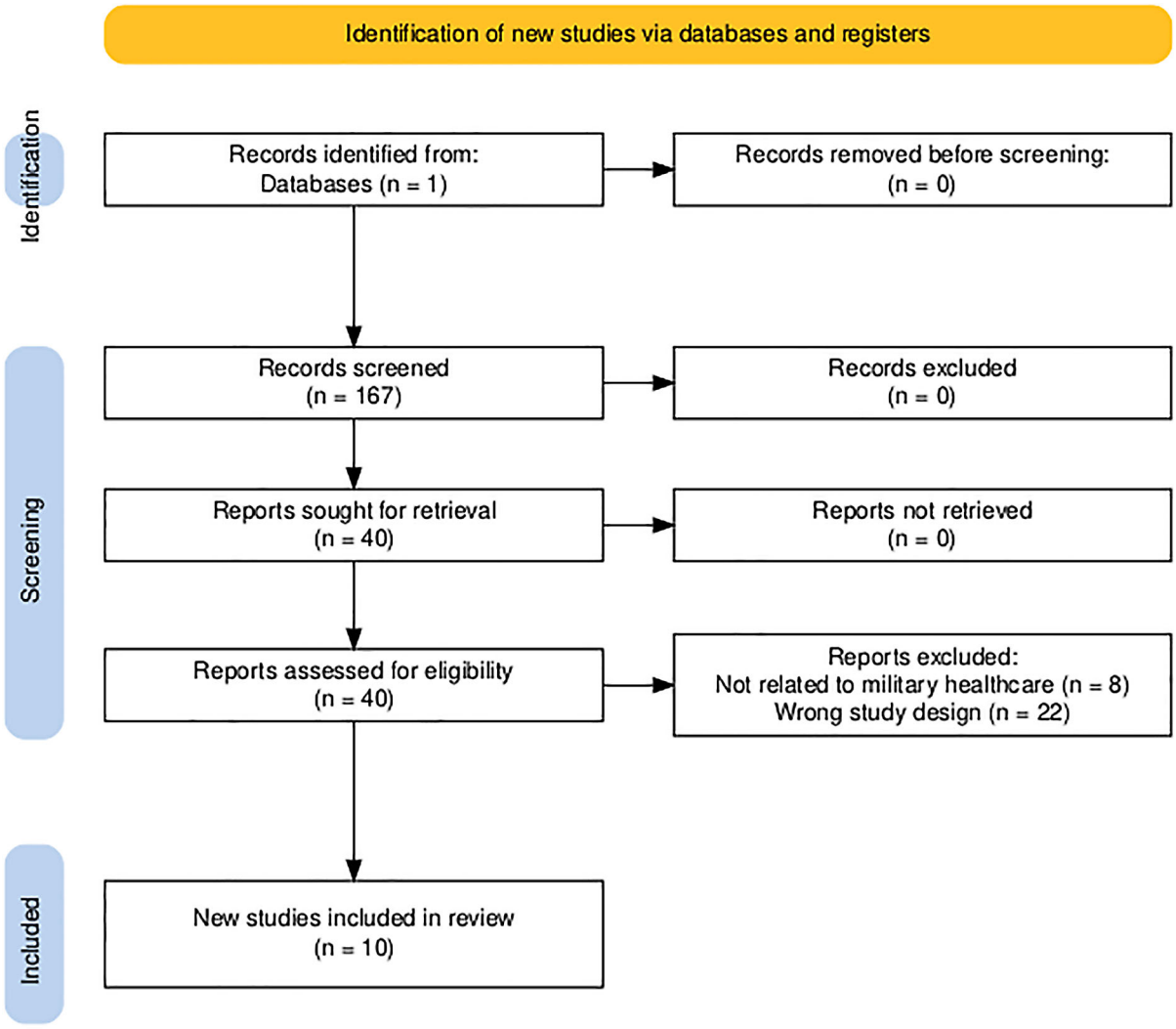
• Keywords in the whole text of the article - ("digital health" OR "digital transformation") AND ("military medicine" OR "military healthcare" OR "military pharmacy")

• Timeframe for publishing – 2020 to 2024

• Type – Review article

This search generated 167 results which were subjected to abstract screening for determining relation with the topic. Total of 40 articles were identified for further whole text reading and eligibility assessment and 10 have been included in the review. Numerous sources identified during the screening of citations in the selected articles from initial sources were explored further and incorporated into the review results. The primary research method used was combined documental and content analysis. (Figure 1)

Fig. 1. Flow Diagram for the review.

