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Environmental Decontamination Following a Large-Scale Bioterrorism Attack: Federal Progress and Remaining Gaps

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The process of environmental decontamination is a key step in a successful response to a large-scale attack involving a biological agent. Costs for the decontamination response following the 2001 anthrax attacks were estimated in the hundreds of millions of dollars, and some facilities could not be reopened for more than 2 years. However, a large-scale biological attack would likely result in an even greater amount of contamination, more areas that need to be cleaned and made safe, and a much greater cost to the American public. This article identifies gaps in decontamination policy and technical practice at the federal level and provides practical recommendations that will better enable the U.S. to undertake a biological decontamination response.

The process of environmental decontamination—that is, removing biological hazards from buildings, vehicles, and outdoor areas—is a key step in a successful response to a large-scale attack involving a biological agent. After the anthrax letter attacks in 2001, environmental decontamination was necessary for the mail sorting facilities that handled the contaminated letters and for the Congressional offices and media buildings that received them. The 2001 anthrax event, which resulted in 5 deaths and more than 20 illnesses, was the "worst case of bioterrorism in U.S. history"[1] thus far, but it is considered to be a small attack compared to the potential hundreds of thousands of illnesses and deaths that could result from a large bioterrorism event.[2] Still, remediation of the 2001 anthrax attacks was expensive and time consuming. Costs for the 2001 anthrax decontamination response were estimated in the hundreds of millions of dollars (not including lost time and productivity costs), and some facilities could not be reopened for more than 2 years.[3]

A large-scale biological attack would likely result in a greater amount of contamination, more areas that need to be cleaned and made safe, and a much greater cost to the American public. A biological attack on a U.S. city could contaminate both indoor and outdoor environments. Contaminated areas might include buildings, streets, parks, and vehicles, which would probably all need to be decontaminated before an affected city could be inhabited again. Given the U.S. experience with the 2001 anthrax attacks, it is possible that a city might be uninhabitable for an extensive period of time following a large biological attack.

Biological Agents of Concern

The Select Biological Agents (biological organisms of particular concern) can be categorized along a continuum of decontamination difficulty, ranging from not problematic to very problematic, with a range of difficulty in between. Factors influencing the difficulty of decontamination for a particular agent following a biological attack would include both the natural stability of the agent in the environment

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and added man-made stability through weaponization. When a biological agent is referred to as "weaponized," it usually means that it has been "manipulated or treated in such a way as to improve its effectiveness as a weapon such as making it more virulent, more easily disseminated as an aerosol, or more stable."[4]

Biological agents that are of lesser concern for decontamination include agents such as the Ebola virus. While Ebola is highly contagious, deadly, and difficult to treat, the virus does not survive well in the environment. Thus, extensive decontamination efforts would likely be unnecessary following an attack involving Ebola. On the other end of the spectrum, *Bacillus anthracis*, the causative agent of anthrax, is considered to be the most problematic agent of concern. Anthrax is both a threat to human health and extremely hardy in the environment. Thus, anthrax requires extensive environmental decontamination following a release.

Other agents such as ricin and *Francisella tularensis* (the causative agent of tularemia) would also pose significant decontamination challenges. While the remaining biological agents of concern would likely not cause as many problems for decontamination, it is possible that these agents could be prepared or weaponized in a way to make them more stable in the environment and more significant as decontamination threats. Plague bacteria, for example, while naturally fragile as an aerosol, was reportedly weaponized by the Soviet biological weapons program to survive and perform well in an aerosol release[5] (Table 1).

Purpose of This Analysis

The main purpose of this analysis is to identify the gaps in decontamination policy and technical practice at the federal level, including safety standards, that must be addressed in order to facilitate a successful response to a large-scale attack involving a biological agent. This analysis provides practical recommendations for the Administration and Congress that, if implemented, will better enable the U.S. to undertake a large-scale decontamination response.

This analysis provides an overview of federal progress, gaps, and needed improvements in the field of decontamination following a large urban area biological attack. We provide a brief overview of the major programs and recent progress in decontamination among the participating federal agencies. However, this is not meant to be a comprehensive review of all federal, state, and local efforts in biological decontamination, as they are numerous and varied.

