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Smallpox Bioterrorism Preparedness: The Importance of Technology and Education for Early Detection and Response

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The Importance of Technology and Education for Early Detection and Response

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Abstract

The use of biological agents as weapons has been prevalent throughout history. Only when the US experienced a bioterrorist attack in 2001 did additional funding begin to invest in preparing for other potential attacks. These initial investments, along with others, have funded preventative measures such as mass surveillance through biosensor technology and the development of preparedness programs such as the Laboratory Response Network and Hospital Preparedness Program. Based on learnings from previous outbreak events, in the event of a bioterrorist attack involving smallpox early detection will be the key to initiating a rapid and effective response. Additionally, further measures need to be taken to detect smallpox release either in the form of lab modified pathogens or laboratory compromise. Technologies must be made more accessible especially in rural areas where access may be limited. Because access may be limited, investments must be made into programs to better train medical personnel in identifying smallpox. This education must include topics not only on how to identify potential cases and management, but include topics related to identifying available resources and correct use of personal protection equipment to prevent further infection. Based on research, this education would improve healthcare personnel's willingness to respond during an attack to improve containment. Finally, preparing education for the public prior to an event is important as they can assist in early identification and reduce panic. Improving bioterrorist attack readiness involving smallpox in the above areas is the key for reducing morbidity, mortality, and its overall impact on public health.

Introduction

The use of biological agents has long been recognized as a potential weapon by militaries, governments, and terrorists alike for hundreds of years. The earliest methods consisted of launching infected cadavers into cities using catapults and poisoning water wells. Even during the Civil War the Confederates sold clothing from patients infected with yellow fever and smallpox patients to Union Troops. [1] Some treaties do exist, which address biological weapons such as the 1972 "Convention on the Prohibition of the Development, Production, and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction." This treaty aimed to prohibit the development, production, and stockpiling of biological warfare agents held in "quantities that have no justification for prophylactic, protective or other peaceful purposes." [2] However, countries who have signed this treaty continue to conduct prohibited activities and research into biological agents for medical defense purposes. Research into biological agents occur because the potential for these agents to be used as weapons continues to be a threat.

Smallpox is one such agent and is attractive to those who wish to execute a biological terrorist attack. This is because smallpox has had devastating effects throughout human history with up to 500 million people being affected by it worldwide during the 20th century. [3] With the last naturally occurring case of smallpox being reported in 1977 in Somalia, the Global Commission for the Certification of smallpox Eradication declared the eradication of smallpox in December 1979 which was ratified by the World Health Assembly (decision-making body of World Health Organization) 6 months later. [3] However,

known batches of VARV still exist to this day for research purposes at two containment facilities designated "Biosafety Level 4 laboratories"; the Center for Disease Control and Prevention (CDC) in Atlanta, Georgia USA and the State Research Centre of Virology and Biotechnology (SRCVB) in Koltsovo, Siberia, Russia. [4]

Despite being contained in special containment facilities, the threat of smallpox as a weapon of bioterrorism still exists. However, it's important to note that these containment facilities represent a security risk as demonstrated by the 2001 anthrax attacks where an individual working in a United States Army Laboratory facility at Fort Detrick stole Anthrax samples to carry out attacks. [5] Additionally, there are samples of smallpox vials that have not been catalogued properly. One example of such an event was in 2014 where sealed vials of viable smallpox samples were discovered in a Food and Drug Administration (FDA) building which once served as a storage room for the National Institute of Health. [6] Finally, in 2017 Canadian Scientists synthetically created the extinct poxvirus. This virus is closely related to the smallpox virus and they did so for approximately $100,000 in a laboratory using mail-ordered genetic sequences. [7] These are a few examples of the security risks that are present with regards to biological pathogens.

Due to the ever-present risk of smallpox and because of the dangers associated with its release, measures need to be in place to counter and respond to such a threat. While the scope of necessary planning is wide, one of the most important aspects of responding to this threat is early detection. Unlike other terrorist attacks involving chemical weapons or explosives, the release of a biological pathogen is not always immediate due to incubation periods. In the case of smallpox, the average incubation period is twelve days with a range

of nine to fourteen days. Additionally, the smallpox virus is highly stable and infectious via the aerosol route and is easily transmitted from person to person. [9] While current protocols and programs are in place, it is unknown whether these can be put into practice. Through the examination of published literature, this article attempts to determine if the medical system is currently prepared to face the threat of a smallpox attack.

