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How Clean is Safe? Improving the Effectiveness of Decontamination of Structures and People Following Chemical and Biological Incidents

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ABSTRACT

This report describes a U.S. Department of Energy, (DOE) Chemical and Biological National Security Program project that sought to establish what is known about decontamination of structures, objects, and people following an exposure to chemical or biological materials. Specifically we sought to identify the procedures and protocols used to determine when and how people or buildings are considered "clean" following decontamination. To fulfill this objective, the study systematically examined reported decontamination experiences to determine what procedures and protocols are currently employed for decontamination, the timeframe involved to initiate and complete the decontamination process, how the contaminants were identified, the factors determining when people were (or were not) decontaminated, the problems encountered during the decontamination process, how response efforts of agencies were coordinated, and the perceived social psychological effects on people who were decontaminated or who participated in the decontamination process. Findings and recommendations from the study are intended to aid decision-making and to improve the basis for determining appropriate decontamination protocols for recovery planners and policy makers for responding to chemical and biological events.

LIST OF ACRONYMS AND ABBREVIATIONS

AMI	American Media, Inc.
ARIP	Accidental Release Information Program
ATSDR	Agency for Toxic Substances and Disease Registry
CDC	Centers for Disease Control
CERCLA	Comprehensive Environmental Response, Compensation and Liability Act
CFR	Code of Federal Regulations
CIRC	Chemical Incident Reports Center
CSB	Chemical Safety and Hazards Investigation Board
CSEPP	Chemical Stockpile Emergency Preparedness Program
DC	District of Columbia
DHHS	Department of Health and Human Services (U.S.)
DOE	Department of Energy (U.S.)
ED	Emergency Department
EMA	Emergency Management Agency
EMS	Emergency Management System
EMT	emergency medical technician
EPA	Environmental Protection Agency (U.S.)
ER	emergency room
ERNS	Emergency Response Notification System
FBI	Federal Bureau of Investigations
FEMA	Federal Emergency Management Agency
ft	feet
ft^2	square feet
FTP	file transfer protocol
GAEMA	Georgia Environmental Protection Agency
gal	gallon
GSA	General Services Administration
HF	hydrogen fluoride
HAZMAT	hazardous materials
HSEES	Hazardous Substance Emergency Event Surveillance
HVAC	heating, ventilating, and air conditioning
JAMA	Journal of the American Medical Association
lb	pound(s)
LD_x	lethal dose ($_x$ represents the percentage of population expected to die when exposed to this dosage)
MARTA	Metropolitan Area Rapid Transit Authority (Atlanta)
m	meter
m^3	cubic meters
mg	milligram
min	minute(s)
MSDS	Material Safety Data Sheet
NCEH	National Center for Environmental Health
ng/m^2	nanogram per square meter
NIH	National Institutes of Health
NIOSH	National Institute of Safety and Health (U.S.)

NMRT	National Medical Response Team
NO_x	nitrogen oxide
NRC	National Response Center
	National Research Council
NTSB	National Transportation Safety Board
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
PCDD	polychlorinated dibenzodioxins
PPE	personal protective equipment
ppm	parts per million
PTSD	Post Traumatic Stress Disorder
RCRA	Resource Conservation and Recovery Act
SARA	Superfund Amendments and Reauthorization Act
SCBA	Self Contained Breathing Apparatus
SOP	standard operating procedure
SSI	
TCDD	tetrachlorodibenzo-p-dioxin
US	United States
USAMRIID	U.S. Army Medical Research Institute of Infectious Diseases
WHO	World Health Organization

1. INTRODUCTION

Decontamination is the process of removing or neutralizing a hazardous substance from people, structures, articles, equipment and the environment following exposure to that substance. Decontamination is a multi-faceted topic involving health issues, hazardous materials (HAZMAT) issues, emergency response issues, and crime scene issues. Understanding the issues associated with decontaminating an area, person or object to a level that is considered “safe” is the central foci of this study. This includes chemical and biological materials. Although most of the events examined in this study involve chemicals, an analysis of the decontamination of Anthrax from the Hart Senate Office building is also included.

1.1 OBJECTIVE

The main objective of this research is to examine historical and current incidents in which people or buildings were decontaminated in order to gain a better understanding of the interplay between scientific, social, and policy issues regarding decontamination. By examining protocols and criteria regarding reentry, the need to perform decontamination, and the standards set for reentry or public safety, we sought to identify critical factors that require further research or policy formation. The question of "how clean is safe" is more than a technical or logistical issue; it has profound social and political dimensions that need to be considered in policy setting, emergency planning, and response procedures. The study identified how the current lack of scientifically validated standards affected decontamination decision making. We intend to use the findings from this research to better define the critical parameters that will facilitate an effective and timely response to a chemical or biological warfare agent event.

1.2 GOALS OF THE STUDY

The study was designed to systematically examine reported decontamination experiences to determine:

- what procedures and protocols are currently employed for decontamination,
- the timeframe involved to initiate and complete the decontamination process,
- how the contaminants were identified,
- the problems encountered during the decontamination process,
- how response efforts of agencies were coordinated, and
- the perceived social and psychological effects on people who were decontaminated.

Findings from the study are intended to aid decision-making and to improve the basis for determining appropriate decontamination protocols for recovery planners. Further, the study should identify issues needed to be addressed by policy decision-makers in areas involving response and recovery to chemical and biological events.

1.3 ORGANIZATION OF THE REPORT

The report is organized as follows. After presenting a background for this study, the report discusses the methods used to conduct the research. This includes discussions of database development, collection of bibliographic information, development of a data collections protocol, and the approach to conducting the case studies. Section 3 presents a concise review of literature. We have distinguished between biological and chemical agents where appropriate and decontamination of people and buildings when possible. This is followed by reviewing findings on twelve cross-cutting topics. These included types of decontamination, model procedures, special populations such as children, policy issues, wastewater disposal, personal protective equipment, decontamination solutions, secondary contamination, decontamination effectiveness, hospital preparedness for decontamination, epidemic hysteria, and psychological and social consequences associated with the decontamination time experience. This section concludes with the identification of general findings. The bibliography is organized in a similar manner. The next section summarizes the twelve case studies conducted to examine those issues. Also discussed are other case studies brought to our attention during the study period. For each case study we present a background, incident timeline, response and consequences. Findings specific to the study are also provided. The section concludes with a presentation of the general findings. The next section presents our conclusions and recommendations for policy and recommendations for further research.

1.4 BACKGROUND

An initial review of reports involving decontamination of buildings and persons indicated decontamination experiences had never been documented in a systematic fashion or examined for the important lessons learned. Such documentation is essential to developing effective protocols and consistent and valid information to give to the public and emergency managers and agencies on the appropriate decontamination procedures and other protective measures.

This study did not examine transportation accidents, radiological accidents, or soil or other environmental media contamination. Transportation events were excluded because they rarely involve widespread contamination of people or buildings and the data provided on the numerous transportation accidents by the National Transportation Safety Board (NTSB) is extensive. Radiological events were not included because they are investigated using very different criteria for remediation than those for chemical and biological accidents and radiological contamination is easy to detect with the appropriate instruments. Environmental decontamination (soils, aquifers, etc.) was excluded because of the extensive literature and case studies on remediation activities performed under Comprehensive Environmental, Response, Compensation, and Liability Act (CERCLA) or the Response Compensation and Liability Act (RCRA). Some of the biological agent exposure threats, as well as hoaxes, were reviewed to assess the lessons learned from emergency response actions for their similarity or dissimilarity to chemical decontamination procedures. In addition decontamination issues related to anthrax contamination were examined for the Hart Senate Building and the American Media, Incorporate (AMI) facility in Boca Raton, Florida. Other cases that were brought to our attention on potential biological contamination are also included in this report.

1.4.1 Definition of Decontamination

For the purposes of this document, decontamination is defined as the process of neutralizing or removing chemical or biological agents from people, structures, articles and/or equipment, and the environment (NRC 1999). For decontamination to be effective, three elements must be in place:

- the contaminants involved are correctly identified,
- the procedures and equipment are available and are appropriately employed to remove or neutralize the contaminant, and
- the reduction of risk from the contaminant is defensible by scientific and regulatory standards.

Most current decontamination systems are labor intensive, require excessive quantities of water, and may be environmentally unsafe. The issue is further complicated by the use of ultra-conservative standards to determine when it is safe to reenter a structure or transport victims to a health care facility after a chemical or biological release. As the American Medical Association has pointed out, most decontamination guidelines for treating people exposed to hazardous chemicals were created by the military and are inappropriate in a civilian health care setting where resources and personnel are not as readily prepared nor deployable (Macintyre et al. 2000).

The growing number of serious chemical accidents has prompted the federal government and states to enact regulations for reporting such occurrences. For example, under the provisions of Section 303(g) of the Emergency Planning and Community Right to Know Act of 1986 [Superfund Amendments and Reauthorization Act (SARA Title III)], federal law requires that all chemical and oil spills be reported to the National Response Center (NRC) located in the U.S. Environmental Protection Agency (EPA). In 1999 the NRC received reports of 30,175 incidents. The Occupational Safety and Health Administration (OSHA) steps in when an accident at a facility involves a fatality or results in three or more workers being hospitalized. In 1992, the federal government initiated the Chemical Safety and Hazards Investigations Board (CSB) to report incidents involving chemical releases and to examine procedures to improve the safety of the chemical industry.

Recent criticism has been directed at the large number of people decontaminated on site or at medical facilities based solely on perceived exposure or self-reported exposure. Moreover, studies of the decontamination process are spotty and not well documented in the open literature because the event often involves several agencies with overlapping responsibilities and decontamination is required as a function of first responder activities. Highly trained HAZMAT teams responding to the site may decontaminate civilians as well as response personnel as part of standard operating procedures (SOPs) as a precautionary measure. Victims are then sent or self-evacuate to a health care facility, which may or may not know of the instigating incident. For example, a pesticide release in California several years ago reportedly resulted in over 4000 civilians reporting to hospitals after exposure to oleum (concentrated sulfuric acid) (Morris and Ginley 1993).

Often the chemical release contaminates buildings and property requiring evacuation of occupants. Commercial decontamination vendors are then called in for cleanup and for remediation. To further complicate the decontamination issues, there are often overlapping responsibilities among agencies and jurisdictions on decisions to reoccupy a decontaminated area or to release property to owners. Although local first responders are first on the scene and perform the critical identification of the contaminants and conduct response actions, procedures require notification to appropriate state and federal agencies who may not respond for several hours or even days after the event. Official final reports often take months to prepare and disseminate.

To address this issue, this study examined how and where the decontamination was conducted, what logistical problems were encountered, if members of the public cooperated, and if not, what were the refusal rates. Also examined were the procedures to ascertain the safe levels of residual contamination. To determine the time sequence of various events, the study also examined when decontamination efforts were initiated and how many people were decontaminated over what time period. The study also sought to identify who made the decision to reenter the impacted area and the factors influencing that decision. Finally, the study examined changes following an incident such as how state or local governments or agencies changed procedures on decontamination as a result of lessons learned from the event.

2. METHODS

2.1 APPROACH

The *How Clean is Safe* study was national in scope and was designed to gather qualitative and quantitative information on the existing procedures and protocols as well as knowledge and practices of workers involved in performing decontamination. Early on the study focused on the decontamination of people as the number of building decontamination incidents was small and largely anecdotal. With the anthrax contamination of the Hart Senate Building in Washington, DC, and the American Media, Inc. (AMI) Building in Boca Raton, Florida, enough information was available to include issues related to anthrax decontamination.

Two broad techniques were used:

(1) a secondary source review, which included examination of existing data collected by federal or other agencies, and
(2) a structured dialogue with various informants using an open-ended questionnaire format, with sections deleted as appropriate depending on the responder. These interviews also resulted in the collection of documents and other reports related to the individual incidents, which would likely not have been found without the informant's help.

Matrices were developed to help guide the research and to draft the preliminary report. To associate the decontamination process model with actual field events, timelines were developed for events. This determined that the model was robust and likely capable of use in wider applications of research on decontamination incidents.

2.2 DATABASE DEVELOPMENT

We obtained information on historical events through extensive literature and electronic database searches to develop a historical incident database. ORNL staff searched Science Citation Index, Current Contents, Medline, Toxnet, DOE databases, and commercial databases such as Northern Light. The bibliography currently contains numerous references describing research on decontamination, decontamination events, and decontamination recommendations by experts.

Recent chemical events were identified and characterized for possible selections as case studies for further examination. We examined the pertinent federal databases on chemical accidents: the Chemical Safety hazard and Investigation Board's Chemical Incident Reports Center (CIRC), EPA's Accidental Release Information Program (ARIP), the National Response Team's Emergency Response Notification System (ERNS), and the Hazardous Substances Emergency Events Surveillance (HSEES) system established by the Agency for Toxic Substances and Disease Registry (ATSDR).

The Chemical Incident Reports Center (CIRC) is updated daily by the Chemical Safety Board (CSB). Every day the CSB receives initial reports about chemical incidents that have occurred worldwide, although most reported occur within the United States. The information is obtained from official government sources, the news media, eyewitnesses and others. The CSB is an independent federal agency (non-regulatory) whose mission is to ensure the safety of workers and the public by preventing chemical incidents. The CSB determines the root causes of accidents, issues safety recommendations, and performs special studies on chemical safety issues.

The CSB incorporates incident information into databases that it maintains, shares incident information with other government agencies and chemical safety stakeholders, and makes decisions about whether to deploy investigation teams based on supplementary information developed after the initial report is received. The searchable online database of chemical incidents is intended to inspire actions by a researcher, a government agency or others in support of improving chemical safety. Although the CSB claims to never knowingly post inaccurate information, the agency is unable to independently verify all information that it receives from its various sources, much of which is based on media reports.

The data could be improved by cross checking information sources instead of generally relying on news reports. Our examination of the CIRC reports showed a significant bias toward reporting larger numbers of people involved in an incident. While the data reports include evacuations, they do not systematically report on incidents where sheltering was advised or where decontamination of buildings or people was employed. Intended to improve safety in the chemical industry workplace, the CIRC database does not incorporate critical data available from other data sources but was useful as a starting point for further scientific investigation.

The ARIP database collects information from fixed facilities that have had significant releases of hazardous chemicals. The data are collected by the EPA regional offices through the ARIP questionnaire, and then forwarded to EPA headquarters for inclusion in the ARIP database. The questionnaire consists of 23 questions about the facility, the circumstances and causes of the incident, and the accidental release prevention practices and technologies in place prior to, and added or changed as a result of, the event. The questionnaire focuses on several areas of accident prevention including hazard assessments, training, emergency response, public notification procedures, mitigation techniques, and prevention equipment and controls. ARIP analyzes the collected information and disseminates the results of the analysis to those involved in chemical accident prevention activities. ARIP also helps to focus industry's attention on the causes of accidental releases and the means to prevent them. There are no questions related to contamination or decontamination of structures or people.

The National Response Team's Emergency Response Notification System (ERNS) contains reports on discharges of oil and other hazardous substances. The data is compiled from spill reports submitted to the Environmental Protection Agency (EPA), U.S. Coast Guard, the National Response Center or the Department of Transportation. The reports include the types of hazardous substances involved, whether there has been any property damage, and injuries or deaths occurred as a result of the spill. The primary purpose of ERNS is to standardize and collect notifications made to the Federal government of releases of oil and hazardous substances so they can be used to determine the appropriate federal response.

Because ERNS is a database of initial notifications and not incidents, exact details are often unknown and limit the data. The spill reports also vary widely in description depending on who reports the spill and what information the individual can provide. Nor are the inputs updated unless an ERPA region is involved in the response. There also may be multiple reports for a single incident. Furthermore there are no specific fields related to contamination or decontamination efforts, although EPA's Office of Emergency and Remedial Response maintains a subset of the ERNS database online. This subset contains the most frequently used data fields. (Information protected for privacy purposes is not available.) Data can be downloaded through the World Wide Web or retrieved through EPA's Gopher server and anonymous file transfer protocol (FTP) server.

HSEES was designed to collect and analyze information about releases or threatened releases of hazardous substances that result in a public health action such as an evacuation. The goal of HSEES is to reduce the morbidity and mortality that result from hazardous substances events experienced by first responders, employees, and the general public. Although HSEE captures data for more than 5000 events yearly on fixed-facility and transportation events, only sixteen state health departments currently participate with ATSDR in providing data to HSEES.

An HSEES event is defined as any release(s) or threatened release(s) of at least one hazardous substance. A substance is considered hazardous if it might reasonably be expected to cause adverse human health effects. Releases of only petroleum products are excluded from this system. Besides time and place, data collected includes contributing factors, environmental sampling and follow-up health activities, specific information on injured persons, personal protective equipment (PPE) used, information about decontamination, orders to evacuate or shelter-in-place, land use and population information to estimate the number of persons at home or work who were potentially exposed, and whether a contingency plan was followed and which plan (ATSRD 2002). Over 90% of all events reported to HSEES involve the release or threatened release of only one hazardous substance.

The HSEES data show that employees (including students) is the population group most often injured, followed by the general public and first responders. The majority of all victims are treated at a hospital for their injuries and then released. The vast majority of persons do not wear PPE or they wear PPE that is not protective against chemicals. The data could be verified by having greater state participation.

Because only the CIRC data recorded information on events where decontamination may have occurred, we relied on the CIRC data to identify current events for further investigation. Using key word searches, we found 26 chemical releases that resulted in decontamination between October 12, 1998 and October 30, 2000.

One problem with CIRC reports is the heavy reliance on media reports that makes systematic analysis difficult as to what occurred and problematical as to validity of input. However, by using key word searches, we identified a number of events that likely resulted in decontamination of buildings or people. After the incident was identified, follow-up included gathering secondary data from reports on the event. Two examples of studies of historical decontamination incidents that were particularly relevant to this study are the extensive remediation of a government building in Binghamptom, New York, and the decontamination following the ebola outbreak among primates at a Reston, Virginia, laboratory.

2.3 BIBLIOGRAPHIC RESOURCES

We extracted the key findings from and annotating the references in the bibliography that describe research on decontamination and the expert's recommended decontamination practices. The references have been grouped into the following categories:

- biological decontamination for buildings,
- biological decontamination of people,
- chemical decontamination for buildings,
- chemical decontamination of people,
- reentry criteria and human toxicology,
- psycho-sociological and epidemic hysteria situations, and
- both chemical and biological decontamination.

This report contains a bibliography grouped by these categories.

2.4 INFORMATION COLLECTION PROTOCOL

We developed an information collection protocol tool that was reviewed and tested for efficacy and ease of data collection. A questionnaire was designed to systematically collect information on decontamination incidents through telephone interviews with responders and/or managers of the incident. The questionnaire was slightly altered to adapt to the issues related to health care facilities.

The questionnaire included separate modules to address three possible aspects of decontamination:

- buildings (e.g., surfaces, attached fixtures, air spaces),
- articles (e.g., fixtures or items that could be removed from a structure), and
- people, including medical treatment, if any.

After a few interviews had been completed, it was evident that questions on decontamination of articles was subsumed under buildings or people by respondents and was not eliciting information. The telephone interview method was selected as the most efficient method to collect information, especially given the DOE restrictions on travel that were imposed during the fiscal year the project was initiated that prevented site visits. In addition, we needed to interview a number of responders regarding an incident because of the overlap in responsibilities for decontamination procedures.

2.5 INITIATION OF INVESTIGATIONS

Twelve case studies of recent building decontamination experiences were completed between October 1999 and March 2002. The investigations were conducted by research staff unfamiliar with the literature findings. We did this to insure that the information collected from respondents would not be directed toward findings from the literature review and thus bias the results. Informants were chosen for their specific involvement in the event. Although firefighters or other first responders were interviewed in every study, some studies included a dozen or more informants while others included only six. When informants offered the names of other respondents with specific knowledge of the incident, those persons were interviewed also. These "snowball" methods provided a comprehensive overview of each event from which findings were derived.

Priorities for selecting events to investigate included:

- federal facilities as they are high risk for terrorist attacks,
- transportation facilities because of their strategic and economic importance,
- educational facilities, as elementary schoolchildren are particularly vulnerable subgroup, and
- hospitals, as the potential for secondary contamination of medical personnel or facilities can dose emergency rooms for lengthy periods of time. In a mass casualty event, every medical facility would have to be prepared and closure of one could result in unnecessary casualties.

3. LITERATURE REVIEW

This section describes selected findings from the review of the open literature. To aid the reader in distinguishing between the chemical and biological literature, the findings are categorized into three headings:

- biological,
- chemical, and
- cross cutting issues.

3.1 BIOLOGICAL

3.1.1 Building Decontamination

Event: Reston Primate Facility

Jax and Jax [in Department of Health and Human Services (DHHS) 1995] and Peters and Olshaker (1997) discuss the decontamination procedures used at the Reston Primate facility where 450 monkeys were destroyed when an ebola virus was discovered. The monkeys were disposed of and supplies were incinerated, all particulate matter was scraped from surfaces, and then surfaces and drains were drenched with bleach. Thirty-nine electric fry pans were placed on timers and filled with paraformaldehyde mixed with water. Every seam in the building was tightly taped and the paraformaldehyde was cooked off with a target of 10,000 ppm. The building was put up for sale but eventually demolished when the asking price dropped below the value of the land (Alexander 1998).

