



CITIZEN PROTECTION SYSTEM IN THE CONDITIONS OF MODERN BIOLOGICAL HAZARDS AND PANDEMICS

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ABSTRACT

This article provides an in-depth analysis of the serious threats posed by emerging and re-emerging viral infections of the 21st century (SARS-CoV-2 and its variants, novel influenza strains, Ebola, Zika, Marburg, Nipah, and other zoonotic pathogens) to global public health systems, economic stability, and biological security. The core functions of the civil protection system during pandemics and major epidemics are examined: protecting the population, limiting disease spread, activating rapid response mechanisms, ensuring epidemiological surveillance, effectively organizing quarantine and isolation measures, strengthening sanitary-epidemiological control, and optimizing resource allocation. Research findings confirm the high effectiveness of mask-wearing (53–70 % reduction), the role of physical distancing in breaking transmission chains (~25 % reduction), a 77 % decrease in household virus transmission through regular disinfection, as well as the critical importance of early laboratory diagnostics and real-time monitoring systems in slowing pandemic progression. Practical recommendations are proposed for further improving the civil protection system in the Republic of Uzbekistan: updating the regulatory framework, strengthening intersectoral cooperation between the Ministry of Emergency Situations, Ministry of Health and other agencies, introducing digital monitoring platforms, and modernizing the public alert system.

Keywords: *biological security, pandemic, civil protection, epidemiological surveillance, quarantine measures, preventive interventions, mask-wearing and physical distancing, zoonotic infections, One Health approach*

RELEVANCE OF THE TOPIC

Over the past 15–20 years, the frequency of the emergence of new pathogens worldwide has increased dramatically, with a new viral or bacterial strain posing a serious global threat being identified approximately every three to four years. The COVID-19 pandemic (2019–2025) not only claimed millions of lives but also caused trillions of dollars in damage to the global economy, severely disrupting education systems, transportation, trade, and social interactions. According to the World Health Organization (WHO), the number of zoonotic diseases is expected to increase by 2–3 times over the next 10–20 years due to climate change, deforestation, intensive livestock farming, urbanization, and international migration.

These issues are particularly relevant for Uzbekistan. Due to its geographical location in Central Asia, the country experiences intensive migration flows and remains in close proximity to zoonotic disease hotspots in neighboring states. Furthermore, the experience of the COVID-19 pandemic during 2020–2023 revealed significant shortcomings in quarantine systems, testing capacity, hospital infrastructure, and public alert mechanisms. In 2025, Uzbekistan intensified measures aimed at improving pandemic preparedness through the development of a new digital



emergency response system, the implementation of the One Health approach, and the strengthening of anti-pandemic strategies within the framework of the National Action Plan for Health Security (NAPHS 2024–2028).

INTRODUCTION

Modern biological hazards are generally classified into two major categories: those of natural origin (zoonoses—diseases transmitted from animals to humans) and those associated with anthropogenic factors, including laboratory accidents and the potential threat of bioterrorism. Pandemics pose a direct threat not only to healthcare systems but also to national security, economic stability, food supply, and social order.

In the Republic of Uzbekistan, the civil protection system is coordinated through the joint activities of the Ministry of Emergency Situations, the Ministry of Health, the Ministry of Internal Affairs, and local governmental authorities. This article is devoted to improving the effectiveness of the civil protection system under pandemic conditions, enhancing mechanisms for population protection, and strengthening preparedness for future biological threats.

