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Combating Infectious Diseases in the Military: Challenges and Future Directions

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ABSTRACT

Emerging infectious diseases, such as COVID-19 and Zika, have posed significant challenges to military strategy and operations. Such challenges include mission disruption and health compromisation of military personnel. Existing solutions like rapid diagnostic tests (3.7 million were distributed to 63 countries in 2020 during the COVID-19 pandemic), social distancing, and vaccination campaigns have been extremely helpful. However, some weaknesses and areas for potential improvement have come to light in terms of combating pandemics. These include a lack of reliable virus-tracking systems and vaccine hesitancy. This research paper will delve into the existing solutions and possible improvements that can be made to them in order to better address the military community.

Introduction

Protecting the health of soldiers across the world is a significant security concern as they comprise the air, sea, and ground. These military forces are "strategic assets that require months to select and train, and several more years to acquire experience in their specialized operational and supportive tasks" (Hatfill, 2022, p. 3). Infectious diseases have disrupted military strategy and operations in the past two decades and they have highlighted critical gaps in preparedness and response. "Military forces worldwide encountered the same challenges" of containing the spread of COVID-19 during its emergence (Segal et al., 2020).

An infectious disease surveillance study was conducted by the Australian Defense Force in conjunction with the PNG (Papua New Guinea) Defense Force in April 2019. In total there were 208 military participants from the Manus Island Barracks and the Wewack Barracks. It was found in the study that out of 208 ELISA-reactive samples, 135 showed neutralizing antibodies (Grant et al., 2022). This neutralization positivity data provides a strong indication of Zika virus presence because neutralizing antibodies are directly related to the immune response against the virus- pointing straight to Zika infection. It was concluded by the authors that the "shortage of reliable diagnostic, reporting, and monitoring systems that track virus transmission may be a partial explanation" as to why Zika virus related occurrences have not been reported in PNG despite the high seroprevalence of antibodies seen in the PNG military personnel.

After the Coronavirus disease was detected in December 2019, it spread quickly across the planet and caused many people to start social distancing. To prevent the further spread of disease, millions of people were ordered to work from home. However, one demographic had to remain at work during this dangerous time : members of the Armed forces. They were deployed across the globe and were often put in crowded conditions which made social distancing infeasible. There were more than 4000 U.S. Navy sailors aboard the USS Theodore Roosevelt and 23 had tested positive for COVID-19 as of March 26, 2020 (Dutton et al., 2021). This number increased rapidly and eventually reached over 1100 cases by April 30 ; the rapid spread of disease across the ship led to its then-commanding officer, Capt. Brett E. Crozier, requesting to move 90% of the ship's crew into isolation on Guam. Due to altering operational plans, a "tremendous financial burden" was placed on the government ; it also impacted "national security posturing abroad in which the US Roosevelt was "forced to conduct an extended stay in Guam to address the outbreak, limiting the ability to remain at sea to support a forward presence critical to the U.S. mission and homeland defense" (Holst, 2021). This emphasizes the need for military leadership to urgently address vaccine-hesitancy within their ranks and have a strong response in terms of masks and social distancing.

During the COVID-19 pandemic, some military forces did not mandate vaccination and this was a threat to military readiness as new variants of the SARS-CoV-2 virus were emerging ; hence, it was of utmost importance to vaccinate populations against this disease. In the military forces that did not mandate vaccination, there was hesitancy or refusal of the vaccine. Data from the Military Health System was inserted and summarized in an article named "COVID-19 Vaccine Hesitancy Among Deployed Personnel in a Joint Environment". In Table I of the article it can be seen that in a sample including 1,809 individuals (most were from the Army and some were employees of the Department of Defense), 38.6% of them declined the COVID-19 vaccine (Higginson et al., 2021). The low vaccine acceptance among personnel of certain branches of the military suggests that all service members should have access to and be encouraged to have discussions with health care providers to address concerns related to vaccination.

