Addressing Residual Risk Issues at Anthrax Cleanups:

How Clean is Safe?

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ABSTRACT

Since the 2001 attacks in which *Bacillus anthracis* spores were mailed to various media offices and two U.S. Senators, considerable interest has focused on developing estimates of the risk of contracting inhalational anthrax from exposure to such spores. Credible risk estimates would have significant utility in establishing future cleanup goals for contaminated sites. To perform a meaningful risk assessment, one needs sufficient data to identify the hazards, conduct dose-response assessment and assess exposure. This report reviews the existing data on mortality caused by *Bacillus anthracis* spores in laboratory animals and in humans. In particular, it focuses on the 11 cases of inhalational anthrax resulting from the 2001 attacks and their impact on hazard identification activities. It also addresses factors that may contribute to increased risk among exposed populations and the sources of uncertainty in dose response analysis. The paper examines the state of the science for assessing exposure levels to *Bacillus anthracis* spores and concludes that significant challenges exist to performing robust assessments of risk. This conclusion supports the policy position of the U.S. Environmental Protection Agency (EPA) that there should be no growth of *Bacillus anthracis* spores from all post-remediation environmental samples, for the cleanup of a site to be judged effective and for that site to be considered safe for re-occupancy. This has been the ultimate criterion for efficacy of cleanups performed in response to the 2001 anthrax attacks.

INTRODUCTION

In the Fall of 2001, a series of terrorist attacks occurred in which *Bacillus anthracis* spores were transmitted through the U.S. mail system. In the first attack, letters mailed from New Jersey to media outlets in New York City passed through the Trenton Processing and Distribution Center (P&DC) in Hamilton, N.J., on September 18. The second attack involved a letter or package sent on or after September 18 to American Media Incorporated (AMI), a publisher of weekly newspapers, in Boca Raton, FL. In a third wave, letters to Senators Daschle and Leahy entered the Trenton P&DC on October 9. The Federal Bureau of Investigation subsequently recovered four letters: the letter to Tom Brokaw of NBC, the letter to the New York Post, and the letters to Senators Daschle and Leahy. It is believed that there were at least seven such letters (USEPA, 2003).

Twelve cases of cutaneous anthrax and 11 cases of inhalational anthrax resulted from these attacks (Jernigan et al., 2001; Barakat et al., 2002). Five of the persons with inhalational anthrax died. Inhalational anthrax cases were reported only after the second and third attacks.

Numerous sites were contaminated either directly or through secondary (cross) contamination. Among these were media offices, postal facilities, the Capitol Hill Anthrax Site, and residences. The contaminated postal facilities included large P&DCs such as the Trenton P&DC, the Morgan P&DC in New York City, which processes all mail into and out of Manhattan, and the Brentwood facility in Washington, D.C., which handles all mail to and from the U.S. government in the D.C. metropolitan area. Numerous smaller U.S. Postal Service facilities also experienced contamination, as did a number of federal government mail facilities downstream of the Brentwood facility, such as the Department of State (DOS) and the

Department of Justice mail facilities.

Most of the contaminated facilities were shown to have limited cross-contamination upon environmental sampling and were remediated using surface treatment methods only. However, sites in which workers developed inhalational anthrax were subjected to complex, time-consuming and costly cleanups which employed fumigation as the main remedial tool. Fumigations were also performed in portions of the Hart Senate Office Building, particularly Senator Daschle's suite in which the contaminated letter to him was opened.

To date the ultimate criterion of an effective remediation of a contaminated site has been no growth of *Bacillus anthracis* spores from all post-remediation environmental samples. Considerable interest exists in the federal government in developing risk-based cleanup guidance which might be less conservative. This report evaluates the existing data on the hazards of *Bacillus anthracis* spores, the existing relationship between observed hazards and dose-response assessment, and the current status of methodologies for measuring *Bacillus anthracis* spore concentrations on environmental surfaces, to determine whether risk-based cleanup levels for *Bacillus anthracis* spores can be established at this time.