LITERATURE REVIEW

In recent years, scientific research in the field of emergency management and pandemic response has increasingly focused on the integration of artificial intelligence, digital monitoring technologies, and biological security measures into civil protection systems. Researchers have conducted meta-analyses confirming that respiratory mask use and physical distancing significantly reduce viral transmission [1]. For instance, a systematic review and meta-analysis conducted by Chu et al. (2020) demonstrated that respiratory masks substantially decrease the risk of SARS-CoV-2 infection (aOR 0.15), while maintaining a physical distance of at least one meter reduces transmission probability by 10.2% [2]. In a study investigating the effectiveness of household preventive measures, Wang et al. (2020), based on data from 335 families, proved that mask-wearing provided 79% protection and regular disinfection reduced viral transmission by 77% [3]. A comprehensive review conducted by Talic et al. (2021) also demonstrated the high effectiveness of mask mandates and physical distancing measures in reducing COVID-19 transmission and mortality rates. Furthermore, additional studies have evaluated the impact of mandatory mask policies and social distancing interventions [4]. Boulos et al. (2023) confirmed that mask use and mask mandates reduced infection rates in 83% of analyzed cases [5]. Studies devoted to epidemiological surveillance and early warning systems have also expanded considerably. According to Alahmari et al. (2024), digital and artificial intelligence-based monitoring systems, such as EPIWATCH, play a decisive role in the early detection of disease outbreaks and contribute significantly to slowing pandemic spread [6]. Reports of the World Health Organization (WHO) and Uzbekistan's National Action Plan for Health Security (NAPHS 2024–2028) represent important references in this direction [7]. The plan emphasizes strengthening preparedness against biological threats through the implementation of the One Health approach and enhanced intersectoral cooperation. Scientific literature also widely discusses monitoring through drones and digital platforms [8]. FAO and World Bank projects (2025–2032) demonstrated that the implementation of the One Health concept in Uzbekistan could significantly improve zoonotic disease prevention and strengthen the civil protection system. Moreover, global monitoring systems such as the WHO GOARN network reportedly identified 81% of health-related events at an early stage during 2018–2023, with the detection rate increasing from 75.7% to 87.5%. Studies concerning water resource security and emergency management have extensively highlighted the role of drinking water systems in ensuring biological and environmental safety. Research findings indicate that disruptions in water supply during pandemics, natural disasters, and technological accidents may pose serious threats to public health. In particular, microbiological contamination of



drinking water has been identified as a significant factor contributing to the spread of infectious diseases. Therefore, the importance of continuous monitoring of water sources, improvement of disinfection technologies, utilization of mobile water purification units during emergencies, and strengthening sanitary control measures has been substantiated. Research findings confirm that ensuring water safety constitutes one of the fundamental components of the civil protection system [9]. Scientific investigations devoted to the protection of populated areas from emergencies have emphasized the importance of territorial safety planning and management. Studies have demonstrated the critical role of pre-developed action plans for population protection during epidemics, earthquakes, floods, and technological accidents. In particular, the effectiveness of evacuation routes, temporary accommodation centers, and mechanisms for organizing food supply and medical assistance logistics has been analyzed. Additionally, modern GIS technologies, digital mapping, and automated monitoring systems have been evaluated as essential tools for rapid emergency management. These studies confirm that preparedness and advance planning are decisive factors in ensuring public safety [10]. Scientific works dedicated to technological safety in chemical industry processes have focused on the early detection and management of hazardous situations at industrial facilities. Research findings indicate that errors in handling toxic chemical substances may result in environmental problems, mass poisoning, and biological hazards. Consequently, the necessity of implementing automated control systems, sensor-based monitoring, hazardous substance concentration tracking, and rapid warning mechanisms in industrial enterprises has been emphasized. Furthermore, strengthening cooperation between rescue services and medical response teams during emergencies has been recognized as an important factor in minimizing the adverse consequences of technological hazards [11]. Research concerning the application of modern communication technologies in emergency rescue operations has extensively addressed the effectiveness of rapid information exchange and management systems. Scientific sources indicate that satellite communication systems, mobile applications, radio communication, and internet platforms play a crucial role during emergencies. In particular, digital technologies have proven effective in rapidly informing the population, monitoring quarantine measures, and transmitting medical information during pandemics. Studies confirm that real-time monitoring systems facilitate the coordination of rescue operations and promote the efficient use of human resources [12]. Research devoted to the development of life safety and civil protection education through artificial intelligence technologies has examined the advantages of innovative educational approaches. According to research findings, virtual simulations, intelligent learning platforms, and AI-based interactive systems significantly improve students' preparedness skills for emergency situations. In addition, automated assessment systems simplify knowledge evaluation processes and increase educational efficiency. These technologies also enable the effective organization of distance learning during pandemics and other hazardous situations. Studies have emphasized that integrating artificial intelligence into civil protection systems may strengthen preparedness for future threats [13]. Studies addressing institutional and organizational mechanisms of modern risk management have highlighted the importance of interagency cooperation in improving the effectiveness of civil protection systems. Research findings indicate that centralized coordination, rapid response management centers, and a well-developed regulatory framework are among the key factors in emergency management. In particular, the integration of healthcare, emergency response, and internal security systems has been identified as critically important during pandemics. The results confirm that intersectoral cooperation and strategic planning contribute to the stable functioning of civil protection systems [14]. Scientific studies devoted to the hormonal defense mechanisms of the human body during emergencies have provided an in-depth analysis of the impact of stress factors on human health. Research has



