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ORIGINAL ARTICLES

Health sector organization to respond to a bioterrorist attack

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Abstract: *Bioterrorism constitutes a major health threat to global communities, with many specific features that carry the potential to extraordinary stress the Public Health Sector (PHS) of any country, because of the needs of resources and of a coordination network required for a successful response to such incidents. Bioterrorism incidents of the near past prove that public mortality and morbidity can be further reduced if a functional protocol would allow first responders, hospitals, and officials of the PHS to steer more efficiently the public expectations. At the national level, the PHS director is responsible to mobilize and coordinate that network of the critical human, financial and logistical resources during the preparedness and response phases after a bioterrorist attack to mitigate its effects. Both these phases include many specific functions and responsibilities, which will be beneath analyzed.*

Keywords: *bioterrorism, public health sector, health preparedness*

BACKGROUND

Bioterrorism is the deliberate use of biological agents to disseminate life-threatening diseases to threaten or devastate a population [1]. The bioterrorist threat consists of a rapidly growing and perhaps the most frightening menace to world health security [2]. The weaponized application of pathogens to disorder populations has been established throughout history [3]. However recently, the profound development of bio-molecular engineering combined with the worldwide proliferation of high-level biosafety laboratories has aroused concern about the increased accessibility of biotechnology [4] and potential misuse of biological agents [5]. Bioterrorism manufacture requires just culture samples, the means to grow, purify, stabilize and disseminate them [6].

The motives underlying bioterrorist incidents of the last years have been nationalistic objectives, revenge, or a mix of paranoid – conspiratorial – apocalyptic prophecy [7]. Additionally, large terrorist organizations such Al-Qaida would always seek ways to acquire biological weapons [8].

The biological agents considered suitable for terrorism should have high inter-human infectiousness, high morbidity and/or lethality, ease of manufacture, storage, and delivery in adequate quantities, environmental stability after dispersion, and absence of effective treatment [9].

Most of the abovementioned characteristics are easily achievable and that raises concerns about the devastating power of biological weapons, because of various reasons: they disseminate in various ways, extremely small quantities of them are lethal, manufacture information is readily obtainable, and a bioterrorist attack can initially be covert since the appearance of symptoms and illness will lag for several hours or days [10].

Bioterrorism agents are classified into bacteria and viruses and yet into three categories; A, B, and C, depending on the ease of dissemination, severity of illness caused, and ability

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to cause death [11]. Of those, microorganisms of Category-A (i.e. anthrax, botulism, plague, smallpox, and viral hemorrhagic fevers), carry the potential to extraordinary stress the PHS, because:

1. The initial release of the bioterrorist agent could go undetected until the onset of disease, creating a sudden influx of severe illness;

2. Incidents that result in impairment of food and water supplies, as well as transportation and communication barriers, may gravely affect the national stability;

3. Contamination risks and subsequent fears of exposure may further complicate recovery operations and cause civil disorder [12].

Up to now, bioterrorism remains a challenge for the PHS of every nation, mainly due to the need for resources and a coordination network required for a successful response to an incident [13]. At the national level, the PHS director is responsible to mobilize and coordinate that network of the critical human, financial and logistical resources during the preparedness and response phases after a bioterrorist attack. Both these phases include specific functions and responsibilities of PHS, which will be beneath analyzed.

PREPAREDNESS PHASE

Risk Assessment

Among weapons of mass destruction, biological agents are much more destructive than chemical weapons, including nerve gases, whilst under certain conditions, biological weapons can be equally devastating to nuclear ones. For example, according to a traditional disaster simulation model [14], a few kilograms of anthrax in a dense urban area can kill as many people as a Hiroshima-size atomic bomb, or cause even more casualties when considering the current suburban living situation of a western Metropolis, combined with favorable upwind conditions [15].

Risk assessment is a multidisciplinary activity, aiming at identifying those who may wish to use biological weapons against the population, the agents that may be used, and the circumstances under which they may be used. Risk assessment of biological threats often involves modeling approaches based on certain risk assumptions. To understand these risks, planners assess them as a function of their likelihood to occur, their potential consequences, and the possible measures that could be taken to control them, based on an understanding of existing surveillance data, the literature, past experiences, and opinions of experts [16].

