Chapter 2. Methods

Technical Expert Advisory Panel

For advice on the scope of the project, refinement of the Key Questions, and preparation of this Evidence Report, we consulted technical experts in the following fields: bioterrorism/biodefense, public health, supply chain management, surveillance, disaster epidemiology, disaster logistics, and emergency management (Appendix A).

Target Audience and Population

The decisionmakers addressed in this Evidence Report are clinicians, emergency preparedness officials, public health officials, and policymakers. For the purpose of this Report, clinicians include all clinical health providers such as physicians, nurses, respiratory technicians, and community health workers. First responders include paramedics, fire, police, and hazardous materials professionals. Public health officials and policymakers include those at the local, state, federal, and international levels.

The ultimate target population of this Report is the U.S. population at risk for morbidity or mortality resulting from bioterrorism. We are interested in systems and organizations relevant to regionalized bioterrorism preparedness plans that affect the entire U.S. population at risk for bioterrorism, including those of all racial and ethnic backgrounds, all ages, and both genders.

Key Questions

We developed the Key Questions in collaboration with AHRQ and our Technical Expert Advisory Panel.

The Key Questions addressed in this Report are:

1. What are the key tasks of local responders such as local public health officials, clinicians, and emergency medical personnel during a bioterrorism event?

2. What resources (e.g., laboratory supplies and services, vaccines and pharmaceuticals, hospital capacity, training, and information) do local responders require to perform the tasks identified in Key Question 1?

Note: Appendixes are provided electronically at http://www.ahrq.gov/clinic/epcindex.htm

3. Which existing regional systems for delivery of goods and services could be relevant to supplying the resources identified in Key Question 2? Which elements of these systems have been critically evaluated? What are their strengths and limitations?

4. Can regionalization of bioterrorism preparedness planning facilitate supplying needed resources (including personnel, material, and information) to local responders during a bioterrorism event?

5. How do geographic variations in the affected population (e.g., urban as opposed to rural), special populations (e.g. children, elderly, or disabled), and the interplay of private and public sector players affect regionalized systems?

Development of an Analytic Framework

The analytic framework for this Report advanced logically from our 2002 Evidence Report for AHRQ titled, "Information Technologies and Decision Support Systems for Bioterrorism Preparedness."[3] In that 2002 Report, we evaluated the potential utility of 217 information technologies and decision support systems designed to support the tasks and decisions of clinicians and public health officials during a bioterrorism response. For the current project, our analytic framework focuses on the decisions and tasks of local responders and the resources (i.e., material, trained personnel, and information) they require to perform their key tasks. We considered how these tasks changed depending upon whether they were performed by local, state, or federal responders (i.e., depending on the unit of regionalization). To inform our analytic framework, we sought published guidelines describing relevant tasks associated with robust bioterrorism response planning, such as those published by government and professional organizations,[4-8] the Institute of Medicine,[9] individual state plans,[10-15] the Joint Commission on Accreditation of Healthcare Organizations' list of potential hospital criteria,[16-28] guidelines published by the American Hospital Association,[29, 30] and input from our Expert Advisory Panel. We describe the development of the specific evaluation criteria in the "Determination of Methodologies for Evaluating Relevant Regional Systems" section of this chapter.

Development of Inclusion and Exclusion Criteria

Based on input from our expert advisors, our conceptual model, and practical considerations, we developed inclusion and exclusion criteria to identify potentially relevant systems of regionalization for bioterrorism preparedness and response. Two types of articles potentially met our inclusion criteria. First, we sought articles describing systems specifically designed for regional bioterrorism or related disaster preparedness or response (e.g., the Strategic National Stockpile, the Metropolitan Medical Response System, the Disaster Medical Assistance Teams, and the Laboratory Response Network). We searched for articles that described the design,

implementation, or evaluation of these systems at local, state, federal, and other regional levels (i.e., multi-county, multi-state, international). Second, we sought articles describing systems that have regionalized the key tasks and decisions outlined in our conceptual model (e.g., evaluation of triage methods used in trauma care) and articles describing the regionalization of the distribution of bioterrorism-relevant material, trained personnel, and information (e.g., case studies from supply chain management that describe cost-effective design of manufacturing, distribution, and warehousing networks).

We excluded articles describing regionalization of medical services for chronic conditions or other services that do not necessitate a rapid response. We excluded articles about specific bioterrorism-preparedness material (e.g., descriptions of personal protective equipment or rapid diagnostic tests) unless those articles discussed the use of such equipment as part of a bioterrorism response or preparedness plan. Because training, exercises, and bioterrorism preparedness drills for hospital personnel and other first responders has been the topic of other Evidence Reports prepared by the Johns Hopkins University Evidence-Based Practice Center,[31] we did not include systems principally intended to support responder training or exercises and drills.

Development of Search Strategies

The objective of our search strategy was to identify systems and regional organizations that perform tasks relevant to a bioterrorism response, as identified in our conceptual framework. The heterogeneity of these tasks necessitated a search strategy that differs in two significant ways from traditional systematic reviews of health care topics. First, many relevant systems are described in non-medical sources such as the supply chain management and emergency management literatures. Because these literatures have not been cataloged in comprehensive databases like MEDLINE®, they cannot be systematically searched using keywords. Thus, it was necessary for us to seek bibliographic recommendations from our Expert Advisors in order to perform manual searches of the tables of contents of relevant journals and conference proceedings, as well as to conduct Web searches for information disseminated by relevant organizations.

Second, because of the many types of potentially relevant systems and regional organizations, and the diverse literature on each relevant system, we did not attempt to collect all published reports of any included system. Instead, we adopted an iterative search strategy of preliminary searches to identify potentially relevant systems, followed by focused searches to evaluate the relevance of such systems to regionalization of bioterrorism preparedness. We performed the preliminary searches of each relevant literature source in a hierarchical manner: we searched for systems specifically related to regionalization of bioterrorism preparedness, planning, and response prior to searching for systems associated with less specific bioterrorism-related events (e.g., infectious disease outbreaks, natural disasters, and man-made disasters). For example, we performed focused searches to identify published reports of the responses of the American Red Cross to bioterrorism-relevant events, particularly those that discuss the effects of regionalization on such a response. We did not include descriptions of Red Cross responses to non-bioterrorism-relevant events. Similarly, we did not attempt to evaluate the preparedness plans and capabilities of every public health and emergency management jurisdiction in the

United States. Instead, we sought a general understanding of local and state public health approaches by reviewing a representative sample of geographically distributed and organizationally diverse public health infrastructures.

Identification of Literature Sources

Published work on bioterrorism preparedness planning and on regional systems for delivery of goods and services is found in four primary literature sources: the medical, emergency management, and supply chain management literatures, and government documents. We developed separate search strategies for each of these literature sources. Details of our literature sources are presented in Table 1.

From the medical literature, we sought articles describing bioterrorism preparedness plans, vaccination strategies, and evaluations of regionalized health care delivery systems. For this literature we searched two databases (MEDLINE® and Cochrane), bibliographies of relevant articles, Web sites of relevant organizations (e.g., American Hospital Association, the National Association of County and City Health Officials), and reference lists provided by our Expert Advisors (Table 1).

From the emergency management literature, we sought case studies of emergency responses, descriptions of disaster preparedness plans, and evaluations of disaster responses. For this literature, we searched six databases (e.g., HazLit), reviewed the past five years of articles from four prominent journals in the field of emergency management (e.g., *Disasters*), and searched Web sites of relevant organizations (e.g., the Natural Hazards Center at the University of Colorado at Boulder). We also reviewed reference lists provided by our expert advisors and bibliographies of included articles.