Background

Bioterrorism and Smallpox

The use of biological agents by non-state sponsored groups have been a concern over several decades. One notable incident being the use of *Salmonella typhimurium* by the Rajneeshee cult in September 1984 when 751 cases of severe enteritis were reported with forty-five victims needing hospitalization. [2] As a result of these events and others, the uses of biological agents that have a public health impact have been defined as a biological terrorist attack and are presently still a threat. In response, the CDC developed a categorization method for possible biological agents. The three different categories are from A to C with Category A agents being identified as easily disseminated or transmitted from person to person, result in high mortality rates, and represent the potential for major public health impact. [10]

While smallpox has been eradicated, it still exists as a bioterrorist threat to the population today. One risk is the fact that stocks of the virus still exist and being used for research purposes. As evidenced by the anthrax attacks of 2001, lab security as an insider threat is one possible source of release that needs to be considered. [5] There has also been a

number of breaches involving pathogen security such as one involving six vials of smallpox discovered in a cold storage room with two testing positive for the live virus. [11] While there is conflicting evidence on the subject matter there may be stockpiles that exist in China, North Korea, Pakistan, Iraq, and Iran. [12, 4] Risk of reintroduction of smallpox into the population increases even if one of these countries lacks the necessary security to protect their stockpile and the viral samples are stolen. Another area of concern, smallpox samples that have been stored without being properly documented at laboratory locations where the virus was studied has been identified. One example of this can be found when freeze-dried samples of viable smallpox virus were found in an FDA facility. [6]

The advancement of new technology has aided the development of a once extinct virus closely related to smallpox. Noyce et al. [7]originally set out to examine whether a horsepox virus vaccine could provide a better alternative due to their shared ancestry. Due to the only known specimen of horsepox virus being unavailable for investigation, they set out to determine if it could be obtained by large-scale gene synthesis. As a result of this study, they confirmed successful synthesis of the poxvirus and exposed mice to this synthesized virus. What they found was that the synthesized virus produced smaller plaques, produced less extracellular virus, and exhibited less virulence compared to vaccinia virus. [7] More importantly, these closely related viruses represent a natural risk to the human population. In the past few decades, there has been an increasing number of reports of zoonotic *orthopoxvirus* species which represents another possible source of release into the public to cause an outbreak. [8] Not only is orthopoxyvirus a risk to the public naturally, scientists have been successful in making it more virulent through genetic manipulation. [9]

Current Protocols and Methods of Detection

The prevention and identification of a bioterrorist attack includes multiple safeguards from many different agencies that involve a number of different specialties from international intelligence agencies to local health care systems. These international intelligence agencies focus on tracking and preventing terrorist groups from obtaining and using biological agents by utilizing insiders from the region an attack may take place. [13] On a national level the Laboratory Response Network, which involves approximately 25,000 commercial and private sentinel laboratories, is available for initial detection of potential biologic agents to then be confirmed by another 150 reference laboratories. These facilities are backed by the military laboratory network that can deploy quickly in response to a possible outbreak. [14] Other programs that are used for early detection include the CDC's National Electronic Disease Surveillance System and the Department of Homeland Securities BioWatch program which works in collaboration with the Environmental Protection Agency to monitor air quality in metropolitan areas for potential pathogens [15, 13]

At the state level, the Bioterrorism Act of 2002 authorized funding for states, municipalities, and territorial governments. This was done through cooperative agreements with the Health Resources and Services Administration and the CDC which provided for emergency funding outside the annual federal budgeting cycle in response to the events of 9/11. [15] The Strategic National Stockpile is also a resource available to states in the event of an outbreak. This stockpile is located in areas throughout the country and houses medical and surgical supplies to be used to supplement and re-supply state and local health agencies upon request by the governor. This program can then send out an

initial shipment of over 100 cargo containers of 12 hour "push packages" that can reach areas in need within 12 hours. [16] Finally, with guidance from the CDC and Health Resources and Services Administration, state and federal agencies have created response plans and training of medical personnel. Ideally, per the report from the Institute of Medicine (US) Committee on smallpox Vaccination Program Implementation [17] these response plans include features such as having a core set of workers to provide initial response, education and training sessions, and development of relationships with those that might help enhance surveillance and response.