Militaries face critical challenges during emerging infectious disease outbreaks, such as COVID-19 and Zika. If the preceding case studies weren't proof enough, in 'The Military in the Time of COVID-19: Versatile, Vulnerable, and Vindicating' it was stated that in the United States, the Pentagon reported 6,493 service members with coronavirus in June (Wilén, 2021, p. 26). The military faces enormous health risks in times of epidemics and they must be protected. Understanding these shortcomings is essential for developing more robust preventative measures and operational guidelines.

Methodology

The primary objective of this study is to assess the impact of emerging infectious diseases, such as COVID-19 and Zika, on military strategy and operations. This research employs a secondary literature review, drawing from multiple primary studies and informational research articles. A qualitative analysis approach was used to evaluate how these outbreaks have influenced military readiness, operational effectiveness, and personnel health. Various primary studies and the infographics from those studies were examined to collect data on the effects of COVID-19 and Zika on military activities. Conclusions were drawn regarding the efficacy of current measures and areas needing improvement. The study also investigated the role of military health protocols in both contributing to and mitigating the impact on operations. As part of this research paper, an enlisted member at the United States Air Force was interviewed and provided some insight into this research gap. The research identified the overall impact of these outbreaks on military operations, the causes of operational and health issues, and potential strategies to enhance preparedness. The study did not use any physical tools beyond online resources.

Existing Protocols/Health Infrastructure in the Military

The military puts in place certain protocols during times of infectious disease outbreaks. Specifically, the U.S. The Navy outlined their basic protocols in their "U.S. Navy COVID-19 Standardized Operational Guidance Version 3.1". These protocols include stringent health protection measures like the use of cloth face coverings to reduce the spread of the virus. For high-risk situations, surgical masks or N95 respirators might be used but the cloth masks are recommended for general use by all personnel. The guidance also states that regular testing is mandated for personnel in certain high-risk environments or those that show symptoms of COVID-19. This includes both PCR (polymerase chain reaction) tests and rapid antigen tests. Personnel who test positive for COVID-19 are required to isolate themselves from others to prevent the spread of the virus. As part of this research paper, an interview was conducted with an enlisted Air Force member. When he/she was asked, "Have there been any specific protocols or measures implemented in response to these outbreaks within your unit?", they answered that, "Certain members would go into 2 weeks of quarantine and they'd do that in a rotation. It would be work, two weeks of quarantine, then back to work."

In addition to these protocols, Army scientists collaborated with DARPA in 2021 to develop a COVID-19 sensor designed for military use (U.S. Army DEVCOM Army Research Laboratory Public Affairs, 2021). The sensor, based on a SenSARS graphene platform, employs Protein Catalyzed Capture (PCC) agents to detect SARS-CoV-2 with high sensitivity. Dr. Matthew Coppock highlighted that ARL's biodetection technology is essential for ongoing biosensing in operational environments. The sensor's exceptional thermal and biological stability ensures a significantly longer shelf life and eliminates the need for cold-chain storage, which is "a necessity for performance in Army working conditions". Likewise, the Pentagon is reportedly increasing its use of fitness trackers to better detect diseases (Lawrence, 2023). In "Military Expanding the Use of Fitness Trackers to Detect Disease Outbreaks Such as COVID-19", the Defense Innovation Unit, a Pentagon organization, utilized an artificial intelligence algorithm combined with a commercial fitness tracker to detect infections during the pandemic. In summary, the military addressed infectious disease outbreaks by implementing strict health protocols and developing advanced technologies. They used measures like face coverings and regular testing, and took steps such as developing specialized sensors and integrating fitness trackers to enhance detection and ensure readiness.