From the supply chain management literature, we sought case studies and articles about regional practices to increase the efficiency of manufacturing and distribution services and methods for evaluating supply chains. For this literature, we searched seven databases (e.g., databases of case studies at prominent graduate business schools), reviewed the past five years of articles from five prominent journals in the field of supply chain management (e.g., *Interfaces* and *Harvard Business Review*), and searched Web sites of relevant associations (e.g., the Institute for Operations Research and Management Science and the Fritz Institute). We also reviewed reference lists from our expert advisors and bibliographies of included articles.

Finally, from relevant government documents we sought local and regional bioterrorism preparedness plans, descriptions and evaluations of government programs responding to bioterrorism events (e.g., 2001 anthrax cases), and bioterrorism-relevant events (e.g., naturally occurring outbreaks and disaster responses). For this literature, we searched three government databases (i.e., GrayLit, the National Technical Information Services, and the National Academies Press), reviewed the past five years of articles from *Military Medicine*, and searched the Web sites of relevant government agencies (e.g., the Centers for Disease Control and Prevention and the Federal Emergency Management Agency), including those named as primary or support agencies in the Federal Response Plan.

Table 1. Literature Sources

Literature	Databases for published material (articles, books, reports, and Websites)	Key journals and conference proceedings	Examples of Relevant Organizations (for Web-based searches)
Medical	MEDLINE® Cochrane	Conference proceedings for the last two years (2001-2) for: American Medical Informatics Association Medical Decision Making Infectious Disease Society of America American Public Health Association American Pharmaceutical Association	American Hospital Association Joint Commission on Accreditation of Healthcare Organizations Council of State and Territorial Epidemiologists ProMED-mail National Association of County and City Health Officials National Professional Society of Pharmacists American Pharmaceutical Association Center for Civilian Biodefense Strategies
Emergency Management	Fire Academy (FEMA) HazLit (UC Boulder) Disaster! Finder (NASA) Global Emergency Management System Health and Safety Sciences Abstracts Risk Abstracts	*Disasters* *Prehospital Disaster Medicine* *Disaster Prevention and Management* *Disaster Recovery Journal*	Center for Excellence in Disaster Management and Humanitarian Assistance Natural Hazards Center (University of Colorado, Boulder)
Supply Chain	Harvard Business School case database Stanford Graduate School of Business case database Darden School of Business Administration (University of Virginia) case database Institute for Operations Research and Management Science (INFORMS) bibliographic database	*Interfaces* *Operations Research* *Management Science* *Harvard Business Review* *Manufacturing and Service Operations Management*	Institute for Operations Research and Management Science Fritz Institute American Red Cross
Government Documents	GrayLit National Technical Information Service National Academies Press	*Military Medicine*	Centers for Disease Control and Prevention (CDC) Federal Emergency Management Agency (FEMA) Metropolitan Medical Response System National Disaster Medical System (NDMS) Department of Veterans Affairs (VA) Health and Human Services (HHS) National laboratories U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) Global Emerging Infections System, Department of Defense (DoD) U.S. General Accounting Office (GAO)

Preliminary Searches

This section describes our preliminary searches for potentially relevant response organizations, bioterrorism-related and naturally occurring outbreaks, responses to natural disasters, and supply chain management cases.

Preliminary Medical Literature Database Searches

To identify potentially relevant articles in the medical literature, we searched MEDLINE® and Cochrane databases and references provided by our Expert Advisors.

MEDLINE® search strategies. We searched MEDLINE® (January 1966 to February 15, 2003) using the search terms described in Table 2.

Table 2: MEDLINE® Searches to Identify Potentially Relevant Systems and Organizations

Search	Search Terms	Citations reviewed	Articles retrieved
Bioterrorism-relevant Events			
Anthrax attack, 2001	"anthrax"[MESH] AND bioterror* AND 2001	219	25
Salmonella bioterrorism , The Dalles, Oregon, 1984	"food contamination"[MESH] AND "disease outbreaks"[MESH] AND Oregon AND salmonella	2	2
Natural Outbreaks			
Smallpox, New York City, 1947	"smallpox"[MESH] AND "New York City"	7	0
Smallpox, Boston, 1903-4	"smallpox"[MESH]AND Boston AND 1903	2	2
Hantavirus pulmonary syndrome	"hantavirus"[MESH] AND "Disease Outbreaks"[MESH]	90	30
Meningitis, Minnesota, 1995	"meningitis"[MESH] AND "disease outbreaks"[MESH] AND Minnesota	4	2
Meningitis, other	"disease outbreaks"[MESH] AND "meningitis"[MESH] AND "North America"[MESH]	112	49
West Nile Virus (WNV)	"West Nile Virus"[MESH]AND "North America"[MESH]	198	46
Cryptosporidiosis, Wisconsin, 1993	"cryptosporidium"[MESH]AND Milwaukee	22	9
Severe acute respiratory syndrome, 2002-3	“severe acute respiratory syndrome” OR “SARS virus”[MESH]	140	29
Natural Disasters			
Disaster planning	“Natural Disasters”[MESH] AND “Disaster Planning”[MESH]	525	87
Hurricane Andrew	"Natural Disasters"[MESH] AND "Hurricane Andrew"	92	43
Hurricane Hugo	"Natural Disasters"[MESH] AND "Hurricane Hugo"	48	12
Hurricane Iniki	"Natural Disasters"[MESH] AND "Hurricane Iniki"	12	4
Loma Prieta earthquake	"Natural Disasters"[MESH] AND "Loma Prieta"	27	13
Northridge earthquake	"Natural Disasters"[MESH] AND "Northridge"	34	3
Mass Gatherings			
Olympics	Olympic* AND (surveil* OR “disaster planning”[MESH])	43	33
Political conventions	“Disaster Planning”[MESH] AND “Politics”[MESH]	64	21
Sporting events	"sports"[MESH] AND "disaster planning"[MESH]	32	29
Hajj-related	"disease outbreaks"[MESH] AND hajj	13	7
Man-made disasters			
Bombings	(“Terrorism”[MESH] OR bombing) AND “Oklahoma City”	85	24