Assessing the Threat and the Government's Ability to Respond

The U.S. intelligence community, including the Central Intelligence Agency (CIA), the Defense Intelligence Agency (DIA), the Department of State, the National Intelligence Council, and the Defense Science Board, has assessed the threat of an attack on the U.S. using biological weapons, and they have determined that the threat of a biological attack on the U.S. is current and real.[14] Yet, as noted by the Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism (the Commission) in their *World at Risk* report released in December 2008, the U.S. remains vulnerable and unprepared to deal with such an attack.[15]

The *World at Risk* report concluded that, unless the international community acts resolutely and with great urgency, there is a high likelihood that a weapon of mass destruction (WMD) would be used in a terrorist attack somewhere in the world by 2013. The Commission emphasized that the weapon is more likely to be biological than nuclear, and the Director of National Intelligence publicly agreed with the report's threat assessment, saying, "We [the intelligence community] assess biological as the more likely and it's better than an even chance in the next five years that an attack by one of those weapons systems will be conducted in some place on the globe. . . ."[16] In addition, the Commission concluded

Table 1. Examples of Biological Agents of Concern and Their Stability in the Environment

Biological Agents of Concern (Disease)	*Environmental Stability of the Organism*
Bacillus anthracis (anthrax)	Very stable in most environments; risk of secondary aerosolization unknown.[6]
Brucella (brucellosis)	Stable in moist conditions.[5(p43)]
Burkholderia mallei (glanders)	Stable in water and moist conditions; unstable in dry conditions and UV exposure.[7]
Yersinia pestis (plague)	Unstable in the outdoor air; stable for years in soil and live tissues.[8] Weaponized agent may be more stable.[5(p43)]
Francisella tularensis (tularemia)	Stable in cold, moist conditions; stability following intentional aerosolization is uncertain.[9]
Coxiella burnettii (Q fever)	Stable for months on wood and sand.[5(p43)]
Variola major (smallpox)	Unstable: the virus would be nearly completely destroyed in the environment after 24 hours.[10]
Viral hemorrhagic fevers (Ebola, Marburg, etc.)	Unstable in their natural state; these viruses are not expected to persist in the environment.[11]
Botulinum toxin (botulism)	Relatively unstable, will degrade naturally in outdoor environments within a few days; stable for weeks in food and standing water.[12]
Ricin	Stable in the environment but heat sensitive.[13]

that, to date, the U.S. government has placed greater emphasis on programs to prevent nuclear terrorism, and that the government "should make the more likely threat—bioterrorism—a higher priority."[15(p24)] Ellen Tauscher, Under Secretary for Arms Control and International Security for the U.S. Department of State, echoed the Commission's conclusions in her remarks at the annual meeting of the states parties to the Biological Weapons Convention on December 9, 2009, saying, "When it comes to the proliferation of bio weapons and the risk of an attack, the world community faces a greater threat based on a new calculus."[17]

On January 26, 2010, the Commission released a *Report Card* assessing the government's progress toward meeting the goals outlined in the *World at Risk* report.[18] The Commission found that the U.S. government is not taking the necessary steps to protect the country from the threats posed by WMD and terrorism. Specifically, the report card includes 3 failing "F" grades for the federal government's response to biological threats: the government has "no national plan to coordinate federal, state, and local efforts following a bioterror attack, and the United States lacks the technical and operational capabilities required for an adequate response."[18(p6)] Also included in this failing grade is the federal government's inability to perform environmental cleanup following a biological attack.

According to estimates from the 2005 Homeland Security Council (HSC) National Planning Scenarios (NPS), a biological attack on a major U.S. city using *Bacillus anthracis* has the potential to kill tens of thousands of people, sicken hundreds of thousands, and cause billions of dollars in economic damages associated with the closure of affected buildings and necessary decontamination efforts.[2] In November 2009, the White House National Security Council (NSC) released the *National Strategy for Countering Biological Threats,* concluding that the potential consequences of a biological attack are even greater than previously thought. The NSC determined that

> . . . the effective dissemination of a lethal biological agent within an unprotected population could place at risk the lives of hundreds of thousands of people. The unmitigated consequences of such an event could overwhelm our public health capabilities, potentially causing an untold number of deaths. The economic cost could exceed one trillion dollars for each such incident.[19(p1)]

This threat of a large-scale biological attack on U.S. soil warrants adequate federal capabilities for prevention, preparedness, response, mitigation, and recovery. Efforts to prevent a biological attack should be strengthened. However, unless policies can ensure that a biological attack will not and cannot happen, the federal government must also invest in consequence management. A key aspect of this will be environmental decontamination.