Learning from Outbreak Investigations and Modeling

Despite having all this planning in place, early detection is still a critical factor when responding to the dissemination of a biological agent during a terrorist attack. When examining outbreaks, it is possible to apply lessons learned from successes and failures to prepare for future bioterrorist attacks. One such lesson can be learned from the CDC response during the 2014–2016 Ebola Virus epidemic in West Africa. After analyzing the response, Bell et al. [18] determined a number of challenges that limited response. This included aspects such as wide geographic spread of cases, poor public health and society infrastructure, and locals lacking familiarity with the Ebola Virus. The authors also noted that developing close working relationships with local medical personnel, the deployment of forward teams into the affected areas, and early treatment all helped prevent the spread of the Ebola Virus.

Another article by Ashford et al. [19] examining outbreak investigations conducted by the Centers for Disease Control and Prevention's Epidemic Intelligence Service from 1988 to 1999 provides new perspectives when looking at bioterrorism. Through examining these outbreak infections, they found that reporting of possible outbreaks due to bioterrorism was delayed for up to 26 days. While these events did occur prior to 2001 when terrorism began to receive more national attention, they did find that the most important component of early reporting were from frontline healthcare providers to local health departments. Additionally, because there were some cases where intentional contamination was determined to be the cause of an outbreak years later, the authors suggested that bioterrorism should be considered early when treating possibly infected patients.

Due to there being no recent events of a widespread smallpox bioterrorist attack, it is difficult to determine if current preparations are enough to contain an outbreak. However, Longini et al. [20] utilized a computer simulation approach to examine if current surveillance and containment measures would be sufficient enough to contain an outbreak. The authors applied the stochastic simulation model which simulated the spread of smallpox due to a large bioterrorist attack. Then measures determined by the smallpox Modeling Working Group, The Secretary's Advisory Council on Public Health Preparedness, and the Department of Health and Human Services were applied. The results of their study suggested that the current federal government policy of post-release surveillance and containment, if effectively implemented, could be sufficient to contain either a small or large intentional release of smallpox. Following these results, they conducted some follow-up sensitivity analyses and found the most sensitive factor was timing of withdrawal to the

home and isolation of cases. The authors found that a delay in recognition of cases by one or more days beyond the hypothesized control strategy outlined resulted in poorly contained simulated epidemics. The authors concluded that while surveillance and containment are effective in controlling outbreaks with a large number of initial cases, and further pre-emptive vaccination of the population of the USA would be counter-productive. However, a rapid and well-organized response to a smallpox bioterrorist attack would be needed to make containment efficient if no pre-vaccination was conducted.

Lack of Preparedness Among First Line Healthcare Providers

Researchers have conducted various studies on the preparedness of healthcare providers in the United States based on their capabilities in recognizing, diagnosing, and treating in the event of a bioterrorist attack. For example, SteelFisher et al. [22] set out to provide a more in-depth review of US physician preparedness for public health emergencies which included a bioterrorist attack. Between October 2011 and January 2012, the researchers conducted a national poll of 1,603 practicing physicians in a range of specialties both in hospital and non-hospital settings. The authors found that while one-half of physicians felt prepared to handle either a natural disaster, a major outbreak of an airborne infection, or a major foodborne illness, only 34% felt prepared to handle chemical, biological, radiological, nuclear, or explosive (CBRNE) incidents.

These results are consistent with other studies including one conducted by Spranger et al. [22] where 90% of 417 physicians who responded to their survey self-reported a poor level of knowledge regarding bioterrorism threats. Additionally, 79.3% of 360 responding

physicians reported not having participated in any bioterrorism preparedness and response training. In addition to feeling unprepared, among 631 of those who voluntarily completed a training module on biological terrorism in a study conducted by Cosgrove et al. [24] a pre-test conducted showed 50.7% of the respondents answered smallpox diagnosis questions correctly but only 14.6% knew how to manage it. Education of medical personnel will also increase their willingness to respond. In a cross-sectional survey conducted by Barnett et al. [24] the researchers found that 22-48% of respondents stated they would be unwilling to respond in the event of a bioterrorist attack regardless of the severity. More importantly the authors discovered that more would be willing to respond if they felt adequately prepared.