Decontaminating the fecal matter of the monkeys remained a problem. The United States (US) Army Medical Research Institute of Infectious Diseases (USAMRID) wanted to soak material in Clorox and send it down the sewer. Virginia environmental officials objected to putting the disinfectant down the sewer. Permission was finally given to proceed with the disposal when the Army told the state they would leave it for the state to dispose of.

Event: Hospital Autopsy Room

Coldiron and Janssen (1984) describe the decontamination of a hospital autopsy room and ventilation system using formaldehyde. This was done because the ventilation system of the autopsy section was being remodeled. Hospital officials were concerned about potential transmission of disease from infected tissues or pathogens to the workers. Following the National Institute of Health (NIH) procedures, rooms and ventilation systems were exposed to paraformaldehyde concentrations estimated to be between 18,600 to 14,000 ppm for 3B4 hours. Tests performed after the procedure indicated no spore development after a 48-hour incubation period indicating effective sterilization.

Key Research Findings

Very little research has been performed on biological decontamination of buildings. Pasanen et al. (1997) tested eight biocides to assess their effectiveness of surface decontamination. The solutions containing sodium hydrochloride and glycol containing detergents performed best. Both completely prevented microbial growth on a dusty sheet metal and significantly inhibited growth on wallpaper. Debus et al. (1998) describe a hydrogen peroxide gas plasma sterilization procedure to decontaminate Mars 96 small station landers.

Alexander (1998) reviews the issue of building decontamination for biological agents, relying primarily on second-hand information based on interviews with public officials. He concludes that there are no civilian standards to certify a building is clean and safe for reoccupation.

Surface decontamination technologies for buildings have been well documented (Hawely and Eitzen, 2001). Recent tests show that liquid household bleach killed 98.5% of anthrax spores on inanimate surfaces in 1 minute. A 1 to 20 dilution of household bleach had a 100% kill rate after 15 minutes of contact. A 5-minute contact with a 0.5 % (a 1 to 10 dilution) bleach solution resulted in a 90% reduction in spores. Other types of effective surface decontaminants include alcohol, halogens, quaternary ammonia, phenolics and glutaraldhyde.

Space decontamination is building is primarily accomplished by fumigation with a number of different gases (Hawley and Eitzen, 2001). Formaldehyde is a widely used fumigant in controlled settings such as laboratories. Formaldehyde, however is a safety hazard because it is a carcinogen and also poses an explosive hazard. Chorine dioxide is an alternative fumigant that is effective at concentrations of 20mg/L at 50% humidity. Other potential gases for decontaminating spaces are ozone and vapor-phase hydrogen peroxide. Ethylene oxide has also been proposed for building decontamination, but its human health hazards makes it a poor choice.

There are a number of emerging technologies for biological decontamination. Seven of these technologies were tested at Dugway Proving Ground for their ability to kill an anthrax simulant on a variety of surfaces including painted metal, painted wallboard, concrete, ceiling tiles, and carpet (O'Conner, 2001). Two technologies, an aqueous foam developed by Sandia National Laboratory and an oil emulsion developed by the University of Michigan proved to be the most effective. While both achieved high kill rates on solid surfaces, neither was 100% effective on porous surfaces or carpet.

Decontamination of buildings following the fall 2001 anthrax contamination in Florida, Washington DC and New York proved to be more difficult than envisioned in the early planning phases. It did provide a unique opportunity to investigate topics for which little empirical evidence existed. For example, tests were conducted in the Hart Senate Office Building to assess the potential re-aerosolization hazard. In one test 17 blood agar gel plates were placed around a contaminated office and normal office activities were simulated. Of the 17 plates, 16 yielded anthrax spore cultures, indicating that routine office activities could create significant hazards (Ingelsby et al. 2002).

3.1.2 People Decontamination

Event: B'nai B'rith Headquarters

A package was mailed to the B=nai B=rith headquarters in Washington D.C. that contained a petri dish labeled as a biological weapon. The District of Columbia (DC) Fire/ Emergency Management System (EMS) Department responded and arrived on scene 1 hour and 20 min after the package was opened. After consulting with the Centers for Disease Control (CDC), it was decided to shelter people in the building and set up a decontamination line. A total of 30 people were decontaminated including civilians, police officers and fire personnel (U.S. Fire Administration, 1997).

Decontamination was problematic because no enclosed spaces were available and the operation was performed in front of live media cameras. Two police officers refused to go through the decontamination line and struck a fireman in charge of the quarantined areas. About 4 hours into the event, a security guard developed chest pains. He was carried through the decontamination line in a chair and transported to a hospital. Nine hours after the package was opened, analyses showed no chemical or biological hazard and people in the building were released. None of the findings in the Fire Administration report directly concerned decontamination.

Key Research Findings

Need to decontaminate. A variety of experts have recently published on the need for decontamination for biological agents. Franz et al. (1998) note that decontamination following an aerosolized biological attack is less likely to be needed than for a chemical at release. In most cases of biological contamination, decontamination is not needed; the main exceptions are for toxins (English et al. 1999). Skin decontamination for biological aerosols would be of minimal or no benefit (Keim and Kaufmann 1999). People with grossly visible evidence of direct skin contamination by an etiological agent should be decontaminated thoroughly (Keim and Kaufmann, 1999, English et al., 1999).

Garland et al. (2000) suggest that reaerosolization of biological agents may be a problem after the deposition of aerosolized agent. They note that decontamination may cause reaerosolization although it has not been quantified. This may lead to a need for multiple decontamination of exposed patients.

Most of these observations, however, are based on opinion and not empirical evidence and some conclude that the need for decontamination of individuals exposed to infectious agents has not been carefully evaluated (Balk et al. 2000).

Methods of decontamination. Patients with acute exposure to a biological aerosol should shower at home (Richards et al. 1999). The preferred method of decontamination for a biological aerosol is to have people go home, bag their clothes, and shower with soap and water (Keim and Kaufmann 1999).

Given a patient with visible skin contact with a biological agent, they should be washed with soap and water and then swabbed with a bacterial sporicidal solution such as 0.5% bleach (Richards et al. 1999).

Workers bitten or scratched by an animal in a primate facility must scrub with soap and bleach for 5 min and then for 10 min with Betadyne (Gerone 1996).

The Journal of the American Medical Association (JAMA) has initiated a series of consensus articles on biological agents. Each article contained a section or statement on decontamination. Based on these article the following decontamination recommendations are offered.

Anthrax. Thoroughly wash exposed skin with soap and warm water. Wash clothing in soap and water (Inglesby et al, 2002).

Plague. No need for decontamination (Inglesby et al, 2000).

Smallpox. No need personnel decontamination. Follow infectious disease protocols for clothing and surface contamination (Henderson et al, 1999).

Tularemia. Wash all potentially exposed skin with hot water and soap. Clean exposed surfaces with 10% bleach solution and then with a 70% alcohol solution (Dennis et al. 2001).

Hemmoragic Fevers. Follow standard hospital procedures for decontamination of clothes and surfaces. It is unclear if there is a need for environmental decontamination (Bario et al., 2002).

Bot Tox. Wash exposed skin and clothing with soap and water. Wash exposed surfaces with a 0.1% solution of bleach (Arnon et al. 2001).

Infection control. Virus infections can be managed effectively using standard hospital practices for dealing with infectious diseases, including barrier nursing, contact precautions, and respiratory protection (CDC 1998). Keim and Kauffman (1999) note that every infectious biological agent has a non-warfare biological disease counterpart that hospitals are prepared to handle. Thus, standard hospital procedures should be adequate to handle any biological warfare agent induced disease. However, a massive exposure may overwhelm health care capacities (Osterholm 1999).

Lessons from Fall 2001. The experiences in the fall of 2001 with the anthrax contamination certainly challenge the previous tenets and ways that public health experts viewed the anthrax hazard (Inglesby, 2002). Among the revelations from these experiences are:

- anthrax exposure can occur from handling unopened letters containing anthrax spores.
- anthrax exposure may be possible from cross-contaminated mail.
- a letter containing anthrax spores can create a hazard for people in the environment in which it was opened as well as for the person who opened the letter.
- postal sorting devices may release anthrax spores from an unopened letter into the environment.
- inhalational anthrax can occur without forensic evidence of exposure to anthrax in the environment.

Such observations run counter to prevailing thinking about anthrax hazards prior to those events. These included that there is little inhalation risk from re-aerosolization of anthrax spores deposited on clothing or surfaces (Cole, 2000) or little risk from handling sealed packages or letters containing anthrax spores or even opening a letter containing the spores (Cieslak and Eitzen, 1999).

Such findings underscore the importance of decontamination following potential clothing or skin exposure to anthrax to avoid aerosol exposure. Once anthrax has been inhaled decontamination is no longer a means to reduce the hazard.

Lethal Doses for Anthrax

An important issue in determining reentry criteria for buildings exposed to anthrax contamination is the amount of agent, (i.e., number of spores) needed to cause a human fatality. During the fall of 2001 anthrax incidents it was widely cited by the Centers for Disease Control (CDC) and reported by the national media that a person needed to inhale 8,000 to 10,000 spores in order to contract inhalational anthrax. The impression given was that this was a threshold dose that needed to be met or exceeded to be at risk. In early stages of response to the contamination at the Hart Senate Office Building, this was an officially documented position taken in the clean-up plan. The scientific literature, on the other hand, suggest this number of spores is the LD_{50} or amount of agent required to cause lethality to 50 percent of the population exposed to this level of anthrax.

This estimate is largely derived from experiments with monkeys conducted at Ft. Detrick. These tests, however, show a fairly flat dose response curve. At 100,000 spores exposure 80% of the population died, at 1000 spores 33% died, and at 100 spores 14% died (Gober, 2001). In the Serdlovsk incident in the former Soviet Union, Meselson (1994) estimated the LD_2, or number of spores to kill 2% of the population exposed was 9 spores. Meselson has also taken the position that there is no threshold dose below which infection cannot occur and that theoretically a single spore could result in disease, albeit a very low probability (Meselson, 2001). Peters and Hartly (2002) estimate the LD_1 for anthrax is 1 to 3 spores, which appears to be a linear interpolation of the Meselson LD_2 estimate.

In addition, there is conflicting data about the toxicity of naturally occurring anthrax spores associated with goat hair processing mills. One study reported daily inhalation of up to 500 spores resulted in no cases of inhalation anthrax (Inglesby et al., 2002). Other cases of inhalation anthrax have been documented in populations near mills where people contracted the illness who worked or lived in the vicinity of a mill but not work in the mill (Furmanski, 2001).

It is also thought that a variety of factors may affect the inhalational anthrax disease formation process including the anthrax strain, aerosol particle size, and method of preparation and storage (Meselson, 2001). In addition, age seems to be a major factor in determining vulnerability to illness.

3.2 CHEMICAL

3.2.1 Building Decontamination

Event: Binghamton State Office Building

One of the most interesting cases of building decontamination involves the Binghamton State Office Building in New York. A transformer fire in the basement of this 18-story modern office building in February 1981 contaminated the building with polychlorinated biphenyls (PCBs), dioxins, and dibenzofurans. A 30-min fire generated dense smoke and because of the design of the heating, ventilation and air conditioning (HVAC) system, contaminated all 18 floors. The cleanup efforts have been documented in several journal articles (see Schecter and Charles 1991 and Schecter 1986) and numerous state reports.

Twenty-four-hour cleanup activities began immediately by state workers, but were suspended in late February after tetrachlorodibenzo-p-dioxin (TCDD) was detected. The state spent the next 6 months developing a protocol to guide the decontamination process. Reentry criteria were established for renovation workers and for office workers for both surfaces and air (Kim 1983). The criteria were based on working in the building for 250 days per year for 30 years. The exposure values were calculated based on not exceeding a cancer risk of 1×10^{-2} (Kim & Hawley 1982).

It was estimated that it would take 6 years to clean the building to a level where re-use could occur. As of 1991, floors 2B18 were authorized for reentry (Schecter and Charles, 1991), but reentry did not occur because the first floor, basement, and sub-basement were still sealed off. As of 1991, the cost of cleanup was $40 million for a building that originally cost $17 million.

By 1994, state officials decided to initiate efforts to reopen the building, however, environmental sampling showed levels of polychlorinated dibenzodioxins (PCDDs) in recessed light fixtures that exceeded reentry criteria (NYDH 1999). After additional cleanup, tests were conducted in August and September showed residual contamination to be considerably lower than the reentry criteria. Building reoccupancy began in October and was complete in December 1994. Extensive information materials were provided to workers in the building.

Plans were established to perform additional cleanup efforts every 3 years and to conduct yearly sampling. A long-term sampling plan was established and was signed off by labor unions, the Governor's Office, the BSOB Committee on Safety and Health (independent experts), the State Office of General Services, and the State Office of Health. All tests conducted since reoccupancy showed levels of PCBs and PCDDs to be well below the reentry criteria.

Event: Canadian Laboratory

In 1984 a high voltage testing laboratory in Canada experienced a fire resulting in widespread PCB contamination. A cleanup and repair committee was established based on Hydro-Quebec=s organization for managing the construction of nuclear generating stations. Partial reuse of the 0.5 million-m^3 space was achieved in 3 months and full reuse was achieved in 11 months (Train et al. 1987).

Event: San Francisco Office Building

In 1983 (May 15), a 28-story office building in San Francisco experienced a transformer fire that contaminated a portion of the building with PCBs and several harmful byproducts (Maslowski and Rose 1985). Among the lessons learned from this experience are

1. Immediately organize a restoration management team to organize the cleanup efforts.
2. Develop a sampling plan and procedure. In the course of this cleanup, 11,000 samples were taken.
3. Establish formal work procedures for decontamination activities.

In recovering from the fire, it took 5 days to restore power to the building. Floors 7B28 of the building, which operate on a different air system from the one affected by the fire, were declared free of contamination and were re-occupied 10 days after the fire.

Background testing became a major issue associated with the cleanup. Since no background levels of contamination were known, it was assumed that the pre-accident level of contamination was zero.

The City Health Department established the final reentry criteria for the building along with assistance from the state. These were based on 8 hours per day, 250 days per year and 40 years of exposure. The criteria were the same as those established for the Binghamton State Office building. The building was re-occupied in late March 1994, 9.5 months after the incident.

Event: Baltimore Loft Apartment Building

In December 1994 residents of a condominium, recently converted from industrial use, observed mercury pods forming. The residents hired consultants and physicians to do environmental testing and biological monitoring of mercury levels in two units. Two of the children tested showed elevated mercury levels. In December 1995, the New Jersey Department of Health and DHHS were asked to evaluate the health impacts from the contamination. When their testing confirmed that a mercury hazard was present, the ATSDR issued a Public Health Advisory and the local health board declared the building unfit for human habitation. Future human occupancy will depend on the feasibility of remediation (Orloff et al. 1997).

Event: West Helena Hospital

Shortly after 1:00 p.m. on Thursday, May 8, 1997, clouds of foul-smelling smoke began pouring from an herbicide and pesticide packaging plant in West Helena, Arkansas. An alert was sounded, employees evacuated, and the West Helena fire department was called. As the odorous smoky cloud drifted away from the plant, authorities ordered residents in a 2-mile area downwind of the plant to evacuate and those in the 2- to 3-mile zone to shelter in place. The incident began when smoke was emitted from a 1500-lb bulk container of azinphos-methyl, a commercial brand of parathion, with a toxicity similar to the chemical nerve agent Sarin (Vogt and Sorensen 1999).

Included in the evacuated area was the Phillips County Regional Medical Center. Established in 1909, the Center moved to its present location across the highway from the fields surrounding the industrial park in 1979. It is a complete service hospital, providing care for residents in a 50-mile radius. The hospital employs 325-330 people and has 155 beds. Included in its services is obstetrical care; last year the center had 500 births. The not-for-profit, fully accredited facility is owned by the county but professionally managed by Quorum.

Although monitors indicated no contamination in the facility, the state health department required a thorough cleanup of the hospital before patients could be admitted. This meant that all hard surfaces had to be scrubbed and all soft materials (drapes, etc.) had to be removed. The health department also required that all filters in the building be replaced before the interior cleanup was started. Staff were unable to locate the filters because of the special design and the fact the company making them did not operate on weekends. Recognizing the urgency of having the regional hospital operational, pressure was exerted from state officials to convince the company to alter its policy. The company extended its hours and worked through the night, delivering the replacement filters to the hospital on Saturday. The hospital staff started cleaning on Sunday in shifts, starting with the rooms where filters were replaced. The emergency room was considered priority and cleaned first. On Tuesday (6 days after the initial evacuation) the hospital was reopened.

Key Research Findings

Reentry criteria. PCB incidents are discussed by Rappe et al. (1986) in San Francisco, Santa Fe, Finland and Sweden. Each incident used a different level of residual surface contamination as the reentry standard. For PCDDs, these ranged from 1 to 50 ng/m^2.

One problem encountered by officials is the lack of baseline data on chemical contamination in a building. This affects decontamination efforts as the conservative assumption that the baseline is zero contamination is usually adopted (Perdek et al. 1991). It also has been noted that it is extremely difficult to established meaningful reentry criteria and make accurate measurements to verify it as safe to re-occupy a building (Stephens 1986).

Cleanup cost effectiveness. Little research has been conducted on the cost and effectiveness of alternative cleanup techniques. In one of the few studies identified, EPA compared two technologiesCone chemical and one physical to cleanup a PCB-contaminated building. The first process involved treatment with an alkali metal/polyethylene glycolate mixture and the second involved shot blasting to remove the contaminated concrete surface. The study concluded that both techniques were effective at removing PCBs but not sufficient to meet cleanup criteria. The reagent technique cost $0.85/ft^2$ and the shot blasting cost $2.19/ft^2$ (Barkley 1990).

As part of the World Trade Center cleanup, in 1993 the Port Authority cleaned all exposed surfaces in the building. It took 900 workers per shift, 3 shifts a day, for 3 weeks to complete the cleaning (Kirshner and Bleach 1994), amounting to about 450,000 person-hours of labor.

3.2.2 People Decontamination

Event: Tokyo Subway

On the 20th of March 1995 there was a coordinated terrorist attack on three subway lines in Tokyo, Japan during morning rush hour (7B8 a.m.). The nerve agent Sarin was released as a liquid in five subway cars. Sixteen subway stations were affected as passengers rushed out of the trains. The first emergency call reached the police at 8:14 a.m. and between 8:30 and 9:00 a.m. over 11,000 emergency workers were dispatched. Most patients were treated at four large hospitals in the vicinity of the attack, although over 275 medical facilities were eventually involved. An estimated 5500 people were contaminated (NCEH 1995).

In the Tokyo subway incident, there was no decontamination conducted at the scene of the accident (Okumura et al. 1998a) In that incident, it took about 3 hours to determine GB was the chemical involved (Okumura et al 1998a). Decontamination began only after the nerve agent was identified as the cause. The decontamination procedure was to undress and shower. There are no estimates of the number of patients that were decontaminated. Mildly exposed victims were not decontaminated due to lack of changing and showering facilities (Okumura et al. 1998b).

Sidell (DHHS 1995) notes that decontamination in the Tokyo incident was not needed for most of the victims because most people were exposed to low level vapors.

One of the major difficulties in the Tokyo subway attack was undressing of victims and disposing of clothing due to the shear volume of exposure (Holloway et al. 1997). A major impact of lack of decontamination areas at the hospitals was secondary contamination of hospital staff. In one study, 23% of the staff indicated acute symptoms of nerve agent exposure (Okumura et al. 1998b). Lack of ventilation also contributed to secondary exposure (Okumura et al. 1998b).

The train cars and subway stations exposed to Sarin in the Tokyo incident were decontaminated with water and detergent combined with industrial-strength cleansers. It was quickly applied and then washed off immediately, whereas a 15- to 20-min application before rinsing would be recommended (DHHS 1995). The decontamination was performed by both military personnel and firefighters. It took about 3 hours and 20 min on two of the lines, and was completed 9.5 hours after the release occurred. On the third line it took about 15 hours and was completed 21 hours after the release (Watson 1998).

Key Research Findings

Chemical warfare agents. There is a fairly large body of knowledge about chemical agent decontamination, most of which has been generated by the military. Sidell and Franz (1997) observe in *Medical Aspects of Chemical and Biological Warfare,*

> The only decontamination that prevents or significantly reduces damage from a chemical agent is that done within the first several minutes: self-decontamination. The importance of rapid self-decontamination cannot be overemphasized and must be clearly understood by anyone who might be exposed to chemical agents. To successfully reduce damage to the casualty, decontamination must be performed within minutes of exposure.

Other experts agreeCdecontamination for chemical agents is most effective if done within 1 min of exposure (Brennan et al. 1999). This is a strong argument against the establishment of national response capabilities or even regional capabilities. By the time a national response team could respond to a no-warning chemical agent attack, the incident would be over (Tucker 2000). Response will essentially be a locally managed situation for hours into the event.