Intelligence

Preparedness for bioterrorist attacks includes international collaboration for the secure exchange of sensitive information regarding the capabilities of terrorists [2]. Accurately predicting potential biologic threats is difficult without the implementation of intelligence data, adequate funding [17], strategies of data- and cyber-security, and expanding use of electronic information, reporting and surveillance systems [18]. Furthermore, networked video cameras and advanced software designed to verify important intelligence information have become powerful tools for counterterrorism operations [19]. Notification to WHO is required for all cases of sufficient seriousness, such as diseases with severe public health impact, risk of international spread, cases of unusual or unexpected nature, and of course all cases of category A diseases, which constitute a "public health emergency of international concern" [20].

Disease Surveillance

The cause of a bioterrorist disease may be difficult to determine, especially if the initial cases are few. Because of rapid progression to illness and the potential for dissemination of bioterrorist agents, authorities of the PHS should apply accurate, sensitive, and specific surveillance systems to promptly recognize non-specific disease patterns that might indicate the early manifestations of a biological attack. That can be accomplished through two pillars; epidemiological and syndromic surveillance.

Epidemiological surveillance

Following a confirmed case of biological exposure or clusters of unusual symptoms or diseases detected by PHS surveillance, forensic epidemiology tracks back to identify the population at risk. This procedure is called the epidemiological investigation and uses descriptive, analytical, and molecular epidemiologic tools to identify the source and possibly to prevent further events [21, 22]. For that to be accomplished, epidemiological models encompass the potential agent to be used, the specific geographic location of an attack, the level of preparedness, and early intervention on a local and national level. Epidemiologic principles must be used to assess whether a patient's presentation is typical of an endemic disease or is an unusual event that should raise concern. An epidemiological alert system should include multiple sub-systems regarding disease reporting, laboratory network surveillance for specific pathogens, sentinel hospital surveillance for infectious diseases based on primary healthcare data, and a rapid response system with a 24 h/7 d epidemic response team [23].

Syndromic surveillance

The concept involves real-time collecting and analyzing statistical data in a given population, focusing on symptoms rather than laboratory confirmation of diagnosis. Syndromic surveillance systems register suspicious or confirmed cases reported by physicians, and the data are used to monitor the progress of a bioterrorism outbreak [2]. The technique may be affected by various factors, such as data selection criteria, seasonality, size and dispersion of the infected population, the incubation period, selection of statistical detection thresholds, duration of follow-up, access to diagnostic practices or reference laboratories, and reporting procedures; all these results in potentially false alarms and overuse of resources to investigate them [24]. Specificity for distinguishing random variations of ordinary illnesses from bioterrorist attacks may be low when the early symptoms of bioterrorism-related illness overlap with those of many common infections, whilst respective sensitivity may also be low if detection thresholds are reduced to enhance specificity [25]. Lastly, syndromic surveillance is planned to enhance, rather than replace, existing diagnostic tools to epidemic detection [26].

Early Warning and Response System (EWRS)

Numerous biological agents may be used in bioterrorism; terrorists might use combinations of them, common or new, drug-resistant or genetically engineered pathogens, or attack in more than one location simultaneously. Early detection and response to highly contagious biological agents are hence crucial. That can be accomplished through an EWRS, i.e. a rapid web-based alert system used for exchanging information on health threats resulting from the deliberate release of a chemical, biological and radiological agents, but mostly for monitoring epidemics. A major benefit of global collaboration at a technical level is the development of trust networks among experienced scientists and clinicians, for both natural and intentional outbreaks [27].

Emergency Planning

Terrorist attacks are more frequently covert compared to bombings or even chemical attacks. That is an intrinsic feature of bioterrorism, due to the incubation period of pathogens that brings a delay between exposure and onset of symptoms and consequently, between the attack and the involvement of PHS and civil security agencies [28]. The importance of emergency planning lays in the fact that public health infrastructure should be prepared to confront a rapid sequence of emergency events, including a delayed massive wave of illness, rapid dissemination in the population, and the need for prevention strategies, analyzed below.