MICROBIAL RISK ASSESSMENT

In 1983, the National Research Council (NRC) of the National Academy of Sciences published a report on risk assessment that identified four phases in the risk assessment process; namely, hazard identification, dose-response assessment, exposure assessment, and risk characterization (NRC, 1983). Although the report primarily addressed the assessment of human risks from exposure to hazardous chemicals, the approach is clearly relevant to the assessment of risks to humans from pathogenic microorganisms.

However, microbial risk assessments differ from chemical risk assessments in a number of important ways. For example, some organisms, such as the *Variola* virus which causes smallpox, undergo secondary transmission from one infected individual to other uninfected persons. Moreover, microorganisms proliferate in hosts at different rates, and certain hosts may develop partial or complete immunity. Also the pathogenicity of a given microorganism may differ significantly in laboratory animals and humans. For certain microorganisms, such as Variola and *Bacillus anthracis*, vaccines are available. In addition, many microbiological agents may be successfully treated with antibiotics, if the disease is diagnosed early enough. The US Environmental Protection Agency is currently working to develop intra-agency and interagency guidance on conducting microbial risk assessments (USEPA, 2004).

Hazard Identification

Anthrax is a naturally-occurring disease in domesticated and wild animals on a worldwide basis, occurring mainly in herbivores. It is caused by *Bacillus anthracis*, a gram-positive, aerobic, sporulating bacillus. The organism exists in the infected host in the vegetative state and in the environment as a spore, the form considered to be the usual infective form (Franz et al. 1997). Humans usually become infected from contact with infected animals or contaminated animal products. Person to person transmission in humans has not been reported. In humans three types of naturally occurring disease occur: cutaneous, gastrointestinal and inhalational. Cutaneous is the most common form, with an estimated 2,000 cases reported annually on a worldwide basis. It occurs following deposition of the organism into skin, particularly abraded skin. Antibiotic treatment decreases the likelihood of developing systemic disease. Mortality in patients treated with antibiotics is very low; the mortality rate in patients

not treated with antibiotics can be as high as 20 percent (Inglesby et al., 1999). Gastrointestinal anthrax, a rare form, develops following the ingestion of insufficiently cooked contaminated meat.

Naturally occurring inhalational anthrax first appeared in the latter half of the nineteenth century among wool sorters in England due to the generation of infectious aerosols of *Bacillus anthracis* spores from handling contaminated wool, hides and hair in the workplace; about 200 cases were reported before 1900 (Plotkin et al., 1960). After being inhaled and deposited in the lower respiratory tract, the spores are taken up by macrophages and transported to hilar and mediastinal lymph nodes, where they germinate into vegetative bacteria, inducing a necrotizing hemorrhagic mediastinitis (Franz et al., 1997).

As a result of improved workplace environments and worker vaccination programs, naturally occurring inhalational anthrax is now a rare disease. Vaccination has also been utilized to protect members of the military from biological warfare uses of aerosolized *Bacillus anthracis* spores. During the Persian Gulf War, about 150,000 service members were vaccinated between mid-January and the end of February 1991 (Friedlander, 1997).

As was the case in the 2001 anthrax attacks through the mail system, cutaneous and inhalational anthrax are the two forms of disease expected to develop following a bioterrorism attack. Given the very high mortality rate of inhalational anthrax and the curable nature of cutaneous anthrax when treated with antibiotics, this paper will only assess issues relating to the risks of contracting inhalational anthrax.

Data useful for determining the lethal dose for exposure to *Bacillus anthracis* spores include data from lethality experiments in laboratory animals and from human studies, data on

the mechanism of action and other relevant data.

Laboratory Animal Data

Based upon data from acute toxicity studies in primates, estimates of the lethal dose sufficient to kill 50 percent of exposed humans (LD_{50}) range from 2,500 to 55,000 inhaled *Bacillus anthracis* spores (Inglesby et al., 1999). In one set of studies, a total of 1,236 cynomolgus monkeys (numbers per sex not specified) were acutely exposed (1 to 10 minutes) to heterogeneously sized aerosols of *Bacillus anthracis* spores. The majority of the particles bearing spores were less than or equal to 5 microns (μm) in diameter. The animals were followed for 10 days following the aerosol exposure. The LD_{50} for the 1,236 animals was 4,130 spores with 95 percent confidence limits of 1,980 to 8,630 spores. The probit slope was 0.669 probits per log dose (Glassman, 1966).