In contrast to aerosol or liquid exposure, decontamination for chemical agent vapor exposure is not necessary (Sidell in DHHS 1995). Others are less definitive about this topic: decontamination may not be needed for persons exposed to chemical vapor only (Brennan et al. 1999). Hazardous contamination from a vapor release would likely be limited to materials, such as clothing, which are in contact or very close proximity to the human body and should be best dealt with during personal decontamination (Shumpert et al., 1996).

HAZMAT decontamination. The major arena in which civilian decontamination has been addressed is HAZMAT response planning, exercises, and response. Most HAZMAT decontamination is patterned after the traditional military decontamination line consisting of a hot zone, warm zone, and a cold zone. Several major criticisms of this model have been made. Moles (1999) notes that mobile decontamination units will be too slow in mobilizing and deploying. In a decontamination line, the removal of contaminated clothing is a dangerous, time consuming, and exhausting job (Bellanger et al. 1993). The HAZMAT model of response to some chemical or biological agents may not be appropriate because of the time and labor intensiveness of decontamination (Waeckerle 2000). The Chemical Stockpile Emergency Preparedness Program (CSEPP) program advocates the use of self and buddy decontamination because of this issue (Copenhaver 1992).

The slow deployment of decontamination units may also allow contaminated victims to escape treatment (Moles 1999). In addition, civilian medical response to a toxic release is essentially different than military response (Baker 1999). Military responses are well planned and anticipatory. Civilian response is situational and typically conducted without detection capabilities.

HAZMAT decontamination involves both field and hospitals decontamination. Some have questioned the realities of decontamination process at hospitals (Pons and Dart 1999). It is not very clear as to what exposures can be safely decontaminated in the emergency department. Burgess et al. (1997) conducted a survey of 95 emergency care facilities in the state of Washington. Of those, 39 (41%) had no designated decontamination facilities and 53 (66%) did not have the ability to receive contaminated patients. Macintyre (2000) describes a model decontamination plan and facility for a hospital.

One practice advocated by some HAZMAT guides is reverse isolation where contaminated victims are placed in bags to prevent exposure to emergency technicians. Moles (1999) strongly urges the avoidance of reverse isolation techniques because it exacerbates exposure to the victim. Others have recommended this technique after being decontaminated with water (McMullen 1996)

3.3 CROSS CUTTING ISSUES

A number of issues surfaced that cut across chemical and biological agents. These are summarized in this section.

3.3.1 Types of Decontamination

Moles (1999) identifies two types of decontaminationCimmediate, which permits safe triage and full, which permits safe evacuation.

The military identifies three basic methods of decontamination: physical removal, chemical deactivation, and biological deactivation of the agent. Biological deactivation has not been developed to the point of being practical (Eitzen et al. 1998).

Following the Tokyo subway incident the French government established a plan for responding to an urban toxic release (Laurent et al. 1999). When a release occurs, they establish a liquid hazard area, a vapor hazard area, and a security zone. In general, the plan calls for decontamination, and then medical care, and evacuation to a medical facility. However, the plan also calls for physicians in protective suits to perform medical treatment within the hazard area. Following a release, a contamination detection point is set up outside the hazard area. Casualties are routed to this point and sent to the decontamination line or an exit from the security zone. The French approach to decontamination differentiates between emergency decontamination and zone decontamination (Laurent et al. 1999). Emergency decontamination using both wet and dry methods is performed when there is a need for rapid and immediate removal of the toxic substance. The wet method utilizes special portable sprinklers and a decontamination solution. The dry method uses Fuller's earth or talc that is gently removed after application. The zone method takes at least 1 hour to set up after arrival on the accident scene. The decontamination line has four operations:

- undressing and sealing clothes and effects,
- washing with water and then a specific decontamination solution,
- a check for remaining contamination, and
- dressing.

The victims are then processed through a triage point where they are transported to a medical facility or sent to an evacuation holding area.

3.3.2 Model Procedures

Currently there are no practical models for healthcare response that requires decontamination of mass casualties (Macintyre 2000). The National Center for Environmental Health (NCEH) [1995] report from the Medical Delegation to Japan suggests that international decontamination standards should be developed, including planning for large-scale patient decontamination. Macintyre (2000) recommends that decontamination be simplified by establishing a universal protocol for all incidents. Others disagree and argue that decontamination techniques are specific to certain classes of chemicals and biological threats.

SSI Services (1996) describes an analytical technique to estimate resources needed to perform decontamination for various chemical agent accident scenarios. They used a combination of atmospheric dispersion models and protective action models to estimate levels of exposure for a variety of accident scenarios.

3.3.3 Children

Children are disproportionally impacted by a chem/bio release for several reasons:

- They have a higher respiratory rate than adults, thus will receive a higher dosage of vapors or aerosols.
- They have more permeable skin and a higher surface to body mass relationship; thus, they will receive a higher absorbed dosage.
- Their breathing zone is lower to the ground and more vulnerable to dense gases (Balk et al. 2000).

Skin decontamination is more problematic for children and infants who, because of their proportionally larger body surface area, lose heat rapidly when showered with water. Special provisions such as heat lamps or other warming apparatus may be needed (Balk et al. 2000).

The Balk et al. (2000) recommend decontamination by showering for children in known chemical or biological exposure. In a suspected chemical event involving nerve or corrosive agents, decontamination is recommended if symptoms are present. If no symptoms are present, observation for a 2- to 4-hour period is recommended. In a suspected infectious agent with no appearance of a hoax, it is recommended that decontamination be considered.

3.3.4 Policy Issues

Cole (2000) notes that the legal authority to respond to a bioterrorism incident is not clear, particularly regarding the legality of forcing people to undergo treatment. Several possible mechanism in the federal government can guide response to a chem/bio event (Alexander 1998). These include the Presidential Decision Directive 39, the Federal Bureau of Investigations (FBI's) C/B Incident Contingency Plan, Federal Emergency Management Agency's (FEMA's) National Response Plan, and EPA's National Contingency Plan.

3.3.5. Wastewater Disposal

Decontamination can produce considerable amounts of wastewater. Whether this is or should be a serious concern is not known. It has been observed that the risks associated with such wastewater are largely unknown (Macintyre 2000). Disposal of contaminated water was a major problem in the Binghamton state office building decontamination (Kim 1983). Using household bleach will help neutralize the contamination from chemical agents (Watson 1998).

Pons and Dart (1999) question the feasibility of controlling run-off fluids in a hospital environment. For example, is a separate drain and holding tank affordable to install and maintain? Can effluent go into the sewer system or storm drains? Is dilution an alternative to containment?

EPA (2000) discusses liability issues associated with mass decontamination wastewater runoff. They conclude that based on the "good Samaritan" provision in CERCLA (Section 107d), first responders should undertake any necessary emergency action to save lives and protect the public and themselves. Section 107d states that no person will be liable for costs or damages resulting from actions taken or not taken rendering care, assistance, or advice under the National Contingency Plan or at the direction of the on-scene coordinator. This does not preclude liability for damages resulting from negligence. EPA recommends that once imminent threats to human life are addressed, reasonable attempts should be made to contain wastewater and prevent environmental insult.

3.3.6 Personal Protective Equipment

Currently there is no standardization of PPE to be used by the medical community while performing decontamination or other medical tasks (Macintyre 2000). Pons and Dart (1999) also note that there is a lack of information on what PPE is needed to perform decontamination in a hospital.

Very little empirical data exist on the risk of decontamination to emergency personnel. Schultz et al. (1995) performed experimental tests to determine level of exposure to emergency workers from chemicals while decontaminating a mannequin contaminated with chemicals or particulates. The breathing level tests showed that exposure to the workers was significantly lower than control limits. They concluded that decontamination did not pose a respiratory threat to the workers given the chemicals used in the test.

An emerging issue from the experiences with the events of 9/11 and the fall 2001 anthrax releases concerns decontamination of PPE (Jackson et al., 2002). For example, emergency workers at the World Trade Center site in New York had only one set of protective gear. Many workers choose not to decon their gear because they did not want to work in a wet suit. Consequently many workers never decontaminated their PPE.

3.3.7 Decontamination Solution

A major issue in both chemical and biological contamination is whether to use bleach or not to use bleach (Macintyre 2000). Most agree that bleach or a hypochlorite solution is needed for liquid chemical exposure. While the military uses a 0.5% solution of hypochlorite, most civilian emergency units use 1.0% to 2.0% concentrations (Brennan et al. 1999). The Chemical Stockpile Emergency Preparedness Program (CSEPP) recommends a full strength solution of household bleach (5%) (Copenhaver 1992). The most desirable decontamination for chemical warfare agents would use undiluted household bleach blotting (not swabbing or wiping) with a cloth wetted in the bleach followed by washing with lukewarm soapy water and rinsing with clear lukewarm water (Shumpert et al., 1996).

3.3.8 Secondary Contamination

Burgess et al. (1999) studied ten hospital evacuations in Washington State hospitals due to hazardous materials incidents. Two of those events resulted from secondary contamination of emergency room personnel from treatment of patients with chemical exposures who were not decontaminated prior to arrival. Kim and Burr (2000) studied hospital responses to three hazardous material incidents in Utah and found secondary contamination to be a significant problem in two events. In a survey of Level 1 Trauma Centers it was noted, that in one incident 13 staff required medical treatment after attending contaminated patients (Ghilarducci et al. 2000) Secondary contamination was also a problem during the Tokyo subway attack in hospitals and for emergency workers (Watson 1998).

3.3.9 Decontamination Effectiveness

A major issue concerns determining when a person is "clean." Moles (1999) notes that full decontamination is not currently quantifiable because of the lack of standard protocols and because measurement techniques and instruments have not been developed and approved. Some experts estimated that 75B95% of contamination is removed when people disrobe (Macintyre et al., 2000; Cox, 1994). There has been little research to support this assumption made by many "experts."

Tèorngren et al. (1998) conducted experiments to determine the effectiveness of a decontamination station and self-decontamination. Subjects wearing PPE were contaminated with Mustard and Sarin simulants. After a two-stage decontamination process, the air concentration of simulant was reduced by a factor of 10,000. In the self-decontamination experiment there was still a significant air concentration of simulant after decontamination due to absorption by the subject's underwear.

3.3.10 Hospital Preparedness for Decontamination

Several surveys have been conducted in the past several years on hospital preparedness for hazardous materials accidents. A key focus of the surveys is capabilities for performing decontamination of patients. Ghilarducci (2000) surveyed 256 level 1 trauma centers in the US. Only 6% have all the necessary equipment and facilities to perform safe decontamination.

Wetter (2001) studied 224 hospitals with emergency rooms in Federal Region X. Only 21% had an indoor integrated decontamination space with showers and water containment. Another 24% reported having an outdoor decontamination capability. An additional 27% had access to conventional showers. A total of 25% had no decontamination capabilities at all.

Treat (2001) performed a similar study in Federal Region III. Only 13% of the hospitals surveyed had a mobile decontamination unit. Most would use an ad-hoc room to perform the decontamination if it was needed. Another 13% had no plans or capabilities for decontamination.

Overall the surveys indicate that the majority of the hospitals in the US have little capabilities for conducting safe decontamination operations and would be unprepared for a mass casualty situation.

3.3.11 Epidemic Hysteria

Epidemic hysteria or mass psychogenic illness is the spread of the belief of an illness (symptoms and the origins of the symptoms) through a population (Greenberg, D.R et al. 1998). The report of an acute illness involving a large number of clustered children generally elicits a urgent medical response but professional caring for children must consider epidemic hysteria along with other causes of mass illness (Krug, S.E. 1992).

Cases of epidemic hysteria have been found to exacerbate emergency response situations. Young children are especially vulnerable (Baker 1992). Officials and emergency responders should be taught how to recognize the symptoms of epidemic hysteria and immediately intervene to control the outbreak (Baker 1992). Granot and Brender (1991) have developed a checklist titled the *Emergency Behavior-Response Wheel* to train emergency responders to cope with the 19 forms of behavior typically found at emergency sites. The authors then provide parallel coping behaviors for responders.

Selden (1989) studied a case of an explosive epidemic hysteria that occurred when 15 adolescent female students from a junior high school appeared ill from exposure to sewer gas. Seven hundred students and staff were triaged by paramedics and the physician EMS director at the school. The absence of laboratory and physical findings confirmed there was no organic cause. Symptoms in patients abated within 1 hour as patients disbanded and all were released within 2 hours. One student self-admitted to the ED that evening but was found asymptomatic and discharged to her parents.

3.3.12 Psychological and Social Consequences

The psychological and social consequences and impacts of decontamination experiences have only been examined conceptually or anecdotally and have not been well researched using a scientific method. Cole (2000) conducted case studies on 6 anthrax hoax events. He concluded that the methods used for decontamination were profoundly embarrassing and discomforting for many victims. Among the problems Cole noted were showering while naked in front of emergency workers and television cameras, having to tolerate extremely hot or cold water, walking barefoot in the snow, being decontaminated multiple times (as many as four times) and being placed in a body-bag after decontamination. Such experiences left people bitter and distrusting of officials and responders.

Holloway et al. (1997) notes that the idea of a potential infection or sickness caused by an invisible agent touches a deep human concern of being hurt or destroyed by imperceptible force that is extremely difficult to address with tools of reason. Following a chemical or biological attack or hoax one can anticipate there will be both acute and chronic psychological impacts such as feelings of horror, anger, fear, paranoia, isolation, and demoralization. Physical responses such as muscle tension, rapid breathing, sweating, and tremors are possible.

While the event itself is a major source of stress, additional stressors arise from the logistical demands of mass contamination, especially if privacy and the assurance of conventional modesty important to an individual's sense of control and autonomy must be sacrificed (Holloway et al.1997). Moreover, PPE worn by responders impedes communication with victims and can make the care of patients more difficult which also can create additional stress for the victims.

This is compounded by the number of organizations with overlapping and sometimes conflicting goals and responsibilities (e.g., health-care, law enforcement, and social welfare) and can increase the confusion and anxiety felt by the individual (Holloway et al. 1997).

While most people experiencing short term stress symptoms will not develop long term mental health effects, the incidence and prevalence of psychological stressors can result in posttraumatic stress disorder (PTSD). The incidence of PTSD has been well documented following other traumatic events such as earthquakes, airplane crashes, terrorist bombings, inner-city violence, domestic abuse, rape, war, genocide, and other disasters, both natural and human made. It has been found that the greater the trauma from the event, the greater the prevalence of PTSD is found in the population involved with the event (Holloway et al. 1997). The American Psychiatric Association notes that PDST has often been misunderstood or misdiagnosed, even though the disorder has very specific symptoms, affects both female and male civilians, but strikes more females than males. In some cases the symptoms of PTSD disappear with time, whereas in others they persist for many years. PTSD often occurs with - or leads to - other psychiatric illnesses, such as depression. Everyone who experiences trauma does not require treatment; some recover with the help of family, friends, or clergy. But many need professional treatment to recover from the psychological damage that can result from experiencing, witnessing, or participating in an overwhelmingly traumatic event. Today, psychiatrists and other mental health professionals have good success in treating the very real and painful effects of PTSD using behavior therapy, psychotherapy, family therapy, discussion or peer-counseling groups, and/or medication.

Burgess et al. (1999) note that health care systems are often overwhelmed after a chemical release. They examined one incident where 117 individuals were evaluated at 13 emergency departments for exposure to NO_x and 13 individuals admitted for observation. Eighteen of the 117 patients were transported to a major trauma center where 7 were admitted for observation and released the following day. Given the estimated low-level dose of NO_x exposure and the patient’s persistent hyperventilation after the exposure ceased, the authors suggest the cause of distress was anxiety, not chemical exposure. Their study emphasizes the need to study the psychological effects, not just the physiologic effects of large-scale chemical incidents when planning treatment of victims.

3.4 SUMMARY OF FINDINGS FROM THE LITERATURE REVIEW

Biological Decontamination of Buildings

Although the techniques for performing decontamination are known and documented, experiences with the actual application to buildings indicate that implementing the techniques can be quite problematic. Solid surfaces in buildings can be decontaminated using biocides and hypochlorite solutions. Fumigation techniques are routinely used in closed building systems such as laboratories, but may prove to be difficult to use in complex building environments. Porous and textured surfaces, carpeting, and HVAC ducts are particularly problematic.

Currently there are no defined standards for the decontamination of buildings exposed to biological agents. The wide disparities in the scientific literature make setting a reentry standard difficult. For example, based on the available data on Anthrax, zero spores would be the conservative standard. This, however, raises the issue of what type of testing and how much testing is needed to prove a zero spore level.

Biological Decontamination of People

There is not a strong consensus for the need and methods of decontaminating people exposed or potentially exposed to aerosolized biological agent. Although the consensus regarding anthrax prior to the fall 2001 events was that decontamination was not essential, events suggest a more conservative stance may be appropriate. Procedures for other agents are being recommended but have not been widely tested.

Chemical Decontamination of Buildings

There has been a fair amount of experience with the decontamination of building, although much of the experience has been associated with PCB contamination. The most significant problem encountered in these experiences has been establishing a scientifically defendable reentry criteria for both surfaces and air. This is often exacerbated by the lack of information or data on background contamination prior to an incident. Experience suggest it is critical to establishing a decontamination management team to develop a comprehensive plan to guide decontamination efforts including establishing reentry criteria, defining a clean-up protocol, establishing a sampling plan, communicating information to affected parties and defining a decision-making process. Developing rigorous procedures for sampling and tracking the results of the sampling is also very important.

The time and cost of building decontamination is almost always underestimated, and at times is significantly off. Decontaminating a building and putting it back into use can exceed the original cost of the building.

Chemical Decontamination of People

The standard hazardous materials model for decontamination of people exposed to chemicals including chemical warfare agents uses the military model of a decontamination line. This procedure will be ineffective for any chemical where immediate decontamination is needed to prevent serious health effects. For example, chemical warfare agents require decontamination within a minute of liquid exposure. A decontamination line may take several hours to deploy and set-up in the best of circumstances.

There is not a consensus on the need for decontamination or the best methods of decontaminating people exposed to chemicals. Decontamination is not needed for exposures that do not lead to symptoms of exposure or to negative health effects. Often the inability to detect what chemical is involved hampers the timeliness of decontamination. Establishing thresholds and determining the need in a field setting is problematic. For example, deciding whether people require decontamination when only exposed to vapors is problematic due to a lack on consensus on the need to do so. Establishing protocols for performing decontamination is also problematic when scientific disagreement is found. For example, for chemical warfare agents, some experts recommend using a bleach solution while others insist that soap and water is sufficient.

Cross-cutting Issues

Decontamination procedures to date have treated the public as a homogeneous entity and have not differentiated needs of specific subgroups. For example, decontamination techniques for adults are not applicable to children and infants or the elderly who require a heated environment. Decontamination has been a humiliating and degrading experience for women and men who are forced to strip off their clothing in front of other people.

Secondary contamination has been noted as a major concern. Hospital emergency rooms have been closed when contaminated victims have been admitted without decontamination. This was a major problem in the Tokyo subway sarin incident. Other secondary contamination issues of note include control of run-off of fluids used in decontamination and the handling of contaminated remains such as clothing and personal effects.

Another significant national issue is the lack of hospital preparedness for handling contaminated patients or performing decontamination operations. Although many have plans in place, few actually have the necessary facilities. Those with facilities can only process a limited number of patients at a time. One of the critical issues in hospital preparedness is the availability and use of appropriate PPE. Few have PPE and hospital personnel appear reluctant to use it.

The psychological dimension of exposure to a chemical or biological substance and the subsequent decontamination is an important, but not fully understood, topic. Epidemic hysteria has been associated with perceived exposure to toxic substances among adolescent groups. Concerns exist that psychological stress triggered by an accident will result in symptoms resembling actual exposure and people with such stress symptoms may report to medical facilities seeking treatment. Little documentation exists, however, to support this concern. Of greater concern is the short and long term psychological consequences of people actually exposed to a chemical or biological substance who experience negative health effects. Negative psychological effects from such experiences may be compounded by the decontamination process. Short-term stress symptoms, may, in some cases, lead to long-term debilitating psychological effects, which are referred to as posttraumatic stress disorder.

Finally, a major question remains concerning the effectiveness of decontamination techniques and how one determines if a building and person is “clean”. This is less problematic for buildings where time allows multiple actions and extensive testing. The question if people are clean following decontamination is much more problematic. Little research exists on the effectiveness of alternative techniques. The ability to prove a person is clean is hampered by the lack of ability to test for and verify levels of residual contamination following decontamination procedures. The question “How Clean is Safe?” still holds many uncertainties and unresolved issues.

4. CASE STUDY SUMMARIES

This section describes the events and the information obtained from informants interviewed about the incidents. The number of informants varied by study. For example, over a dozen interviews were conducted for the Commerce Building study but only four respondents were interviewed for the Airborne Express study. These differences in the number of respondents arose in part because some persons identified refused to provide information, felt they were not involved, or cited liability concerns. The reader is cautioned that descriptions of the event and the information are subject to the informant's perception and recollection of the event.

The report from which the incident was derived is first described and then the information collected from respondents is presented. Names and contacts are withheld from the reports to maintain privacy. Findings from the case are then presented. Table 1 summarizes the characteristics of the cases investigated.