Laboratory Preparedness

A solid laboratory network would enable quick and accurate detection and subsequent response to biological threats. The response capacity of those laboratories is classified into four Biosafety Levels (BSL); from BSL-1 (clinical laboratories with minimal biosafety requirements), up to BSL-4 (implementing the highest biosafety standards), according to their scientific background, expertise, and infrastructure to support the diagnostic needs of a highly hazardous biological event [4]. During such, a proper laboratory network enables the following functions:

1. Activating all BSL laboratories nationwide.

2. Prioritizing and sharing information among sentinel laboratories and PHS officials on an emergency, 24/7 day basis, to ensure that the public received precise and prompt messages [18].

3. Recognizing and responding to any covert event involving the collection, preservation, transport, and testing of highly infectious human specimens according to uniform guidelines for handling samples of pathogens of public health interest [29].

Food and Water

Biological agents constitute a major concern regarding the safety of food [30, 31]; contamination of water with biological agents should be also considered, albeit that is improbable to be the major target of bioterrorism, due to chlorination, dilution, and the need for large quantities of the agent to cause a significant biological threat [32]. Nevertheless, quantities far less than a kilogram of botulinal toxin, for example, in the main water supply of a city may cause 28-40,000 deaths, depending on how early symptoms will be recognized and remedial measures will be applied [14].

Stockpiling

The strategic medical stockpile of a country is a national repository of vaccines, drugs (antibiotics, antidotes, etc), and general medical supplies that can be deployed to areas affected by various sorts of public health disasters, including bioterrorism. In the case of the dissemination and subsequent detection of a biological agent, strategic stockpiles of respective medication against the agent should be provided to the affected area within less than 24 hours; subsequently, the medical countermeasures should be appropriately dispensed in the affected community within another 24 hours [33]. Strategic stockpiling has to be considered within the framework of cost-effectiveness;

stockpiling of pharmaceuticals with a sort expiration date may be costly and problematic since the turnover inventory would require a significant monetary amount to maintain stockpiling facilities for continuous checking and renewing [34].

Training

Improved awareness and readiness during a bioterrorist attack include among others education of all medical personnel, especially primary-care providers and first responders to patients affected by a biological attack35. Training inserts knowledge about basic epidemiologic principles, disease patterns, clinical information on diagnosing and treating infected patients [36] and should be refreshed periodically with large-scale exercises to ensure that skills remain up-to-date [37]. Additionally, analysis of actual previous incidents provides precious information regarding proper response. Most importantly, the lessons learned should be incorporated into future planning to identify areas of improvement. Finally, education of health departments and the community on biosafety items, including information for crisis-phone hotlines, contributes to mitigating the negative health effects of a bioterrorist attack [38].

RESPONSE PHASE

Detection-Verification

Prompt diagnosis should be urgent in a probable bioterrorist incident, because for both health and security reasons [39]. The earlier a dissemination is detected, the faster the response and the lower the morbidity and mortality rates. Apart from significant awareness by the PHS, this also requires advanced diagnostic technology. Highly sensitive and specific and yet portable laboratory diagnostic systems are nowadays available to a greater extent than a decade ago, enabling a faster, cheaper, and more accurate verification of the infectious agent. Moreover, increased networking and collaboration of higher-level biosafety laboratories also improve response to biohazards [40]. The critical factors in reducing mortality following a biological incident were found to be early detection of exposure, registering of cases, and dispensing capacity at local and national levels [41, 42]. The verification of a possible bioterrorist attack should fulfill most of the following epidemiological criteria [43]:

1.Occurrence of a specific epidemic disease with similar symptoms in a discrete population;

2.Single case infection caused by an uncommon or class A biological agent;

3.Unusual disease for a specific geographic area or a specific age group;

4.Unusual season of transmission;

5.Many unexplained disease or death incidents;

6.Unusual high level of disease severity with resistance or response failure in standard treatment;

7.Unusual exposure routes of a “known” pathogen;

8.Higher incidence of occurrence in certain area zones, depending on whether the biological agent was released in- or outdoors;

9.Relevant claims by terrorists of a bioterrorism attack or existing intelligence for a potential threat.

