OPERATIONAL SURVIVABILITY IN A BIOLOGICAL ENVIRONMENT

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Introduction

Throughout history, disease has been a constant companion of warfare, often proving as deadly as the weapons themselves. From ancient times to the present day, the impact of disease on military campaigns remains a significant hindrance to the combat power of troops. Disease outbreaks were common among armies due to crowded living conditions, poor sanitation, and lack of medical knowledge. Epidemics such as the Plague of Athens during the Peloponnesian War and the Antonine Plague during the Roman Empire weakened armies and even contributed to the fall of empires.[1,2] The 20th century saw advancements in medical science, but disease remained a formidable foe in warfare. During World War I, millions of soldiers died from diseases such as influenza and trench fever.[3] World War II saw other diseases like typhus and malaria, which affected troops in various theaters of war.[4] In recent decades, advances in medicine and public health have reduced the effect of disease on military operations. However, infectious diseases such as Ebola, Zika, and COVID-19 continue to pose significant challenges to modern military forces, highlighting the ongoing threat that disease presents in warfare.[5]

The convergence of increasingly complex systems, diseases, and warfare presents a multifaceted challenge in contemporary times. Advancements in technology have led to the creation of interconnected structures, from global transportation networks to digital infrastructure. While these organizations have brought benefits, they have also introduced vulnerabilities in cyber-biosecurity and automation of biomaterial manufacturing that can be exploited by malicious actors. In the realm of public health, the emergence of new infectious diseases and the threat of pandemics are exacerbated by factors such as urbanization, global travel, and climate change; the intersection of complex systems and disease creates new challenges in the context of warfare. As conflicts become increasingly focused on large scale combat operations, the deliberate use of disease as a weapon adds a new dimension to military strategy.

Problem Statement

Deliberate biological weapon attacks, accidental biological leaks, and natural disease outbreaks all create large looming threats in today's world, with potential consequences ranging from localized disasters to global pandemics. Deliberate biological weapon attacks can occur in various settings, from terrorist acts in urban centers to state-sponsored operations targeting military or civilian populations. Accidental biological leaks may occur in high-security laboratories or research facilities, where dangerous pathogens are studied. Such incidents can lead to unintended outbreaks with severe consequences. These events can occur anywhere in the world, but densely populated urban areas, regions with inadequate healthcare infrastructure, and areas prone to political instability are particularly vulnerable.

While military forces have long recognized the biological weapons and natural disease outbreaks, there remains a lack of comprehensive doctrine and operational protocols for conducting military operations in such environments. Although certain documents address strategy and tactics, there is a lack of guidance and implementation to turn strategic goals into successful missions, especially at the operational level. Because of the lack of guidance, as noted in the last CWMD journal issue, current Joint and Service Component staffs face challenges in defining operational CWMD activity when confronting competition from adversaries.[6] Joint Force Staffs are tasked with coordinating strategy to enforce arms control treaties and export controls, operating to track and mitigate WMD capabilities, and preparing tactics to counter WMD use on the battlefield. Joining together these CWMD-related activities into theater-level planning and targeting presents a challenge for the operational staff, as they are primarily focused on other efforts. Many staff officers have limited knowledge of CWMD procedures except for the fundamentals usually found at the strategic and tactical levels of leadership.

Another complication within the CWMD field is that biological diseases behave differently when compared to the other three letters. The other notable CBRN weapons, nuclear, radiological and chemical weapons, have effects that while devastating are relatively straightforward to measure and model once a few conditions are set. The US military has decades of experience with nuclear and chemical tests that form a backbone of health and damage data that models rely upon. Biological models do not have this history of data. Additionally, the biological environment has a different challenge set compared to other environments; it is more difficult to detect production and employment, produces easier, can spread contagiously, uses a variety of delivery methods, needs a much lower dose of agent to be effective, can linger in the environment, has a less straightforward detection and treatment methods, and is cheaper to manufacture.[7]

Measuring the Effects of the Biological Environment

Addressing these interconnected challenges requires a holistic approach that integrates soldier's health and materiel survivability measures to mitigate the risks posed by the convergence of complex systems, disease, and warfare. To best tackle this problem, the U.S. Army Nuclear and Counter Weapons of Mass Destruction Agency (USANCA) has proposed the merging of two concepts. The first is the operation, which is defined doctrinally as "a sequence of tactical actions with a common purpose or unifying theme or a military action or the carrying out of a strategic, operational, tactical, service, training, or administrative military mission."[8] The second concept is survivability, which is "all aspects of protecting personnel, weapons, and supplies while simultaneously deceiving the enemy."[9] Fusing these two terms, the definition becomes "operational survivability" which is the ability of personnel and materiel to survive in and through CBRN environments while solidifying the convergence of the human-materiel interface informing commanders of combat power availability, reliability, and operability, both looking at short- and long-term outcomes.