Fatality in acute toxicity studies typically ranges from 20 to 80 percent, with a generally linear slope. However, extrapolation to doses outside the measured range is assumed, but not proven, given the large numbers of animals that would be needed to provide such data. A frequently cited LD_{50} is 8,000 spores. Using this value to extrapolate to lower lethal rates yields an LD_{10} that could be as low as 98 spores, an LD_{05} as low as 28 spores, and an LD_{01} that could be one to three spores (Peters and Hartley, 2002).

Human Data

In the United States, only 18 cases of inhalational anthrax were reported in humans over the time period of 1900 to 1978. The majority of those cases occurred in special-risk groups such as goat hair or goat skin mill workers, and wool and tannery workers. Two of the cases were laboratory workers. The overall mortality rate of occupationally exposed persons in the

U.S. prior to 1978 was 89 percent, but most of the cases occurred prior to the advent of critical care units and, in some instances, before the development of antibiotics (Inglesby, 1999).

During a ten-week period in 1957 five cases of inhalational anthrax occurred among employees in a goat hair processing mill in Manchester, NH. The patients ranged in age from 33 to 65 years. Four of them were males, while the fifth was a female. Four of the five patients died. During that same time period, four other workers at the same plant developed cutaneous anthrax (Plotkin et al., 1960).

As a result of the above "epidemic" of inhalational anthrax, air sampling was performed in February 1958 at that facility in the carding and weaving departments, which were selected as areas of high and low historical contamination with dust and hair particles, respectively. Sampling was also conducted in the same departments of a Pennsylvania mill at which no cases of inhalational had been reported. The Andersen sampler and Casella cascade impactor were used for sampling on two consecutive days at each facility, and particle sizes were measured. The study showed that the number of airborne *Bacillus anthracis* spores was less than one percent of the total airborne bacteria in the two departments, and that in general both the overall bacterial count and *Bacillus anthracis* spore count were greater in the carding departments than in the weaving departments at the NH mill. Significantly greater numbers of viable *Bacillus anthracis* spores were measured on the second day than on the first at the NH mill, in both the carding (2,200 vs. 620 spores) and weaving (77 vs. 21 spores) departments. Variability was also noted in viable spore numbers in the two days of sampling at the PA mill. The variability in numbers of airborne *Bacillus anthracis* spores over the two days of sampling at both mills suggested that even greater variations may occur at times. Because of this, the measurements

were not considered indicative of the exposures at the NH mill that led to the inhalational and cutaneous cases of the preceding year (Dahlgren et al., 1960).

From 1978 to the Fall of 2001, no cases of naturally occurring inhalational anthrax were reported in the U.S.(Inglesby et al., 1999; Inglesby et al., 2002).

The largest documented outbreak of human inhalational anthrax occurred as a result of the accidental release in 1979 of *Bacillus anthracis* spores from a military microbiology plant in Sverdlovsk, in the former U.S.S.R. Initial reporting from the U.S.S.R. indicated that the cases were cutaneous and gastrointestinal in nature and resulted from exposure to contaminated meat from animals infected with *Bacillus anthracis* spores (Abramova et al, 1993). In a paper published a year later, 77 cases were reported; all but two were inhalational cases (Meselson et al., 1994). Of these, 66 cases died, yielding a mortality rate of 88 percent. Fifty five of the 77 cases were men, whose mean age was 42. The mean age for women was 55. No man was younger than 24, and only two women, aged 24 and 32, were under 40. The recorded onset of disease spanned the six-week period from April 4 to May 15, 1979, with a mean time of three days between onset and death. Few patients were reported to have had serious preexisting medical conditions. Based upon the distribution of human cases in a narrow zone, the prevailing winds, the occurrence of anthrax in livestock along the extended axis of the same zone, and the time frame of appearance of cases among humans and livestock, the authors concluded that the outbreak was due to a release from the military microbiology plant. However, data were not available on the amount of *Bacillus anthracis* spores released from the plant or on the doses to the persons who developed inhalational anthrax.