While many federal agencies have addressed the issue of decontamination, several major gaps in policy and practice remain. Attention to biological decontamination for indoor bioterrorism events was high following the 2001 anthrax attacks[20] but has waned as time has passed. Overall, the investment in this area has been small compared to bioterrorism prevention and preparedness programs.

Recent guidance documents released by the White House, the Department of Homeland Security (DHS), and the Environmental Protection Agency (EPA) have contributed to moving the issues of mitigation and decontamination forward. In particular, the *Draft Planning Guidance for Recovery Following Biological Incidents,* issued by the White House Office of Science and Technology Policy (OSTP), DHS, and EPA in May 2009, is a good tool for federal, state, and local responders involved in decontamination planning and response.[21]

What Is Decontamination?

Decontamination is the process of removing or inactivating a hazardous substance (in this case, a biological agent) from contaminated environments or surfaces, including skin, clothing, buildings, air, and water, in order to prevent adverse health events from occurring. Remediation following an attack with a biological weapon will involve a number of different phases of response, including:

- *Sampling, Testing, and Analysis:* During this phase, sampling of the suspected contaminated area is done to detect the presence of the biological agent and to characterize the extent and levels of contamination. These samples must be tested, either rapidly on the scene (if the technology is available) or sent to a laboratory.
- *Containment and Mitigation:* In this phase, scientists, responders, and decision makers in the government assess the risks associated with the attack, including the risks of spreading the agent through movement, re-aerosolization, and other methods of dispersion. This risk assessment will help determine decontamination methods and timelines.
- *Decontamination, Confirmatory Sampling, and Testing:* During this phase, decontamination methods and technologies would be used to clean the contaminated area and dispose of contaminated materials. Cleanup criteria will need to be set and measured to determine when decontamination is complete and the area can be reinhabited. This also involves confirmatory sampling and may require re-decontamination procedures and further sampling and analysis.

Ongoing Biological Decontamination Research

EPA and DHS contribute a majority of the U.S. research for biological decontamination following agent releases affecting civilian populations, and the Department of Defense (DoD) leads biological decontamination research

for military purposes. Other federal entities, such as the U.S. Department of Agriculture (USDA) and the Centers for Disease Control and Prevention (CDC), also contribute to decontamination research efforts and participate in interagency working groups. For example, the CDC's Environmental Microbiology Program, along with the EPA, leads an Interagency Microbial Risk Assessment Guideline Working Group to evaluate remediation and clean-up of microbial risks in the environment.[22,23] The working group is composed of U.S. federal agencies that have a role in or use microbial risk assessment (MRA) procedures.

Environmental Protection Agency

The EPA established its National Homeland Security Research Center (NHSRC) program on indoor and outdoor decontamination following the anthrax attacks of 2001. The EPA's decontamination research focuses on improving the nation's ability to respond to terrorist attacks affecting both indoor and outdoor environments. Specific focus areas include detection research, containment and mitigation research, remediation research, and disposal research.[24]

The EPA's future biological decontamination research will focus on decontamination for wide-area urban biological releases. Detection research will involve evaluation of additional detection instruments; advancement of real-time, portable biological detectors; and development of more sensitive sampling and analysis methods. Containment studies will address infiltration contaminants into buildings, re-aerosolization, methods to decontaminate personal protective equipment, and the development of advisory and acute exposure guidance levels. In the area of remediation, future research efforts will focus on assessing and improving decontamination and hazardous material disposal methods, developing improved biological indicators to assess fumigation efficacy, and implementing full-scale remediation field tests.[24]

EPA, DHS, and DoD agreed in 2009 to establish a tri-agency memorandum of understanding (MOU) for research in the area of chemical and biological defense. This MOU lays the groundwork for possible future scientific collaboration among the 3 agencies and is intended to "encourage and enable these agencies to more quickly establish joint projects, exchange data, and coordinate or co-fund programs of mutual interest without having to set-up separate agreements each time."[25(p57)] One of the areas of mutual interest and focus under the MOU is decontamination research.

