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The Effects of Biological Disasters on Public Health

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Summary: Biological disasters present a significant public health concern. Public health plays a crucial role in managing these disasters by facilitating the timely and accurate detection of biological hazards and ensuring appropriate medical preparedness. This study examines the role of public health in managing biological disasters and the impact these events have on public health systems. It seeks to raise awareness about the importance of enhancing the capacity and preparedness of public health professionals. Furthermore, the study highlights the need for strengthened cooperation and policy development among institutions, organisations, and communities during the preparation and response phases of potential future biological disasters, contributing to greater visibility of these efforts.

Key words*:* biological disasters, public health, biological agents

Natural and human-made disasters, which disrupt or completely halt normal life, directly or indirectly affect human health and, as a result, remain a global public health issue (Source: WHO). The use of unhygienic and unsafe water and food due to natural disasters or deliberate human activities can lead to diseases such as typhoid and cholera; the inability to control vectors can cause malaria and plague, and contact-based transmission can result in respiratory illnesses and hepatitis A. The occurrence of these diseases can exacerbate the severity of the disaster and lead to the emergence of biological disasters [14].

Biological disasters, which can affect various living beings within a short period, contribute to the intensification of disaster interventions and give rise to other public health problems (Tercan, 2020). Public health services during and after disasters include trauma care and triage assistance, management of death crises, community care, coordination of emergency response teams and volunteers, and additional services [7]. The early detection of disasters, such as epidemics, and medical preparations planned against biological hazards enable timely and accurate diagnosis and treatment, contributing to the establishment of sustainable and robust public health planning and efforts to combat biological disasters [20].

In addition to the responsibilities public health assumes within the scope of disaster management, it is particularly vulnerable to disasters caused by biological agents. As a result of these disasters, individuals may experience psychological issues such as depression, anxiety, and post-traumatic stress disorder, as well as social challenges like the loss of schooling and employment, alongside economic difficulties. Consequently, disasters pose a significant threat to sustainable public health and development [40]. Public health services related to disaster impacts should be integrated into disaster preparedness training, programs, and drills. Enhancing public health personnel's awareness and response capacity in these training efforts is crucial [11].

This study draws attention to biological disasters and their impacts on public health. It highlights the vulnerabilities and destructive effects that may arise in the face of biological

disasters, emphasising the critical role of public health. It underscores that public health professionals must continually expand their knowledge and expertise by understanding the significance and impact of biological disasters. Additionally, the study explores biological disaster management methods and policies from a public health perspective. By linking key elements and information about biological disasters with public health services, the study aims to contribute to ongoing discussions and emphasises the importance of cooperation among communities, policymakers, and public institutions and organisations in the preparation and response processes for potential future events.

2. Biological Disasters. Biological disasters typically arise from intentional human activities, such as the deliberate infection of animals and plants with biological agents, leading to the transmission of diseases to humans or through the consumption of contaminated food and water. However, they can also result from natural factors, such as insect infestations that carry or spread biological agents [27].

Throughout history, biological agents responsible for such disasters have caused numerous epidemics and mass fatalities, marking them as a high-risk group. One historical example is from the 14th century during the Siege of Kaffa, where the Tatars reportedly used plague-infected corpses, launching them into besieged areas via catapults. Another significant event in history was the Spanish Flu during World War I, which led to widespread deaths. These events underscore the importance of recognising the effects of biological disasters [36].

3. Classification of Biological Disasters. Biological disasters are classified into three categories: epidemics, insect infestations, and animal accidents [15].

Epidemics: Epidemics, which can emerge following natural or human-induced disasters such as earthquakes, floods, environmental pollution, and climate change, have been documented throughout history. The first known epidemic occurred around 430 BCE during the Peloponnesian War. It is believed that the disease was likely spread by rats carrying agents like hantavirus. Symptoms included fever, throat inflammation, pain, redness in the eyes, severe spasms, dehydration, and coughing [22]. Historical sources suggest that typhus was the primary cause of this epidemic, which also influenced the course of wars at the time [25]. The most impactful event in history was the "Black Death," caused by the *Yersinia pestis* bacterium in the 14th century, which led to the death of nearly one-third of Europe’s population [29].