Coordination

Biodefense is a complex procedure requiring a multidisciplinary approach. In any bioterrorist incident, interoperation mechanisms between major local, national and international, health- and non-healthcare agencies must be applied. Coordination should be reinforced and biodefense protocols effectively integrated into existing plans [10]. Government stakeholders called to react and collaborate to a bioterrorism incident include policy makers, law enforcement officials, emergency responders of PHS, special centers from scientific, research, forensic, and professional societies and technicians, along with the commercial branches of medical, safety, and decontamination equipment suppliers [28]. In any case, the management of a large-scale bioterrorism outbreak is well beyond the resources and capabilities of most countries; thus many lives can be saved in bioterrorist outbreaks by early mobilization of large-scale international assistance by W.H.O. Furthermore, many national armies afford special Chemical-Biological-Radiological (CBR) units, able to respond to a bioterrorism event; these have the means and often the war expertise to detect, verify and neutralize biohazard threats and to decontaminate victims and areas exposed to such agents.

Rapid Response

Following alleged or genuine dissemination of biological agents, a large number of people will probably seek medical care. Fear and panic are expected in symptomatic patients, yet also in involved health personnel of public hospitals and private clinics, who may be the first to recognize a biohazard outbreak and initiate a response. A broad network of communication towards many stakeholders must then be rapidly activated [44]. Moreover, a plan dealing in detail with the possibility of great numbers of people who concurrently

might seek medical care, along with means for psychological support and medical treatment is of utmost importance in the triage rapid response process conducted by various health care professionals. These should operate according to the national SOPs regarding response to the outbreak of a biological agent [18]. Unfortunately, the mobilization of a specialized CBR unit can never match the 24-hour availability and general emergency-management experience of existing emergency response and public health services, whilst the use of CBR protective equipment also requires special training and the adaptation of existing procedures for emergency management [45]. Furthermore, in case of risk for international dissemination of the disease, the International Health Regulations (IHR) should be implemented to prevent the worldwide spread of diseases [46].

Mass Prophylaxis/Infection Control

For most biohazard agents, specialized testing is necessary by PHS specialists or laboratories. Then, vaccination and/or treatment with antibiotics or antitoxins must be started early for viral agents and bacterial diseases. Before undertaking a mass prophylaxis plan, the PHS should identify the population at risk, the sort and the availability of medication to be applied, and the mechanism of administration of such a plan. The decision to apply a mass prophylaxis plan is based on various factors, such as data from epidemiological analysis, hospital bed availability, availability and determination of the quantities of drugs required to support the plan, immunity delays till antibodies development, side-effects of a massive immunization and the estimated number of exposed or ill people [47]. For starting mass prophylaxis, the following admissions should be considered:

1. An adequate stockpile of vaccines and medications is maintained at the national level;

2. The biohazard situation is anticipated to (or already did) overwhelm the regular public health care system;

3. There are shortfalls in local capacity to dispense disease-specific health care services;

4. Multiple biohazard incidents in many locations are already involved with, or without parallel requests for specialized health care provision;

5. A request for international aid has already proceeded.

Vaccination or prophylactic antibiotic treatment of healthcare providers may also be sound, especially in the biological threat of category A biohazard agents, since the occurrence of infection in that cohort will not only severely compromise the ability of PHS to manage the incident, but will also lead the population to the erroneous perception that health care personnel constitute a high-risk source of infection [48].

Personal Protection/Decontamination Issues

During the spread of an aerosolized biological agent, the primary route of exposure will be via the airways and respiratory tract. Respiratory protection will then be the most important component of physical protection. Furthermore, all patients in healthcare facilities with suspected or confirmed bioterrorism-related illnesses should be managed to utilize standard precautions; these are designed to reduce transmission from both recognized and unrecognized sources of infection in healthcare units [49].