Search	Search Terms	Citations reviewed	Articles retrieved
Sarin attacks, Tokyo, 1995	“Tokyo”[MESH] AND “Sarin”[MESH]	24	9
Plane crashes	"Disasters"[MESH] AND plane AND crash	20	7
Nightclub disasters	Nightclub AND (fire OR stampede)	1	1
Bhopal chemical spill	"Disasters"[MESH] AND Bhopal	95	12
Chernobyl nuclear disaster	"Disasters"[MESH] AND Chernobyl	44	9
Preparedness Plans for Bioterrorism			
General preparedness plans	Bioterror* AND “disaster planning”[MESH]	385	155
Hospitals plans	"disaster planning"[MESH] AND "hospitals"[MESH] AND bioterror*	18	17
Public health department plans	"public health"[MESH] AND "disaster planning"[MESH] AND bioterror*	213	81
Government plans	"Government"[MESH] AND "disaster planning"[MESH] AND bioterror*	74	61
Laboratories plans	"laboratories"[MESH] AND (bioterror* OR "disaster planning"[MESH])	55	21
Bioterrorism-relevant Tasks			
Planning and Preparedness			
Relationship development	"disaster planning"[MESH] AND ("relat*"[TITLE/ABSTRACT] OR "partner*"[TITLE/ABSTRACT])	3	3
Warning systems	“warning system” AND “disaster planning”[MESH]	6	4
Resource stockpiling	stockpile AND (disaster[MESH] OR bioterror*)	15	9
Field Assessment and Triage			
Rescue and stabilization of victims	("emergency treatment"[MESH] OR "emergency medical services"[MESH]) AND bioterror*	94	77
Rescue and stabilization of victims	("Regional Medical Programs"[MESH] OR "regional health planning"[MESH]) AND ("trauma centers"[MESH] OR "burn units"[MESH])	240	115
Transportation of victims	transport* AND bioterror*	14	7
First responder protection	("safety management"[MESH] OR "first responder"[TITLE/ABSTRACT] OR “personal protect*”) AND bioterror*	13	12
Field assessment	“Emergency Medical Services”[MESH] AND bioterror*	100	78
Triage	“triage”[MESH] AND bioterror*	9	6
Hazard assessment	(hazard OR danger) AND assess* AND bioterror*	4	3
Diagnosis			
Diagnosis and agent identification	("diagnostic equipment"[MESH] OR "laboratories"[MESH]) AND bioterror*	42	19
Management			
Decontamination of victims	"decontaminat*"[TITLE/ABSTRACT] AND bioterror*	20	9
Definitive medical care	("critical care"[MESH] OR manag*) AND clinic* AND bioterror*	24	12
Definitive medical care	("regional health planning"[MESH] OR "Regional Medical Programs"[MESH]) AND "Intensive Care Units, Neonatal"[MESH]	79	40
Distribution of supplies, equipment, pharmaceuticals	(“equipment and supplies”[MESH] OR pharmacy*) AND distribut* AND bioterror*	20	13
Prevention			
Immunization and prophylaxis	("mass immunization"[MESH] OR prophylax*) AND bioterror*	74	48
Isolation and quarantine	("quarantine"[MESH] OR "patient isolation"[MESH]) AND bioterror*	16	12
Surveillance			
Surveillance	(“epidemiology”[MESH] OR surveil*) AND bioterror*	135	103
Detection	Detection AND bioterror*	58	32
Outbreak Investigation			

Search	Search Terms	Citations reviewed	Articles retrieved
Outbreak investigation	“Contact Tracing”[MESH] AND bioterror*	0	0
Evaluation of responder, caregiver and victim health	"epidemiologic methods"[MESH] AND bioterror*	268	81
Communication			
Communication system development	("communication"[MESH] OR "communications media"[MESH]) AND bioterror*	81	46
Addressing the information needs of the public/media	("telecommunications"[MESH] OR "persuasive communication"[MESH] OR "Information dissemination"[MESH] OR "mass media"[MESH] OR "Hotlines"[MESH]) AND bioterror*	33	19
Emergency Management			
Command and control	(“incident command” OR “command and control” OR command control”) AND bioterror*	5	5
Volunteer utilization and control	("international agencies"[MESH] OR volunteer*) AND bioterror*	38	13
Mental health services for responders, victims, caregivers and families	("mental health"[MESH] OR counsel*) AND bioterror*	7	6
Fatality management	("coroners and medical examiners"[MESH] OR "fatality management") AND bioterror*	5	2
Mutual aid agreements	“mutual aid”	143	11
Bioterrorism-relevant Resources			
Material			
Pharmaceuticals and related equipment (syringes, gloves, etc.)	pharm* AND bioterror*	32	15
Communications equipment	Communicat* AND equipment AND bioterror*	3	3
Patient transportation equipment, including helicopters and ambulances	"Transportation of Patients"[MESH] AND bioterror*	2	2
Laboratory	"laboratories"[MESH] AND bioterror*	44	15
Trained personnel			
General personnel	Personnel AND bioterror*	157	48
Medical: physicians, nurses, hospital administrators, pharmacists	(doctor*[TITLE/ABSTRACT] OR nurs*[TITLE/ABSTRACT] OR physician*[TITLE/ABSTRACT] OR pharmacist*[TITLE/ABSTRACT] OR administrator*[TITLE/ABSTRACT]) AND bioterror*	92	66
Public health: local, regional, state and national officials; epidemiologists	"public health"[MESH] AND ("local"[TITLE/ABSTRACT] OR "state"[TITLE/ABSTRACT] OR "epidemiolog*"[TITLE/ABSTRACT]) AND bioterror*	65	58
Emergency response	("Emergency Medical Technicians"[MESH] OR firefighter*) AND terror*	35	10
Total		4669	1852

The use of the asterisk expands search terms such that all combinations of terms with the phrase preceding the asterisk will be returned in the search (e.g., bioterror returns searches for bioterrorism, bioterrorist, bioterror, etc.).
MESH = Medical Subject Heading

Cochrane search strategies. We searched the Cochrane databases from January 1, 1990 through May 1, 2003 (Ovid, Evidence Based Medicine Reviews Multifile) using the search terms described in Table 3.

Table 3: Search Terms and Citations for Cochrane Databases

Search terms	Citations reviewed	Articles retrieved
Anthrax	7	0
Bioterrorism OR bioterrorist OR terrorism OR terrorist	1	0†
Salmonella AND outbreak	4	0
Outbreak	137	4
Smallpox	38	1
Hantavirus	4	0
Meningitis AND outbreak	11	1
West Nile Virus	2	0
Cryptosporidiosis	22	0
SARS OR severe acute respiratory syndrome	9	0
Disaster	31	1
Hurricane	3	3
Earthquake	6	4
(Olympic OR Olympics) AND (sport OR game)	3	0
national convention AND politic*	0	0
Hajj	2	0
Bhopal	0	0
Chernobyl	10	0
Emergency AND prepare*	13	0
AND government	2	0
AND hospital	73	0
AND public health	13	1
AND laborator*	19	3
Regional trauma	8	1
Regional burn	1	0
First responder	6	2
Triage	126	1
Mass immunization	7	1
Quarantine	7	0
Coroner OR medical examiner	1	0
Media and public and communication	28	4
Hospital capacity	2	0
Laboratory capacity	0	0
Disease surveillance	7	0
MMRS OR Metropolitan Medical Response System	0	0
DMAT OR Disaster Medical Assistance Team	1	0
National Pharmaceutical Stockpile	0	0
Total	613	27

The use of the asterisk expands search terms such that all combinations of terms with the phrase preceding the asterisk will be returned in the search (e.g., bioterror returns searches for bioterrorism, bioterrorist, bioterror, etc.).
†This reference discusses clinical aspects of the anthrax vaccine but does not address regionalization.

Preliminary Emergency Management Database Searches

We searched six emergency management databases, using a similar search strategy for each (Table 4). Two databases (NASA's Disaster! Finder and FEMA's Global Emergency Management System) were eliminated after we searched them using terms similar to the terms

listed below and determined that they did not contain reports or articles meeting our inclusion criteria.

Table 4: Search Terms and Citations for Emergency Management Databases

Search Terms	Fire Academy (FEMA)		HazLit (UC Boulder)		Health and Safety Sciences Abstracts		Risk Abstracts	
	Reviewed	Retrieved	Reviewed	Retrieved	Reviewed	Retrieved	Reviewed	Retrieved
Mutual aid AND (health* or medicine)	16	6	2	1	0	0	0	0
Bioterror*	123	23	0	0	43	7	33	11
Regionalization	45	14	6	2	13	1	0	0
Total	184	43	8	3	56	8	33	11

The use of the asterisk expands search terms such that all combinations of terms with the phrase preceding the asterisk will be returned in the search (e.g., bioterror returns searches for bioterrorism, bioterrorist, bioterror, etc.).

Preliminary Supply Chain Management Database Searches

The search strategy used for supply chain case databases (e.g., Harvard Business School's case database and the Stanford Graduate School of Business case database) and for other supply chain management databases (e.g., databases maintained by the Institute for Operations Research and Management Science (INFORMS)) is presented in Table 5.