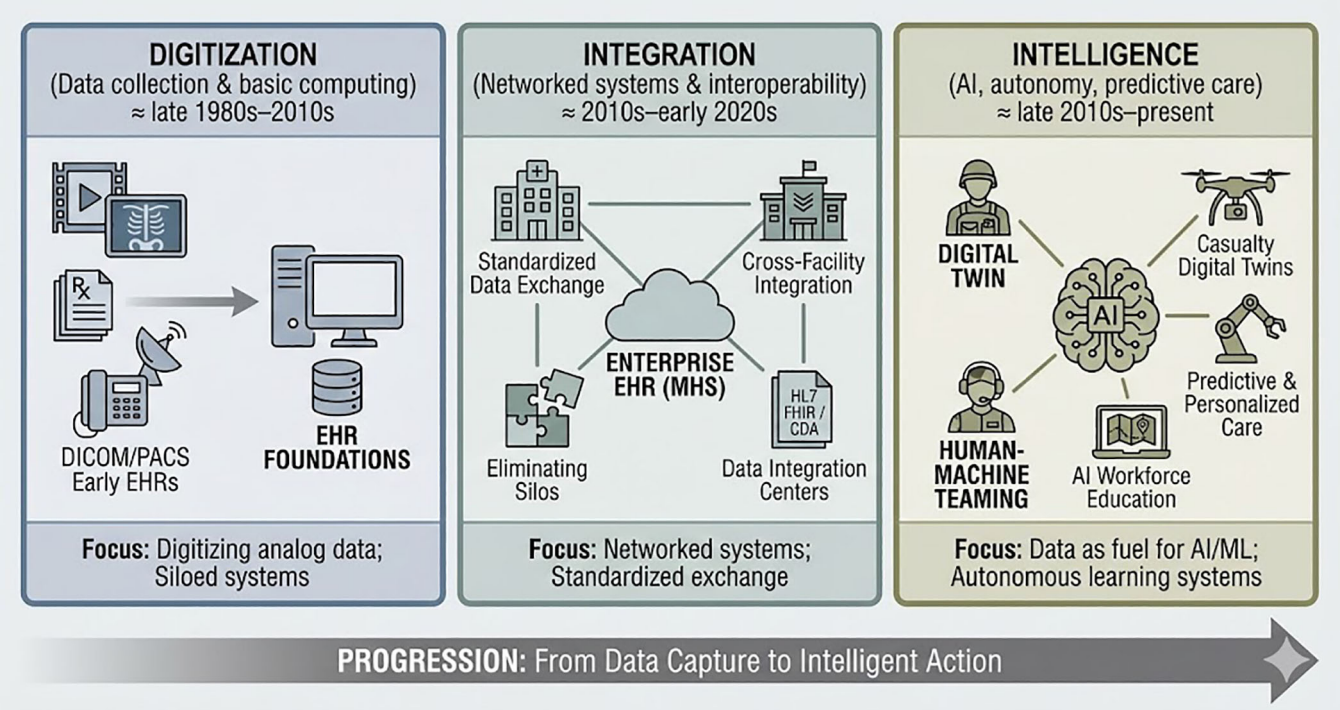


In addition, the websites of government institutions related to military operations (Department of War and European Defense Agency) were analyzed for establishment of the most prominent and innovative digitalization efforts and better categorization of the articles.