Department of Homeland Security

Under the Department of Homeland Security's Science and Technology (S&T) Directorate, the Biological Countermeasure Thrust Area's Response and Restoration Program is responsible for research into decontamination following a biological incident or attack. The Response and Restoration Program's objective is to provide a decontamination response that is more rapid and effective and less expensive. The program works to provide advanced planning, concepts of operation (CONOPS), and decontamination exercise and training opportunities.[26] The S&T Directorate partners with EPA, DoD, the Department of Justice Office of Information Policy (OIP), the Transportation Security Administration (TSA), the Occupational Safety and Health Administration (OSHA), and state and local public health and response communities.[27]

Ongoing S&T projects center on the restoration of wide urban areas following the aerosol release of a biological agent, and specifically high-traffic areas (such as transit and transportation facilities) and DoD infrastructures. The S&T Directorate is now involved in the Interagency Biological Restoration Demonstration (IBRD), a Defense Threat Reduction Agency (DTRA)–DHS co-sponsored program also involving EPA, the Department of Health and Human Services (HHS), Seattle-King County, and other county authorities and agencies, which focuses on restoring wide urban areas, such as city neighborhoods, following a biological attack.[26] Upon its completion, the IBRD will provide a set of protocols, concepts, and tools that communities can adopt and modify for development of restoration plans. Another specific aim of this project is to provide validated interagency sampling plans.[27]

Department of Defense

The DoD Chemical and Biological Defense Program (CBDP) strives to develop capabilities for decontamination research and response "that enable the quick restoration of combat power, maintain/recover essential functions that are free from the effects of CBRN hazards, and facilitate the return to pre-incident operational capability as soon as possible."[28(p9)] The DoD CBDP focuses on decontamination for military assets and operations. However, DoD is also party to the tri-agency MOU and collaborates through the IBRD as noted above.

Major Challenges in Decontamination After a Large Biological Event

Although efforts are underway and advancements have been made in the field of biological agent decontamination, there are a number of high-level policy and scientific questions that have not yet been resolved. These gaps will be major stumbling blocks to a successful decontamination response following a large bioterrorism attack. Gaps include challenges in leadership, research coordination, funding, and decontamination response.

Unclear Federal Roles and Responsibilities

Numerous federal agencies have responsibility for portions of the decontamination response to a bioterrorism attack.

Yet, federal plans do not sufficiently delineate decontamination leadership roles and responsibilities. Following the 2001 anthrax attacks, policymakers found that the federal system for coordinating a decontamination response to a biological event was "extremely fragmented," without a clear lead response agency at the federal level.[20] Unfortunately, this system is not much better organized in 2010 than it was in 2001.

After the anthrax attacks of 2001, the EPA's role as the lead federal agency for hazardous materials cleanup and environmental decontamination of hazardous materials was expanded to include protecting human health and the environment from terrorism, and decontamination of indoor and outdoor areas following a biological attack. Homeland Security Presidential Directive 7 (HSPD-7 Critical Infrastructure Identification, Prioritization, and Protection),[29] HSPD-9 (Defense of the United States Agriculture and Food),[30] and HSPD-10 (Biodefense for the 21st Century)[31] all identify the EPA as the "primary federal agency responsible for public water supplies and remediation following an attack on indoor or outdoor areas."[32] This role as lead agency for indoor and outdoor remediation is also integrated into EPA's Homeland Security mission. Still, other agencies, including DHS, DoD, HHS, USDA, and the Department of the Interior (DOI), all have roles to play in decontamination following a bioterrorism attack.