Not only do physicians feel they are inadequately prepared to respond to a bioterrorist attack, they feel their local healthcare systems are also ill-prepared. Alexander et al. (2006) found that in a survey of 744 responding physicians, 23% felt their local health care system was not prepared to meet the needs. It is interesting to note that in this study the authors also found that only 21% felt bioterrorism preparedness efforts are beneficial but noted 46% of the responding physicians stated their health care systems were prepared for a natural epidemic. The authors concluded from their survey that in order to improve preparedness for bioterrorism threats, the efforts need to be expanded more broadly to cover a number of different outbreaks. This decrease in preparedness was also observed in an article authored by Davis et al. [25] over a three-year period. The authors concluded that this reduced preparedness may be due to funding cuts and job losses. This finding was also revealed to be of concern by the Committee on smallpox Vaccination

Program Implementation [17] which determined there is a lack of financial resources and fragmentation in public health systems.

In the event of an outbreak, hospital infection control is an important topic to address in preparedness training to prevent the spread of infection to hospital personnel as highlighted by Dembek. [9] This finding was shared by Ziskin et al. [15] who stated healthcare personnel must not only know how to treat victims of a bioterrorist attack, but must also know how to protect themselves. However, when healthcare personnel were evaluated for their proficiency in personal protective equipment (PPE) use, the authors found that even though self-perceived efficacy of protection among health care workers was high. When observed, the health care workers committed mistakes that they were not aware of making. This led to the authors concluding that self-perceived efficacy is a poor predictor of appropriate PPE use. [26] This suggests the presence of poor awareness of appropriate PPE use would be detrimental in an actual contagious outbreak. These results are similar to those found by Mitchell et al. [27] who found that 54% of the observed health care workers removed their PPE in the incorrect sequence and hand hygiene adherence was suboptimal. The authors concluded that their study ultimately highlights the gaps in PPE that may increase the opportunity for transmission of infection.

Methods

A literature review was conducted regarding bioterrorism utilizing journal articles provided by the Lindell Library and the PubMed database. Potential research articles were reviewed and read for relevancy pertaining to the topic prior to inclusion. Articles were reviewed to ensure focus on the bioterrorism aspect of smallpox and the necessary

preparations that need to be made to have an adequate response. Additional criteria for articles were that they needed to be peer reviewed. Articles written by those with a military background or current work in a government organization were analyzed in extra detail. This is because these authors tend to have specialized training in this area. In order to obtain background information on the history of bioterrorism and smallpox, articles written by experts in those respective fields were reviewed which included both civilian and military authors.

To determine the availability of smallpox for use in a bioterrorist attack, government agency sources were investigated regarding current stockpiles and a literature review was conducted to determine other means of acquiring viable samples. Three causes of possible release were explored. The first possible cause of release is the possibility that laboratory personnel became compromised in some way either through intentional or unintentional release of the pathogen they work with. A second was the possibility of other samples existing outside of current known stockpiles and the third explored the possibility that the smallpox virus could be synthesized in a laboratory setting.

A review was then conducted to determine overall preparedness for a bioterrorist attack regarding these possible threats. Three areas of focus were reviewed. The first included researching the capabilities of medical personnel. This included examining public health protocols related to how to respond to a bioterrorist attack, education on the topic, and readiness capabilities. Detection and diagnosis methods were the second focus which included methods available both for an individual patient as well as for detecting release of

a pathogen in a public setting. Finally, current public health policies were reviewed looking at the current government policies and programs in place.