4.1 CASE STUDY 1. SPILL AT AIRBORNE EXPRESS DISTRIBUTION FACILITY IN NEWTON, MA

Occurrence Date:	13 September 1999
Location:	Newton, MA
Source:	Leaking Container
Material:	Styrene monomer
Impacts:	Unknown
Quantity Discharged:	1-2 cups

4.1.1 Background

Styrene (monomer) is a commercially important chemical used in the production of polymers, copolymers, and reinforced plastics. Exposure mainly occurs in industrial facilities and operations using styrene, and industrial sources are the most likely cause of general population exposure. Other potential sources of general population exposure include motor vehicle exhaust, tobacco smoke, and other combustion/pyrolysis processes. Acute effects can occur at exposure levels of 420 mg/m^3 (100 ppm) and above and cause irritation of the mucous membranes of the eyes and the upper respiratory tract in humans [World Health Organization (WHO) Working Group 1983].

The study was instituted in response to the CIRC 1999-4362 report describing a chemical spill at an Airborne Express facility in Massachusetts that sent 22 to the hospital after being decontaminated on site. Shut-down of such a facility because of contamination of articles or a building could affect or cripple essential airline transport networks.

4.1.2 Incident Timeline, Response and Consequences

At approximately 7:45 a.m. on September 13, 1999, a worker at a distribution facility of Airborne Express removed a package from a conveyer belt and placed it on the floor. The worker noticed the package was leaking and called for a supervisor. Two supervisors approached, unwrapped the package, and discovered a broken container leaking a liquid. The supervisors rewrapped the container in the package and took it outside the building. 911 was called. Police responded as did the fire department and a representative from OSHA. At the time of the incident, there were 12 people who had been in the immediate vicinity of the container and 95 overall in the facility. Within 20 minutes after arrival, personnel from the fire department decided to decontaminate potentially exposed workers before sending them to the hospital. Potentially exposed workers were identified as those who were in the immediate vicinity of the spill. Others who thought they may have been exposed were also decontaminated. In all, firefighters decontaminated 22 people in about 1 hour. The decontamination process included disrobing and placing personal items in plastic bags, then showering in temporary decontamination units in the building's parking lot. Those decontaminated then donned disposable jumpsuits and were transported to one of three hospitals. Women complained of being viewed by male firefighters while showering and not having separate facilities.

A commercial contractor was called to cleanup the spill and check for contamination. The vendor wore appropriate PPE, including a respirator. Absorbent materials were used to pick up the liquid on the floor and the vendor took air samples. Cleanup took about 2 hours. At that time decontamination was considered effective after the vendor showed the negative air samples to the manager and no lingering odor was noticed in the facility. Samples were not sent to a laboratory for confirmation.

4.1.3 Findings

1. Privacy was an issue in the decontamination process as women did not find the makeshift facility appropriate for disrobing and showering.
2. Supervisors did not follow training procedures about handling leaking containers, possibly contributing to further contamination.
3. Decontamination was determined effective by relying on vendor's monitoring equipment and subjective sense of smell and not based on a laboratory's confirmation.
4. The call to 911 was transferred to police rather than an appropriate responding agency (firefighters and HAZMAT team).
5. The media inaccurately reported 300 evacuated when there were only 95 workers in the building at time of event, contributing to misinformation in the CIRC database.

Table 1. Factors affecting decontamination procedures in case studies

Case Study	Incident Time/Date	Facility Type Location	Substance	Structure Decon.?	Articles Decon.?	Population Decon.?	Consequences
Case Study 1	Leaking package 7:45 a.m. 9/13/1999	Airborne Express, MA	Styrene monomer 1-2 cups	Yes-private vendor	Yes-conveyor belt	Yes-22 workers	95 evacuated from facility; 22 deconed and sent to local hospital
Case Study 2	Chemical spill 11:00 a.m. 5/12/2000	Chemical plant, GA	20 gal. Of hydrofluoric acid	Yes-private vendor	Yes	Yes-14 workers	1 fatality; outside HAZMAT response delayed
Case Study 3	Electrical fire 6:15 a.m. 10/19/2000	Commerce Building Washington, D.C.	Small amount of PCBs in oil	Yes-private vendor	Yes	Yes-30 workers, 12 firefighters & emergency management technicians (EMTs)	Building totally evacuated; reopened 3 days later; PCB clean-up takes 3 months
Case Study 4	Mercury spill 2:00 p.m. 10/26/1999	Elementary school, IN	Mercury 50 cc.	Yes	Yes-desks, floors; other items discarded	Yes-20 students & staff	School evacuated; students deconed in parking lot over storm drain
Case Study 5	Overheated chemical 6:00 p.m. 9/14/2000	Lawn and garden product company, NY	Dimethoate fumes	Unknown	Unknown	Yes-11 workers 7 emergency room (ER) staff	Untreated workers sent to hospital cause secondary exposure to 7 ER staff; ER closed 2 hours
Case Study 6	Mercury spill 10:30 a.m. 9/15/2000	Indianapolis International Airport IN	Mercury - "amount in thermometer"	Yes-private vendor	Yes-conveyor belt	Yes-34 workers	3 workers exposed and others deconed at site sent to hospital; bagged items used by victims
Case Study 7	Inadvertent chemical mix 9:51 a.m. 9/13/2000	Chemical plant, KY	Sulfuric acid mixed with aminonic shield conditioner	Yes-private vendor	Unknown	Yes-40 workers	138 evacuated; workers deconed in parking lot; all clothing replaced, taken to hospital
Case Study 8	Release by passenger 6:00 p.m. 6/11/1999	Metropolitan Area Rapid Transit Authority (MARTA) subway, GA	Unknown	No	No	Yes - 16 passengers 2 responders	Passengers deconed twice (site and hospital); possibly exposed (untreated) continued on subway trip

Table 1 (cont)

Case Study	Incident Time/Date	Facility Type Location	Substance	Structure Decon.?	Articles Decon.?	Population Decon.?	Consequences
Case Study 9	Construction unearths chemicals 1:00 p.m. 5/21/2000	Jail complex, LA	Unknown	No	Unknown	Yes - 6 sent to hospital	Building evacuated; 110 degree temp. made PPE wear difficult; untreated victims taken directly to ER
Case Study 10	Liquid sprayed in subway 11:00 a.m. 10/01/2001	Metro subway, MD	Unknown	No	No	Yes – perpetrator plus all responders	Miscommunications allowed train to continue on route with possible contamination
Case Study 11	Death from anthrax Time unknown 10/05/2001	Boca Raton, FL	Anthrax	Not at this time	Not at this time	No – unknown number given nasal swabs	Labeling crime scene stalled effective health response; size and cost delayed building decontamination
Case Study 12	Anthrax in letter Time unknown 10/15/2001	Hart Senate Bldg., Washington, D.C.	Anthrax	Yes	Yes	No – given nasal swabs	Confusion on effectiveness of decon solutions delayed reentry for 3 months; self report; approximately 5000 people eventually tested

4.2 CASE STUDY 2. SPILL AT CHEMICAL PLANT IN TWIN CITY, GEORGIA

Occurrence Date:	12 May 2000
Location:	Twin City, Georgia
Source:	Spill when clamps loosened during transfer of liquid
Material:	Hydroflouric acid
Impacts:	1 fatality, 7 decontaminated
Quantity Discharged:	10-20 gal.

4.2.1 Background

On contact hydrofluoric acid [aqueous hydrogen fluoride (HF)] is an extreme irritant to any part of the body. The danger of hydrofluoric acid solutions depends on their concentrations. Signs and symptoms are likely to be immediate if the concentration is greater than 20%. The main route of exposure to HF is inhalation, followed by dermal contact for acute exposure and ingestion for chronic exposure. On contact with water, the decomposition product is HF.

This case was investigated because the affected employee immediately showered to remove the contaminant, would not allow paramedics to treat his contamination, entered the ambulance by himself, and died in transport to the hospital. However, the hospital refused to accept the employee=s body until it had been decontaminated by the HAZMAT team.

4.2.2 Incident Timeline, Response, and Consequences

On May 12, 2000, an employee who had worked at the chemical plant for several years was transferring hydrofluoric acid from one drum to another without wearing protective equipment. One of the hose clamps became detached spilling between 10 to 20 gallons of hydrofluoric acid onto the floor and splattering the employee. The employee immediately undressed and showered but the water reacted with the chemical to create a toxic vapor, which the employee inhaled. The employee went to the office and told the staff to leave the building and call 911. When the ambulance arrived, the employee refused treatment because he was contaminated and entered the vehicle on his own. He died on the way to the hospital but the body was left in the ambulance for six hours until the commercial vendor completed their work at the site. Later the vendor decontaminated the employee=s clothes so they could be returned to the family who had requested them.

A policeman, who was also a volunteer firefighter, immediately responded along with the County Fire Chief and the County Emergency Management Agency. The policeman came in contact with the fumes on entering the building. The policeman then drove himself to the hospital because he was not feeling well. Unable to get out of the car by himself, hospital staff started immediate treatment and the person was revived, leaving the hospital after another few days.

The responding firefighters, all volunteers with little to no training, obtained the name of the chemical spilled, called the company and talked to the company biochemist. The manufacturer of the chemical recommended that any exposed person go to the hospital immediately. The manufacturer also recommended obtaining 12B15 50-lb bags of lime for cleanup. The manufacturer then called the hospital and explained how to treat the exposed people once they arrived. No decontamination occurred on site. Persons exposed spent approximately 2 days in the hospital.

Recognizing that decontamination would be required from the description of the chemical provided by the manufacturer and from learning of the employee's death en route to the hospital, the firefighters called in a HAZMAT team from Augusta, approximately 65 miles away. While waiting, an employee tried flushing the chemical on the floor down a drain in the building with a high pressure hose but a filmy residue remained on the floor. When the HAZMAT team arrived outfitted in PPE, they spread the lime on the floors then used a mixture of lime and water to clean the drums and the employee's clothing. Also responding was the Georgia Environmental Protection Agency (GAEMA) who contracted a commercial vendor from Augusta to decontaminate the building and the articles exposed. Also responding were personnel from the Georgia Department of Natural Resources and the Georgia Emergency Management Association.

There was conflicting information on whether evacuation of residents nearby was advised. After the incident the secretary walked across the street to the drugstore. Fears that she could have tracked contaminant to the store prompted the team to decontaminate the drug store's carpeted area. Eventually a one block area with a doctor's office, drug store, and health clinic was evacuated. Later that day when GAEMA sent people in "space suits" with monitoring equipment, one respondent noted that the number of people complaining of breathing problems increased substantially. After the event the police car and the ambulance were also decontaminated.

The decision to reenter the building was initiated by the HAZMAT team following cleanup. After the HAZMAT team finished, they turned it over to the GAEMA who turned it over to the Georgia Department of Natural resources, who turned it over to the firefighters, who turned it over to the owner of the building.

4.2.3 Findings

1. Lack of resources at the local level prevented prompt decontamination from occurring at the scene and may have lead to secondary contamination (at the drugstore and hospital). The HAZMAT team from Augusta likely took between 1.5 and 2 hours to mobilize and travel to the scene.
2. Lack of training at the local level placed the first responder (a policeman) in danger after breathing in the toxic fumes.
3. The characteristics of chemicals stored in the plant were unknown to emergency responders.
4. The manufacturer provided essential information in a timely manner.
5. The issue of not accepting the employee's body into the hospital could have been avoided with written cooperative agreements.

4.3 CASE STUDY 3. PCB RELEASE AT COMMERCE BUILDING, WASHINGTON, DC

Occurrence Date:	1 October 1999
Location:	Washington, D.C.
Source:	Leak from electrical capacitor
Material:	PCB contaminated oil
Impacts:	Unknown
Quantity Discharged:	Unknown

4.3.1 Background

Despite a ban on the manufacturing of PCBs since 1977, significant quantities remain in older equipment such as electrical transformers and capacitors. Exposure to PCBs and related compounds has been reported to be neurotoxic to both humans and animals during embryonic development (Tilson et al. 1998). Historical events involving PCB contamination suggest that decontamination is difficult and costly, especially when fires release toxic by-products into air vents and HVAC systems. The case was chosen for further investigation based on media reports including CIRC report 1999-4381 that a PCB release had occurred at the Commerce Building in Washington, DC. Since federal buildings are considered highly vulnerable structures as targets for terrorists suggested this event was an appropriate case study. Information was obtained from about a dozen informants, including the head of the emergency room at the hospital where victims were taken. The systematic telephone interviews with respondents involved directly in the response or management of the event suggest a very different scenario than reported by the media. How and where the media obtained their information remains unclear.

4.3.2 Incident Timeline, Response and Consequences

The scenario developed from interviews suggests an electrical power surge at 6:15 a.m. resulted in a fire in one of the cabinets containing capacitors that regulated the Simplex clock system for the entire building. The clock system integrates the technology that insures all clocks in the building report the exact same time. The capacitors leaked oil containing PCBs onto the floor, the cabinet, a toolbox and its contents, and other electrical equipment in the vicinity. The clock system was located in one of the six vaults in the buildings sub-basement.

The housekeeping staff in the area at the time initiated the discovery of the leak when they noticed smoke coming from one of the six vaults and alerted the building security. Security officers called 911 and at 6:30 a.m., the D.C.=s fire department arrived at the scene. Noticing that only one door (the door to the vault with the capacitor fire) was not marked with a placard stating "No PCBs," fire department personnel decided it prudent to treat the oil as possibly contaminated with PCBs and to treat persons, including responders, who had been in contact with the oil or smoke as contaminated. The few occupants in the building were evacuated and employees arriving at work were told to go home as the building was expected to be closed for the week-end. Fourteenth Street between Pennsylvania Avenue and Constitution Avenue was shut down, disrupting early morning traffic and a number of converging spectators. One respondent reported that the confusion was especially problematic because the second floor of the building housed a child-care facility and no information about the status of the facility was forthcoming.

As the D.C. fire department lacked the appropriate equipment to detect PCBs, immediate calls were made to surrounding jurisdictions to obtain an air sampling monitor for PCBs and dioxins that might have been released in the fire and consequent soot. Such equipment did not arrive until 1.5 hours after the initial calls. On arrival, the monitor was found to be outdated but air samples were collected and sent to a commercial laboratory for analysis. After controlling the fire, initial cleanup of gross materials was completed by the HAZMAT team.

As required, the National Response Center was notified of a possible hazardous materials release at 8:27 by the D.C. Emergency Management Agency (EMA) (NRT 1999). Other responders included representatives from the General Services Administration (GSA) Safety and Health (the building is federal property), EPA, FEMA, the FBI, OSHA, the Secret Service, the Federal Protective Services, the district's administration as well as the district's EMA, PepCo (the power company servicing the city), and representatives from the Simplex Clock company (manufacturer of the clock system containing the faulty capacitor).

Besides the number of agency personnel arriving at the scene, both onlookers and media converged at the site. In addition, a number of the building employees attempting to view the scene had walked through the oil that had leaked onto the floor and tracked it to other parts of the corridor outside the vaults. Uncertainty of the consequence of this behavior led the D.C. HAZMAT team to set up a portable unit in the building's courtyard parking lot for decontaminating persons. The decontamination process had individuals disrobe, separate their clothes and personal items into separate bags, shower, scrub with a bleach solution, and then shower again. Victims were given a clean disposable jumpsuit to wear before being transported to the hospital. In all 22 people were processed before going the hospital. Two workers in the basement were sent to the hospital with no decontamination. The entire decontamination of the 22 people took approximately 1 hour and occurred approximately 4 hours after the event had started. Before being admitted to the hospital, victims were again decontaminated in the facility's two decontamination corridors which supply a continuous stream of warm water and are separated for males and females. The 45 victims were diagnosed as non-symptomatic, observed, presented with a sheet of paper describing possible psychological effects from such incidents, and released.

When the HAZMAT team left, the GSA and building's management decided to call in a commercial vendor to decontaminate the building. Sampling continued with surface wipes and air samples sent to a commercial laboratory for analysis. The GSA's decision to reopen the building to workers the following Monday was based on several factors. Although the entire building's heating, ventilating, and air conditioning (HVAC) system had been shut down as a precaution at the time of the event, the HVAC system that supplied the vaults where the capacitors were located was entirely separate from that supplying the rest of the building where employees were located. The vault HVAC system also vented directly to the outside. Responders reported that no soot or other fire debris was found outside the vault or in any of the ventilation systems, only sooty glove prints from responders hands and oil residue from foot prints were found on the outside corridor. However, as a precaution, the main building's HVAC system was sampled and found without contamination. After the section of the basement with the contaminated vault was closed to employees, the decision was made to reopen the main building offices to employees on Monday while cleanup continued in the vault itself. Shortly after cleanup resumed in the vault area, it was found necessary to post a guard in the area to restrict employees from using the area as a shortened route between areas of the building.

Decontamination of the vaults in the second story basement would take another 3 months to complete. Absorbent materials were used for gross contamination followed by the use of solvents (turpentine, PipeX and MetalX) on all metallic surfaces. Non-metal articles were discarded. The surface of the cement flooring was cleaned with a commercial product (Less Than Ten) and mechanical means. When wipe samples of the floor and air monitoring samples finally came back negative, the area was declared safe.

4.3.3 Findings

1. Inadequate detection/monitoring equipment at the local level delayed efforts to identify the contaminant. The lack of equipment is troublesome in that Washington, D.C., supposedly has one of the best trained emergency response force in the nation.
2. Inadequate control of convergers at the site of the release may have led to unnecessary decontamination of people and resulted in secondary contamination of building surfaces from foot traffic.
3. The extensive number of organizations and agencies involved promoted a chaotic environment not conducive to efficient control of the situation. In this urban area, it snarled traffic for hours and exacerbated an already tense situation.
4. Misinformation provided by the media led to misrepresentation about the event in national databases.
5. Separate decontamination facilities are needed for decontaminating men and women on site.
6. A response time of 4 hours to initiate decontamination is too slow for many chemical release scenarios.
7. There is no evidence of long-term post-reentry monitoring of vault floors even with evidence that PCBs migrate to surfaces.
8. The biggest bottleneck in the decontamination process was the time taken to disrobe and place items, especially checkbooks and paychecks, in the two plastic bags.
9. Forty-five strangers disrobed and went through the decontamination process at hospital without a problem.
10. The doctor in charge of the event credited the well-executed hospital response to a well-conceived and exercised plan that prepared the hospital for such an emergency.
11. Hospital emergency room staff found PPE required by OSHA to be cumbersome and restricting when treating patients.
12. Given the circumstances of the magnitude of the exposure to most persons, decontamination was likely unnecessary except for those responders in direct contact with soot or oil.
13. The number of people who thought themselves exposed was not based on objective criteria and likely based on overreaction and unfamiliarity with the toxicity of PCBs in oil.
14. Perceptions of the toxicity of PCB was that it was a highly toxic chemical. Knowledge of how to decontaminate if a person is exposed to PCB and what signs and symptoms to look for could have avoided the overreaction.

4.4 CASE STUDY 4. MERCURY RELEASED IN ELEMENTARY SCHOOL

Occurrence Date:	26 October 1999
Location:	North Grove Elementary School, Indiana
Source:	Substance brought to school and dropped
Material:	Mercury
Impacts:	Children and staff decontaminated, no injuries
Quantity Discharged:	50 cc

4.4.1 Background

Mercury, a silver, odorless, liquid, sometimes called "quicksilver," was a common substance in many households. Thermometers, blood pressure gauges, and older gas meters all contained the substance. Mercury poisoning can damage the brain and kidneys and harm a developing fetus. Purdue University (2000) reports that acute exposure to elemental mercury produces symptoms of metallic taste, burning, irritation, salivation, vomiting, diarrhea, abdominal pain and hemorrhaging. High levels of exposure usually cause sudden fever, chills, malaise, nausea, coughing, shortness of breath, chest pain and tightness. Exposure to high levels of mercury can cause death. Lower-dose, chronic inorganic mercury poisoning can cause tremors, memory loss, insomnia, depression, irritability, excessive shyness, emotional instability, delirium, and acrodynia and may result in a neurologic syndrome known as "mad hatter syndrome@ (Purdue University 2000).

Information from CSB Report 1999-4440 stated that an Indiana elementary school had been evacuated after a student brought liquid mercury to school and spilled it inside a building. The report stated that firefighters hosed off more than 20 students and staff members who feared they came in contact with the substance. Because of the issues regarding decontamination of children and the possible psychological reactions, this incident was chosen to be a case study.

4.4.2 Incident Timeline, Response, and Consequences

The respondents surveyed reported that on Oct. 26, 1999, at 2:00 p. m., a call to 911 alerted the White River Township Fire Department that a quantity of mercury had been released at the North Grove Elementary School located in Greenwood, Indiana. A student had brought approximately 50 cc of mercury from his home to school where he shared the substance with friends while in his homeroom, two classrooms, and in the school cafeteria. While playing with the substance in one of the classrooms, the mercury fell to the floor and splattered.