The National Response Framework (NRF), which guides the federal response to events like bioterrorism, does not clearly name any one federal agency as the lead for decontamination following a bioterrorism event. In the NRF, the lead agency for decontamination response differs depending on the Emergency Support Function (ESF) and the scenario. ESF-10 indicates that the EPA is the primary agency in charge of a hazardous materials response (including response to a biological agent release or other WMD contamination).[33] However, other ESF sections and annexes of the NRF are contradictory. For example, the Biological Incident Annex of the NRF names HHS as the agency in charge;[34] the Catastrophic Incident Annex names DHS as the agency in charge;[35] and ESF-11 names the USDA as the agency in charge of decontamination in the event of agroterrorism.[36]

Agencies will also have overlapping decontamination responsibilities that will require use of the same limited resources following an attack. For example, EPA, HHS, and the Federal Bureau of Investigation (FBI) would all lead environmental sampling efforts following a bioattack: EPA for decontamination, HHS for epidemiology and other public health response efforts, and the FBI for a criminal investigation. Portions of all of these environmental sampling efforts would require the use of the same people, technologies, and laboratory resources. However, resources for a decontamination response are finite and must be shared by federal, state, and local agencies, responders, and private sector businesses. These conflicting resource needs will be a major limiting factor in a decontamination response, and coordination among federal agencies will be paramount.

In May 2009, the White House Office of Science and Technology Policy (OSTP), DHS, and EPA released *Draft Planning Guidance for Recovery Following Biological Incidents.*[21] This guidance provides a much needed framework for federal, state, and local planning and response to a biological incident. However, it does not attempt to alter federal roles and responsibilities (illustrated in Appendix 3 of the guidance), and it does not effectively clarify these roles.[21]

Research Is Not Coordinated among Federal Agencies

Currently, the U.S. lacks a coordinated and sustained federal research program in biological decontamination. While significant steps have been taken to enhance interagency coordination of individual agency research programs, as evidenced by the EPA-DHS-DoD tri-agency MOU and the DoD Interagency Biological Restoration Demonstration, there are at least 5 federal agencies with significant ongoing research programs, all with differing missions, goals, and levels of funding. More can be done to strengthen and coordinate decontamination research efforts across the federal government.

Research Is Underfunded

Decontamination after the 2001 anthrax attacks, which was considered to be a small biological event, cost the country hundreds of millions of dollars and took over 2 years to complete.[3] However, compared to funding for programs that address other aspects of the bioterrorism threat, such as prevention and preparedness, decontamination programs claim a small piece of the pie. Investment now in biological decontamination research to improve technologies and methods has the potential to save the country tens of billions of dollars in clean-up costs for the next event.

The total federal civilian biodefense budget for FY2011, including prevention, preparedness, and mitigation programs, is approximately $6.6 billion.[37] However, the FY2011 EPA research budget for chemical, biological, and radiological decontamination activities is only $15.1 million (biological remediation research activities comprise approximately 60% of the budget), a decrease of $8.5 million from an estimated FY2010 appropriation of $23.6 million.[38] The FY2011 DHS budget for the biological Response and Restoration Program is only $8.2 million, which is approximately 6% of the $127.2 million total FY2011 budget for the biological portion of the DHS Biological Countermeasures Thrust Area.[39]

Furthermore, the overall focus of decontamination research has been limited mainly to small biological events and indoor releases. This has been due both to limited

funding and to the nature of recent experience with the 2001 anthrax attacks and other accidental biological releases, which have been smaller indoor events. The U.S. has never experienced a biological attack on the scale of those envisioned in the National Planning Scenarios before, and funding levels have limited the amount of research that can be undertaken for such a daunting challenge. Only in the past few years have these programs begun to shift their research toward studying solutions for wide-area contamination.

Resources and Methods Lacking for Sampling, Testing, and Analysis

Sampling and laboratory testing of contamination following a large urban-area biological attack have never been done before. Consequently, the resources and technologies for this type and scale of response have not yet been developed.

U.S. experience and research in sampling and testing for contamination following a biological release has been limited to small indoor events. Sampling research and experience has therefore been limited mainly to those surfaces found indoors (eg, glass, walls, stainless steel, carpet, brick, and cloth). As a result, sampling technologies (eg, swabs, wipes, vacuum collectors) have been designed to collect samples from these surfaces in small areas ranging from 10 cm^2 to 1 m^2 in size.[40] However, in a large outdoor urban release of a biological agent, this sampling methodology will be inadequate to characterize the geographic boundaries and levels of contamination.* A large outdoor urban decontamination effort will require these technologies to perform on a much larger scale and on new surfaces (eg, pavement and asphalt, tall rooftops, trees, cars, and the sides of buildings).