Vaccine Hesitancy and its Implications

Vaccine hesitancy is the reluctance or refusal to have oneself or one's children vaccinated against an infectious disease or diseases. The World Health Organization (WHO) states that, "People who delay or refuse vaccines for themselves or their children are presenting a growing challenge for countries seeking to close the immunization gap". As a result of this, "Globally, 1 in 5 children still do not receive routine life-saving immunizations, and an estimated 1.5 million children still die each year" due to diseases that could have been prevented by existing vaccines (World Health Organization, 2015). Vaccine hesitancy is not an issue only among less-educated groups ; in fact, "a number of studies identify higher education as a potential barrier to vaccine acceptance". WHO also states that there are many factors that may drive hesitancy such as : "concerns about vaccine safety", "negative beliefs based on myths" (for example, that vaccination of women will lead to infertility), "misinformation", and mistrust in the health care system.

Despite all the hesitancy in taking the COVID-19 vaccine, it is proven that getting vaccinated is safer than not getting the vaccine- regardless of the person's level of pre-existing immunity. In Figure 1, which was retrieved from an article by Moghadas et al., (2020) it is evident that the number of hospitalizations and total death per 10,000 population were significantly higher for the groups that went without vaccination than those that were vaccinated. In fact, the number of deaths and hospitalizations for those who took a vaccine with reduced efficiency was still lower than the number of deaths and hospitalizations for non-vaccinated groups.

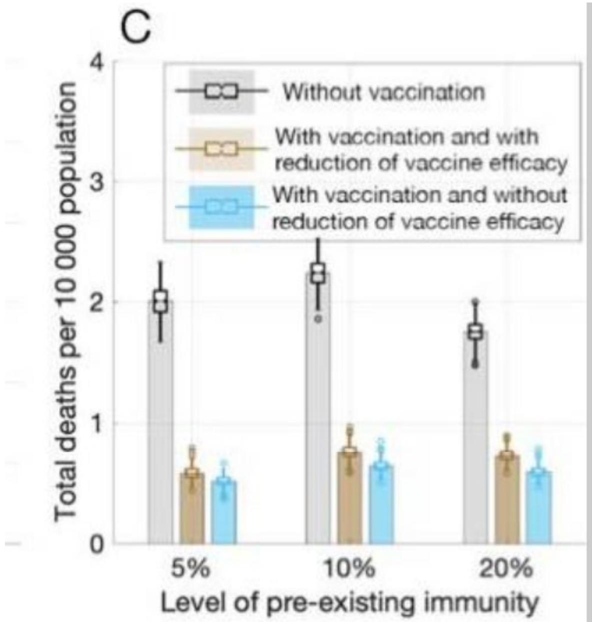

Figure 1. Shows the projected total number of ICU Hospitalizations (B) and deaths (C) per 10,000 populations with 5%, 10%, and 20% levels of pre-existing immunity over 300 days. Colored bars with vaccination correspond, respectively, to scenarios with (brown) and without (blue) reduction of vaccine efficacy in comorbid individuals and the elderly. (Moghadas et al., 2020)

Combatting Vaccine Hesitancy in the Military

Vaccine hesitancy can be the result of a population not being adequately informed and educated on the specifics regarding the vaccine, and it is important to raise awareness about vaccines to increase vaccination numbers. In a recent interview with an Air Force enlisted member, it was revealed that during the COVID-19 pandemic, "the Air Force force retired older staff and technical sergeants and a lot of officers because they wouldn't comply with the vaccine order". Hence, the Air Force lost out on insights from these experienced older staff. This also affected retention numbers in the Air Force. It was disclosed during the interview that the Air Force members that refused to comply with the vaccine order, did so out of fear due to the lack of awareness surrounding the vaccine.

Fortunately, there is a solution : with vaccination awareness campaigns, involving informational sessions, question and answer forums, and transparent discussions led by medical professionals and trusted leaders within the military community, the Air Force can reduce vaccine hesitancy. Such a campaign would provide clear and accurate information to the military personnel, and it would foster an environment where concerns can be openly addressed. Ultimately this would lead to increased vaccination rates and improved retention.