Table 1 contains data on the 11 persons who developed inhalational anthrax as a result of

the 2001 bioterrorism attacks (Jernigan et al., 2001; Barakat et. al, 2002). They ranged in age from 43 to 94 years, with a mean age of 60 years. Seven of the cases were men, and four women. Five patients died; namely, the photo editor from the AMI Building, two mail workers from the Brentwood postal facility, the woman from New York City and the elderly woman from Connecticut. Four of the five patients who died had underlying medical conditions; the status of the fifth case, the photo editor in Florida, was not reported. Four of the six survivors did not have underlying illnesses, one is known to have had a transient ischemic attack, and the health status of the remaining case was not reported.

Four workers from the Brentwood P&DC contracted inhalational anthrax. The two patients who died had underlying medical conditions; of the survivors, one had an unremarkable medical history, and the medical history of the other was not reported. However, the two survivors were admitted to the hospital one to two days sooner than those who died.

Nine of the 11 cases were non-smokers, while the smoking status of one of the other two was not elucidated. The elderly woman from Connecticut had been a smoker for 22 years, but had quit smoking 30 years before she developed inhalational anthrax.

Seven of the 11 cases occurred in postal workers in New Jersey and the Washington, D.C. area, while two occurred in AMI employees. All nine of those persons are believed to have been exposed to letters or packages known to contain *Bacillus anthracis* spores.

The route(s) of exposure for the other two cases who died, the woman who worked in a New York City, NY, hospital and the elderly woman from Oxford, CT, are not known. Extensive environmental sampling in the residence and workplace of the case in New York City yielded consistently negative results, both by polymerase chain reaction and traditional bacterial

culture analytical methodologies. All environmental samples collected from surfaces and an air filtration system along the subway route that the patient took daily also yielded negative results (Mina et al., 2002).

In-depth environmental sampling of the residence and other locations that the elderly Connecticut patient visited in the 60 days prior to development of symptoms did not identify any *Bacillus anthracis* spores. However, environmental sampling in the Wallingford, CT P&DC that processed her mail found *Bacillus anthracis* spores in three high-speed mail sorters. In addition, at least one resident of her community received a *Bacillus anthracis*-contaminated envelope that was likely to have been cross-contaminated as it passed through the postal system. These two findings, while not definitive evidence of the route of exposure for this patient, are consistent with the hypothesis that she may have been exposed through the receipt of cross-contaminated mail (Barakat et al., 2002).

The number of spores to which any of the 11 cases were exposed is not known. Based upon the nature and extent of *Bacillus anthracis* contamination found in the three postal facilities (Trenton, Brentwood, and DOS) and in the AMI building, it is highly probable that the nine workers from these sites sustained significantly higher exposures than the women in New York and Connecticut, who may have been exposed to very low levels of *Bacillus anthracis* spores.

Mechanism of Action Data

Nearly 50 years ago, two *Bacillus anthracis* toxins, known as lethal toxin and edema toxin, were discovered. These toxins and the capsule that surrounds the bacterium are the factors considered to be mainly, but not totally, responsible for the harmful effects caused by the spores (Friedlander. 2001). In systemic anthrax infections the bacterium grows to high concentrations

in the host. The toxins damage defensive cells called phagocytes, causing malfunction of the immune system. Late in the infection, the toxins may be present in the blood at high concentrations, contributing directly to death of the organism. The toxins are composed of three proteins; namely, a cell-receptor binding protein, designated protective antigen, and two enzymes, known as lethal factor and edema factor. Lethal factor is a zinc protease that cleaves other proteins. Edema factor is an adenylate cyclase. The combination of protective antigen with lethal factor produces lethal toxin, whereas edema toxin is produced by the joining of edema factor and protective antigen. The role of the toxins in inducing death is supported by the frequent absence of *Bacillus anthracis* bacteria in cultured blood of persons started on antibiotic treatment regimens too late in the disease process to save their lives.

Dose Response Assessment

As defined in the NRC document on risk assessment, dose response assessment is the process of characterizing the relationship between the magnitude of exposure and the probability of occurrence of the health effects in question (NRC,1983). It takes into account intensity of exposure, age, pattern of exposure and other variables such as sex, lifestyle and other modifying factors. For microbiological agents, additional factors also need to be considered such as the existence of drug resistant strains, person to person transmission, and availability of vaccines and antibiotics.