Discussion

One of the main defenses against smallpox being used as a modern bioterrorist weapon is its inaccessibility. However, with the possibility of uncatalogued samples existing, along with the development of technology leading to the possibility of a lab synthesizing the virus, and the ability to genetically modify related *orthopoxviruses,* adequate measures need to be in place to detect a possible release of the pathogen. In the event of an outbreak, any delay in identification can have considerable impact. As evidenced by computer simulations, even the delay of a diagnosis by a few days can lead to a poorly contained outbreak. [20] This is where technology can assist medical personnel in early diagnosis. While national programs such as BioWatch and the National Electronic Disease Surveillance System can be used to detect the release of a pathogen, it is important these systems be constantly updated with emerging pathogens. [15, 13] As such, inter-agency cooperation will be vital. Only through diligent monitoring by intelligence agencies of potential developing threats and consistent communication of these findings can these systems be updated effectively. Without constant surveillance, smallpox as well as other pathogens can be modified to evade current detection and countermeasures. Unfortunately, lack of funding for the programs, which includes funding for upgrades, is putting the effectiveness of the BioWatch program at risk.

At the state level, surveillance systems are currently implemented but need to be constantly evaluated to ensure they are up to the task. Coordination with the CDC is needed to allow rapid laboratory screening leading to earlier detection. On a more local level, advances in identification technology will prove to be invaluable to medical personnel in early diagnosis during a possible bioterrorist attack. For example, portable real-time polymerase chain reaction (PCR) platforms have become more accessible to laboratories as they become more cost effective.[14] As more laboratories have access to PCR and the training to use them, it gives medical providers additional resources to more rapidly diagnose patients they suspect may have been exposed in a bioterrorist incident. In the event of an outbreak, easily deployable point-of-care diagnostic assays will help reduce the time it takes to confirm a possible infection. This would be especially useful in rural areas where laboratories might not have the resources to analyze samples and shipping to an outside lab for analysis would take up valuable time. The development of oligonucleotide microarray as future diagnostic tools also shows some promise allowing more reliable early detection of these new species for providers through the use of sequencing technologies and active surveillance of new species. [14] In addition to surveillance, the Strategic National Stockpile exists to provide emergency aid in the event of an outbreak within 12 hours. [16]

Although technology can aid in early identification through active surveillance and assist in diagnosing, there is no guarantee that it will be available everywhere. If an attack were to be carried out, metropolitan areas with high population densities are considered the primary targets. However, a potential victim may not always present to a provider in these metropolitan settings if the initial bioterrorist attack was not identified. With how

easy it is to travel, an individual that has been exposed may present to their primary care provider either across the country or in a rural area. This can lead to secondary infections outside of the initial area the pathogen was released. This necessitates the need to train all healthcare providers nationally to recognize the symptoms of smallpox to improve outcomes and reduce morbidity and mortality. This is especially true in rural areas where providers may not have access to the same resources as their colleagues in a metropolitan setting.

Through analysis of other outbreaks, the need to prepare healthcare providers proves to be invaluable. The post analysis is important as often improper preparation and other shortcomings are only evident after an outbreak has occurred. Upon investigating the 2014-2016 Ebola epidemic response was slowed due to multiple factors including local unfamiliarity with the disease. This outbreak also highlighted the importance of interagency communication and the improvement of infection prevention strategies in a healthcare setting to reduce spread. [18] Moreover, it is often primary care providers that are the first to recognize the use of biologic weapons. [19] This necessitates the need for healthcare providers, at all levels, to be aware of how to report a possible case or acquire assistance. Research, however, suggests that healthcare providers are not always aware of the resources available to them or whether their hospital has emergency response plans in place. Not only are healthcare providers not always aware of the resources available to them but multiple studies have suggested that they do not feel prepared to handle a possible bioterrorist attack. [22, 23, 21] This lack of preparedness of medical personnel is important to consider when responding to an attack.

In the event of a large scale bioterrorist attack, all available resources will be mobilized to respond. The response to this attack relies upon medical personnel's willingness to respond to such an event. As mentioned previously, healthcare providers do not feel adequately prepared to respond to a bioterrorist attack which can ultimately affect the response to a possible attack. While those who perceived themselves to have important roles responded more readily, 22-48% of respondents stated they would be unwilling to respond in the event of a bioterrorist attack, such as anthrax, regardless of severity. [24] The authors concluded that in order to increase the percentage of those willing to respond, medical personnel must be adequately prepared. This necessitates the need to fill the knowledge gap so that medical personnel feel like they can adequately respond in the event of a bioterrorist attack. This is especially important in rural areas where there may be a minimal amount of trained medical professionals.