Table 5. Search Terms and Citations for Supply Chain Databases

Search Terms	Harvard Cases		Stanford Cases		Darden Cases		Bibliographic INFORMS	
	Reviewed	Retrieved	Reviewed	Retrieved	Reviewed	Retrieved	Reviewed	Retrieved
Bioterror	0	0	0	0	0	0	0	0
Supply chain	65[†]	11	31	7	6	0	69	7
Disaster	12	1	0	0	7	1	8	2
Logistics	67	7	3	0	8	2	34	2
Terror	5	0	0	0	0	0	1	0
Total	149	19	34	7	21	3	112	11

[†]Note that these search terms were often duplicative; for example, not surprisingly, the supply chain and logistics searches in any given database often returned the same articles.

Preliminary Government Documents Database Searches

The search strategy employed for government databases is presented in Table 6.

Table 6: Search Terms and Citations for Government Databases

Search Terms	GrayLit		NTIS**		NAP[††]	
	Reviewed	**Retrieved**	**Reviewed**	**Retrieved**	**Reviewed**	**Retrieved**
Bioterror*	80	35	89	29	15	7
Disaster AND "preparedness plan*"	39	1	0	0	15	6
Laboratory AND region*	201	2	10[†]	0	15	2
Disaster AND (manage* OR	213	48	100[§]	29	15	2

Search Terms	GrayLit		NTIS**		NAP††	
	Reviewed	Retrieved	Reviewed	Retrieved	Reviewed	Retrieved
respon*)						
All Hazards AND "preparedness plan*"	50	2	0	0	15	5
All Hazards AND (manag* OR respon*)	148	1	0	0	15	4
Total	731	89	185	58	90	26

The use of the asterisk expands search terms such that all combinations of terms with the phrase preceding the asterisk will be returned in the search (e.g., bioterror returns searches for bioterrorism, bioterrorist, bioterror, etc.).
†laboratory AND regionaliz* ; §disaster AND management AND response; **National Technical Information Service; ††National Academies Press

Focused Searches

Having reviewed the citations obtained in our preliminary searches, we identified systems and organizations that performed one or more of the tasks identified in our conceptual framework or facilitated the timely distribution of relevant material, personnel, and information. We then performed focused searches of these systems and organizations for articles describing their participation in regionalized responses to bioterrorism-relevant events (Table 7).

Table 7. List of Potentially Relevant Systems for Focused Searching by Primary Task

Main Task	Example System or Organization
Planning and preparedness	Systems for training (e.g., National Laboratory Training Network; State fire training centers (FEMA); National Emergency Training Center (Federal Emergency Management Agency); Metropolitan Fire and Emergency Medical Services Training Program (Department of Justice); Public Health Training Network) Organizations for hospital preparedness (e.g., Joint Commission for the Accreditation of Healthcare Organizations, the American Hospital Association) National Domestic Preparedness Consortium National Domestic Preparedness Office (Federal Bureau of Investigation) Office of Emergency Preparedness Office of Public Health Preparedness Domestic Preparedness Program (DoD) Bioterrorism Preparedness and Response Program (HHS)
Field assessment and triage	Castro Halloween Party Emergency Management System (San Francisco) Aeromedical Evacuation System U.S. trauma care system
Diagnosis	Laboratory Response Network
Management of the acutely ill	Systems for tracking capacity (e.g., BEDTRACK, HERIS) Systems that regionalize trained personnel (e.g., *Medicins Sans Frontiers,* Medical Reserves Corps, Disaster Medical Assistance Teams (DMAT), National Pharmacists Response Team, National Nurses Response Team, Metropolitan Medical Strike Teams, National Medical Response Teams) Systems that regionalize delivery of specialized medical care (e.g., trauma care, burn units, neonatal intensive care systems) Rapid delivery of essential medical supplies (e.g., America's Blood Centers, American Association of Blood Banks, Organ Procurement and Transplantation Network, United Network for Organ Sharing) Hospital Emergency Response Data System Emergency Management Strategic Healthcare Group (VA)

Main Task	Example System or Organization
	Modular Emergency Medical System (i.e., Neighborhood Emergency Help Center and Acute Care Center) from U.S. Army Soldier and Biological Chemical Command Modular Assistance Medical System Metropolitan Medical Response System
Prevention of the spread of disease	Strategic National Stockpile
Surveillance	Influenza systems (e.g., FluNet, FluWatch, Worldwide Influenza Surveillance Program [DoD], EuroGROG) Syndromic surveillance systems (e.g., ESSENCE, BioSTORM, RODS) Surveillance for food borne illness (e.g., FoodNet, PulseNet) Healthwatch (U.S. Army) DARPA Biosurveillance Project National Electronic Disease Surveillance System National Weather Service Smallpox vaccine related surveillance systems (e.g., Smallpox Vaccine Adverse Events Monitoring and Response System, Hospital Smallpox Vaccine Monitoring System, Vaccine Adverse Event Reporting System) Global Outbreak Alert and Response Network Biowatch ProMed
Outbreak investigation	Epidemic Intelligence Service (EIS)
Communication	Among public health systems (e.g., Health Alert Network, Epi-X) Communication to the public (e.g., Amber Alert, FCC Public Safety Program, Emergency Alert System, Disaster News Network, Cable News Network (CNN), National Communications System, Homeland Security Advisory System, Farm Disaster Helpline) Warning systems for military responders (e.g., LERTCON system) Public Safety Radio Pool Rapid Response Information Center (FEMA) Warning systems for emergency medical services (e.g., FirstWatch)
Emergency management	Mutual aid agreements (e.g., California Master Mutual Aid Agreement, Emergency Management Assistance Compacts) Federal Response Plan Charitable organizations (International Federation of Red Cross and Red Crescent Societies, Red Cross, USAID) Federal Emergency Management Administration (FEMA) National Association for Search and Rescue Transportation systems (e.g., U.S. Postal Service, Federal Express) Global Expeditionary Medical Systems Chemical and Biological Rapid Response Teams (DoD), National Guard Weapons of Mass Destruction Civil Support Teams, Civilian Support Teams (National Guard), Emergency Response Team (EPA), Technical Escort Units (DoD), Strike Teams (Coast Guard), Chemical and Biological Response Teams (National Guard), DMORTs, Community Emergency Response Team Incident Management Systems (e.g., Unified Command System, National Interagency Incident Management System, Hospital Emergency Incident Command System) Enhanced Consequence Management, Planning and Support System Specially trained military responders (e.g., Soldier's Biological and Chemical Command, Chemical and Biological Immediate Response Force) Biological and Chemical Weapons Improved Response Program Joint Forces Command: Force Packages (DoD) Joint Programs Office for Biological Defense (DoD) U.S. Government Interagency Domestic Terrorism Concept of Operations Plan Bomb Data Center (DOJ)

Abstract Review

To identify potentially relevant articles for focused searching, at least one investigator reviewed each article. For the MEDLINE® search, two investigators reviewed a random selection of titles to ensure consistent application of the inclusion and exclusion criteria. Discrepancies in inclusion were resolved by discussion and re-review. An expert in the field of supply chain management research reviewed titles of potentially relevant cases from the supply chain literature.

Data Abstraction

All retrieved articles were reviewed by one or more investigators to determine if they met inclusion criteria. From each description or evaluation of a system, we abstracted the following data: information describing the regional system, methods and results of evaluations of the system, information about the quality of the study, as well as references in the bibliography that might meet inclusion criteria (Abstraction Form, Appendix B).

Determination of Methodologies for Evaluating Relevant Regional Systems

From each of the four literature sources (i.e., medical, emergency management, and supply chain management literatures, and government documents), we sought methods for evaluating the effectiveness of relevant systems. Specifically, we sought methodologies for evaluating whether a regional system would assist the key decisions and tasks required for effective bioterrorism preparedness and response. The following sections describe the relevance of each of the literatures to regionalization of bioterrorism preparedness planning, and describe our rationale for selecting the evaluation criteria from this literature. For each included article we abstracted information about only those evaluation concepts relevant to that article.