To understand the impacts of the biological environment on the military's effectiveness, one must understand combat power. It provides a comprehensive assessment of capability to achieve military objectives across diverse operational environments. Combat power, defined as the total means of destructive and disruptive force that a military unit or formation can apply against the opponent at a given time, serves as a holistic metric encompassing multiple elements of military strength.[10] The concept of combat power embodies the army's ability to bring together its personnel, equipment, leadership, information systems, and supporting infrastructure to achieve mission success. Within its structure, the army contains the capacity for maneuver, firepower, protection, sustainment, and command and control.

Maneuver refers to the movement of forces into advantageous positions relative to the enemy to gain positional advantage and achieve operational and tactical objectives. Firepower denotes the application of lethal and non-lethal force against enemy forces, structures, and systems. Protection involves safeguarding personnel, equipment, and critical infrastructure from enemy threats, including direct and indirect fire, chemical, biological, radiological, nuclear (CBRN) hazards, and cyber-attacks. Sustainment encompasses the army's capability to maintain operations by providing personnel with the necessary logistics, personnel services, and health support. Command and control (C2) incorporates the army's ability to plan, direct, coordinate, and control military operations. By integrating the information systems, communication networks, and decision-making processes, leaders can make rapid and directive decisions.[11]

By assessing combat power, military leaders can evaluate the Army's readiness, capability, and capacity to conduct operations across the full spectrum of conflict. Such activities can be related to conventional warfare, irregular warfare, stability operations, humanitarian assistance, and disaster relief missions. Biological diseases, however, can significantly degrade combat power by reducing the health and effectiveness of military personnel. Outbreaks of infectious diseases lead to high rates of illness, hospitalization, and death among troops, thereby reducing the army's overall manpower and operational readiness. Moreover, diseases such as influenza, malaria, and COVID-19 can spread rapidly within military units, disrupting training, operations, and logistics. Additionally, the need to implement preventive measures, such as quarantine and social distancing, can further strain military resources and limit the army's capacity to conduct successful operations. Despite advances in the medical sciences, biological diseases can surprise and evolve to pose a significant threat to combat power by undermining the health and readiness of military forces.

Factors in the Pre/Post Sneeze Environment

The operational impacts of biological diseases need to be explored within the context of large-scale combat operations, especially considering advancing medical and biotechnology, as well as other enabling technologies that converge with biomedical advances. Understanding these new potential consequences of biological threats on military operations is essential for preparedness and response. New biotechnologies are poised to significantly influence battlefield operations, offering both opportunities and challenges for military forces. These advances rapidly detect and mitigate the effects of biological threats on the battlefield through newly developed diagnostic tools, next-generation vaccines, and therapeutics. Additionally, developments in biotechnology enable the creation of advanced biosurveillance systems capable of detecting and identifying pathogens in real-time, enhancing situational awareness and early warning capabilities.[12] Moreover, the capability to engineer biological systems may lead to the development of novel materials, fuels, and sensors, as well as the creation of genetically modified organisms for environmental sensing and decontamination. Advancements in genomics and precision medicine also enable personalized medical treatments tailored to individual soldiers, improving health outcomes and resiliency on the battlefield. Biotechnologies such as CRISPR-based detection systems and nanoscale biosensors offer rapid and sensitive detection of biological threats, enhancing force protection and readiness.[13] The integration of biotechnology with big data analytics and artificial intelligence enables the rapid analysis of complex biological data, facilitating decision-making and operational planning.[14] Nature-inspired designs, such as biomimetic materials and bio-inspired robotics, offer innovative solutions for camouflage, sensing, and mobility in diverse battlefield environments.[15] These advancing biotechnologies have the potential to revolutionize military operations, enhancing the army's resources to detect, prevent, and respond to biological threats while also providing new opportunities for innovation and capability development.

Increasing the operational survivability of the Army requires a multifaceted approach that encompasses training and exercises, biosurveillance, early warning systems, planning, fighting in a persistent environment, and understanding the risk to the mission versus the risk to the force. Additionally, the use of protective gear, while essential, presents its own set of challenges. Practical training and realistic exercises are crucial for preparing military personnel to operate in environments contaminated with biological agents. Training should focus on recognizing biological threats, using protective equipment, and implementing decontamination procedures. Regular exercises allow units to practice response protocols and identify areas for improvement, especially for novel or rare diseases. Biosurveillance systems provide real-time monitoring of biological threats, allowing for early detection and rapid response. These systems integrate data from various sources, including medical facilities, environmental sensors, and intelligence reports, to identify potential outbreaks and track the spread of disease.[16] Comprehensive planning is vital for a functional response to biological threats by developing protocols for medical treatment, decontamination, and force protection, as well as coordinating with civilian and industry authorities and international partners. In the contested biological environment, military commanders must weigh the risk to the mission against the risk to the force when operating in biological threat environments, balancing the need to accomplish objectives with the need to protect personnel from exposure to biological agents. Military operations may require personnel to operate in environments contaminated with biological agents for extended periods, which will require specialized training, equipment, and logistical support to ensure the health and safety of personnel. While protective gear mitigates the risks posed by biological threats, it also has downsides. Protective equipment can be cumbersome, impede mobility, and impair communication, making it more difficult for personnel to perform their duties effectively. Additionally, operating in protective gear for extended periods can lead to fatigue and heat-related injuries.[17]