A study was conducted using Nigerian acute flaccid paralysis surveillance data from 2004 to 2014 and campaign history to analyze the effectiveness of vaccination campaigns and population immunity to support and sustain polio elimination in Nigeria. As part of their study, Upfill-Brown et al. (2016) analyzed data from Kano state and found that the relationship between reported number of doses received and the number of campaigns experienced has "strengthened over time" ; this can be seen in Figures 2a and 2b which were retrieved from their article. Figure 2a displays data from 2004 and Figure 2b displays data from 2010. Both of the figures show a clear, positive correlation between the reported number of doses received and the number of vaccination campaigns experienced and they prove that this correlation is only growing with time. If the Air Force implemented more vaccination campaigns it is very likely that there will be increased acceptance of vaccinations which will allow more retention in numbers so that personnel won't need to be force retired.

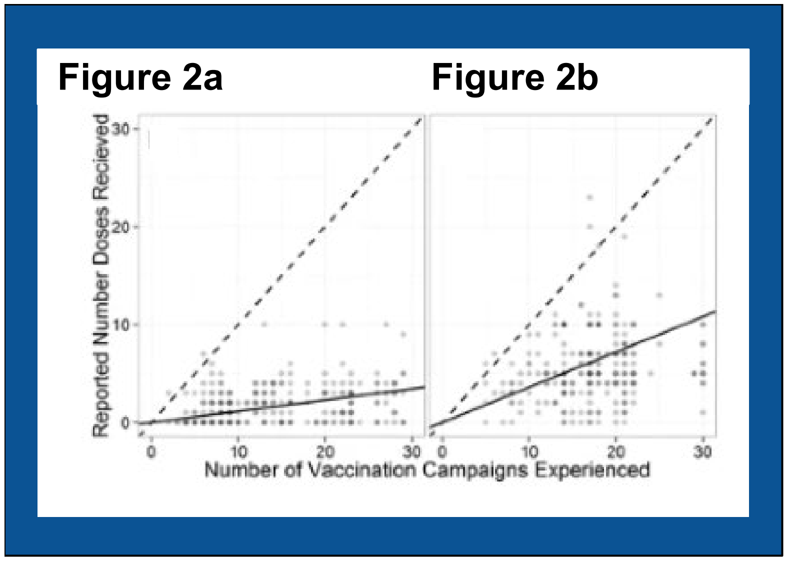

Figure 2a and 2b. Reported number of doses received relative to estimated number of campaigns experienced for NP-AFP cases in Kano born in 2004 (**a**) and 2010 (**b**). Data retrieved from the article titled, "Analysis of vaccination campaign effectiveness and population immunity to support and sustain polio elimination in Nigeria" by Upfill-Brown et al. (2016).

Artificial Intelligence and Big Data in Disease Surveillance

As previously mentioned in the introduction, an infectious disease surveillance study that was conducted by the Australian Defense Force concluded that one reason for the high count of unreported Zika virus related occurrences was the "shortage of reliable diagnostic, reporting, and monitoring systems that track virus transmission" (Grant et al., 2022). Artificial intelligence, or AI, is a thriving technology that can be used to detect diseases and even diagnose them. According to Pham et al. (2020), the currently used method for classifying respiratory viruses is the reverse transcription polymerase chain reaction (RT-PCR) detection technique. However, alternatives are needed due to how costly and time consuming it is. In fact, most countries are suffering from a lack of testing kits due to budget limitations. RT-PCR testing is also highly variable and has not been reported in a clear and consistent manner to date (Wang et al., 2020). Hence, this standard method is not suitable to meet the requirements of fast detection and tracking during pandemics. A simple, low-cost solution for COVID-19 identification is using smart devices together with AI frameworks.