Evaluation Concepts from the Medical Literature

Evaluation concepts from the medical literature are relevant to considerations of bioterrorism preparedness because a major component of the response to bioterrorism includes the evaluation, treatment, and prevention of illness resulting from biothreat agents. Studies of health-related interventions vary with respect to outcomes and processes under evaluation. For example, evaluations of medical interventions (e.g., treatments for bioterrorism-related illness) may be designed to determine whether the intervention is effective, cost-effective, or safe. Such evaluations may directly measure clinical and financial outcomes (e.g., morbidity, mortality, or cost). Some evaluations of health care interventions consider process outcomes rather than

clinical outcomes. For example, evaluations of diagnostic decision support tools for bioterrorism may study whether the decision support tool increases the likelihood that a clinician makes the correct diagnosis, or orders an appropriate diagnostic test. From each included article we abstracted information about any evaluative outcomes of interest, including clinical, financial, and process outcomes such as morbidity, mortality, cost of the intervention, adherence to clinical protocols, and timeliness of administration of definitive medical care.

High volume has been associated with better health-related outcomes for numerous health interventions. Often the volume-outcome association is described in terms of "practice makes perfect," although there is the related phenomenon that physicians and hospitals with demonstrated excellence in clinical outcomes tend to receive more referrals and thus accrue larger volumes.[32] For example, as we will describe in greater detail in Chapter 3, sub-section "Application of Evaluation Criteria to the Trauma Literature," regionalized systems for the delivery of trauma care have achieved cost savings and improved health outcomes by concentrating the treatment of severely ill patients at trauma centers.[33-38] Because bioterrorism is a rare event, clinicians, public health officials, hospitals, and others have little opportunity to practice some bioterrorism-related response tasks (e.g., medical treatment of highly contagious, critically ill patients; and mass vaccination of an exposed population). By regionalizing services, some responders may gain sufficient skills for managing bioterrorism-related events. Thus, from each included article we abstracted information about how regionalization of bioterrorism-related services may increase the volume or expertise of response organizations, and thus potentially improve clinical or financial outcomes.

Evaluation Concepts from the Emergency Management Literature

Bioterrorism requires rapid responses characterized by the deployment of trained personnel (e.g., first responders, medical personnel, hazardous materials experts, and emergency management professionals), mobilization of supplies, and an effective command structure. Thus, evaluation concepts from the emergency management literature are relevant to considerations of bioterrorism preparedness. The emergency management literature largely comprises case studies (i.e., descriptions) of responses to particular events such as fires, hurricanes, and earthquakes. Occasionally, authors compare responses across similar types of disasters. The outcomes of interest in emergency management studies include morbidity and mortality associated with an event and responses to it;[*39, 40] the timeliness of the response; measures of cooperation, coordination, and communication among responders; and costs resulting from the disaster and/or the response.[41-45] The emergency management literature emphasizes the importance of a clear chain of command for efficient decision making and execution of response tasks, and repeatedly recommends the use of the Incident Management System when managing an emergency.[44] This system, developed in the 1970s in California for firefighting, is based on military command and

[*] Numerous articles about disaster responses describe injuries sustained by responders attempting to aid victims. For example, during the 1995 Tokyo sarin attack, 135 paramedics (9.9% of the total affected population), became ill after they were exposed to sarin from the clothes of victims. Similarly, following the 1985 earthquake in Mexico City, volunteers served a large role in rescuing victims trapped in collapsed buildings. However, the cost was considerable: 800 people were saved but 100 volunteers were killed during attempts to save victims. The enormity of the impact of this disaster on untrained volunteers stimulated several programs to train community members for natural disasters as described in greater detail in Chapter 3, sub-section "Lessons Learned from the Disaster Literature for the Regionalization of Services for Bioterrorism Preparedness."

control models, and has been expanded to an "all-hazard/all-risk" system routinely used in the management of a wide array of emergencies.[44] It includes "organization, unity of command, incident planning, integrated logistics and other key operational command and control elements."[46] From each included article, we abstracted information about any evaluative outcomes of interest, including emergency- and response-related morbidity, mortality, timeliness, costs, and information about the incident command structure used and how it affected the regionalized response.

Evaluation Concepts from the Supply Chain Literature

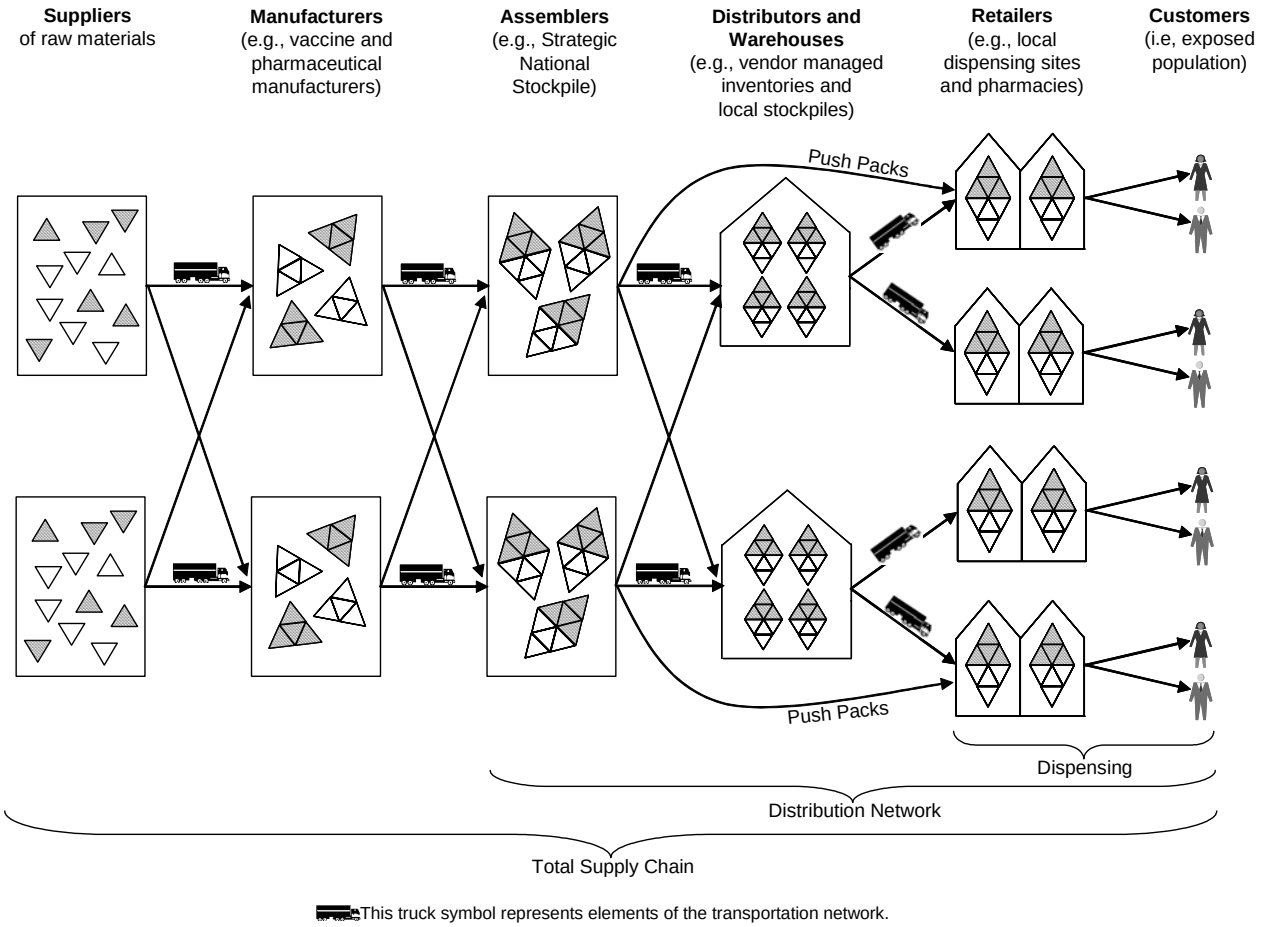
Supply chain management concepts are directly relevant to those elements of a bioterrorism response that require the purchase, inventorying, distribution, and rapid dispensing of medical supplies (e.g., antibiotics, vaccines, and equipment) to remotely located users (e.g., hospitals, pharmacies, and local dispensing sites). A traditional supply chain is the integrated network of entities involved in all aspects of the manufacture of goods, including the procurement of raw materials, their assembly into the manufactured product, transportation of the product to distributors, and distribution to final customers.[47] The bioterrorism response supply chain has several key components: suppliers of raw materials, manufacturers of goods (e.g., product manufacturers such as drug and device manufacturers), purchasers (e.g., group purchasing organizations, wholesalers, mail-order distributors, and federal and local government agencies), providers who distribute the products (e.g., clinicians, hospitals, pharmacies, integrated delivery networks, and dispensing sites), customers/payors (e.g., the government, employers, and individuals), and the transportation systems that connect these components.[48] The bioterrorism response supply chain is a particular type of health care supply chain. We direct interested readers to a recent comprehensive review of the health care supply chain by researchers at the Wharton School, University of Pennsylvania.[48]