Aware of the potential hazards from exposure to elemental mercury, the HAZMAT team called in as back-up recommended decontaminating students and staff exposed to the substance. The recommendation was highly disputed as unnecessary by the school principal, but the team proceeded and set up a portable decontamination station in the outdoor parking lot adjacent to the building. Decontamination was initiated 20B30 minutes after the initial call. Approximately 50 people were decontaminated in the school parking lot over the storm drain The Indiana Department of Emergency Management was also notified and a commercial contractor called in to decontaminate the building. None of those exposed were sent to a medical facility nor monitored after being sent home. Instructions on signs and symptoms of mercury poisoning were given out and people told to go to the hospital immediately if any symptom occurred. Because of the perceived necessity to decontaminate students as soon as possible, no attempt was made to contain the water that flowed into the storm drain.

One issue brought up by one respondent was establishing a quarantine area to prevent cross contamination. The decontamination zone was quite a distance from the school building, which meant the firefighters were walking in areas they should not have been allowed to enter. Another issue involved the media=s presence. The newspaper printed a front page photo the next day of children being decontaminated by firefighters.

Determining what to decontaminate and when to safely reenter building was left to the commercial vendor. Some books, clothes, and carpet were thrown away but desks were decontaminated. The vendor used a field screen with black light to identify where the mercury was located. Mercsorb, a substance that absorbs mercury, was used with a vacuum recovery system. Cleanup personnel used saranix suits, booties, double layer latex gloves and respirators for PPE. Because respondents noted that it was difficult to know where all students with the mercury had been located in the classrooms, the vendor used a "plume definition" approach.

To determine areas were safe to reenter, the vendor relied on a visual inspection using the field screen with black light and the special powder that turns blue when mercury is present and air monitoring. Total time to decontaminate the building, surfaces, and desks was 72 hours. One respondent noted that no state or government agency can call for a cleanup vendor unless they are willing to pay the bill. The owner of the business, vehicle, etc., involved in the incident must be located because the owner is liable, not the state or agency.

4.4.3 Findings

1. A school official unfamiliar with mercury’s potential health hazards posed a problem in decontaminating students for exposure to mercury.
2. Students and staff were decontaminated in a portable structure that allowed mercury to flow directly into the storm water drain.
3. Students and staff were decontaminated with water from fire hoses in October in Indiana. Hypothermia was not considered even though young school children were involved.
4. Cross contamination was a problem because no quarantine area was established.

4.5 CASE STUDY 5 WORKERS EXPOSED AT LAWN AND GARDEN TREATMENT PRODUCT COMPANY

Occurrence Date:	14 September 2000
Location:	Bonide Corporation, New York Mills, New York
Source:	Overheated substance
Material:	Dimethoate
Impacts:	11 workers sent to hospital, 7 hospital employees exposed to victims also treated for exposure
Quantity Discharged:	Unknown

4.5.1 Background

Dimethoate, a pesticide, is described as an organophosphate cholinesterase inhibitor similar to nerve agent. When inhaled, it may cause increased watery nasal discharge, a sensation of chest tightness, and prolonged wheezing. Absorption by the lungs may produce these and other symptoms of cholinesterase inhibition within a few minutes or up to 12 hours after exposure. It is recommended that emergency personnel wear gloves and avoid secondary contamination. The incidence of secondary contamination affecting hospital emergency room personnel reported in CIRC document 2000-4958 suggested this was an appropriate case study. Anecdotal reports from hospital staff have indicated that wearing PPE in the emergency room is difficult when treating patients and recommendations to do so are often disregarded. Secondly, without knowledge of the substances to which patients reporting to the emergency room have been exposed, it is uncommon for staff to routinely don PPE to treat patients.

4.5.2 Incident Timeline, Response, and Consequences

Workers at a lawn and garden treatment product company inadvertently overheated an organophosphate pesticide. Instead of heating the dimethoate to the prescribed 150°F, the material was overheated to 220°F and began emitting fumes. Inhalation of dimethoate fumes can quickly result in severe respiratory problems and other symptoms requiring immediate medical treatment. Eleven workers transported themselves to a nearby hospital in Utica, New York, and walked into the emergency room without being decontaminated. Several hospital employees treating the workers became ill themselves.

When the emergency room doctor saw his staff becoming ill, he immediately called the Assistant Fire Chief (and HAZMAT coordinator for Utica) at his home to ask why the staff was getting sick. The Chief told him to immediately remove the people from the emergency areas and to treat everyone who had been in contact with them as contaminated. Outside in the parking lot, the male plant workers were decontaminated in a unit set up by the HAZMAT team. The emergency room workers and the three female plant workers were decontaminated inside the hospital emergency room area where showers were present.

Some male workers refused at first to be decontaminated, stating they worked with the chemicals every day but they finally agreed to undergo decontamination. Fire department personnel wore Level B PPE when decontaminating victims. Approximately 20 people altogether went through the decontamination process, which took approximately 1 hour. The decontamination process is a four-step procedure using a corridor. To prevent the pesticide from entering the area drain, neoprene pads were placed over the drain. The wastewater was then pumped into 55-gal drums and given to the hospital for proper disposal.

Hospital housekeeping staff dressed in scrubs, gloves, hairnets and wearing air filters were responsible for cleaning the emergency rooms where the exposed had first been taken and for the articles in those rooms. All walls were washed as well. The entire emergency room was shut down during the 2 hours it took to decontaminate the area. It is unclear who made the decision to reopen the emergency room to patients.

4.5.3 Findings

1. Procedures for screening for contamination in the emergency room were not in place for unannounced incidents involving persons contaminated with a toxic chemical.
2. Hospital personnel had no training in identifying the symptoms of a hazardous chemical exposure.
3. Lack of communication between jurisdictions was a significant problem. Although people exposed came from New York Falls, the emergency room doctor had to call the Utica fire chief to help identify the problem of his staff getting ill from treating victims.
4. Hospitals that receive patients from many jurisdictions should have information on all chemicals that could result in potential toxic exposure to better treat patients.
5. The hospital did not have a separate containment area for potentially exposed patients.
6. There were no separate decontamination facilities for men and women. Having the female plant workers shower inside in separate facilities from the male plant workers showering outside the hospital avoided the privacy issue associated with a single facility.
7. Even though male workers did not feel it necessary to decontaminate, they eventually decontaminated as recommended.
8. Using housekeeping staff wearing minimum protection allowed the area to be cleaned rapidly and the emergency room to be reopened within 2 hours of shut-down.

4.6 CASE STUDY 6 MERCURY RELEASE AT INTERNATIONAL AIRPORT POSTAL HUB

Occurrence Date:	15 September 2000
Location:	Indianapolis International Airport, Indianapolis, Indiana
Source:	Leaking package
Material:	Mercury spill
Impacts:	3 workers transported directly to hospital, 40 others taken to hospital by airport shuttle
Quantity Discharged:	Unknown

4.6.1 Background

This incident was investigated because airports have been identified as primary targets for terrorist chem/bio attacks. Employees at this postal hub at a large international airport routinely handle very large quantities of materials and how they react to a toxic substance in such an environment is largely unknown in the literature. The postal hub is operated by a private firm, not the U.S. Postal Service.

4.6.2 Incident Timeline, Response, and Consequences

On an early Friday morning, a small amount of mercury about the size "found in a thermometer" was discovered on a conveyer belt in a sorting area of a large international airport postal hub. A supervisor was informed that an employee had picked up and handled some mercury. The supervisor decided the incident should be treated as a HAZMAT situation and the company called the airport fire department that in turn called the Wayne Township fire department. About 10:30 the fire department arrived on scene. The one employee who had been in contact with the mercury and two others who complained of breathing problems were sent to the hospital by ambulance. The fire department then proceeded to decontaminate approximately 40 others including anyone in the vicinity of the sorting area around the conveyor belt. Persons placed their clothes in one bag and personal articles in another bag, both of which they were allowed to carry with them into the hospital. One respondent observed several employees take cell phones from the bagged articles and use the equipment while in the hospital.

The Wayne County Emergency Department has a decontamination truck that was used to decontaminate female employees inside the unit. Male employees were decontaminated by firefighters outside in the parking lot near the facility. Both men and women had warm water for showering. Once decontaminated, persons were reclothed in Tyvek jumpsuits and told to go to the waiting buses for transport to the hospital.

About 11:30 a.m., representatives arrived from the County Health Department. Health officials reported conflicting statements by company personnel about the incident. Seeing the airport shuttle buses waiting to take the people to the hospital, they requested permission to check people for mercury contamination using a Jerome meter. They also checked another 40B50 people in street clothes for possible contamination. No contamination was found on anyone, and the employees who had been decontaminated were taken to the hospital. At the hospital, people were interviewed, charted, and checked for vital signs.

Urine and blood samples were collected and analyzed checked for mercury. After each person was evaluated, the patients were sent to the hospital auditorium for debriefing and told what signs and symptoms to watch for. One respondent reported that several people not in the original group that had been decontaminated arrived the day after the incident to be evaluated for mercury exposure.

Once all the employees had been taken to the hospital, a reconnaissance team entered the building to check for contamination and a commercial cleanup team hired for cleanup started decontamination. At that time the county health department personnel went to the hospital to check the clothing for contamination. One pair of shoes worn by the employee who had handled the mercury was found contaminated and disposed of. The health department then went back to the airport to check for contamination in employee=s cars. None was found. Informational factsheets on mercury were distributed to all employees.

Meanwhile a commercial company had been hired to provide air monitoring. Once everything checked out, the company requested the health department personnel to certify the building was safe to begin work in again. The health department went through with the Jerome monitor and okayed the building for re-entry.

4.6.3 Findings

1. There were no objective criteria to distinguish people who were contaminated from those who were not.
2. County health department equipment and personnel arrived an hour after the incident, well after decontamination efforts had started.
3. Bagged articles taken with employees to hospital were not checked for contamination before being brought into the hospital.
4. Removing cell phones and other items from bags could have led to secondary contamination at the hospital. Information about the importance of keeping bagged items secure should have been conveyed to all victims.

4.7 CASE STUDY 7. INADVERTENT MIXING OF CHEMICAL INTO SULFURIC ACID CREATED TOXIC FUMES

Occurrence Date:	13 October 2000
Location:	S & R of Kentucky, Bowling Green, Kentucky
Source:	Mixing of incompatible chemicals
Material:	Sulfuric acid mixed with aminonic shield conditioner
Impacts:	40 workers decontaminated and taken to hospital
Quantity Discharged:	Fumes from unknown quantity of mixture

4.7.1 Background

The spill at the chrome plating factory illustrates the problems emergency responders have in responding to events in which the chemical release is unknown and people are experiencing severe respiratory distress, such as would be evident in a nerve agent release. The incident emphasizes the need for companies to establish work rules and retrain employees when new products are being tested or produced.

4.7.2 Incident Timeline, Response, and Consequences

According to the CIRC report, the spill at the chrome plating plant allegedly occurred just before 11:00 a.m. However, the emergency service unit and the fire department reported they received the 911 calls at 9:50 a.m. and both immediately headed for the plant. The plant is located in an industrial park approximately 8 miles from the town. Upon arrival at the plant, the responders reported seeing numerous people lying on the ground. Dressed out in the appropriate PPE and unsure as to the contaminant, the responders corded off the area, telling employees by hand signals and verbal commands to keep in that area. Employees were upset with this strategy and tried to reach responders.

A decontamination facility was set up and about 40 workers were hosed down. Clothing was replaced when necessary. Both men and women were concerned about the decontamination procedures but once the dangers with not being decontaminated were explained, all agreed to procedures.

Employees were decontaminated in small pools but one pool leaked and another overflowed. The water ran down hill to an area of pavement that had been trenched and covered with gravel. Later EPA checked and concluded that the gravel would help neutralize the acid in the wastewater and the overflow did not present problems. It took approximately 2 hours to decontaminate all employees exposed. One respondent noted that there was only one decontamination line and that two lines would have helped speed up the process.

After decontamination, employees were checked for vital signs by EMTs. Seven people were sent to the hospital for further monitoring and chest x-rays. Later other employees not decontaminated at the site reported to the emergency room on their own. Knowing they had come from the plant, hospital staff ushered them out and decontaminated them before allowing them into the emergency room.

One respondent reported that the media with their cameras were also a detriment at the hospital decontamination site and that the emergency vehicles had to be placed to obscure the media personnel from photographing the victims being decontaminated. One media representative questioned the fire chief as to whether decontamination was really necessary under the circumstances. This annoyed the fire chief as the incident commander.

The owner of the plant was required to retrain all workers in the use of equipment and the characteristics of the chemicals found on site. He was also required to submit Material Safety Data sheets (MSDSs) on all chemicals at the facility to responders. An outcome has been the dedication of a three-room mini-shower unit by the hospital EMS team to the local firefighters for use by their HAZMAT team for decontamination. Issues on decontamination of people before entering an ambulance or the emergency room have been reviewed and, when necessary, revised.

4.7.3 Findings

1. The company was lax on updating MSDSs, slowing the identification of the chemicals involved in the release by emergency responders.
2. Media presence was a problem that contributed to patients’ unease about decontamination procedures.
3. Emergency responders lack of knowledge about characteristics of chemicals involved slowed initiation of decontamination procedures.

4.8 CASE STUDY 8. UNKNOWN SUBSTANCE SICKENS MARTA PASSENGERS, ATLANTA, GA

Occurrence Date:	11 February 1999
Location:	Atlanta, Georgia
Source:	Coughing adult male walking through subway car
Material:	Never identified
Severity:	16 sent to the hospital and decontaminated, 14 year old male hospitalized 36 hours
Quantity Discharged:	Unknown

4.8.1 Background

The opportunity for a terrorist to infect a large number of victims via a busy transport network has worried transportation officials since the Tokyo subway sarin release. If the substance released can not be immediately identified, it may lead to unnecessary delays in assessing the hazard, possibly contaminate emergency responders through secondary exposure, and delay decontamination of victims. This also presents a problem for ER personnel who typically do not wear PPE unless warned that persons they are treating were exposed to a hazardous substance. This study was chosen because of its implications for transportation officials, response agencies, and secondary contamination concerns.

4.8.2 Incident Timeline, Response and Consequences

Just before 6:00 p.m. a male coughing and wheezing entered the middle door of a MARTA train car southbound for the Atlanta International Airport. After passing 3 rows of passengers, he turned back and exited the same middle door as it was closing (there are 3 doors to a train car). During the 2 - 3 minute ride to the next station those passengers he had passed experienced a burning sensation on their face and in air passages, shortness of breath, and coughing. Several moved away from the seats at the middle of the train to the ends of the car. A 14 year old male sitting with his mother at the end of the car began coughing violently and vomiting.

One passenger who started coughing moved to the front of the train and notified the transit operator that he thought someone had set off tear gas or pepper spray. The operator radioed ahead for help to meet her at the next station. When the train reached the next station (Oakland City), most passengers exited through the front and rear doors of the car. Several people got off the train and walked away. At the same time the two MARTA police officers that met the train at the Oakland City station began separating those visibly affected from the other passengers. Those victims were taken to the south end of the platform where police took down information and monitored for signs and symptoms. The entire train was then evacuated and the train sent to a holding area or "pocket." The train was vented by opening doors and windows and filters were later replaced. It is unclear if any decontamination of the train's interior surfaces was conducted.

Because the substance remained unidentified, the filters taken from the cars were examined and found to contain trace amounts of toulene. However, the cleaning fluids used daily in the cars also contain toulene and cannot be ruled out as the contaminant. Through miscommunication, a second southbound train arrived at the Oakland City station shortly after the evacuated train left. Several people exposed to the substance immediately entered that train which proceeded to the Atlanta international airport.

The Atlanta Fire Department arrived at 6:15, took over control from the transit officials, and closed the platform and station. The group of 16 victims were moved to the lower level of the station where they were monitored for signs and symptoms. Two of the police officers who had stayed with the victims on the platform also experienced some symptoms of exposure. Eventually victims went through decontamination and were sent to Grady hospital along with the affected responders. Before entering the hospital, victims were again decontaminated by emergency medical personnel. The young male remained under mechanical ventilation for 3 days; the others were examined and released.

Clothing and personal effects were bagged and taken by the FBI. Victim's clothes were washed and the water examined for contaminants but none were found. PPE worn by the entry team was decontaminated once and disposed of (standard procedure for the Atlanta Fire Department).

Because of the unknown nature of the substance, the Georgia Department of Public Health initiated an investigation following standard epidemiological procedures. Victims who had been treated were interviewed via telephone about their experiences. Out of 16 victims, 14 were interviewed about the incident but the type of substance remains unknown. The investigation ruled out the incident as the result of epidemic hysteria and found that several victims returned to MARTA use without recurrence of symptoms. The primary question is whether or not it was an intentional release or a rehearsal for a later attack using the same mode of dispersal of substance.

4.8.3 Findings

1. Detection equipment lacking making rapid assessment of substance impossible.
2. Miscommunication between transit authorities and first responders resulted in second subway train entering station thereby allowing potentially exposed passengers to exit from scene.
3. Appropriate response by police to maintain perimeter control (only 2 officers remained with victims) likely controlled secondary exposure among responders.
4. Victims decontaminated twice (second time at hospital).
5. GA Dept. of Public Health investigation ruled out the incident as the result of epidemic hysteria; substance never identified and perpetrator never found.

4.9 CASE STUDY 9. JAIL CONSTRUCTION RELEASES CHEMICAL

Occurrence Date:	21 May 2000
Location:	St. Tammany Parrish, Louisiana
Source:	Glass bottles unearthed in construction
Material:	Various chemicals
Severity:	5 injured sent to hospital where decontaminated, jail shut down
Quantity Discharged:	Unknown

4.9.1 Background

The number of chemicals unearthed during construction activities suggests that construction and contract workers should be trained to recognize the risks associated with unearthed substances. The problem is likely to spread as new uses are found for formerly abandoned industrial sites or those associated with former military activities. Often the substance can not be immediately identified, leading to unnecessary delays. This also presents a problem for ER personnel who typically do not wear PPE unless warned to do so when treating those exposed. The study was chosen because of its implications for law enforcement officials and agencies.

4.9.2 Incident Timeline, Response and Consequences

The incident occurred while a construction company was working on the expansion of a jail complex. A construction worker was digging a trench with a backhoe and hit some bottles containing substances. The odors from the broken bottles overcame the worker who fell to his knees. A prison trustee at the scene immediately reported the incident to the Captain who evacuated a dozen or so workers away from the site and closed the door to the building because it was downwind of the release. Two district fire departments and the Acadian EMS team responded. Ambulance personnel arrived at the scene to find victims lying on the ground, vomiting and having respiratory problems with complaints of eyes and throats burning. Advised at first that a gas line had been ruptured one ambulance service placed four victims in the back of the ambulance and immediately left for the hospital. While en route, the paramedic attending the victims became ill herself on the way to the hospital. All five victims were decontaminated and treated at the hospital. Since the event involved fumes and no one was splashed with liquid, the entry team was not decontaminated until 2 hours after the event occurred. Eventually approximately 30 persons were sent to medical facilities for treatment. Those decontaminated had personal effects such as wallets, keys, clothes, shoes taken from them and disposed of by the clean-up contractor.

The construction company immediately ceased operations and a company with hazardous materials experience was called to finish the job in the event more materials were uncovered.

One of the major issues involved the security of several prison trustees (not locked up) around the complex who also were in danger of being exposed to the fumes. One was exposed and hospitalized. Another problem was the temporary loss of access to the Information Systems and

Warrant offices. Existing warrants could still be served but new ones could not be entered into the computer system. Security for the site was necessary for 3 weeks following the incident.

4.9.3 Findings

1. Emergency response personnel need better information about an incident than they are currently obtaining from emergency calls. This is especially important for ambulance and emergency room personnel who may not know until they become ill that they have been exposed.
2. Paramedics need additional training in identifying the symptoms of a hazardous chemical exposure.
3. The security of the prison trustees fell to the police, thus removing an emergency resource often counted on to help in response.
4. The taking of personal effects from those decontaminated appears unnecessary given the type of fume exposure.
5. Temporary loss of access to information systems could result in unnecessary delays of warrants being issued.
6. Inaccurate reporting by media on location of incident was picked up as correct in CIRC report database.

4.10 CASE STUDY 10. UNKNOWN LIQUID SPRAYED IN METRO SUBWAY CAR PRINCE GEORGE COUNTY, MD

Occurrence Date:	1 October, 2001
Location:	Metro Subway Station, Prince George's County, Maryland
Source:	Male sprayed liquid from plastic bottle
Material:	Unknown
Severity:	Decontamination of male and immediate responders not wearing appropriate PPE; FBI response team investigation
Quantity Discharged:	Unknown

4.10.1 Background

After the terrorist events of September, 11, 2001, transportation personnel were on heightened alert for other terrorist related incidents. The ambiguity of not knowing where the next attack would occur forced transit authorities to take greater precautions when an alarm was sounded. This incident was examined to determine if changes in the previous decontamination paradigm had occurred in the wake of the 9/11. The incident could also be compared to the event examined in Atlanta, GA, involving MARTA.