Throughout history, epidemics have not only caused widespread death but also significantly altered societal lifestyles and production patterns. After the transition to settled life, the availability of safe drinking water decreased, and finding clean water sources became more challenging. As a result, various diseases emerged in different regions. With the growth of urbanisation, people began living in smaller and more crowded spaces, which facilitated the rapid and easier spread of epidemics [29].

The recent COVID-19 pandemic, like other historical epidemics, has profoundly affected society. It is believed that the unprecedented rapid spread of COVID-19 was largely driven by human activities and commercial interactions [13]. Following this epidemic, society had to adapt to significant political, economic, and social changes. The pandemic also led to an increase in people's desire and movement towards rural areas. As seen with past epidemics, the impacts of such events can be devastating [33]. Therefore, it is essential to take precautions against potential future epidemics.

Additionally, the U.S. Centers for Disease Control and Prevention (CDC) has listed biological agents that can easily spread within communities and potentially cause biological disasters. These agents are classified into three groups-A, B, and C-based on the severity and distribution of the diseases they cause, as shown in Table 3.1 [6].

Insect Infestations and Animal Incidents. Insect infestations and animal incidents are subcategories of biological disasters. According to the EM-DAT database, numerous locust

infestations and a smaller number of armyworm infestations have been recorded. Between 1900 and 2020, 82% of these infestations occurred in Africa, followed by 11% in Asia [15].

Table 3. Biological Disaster Categories

Category	Biological Agents	Diseases	Potential
A	➔ Variola Major ➔ Bacillus Anthracis ➔ Yersinia Pestis Clostridium Botulinum Toxin ➔ Francisella Tularensis	Smallpox Anthrax Plague Botulism Tularemia	They are agents that pose high threats to international security and public health, spread easily and cause high mortality rates.
	Filoviruses (Ebola, Marburg) Arenaviruses (Lassa, Junin, Machupo)	Viral hemorrhagic fever	
B	Coxiella burnetti Brucella spp. Burkholderia mallei/pseudomallei Alphaviruses (Venezuelan eastern and western equine encephalomyelitis)	Q fever Brucellosis Glands/Melioidosis Encephalitis	Agents that pose the second highest risk to public health are those that cause disease and have a lower mortality rate.
	Toxins (Ricin, Clostridium etc.) Rickettsia prowazekii Chlamydia psittaci Salmonella spp. Shigella dysenteriae Escherichia coli Cryptosporidium parvum Vibrio cholera	Toxic syndromes Typhus Psittacosis Salmonellosis Dysentery Food poisoning Cryptosporidiosis Cholera	
C	Nipah virus Hantavirus Tick-borne hemorrhagic fever viruses Tick-borne encephalitis virus Multidrug-resistant Mycobacterium tuberculosis	It is expected that the diseases will become definite in the future	They are agents that cause high rates of illness and death due to their easy production and availability.

Source: (CDC, 2018a)

Insect infestations that reach the level of a biological disaster can cause significant damage to food sources and lead to losses. Infestations, particularly those threatening plant-based products, have a direct impact on community nutrition [26]. They result in agricultural losses and damage to crops, thereby posing serious food security issues. In some grains affected by infestations, reductions in nutrients such as zinc, iron, and fats have been observed, while in others, increases in fibre and protein have been noted. However, foods affected by insect infestations should not be consumed, as they may lead to toxic outcomes [34].

4. Transmission Routes of Biological Disasters. Biological disasters spread through the transmission of diseases caused by biological agents present in animals, the dispersal of aerosols, and the contamination of the environment, water, and food with biological agents [14].

Aerosols: Aerosols are defined as the dispersion of liquid droplets and small solid particles in the air or within a gas. If the biological agent exists in a particle compatible with aerosol form, it can enter the systemic circulation through the lungs. For particles to be suitable for aerosol formation, they must be between 0.5 and 10 microns. Biological warfare agents can be freeze-dried and sprayed via carriers, making the particles appropriate for aerosol formation [32].

Contamination of Water and Food: Some biological warfare agents target open wounds with compromised skin integrity and mucosal surfaces [32]. Detecting biological agents upon initial contact is challenging due to the incubation period, and it may take days or weeks for symptoms to appear. Once infected, individuals can transmit the disease to healthy people, causing a rapid increase in the total number of infected cases [3].