REVIEW RESULTS

Our review identified the following key stages (Figure 2) of digital transformation as well as the below areas of military operations where it is utilized:

Fig. 2. Phases of digital transformation of military healthcare (DICOM - Digital Imaging and Communications in Medicine, PACS - Picture archiving and communication system, HER – Electronic Health Record)



Patient assessment and triage

The time between injury and arrival at a definitive role of care can vary widely depending on the combination of the setting, the evacuation chain, and various other factors specific to the overall scenario which limits the time for accurate patient assessment and triage. The main focus of digitalization of this part of battlefield care is on detecting conditions like traumatic hemorrhage, hemorrhagic shock and pneumothorax/hemothorax. The use of new vital parameters, including half-rise to dicrotic notch (HRDN) part of the arterial blood pressure (ABP) waveform acquired via photoplethysmography have been studied as potential inputs into machine learning (ML) algorithms used to predict hemorrhage. [8] Nemeth et al. report the development of Nett Warrior phone- and tablet-based decision support system (DSS) for prehospital tactical combat casualty care (TCCC) that is able to detect and differentiate shock using only vital signs data. Automated patient identification and vital sign data collection could mitigate current difficulties with accurate documentation of patients in the field. Development of shock recognition algorithms can simplify medical data collection and analysis to improve and speed diagnosis of patient condition for more effective care. Seamless connection to different joint military medical systems promises to improve medical data continuity from point of injury onward. [9] Using hybrid data inputs, these systems are able to attain significantly greater accuracy when basic information about the level of consciousness is assessed by nursing checks in a hospital environment. Such tools have been studied with the intent for eventual incorporation into en route field care, allowing personnel to modify fluid resuscitation (and other pertinent interventions) more appropriately until definitive care is reached. [10]

Telepsychiatry

As one of the first instances where digitalization was included in the military community, telepsychiatry nowadays remains one of the main aspects in military telemedicine. This trend can be explained by the various psychological conditions which can develop after combat, deployment, and other military operations. These include high risk of post-traumatic stress disorder (PTSD), insomnia and alcohol and substance abuse, the primary prevention of which can be helped by adjuncts to conventional clinical treatments such as personal self-help resources, resilience building and stress inoculation training programs. In this light the Personal Health Intervention Toolkit (PHIT), a mobile application framework for personalized health intervention, is implementing PHIT for Duty. This is an evidence-based app with mindfulness-based relaxation training, behavioral education in sleep quality and alcohol use, and psychometric and psychophysiological data capture for mobile health research. [11]

The emergence of telehealth services in the psychiatry is especially valuable for military personnel because of the high risk of developing different conditions. On the one hand, this can play a key role in the prevention of these cases or detection of sub-clinical symptoms which can be crucial both in war- and peacetime. On the other hand, the prevention and early detection could save the system human and financial resources by lowering expenses for treating severe cases, levels of addiction to substances and suicide rates.

Medical Military Supply

In this area the most prominent advantage of digitalization is using complex algorithms and AI for analyses and simulations. Militaries around the world are constantly training and updating their operational concepts to retaliate a hostile action, experiment, innovate life-saving systems, and foster best practices via tabletop exercises (TTX), wargaming, and live exercises (LIVEX). Example for this is the NATO Vigorous Warrior (VW) Live Exercise - a series of large-scale, multinational military medical exercises with the most recent one, took place in 2024 in Hungary and involved over 1600 participants from 35 NATO and partner nations. This exercise was used to generate data for refinement and validation of the SIMEDIS simulator. Developed historically with a civilian approach to Mass Casualty Incidents (MCIs), SIMEDIS has recently transitioned to battlefield situations through a joint effort between the Royal Military Academy of Belgium and academia. Using simulators like SIMEDIS the steps of evacuation, triage, and treatments from the Point of Injury/Point of Wounding/Point of Exposure to the Role 1/Role 2 medical treatment facilities for a variety of complex cases of patients combining polytrauma and CBRNe injuries can be further examined. In addition, this can ensure better prospective medical planning and supply using retrospective data which leads to reduced preventable morbidity and mortality. [12, 13, 14]