In addition to the challenges of sampling in a large outdoor area, these samples must also be tested and analyzed rapidly and in large quantities. Currently, the U.S. does not have the capabilities to process samples confidently, in real time, in the field.[42] Samples will need to be sent to laboratories around the country for testing and analysis. Thousands of public health and laboratory professionals will be critical to this effort.

In a large urban-area bioterrorism event, the public health workforce and clinical laboratory resources (including the CDC Laboratory Response Network [LRN] laboratories) will likely be overburdened very quickly by the public health and medical response and will probably be unavailable to help with a decontamination response.[43] In addition, the LRN traditionally only deals with clinical samples, not environmental samples, and therefore will likely not be of significant assistance in the processing and analysis of environmental samples in a decontamination response. In order to fill the gap of environmental sample processing and analysis, the EPA has begun to develop an Environmental Response Laboratory Network (ERLN). However, the ERLN does not have the resources or funding of the LRN clinical laboratories, is currently in the laboratory recruiting phase, and is not fully operational at this time.[44]

*Contamination may span the geographic area of an entire U.S. city. For example, the land area of New York City is 304.8 square miles (789 km^2).[41]

Unresolved Scientific and Technical Issues

Once the contaminated area has been identified and its extent characterized, the scientific community will need to provide decision makers at the local, state, and federal levels with a rapid assessment of the risks to human health, the potential economic costs associated with decontamination, and a time estimate for the decontamination process. This information will be difficult to provide because of remaining scientific uncertainties about biological agent properties, weaponization or preparation of the agent, the relative effectiveness of decontamination methodologies, and risks to human health.

Risk of Secondary Aerosolization

The first major unknown in a decontamination response, for anthrax in particular, is the risk of secondary aerosolization (or the risk of infection when an agent is re-aerosolized following an initial aerosol release). The risks of secondary aerosolization are important to understand, because they will greatly affect decontamination methods and standards, as well as policy decisions surrounding evacuation, transportation, and population movement. Several studies looking at the risk of secondary aerosolization following an anthrax attack have found that the risk depends on a number of variables, including types of surfaces in the environment, weather conditions (in an outdoor release), airflow (in an indoor environment), physical movement through the area, and susceptibility of the host (person exposed).[6]

Studies have drawn mixed conclusions about the risks that re-aerosolized anthrax spores pose to human health. For example, the original study analyzing the outdoor anthrax release at the Sverdlovsk weapons facility in Russia in 1979 found that infection resulting from re-aerosolization of anthrax spores was negligible.[45] In contrast, a study examining secondary aerosolization of anthrax spores in a United States Postal Service (USPS) mail facility in the 2001 anthrax attacks determined that the risk of infection due to re-aerosolization was high. This increased risk was thought to be due in part to the high-level of physical activity in the mail processing facility.[46]

A limited number of laboratory and field studies are being undertaken to evaluate re-aerosolization of anthrax spores from a variety of surfaces and to determine their viability (growth in the laboratory) following re-aerosolization.[47] However, no studies to date have yet resolved the risks of infection posed by secondary aerosolization. Thus, it remains an uncertain variable in any decontamination response.

No Federal Decisions on Decontamination Standards

One of the most important issues in biological remediation is the question of a standard for decontamination. Is it possible to have a standard that will protect public health while lowering the costs and resources required for remediation?