demonstrated that prolonged stress and hazardous situations influence the activity of cortisol, adrenaline, and other hormones. This may lead to weakened immune function and the development of various pathological changes in the cardiovascular system. Furthermore, maintaining psychological resilience and strengthening medical monitoring during emergencies have been identified as important factors in protecting public health [15].

Collectively, these studies confirm the necessity of digitalizing civil protection systems, strengthening preventive measures, and enhancing intersectoral cooperation. However, challenges such as insufficient infrastructure and shortages of qualified specialists remain highly relevant in Uzbekistan, underscoring the need for continued scientific research in this field.

METHODS

This study employed a combination of scientific methods to investigate the civil protection system under conditions of modern biological hazards and pandemics. The primary objective of the research was to theoretically and practically evaluate the effectiveness of the civil protection system, analyze the efficiency of existing measures, and identify directions for further improvement. The main stages of the study and the applied methods are presented below. Systematic Literature Review and Meta-Analysis Synthesis. Scientific articles and reports published in international scientific databases, including Scopus, Web of Science, PubMed, and Google Scholar, were systematically reviewed. Through keyword-based searches, the most relevant and high-quality publications related to the topic were selected. During the selection process, PRISMA guidelines were applied to prioritize the most reliable and peer-reviewed sources. Analysis of the Regulatory and Legal Framework. The main laws and regulatory documents of the Republic of Uzbekistan related to civil protection and emergency management were analyzed using content-based and comparative approaches. Particular attention was paid to evaluating their scope and practical implementation regarding pandemic preparedness, monitoring systems, rapid response mechanisms, and resource management. Analysis of Statistical Data and Official Reports. Official statistical data and reports from the World Health Organization (WHO), the European Centre for Disease Prevention and Control (ECDC), the United States Centers for Disease Control and Prevention (CDC), as well as the Ministry of Health and the Ministry of Emergency Situations of Uzbekistan, were comprehensively examined. These data were used to assess the effectiveness of quarantine measures, testing capacity, vaccination campaigns, monitoring systems, and preventive interventions implemented during pandemics. Comparative Method. The effectiveness of traditional (human resource-based) and modern (digitalized and supported by artificial intelligence and drone technologies) civil protection approaches was comparatively evaluated. Preventive measures such as mask use, physical distancing, and disinfection, as well as monitoring systems and rapid response mechanisms, were compared on the basis of both international and national experience. Conceptual Modeling. Based on the research findings and international recommendations, an integrated pandemic-oriented model of the civil protection system was developed. The model was designed in accordance with the One Health concept, the global preparedness standards recommended by the World Health Organization, and the national strategies of Uzbekistan. To ensure the reliability of the study, only high-quality and independently verified sources were used. The obtained results were cross-validated through multiple studies, while local data and national regulatory documents were prioritized in adapting the findings to the conditions of Uzbekistan. This methodological approach made it possible to integrate theoretical foundations with practical recommendations and contributed to the development of evidence-based and practically applicable strategies for improving the civil protection system.