E-learning and telementoring

Digital transformation is a powerful tool for enhancing the different forms of education and it creates platform for e-learning capabilities. This is essential when medical expertise is not always available at the patient's location. Loki is a novel system that leverages video, audio and spatial capture along with mixed-reality presentation methods to allow users to explore and annotate the local and remote environments, and record and review their own performance as well as their peer's. [15] ARTEMIS is the first surgical telementoring system to give experts an immersive VR operating room where they can use gestures and 3D annotations on a 3D reconstruction of the patient's body to guide novice surgeons in Augmented Reality. ARTEMIS intuitive AR experience allows local surgeons to focus on the patient and the tasks at hand, rather than having to interact with complicated AR interfaces. [16] In military operations trauma injuries are one of the most complex to handle because they require timely life-saving interventions. In such cases systems like Loki and ARTEMIS enable novices and experts to communicate with increased precision, accuracy, and clarity as well as non-trained personnel to successfully perform specific surgical procedures which save lives. In addition, digital transformation can be used for e-learning and telementoring also in peacetime. Naval Hospital Camp Pendleton (NHCP) is a small community hospital located 41 miles north of Naval Medical Center San Diego (NMCSD) and the two facilities engaged in Tele-critical care (TCC) program. This allowed intensivist physicians from the NMCSD to address the staffing challenges in front of the smaller hospital with 24/7 coverage using low-cost, off-the-shelf, synchronous high-definition video-teleconferencing equipment, and remote access to electronic medical records, imaging studies, and laboratory data. The tele-Intensivists also participated in multidisciplinary teaching rounds with the NHCP house staff. Data from this program shows a trend toward increasing volume of admissions per month (22.9 ± 7.5 vs. 27 ± 6.6, $p = 0.11$), a decrease in total number of avoidable disengagements (12 ± 0.9 vs. 0, $p = 0.0008$) and increased maximum Acute Physiology and Chronic Health Evaluation II score. On top of that, the reduction in disengagements correlated with savings in out-of-network expenditures of $1.3 million over the 19 months of program operation. This program shows once more that digitalization of medical consultations and education can be beneficial for doctors (enabling non-specialized personnel to perform specific activities), patients (increase in quality of health care) and healthcare system (lowering total expenses). [17]

Medical devices

Digitalization and AI can play a role in developing multifunctional medical devices as well. This can be seen in the DoD funded program at the University of Pittsburgh called TRAuma Care In a Rucksack (TRACIR). Its product is the autonomous robotic enabled cardiopulmonary resuscitation platform with a form factor that fits in a rucksack and placed on unmanned air or ground vehicles can support casualty emergent prolonged field care and evacuation missions. [18] With the advancement of technologies and the share of unmanned operations medical devices rise as opportunity to additionally lower human involvement even in battlefield medical situation. With already collected patient data and knowledge of the circumstances at the PoI/PoW/PoE the armed forces can lower the risk for casualties in evacuation operations.

Telepharmacy

In this field teleconsultations about the medicines use and therapies assignment are the most common means of digital transformation. Another example for more structured and comprehensive mechanism of telepharmacy is the US Department of Veterans Affairs (VA) Centralized Mail Order Pharmacy (CMOP). This represents a network of 7 highly automated pharmacies around the country which during fiscal year 2016 processed 119.7 million outpatient prescriptions. The use of CMOP results in lower processing costs and increased convenience for veterans compared with filling prescriptions at pharmacies at individual VA facilities. The inclusion of digital sys-

tems in the whole process allow on-site pharmacy staff to focus on providing customer service for veterans requesting medication counseling from a clinical pharmacist, as well as those with new, changing, or urgent prescription needs and in addition can help control the VA facility pharmacy budget. [19]

In addition, we found information about the following challenges that digital transformation is facing in the armed forces:

Technical challenges

One of the most significant challenges in implementing telemedicine in war zones is the lack of accessibility and connectivity. Conflict often disrupts communication infrastructure, leading to limited or unreliable internet access, particularly in remote or conflict-affected areas. This can hinder the use of telehealth technologies and limit the ability of healthcare providers to connect with patients. To overcome these limitations, innovative solutions are needed, such as utilizing satellite communication systems, deploying mobile clinics equipped with telemedicine capabilities, and developing offline data storage and transmission methods. [20] Healthcare professionals training on telehealth services is paramount for effective utilization of telehealth services both in war zones and peacetime. This imposes the development of specific programs tailored to individual deployments, therapeutic areas, local cultures and languages, and other parameters which can lead to the expenditure of vast financial and human resources where the latter can be harnessed in other more useful activities.