Animals: Some diseases, capable of reaching disaster-level proportions, can be transmitted by infected animals such as birds, mosquitoes, rats, and fleas, which act as vectors [3]. Secondary contamination from biological agents is also a significant factor in increasing the transmission rate. The rapid rise in transmission leads to an increased risk of disaster [14].

5. Impacts of Biological Disasters on Public Health. Public health services bear significant responsibilities in responding to both natural and human-induced disasters. Key medical responsibilities include the detection and treatment of disease agents, surveillance of disease outbreaks, and organizing logistics for medication [11].

Throughout history, biological disasters have caused psychosocial, economic, and physical destruction on both regional and global scales. One notable example of physical devastation caused by a biological disaster is the COVID-19 pandemic, which led to millions of cases worldwide and significant loss of life. In addition to its physical toll, COVID-19 has also had a profound impact on mental health, a critical public health issue (Bilge Yıldız & Bilge Yusuf, 2020).

A study conducted in China with 1,210 participants investigated the psychological effects of the COVID-19 pandemic. It found that 54% of the participants experienced moderate to severe psychological distress, 29% reported moderate to severe anxiety, and 17% showed moderate to severe depressive symptoms [43]. In Türkiye, a similar study reported psychological conditions such as anxiety, anger, depression, and obsessive-compulsive disorders during the pandemic [5]. These findings illustrate the far-reaching psychological impacts of biological disasters and emphasise the need for pre-disaster psychological preparedness and training. Public health workers must also be educated in psychological first aid and appropriate psychosocial support techniques [10, 28].

Another study during the COVID-19 pandemic explored the motivations of Australian healthcare workers, finding that access to equipment was the most significant factor affecting their motivation. This study highlights the concerns some healthcare workers may have regarding protection during disasters [9]. Such issues can exacerbate crises, making it crucial to ensure that healthcare workers feel secure and have full access to equipment during any disaster.

In the study conducted by Şen and Ersoy in 2017, titled "Evaluation of the Knowledge Level of the Hospital Disaster Team Regarding Disaster Preparedness," the knowledge levels of the team members responsible for the Disaster Plan at Dokuz Eylül University Faculty of Medicine were measured. According to the results of the research, 42.1% of the participants were found to have sufficient knowledge regarding disaster planning [31]. The findings of this study highlight the importance of increasing the knowledge levels of emergency teams within the framework of hospital disaster plans.

A study conducted in 2019, titled "Examination of the Incident Response Methods of CBRN Teams: The Case of Adana AFAD," investigated the CBRN (Chemical, Biological, Radiological, and Nuclear) Service Group Operation Plan in the province of Adana. In this study, the necessity of protecting public health and the environment against potential hazards within the scope of the Adana Disaster Response Plan was emphasised. Additionally, the study focused on the necessary measures to reduce potential losses [44].

Biological agents in Category A, which cause biological disasters, pose a high risk to public health. Since these agents can spread quickly and easily, they can lead to chaos in society and cause significant destruction. Public health services should create effective plans to respond swiftly to such biological disasters [8]. Biological disasters especially place emergency response and public

health workers at higher risk, making it crucial for hospitals and healthcare workers to be protected from contamination caused by these agents [41].

Large-scale disasters caused by biological agents can negatively impact local and national public health planning. Medical tools, personnel, and tests used during or after a disaster are essential elements that enhance the effectiveness of the response [12]. Biological disasters create situations where both individuals experiencing anxiety and those contaminated with biological agents urgently require public health services. This indicates that public health workers may face challenges in making effective interventions while at risk of contamination from biological agents. Such scenarios underscore the importance of a disaster surveillance system [41].

The disaster surveillance system enables the detection, analysis, and interpretation of data. It generally allows for the initial use of laboratory data outputs and individual and community health indicators to diagnose potential diseases. Surveillance functions as an early warning system to protect the health of the community exposed to risk factors resulting from the disaster [19].

6. Response to Biological Disasters and Public Health

According to data from the Centre for Research on the Epidemiology of Disasters (CRED), 399 disasters occurred in 2023, resulting in 86,473 deaths and affecting 93.1 million people. These disasters also caused economic losses amounting to 202.7 billion USD. While major catastrophes such as earthquakes, floods, tornadoes, erosion, wars, and tsunamis have immediate and severe impacts, longer-term developments like epidemics, famine, drought, and insect infestations can cause even greater devastation and result in higher death tolls due to their prolonged nature [42].