4.10.2 Incident Timeline, Response, and Consequences

The incident occurred at the Southern Avenue Metro Station in Prince George's County, MD, on October 1, 2001. Earlier that morning—about 10:00 a.m. - the D.C. Transit Authority, after receiving a call that "something" was planted at 3 Metro stations, had instituted a system wide check of all stations and placed all officials on high alert. Around 11:00 a.m., a 27 year old male was reported by a rail supervisor to have not paid a fare. On boarding the train car, he was asked for identification by a Metro police officer. Rather than identify himself, the male pulled a plastic bottle labeled Resolve from his coat and began spraying a clear liquid in the area. The officer immediately called for back-up, then tried to subdue the male. During the scuffle at the next Metro station the two fell out an open doorway onto the platform and additional liquid spilled on the platform. Police who had arrived at the station then used pepper spray to subdue the male. However, while handcuffed, the male managed to pull out a gun and fire at a police officer. When asked what was in the bottle, the male replied "GOD." Passengers in the car meanwhile moved to the three forward cars. The car with the liquid was disattached and sent to a holding area. The train continued on to five other stations before dispatchers realized that other areas could be contaminated by the passengers who had been in the car when the assailant was spraying the liquid.

To secure the Southern Avenue station, the manager called for an immediate evacuation of the station and bus lanes were blocked to prevent bus entry. The Prince George's HAZMAT team was called but as the unit had to assemble from several different locations, this took some time. Meanwhile one of the15 responding officers called a member of the National Medical Response Team (NMRT) to tell him what was happening. The member came down on his own to the hot zone wearing Level C PPE. He was assigned to guard the prisoner until the prisoner could be decontaminated and taken to a hospital for his injuries. The incident was now labeled a crime scene as well as a HAZMAT incident.

The FBI Terrorism Task Force arrived and set up two pop tents on the station platform—one as a laboratory for testing the liquid and the other as a decontamination tent. From the testing with monitors and the lack of symptoms among responders, FBI personnel determined that there was no threat but that the situation should still be treated as HAZMAT scene. The FBI took the bottle for further testing which later turned out to be ordinary cleaning fluid. While collecting evidence, technicians wore powered air respirators but the police that had initially responded to the scene had no PPE. The HAZMAT team first decontaminated the prisoner with a bleach and water solution, then EMTs took him to medical facility. All responding police had their clothes bagged and were issued tyvek suits. After Metro employees and police were debriefed at the scene, responders were then bused off-site for decontamination.

Although respondents were generally comfortable with the overall management of incident, there were some issues they considered should be examined. The first was the location of the members of the Hazmat team. The general feeling was that Prince George's County should have one team who would be on call 24/7. This would save time when responding to events and should be given priority because of the Metro's proximity to Washington, D.C. Communications were also problematic. Passengers on the car where the liquid was sprayed should have been isolated until the liquid was identified as benign. Communication was a problem among those responders wearing full respirators and PPE. Resorting to hand signals further complicated communications.

4.10.3 Findings

1. Miscommunication between responders and the train dispatchers allowed possible contamination to spread throughout the system by continuing the train with the car's passengers on its route.
2. Responders put themselves at risk by responding without appropriate PPE. This could have resulted in disaster if the liquid had been toxic and prevented responders from fulfilling their mission.
3. Having to assemble a HAZMAT team from various locations took valuable time away from rapid decontamination of people.
4. FBI response was rapid and efficient, suggesting an improvement in procedures since 9/11.
5. Identification of liquid as benign cleaning fluid was rapid with FBI lab set up on Metro platform.
6. Procedures to ensure communications between those wearing respirators and those without PPE should be improved either through technology and/or training. Using hand signals to communicate with civilians could raise anxiety among victims.

4.11 CASE STUDY 11. ANTHRAX CONTAMINATION AT AMERICAN MEDIA INCORPORATED (AMI)

Occurrence Date:	5 October 2001
Location:	Boca Raton, Florida
Source:	Contaminated letter
Material:	Anthrax spores
Severity:	1 death, 2 hospitalized, 700 given nasal swabs and antibiotics
Quantity Discharged:	Unknown

4.11.1 Background

Documentation of the anthrax decontamination of the American Media Incorporated (AMI) facility in Boca Raton, Florida, was also sought because it was the first confirmed case of inhalational anthrax. The death of a 63-year-old Sun photographer editor from anthrax on October, 5, 2001, was the first documented case of anthrax after the Sept. 11, 2001, terrorist attacks on the World Trade Center in New York.

Although a naturally occurring zoonotic disease in nature when ingested by herbivores, the number of aerosolized anthrax spores necessary to induce infection was previously thought to be too high—between 8,000 and 10,000 – to harm civilians handling mail. Even military experts before AMI were convinced that the ability to produce spores of the appropriate size that could aerosolize was only available in military circles. That some militarized product could get into the hands of either a foreign or domestic terrorist was considered highly unlikely.

The anthrax incidents -- which subsided after the November death of an elderly widow in Connecticut—prompted significant changes in how the U.S. Postal Service handles and treats the mail, including the installation of new cleaning equipment and irradiation of all mail sent to federal agencies and Congress.

4.11.2 Incident, Timeline, Response and Consequences

On October 5, 2001, the FBI was notified by a hospital in Boca Raton, Florida, that a patient who had worked at the AMI offices as a photo editor had died from inhalational *Bacillus anthracis*, or anthrax. AMI was the first facility to be targeted through anthrax contaminated mail—before NBC News in New York and before the Daschle letter was received at the Hart Senate Building. After learning of the anthrax death, the AMI building was evacuated and labeled a crime scene as FBI specialists investigated where the anthrax was located. Anthrax spores in powder form were found on the computer keyboard of the deceased as well as in the facility’s mail room, indicating that the contamination likely occurred through the mail.

All employees were given nasal swabs. Eventually 1000 nasal swabs would be performed on people who either worked or visited the AMI building before, during, or following the time the first anthrax victim tested positive. The post office that handled the mail was also investigated and the employees tested and placed on antibiotics as a precaution.

When asked what procedures were in place to determine when decontamination of people was needed, one official said that in general if a person receives a suspicious package or envelope they notify law enforcement. Law enforcement personnel examine the scene and if the situation looks suspicious they call one of four Palm Beach Fire Department HAZMAT teams–whichever fire station is closest to the location of the suspicious mail. That HAZMAT team assesses the situation. If the item appears contaminated they decontaminate the people with soap/water and/or a .5% bleach solution. They also decontaminate the surrounding area where the package was opened (i.e., office space, floor, furniture, car, etc.) with .5% hypochlorite solution. They collect a sample of the suspicious material, bag it, and send it to a lab in Miami. However, the Miami lab was so inundated with samples they had to prioritize testing to samples that were the most suspicious. The people tested were told "No news is good news" and briefed on anthrax symptoms. If any symptoms appear they were told to go to their personal physician for monitoring but they needed antibiotics only if they tested positive for exposure. Of the 1000 nasal swabs performed on people only two people tested positive.

When asked about how the decontamination was performed, one respondent reported that this was the responsibility of a team composed of representatives from EPA, National Institute of Safety and Health (NIOSH), CDC, FL Health Department, U.S. Army Medical Research Institute of Infections Diseases (USAMRIID), and the FL National Guard Civil Support Team (who specialize in HAZMAT, decontamination, biological /chemical agents). This team at the time of the interview was assessing how best to decontaminate the AMI building but they had not started the decontamination yet. There was also a problem of expense as the AMI building is a commercial facility, not government owned.

Other buildings (post offices, businesses, etc.) that report suspicious material are visited by the team as well. In those situations, swabs are taken of different surfaces and placed on agar growth plates. Using different growth media they try to get the matter to grow so they can determine exactly what it is, if anything. In some of the cases the residue is readily seen on surfaces but in locations where they can't see any material they swab broad areas.

In Boca Raton, a decontamination crew sent by the U.S. EPA descended on the city's main mail distribution center after closing time. State health officials reported "minuscule" amounts of the spores had turned up in a processing area at the facility that served AMI. Meanwhile, the Florida Department of Health announced that tests showed that an AMI mailroom employee had contracted anthrax. Earlier tests indicated that person had only been exposed to anthrax spores. The agency also reported that the victim had been on antibiotics since first being connected to the anthrax outbreak.

The labeling as a crime scene has stalled decontamination of the building. The AMI's quarantined building remains locked and guarded at the time of this report. The EPA confirms that contamination of the 70,000 square foot building is widespread and the cost of clean-up will be in the millions. An EPA spokesperson said no federal funds are forthcoming because AMI is a private business. A team was assembled from the EPA, NIOSH, CDC, the Florida Health Dept., USAMRIID, and the Florida National Guard Civil Support Team (who specialize in hazardous materials, decontamination, and bio/chemical agents) to assess how best to decontaminate the AMI building. The team is considering using chlorine dioxide as in the Hart Building decontamination but the large spaces and widespread contamination may not allow such use.

4.11.3 Findings

1. Confusion on the number of spores needed to infect a person slowed the response effort.
2. Labeling the building as a crime scene stalled decontamination efforts and may have been the reason for health officials to delay treatment of potential victims.
3. The issue of who pays the cost of clean-up remains unresolved when such a large facility is involved and when it is considered a crime scene.

4.12 CASE STUDY 12. ANTHRAX CONTAMINATION OF OFFICES IN HART SENATE BUILDING WASHINGTON, DC

Occurrence Date:	15 October 2001
Location:	Washington, DC
Source:	Letter contaminated with powdered anthrax
Material:	Weaponized grade anthrax spores
Severity:	23 people decontaminated, 6000 receive antibiotics
Quantity Discharged:	2 grams

4.12.1 Background

The threat of *Bacillus anthracis* (anthrax) contamination to the American public prior to October 15, 2001, was considered by most risk analysts of very low probability. Although the FBI had responded to a number anthrax hoaxes, most of the security and medical communities did not believe enough viable anthrax spores could be disseminated to effectively sicken large numbers of civilians. The data for this assumption—that 10,000–12,000 spores between 1-4 microns in size—had been extrapolated from data presented in Messelson et al. 1994 study as a result of organisms released from a biological weapons factory in Sverdlosk, Russia, in 1979 and from animal studies conducted at USAMRIID to develop appropriate vaccines for military personnel exposed to biological warfare agents. During the 20th century there were only 18 cases of anthrax reported in the US with most occurring before antibiotics were available (NIOSH 2001). Thus, most practicing physicians in the US had never seen or treated cases of cutaneous or inhalational anthrax.

Anthrax is non-contagious, zoonotic disease that occurs naturally in domesticated and wild animals from ingesting spores from contaminated soils. Under natural conditions humans contact the disease through infected animals or contaminated animal products, most often through cutaneous routes and rarely through the gastrointestinal or inhalational routes. Anthrax was once known as the woolsorters' disease because of the number of infections transmitted to those working with contaminated animal hides in small workrooms. Before antibiotics and aggressive treatments, the inhalational form of anthrax was almost always rapidly fatal.

The lack of empirical and historical information on decontamination of anthrax contaminated spaces both hindered and helped emergency and medical responders in implementing procedures to decontaminate buildings and objects contaminated with *bacillus anthracis* organisms after an anthrax laden letter arrived in the Hart Senate Building.

The lack of quantitative information on dose response was unknown for diverse groups, the data having been calculated primarily for healthy young military men. This also made appropriate prophylatic response for a diverse civilian population uncertain. The use of LD_{50} exposure levels to determine level of risk has also been challenged as inappropriate for diverse civilian populations. Conversely, outdated and inappropriate procedures were not in place to hamper innovative clean-up techniques with appropriate PPE. The number of agencies and individuals involved, the congressional oversight, and the intense media scrutiny made this decontamination situation the most publicized in history.

It is clear since the tragic events of September 11, 2001, that federal buildings are highly vulnerable to terrorist attack, either through groups or individuals acting alone. This study sought to identify any changes in response after the September events.

Information was obtained from informants and secondary sources including agency reports, proceedings, and media reviews. The systematic interviews with respondents suggest communication between agencies and the media was beneficial to the general population both in alerting the public to the risks associated with anthrax and in preventing an overreaction to mail handling and use. The reaction of postal authorities to prevent further events by segregating and irradiating mail routed to government offices may have been more reactive than necessary, but the impact of that strategy will not be known until a much later date. What remains uncertain is how local communities could afford the extraordinary cost of clean-up if government resources are unavailable to carry out the "zero spore is clean for reentry" hypothesis and the actual number of anthrax spores that would cause an infection.

4.12.2 Incident, Timeline, Response, and Consequences

October 15, 2001

On Monday, Oct. 15, 2001, a letter containing a white powder was received in Senator Daschle's office on the 6th floor of the Hart Building was opened by aide. Daschle's 3000 sq. ft. suite on the 5th and 6th floor is connected by an interior stairwell. When the aide observed the white powder inside the envelope, the Capitol police and the Capitol Hill Physician, Dr. John Eisold, were notified. Given a response plan in place that had been reviewed at a conference briefing among agencies 2 weeks prior to the incident, the physician immediately performed nasal swabs on all workers in the immediate vicinity. Cultures of 13 people in Daschle's office where the letter was opened came back 14 hours later as very positive—colonies had grown so vigorously that overlapping colonies made individual colony morphology impossible to identify. Seven of the 23 people in Daschel's fifth floor office adjoined by a stairwell also tested positive. Two of the 18 people in Senator Feingold's office, which is adjacent but without a direct connection to Daschel's office tested positive. Five of the nine first responders (Capitol police), other members of Dr. Eisold's team, and a Capitol security guard who was present in the hallway outside the fifth floor at the time the letter was opened also tested positive. Although later research would indicate that distinctions between levels of exposure based on culture plates would prove inconclusive, the epidemiological curve would show that if a person was in the office with the person who opened the envelope, that individual was much more likely to have more spores in the nostrils than others further away. Heavy doses of antibiotics were given to those tested.

Nonetheless, it took two days for authorities to close the Hart building. At first, the Capitol Police draped yellow tape around a few offices and told people to stand back. Early briefings informed staff that the anthrax was only "garden variety" and that people should have to inhale at least 10,000 spores to be affected.

When evidence of exposure came back, the entire Hart building was evacuated and closed until decontamination was completed. Mail delivery was suspended to all congressional offices. All six of Congress' main office buildings, the Rayburn, the Cannon, the Russell, the Dirksen, the Ford, and the Hart Senate Office building, were shuttered the evening of Oct. 17 for anthrax testing. Even the House portion of the Capitol was off-limits for several days while tests were conducted.

October 17, 2001

On Wednesday, Oct. 17, 2001, two days after Hart office building closed, CDC issued a Health Alert for the Hart building:

> "Any person who was on 5th or 6th floor, southeast wing of the Hart Senate building between 9 a.m.-7p.m. should receive 60 days of prophylaxis for possible anthrax exposure. This includes staff and visitors. The individuals should NOT be given nasal swabs as a preliminary test for exposure. Nasal swabs are primarily used for epidemiological investigation, not for individual diagnosis, prophylaxis, or treatment. The D.C. Department of Health call center is 202/442-9196."

October 18, 2001

On Thursday, Oct. 18, 2001, EPA issued a Draft Report, "Guidelines for Cleanup of a Facility or Habitation Following an Anthrax Attack." EPA also assumed primarily authority as the lead agency for environmental hazards and cleanup of the Hart building. EPA noted that "clean-up strategies must be made on a case-to-case basis involving consultation with the EPA, state and local health departments, the manufacturers of building contents, and others as needed." Following the text on simple cleaning only, the guidelines state that "local authorities must determine whether the degree of cleaning will result in a safe and acceptable environment." The guidelines recommended a 1 part sodium hypochlorite (household bleach) to 9 part water solution for non-porous surfaces and a formaldehyde gas using paraformaldehyde crystals to disinfect contaminated spaces such as rooms and buildings (with the appropriate humidity maintained for a specific contact time). The caveat, EPA warns in the guidelines, is that formaldehyde is considered a potential carcinogen and that after treatment, the formaldehyde must be neutralized with ammonium bicarbonate. Furthermore, EPA notes this treatment should be used only if no other option is practical.

Concerns about the formaldehyde procedure force EPA to seek other solutions. Chlorine dioxide gas was chosen as less hazardous to decontaminate the Hart building.

October 20, 2001

Contracted technicians prepared to decontaminate Hart Building by pumping chlorine dioxide gas but had to wait until scientists confirmed that the technique was an effective way to kill anthrax. Once experts approved using chlorine dioxide, the building will be sealed off and EPA will start the process, expected to last 16 days. If the gas works, the 50 senators with offices in the Hart Senate Office building was expected to be able to reopen in mid-November - a month after they were initially closed.

Chlorine dioxide, which is used to purify water in many American and European communities, had not been used to kill anthrax in the field before this event, but it had been successful against bacteria that were considered even harder to destroy (Paul Schaudies, a microbiologist and a consultant to the EPA). In essence, the gas should punch holes in the hard coating around the anthrax spores and destroy its genetic matter.

Meanwhile, trace amounts of anthrax were found in a Capitol Police office in the Ford House Office Building. Officials think the anthrax was tracked in by officers who went to Daschle's office the day the letter was received. The Ford building, which houses the Congressional Budget Office but no lawmakers' offices, remained closed. Anthrax had already been found on a mail sorting machine in that building. The Longworth House office building also remained closed as testing for anthrax there continued.

Over the weekend, anthrax traces were found in the 6th and 7th floor offices of three representatives. No additional anthrax has been found since then, officials said. "Until every single test is documented and confirmed, we simply won't open that building up," said Rep. Bob Ney, R-Ohio, chairman of the House Administration Committee. The Hart and Longworth buildings are the buildings with lawmakers' offices that have not reopened.

November1, 2001

On Thursday, Oct 25, Daschle told reporters that the entire portion of a Senate office building where anthrax was discovered last week will have to be sealed off indefinitely. However, Daschle also told reporters that anthrax found Wednesday in a new location in that same Hart office building was just a trace amount. Doctors consider the discovery to be relatively low risk and had not ordered any new tests of people who may have been exposed. Capitol police officials said the new anthrax discovery was made in a freight elevator area on the first floor of the Hart building's southwest quadrant used to carry mail - which could mean that the bacteria came from the Daschle letter.

Daschle said the entire southeast portion of the Hart building would have to be sealed off, in effect shutting down the main offices of a dozen senators. The eight-story building houses the offices of half the Senate's 100 members. Senators should be able to get into the rest of the building sometime next week, Daschle said, but no one will be allowed into the southeast quadrant offices to retrieve anything prior to sealing. The offices would be sealed off with special material because the anthrax spores in Daschle's letter were barely more than a micron in size and could slip through most standard filters. There are 25,000 microns in an inch.

Meanwhile, tests continued on a woman at a local hospital being treated for possible inhalation anthrax. The woman, a female employee of an electronic news organization, was outside Daschle's office the day the letter was opened and had complained of flu-like symptoms. If it is confirmed that she has inhalation anthrax, she would be the first person to have contracted the disease inside the Capitol complex. The woman apparently was not among the 28 people whose nasal swab tests showed had been exposed to anthrax. Authorities have identified those 28 - out of more than 5,000 people tested - as being aides to Daschle and Sen. Russell Feingold, D-Wis., and police officers who reported to Daschle's suite the day the letter was opened. Feingold's office is next to Daschle's.

Two of the three chief House office buildings - the Rayburn and Cannon buildings reopened Thursday, Oct. 25, 2001, following the reopening of the Russell Senate Office Building on Wednesday, Oct. 24. Daschle said he hoped the Dirksen Building could be reopened Friday. An anthrax-contaminated mailroom there was cleansed with an anti-bacterial foam Wednesday night and will be sealed off before the rest of the building opens. The Ford building—where traces of anthrax were found at the mail facility—is expected to open Friday, Oct 26, following decontamination there.

November1.2001

At this time, the anthrax crisis in the United States looked like this:

- More than two-dozen buildings in Florida, New York, New Jersey and the District of Columbia were thought contaminated with anthrax, and there was increasing anxiety over the sufficiency of the plans to clean them. Postal unions representing 20,000 workers in New York and Florida had sued the Postal Service in federal court demanding that all mail facilities be shut down and tested for anthrax.
- Postmaster General John Potter had warned Congress that safeguarding the mail will cost several billion dollars. He said the Postal Service, which was struggling financially before the terrorist attacks, will need a bailout from Congress.
- Doctors at the CDC in Atlanta were re-evaluating their earlier conviction that it is extremely difficult for anthrax spores to leach from a contaminated letters onto other mail and other surfaces, such as mail-processing machines. They also are considering whether infections can be caused by far fewer than the earlier estimates of 8,000 spores.

The Postal Service did not initially believe that the Brentwood mail-distribution center, which handles all of the city's mail, was contaminated even after it was learned that a lethal anthrax-laden letter sent to Senate Majority Leader Tom Daschle passed through the facility. Postal officials were following the advice of CDC doctors, who recommended that inhalation anthrax would not be caused by only a small number of aerosolized spores.

About the same time Postmaster General Potter was testifying, health officials announced the discovery of anthrax spores in two D.C. post offices, including one that serves the Cleveland Park neighborhood, where many of the city's leading lawyers, media figures, politicians and policymakers live. Spores also were found at a post office in a building near Dulles International Airport, about 25 miles west of Washington. The building's owner reported that he learned of the contamination when he responded to a fire alarm and found a decontamination crew inside.