There have been some efforts made to fill the gap in knowledge on how to respond to a smallpox bioterrorist attack but with mixed results. One example of this is the Hospital Preparedness Program (HPP) by the US Department of Health and Human Services which was implemented in 2002. This program launched several local and regional coalitions of hospitals, medical providers, and agency representatives to prepare communities for potential bioterrorist attacks. The most established are located in Seattle and King County in New York City, Los Angeles, and Minneapolis. However, these coalitions are not everywhere. These coalitions, along with new ones, face the issue of maintaining their readiness while experiencing issues such as insufficient funding, staffing, improvements, and research. Other attempts to train healthcare personnel include the use of online training modules which has seen some success. [23] The accessibility of the internet has

provided a new way to reach medical personnel and train them. Through the development of electronic training modules it would be possible to take advantage of the shift in provider preference to self-paced electronic training. [22] This would also be beneficial to those in rural areas who might not have access to training events or tested protocols.

As mentioned previously, training also needs to highlight the importance of proper personal protection equipment (PPE) use as infection prevention and control in a healthcare setting to prevent further infection. While some personnel may feel they are proficient in PPE use, this doesn't necessarily translate to actual proficiency. Two particular studies looked at PPE use and found that health care workers committed mistakes that they were not aware of. [26, 27] During an actual bioterrorist attack with smallpox that is easily spread from person to person, this lack of correct PPE use would be detrimental in an actual outbreak. This necessitates the need to ensure constant awareness of not only how to treat and contain patients, but also protect medical personnel. It also highlights the need to be aware of PPE when dealing with patients with an unknown diagnosis as they may be the victim of an as yet unrecognized bioterrorist attack. This training also needs to extend to first-responders as they may be interacting with both infected and non-infected individuals and may unknowingly spread the virus further.

One issue facing bioterrorism preparedness education is the fact that many individuals, including physicians, do not feel it is necessary due to their perception that the risk of a bioterrorist attack is low. Additionally, the public has a minimal understanding of bioterrorism threats yet an attack has the ability to generate fear among the population which can have negative consequences. In order to properly respond to a bioterrorist

attack, both the public and medical personnel must be made aware of the threat it represents and what they can do. However, to have the best response, this must be done in a way that keeps the attention of the population. Research into how to educate the public has shown that people respond to simple information presented in a way where they can feasibly apply the information in order to protect themselves. The participants in these studies specifically wanted to know how to avoid exposure, recognize the symptoms, and treat the effects of the symptoms. [28] By educating the public during a possible terrorist attack, it can be possible to identify potential victims faster and reduce spread. This information needs to be prepared ahead of time to increase the speed at which it is disseminated. Additionally, measures must be put in place to respond to an outbreak that can be quickly implemented.

In order to implement these reforms, funding must be obtained. Not only does funding for such preparedness training need to be implemented, but at the very least there must be more coordination on the use of the limited funding already available. To best prepare the public and medical personnel, one way to justify increased spending, and justify to medical personnel the importance of this training is to present this information through general epidemic preparedness. This is due to the fact, that as mentioned previously, many providers feel that their system is inadequately prepared to respond to a natural epidemic. [23] Through educating medical personnel on how to prepare for a general epidemic, the lessons learned will indirectly provide preparation towards a smallpox bioterrorist attack. This training can increase coordination of resources by providing additional materials that supplement the training of personnel for other outbreak events such as a bioterrorist attack involving smallpox. This coordination of resources remains a

challenge on both the federal and state level necessitating that the training be expanded to a national level. Overall, bioterrorism preparedness is at risk due to funding cuts and job losses which leads to a decrease in the preparedness. By addressing the above concerns in a way that medical personnel will be more willing to listen, there can be better coordination of resources and the establishment of communication networks to better detect and rapidly respond to a bioterrorist attack.