Figure 1 presents the key components of the bioterrorism response supply chain. The supply chain entities labeled in bold (e.g., suppliers, manufacturers, and retailers) refer to the elements of a traditional supply chain (such as for the manufacture of pharmaceutics for routine health care delivery). Examples of the components of the bioterrorism response supply chain corresponding to the traditional supply chain are provided. Although all elements of the supply chain are essential, during a response to bioterrorism, until all antibiotics and medical supplies available through local stockpiles and the Strategic National Stockpile have been consumed, the last three elements of the supply chain—also known as the distribution network—are the most critical. The establishment and coordination of the distribution network is currently the focus of considerable planning by local, state, and federal officials.

To determine criteria for evaluating the bioterrorism response supply chain, we sought descriptions and evaluations of innovations in supply chain management. Evaluations of traditional (manufacturing) supply chains often include considerations of four logistical issues: *strategic* issues, *structural* issues, *functional* issues, and *implementation* issues.[49] Briefly, *strategic* issues involve determining customers' needs and the strategies used to meet them. For example, how should sufficient prophylactic antibiotics be acquired, stored, distributed, and dispensed to a population exposed to bioterrorism? *Structural* issues involve determining which functions need to be performed to achieve a desired level of service and which elements of the supply chain should perform them.[49] For example, how many distribution sites are needed to

supply an exposed population? Which customers and products will be served from each facility or antibiotic/vaccine stockpile? How much inventory should be held in each facility? *Functional* issues involve determining how various tasks will be carried out (e.g., transportation carrier selection, fleet management, warehousing, and inventory management).[49] *Implementation* issues involve creating the information systems to support the supply chain, and installing and maintaining facilities, equipment, and personnel.

Figure 1. The Bioterrorism Response Supply Chain



The literature is inconsistent in its use of the terms *dispensing* and *distribution*. In general, dispensing refers to the end of the supply chain when medical supplies are given to patients—it is the terminal component of the distribution network.

From each supply chain case study, we abstracted information about the supply chain innovation described, and the outcomes of interest. We now describe the five specific concepts from evaluations of supply chains that are relevant to the bioterrorism response supply chain about which we abstracted information from each included article: **network design**, **inventory management**, **postponement and modularization**, **supply chain coordination and management of incentives**, and **management of information**. (We present details of the data abstracted from the supply chain case studies in Chapter 3 under the section "Synthesis of Evidence About Regionalization of Supply Chains".)

Network design. Network design broadly encompasses decisions about the number and location of physical elements of a supply chain (e.g., manufacturing plants and dispensing sites), and relationships between them (e.g., transportation networks). Network design evaluations typically determine whether the number and location of manufacturing and distribution facilities are ideal for achieving strategic goals of the supply chain. The outcomes of interest in evaluations of network designs of traditional supply chains include costs saved, percentage of customer orders that can be filled immediately, and customer satisfaction. For example, an evaluation of network design may find that eliminating redundant distribution centers results in reduced total costs for the supply chain.[50-54]

For bioterrorism preparedness, the key elements of network design include the manufacturers and wholesalers of resources such as antibiotics and vaccines, regional distribution centers, warehouses, hospitals, pharmacies, and other local dispensing sites, and the transportation networks among them. For the bioterrorism response supply chain, the network design outcomes of interest are reductions in morbidity and mortality, and time to provide treatment and prophylaxis. For example, an evaluation of the network design of the bioterrorism response supply chain might determine whether local plans for distributing materials from the Strategic National Stockpile result in reduced response times and reduced bioterrorism-related morbidity and mortality.

Although many supply chains are designed with the minimal numbers of elements to create cost efficiencies, for some industries (particularly service industries), redundancies in the supply chain are essential to making the supply chain robust. This is particularly true for the bioterrorism response supply chain. For example, eliminating redundant distribution centers certainly reduces costs, but if that center should be attacked or otherwise incapacitated, the entire response supply chain could be compromised. Table 8 presents the key evaluation concepts associated with network designs of traditional (manufacturing) supply chains and bioterrorism response supply chains.

Inventory management. Evaluations of inventory management address the costs and benefits associated with maintaining numerous, small local stocks of needed resources, as opposed to regionalizing these into larger centralized inventories. The outcomes of interest in evaluations of the inventory management of traditional supply chains include costs of holding inventories, time to fill customers' requests, and timeliness and accuracy of inventory information. In general, evaluations of traditional supply chains demonstrate that the smaller the number of distribution centers, the lower the costs of holding inventory.[54, 55] However, some evaluations have found that, when delivery times are critical, increasing the number of distribution centers or locally held inventories improves customer satisfaction.[45] Typically, minimizing inventories while maintaining the ability to meet customers' demands requires accurate and timely information about supplies of raw materials and finished products, inventories available locally, and customer demands.[50, 56, 57]

The Strategic National Stockpile[*] (which will be discussed in greater detail in Chapter 3 in the context of responses to the 2001 anthrax incident) has been developed to regionalize the

[*]The Strategic National Stockpile maintains 12 Push Packs containing antibiotics, vaccines, and other medical supplies, which are stored in undisclosed locations around the country for deployment to emergency sites. Once ordered, a Push Pack is designed to arrive anywhere in the United States in 12 hours. The Strategic National Stockpile also maintains Vendor Managed Inventories, designed to arrive after the Push Packs (about 36 hours later). These are tailored according to the specific needs of the requester. The Strategic National Stockpile, formerly under primary CDC control, was previously called the National Pharmaceutical Stockpile and now operates under the control of the Department of Homeland Security.

inventories of resources such as antibiotics and vaccines for a bioterrorism response. For the bioterrorism response supply chain, the outcomes of interest in evaluations of inventory management are the costs of maintaining and storing inventories (including considerations of pharmaceuticals' shelf lives), time to supply the demands of the exposed population, and timeliness and accuracy of inventory information.