In Türkiye, the Disaster and Emergency Management Authority (AFAD) established the Türkiye Disaster Response Plan (TAMP) in 2014 to facilitate rapid, effective, and accurate responses to disasters based on past experiences. The plan was revised and republished in the Official Gazette in 2022. The primary objectives of TAMP include saving lives, maintaining sustainable and effective disaster response efforts, protecting public health, and ensuring continuity [2].

Disasters that can lead to crises must be managed swiftly and accurately. Effective disaster management relies on the deployment of experienced personnel, the selection of appropriate equipment, and the use of suitable tools. In particular, biological disasters caused by small-particle aerosols—biological agents that spread rapidly and inflict significant damage - should be a focal point of preparedness plans designed to safeguard the public and response teams.

Preparing for and protecting the public from the impacts of biological disasters poses significant challenges for public health services and emergency management agencies [41].

The incorporation of CBRN-HAZMAT (Chemical, Biological, Radiological, and Hazardous Materials) planning into biological disaster management introduces additional psychological and practical complexities. The nature of CBRN threats differs from traditional interventions, heightening the potential for conflicts among institutions. Moreover, CBRN scenarios introduce intricate stages in planning, preparedness, and response, necessitating continuous interaction between various individuals, institutions, and organizations [21].

Public health units must prioritise the development of plans that contribute to effective biological disaster management. This includes strategies to mitigate exposure to biological agents and ensure the efficient distribution of medical supplies in response to such incidents [11]. Table 6.1 illustrates a framework of public health preparedness and response activities specifically tailored for CBRN (Chemical, Biological, Radiological, and Nuclear) incidents.

Table 6. 1 Functional Framework for Public Health in CBRN Preparedness and Response

Evaluation Functions	Security Functions
Continuation of diagnostic and examination actions	Provision of emergency medical supplies and services
Investigation of the incident by the responsible institution, organization, and stakeholders	Prevention of victims' minimum needs and ensuring their safety
Assessment of medical needs and victim decontamination	Activation of laboratory emergency response protocols
Continuation of the initial epidemiological investigations	Health-related assessment of mass care centres
	Monitoring the work and health conditions of first aid workers
	Management of contaminated deaths
	Implementation of behaviour training and exercises

Source: (Latourrette & Dausey, 2009)

In the face of a biological disaster, maintaining effective public health surveillance is crucial to ensuring an appropriate and timely response. A rapid reaction must encompass prior epidemiological research, disease prevention strategies, decontamination planning, and medical treatment for individuals affected by biological agents. Preparing for the injuries and infectious diseases associated with biological disasters is essential, complementing public health surveillance and intervention methods designed to protect communities from contaminated water sources, influenza outbreaks, and potential bioterrorism [12].

Individuals exposed to a biological disaster should be transported to medical facilities in a controlled manner. For effective management, it is vital to implement appropriate medical and chemical procedures. Following this, decontamination procedures must be applied separately to contaminated waste and to individuals whose decontamination status has not been confirmed [4].

Before initiating interventions in areas exposed to biological disasters, certain protocols must be strictly followed. These protocols include the following: unauthorized and vulnerable individuals should not enter areas contaminated with biological agents; individuals who have entered the area should not be allowed to exit without undergoing decontamination; decontamination materials should not be utilized without identifying and explaining any unidentified substances; and all individuals exiting the area contaminated by biological agents must have access to medical supplies and examinations [30].

In disaster management, the level of awareness and consciousness within the community is of significant importance. To mitigate the public health issues caused by biological disasters, the community is expected to achieve sufficient knowledge about these incidents and assist in the coordinated efforts of institutions, organisations, and public health workers. Through effective communication tools, the public should be informed before, during, and after a disaster to avoid panic and the chaos it may create. Success in this regard is anticipated through the collaboration of all institutions, organisations, public health personnel, and media outlets. Specifically, a communication system that contributes to disease surveillance should establish a network for the quick and accurate exchange of information regarding anticipated outbreaks, reporting diagnostic results and urgent health news, and coordinating disaster response efforts, thereby raising awareness among public health workers [41].