Reactions to an outbreak of disease include prophylaxis, hygiene, physical protection, identification of infection, decontamination, stabilization of health conditions of soldiers, pathways to reentry of the force, and assessment of operational combat power due to losses of materiel and manpower. Prophylactic measures, such as vaccinations and chemoprophylaxis, are critical for preventing the spread of infectious diseases among military personnel. Ensuring that troops are immunized against common biological threats reduces the risk of outbreaks and minimizes the impact on operational

ABOVE: (MOBILE, Al) - Pfc. Raymond Horace III, a guardsman with Task Force 31, fogging the kitchens of Crowne Health Care of Mobile with disinfectant, April 24, 2020. Task Force teams are going to designated facilities throughout Alabama to include nursing homes, veteran's homes and assisted living facilities. (U.S. Army photo by Sgt. Jaccob Hearn)

effectiveness. Maintaining high standards of personal and environmental hygiene through handwashing, proper waste disposal, and disinfection of equipment and living quarters prevents the transmission of infectious diseases. Physical protection measures, such as personal protective equipment (PPE) and collective protection systems, help to minimize exposure to biological agents. PPE, including masks, gloves, and suits, provides a barrier against contamination, while collective protection systems, such as shelters and sealed environments, offer additional layers of protection. Early identification of infected personnel is crucial for preventing the spread of disease within military formations. Training personnel to recognize the signs and symptoms of infectious diseases and implementing surveillance systems for monitoring health status are necessary components of infection control. Prompt and thorough decontamination of personnel, equipment, and facilities is critical following exposure to biological agents. Decontamination procedures, including washing, disinfection, and sterilization, help to remove or neutralize contaminants and prevent further spread of infection. Providing timely and appropriate medical care stabilizes the health conditions of infected soldiers by promptly administering medical treatments, managing symptoms, and preventing complications associated with the disease. Additionally, clear protocols for the reentry of infected personnel back into the force preserves operational readiness by ensuring that personnel are fully recovered, no longer contagious, and have received medical clearance before returning to duty. Finally, assessing the impact of biological threats on operational combat power maintains mission effectiveness through the evaluation of losses from materiel and manpower, identification of vulnerabilities, and implementation of risk mitigation strategies.

Pathways to Mission Success

In those previous discussed areas, modeling and simulation, along with providing decision support with real-time assessments, is crucial for enhancing operational survivability in a biological environment. Modeling and simulation tools allow military planners to simulate various scenarios involving biological threats, including disease outbreaks, contamination events, and response efforts. These tools can simulate the spread of infectious diseases, the effectiveness of medical treatments, and the impact of different intervention strategies. By running simulations, military commanders and staff can better understand the potential consequences of biological threats and develop response plans.[18] Real-time assessments provide military commanders and staff with up-to-date information on the current situation and allow them to make informed decisions quickly. By integrating data from biosurveillance systems, medical reports, and other sources, decision support systems can provide real-time assessments of the spread of disease, the status of affected personnel, and the efficacy of response efforts. Commanders are then able to adjust their plans and allocate resources more appropriately in response to changing conditions. Lastly, multi-component exercises test and refine military capabilities for both known and unknown biological environments. These exercises involve multiple units and components of the military, as well as civilian agencies and international partners. By simulating realistic scenarios involving biological threats, exercises allow military forces to rehearse coordination, communication, and response procedures in a controlled environment. In addition, the testing of medical treatment protocols, decontamination procedures, and logistical support systems are also simulated.

Conclusion

To address the complexities introduced in a biological environment, operational survivability strives to bulwark its force's combat power and to understand the potential impacts of WMD use. WMD-use challenges large-scale combat across time and a geographically distributed space creating two operational environments. Modernization of survivability regulations, processes, and assessment tools reduce the risk of systems and formations becoming combat ineffective following a CBRN event. Deliberate modernization provides the Army with the tools to assess materiel and personnel survivability in real time. Non-computational training environments do not realistically simulate the breadth and scope of biological effects on Army maneuver units. Therefore, the commander is at a loss due to inadequate information contributing to an inability to develop mitigation strategies that enable operational success. However, available materiel test and evaluation metadata combined with known health effects provide a sufficient mechanism to quantitatively estimate and contribute to the operational survivability assessment. Computational codes can be developed to account for varying bio-environmental effects on materiel and personnel. Simulation platforms play a crucial role in life-cycle management by enabling end user understanding of CBRN weapon effects variability with respect to materiel modifications and alternatives.

Therefore, the goals of operational survivability specifically in the biological realm are:

- Assess biological effects on the force to maximize and coordinate the amounts and availability of critical biodefense supplies.

- Predict force degradation from biological weapons by understanding the long-term impacts on combat power from treatment and decontamination of materiel and personnel.

- Provide critical information to commanders to understand and demonstrate the ability to operate in and recover from the effects of biological environment.

By accomplishing those goals, the Army can achieve its end state of fielding a modernized, trained and equipped force able to operate in and through biothreat environments. Understanding bio incident impacts will empower commanders to adjust operational approaches to minimize risk and effectively mitigate vulnerabilities to fully preserve and employ combat power. ■

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Notes

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