The head of the State Department's medical unit did little to calm employees' nerves Tuesday when he said that anthrax spores were "probably all over" the building. He again reiterated that the spores were not concentrated strongly enough to cause deadly inhalation anthrax. But defining the level of risk puzzled postal workers and others who lived and worked in the affected regions. Throughout the anthrax crisis, officials' early reassurances have been withdrawn, only to be replaced with new information and advice. As State Department workers were assured that their building was safe, congressional leaders announced plans to pump the Hart Senate Office Building with chlorine dioxide gas to rid it of anthrax spores.

The Daschle letter contained spores that had been ground into a highly concentrated and exceptionally deadly powder. The material was so potent that investigators first believed that the Daschle letter alone was responsible for contaminating the buildings here. Now, with spores having been discovered in so many buildings, CDC doctors and other investigators believe several letters containing anthrax were put into the mail system.

In New York, officials faced rising public anxiety as details about the stricken hospital worker emerged. The woman, who has worked at Manhattan Eye, Ear and Throat Hospital for 10 years, became ill Sunday with a suspected anthrax infection. After her diagnosis, the hospital was closed and employees placed on antibiotics.

November 6, 2001

CDC issued updated guidelines on PPE for investigators performing environmental sampling for Bacillus anthracis. "Workers conducting environmental sampling that places them at risk for exposure to Bacillus anthracis should wear PPE, including:

- Powered air-purifying respirator (PAPR) with full facepiece and high-efficiency particulate air (HEPA) filters. Respirators should comply with OSHA respiratory protection standards (29 CFR 1910.134).
- Disposable personal protective clothing (PPE) with integral hood and booties. PPE should be decontaminated immediately after leaving a potentially contaminated area. Protective clothing should be removed and discarded before removing the respirator.
- Disposable gloves - made of lightweight nitrile or vinyl so as not to compromise dexterity. A thin cotton glove can be worn inside a disposable glove to protect against dermatitis, which can occur from prolonged exposure of the skin to moisture in gloves caused by perspiration."

2nd week November

CDC convened a meeting to discuss the anthrax contamination. Two government scientists gave a preliminary report on their experiments in the heavily contaminated Daschle suite. They reported that the number of spores put into the air was likely small but it remains unclear what constitutes a "safe" dose of inhaled anthrax bacteria. The large number of people (28) in and near the room that tested positive to nasal swabs immediately afterward suggests the finely ground powder containing the anthrax floated easily and dispersed rapidly.

The research team, led by an EPA toxicologist, entered the Hart building after it had been sealed for a month. They each wore two plastic oversuits and breathed filtered air as they began their experiments. In the first experiment, they placed 17 culture bacterial plates around the office, eight on the floor and nine on chairs. The researchers moved slowly and tried to disturb the environment as little as possible. An hour later they retrieved the plates. In the afternoon of the same day, they returned and put out another 17 plates. This time three members stayed and spent an hour simulating office work - walking around, sorting and opening mail, shuffling papers, changing paper on the fax machine. Then, as in the morning, they sent the culture plates to the lab.

Out of the 17 plates placed during the quiet morning period, five grew *Bacillus anthracis* with only a few bacterial colonies on the positive plates. (One colony represents the landing of a single spore-containing particle.) Of the 17 plates placed during the simulated work period, 16 grew the bacteria, with one plate producing 20 colonies.

The researchers also sampled the air directly using simulated breathing devices placed at both floor and desk level. A small number of spores were picked up during the quiet period, but many more—in one case, a hundred times more - were detected during the work period.

The question of what dose of anthrax spores is needed to infect a person is especially important, as it touched on many decisions public health officials must make. Those include: when to consider a contaminated place hazardous, when to advise exposed people to take preventive antibiotics for 60 days, and whether an environment must be sterilized to be considered safe.

December 1, 2001

On Saturday, Dec. 1, fumigation of the sealed 3,000 square foot Daschle suite began at 3:00 a.m. using chlorine dioxide gas. The chlorine dioxide gas was mixed in a vessel outside the building, then pumped through chemically resistant plastic tubes to another device inside the suite that vents the gas. No foam was used but some liquid chlorine dioxide was used in the suite beforehand. Rugs and some artwork were left in place for fumigation.

The process went smoothly until the decision was made to extend the fumigation beyond the 12 hours originally planned. After the fumigation, sodium bisulfite gas was pumped into the suite for 6 hours to scrub the deadly chlorine dioxide from the air. The mixture separates into oxygen and an innocuous substance similar to table salt. After the gas stopped flowing, crews, protected by face masks and air tanks, collected samples to test if all anthrax spores were dead. Test results were expected back by the following weekend. Cleanup using liquid or foam decontaminates was started in some of 13 other senators' offices where traces of anthrax were found.

The Daschle suite had been isolated from the rest of the Hart building which was not similarly sealed, but the hallway connecting the Hart to the adjacent Dirksen building and the Hart underground garage was shut down as a precaution against leakage of the toxic gas. Other suites in the Hart building needed to be cleaned up but officials did not believe gas was necessary in those areas.

Throughout the most dangerous phase of the process, 5 men equipped with self contained breathing apparatus (SCBA), full face masks, Tyvek suits and rubber gloves remained just outside the suite in a staging area ready to rescue those inside if necessary.

Post-fumigation analysis from the gassing on Dec. 1, showed trace amounts of anthrax spores on 9 of 377 test samples taken from surfaces in Daschle's office.

December 5, 2001

Controversy erupted about the lack of attention paid to postal workers. Black postal workers complained that Capitol Hill employees were getting better care and more antibiotics after the anthrax-tainted letter was sent to Sen. Tom Daschle. Health officials later said they delayed giving drugs to all workers because they did not believe the workers were at serious risk for inhalation anthrax. Two Washington postal workers died of the inhalation form of the anthrax.

January 22, 2002

Senators and staff finally returned Tuesday, Jan. 22, 2002, to the Hart building that had been closed for three months. Following repeated delays, the 1-million-square-foot Hart building was declared safe last week after several attempts to decontaminate it with chlorine dioxide, a toxic gas. The building's reopening marked a major step in Congress' return to normalcy following a tumultuous autumn. Of the thousands of workers treated with antibiotics as a precaution, no one was reported to have taken ill.

The cost of cleaning anthrax from the Hart Building reached an estimated $14 million in December, 2001, said one senator who questioned "the fiscal integrity of this operation." Since the cleanups were not all finished until January, the senator noted that the cost was certain to exceed $14 million.

The U.S. Capitol Police announced the reopening of the Hart building after final tests showed no evidence of anthrax on cleanup gear or the Hart hallway where the equipment was belatedly found in a ceiling cavity. Hart had been scheduled to reopen to the public and staff on Friday, Jan. 18, but that was delayed after a bag of cleanup gear—gloves and a hazardous material suit—was found late Wednesday in a hallway ceiling outside Daschle's sixth-floor office. Capitol Police spokesman Lt. Dan Nichols said workers returned to Hart Friday afternoon to prepare the building for it's reopening.

Several basement offices in the adjoining Dirksen Senate Office Building were reopened the Friday before the Hart Building was opened. They had been shut as a precaution because they share a ventilation system with a room where the potentially exposed workers had been taken. Tests on those rooms were negative.

After the bag was discovered Wednesday above a ceiling panel, a preliminary test showed no evidence of anthrax. Twenty-five maintenance and emergency workers were put on antibiotics, however, as a precaution. With word of the negative test results, the Office of the Attending Physician of the Capitol recommended that the workers stop taking the antibiotics at the time of this report. Public access is now sharply restricted and lobbyists can no longer roam the corridors or call legislators off the floor. No reports were found of employees who refused to reenter the building.

January 24, 2002

On Jan. 24, 2002, 99 days later at a cost of $20 million in cleanup, half of the U.S. Senate and their staffs returned to offices they were forced to evacuate when the Daschel letter arrived. The goldfish and most of the plants did not survive and the halls and offices reportedly smelled like a "stale swimming pool." The Senate historians on the second floor of the Hart Senate Office Building were concerned about the effect of weeks of 85 percent humidity (necessary to kill anthrax spores), chlorine dioxide gas and decontaminant foam on their 30,000 archival photos. The only greenery to remain was a hardy split leaf philodendron. As the weeks moved on, the threat assessment was revised ever upward. Scientists began to report that even a single spore of this strain of anthrax could be deadly. Even as they declared the Hart building safe to reoccupy, the EPA and the CDC noted that "there is a possibility of residual viable spores." Public access is now sharply restricted and lobbyists can no longer roam the corridors or call legislators off the floor.

4.12.3 Findings

1. Confusion on the number of anthrax spores necessary to cause inhalational infection delayed the delivery of prophylaxis.
2. Reentry criteria or even standard methodologies for establishing criteria were lacking.
3. Inter-jurisdictional overlaps caused delay in clean-up efforts.
4. Extraordinary high cost of decontamination.

4.13 OTHER EVENTS DOCUMENTED

In the course of the study we also gathered information on other events, some of which turned out to be hoaxes. We examined one study that involved a potential exposure to ricin, one of the most potent and easily produced toxins that is derived from the seeds of a common weed plant, *ricinis communis*. The toxin remains in the caster meal after the oil has been extracted and is easily processed into a fine powder. In its natural state, seeds have poisoned children who ingested them. *Ricinis communis* was cultivated in ancient Egypt for the oil's lubricating and laxative effects and later as a laxative known as castor oil. During World War II it was used as lubricating oil for aircraft. Although largely replaced by artificial oils today, castor oil is still produced in large quantities throughout the world. The appeal of ricin as a biological weapon is it's ready availability, easy processing, heat stability, and toxicity. It has also been implicated in previous biological warfare attempts. Although ricin can be deadly if ingested or injected, the complications are not contagious to others.

The ricin event occurred about one o'clock at a technology facility in Irvine, California. A man drove into the Irvine fire station with rags and paper towels in a bag. He had noticed a powdery substance on his desk at a technology facility and used the materials to wipe up the substance. He called the police who told him not to worry about the substance. Still concerned, he drove to the nearest fire station. The fire personnel responded by examining the substance, which initially tested positive for ricin with their field detection unit. Firefighters then called the FBI who collected samples for further testing. Because of the time lag in getting the results from the laboratory, the firefighters went ahead and decontaminated the 22 employees and the building where the substance was found as a precautionary measure. Tests from the FBI laboratory came back negative for ricin.

Another case involved a potential exposure of substances drifting down from a low-flying aircraft over a subdivision located close to a military base in Tennessee. A woman called 911 at 6:37 p.m. to report a low-flying aircraft dispersing fine particles over the subdivision. When firefighters responded, another low-flying aircraft came over and a similar situation occurred. The HAZMAT team then isolated the subdivision by setting up roadblocks and securing the perimeter. Through route alerts using a public address system, people were told to turn off ventilation systems and stay inside. Residents attempting to enter the subdivision were stopped and instructed to remain outside the perimeter. The HAZMAT team started sampling with a military test kit, which showed negative for anthrax. Another sample was immediately sent to a laboratory in Nashville (47 miles away), which eventually (2 a.m.) came back as negative for anthrax. The shelter order was lifted at that time. Members of the HAZMAT team that went into the area to sample and their gear were decontaminated with a bleach/water solution. Later analysis suggested that recent dry weather combined with construction controlled burn a quarter mile away from the subdivision likely produced the substances stirred up by the low flying aircraft. No one presented to a medical facility.

We also examined how a small medical facility would handle a potential biological exposure to anthrax when we investigated an incident in Maryville, Tennessee. Three female employees of a hairstylist salon found a sticky substance on their hands after handling magazines mailed from Florida. Alarmed by the recent reports of the AMI anthrax in mail scares in Florida, the women called 911. The responding officers did not suspect a biological material could be sticky but had the responding EMTs take the women via ambulance to a local medical facility for treatment without decontaminating them. The emergency room doctor prevented the women from entering and quarantined the women and the responders outside the facility where the firefighters prepared to decontaminate them.

Meanwhile media representatives had converged at the facility having obtained news of the anthrax report from police scanners. When the infectious disease coordinator of the facility was notified of the impending decontamination, she requested the decontamination team not decontaminate the women in the parking lot because of the lack of privacy and the large number of media representatives at the scene. The two EMTs and the policeman who responded were decontaminated in the parking lot, however, because they had gone into a situation that could have been hazardous without wearing PPE. Standard operating procedures required that they be decontaminated. The ambulance was decontaminated as well. One staff member noted that the facility had participated in an anthrax drill at the facility a year ago and considered the event a "very good drill."

Another incident reported directly to us involved a female postal worker who encountered a letter covered with a powdery white substance and labeled "anthrax" in Chicago, Illinois. On Thursday, Oct. 11, 2001, she reported to a large emergency room in a major medical center in Chicago. A respondent from the emergency room reported that a woman who worked at a nearby postal facility touched an envelope labeled "anthrax" but did not touch the contents. Her supervisor suspected she nay have been exposed and told her to go to the hospital to be checked out. The worker walked into the emergency room, signed in, and took a seat with other patients. When her name was called, she walked to the desk and told them about encountering the letter. Emergency room staff immediately led her to an isolation room in the in the facility where she was decontaminated 30 minutes later with soap and water. Her clothes were bagged and she was given a scrub uniform. She was then monitored for signs and symptoms for 3 hours—until the FBI assured the hospital staff the letter was a hoax. The wastewater was contained and also turned over to the FBI.

As a result, the emergency room was quarantined and immediately went into its own internal disaster plan. Besides the FBI and the Chicago HAZMAT team who arrived in level C PPE, the staff also notified the Infectious Disease Center, the Illinois Department of Public health, and the hospital's medical director. All emergency room personnel involved remained quarantined until the substance was determined benign three and a half hours later. The hospital is now considering putting in some kind of screening process to identify why each person has come to the emergency room before being allowed into the emergency room for treatment.

These other events collaborate the findings from the in-depth case studies. Mainly, these incidents present evidence of the difficulty of identifying unusual substances by first responders, that medical facilities remain particularly vulnerable to contamination from potential victims that can close emergency rooms for hours, and that there is a chaotic overlap of jurisdictional responsibility for reporting and responding to a toxic or biological incident. The studies also demonstrate that members of the public suspected additional terrorism events after the September 11 attacks and the anthrax mailings and were prepared to take additional precautions to protect themselves and their communities.

4.14 GENERAL FINDINGS FROM CASE STUDIES

The findings from the case studies in this report support many of the general findings from the literature review.

Lack of resources

The lack of resources at the local level delays the identification of the contaminant(s) and consequently the appropriate response procedures, including the need to decontaminate civilians potentially exposed. Delays are further exacerbated by the time required to elicit outside assistance and information about the toxicity and health effects of the contaminate, even when available online (EPA, ATSRD, etc.) or other resources (Chemtrac). However, information contained in MSDSs about chemical characteristics, reactions, and health effects are not consistent among manufacturers who develop them and can confuse both secondary vendors and responders.

This issue is a problem in large urban areas (such as Washington, DC) as well as smaller communities, but is more problematic in smaller communities where first responders are frequently volunteers without the expensive training for hazardous or unfamiliar substances, whether chemical or biological. In larger communities assembling expert teams from various jurisdictions takes valuable time when immediate (within minutes) decontamination may be necessary. Hours can pass before an expert team arrives to assist local responders.

Although plans may be in place between facilities with hazardous materials and local responders as required by SARA Title IV, the information on current inventories on site is often months out of date, contributing to the uncertainty and difficulty of handling incidents that release substances. The dynamic nature of the chemical industry and the push to reduce or limit quantities of materials on site by facility managers are also contributing factors.

Decontamination as precautionary measure

The HAZMAT model to decontaminate people as a precautionary measure is evident throughout the case studies and is not based on scientific criteria. The case studies also demonstrate that self-reports by civilians as to proximity to the substance are often used as the decision criteria for potential exposure. This results in unnecessary decontamination of non-contaminated individuals, poor use of public resources, and unnecessary trauma, especially to youngsters decontaminated without parental support or supervision.

This issue also reflects on the public's general lack of understanding about the risks from chemical and biological substances. For example, while mercury vapor is very hazardous, especially to children's neurological development, using drastic—and very expensive—measures to eliminate all material from surfaces may not be as important as long-term tracking individuals who handled the mercury inappropriately. Decontaminating children without requiring medical follow-up again reflects the HAZMAT departure from prevailing public health models.

Scientific criteria to determine the effectiveness of decontamination are lacking

Criteria to assess the effectiveness of decontamination efforts in the field are lacking at health care facilities receiving those people. As evidences by the case studies, field decontamination methods are considered as gross decontamination by emergency department personnel. This results in repetitive decontamination at the medical facility before victims are admitted for medical treatment. This leads to confusion on the victim's part as to why people were decontaminated at the site and the reasons for repeating the process.

The uncertainty about the effectiveness of field decontamination procedures is evident throughout the case studies. Given the low levels and uncertainty about the toxicity and health effects of many of the possible contaminants, the medical community's concern about secondary decontamination appears unwarranted. Except in large-scale mass decontamination by first responders, medical professionals and first responders require victims to remove and bag clothes and use identical decontamination solutions (often just soap and copious amounts of water or a one to 9 part bleach solution followed by soap and water). Since initial removal of clothing is reported to remove at least 75% of the contaminant, it would appear that medical facilities need better methods of determining the effectiveness of field decontamination efforts and tier their decontamination methods to those employed by EMTs or HAZMAT units.

In another case study the body of a deceased but contaminated victim enclosed in a body bag was not admitted to a hospital morgue because of the contamination. The facility required that the field HAZMAT team decontaminate the body before accepting it. Procedures to resolve such discrepancies about the effectiveness of decontamination methods are needed.

Difficulty in recognition of contaminated individuals by health professionals

On the other hand, unless warned, health care staff have difficulty recognizing patients that have been contaminated and are unprepared to effectively treat them without resulting in secondary contamination. In one study this led to secondary contamination of the emergency department staff and environment and the temporary closure of the facility while clean-up was performed over a period of several hours.

The situation can become even more complex when contaminated people self-evacuate to a medical facility and provide staff with no information either intentionally or unintentionally about the potential hazard. This is exacerbated by the lack of screening before physical entry to emergency medical departments. This situation likely extends to walk-in medical facilities but was not examined in this study. The result is unnecessary exposure to health care providers who should be the most protected during any emergency.

This issue also effects emergency medical technicians and paramedics who respond to an event.

Lack of effective detection equipment

The case studies clearly indicate the lack of equipment and technologies to determine when contamination exists is a major factor in decontamination incidents. This places emergency response personnel at risks and may delay implementing decontamination at the incident site. If contamination is not detected or recognized, victims that might require immediate attention to alleviate the effects of the contaminate will not receive immediate care. In one case study, the victim's symptoms were not recognized as life-threatening and resulted in subsequent death. In another study, a paramedic did not don protective equipment when accompanying victims to the medical facility and suffered from secondary contamination before arriving at the facility.

Commercial field equipment to detect biological agents may produce as many false positives as false negatives. Even with a negative result for biological agents in one study laboratory analysis was necessary to lift the evacuation order and allow people to reenter their homes. This occurred at night and resident were allowed to return about two o'clock in the morning. The case where ricin was initially detected by field equipment resulted in 22 persons being unnecessarily decontaminated at their workplace.

Initial routing of emergency 911 calls needs attention

Routing of emergency calls by 911 operators does not necessarily evoke a HAZMAT or public health response and can place responding police officers at potential risk. Although police officers are well-trained to handle crisis situations, they are usually not cross-trained to deal with hazardous materials incidents, especially with unfamiliar substances. In one case, officers without PPE secured and quarantined the site after finding victims lying on the ground outside the facility. When HAZMAT personnel arrived in full gear, communication was impeded between victims and responders.

Scientific methods to determine reoccupancy lacking

There are no systematic methods to determine when it is safe to reoccupy a structure. The decision to reoccupy a building is made on a case-by-case basis, often decided by the commercial vendor who performed the cleanup. Health officials may or may not be involved in the decision, especially if the structure is privately owned and not regulated or accredited by a state or local agency.

Media reports inadequate to extract information

In every case studied that was initiated by a media report, the findings from informants differed substantially from the media report on the number of people affected. Information from the media is being used in at least one national database without the concurrence of agencies or individuals involved in the actual event, such as firefighters, state or local emergency management agencies, or owners of buildings or companies.

People do not refuse to reoccupy decontaminated structures

No evidence was found from the case studies that people refuse to reoccupy a structure that was decontaminated. No one refused to reenter the Commerce Building during the three months of cleanup of the vault. A guard had to be stationed to keep people from the decontamination area when security roping failed to deter people from moving through the area. Even with the inconsistency and confusion on the number of anthrax spores needed to cause an inhalational infection, no one refused to reoccupy the Hart Senate Building when it was declared decontaminated. A survey taken a few months after the MARTA incident found that those who were affected during the incident had returned to using the rail system without qualms.

No systematic procedures to control wastewater from decontamination exist

Procedures for disposing of wastewater from decontamination efforts—which rely on large amounts of water—are not systematic. This can result in unnecessary expenditures for municipalities or possible contamination with persistent agents downstream. One study found that a municipality was forced to pay a vendor a large sum even when the contaminant was found non-existent in the wastewater.