Cybersecurity

Another important parameter to consider is protecting patient privacy and data security. This is of extreme importance in telemedicine, especially in modern conflict zones where information systems may be vulnerable to breaches leading to giving advantage to hostile parties. The sensitive nature of medical data requires robust security measures to prevent unauthorized access, data leaks, and potential misuse. This can be achieved through implementing strong encryption protocols for all data transmission, utilizing secure cloud storage solutions, and establishing clear guidelines for data access and sharing. It is also crucial to ensure that patient data is stored and managed in accordance with relevant privacy regulations and ethical principles. This requires close collaboration between healthcare providers, technology developers, and regulatory bodies to ensure responsible and ethical use of telemedicine in war zones. [20]

Interoperability

Military structures are characterized by multilayered structure, review and approval processes which in the case with major health initiatives may produce such high transactional costs that telehealth expansion becomes nearly impossible. If these barriers are not overcome, military telehealth can continue to suffer from the same type of "adoption block" previously faced by private healthcare systems. [21] For example as one of the main components of each telehealth service EHRs are described with 4 hierarchically related interoperability levels – foundational, structural, semantic and organizational. Despite most healthcare providing institutions having satisfactory foundational and structural interoperability, they show delays in semantic and organizational types. Only by achieving these higher levels of communication between different systems digitalization can ensure expanded access, exchange of critical data among health care systems, aggregate community-level data from disparate sources, and provide user-centered services to both physicians and patients. [22]

LIMITATIONS

The topics discussed above were identified as most prominent and innovative. There are other areas where digital transformation takes place like teleradiology and teleconsultations which help increase the quality of healthcare but were not discussed in our review due to not falling in our criteria for significance. We can highlight the research of only one database and government institutions only in USA and EU as primary limitation of our review. In addition, we analysed scientific articles only in English which can be further discussed as potential sources of constrains due to the country specific nature of national security and military development.

CONCLUSION

Digital transformation can play a crucial role in military medicine and pharmacy in numerous areas both in war- and peacetime. Different systems can address inherent challenges in the army like limited number of highly specialized medical professionals on the battlefield, risks and costs associated with medical evacuations, prevention and treatment of different psychological conditions, healthcare services for veterans, and others. Most of the challenges in front of digitalization in the military like technical support, cybersecurity and interoperability overlap with the ones facing civilian systems but specific characteristics like multilayered management structure can lead to delayed digital transformation relative, need to address challenges more effectively, and a need of military-customized digital solutions.

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REFERENCES:

1. Berners-Lee T. WWW: past, present, and future. *Computer*. 1996 Oct;29(10):69-77. [Crossref]

2. Admass WS, Munaye YY, Diro AA. Cyber security: State of the art, Challenges and Future Directions. *Cyber Security and Applications*. 2024; 2: 100031. [Crossref]

3. Alowais SA, Alghamdi SS, Alsuhebany N, Alqahtani T, Alshaya AI, Almohareb SN, et al. Revolutionizing healthcare: the role of artificial intelligence in clinical practice. *BMC Medical Education*. 2023 Sep 22;23(1):689. [PubMed]

4. Kelly JT, Campbell KL, Gong E, Scuffham P. The Internet of Things: Impact and implications for Health care delivery. *J Med Internet Res*. 2020 Nov 10;22(11):e20135 [PubMed]

5. Naughton J. The evolution of the Internet: from military experiment to General Purpose Technology. *J Cyber Policy*. 2016 May 8;1(1):5–28 [Crossref]

6. Telemedicine: A Guide to Assessing Telecommunications in Health Care. Institute of Medicine (US) Committee on Evaluating Clinical Applications of Telemedicine; Field MJ, editor. Washington (DC): National Academies Press (US); 1996. [PubMed]

7. MHS Digital Transformation Strategy. www.Health.mil. 25 Mar 2025. [Internet]

8. Gupta JF, Telfer BA, Convertino VA. Feature Importance Analysis for Compensatory Reserve to Predict Hemorrhagic Shock. *Annu Int Conf IEEE Eng Med Biol Soc*. 2022 Jul; 2022:1747-1752. [PubMed]