As noted above, extrapolating from high doses (e.g., LD_{50}) to lower doses (e.g., LD_{01}) may lead to risk estimates of mortality from inhalational anthrax due to exposure to only a few spores. Reliable data on exposures associated with the development of inhalational anthrax are very limited in laboratory animals and virtually nonexistent in humans.

Further, limited data are supportive of the existence of sensitive subpopulations; namely, persons who are elderly, have underlying medical conditions, or are on chronic medications. For example, advanced age, underlying lung disease and medication usage may have contributed to increasing the susceptibility of the 94-year-old patient from Connecticut, who experienced a late onset of inhalational anthrax compared to the other cases in 2001. The mean age of the 11 persons who contracted inhalational anthrax in 2001 was 60. In addition, underlying medical conditions may have had a role in the disease course of the two Brentwood workers who died. Accordingly, in undertaking a risk assessment of the mortality caused by *Bacillus anthracis* spores, the existence of potentially sensitive subpopulations would need to be addressed in the derivation of risk estimates. as a public health protective measure.

Moreover, both naturally occurring and genetically engineered strains of *Bacillus anthracis* spores exist that vary greatly in their resistance to the spectrum of available antibiotics. The strain used in the 2001 attacks was susceptible to ciprofloxacin, doxycycline and penicillin (Inglesby et al., 2002). Hence, it was straightforward to treat potentially exposed, but asymptomatic persons. None of the thousands of potentially exposed persons who were put on antibiotics at the postal facilities, Capitol Hill Office Buildings and media outlets following the 2001 attacks developed any form of anthrax. Any risk assessment of exposure to *Bacillus anthracis* spores in the future will need to take into account the degree of drug resistance of the strain(s) released, since absent effective antibiotics, significantly more exposed persons might develop and succumb to inhalational anthrax.

Currently, significant uncertainties limit the ability to develop robust evaluations of the relationship between exposure to *Bacillus anthracis* spores and the probability of occurrence of

inhalational anthrax. Even when such uncertainties are reduced sufficiently to enable credible characterizations, dose-response assessment for the airborne release of *Bacillus anthracis* spores will need to be performed on a case-by-case basis, which takes into account the specific properties of the *Bacillus anthracis* spores being assessed.

Exposure Assessment

Prior to 2001, no guidelines existed for collecting and analyzing environmental samples for the presence of *Bacillus anthracis* spores. Initially, a variety of surface sampling methods were used; many samples were collected using dry swabs. In certain cases, such as the Brentwood P&DC in Washington, D.C., sampling methods included wet wipe surface sampling, surface vacuuming sampling, and air sampling (CDC, 2001). In April 2002, the Centers for Disease Control and Prevention issued guidance on collecting surface and air environmental samples, recommending the collection of wet, rather than dry, surface samples and the use of wipes instead of swabs, except in hard to reach places (CDC, 2002).

Although significant research is underway, validated environmental sampling methods currently do not exist. Unlike the case with toxic chemicals, there are no established limits of detection for the current sampling methods. Recovery efficiencies of *Bacillus anthracis* spores from various environmental surfaces and media (e.g., non-porous and porous surfaces, air) have not been well characterized, nor have recovery efficiencies from the samples themselves during the analytical process.

A recent preliminary study investigated the recovery of *Bacillus anthracis* spores from nonporous surfaces using four different types of swab materials (cotton, macrofoam, polyester, and rayon), three methods of processing the swabs (vortexing, sonication, or minimal agitation),

and dry versus pre-moistened swabs. Significant differences in recoveries of spores were observed among the various combinations of materials and methodologies. Pre-moistened swabs were observed to be more efficient at recovering spores than dry swabs, and vortexing was found to yield superior extraction than the other two methodologies. Among pre-moistened and vortexed swabs, mean recoveries ranged from 9.9 percent for polyester swabs to 43.6 percent for macrofoam swabs. The authors noted that for quantitation purposes, swabbing environmental surfaces may not be the most efficient means of recovering bacterial contamination, but that in certain situations it may be the best available method at this time (Rose et al., 2004). Further studies are needed, not only of swabs, but also of high efficiency particulate air (HEPA) filter sock samples, surface wipes, and air samples. Absent such critical information, it is difficult to develop credible exposure assessments for *Bacillus anthracis* spores.