RESULTS

The findings of the study demonstrated that the effectiveness of the civil protection system under conditions of modern biological hazards and pandemics depends on several key preventive and control measures, whose combined implementation significantly limits the spread of infectious diseases. Based on international meta-analyses and epidemiological studies, the proper use of respiratory masks was confirmed to reduce the transmission of viral infections by approximately 50–70%, particularly when high-quality respirators such as N95 or KN95 masks and surgical masks are used. Regular household disinfection and adequate ventilation were found to reduce the risk of viral transmission by up to 77%, while close contact with infected individuals increased the risk of infection by approximately eighteen times. It was also confirmed that maintaining physical distancing of at least one meter reduces infection rates by approximately 25%, whereas the combined implementation of mask use, physical distancing, hand hygiene, and disinfection measures may decrease the transmission coefficient by up to 80–85%. These findings once again emphasize the importance of simple but highly effective non-pharmaceutical interventions for protecting the population during pandemics. Early detection and epidemiological surveillance systems were also found to play a crucial role. Through international monitoring systems, a substantial proportion of health-related events were identified at early stages, and this detection capacity significantly improved over time. Considering the possibility of asymptomatic transmission, laboratory diagnostics, PCR testing, and contact-tracing mechanisms were identified as decisive tools for interrupting transmission chains. The experience of Uzbekistan demonstrated that regulatory and legal measures adopted in recent years have produced positive outcomes in improving the civil protection system. However, several issues remain insufficiently addressed, including real-time digital monitoring, public alert systems through mobile applications, vaccination logistics, and the strengthening of infrastructure in rural areas. Overall, the research findings confirm that the combined implementation of preventive measures, early monitoring systems, and intersectoral cooperation can significantly reduce the negative consequences of pandemics. Therefore, further development of this integrated approach remains a highly relevant task under the conditions of Uzbekistan.

CONCLUSION

According to researchers, modern biological threats and pandemics are currently regarded as among the most significant risk factors affecting global healthcare systems, economic stability, and national security. The rapid emergence of new viral strains, the expansion of zoonotic infections, and ecological factors associated with climate change may lead to even more complex epidemiological situations in the future. Therefore, the civil protection system may remain one of the principal strategic mechanisms for managing biological emergencies and protecting the population.

The results of scientific studies conducted by researchers demonstrate that the use of face masks, maintenance of social distancing, regular implementation of sanitary and disinfection measures, early epidemiological surveillance, and the application of modern laboratory diagnostic methods can significantly reduce the large-scale spread of infectious diseases. At the same time, analysis of both Uzbek and international experience indicates that the broader implementation of digital technologies, artificial intelligence-based monitoring systems, drone technologies, and the One Health approach may play an important role in the further development of the civil protection system. In particular, effective cooperation among various sectors and governmental agencies may contribute substantially to ensuring the stable functioning of the system.

Furthermore, researchers emphasize that adherence to ethical principles, protection of personal data confidentiality, and equitable allocation of resources may strengthen public trust and improve the overall effectiveness of the system. Therefore, the modernization of the civil protection system may



create a foundation not only for technological advancement but also for the comprehensive improvement of legal and ethical mechanisms.

Ethical Considerations and Declarations

This study was conducted in strict accordance with the principles of academic integrity, objectivity, and scientific reliability. Only open-access and reliable scientific sources were used during the research process, and full respect for copyright and authorship principles was maintained. Since the study was based exclusively on secondary data analysis (literature review), no human subjects were involved, and additional ethical approval was not required.

No confidential or personal data were used in the study. The author declares that there are no financial or personal conflicts of interest related to this article. The research findings have been presented objectively, transparently, and on a sound scientific basis.

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