Conclusion

Based on lessons learned from past bioterrorism and natural outbreaks, early detection is the key to an adequate response. Outside of a bioterrorist attack where the release of a smallpox pathogen is made known by those responsible, detection will be difficult necessitating the need for up to date equipment and ongoing training of medical personnel. Despite the fact that there has not been a massive outbreak of smallpox due to a terrorist attack, computer modeling indicates that current protocols and programs have the capability of containing an outbreak. However, multiple articles and professional opinion demonstrates that we are not fully capable of responding to a large-scale bioterrorist attack. While lack of funding is partly to blame, adequate management of the funding that is currently available is necessary due to the multiple challenges that need to be addressed including the lack of coordination of resources.

While additional funding would be ideal, the funding that is currently available must be targeted to achieve the best outcomes. It is essential to put the research and time into proactively developing programs, protocols, and medical personnel training before an outbreak occurs. It was only after the anthrax attacks in 2001 did the United States

Government and other nations realize there were shortcomings in their bioterrorist preparations and significant investments were made. If a bioterrorist attack were to occur involving smallpox, the best way to reduce morbidity and mortality would be early identification. These systems of early identification must also be paired with active intelligence of other possible threats. This is due to the fact that as technology develops, it has become easier to develop smallpox in a laboratory setting. Additionally, these labs have the ability to make other *orthopoxviruses* species more virulent through genetic manipulation. This intelligence and security must also be prepared for laboratory personnel becoming compromised leading to them intentionally or unintentionally releasing the samples they conduct research on. This requires regulations into who is allowed access to potential agents of bioterrorism and what specific requirements need to be met to allow research on these agents.

The problem is that most of the widespread surveillance systems and planning is limited to a specific area such as metropolitan areas or large events where a number of people are gathered and these programs face funding issues that affect their readiness. Finally, the ease of travel means that while a victim may be exposed in one area, they may risk exposure in another area where trained personnel may not be located. This necessitates the education of all medical personnel in both rural and metropolitan areas. Furthermore, research needs to be done to identify ways in which to make diagnosing equipment economical and more accessible. The use of electronic education modules can allow more widespread distribution of education material. This material should focus not only on how to diagnose and treat smallpox, but also who to contact in the event of a possible exposure, infection prevention techniques, and resources for providers. This

education is essential to improve the willingness of medical personnel to respond to a call for assistance as it has been identified that the confidence level of medical personnel and the understanding of their role in a situation is directly related to how they respond and participate in a crisis.

Education must also be prepared for public distribution before, during, and after a smallpox bioterrorist attack. During such an event, people will actively search for information that they can use to protect themselves and those around them. By taking advantage of this need, it is important to provide the public with symptoms of possible exposure which can help decrease the time from exposure to detection. Public education can be used to build confidence in the medical response system in order to reduce panic and other negative behaviors. While it may be difficult to justify bioterrorism education and preparedness to both the public and medical professionals, development of the material can piggyback off of natural outbreak preparedness. Many of the necessary measures, such as the use of personal protection equipment (PPE), needed to contain a smallpox outbreak, is important, whether it be a natural outbreak or due to a bioterrorist attack. During previous outbreaks, reducing the spread of infection has been found to be very important in containment. It has been found that medical personnel often do not use PPE correctly so by educating them under the pretense of a natural epidemic preparation it would benefit the response to a smallpox bioterrorist attack. This would be especially true in the case of a smallpox outbreak particularly if a more virulent species was used.

In closing, while it may be easy to discount the possibility of a bioterrorism attack involving smallpox due to the security measures around the facilities where known

samples exist, the risk of other samples either developed in a lab or unaccounted for still remain a threat. Additionally, unlike other terrorist attacks where the evidence of it is immediately evident, it can be days before patients start presenting for evaluation. The characteristics of the virus allow it to be highly stable and infectious necessitating the need for an early response to allow proper containment of an outbreak. With both the correct application of funding and a concerted effort to prepare an adequate response can be achieved if the work is done prior to an outbreak. Ideally, while progress is certainly being made, continued development into areas such as more widespread surveillance through biosensoring and diagnosing technology, education of both the public and medical personnel, and development of programs allowing better coordination among personnel must be accomplished. These are all realistic and financially feasible goals that can have multiple benefits beyond bioterrorism and expand into areas such as natural epidemic control.

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