Decontamination after the 2001 anthrax attacks was completed to a "zero standard," meaning that buildings underwent remediation until no viable anthrax spores were detected.[20(p19),48] This zero contamination goal was set by the CDC because the federal government had never dealt with decontamination of anthrax in "this kind of a situation before."[20(p19)] According to Congressional testimony following the attacks, the anthrax attack situation was "never anticipated, so . . . there [was] not a clear standard" prior to the event.[20] So, the determination was made by the CDC to complete the 2001 anthrax decontamination to a "zero goal." However, as Senator Barbara Mikulski (D-MD) pointed out during the anthrax Congressional hearings, other environmental cleanup efforts such as Superfund and brownfield sites provide a precedent for standards and criteria setting for remediation that could be a useful model for biological decontamination.[20(p19)] Superfund and brownfield sites do not generally strive for a "zero standard" for decontamination, yet their methods are generally well-regarded and accepted in the environmental and public health communities.[49,50]

The anthrax decontamination response using the "zero goal" was long, complicated, and expensive: costs were estimated to be in the hundreds of millions of dollars. Costs to the USPS alone were over $200 million and do not include business continuity costs due to facility closures. In addition, 5 contaminated facilities underwent fumigation and were closed for over 2 years.[1]

In 2005, the National Academies of Science (NAS) National Research Council, with support from DHS, issued a report that addressed reopening indoor facilities after a biological attack. The NAS Committee on Standards and Policies for Decontaminating Public Facilities Affected by Exposure to Harmful Biological Agents was asked to consider these questions: "How clean is safe? Is there a standard that we should anticipate, beyond which additional decontamination efforts would yield insubstantial benefit?"[51]

In its recommendations, the NAS committee did not suggest a "safe" amount of contamination, because it found there was insufficient evidence on which to make firm recommendations. The committee cited knowledge gaps in technical areas surrounding infectious dose, natural environmental background of the agents of interest, risk assessment, and previous decontamination efforts.[51] Instead, the committee laid a "foundation for establishing [future] standards and policies for relevant aspects of biological decontamination."[51] The committee recommended that the EPA and CDC "establish standards for remediation and validation . . . and for the training of remediation teams."[51(p189)]

Also in 2005, the Congressional Research Service (CRS) issued a report to Congress titled *Anthrax-Contaminated Facilities: Preparations and a Standard for Remediation.* The report found that for indoor biological releases specifically, decontamination research and technologies have progressed enough since 2001 that decontamination to a "zero standard" may be feasible. CRS concluded that for indoor releases, this progress in decontamination methods and technology makes developing another remediation standard unnecessary. Additionally, CRS noted that, as occurred in the 2001 decontamination efforts, stakeholders (individuals inhabiting contaminated buildings) may always demand that the "zero standard" be used for decontamination.[52]

Despite these discussions and the suggested frameworks proposed by the NAS committee and CRS, no broad federal decisions have been made on the issue of a biological decontamination standard, particularly for a large outdoor biological release. Currently, the issue is unresolved and has been left to policymakers to settle in the midst of the next biological event. Furthermore, it is unclear where in the federal government these decisions lie.

Too Few Trained Personnel

Human resources are as critical as technology and scientific knowledge to a response to both small and large-scale biological attacks. While federal agencies may lead a decontamination response to a biological release, the actual sampling, analysis, and decontamination activities are carried out at the local level by first responders, the public health community, laboratory workers, and private decontamination companies contracted to do remediation work. The federal government does not have the human resources to carry out a decontamination response on its own, even for a small biological event.

In 2001, the EPA spent approximately $27 million from its Superfund program on anthrax decontamination efforts on Capitol Hill. EPA paid 27 decontamination contractors and 3 federal and state agencies approximately $25 million to conduct contamination assessments and undertake remediation of Congressional office buildings. The remaining

$2 million covered EPA's personnel costs.[53] Like public health and laboratory resources, there are a limited number of private decontamination contractors. These same vendors are often contracted for services with both government and private industry. In a large bioterrorism event, there may not be enough vendor resources to respond to the decontamination needs.

Inadequate Guidance for Building Owners

Although most decontamination efforts following the 2001 anthrax attacks involved government-owned buildings, commercial and residential buildings also are vulnerable to biological attacks. In 2001, the first anthrax attack was perpetrated at a privately owned building that housed American Media, Inc. Remediation of the anthrax contamination in this building was carried out by private contractors.[51]

The U.S. government has asked the commercial real estate sector to develop plans for decontamination of buildings, but there has been little guidance from DHS or other federal agencies on what should be incorporated in these plans or how decontamination should be accomplished.[54] Given the limited number of qualified government decontamination personnel, owners of large buildings will likely need to make arrangements with decontamination vendors. However, there are a limited number of legitimate decontamination vendors, many of which are already contracted to perform decontamination work with the federal government.