7. Public Health Policies and Strategies for Biological Disasters in Türkiye. In response to the disasters experienced in Türkiye, the Disaster and Emergency Management Authority

(AFAD) has developed the Türkiye Disaster Response Plan (TAMP). TAMP was published and came into effect on January 3, 2014, in the Official Gazette No. 28871. However, on September 15, 2022, amendments were made to TAMP, resulting in its reissuance in the Official Gazette No. 31953. TAMP defines the working groups and institutions responsible for intervening in disasters and emergencies, delineating the roles and responsibilities of coordination units. In this context, TAMP outlines the fundamental rules for planning during the pre-, during, and post-disaster phases [2].

The Türkiye Disaster Response Plan (TAMP) encompasses chemical, biological, radiological, and nuclear (CBRN) events within its framework, categorizing them as "chemical events, biological disasters accompanied by epidemics, and radiological and nuclear accidents" (TAMP). On October 1, 2020, the Regulation on Duties Concerning Chemical, Biological, Radiological, and Nuclear Threats and Hazards was published in the Official Gazette No. 31261, under the "Law on the Organisation and Duties of the Disaster and Emergency Management Authority." This regulation aims to minimize or completely prevent harm to society and the environment arising from potential chemical, biological, radiological, and nuclear threats and hazards that Türkiye may encounter, thereby promoting coordinated efforts among institutions, organizations, and other sectors.

Upon reviewing the content of the regulation, it is evident that AFAD is tasked with carrying out intervention activities in the event of a CBRN incident. It is understood that the provincial governorates, provincial response teams, and the General Staff will play crucial roles in the risk and crisis management processes, particularly in situations where risks escalate and capacities are exceeded. Furthermore, it has been reported that public health services are essential during CBRN interventions under TAMP [2].

On May 25, 2021, the “Regulation on Health Services in Disasters and Emergencies” came into effect, delineating the duties and responsibilities of various institutions and organizations concerning CBRN events, including the Turkish Medicines and Medical Devices Agency, the General Directorate of Public Health, and the General Directorate of Emergency Health Services (The Republic of Türkiye Official Gazette, Regulation on Health Services in Disasters and Emergencies, n.d.).

As part of the European Union (EU) harmonisation services, the “National Action Plan for Public Health Emergencies at International Points of Entry (IPEs)” was established in 2012, drawing from data provided by the EU Twinning Project. The primary objective of this plan is “to prevent the proliferation of international public health problems arising from chemical, biological, radiological, and nuclear events and to establish national inclusiveness of the responsibilities of responsible institutions and the mandatory collaboration necessary for an effective public health response” (National Action Plan for Public Health Emergencies at International Points of Entry, 2012).

In the realm of medical measures for CBRN events, infectious diseases, and pandemic influenza, the Biomedical Advanced Research and Development Authority (BARDA) operates under the U.S. Department of Health and Human Services (DHHS). Established in 2006 under the Pandemic and All-Hazards Preparedness Act (PAHPA), BARDA facilitates communication among private companies, universities, and government agencies, such as the U.S. Food and Drug Administration (FDA), regarding the development and licensing of medical supplies. The initiative involves experts from various fields, including biology, chemistry, physics, public health, and engineering [38].

The International Federation of Red Cross and Red Crescent Societies (IFRC) has established the Emergency Response Unit (ERU), designed to rapidly deploy trained specialists to disaster-affected areas and improve overall response capabilities. The ERU, which is also being developed by the Turkish Red Crescent, comprises experienced volunteers capable of providing essential services such as logistics, medical care, water supply, and sanitation following a disaster [17].

8. Conclusion and Recommendations. As demonstrated, during biological disasters, public health services play a crucial role in identifying and mitigating risks to public health while ensuring the coordination of medical treatment. The specific responsibilities of these services may vary depending on the nature and severity of the disaster. The active involvement of public health professionals throughout all phases of disaster management is essential for effective response and recovery efforts. During the risk management phase, public health experts analyze potential hazards and develop strategic plans to address them, thereby contributing to community resilience and improvement [16,24].