9. Nemeth C, Amos-Binks A, Burris C, Keeney N, Pinevich Y, Pickering BW, et al. Decision support for tactical combat casualty care using machine learning to detect shock. *Mil Med*. 2021 Jan 25;186(Suppl 1):273-280. [PubMed]

10. Meyer N, Ullrich L, Goldsmith Z, Verges PD, Papadimos TJ, Stawicki SP. *Applications of Artificial Intelligence in Military Medicine and Surgery. In:* Artificial Intelligence in Medicine and Surgery - An Exploration of Current Trends, Potential Opportunities, and Evolving Threats - Volume 2. Edited by Stawicki SP. *IntechOpen*. 16 Jul 2024. Chapter 7. [Crossref]

11. Kizakevich PN, Eckhoff R, Brown J, Tueller SJ, Weimer B, Bell S, et al. PHIT for Duty, a mobile application for stress reduction, sleep improvement, and alcohol moderation. *Military Medicine*. 2018 Mar 1;183(suppl_1): 353–63. [Crossref]

12. Benhassine M, Quinn J, Stewart D, Arsov AA, Ianc D, Ivan M, et al. Advancing military medical planning in large scale combat operations: Insights from computer simulation and experimentation in NATO's vigorous Warrior Exercise 2024. *Military Medicine*. 2024 Aug 19;189(Suppl_3):456–64. [Crossref]

13. Benhassine M, Meisner K, Stewart D, Ianc D, Ivan M, Quinn J, et al. Recreating the vigorous warrior and clean care exercises in Silico: A Proof-of-Concept Study for the Digital Transformation of Military medical support. *Mil Med*. 2025 Sep 1;190(Supplement_2):312-319. [PubMed]

14. Debacker M, Van Utterbeeck F, Ullrich C, Dhondt E, Hubloue I. SIMEDIS: a Discrete-Event Simulation Model for Testing Responses to Mass Casualty Incidents. *J Med Syst*. 2016 Dec;40(12):273. [PubMed]

15. Kumaravel BT, Anderson F, Fitzmaurice G, Hartmann B, Grossman T. Loki: Facilitating Remote Instruction of Physical Tasks Using Bi-Directional Mixed-Reality Telepresence. In: Proceedings of the 32nd Annual ACM Symposium on User Interface Software and Technology, New Orleans, LA. 2019; 161–174. [Crossref]

16. Gasques D, Johnson JG, Sharkey T, Feng Y, Wang R, Xu ZR, et al. ARTEMIS: A Collaborative Mixed-Reality System for Immersive Surgical Telementoring. In: Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems. 2021 May 6;Art.662:1-14 [Crossref]

17. Davis K, Perry-Moseanko A, Tadlock MD, Henry N, Pamplin J. Successful Implementation of Low-Cost Tele-Critical Care Solution by the U.S. Navy: Initial Experience and Recommendations. *Mil Med*. 2017 May; 182(5):e1702-e1707. [PubMed]

18. Poropatich R. Trauma Care in a Rucksack (TRACIR). *Center for Military Medicine Research*. 2025. [Internet]

19. Carlisle SE, Howard LT, Nazarchyk JC, Elliott WJ. Reducing the Expenditures and Workload Associated With VA Partial-Fill Prescription Processing. *Fed Pract*. 2018 Apr; 35(4): 28-33. [PubMed]

20. Haimi M. Telemedicine in war zones: prospects, barriers, and meeting the needs of special populations. *Front Med (Lausanne)*. 2024 Oct 10;11: 1417025. [PubMed]

21. Madsen C, Poropatich R, Koehlmoos TP. Telehealth in the Military Health System: Impact, Obstacles, and Opportunities. *Mil Med*. 2023 Mar 6;188(Suppl 1):15-23. [PubMed]

22. Zhang X, Saltman R. Impact of Electronic Health Record Interoperability on Telehealth Service Outcomes. *JMIR Med Inform*. 2022 Jan 11;10(1):e31837. [PubMed]

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Address for correspondence:
Evgeni Grigorov
Department of Organization and Economics of Pharmacy, Faculty of Pharmacy, Medical University - Varna;
55, Marin Drinov Str., Varna, Bulgaria
E-mail: evgeni.grigorov@mu-varna.bg,