If commercial and residential building owners are to plan for decontamination independent of the federal government, they will need some assurance that vendors are both reliable and available to provide decontamination services following a biological event.

Recommendations

The following recommendations are practical steps that can be taken to address the major biological decontamination policy and practice gaps identified in this analysis. They are intended to take into account the significant amount of decontamination research that is already being undertaken across the federal government and to facilitate and optimize those ongoing efforts.

1. **The Department of Homeland Security should further define federal agency decontamination roles and responsibilities for large-scale biological events, because the current system is fragmented.** Clearly, during the 2001 remediation efforts no one agency was in charge of decontamination. Still today, the National Response Framework (NRF) does not clearly identify a lead agency for decontamination and contributes to overall confusion surrounding agency roles and responsibilities. In order to clarify these roles, DHS should create an annex to the NRF for decontamination/remediation following large-scale biological events.
2. **Congress should increase funding for biological decontamination research to reflect the critical nature of the threat.** The costs that were incurred from decontamination in 2001 were small compared to what will be necessary for a large bioterrorism attack. Current levels of federal funding for biological decontamination research are insufficient and inadequate to address the magnitude of this threat. Funding must enable research into new decontamination technologies and methods that will facilitate a better response. Therefore, Congressional leadership must increase funds for decontamination research and should appropriate funding to programs, such as EPA's Homeland Security Research Center program on indoor and outdoor decontamination, that have expertise in solving these critical problems.
3. **Future biological decontamination research should focus on the scientific, technical, and social science questions that must be answered in order to respond to a large bioterrorism event.** Extensive research has been done on remediation of small indoor releases. However, in order to respond to a large attack, new research must be conducted on many issues, including how best to sample surfaces for contamination, whether secondary aerosolization is a problem, and developing standards for decontamination. These issues should not be left unresolved for policymakers to tackle in the midst of a crisis. As recommended by the National Research Council Committee on Standards and Policies for Decontaminating Public Facilities Affected by Exposure to Harmful Biological Agents, the EPA, in coordination with the CDC, should take the lead role in setting standards and coordinating and strengthening an interagency process to clarify these critical baseline scientific questions before an attack occurs.[51]
4. **Beyond science and technology, the Administration must invest in human resources for a decontamination response.** The federal government must address the challenges of human resources to ensure rapid and effective decontamination response efforts after a biological attack. This includes providing guidance, training, and funding for decontamination planning at the state and local levels, investing in laboratory personnel and resources, and evaluating the contracting process for decontamination companies to ensure that there are enough people to respond to a bioterrorism event and that remediation goes smoothly.
5. **Federal agencies must develop specific guidance and provide a list of reliable decontamination vendors and other resources for owners of commercial and residential buildings.** DHS has asked commercial building owners to develop their own plans for decontamination of

nongovernment buildings following a biological attack. However, if building owners are to feasibly develop these plans independent of the federal government, they must have access to qualified decontamination contractors. DHS should assist owners of large buildings by providing guidance on pre-event contract arrangements with decontamination vendors. This will help ensure that vendors are reliable and available following a biological event.

Conclusions

The threat of a large-scale biological attack on U.S. soil warrants adequate federal investments in preparedness, mitigation, response, and recovery. Unless biodefense policies and programs can ensure with certainty that a biological attack will not occur, the federal government must also invest in consequence management programs, including decontamination.

While the federal government has addressed the issue of decontamination, several major gaps in scientific knowledge, policy, and practice remain. These include biological decontamination challenges in leadership, research coordination, and funding, as well as major scientific and technical challenges that must be resolved. The nation must be ready to effectively and efficiently respond to and recover from a large-scale bioterrorism attack, and the federal government must take steps now to ensure that the U.S. has the technical and operational capabilities necessary to recover after an attack.

The Administration and Congress should continue to support decontamination research programs, increase funding for these efforts, provide guidance on decontamination to the private sector, and provide a framework for federal decontamination response that clearly lays out agency roles and responsibilities.

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