For example, an evaluation of a bioterrorism inventory management strategy might assess the costs and benefits of maintaining local inventories of antibiotics and vaccines as opposed to increasing the inventory maintained by the Strategic National Stockpile.

Postponement and modularization. Postponement refers to the concept of customizing a product late in the supply chain (i.e., closer to customer delivery). Modularization refers to the use of standard parts that can be used in multiple end products (so that less customization is required). Evaluations of traditional supply chains have found that product costs and inventories can often be reduced by delaying the customization of products and designing final products that can be assembled from common component parts.[58-61] For example, different countries' electrical standards require different plugs on appliances. Thus, electronic equipment manufactured for use in different countries can be designed with a base unit that carries several different plugs, allowing the appropriate plug to be attached, depending on the purchaser's needs. Designing the supply chain to postpone a part of the manufacturing or assembly process can reduce the cost of specifically customizing end products for each target market.[58, 59] Similarly, automotive manufacturers who design their new models to be built out of shared components have been able to reduce inventories of parts and increase profits.[59]

For bioterrorism preparedness, postponement and modularization are relevant for the efficient distribution and dispensing of antibiotics and other essential medical supplies. For example, the TOPOFF exercise demonstrated the importance of having pre-packaged antibiotics in assemblages of materials for use against numerous weapons of mass destruction attacks in the first hours and days after an attack.[62] Push Packs from the Strategic National Stockpile contain antibiotics, vaccines and other medical supplies necessary to respond to bioterrorism. These supplies are pre-packed for rapid dispensing. Recipients of the Push Packs dispense only those items required to combat their particular event. Later, Vendor Managed Inventories (customized inventories containing outbreak-specific resources), are sent to the dispensing site. The outcomes of interest in evaluations of the postponement strategies of traditional supply chains include costs of inventories and time to fill customer requests. Similarly, for the bioterrorism response supply chain, the outcomes of interest in evaluations of postponement strategies are the costs of inventories and time to supply the demands of the exposed population.

Supply chain coordination and management of incentives. Evaluations of supply chains have found that the diverse purchasing, manufacturing, and distribution organizations in a supply chain often operate independently and may have their own (often competing) objectives.[47, 53] Efforts to coordinate the activities of supply chain members may involve better management of information, inventories, and incentives. Explicit evaluation of the incentives offered to each member of a supply chain, and efforts to align these incentives, have resulted in significant cost savings and improvements in customer satisfaction. For example, a cash bonus may be offered to a supplier who modifies his information system to better integrate with the other members of the supply chain, thereby improving the overall efficiency of the supply chain.

For bioterrorism preparedness, incentives might include monetary payments, additional supplies, additional power to respond to potential bioterrorist events, and for some organizations (such as the Red Cross) positive media exposure. (The flows of money associated with the health care supply chain are highly complex. A detailed analysis of these is outside the scope of this project; we direct interested readers elsewhere.[*48])

Management of information. Evaluations of supply chains demonstrate that accurate and up-to-date information about the level of raw materials, finished products and their locations, and customer demands are essential to keeping inventories low and supplying customers in a timely manner.[49, 52] Sophisticated supply chain management information systems—in addition to real-time tracking of products through the supply chain—include decision support tools that optimize routing and scheduling and minimize costs of component parts and inventories.[48, 57] In the health care industry, during the process of ordering goods, clinicians, pharmacists, and other customers submit purchase requests to a procurement officer who identifies the requested items in a distributor's catalog (often paper-based) and submits the order to the group purchasing organization and to the distributor.[48] These orders are communicated to the manufacturer for shipment. The industry is increasingly adopting a common electronic data platform for the direct electronic transmission of standard business forms (e.g., purchase orders, shipping notices, and invoices); however, this protocol is far from universal.[48]

For bioterrorism, management of information about the needs of local responders and the availability of regional inventories is an essential component of a coordinated response.

Table 8. Evaluation Concepts from the Supply Chain Literature and their Relevance to Regionalization of Bioterrorism Preparedness

Key Concepts and Evaluation Criteria For Traditional (Manufacturing) Supply Chains	Key Concepts and Evaluation Criteria For Bioterrorism Response Supply Chains
Network Design	
Entities: • Suppliers and manufacturing plants • Warehouses • Distribution facilities • Customers • Transportation network	*Entities:* • Antibiotic and vaccine manufacturers and wholesalers • Antibiotic/vaccine stockpiles (e.g., Strategic National Stockpile and local inventories) • Hospitals, pharmacies, and local dispensing sites • Exposed population • Transportation network

[*] The Wharton review of the health care supply chain describes some money flows among supply chain members as follows.[48] Products are sold by manufacturers—at prices set by them—to distributors. Distributors sell products to providers, typically at discounted prices resulting from contracts negotiated by a group purchasing organization. Distributors issue credits or rebates to the manufacturer for the difference between the list price that it paid for the goods and the discounted price (plus a handling fee) that it received from the purchaser. In general, the fees paid to distributors for shipping, marketing, and tracking products is about 1-2% of sales. Group purchasing organizations receive contract administration fees from the manufacturer, which typically amount to 2-3% of the sales contract. Depending on the purchasing organization, these fees are sometimes returned to its purchaser members. It is estimated that 40-67% of hospital supplies (approximately $25.1 billion) are purchased through contracts negotiated via national purchasing organizations. The remaining items are purchased via regional and local contracts.

Key Concepts and Evaluation Criteria For Traditional (Manufacturing) Supply Chains	Key Concepts and Evaluation Criteria For Bioterrorism Response Supply Chains
Considerations: • Determining the number and location of manufacturing and distribution facilities • Determining an appropriate distribution network for finished goods • Iterative improvement of an existing supply chain	*Considerations:* • The number and location of stockpiles of necessary resources such as pharmaceuticals, medical supplies, and equipment • Appropriate distribution network for these necessary resources • Iterative improvement of a bioterrorism response supply chain
Evaluation criteria: • Profit • Order fulfillment (percentage of customer requests that can be filled immediately from stock on hand)	*Evaluation criteria:* • Reduction in morbidity, mortality, timeliness of treatment/prophylaxis • Cost
Inventory Management	
Entities: • Inventories of raw materials and finished goods • Information systems that monitor inventories and customer demands	*Entities:* • Inventories of equipment and drugs • Information systems that monitor inventories of needed resources
Considerations: • The fewer distribution centers that serve a region, the less product they must stock to provide the same level of customer service • Fewer distribution centers can often provide the same level of service to customers with reduced total inventory • Marketing affects demand and subsequent inventory (e.g., advertisements for products may enhance demand and require changes in inventory management)	*Considerations:* • Resources required for a bioterrorism response can be held in regional stockpiles rather than in individual local communities • Regionalization of inventories of bioterrorism resources requires accurate and timely information about demands for these resources and the availability of local and regional stockpiles • Communication of information about a suspected or actual bioterrorism event may affect the behavior of the public to seek medical attention
Evaluation criteria: • Time to fill customers' demands • Costs of inventories • Timeliness and accuracy of inventory information	*Evaluation criteria:* • Time to supply the demands of the exposed population • Costs of inventories • Timeliness and accuracy of inventory information
Postponement and Modularization	
Entities: • Subassemblies (i.e., components of the final product) and final products	*Entities:* • Resources required for treatment and prophylaxis of bioterrorism-related illness (e.g., prophylactic antibiotics could be assembled into a variety of products of distribution including individual packages containing multiple days of adult or pediatric therapy)
Considerations: • Products are customized for a specific market late in the supply chain • Products are designed in modular parts that can be used in a variety of end products • Postponement and modularization can minimize inventory while still providing a high level of customer service	*Considerations:* • Individualized packets of supplies can be prepared regionally to reduce the preparation time required at the local dispensing site to divide up and repackage the antibiotic arriving in 500+ tablet shipments. (The Push Packs have pre-packaged antibiotics in 10day regimens and the Vendor Managed Inventories provide pre-packed 25-day regimens.)
Evaluation criteria: • Time to fill customers' demands • Costs of inventories	*Evaluation criteria:* • Time to supply the demands of the exposed population • Costs of inventories