Alternative methods to decontaminate people with bleach or water and soap are lacking

No technologies offer an alternative to the use of soap and water or a diluted bleach solution for decontaminating skin of civilians at this time. HAZMAT and medical personnel rely on these techniques even when water may cause a reaction with the substance (as occurred in one case study) or when the contaminate affects the body through inhalation or ingestion (the mercury incident).

PPE is ignored in routine medical evaluations

Medical staff finds PPE that requires respirators and special clothing cumbersome to treat contaminated patients. Routine evaluations of patients even when potentially contaminated —in emergency departments are made without appropriate PPE and place staff and other patients at potential risk of secondary contamination.

Psychological implications of decontamination experience is discounted

Information (either verbal or written) about the potential reactions of people who have through decontamination helps people understand the psychological reactions they might experience and may alleviate future distress leading to more trauma. This was evidenced in one case where students underwent decontamination to an unknown substance; one student later that evening self-reported to the emergency department citing on-going problems, all of which were psychological in nature. A medical facility in one study routinely provides preprinted information fact sheets written by a staff psychiatrist to patients that have undergone decontamination.

The hidden costs associated with the psychological impacts to those undergoing the process were never discussed as part of the cost of the decontamination efforts. Although we found no refusal to reenter structures, there is evidence from some of the studies that overreaction to potential contamination from an unknown substance occurs, especially since 9/11 and that public and private resources are wasted unnecessarily in resolving the situation. The large number of anthrax hoaxes responded to by emergency personnel as well as the FBI attest to this fear.

Emergencies involving decontamination of hazardous substances stretches the response functions of the agencies involved. Although most of the case studies were completed prior to Sept. 11, 2001 terrorist events and the mailing of anthrax-laced letters, the studies weave common themes associated with the decontamination of people, articles, and/or structures. It is evident a deep schism exists between the paradigms used in the HAZMAT and law enforcement communities and that held by the health care community. Both require the help of the other to adequately determine and treat the root cause of the problem. The problem of overlapping jurisdictional authority further complicates the problem.

The trust agencies place on vendor's affirmation of cleanliness of structures, as evidenced in the case studies, may have suffered with the widely publicized problems in determining the safety of reoccupation following the clean up of the anthrax contaminated Hart Building. Future case studies should examine this impact.

4.15 SIGNIFICANT ISSUES FOR CASE STUDIES

Table 4.15 summarizes the most significant issues that are associated with each of the case studies.

Table 2. Specific findings from case studies

Case Study	Description	Major Issues
1	Spill at mail distribution facility	Privacy—women decontaminated in makeshift unit held by firemen Unnecessary decontamination of most workers Effectiveness determined by vendor via negative air samples 911 call transferred to police rather than fire department
2	Spill at chemical plant	Training of volunteer firefighters inadequate Characteristics of chemicals unknown—water reacted with chemical Employee's body not accepted at hospital until decontaminated inside body bag
3	PCB release from electrical fire	Lack of detection equipment delayed response Overreaction on decontamination of people High cost of 3 month decontamination of building Secondary contamination issues from convergers to site
4	Mercury spill at school	Elementary students decontaminated in parking lot over storm drain Cross contamination because no perimeter control No follow-up of students (mercury can cause mental problems)
5	Organophosphate pesticide overheated at plant	Lack of inter-jurisdictional communications allowed victims to be admitted to ER without decontamination ER contamination closed facility for 2 hours Housekeeping staff cleaned—decision criteria to reopen ER unclear
6	Mercury found in airport postal hub	Bagged personal effects opened enroute at hospital to use cell phones Subjective report of exposure led to unnecessary decontamination Employees self-report to hospital following day unnecessary Misunderstanding of mercury's health effects

Table 2. (continued)

Case Study	Description	Major Issues

7	Inadvertent mixing of chemicals at plant	Substances unknown (MSDSs missing) Media photography decontamination scene made people hesitate to undergo process Pools used to collect decontaminated water overflowed
8	Unknown release in subway car	Substances unknown—never identified Miscommunication among agencies allowed passengers to continue travel to airport Train never checked for residual contamination
9	Unknown substances found at jail construction	Secondary contamination of emergency responders Loss of access to computer services 911 miscommunication resulted in non-contaminated victims arriving at hospital
10	Unknown substance sprayed in metro subway	Miscommunication allowed subway car to continue travel No PPE for first responders put them at risk HAZMAT team assembly delayed response Respirators interfered with communication with others and victims
11	Anthrax contamination of commercial facility	Contamination unknown until employee's death Determined crime scene not health issue Decontamination costs at owner's expense delays cleanup
12	Anthrax contamination of senate building	Building decontamination cost over $14 million Length of decontamination—3 months Confusion on lethal spore dose Prophylaxis antibiotics distribution criteria unknown

5. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The findings from this study are especially relevant given the complex clean-up efforts forced on agencies after the anthrax contaminated letters were sent through the United States mail system. These incidents forced federal, state, and local health departments to reassess decontamination strategies and restoration clean-up plans for future events. The efforts have been exacerbated by a nervous public after experiencing the destructive events of Sept. 11, 2001.

5.1 JURISDICTIONAL ISSUES

One of the major findings from this study relates to jurisdictional boundaries—"who's in charge" is still a major issue. The major question is whether contamination should be viewed as a health issue, an environmental clean-up issue, or a FBI crime scene. When labeled a crime scene by authorities, how does that affect the public health officials striving to protect the public as quickly as possible? Who should have final jurisdiction over the clean-up process—the EPA, which is the designated federal agency for environmental restorations, the CDC, which is the designated agency for public health protection, the state, or local health departments, which may not have the resources or skills to identify unusual substances? Who should have final jurisdiction over the cleanliness of the facility - the owner, the health department, a certified private laboratory? The decision to declare an area a crime scene essentially shuts down any investigation by public health officials until all evidence is collected, which may jeopardize public safety.

Whatever the answer, the question of jurisdiction relationship involves a number of issues that are not resolved by current protocols or even draft procedures. Throughout the study respondents repeated the same lament-"no one seemed to be in charge," "communication was non-existent," or "in-fighting delayed getting things done." Particularly problematic were communications between on-scene responders and health care providers, which resulted in excessive decontamination, failure to decontaminate victims, and on occasion, temporary exposure of ERs. Thus jurisdictional issues have to be clarified if future events are to be dealt with more successfully.

5.2 LACK OF RESOURCES TO DETECT AND IDENTIFY CONTAMINANTS

Plans that were in place for identifying contaminants, the decontamination process itself, and determining when structures were clean enough to reenter, even when well exercised, came under severe duress when actual events occurred. For example, the concept introduced in 1998 of the tiered approach between laboratories for identifying unusual or biological agents such as anthrax or ricin is well established as a concept. Laboratories are classified as level A, B, C or D. Level A are local laboratories - the first line of defense. These are labs found in hospitals and medical schools who perform standard microbiological tests. As envisioned, each successive tier performs progressively more sophisticated tests to identify and confirm disease caused by organisms or toxins (Ember, 2001:27). But when the reality of the anthrax attacks occurred and the necessity to simultaneously gather samples for both clinical and environmental testing, the system was over taxed with redundant samples sent to multiple labs. For this reason level C and military labs were overwhelmed, often working 24/7 to accommodate the needs.

The problem with rapid identification of contaminants occurred across the board in our study. Rapid identification is important because response is predicated on accurate diagnosis. The "better to be safe than sorry" response of HAZMAT responders to unknown substance contamination involves large amounts of resources, both physical and monetary, and is often unnecessarily traumatic for those decontaminated. In one case study, we found that the waiting for results to confirm that no contamination was present resulted in a $5000 bill to the local community for disposal of wastewater used to decontaminate individuals. Had lack of the contaminant been identified early on, the community could have handled the disposal of water.

Findings from this study indicates that current technology employed in rapid field assessments is inadequate and often results in false positives as well as false negatives. In the anthrax investigations, the urgent need to identify organisms forced the FBI to use technologies such as the Navy's Smart Ticket that was developed to detect large amounts of biological material on the battlefield (Ember, 2001:30). The test can detect 8,000 -10,000 spores but below that range organisms will be missed, resulting in false negatives. In a study involving an unidentified powder, ricin was initially identified as the substance by using a hand held unit owned by the HAZMAT team. Based on the initial test, before lab tests came back negative for ricin, 22 people were decontaminated. Since the initiation of this study, officials have decided the field tests with commercial kits are inadequate for anthrax testing. All suspicious powders should be sent to certified laboratories for testing.

5.3 UNCERTAINTY OVER EXPOSURE AND HEALTH EFFECTS

Another issue is the amount of a contaminating substance or organism needed to cause a health effect. The current paradigm among responders is that exposure to a substance results in contamination, i.e., decontaminate as soon as possible. In the case study involving school children contaminated with mercury while handling the substance, the health impacts from mercury on children were clearly unknown. The resulting decontamination of the affected children was handled by the HAZMAT team in the school parking lot although both the principal and local health department employee strongly argued against the procedure. The school cafeteria where the mercury was also deposited had to be cleaned by a private firm who had to use special apparatus to identify where the substance was located. While mercury can be toxic in moderate amounts if ingested or inhaled, the negligible amount the children received while handling it did not appear to warrant the excessive measures taken to ensure their safety.

Material Safety Data Sheets (MSDS) vary significantly depending on the company producing them. Procedures should be developed to standardize health impacts from all chemicals and potential biological organisms and toxins. Delays perpetuated in prescribing antibiotics to mail personnel were unacceptable. In the anthrax cases relying on LD_{50} estimates and data abstracted from early studies was often misinterpreted, even among public health officials. Thus accurate records and databases need to be developed on chemical and biological substances.

The confusion on decontamination efficacy caused additional trauma to victims and resulted in excessive use of resources. Case studies which included trips to a medical facility after initial decontamination by hazmat teams found most victims were decontaminated again before entering the facility, sometimes as many as four times. Procedures should be worked out between responders, EMTs and medical facilities to determine what types of decontamination is appropriate so that people need to be decontaminated only once.

Some cases examined indicated that people self-evacuating to medical facilities should be better scrutinized before entering emergency rooms. One case involved total closure of emergency rooms in a regional medical facility for several hours because patients that self-evacuated brought chemicals on their clothes with them that off-gassed and sickened emergency room personnel. Procedures for entering medical facilities should be reevaluated before an accidental exposure causes severe loss of life.

5.4 METHODS OF DECONTAMINATION

There is a general lack of consensus of how to conduct decontamination of both buildings and people. The experience with the Hart Senate building illustrates the lack of standard protocols to clean up a structure following Anthrax contamination. The process was one of trial and error. Other biological agents can be used to contaminate structures. Will decontamination be done again on a trial and error basis? The experience with the Binghamton State Office Building should have provided a historical perspective on the problems that could be encountered with building decontamination, particularly in complex buildings.

A variety of prescriptive protocols for decontaminating people have been recommended in the literature. While many of the basic procedures are shared in common, some of the more detailed recommendations differ. This is a classic emergency management issue. An all hazard approach suggests a one size fits all solution, but different situations call for different procedures. Decontamination for exposure to chemical warfare agents is much different than for PCBs. Even for a single group of chemicals such as nerve agents, there is disagreement over the use of a bleach solution.

Another major uncertainty involves mass casualty situations. It is unclear if a community could carry out rapid decontamination in an event where a large portion of the community was exposed to a hazardous substance. Following the World Trade Center collapse, many people were decontaminated as they arrived in New Jersey via ferry. Gross decontamination (hose down, disrobe and put on tyvek suit) was conducted. A fairly high volume of people were processed, but it represented only a small fraction of those exposed in the incident. Furthermore, it was conducted by HAZMAT units with a high level of experience.

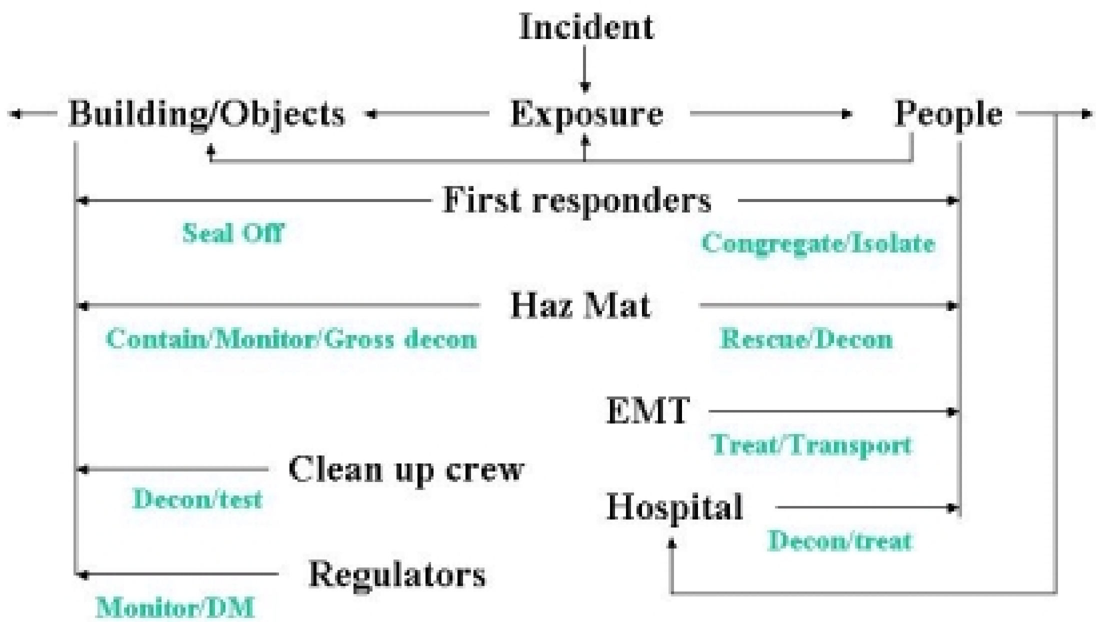
Finally, one neglected aspect of the decontamination process is short and long-term monitoring. Victims are discharged from decontamination locations without follow-up on their heath status. Patients are discharged from hospital and no long term monitoring is conducted. Decontamination protocols should address the issue of monitoring following actual procedures.

5.5 DECONTAMINATION PROCESS

Some of the key findings can be illustrated by using a systems approach to assess the

Figure 1. Decontamination process.

decontamination process. Figure 1. illustrates an overall view of the decontamination process. It



begins with a release of hazardous or harmful substance(s). The release can be accidental or intentional. The materials can be known or unknown at the time of release. The hazard can be real or a hoax, with or without documentation.

Following the release incident, people, buildings, objects and the environment (either within or outside structures, in the immediate vicinity or further away from the release) can be contaminated when exposed to the material released. Exposure impacts can be immediate or delayed. The impacts may be from a single exposure or develop or continue over time. Exposure can result from direct contact with liquid, inhalation of an aerosol or vapor cloud, through cross or secondary contamination, and through ingestion.

Before responders arrive at the scene of the release, people may leave the area of exposure either voluntarily, inadvertently, or through unofficial directives. This can also happen with objects, vehicles, companion animals, livestock, and wildlife that were exposed and contaminated.

Also, people carrying the contaminating substances on their clothes or bodies can expose others to the hazard through secondary contamination, i.e. off-gassing from the substances. Substances deposited on vegetation and vehicles from aerosols can rub off on people and animals and contaminate objects far from the initial scene of the release. People not initially exposed can enter a contaminated area unknowingly and become contaminated. In some events spouses were contaminated from washing clothes of workers exposed to hazardous persistent substances during work hours. The contaminant rubbed off the clothing and onto the hands of the spouse.

Local first responders are often the initial security personnel to arrive at the scene. If the alert came from a call to 911, the most likely responders are the police (the “blue canaries”), but also could involve fire personnel, or even "good Samaritans" or on-lookers helping victims to relocate to a "safe" place. Typically the first responder's initial task is to isolate and congregate people with potential contamination from the exposure, seal off a building from entry, and secure the perimeter from on-lookers and unofficial (i.e., media) visitors. Often this is done in an atmosphere of high uncertainty as to the nature and potential impacts of the release and with very little information on the hazardous characteristics of the substance(s). Especially problematic are those substances reactive with water that are made more hazardous by the common procedure of hosing down victims.

In a major incident a HAZMAT team may be next on the scene, but this can take several hours, especially in rural areas without major cities near-by or if members must congregate from several units. They may (or may not) be equipped to monitor and test the released materials. Often their first efforts are to contain and prevent further release of the substances and to initiate decontamination of people. Rescue efforts may also be performed to remove victims from a contaminated environment. If needed, EMT's with medical equipment and ambulances may screen, treat and transport victims to a hospital. Other victims may be released to continue with their activities. Still others may deliberately escape the scene at this point. Some may self-transport to medical facilities on their own without either decontamination or treatment by emergency personnel (as happened in Tokyo after the sarin incident). Further clean-up of buildings and property is generally left to outside vendors or specialized contractors.

Mortality cases may be left in body bags for periods of time until appropriate decontamination can be done by HAZMAT personnel. In some instances, individual belongings bagged by emergency responders for transport to medical facilities were used en route by victims or in the medical facility on arrival.

At the hospital patients transported by ambulance may again be decontaminated before being allowed in the emergency room for treatment. Alternatively people may self-report to the hospital without going through the field delivery process. These people may be a source of secondary contamination to hospital staff. Victim care typically ends with dismissal from the medical facility. Information to victims on the psychological effects of the experience generally does not occur, although some hospitals have instituted briefing procedures for victims before release from the facility in efforts to prevent repeat visits from victims. Follow-up care is often left to individual private physicians who may or may not be aware of the substances hazardous characteristics or the treatment conferred on the victim at the initial medical facility.

If a building or objects are involved, a commercial clean-up crew is often employed to decontaminate the structure and items. Sampling plans may or may not be developed. Tests may or may not be conducted to determine if a building is clean and ready to be reoccupied. The degree of thoroughness is often problematic, depending on the agencies or vendors involved. Commercial facilities, especially chemical or large industrial complexes, may rely on in-house services, Chem-Trec (a chemical consortium), or other industry analysts and commercial laboratories for confirmation of decontamination success. Regulators may become involved to monitor the building environment and to enforce relevant re-entry criteria or health standards, especially if medical facilities or public spaces are involved. OSHA becomes involved if there are deaths or a significant number of accidents occur. EPA, CDC and other federal and state agencies may intervene when public structures or infrastructures are involved.

Buildings can be decontaminated numerous times (the Hart building in DC) and the process can take from days to years (Binghampton NY). Costs, already high in use of public resources, can escalate exponentially if clean-up must be redone. Except in cases of mass hysteria among children and adolescents, the psychological costs have not been attached to the trauma exacted by the incident.

5.6 RECOMMENDATIONS

The discussion of the decontamination process in general and the findings from specific case studies and literature search raise a number of broad issues.

How can standardized protocols be incorporated into decontamination management? The lack of protocols has led to unnecessary decontamination when needed (common when entering hospitals), no decontamination when it was needed (as on the subway cars), and poorly implemented decontamination in other cases (as occurred with students in outdoor areas). We strongly recommend an investigation of protocols that exist nationally, their strengths and weaknesses, and lessons learned when used by practitioners.

How can communications be improved? Even with improved technologies and plans in place, communications between and within agencies and jurisdictions remain a major deterrent in decontamination efforts. Communications generally improve when face-to-face contact prior to an incident have been made. Exercises that emphasize such contacts should be incorporated into community plans. Some medical facilities regularly send emergency room staff on routine first responder calls or have EMTs schedule time in emergency rooms. Additional training or contingency options for 911 operators may be necessary to improve coordination of resources and communications.

How can the lessons learned from this study be used to improve mass casualty decontamination? Mass casualty situations are uncommon and require unique response actions. As in other disaster situations, emergency care often falls to those on-scene. We strongly recommend a nation wide public education program to teach self- and buddy- decontamination techniques. In a crisis situation reliance on federal or regional resources that may take hours to staff is ill advised. Although first responders usually arrive within minutes, those resources are quickly overwhelmed.

For a chemical release exposure requiring an immediate response, the window of opportunity to decontaminate and prevent casualties can be very slim - within minutes for nerve agents. That medical facilities are unprepared for immediate mass care decontamination indicates more robust and comprehensive outreach programs between medical staff and first responders are critical to effectively handle future incidents. Treatment that includes 2 or more decontaminations is wasteful of time and resources. We recommend a systematic study of field and medical facility decontamination procedures to determine how decontamination can be relegated to a one-time experience acceptable to medical personnel. Employing a health perspective instead of a HAZMAT deterministic procedure could prevent unnecessary decontamination, especially among the more vulnerable population groups such as children.

As the study reflects, the issues of “How Clean is Safe” are complex and multi-dimensional and will require input from many different communities. The need to start addressing the problems can begin with the institution of national database to capture and disseminate decontamination information, placing the issues on the public health and medical agendas, and insuring that public education efforts are made to inform the citizens of the United States what they can do to prevent or reduce potential exposure to toxic substances. At present determining how clean is safe is highly subjective, generally without scientific input, and open to a broad range of interpretation.

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