One example of these solutions is the COVID-Net, a deep convolutional neural network design tailored for the detection of COVID-19 cases from chest X-ray images. Using the finding that patients present abnormalities in chest radiography images that are characteristic of those infected with COVID-19, researchers Wang et al. (2020) introduced the first neural network architecture designed for COVID-19 detection to introduce a lightweight project-expansion-projection-extension (PEPX) design (which enables enhanced representational capacity while greatly reducing computational complexity). It utilizes CXR imaging which is readily available and accessible in many clinical sites and imaging centers as it is considered "standard equipment" in most healthcare systems. CXR imaging also enables rapid assessment of patients suspected of having COVID-19, which helps relieve high volumes of patients especially in heavily affected areas where they have run out of capacity (such as New York, Spain, and Italy).

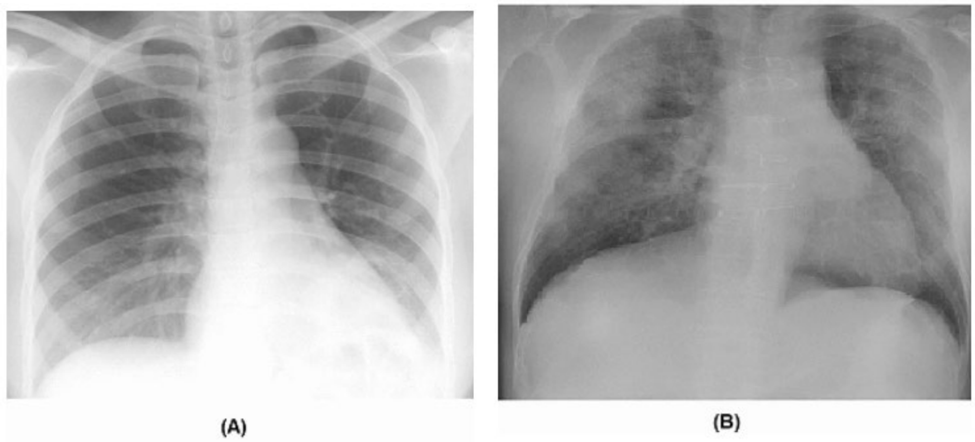

Figure 3a and 3b. Example CXR images of a non-COVID19 infection (A), and a COVID-19 viral infection (B). Images retrieved from the article titled, "COVID-Net: a tailored deep convolutional neural network design for detection of COVID-19 cases from chest X-ray images" by Wang et al. (2020).

It is noted from the works by Wang et al. (2020). that X-ray images and computed tomography (CT) scans are widely used as the input of deep learning (DL) models to automatically detect the infected COVID-19 case. The work uses a three-class classification (normal, COVID-19 infected, and non-COVID-19 infected) which is helpful for the medical staff to determine treatment strategies. Also, by training on an open source dataset with 13,975 images of 13,870 patients (big data), the proposed CNN model can achieve an astounding accuracy of 93.3%.

This model is only one of the many uses of artificial intelligence in the field of epidemiology and demonstrates the potential for AI to revolutionize disease detection and tracking, making it a valuable tool in managing future pandemics.

Conclusion

The research conducted in this paper highlights the significant impact that emerging infectious diseases, such as COVID-19 and Zika, have on military strategy and operations. These diseases not only compromise the health and readiness of military personnel but they also expose critical gaps in the current way of handling such outbreaks. The challenges of vaccine hesitancy and inconsistent virus tracking systems and methods such as RT-PCR underscore the need for more adaptive measures. The integration of artificial intelligence and big data in disease surveillance holds a promising future for more accurate and efficient monitoring which can lead to quicker responses. Additionally, combatting vaccine hesitancy within the ranks through awareness campaigns is vital for maintaining military readiness and retention.

Ultimately, through secondary literature review, drawing from multiple primary studies and informational research articles, as well as holding an interview with an enlisted member of the Air Force, this research paper underscores the importance of continuous improvement in military health protocols and the need for a proactive approach in facing outbreaks. By learning from past outbreaks and investing in innovative solutions such as AI, military forces can better protect their personnel and maintain operational readiness in the face of future infectious disease outbreaks.

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