Key Concepts and Evaluation Criteria For Traditional (Manufacturing) Supply Chains	Key Concepts and Evaluation Criteria For Bioterrorism Response Supply Chains
Supply Chain Coordination and Management of Incentives	
Entities: • Partners in the supply chain: suppliers, manufacturers, distributors, retail outlets	*Entities:* • Partners in the supply chain: pharmaceutical companies, medical supply manufacturers, pharmacies, transportation companies, clinicians, hospitals, governmental agencies responsible for the storage and distribution of antibiotics, vaccines, and medical supplies
Considerations: • Coordination of activities of supply chain members results in lower cost and improved customer service • All partners in the supply chain are incentivized to work toward the same final goal • Different members of the supply chain have different financial incentives	*Considerations:* • Coordination of activities of all relevant bioterrorism responders results in quicker response and improved clinical outcomes • All relevant bioterrorism responders are incentivized to work to protect the public health • Different elements of bioterrorism response (e.g., clinicians vs. pharmaceutical manufacturers) have highly heterogeneous financial and legal responsibilities
Evaluation Criteria: • Profits for the overall supply chain • Satisfaction of supply chain partners	*Evaluation criteria:* • Speed and effectiveness of response to bioterrorism events • Clinical outcomes
Management of Information	
Entities: • Partners in the supply chain: suppliers, manufacturers, distributors, retail outlets • All relevant data	*Entities:* • All relevant bioterrorism response partners • All relevant data
Considerations: • Accurate information on inventory and parts made available in a timely manner to plan for resources required • Centralized database to manage the data, thus making all information readily available in one place	*Considerations:* • Accurate and timely information on inventories of pharmaceuticals, vaccines, medical supplies • Accurate information on number of infected cases and exposed individuals, and availability of personnel and supplies made available in a timely manner to allow for planning of resources required
Evaluation Criteria: • Data completeness and accuracy • Date timeliness (up-to-date)	*Evaluation Criteria:* • Data completeness and accuracy • Date timeliness (up-to-date)

Evaluation Concepts from Government Documents

Because a major component of the response to bioterrorism includes government agencies, evaluation concepts from the military, emergency response agencies, and other governmental responders are relevant to considerations of bioterrorism preparedness. In our review of government documents, in particular those from the military, we found that emergency responses often benefited from a clear chain of command and from careful review of the lessons learned from previous related responses. For example, in its report to NASA, the Columbia Accident Investigation Board described the Navy as having "institutionalized their 'lessons learned' approaches to ensure that knowledge gained from both good and bad experiences is maintained in corporate memory. This has been accomplished by designating a central technical authority

responsible for establishing and maintaining functional technical requirements as well as providing an organizational and institutional focus for capturing, documenting and using operational lessons to improve future designs."[63] From each included article, we sought to abstract information describing lessons learned from each response to bioterrorism-relevant events. In addition, for each broad category of included articles (responses to the 2001 anthrax cases, responses to naturally occurring outbreaks, and responses to natural disasters) we summarize the lessons learned relevant to a regionalized response to bioterrorism.

Simulation Model: Regionalization of Surveillance

Because of the importance of surveillance and the limited evaluative information available in the literature, we conducted supplemental analyses. These analyses were informed by the results of our previous review of the literature of syndromic surveillance systems for bioterrorism-related illness,[3] and additional information abstracted to specifically consider issues relating to the regionalization of surveillance.[64-77] In disease surveillance systems, surveillance data are analyzed to determine whether the number of observed cases exceeds a threshold for an expected number of cases. Locally collected surveillance data can be pooled in several ways to determine whether this threshold has been crossed (e.g., data from multiple hospitals or regions could be pooled, or data for several related syndromes could be pooled). Because each method for pooling surveillance data results in tradeoffs in terms of sensitivity and specificity, we used simulation to explore the effects of various strategies for regionalizing the analysis of surveillance data on the system's detection characteristics. The research questions that we addressed with this simulation model are an extension of Key Question 4. They are:

1. How does regionalization (i.e. pooling) of surveillance data change the probability of detecting an outbreak related to bioterrorism? How does it change the probability of false positives (i.e., false alarms)? Strategies that we considered for analyzing surveillance data were: analysis of local data alone, analysis of pooled data alone, and analysis of both local and pooled data.

2. How do the characteristics of the surveillance data (i.e., correlations in data among local sources) and the disease outbreak (i.e., small as opposed to large outbreaks) effect the pooling of surveillance data?

To answer these research questions, we simulated syndromic surveillance data for two regions (e.g., neighboring counties). We briefly describe this model and the assumptions we used to develop it in Chapter 3 in the section on "Simulation Model Results." We direct readers interested in the details of our simulation elsewhere.[78] Briefly, for each simulated day, we calculated an expected number of patients with syndromes of interest. We assumed that the correlations of disease incidence between the two local sources would be similar to that typically found in surveillance data. We varied the attack size to represent different sizes of bioterrorism events. We considered that an attack had been detected if the surveillance data exceed the thresholds used to distinguish between an expected number of cases and a larger than expected number of cases.

Simulation Model: Inventory Management

The literature is insufficient to evaluate another critical area of bioterrorism preparedness planning and regionalization: inventory management. Thus, we developed a simulation model to address the costs and benefits of differing strategies for pre-attack stockpiling and post-attack distribution of necessary pharmaceutical supplies such as antibiotics. Specifically, we developed a simulation model to evaluate the effects of changes in distribution capacity and policy on health outcomes following anthrax bioterrorism. The simulation model was informed by the results of our review of the literature of inhalational anthrax in the United States (these results are presented in Chapter 3). The research questions that we addressed with this simulation model are an extension of Key Question 4. They are:

1. What are the costs and benefits associated with maintaining local, limited inventories of material to be distributed before the arrival of a shipment from the Strategic National Stockpile? Costs include those of acquiring, maintaining, and storing the inventories; costs of durable and consumable goods; costs associated with the labor to manage and distribute the inventories; and costs associated with treatment of victims of an attack and deaths. Benefits include reduced time to distribute material, lives saved, and access to immediate prophylaxis by emergency responders.

2. What are the costs and benefits of increasing or decreasing the numbers of Push Packs maintained by the Strategic National Stockpile?

To answer these questions, we simulated an aerosol exposure to *B. anthracis* in an urban area of 5 million people. We briefly describe this model and the assumptions we used to develop it in Chapter 3. We direct readers interested in the details of our simulation elsewhere.[79] Briefly, this simulation model incorporates a model of anthrax disease progression in the exposed population and includes the effects of prophylaxis and treatment on disease progression and mortality. We considered scenarios in which the number of people exposed to an anthrax attack was different from the number of people who request prophylactic antibiotics. We used the simulation model to assess the outcomes associated with changes in the size of local inventories, as well as changes in the times required for distribution and dispensing of the Push Packs and regional Vendor Managed Inventories. We performed extensive sensitivity analysis to validate the output of the simulation.

Reviews and Revisions of Draft Evidence Report

In October 2003, we sent a draft of the Report to our expert advisors and to additional reviewers with expertise in bioterrorism/biodefense, public health, supply chain management, surveillance, disaster epidemiology, disaster logistics, and emergency management (Appendix A). We solicited comments on all aspects of the Report, using a structured comment form. The submitted Report incorporates the reviewers' input.