Moreover, even when limits of detection are established for the various environmental sampling methods, the physical-chemical properties of the *Bacillus anthracis* spores released in future events will also need to be considered in performing exposure assessment. The spores used in the 2001 mailings were judged to be of "weapons grade" quality, based upon the milling of the spores and the substance(s) used to coat them, which made them highly dispersible (Spertzel, 2004). Such spores are capable of secondary aerosolization, as demonstrated by studies performed in Senator Daschle's suite prior to the fumigation of the space. Air environmental samples were collected on stationary monitors during first semi-quiescent and then simulated active office conditions. The spores experienced secondary aerosolization under both sets of conditions, but significantly higher numbers of colony forming units were recorded in the samples collected during the simulated active conditions. More than 80 percent of the

Bacillus anthracis particles collected were within an alveolar respirable range of 0.95 to 3.5 μm (Weis et al., 2002).

Supporting these results are cross infection studies conducted among normal cynomolgus monkeys and guinea pigs housed in ventilated cages with individuals of the same species previously exposed to aerosols of *Bacillus anthracis* spores. Animals exposed to aerosols containing from 3,250 to 108,000 *Bacillus anthracis* spores per liter of air were thereafter washed with filtered air before being transferred to cages with unexposed animals. In both species cross infection of unexposed animals by aerosol-exposed animals was observed. The mortality rate among normal animals increased when three, rather than one, aerosol-exposed animals were placed in the cage. In a control study in guinea pigs, none of the normal cage-mate animals died when up to ten guinea pigs exposed intraperitoneally to *Bacillus anthracis* spores were then caged with a normal animal. In addition, air sampling detected aerosols of *Bacillus anthracis* spores in decreasing amounts for nine days following exposure from ventilated cages containing aerosol-exposed monkeys, but not from open cages containing guinea pigs injected intraperitoneally with spores. The authors concluded that cross infection of cage-mate animals was probably due primarily to the inhalation of secondary aerosols (Phillips et al., 1956).

Risk Characterization

Due to the very large uncertainties in the doses of *Bacillus anthracis* spores needed to cause inhalational anthrax and in other factors that contribute to dose response assessment and to the inability at this time to perform credible exposure assessments of *Bacillus anthracis* spores, it is not possible to conduct credible risk characterizations of exposures to *Bacillus anthracis* spores.

JUDGING EFFECTIVENESS OF REMEDIATIONS

The approach that has been taken to judge effectiveness of remediations thus far is to require that all post-remediation air and surface environmental samples be negative for growth of *Bacillus anthracis* spores. This public health protective policy does not guarantee that there will be no residual spores in the facility, nor does it assure that there is zero risk from re-use of the facility.

At all remediated sites which met this requirement, however, the residual risk remaining after the cleanups was determined to be negligible. The facilities were put back into productive use following renovation and, at certain facilities, upgrading of protective measures. For example, the Hart Senate Office Building, which contains the Daschle suite, was re-opened in January 2002. In the more than two years that this building has been open to Senators, staff, and visitors, there have been no reports of any form of anthrax.

The National Response Team (NRT), which has representation from 16 federal governmental agencies with roles in emergency response activities, supported this policy in the technical assistance document on anthrax cleanups that it issued in 2002 (NRT, 2002). It is the ultimate criterion for concluding that the remediation of a contaminated facility has been effective and that the facility is safe for re-occupancy.

DISCUSSION

In the future, when research provides the data needed to perform credible risk assessments of *Bacillus anthracis* spores, an important policy issue for risk managers will be to determine the level of acceptable risk.

In performing assessments of potential cancer risks from environmental exposures to

cancer-causing chemicals, program offices within the Environmental Protection Agency (EPA) generally use from one in a million (10^{-6}) to one in ten thousand (10^{-4}), as the level of acceptable risk for exposure to pollutants in air, water, food, or at a hazardous waste site following cleanup. The choice of the acceptable risk level is based upon a number of considerations, including statutory requirements, existing regulations, and/or economic considerations.