Adequate procedures for routine cleaning, disinfection, contaminated waste disposal, and sterilization of equipment and environment should also be available [50]. For category, agents additional precautions may be needed to reduce the likelihood of transmission. Since in most bioterrorism scenarios anthrax is considered the most likely agent to be dis¬seminated, it is worth noticing that anthrax spores can persist in the environment for months or even years, which requires careful evaluation of the decontamination process [51].

Protection of health-care personnel against infection remains particularly problematic; personal protective equipment should be affordable, effective, and available to use with minimal training and under harsh environments [52]. If agents of contagious diseases are released, standard precautions include basic hygiene and infection-control measures, e.g. gloves, hands-washing (whether or not gloves are worn), PPE masks with eye protection (or face shield), and disposable gowns. In parallel, avoiding as possible direct contact with secretions from infected individuals, keeping exposed persons away from public places, and isolating suspected or symptomatic cases, may be essential in limiting secondary spread. These guidelines may though be impractical in case the number of patients presenting to a healthcare facility is too large to allow routine isolation strategies. The fact that in a mass bioterrorism incident many victims may go to hospitals on their initiative has important implications for the application of triage and decontamination protocols. Grouping affected patients who present with similar syndromes into a designated section of a clinic may be a vital alternative to the dissemination of infection. Community containment strategies, including isolation and quarantine, are the ultimate measures to prevent further transmission. Isolation and quarantine are

optimally performed voluntarily, but basic legal authority should be in place for mandatory isolation and quarantine of people and communities when necessary to protect public health [53].

Communication in crisis

Public preparedness and response capability relies greatly on efficient information dissemination in a clear, reassuring, and unemotional language. That chain of mostly non-confidential intelligence contains readily apprehensible, explicit, and comprehensive instructions of clinical and epidemiological information and communication channels, discouraging the parallel overreaction of the public after an incident. The population should also be told what signs and symptoms to watch out for and whom to call or where to go if they appear. If specific preventive measures are available to mitigate exposure and infection, the public must be clearly and rapidly informed. Failure to provide a clear public information flow-line may enhance anxiety, fear, and misinterpretations, mainly among citizens who feature non-specific symptoms of exposure to a possible biological agent and that may result in local health facilities becoming overwhelmed by uninfected or panicked patients. Convincing and trustable spokespersons, including respected clinicians, skilled scientists, and public authorities must be able to represent the PHS at all stages of the crisis, also taking into account that the global distribution of social networking increases the dissemination of false or misleading information [54].

Mass Fatality care

During a bioterrorist outbreak, laboratories that receive or dispose of suspicious human body specimens must be informed of relevant clinical and operational protocols. Autopsies should be conducted under full personal protective measures, especially when there is an increased risk of aerosolization or splatter of infectious liquids [44]. Concerning management of bioterrorism fatalities, morgue and funeral protective planning should also be implemented along with prompt and accurate electronic reporting details [18].

Psychological Aspects

The psychological impact, even from a minor bioterrorism-related event may be disproportionately strong55. After such an attack, panic can well affect both victims and healthcare personnel. Psychological reactions following a bioterrorist attack include fear, anger, panic, inappropriate or unrealistic worry about possible contagion or illness, social withdrawal, depression, or demoralization. To handle patient and public fears, the psychological preparedness for bioterrorism should aim at minimizing panic by offering a clear explanation of risks and medical support, and by avoiding unnecessary isolation or quarantine. Furthermore, excessive anxiety in unexposed individuals, experiencing objective but irrelevant clinical symptoms should be treated with non-medical psychological support or on occasion with anxiolytic medication administration. Concerning in particular the healthcare workers, their fears can be managed by bioterrorism readiness education, protection plans, and encouragement of participation in acting field-level roles (e.g. disaster triage volunteering) [56].

CONCLUSION

Increased preparedness, response planning, investments, training, and exercises constitute perhaps the best defense of PHS to mitigate the effects of bioterrorist attacks. Most importantly, citizens must always be aware of a possible deliberate biological contamination and how to respond appropriately. Bioterrorism incidents of the near past prove that public mortality and morbidity can be further reduced if a functional protocol would allow first responders, hospitals, and officials of the PHS to steer more efficiently the public expectations.

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