To enhance the preparedness of public health professionals, it is imperative to improve their training programs by incorporating practical scenarios that reflect real-life and potential disaster situations. This approach will enhance the skills and confidence of professionals in the field. Furthermore, collaboration with the community is critical in these scenarios, as it fosters a shared understanding and facilitates effective communication [9].

Chemical, Biological, Radiological, and Nuclear (CBRN) disasters have a significant impact on food safety. To safeguard food from biological contamination, it is essential to package it in airtight materials, such as foil or tin cans. Biologically contaminated foods can be effectively decontaminated using heat. Thus, these foods should be stored in airtight containers and subjected to appropriate decontamination processes before consumption [23].

The effects of biological disasters and the interventions implemented in response to them are of critical importance. To effectively manage these disasters, it is essential to place additional emphasis on public health planning at all stages of an integrated disaster management framework. Given the responsibilities and capacities of public health services, it is evident that preparation for emergencies and the threats associated with emerging infectious diseases should be prioritized. Furthermore, public health must develop comprehensive plans that address all potential threats, particularly Chemical, Biological, Radiological, and Nuclear (CBRN) incidents. Planning for CBRN events should be elevated to both local and national levels.

Public health services should integrate emergency planning with training and drill programs to facilitate effective implementation. This integration is vital, as the foundation of successful public health interventions lies in a robust health knowledge base.

Additionally, there is a pressing need to enhance knowledge and skills related to trauma and psychological conditions that may arise following biological disasters. The increasing frequency of biological disasters can have significant social and economic repercussions, often leading to the displacement of affected populations. As the population grows, the responsibilities of public health services in providing care and implementing interventions also expand. Therefore, public health workers should receive in-service training, and new policies and practices that support these workers should be developed and put into practice.

The occurrence of biological disasters can adversely affect food products, including meat, dairy, and vegetables, thereby posing threats to public health. In this context, it is imperative to conduct safety tests on food in regions affected by biological disasters prior to consumption. Even products deemed suitable for packaged consumption should undergo disinfection processes. Comprehensive and detailed planning is necessary at every stage, from the disposal of contaminated foods to ensuring community nutrition during extraordinary circumstances.

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Bioloji fəlakətlərin ictimai sağlamlığa təsiri

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Xülasə: Bioloji fəlakətlər mühüm ictimai sağlamlıq problemidir. Bioloji təhlükələrin vaxtında və dəqiq aşkar edilməsini asanlaşdırmaqla və adekvat tibbi hazırlığı təmin etməklə bu fəlakətlərin idarə olunmasında ictimai sağlamlıq mühüm rol oynayır. Bu tədqiqatda bioloji fəlakətlərin idarə edilməsində ictimai sağlamlığın rolunu və bu hadisələrin ictimai səhiyyə sistemlərinə təsirini araşdırılmışdır. Məqalə ictimai səhiyyə mütəxəssislərinin potensialının və hazırlığının təkmilləşdirilməsinin vacibliyi haqqında bilikləri artırmaq məqsədi daşıyır. Bundan başqa, tədqiqat gələcək potensial bioloji fəlakətlərə hazırlıq və onlara cavab vermək üçün agentliklər, təşkilatlar və cəmiyyətlər arasında əməkdaşlığın və siyasətin inkişafının gücləndirilməsinin zəruriliyini vurğulayır və bununla da bu səylərin əyaniliyini artırır.

Açar sözlər: bioloji fəlakətlər, ictimai sağlamlıq, bioloji agentlər

Влияние биологических катастроф на общественное здоровье

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Резюме: Биологические катастрофы представляют собой значительную проблему для общественного здравоохранения. Общественное здравоохранение играет решающую роль в управлении этими катастрофами, способствуя своевременному и точному обнаружению биологических опасностей и обеспечению надлежащей медицинской готовности. В этом исследовании рассматривается роль общественного здравоохранения в управлении биологическими катастрофами и влияние этих событий на системы общественного здравоохранения. Оно направлено на повышение осведомленности о важности повышения потенциала и готовности специалистов общественного здравоохранения. Кроме того, в исследовании подчеркивается необходимость укрепления сотрудничества и разработки политики между учреждениями, организациями и сообществами на этапах подготовки и реагирования на потенциальные будущие биологические катастрофы, что способствует большей наглядности этих усилий.

Ключевые слова: биологические катастрофы, общественное здравоохранение, биологические агенты.

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