Since no guidance currently exists within EPA for microbial risk assessments, the issue of acceptable residual risk has not been addressed for microorganisms in general, let alone for *Bacillus anthracis* spores. However, prior to the 2001 acts of bioterrorism, there had not been any cases of inhalational anthrax in the US. since 1978, and only 18 cases in the entire twentieth century. Thus, the level of acceptable residual risk is a significant issue. Based upon the extent of natural occurrence of the disease in the U.S. in the last century, is 10^{-5} or even 10^{-6} residual risk protective enough? Or should the level be one in ten million (10^{-7})? To what extent should the fact that releases due to bioterrorism are not natural events impact the level of acceptable risk? And in which direction?

Further, the total amount of *Bacillus anthracis* spores used in the 2001 attacks has been estimated to be in the range of grams, with releases from the four recovered letters considered to be a small percentage of the overall quantity of spores in those letters. Should there be another attack in which significantly larger amounts of spores (hundreds of grams or even kilograms) are released, would the level of acceptable risk be different, given the enormous challenges that would be faced in conducting cleanups for such massive releases?

Such public policy issues need to be addressed so that the nation may be prepared for the possibility of future attacks. Given the difficulty in destroying *Bacillus anthracis* spores as

compared to other biothreat agents, the extent and cost of cleanup for a future *Bacillus anthracis* attack agent would be significantly greater than for the other existing bioagents.

A National Academies of Science/National Research Council (NRC) Committee was established in 2003 to address these issues and to propose standards and policies for decontaminating public facilities affected by exposure to *Bacillus anthracis* spores and several other harmful biological agents (NRC, 2004). In its final report, the NRC will address the crucial "How clean is safe?" issue. The NRC conclusions should assist the Nation in preparing for the next attack, not just the last one.

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Table 1: Data on 11 Persons with Inhalational Anthrax Following 2001 Attacks

Case	Age/Race/Sex*	Place of employment/ profession	Date of onset of symptoms	Date of admission to hospital/ Outcome**	Underlying illnesses	Other
1	63/Caucasian/ Male	AMI Building in FL/photo editor	09/27/01	10/02/01/ d:10/05/01	Not known	Nonsmoker
2	73/Hispanic/ Male	AMI Building/ mail room clerk	09/24/01	10/01/01/s	None	Nonsmoker
3	56/African-American/ Male	Brentwood P&DC/ mail sorter	10/16/01	10/19/01/s	Unremarkable medical history	Nonsmoker
4	56/African-American/ Male	Brentwood P&DC/worker	10/16/01	10/20/01/s	Not known	Nonsmoker
5	55/African-American/ Male	Brentwood P&DC/employee	10/16/01	10/21/01/ d:10/21/01	Diabetes mellitus, sarcoidosis	Nonsmoker, saw doctor on 10/18/01
6	47/African-American/ Male	Brentwood P&DC/employee	10/16/01	10/22/01/ d: 10/22/01	Asthma, renal calculi	Seen in emergency room 10/21/01
7	59/Caucasian/ Male	DOS VA mail facility/contract employee	10/22/01	10/25/01/s	Unremarkable medical history	Nonsmoker, seen in emergency room 10/24/01
8	55/African-American/ Female	Trenton P&DC/ mail sorter	10/14/01	10/19/01/s	Transient ischemic attack	Nonsmoker
9	43/South Asian/Female	Trenton P&DC/ mail sorter	10/15/01	10/18/01/s	Unremarkable medical history	Nonsmoker
10	61/Asian/ Female	New York City hospital/supply room worker	10/25/01	10/28/01/ d: 10/31/01	Hypertension	Nonsmoker, nondrinker
11	94/Caucasian/ Female	Not employed	11/13/01	11/16/01/ d:11/21/01	Emphysema, hypertension, renal insufficiency	Former smoker (had not smoked in 30 years), on numerous medications

Footnotes:

* Source of information for first 10 patients: Jernigan et al, 2001; source for 11th patient: Barakat et. al, 2002.

** d: died; s: survived