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Chemical, Biological, Radiological, and Nuclear Quarantine

Jeffrey D. Race, Carey Nichols, and Susan R. Blumenthal

Although the term *quarantine* is familiar to most physicians, nurses, and emergency medical services (EMS) personnel from their core training, it may mean many different things depending on where, to what level, or from which discipline or perspective someone was trained. The meanings of quarantine and isolation are quite often different between first responders and first receivers (i.e., those who work in hospitals). Within each first responder discipline (e.g., emergency medical technician [EMT] and paramedic, firefighter, and police officer), there are different roles to play and connections or responsibilities, as determined by position, training, and/or experience. Confusion often occurs between the terms isolation and quarantine; many people use the term quarantine to mean either isolation or quarantine. Both are public health measures used to control the spread of contagious disease:

- *Isolation* is used to separate and restrict the movement of those who are ill with a communicable disease.
- *Quarantine* is used to separate and restrict the movement of those who are still well but who may have been exposed to a communicable disease.

For the purpose of this chapter we will be using the term quarantine to refer to both isolation and quarantine because we will discuss quarantine in terms of both biological and nonbiological exposures.

The quarantine of any population is a troublesome matter for both the society involved and the government agencies overseeing the containment efforts. At a moment's notice a nation must mobilize significant resources to help triage, treat, and contain any communicable and potentially epidemic diseases or exposures. Making the decision to identify and then contain individuals certainly cannot be taken lightly and will have both political and logistical repercussions. For the purposes of this chapter the idea of quarantine will include the management of those exposed to chemical, biological, radiological, and nuclear (CBRN) disasters. In particular this chapter will examine and discuss processes to help control the spread of societal hazards, giving particular attention to medical triage and containment.

In the event of a terrorist attack or growing natural epidemic, a rapid quarantine effort can certainly help to mitigate the damage. Proper deployment and specific targeting will be of critical importance to successfully reduce the overall number of casualties by preventing secondary cases. Obtaining data by examining and monitoring exposed individuals can help to predict the clinical trajectory of future cases and also help medical providers rapidly identify any new cases. This information could also be of tremendous significance should the exposure be more occult in nature to help epidemiologists determine the origins of a previously undetected initial event.

As with any government-mandated health care policy, quarantines of any variety will certainly raise questions regarding ethics. Although restrictive measures discussed in this chapter may be of significant

benefit to the afflicted society as a whole, they may meet resistance and raise ethical dilemmas. This may be alleviated by attempting to induce voluntary compliance by always proposing restrictive measures that are proportional to a given threat and providing transparency at all stages of a restrictive quarantine.¹ In the United States in particular, balancing personal liberties with societal benefit rapidly becomes an ethical dilemma without a clear resolution. The word quarantine often carries a stigma and negative connotation—to restrict movement, isolate, and maintain a safe distance from “contaminated” individuals. This becomes especially problematic when a rapid quarantine is clearly the safest option for the nation as a whole following a significant communicable exposure event.

The purpose of quarantine is clearly to prevent additional spread of contagious disease or environmental toxins within a specific population. Quarantine success demands tailoring preventative measures to specific features of a given exposure. With the overall goal of quarantine being a significant reduction in total casualties, a successful quarantine will look to accomplish the following:

- Identify what and who has been exposed
- Determine which exposed people, animals, and/or goods are likely to be contaminated or infected
- Prevent transmission by managing those who are contaminated or infected
- Prevent subsequent exposures and contaminations

Frequently employed measures to accomplish the above goals include the following:

- Identification of potentially infected or contaminated persons, animals, and goods
- Initiation of protective measures to prevent further transmission of infectious agents
- Initiation of protective measures to prevent exposed persons from becoming infected

CBRN incidents are those due to weaponized or nonweaponized CBRN materials that have the ability to cause significant harm to life, health, or the environment. Traditionally in the United States and Canada, nonweaponized materials are referred to as dangerous goods (DG) or hazardous materials (HazMat) and can also include items such as contaminated food, livestock, and crops. The term *CBRN* includes DG or HazMat plus the same materials weaponized into explosive threats. Typically spills or accidental releases or leakages are considered DG or HazMat, whereas intentional spills, releases, or leakages (whether explosive or not) are considered terrorist incidents.² Although the approach to dealing with the consequences of both types of incidents may be similar, the terrorist incident will involve additional agencies as well as concerns for public and national security and safety.

Advances in technology and training, years of planning, and billions of dollars spent on that training and equipping response agencies has advanced domestic preparedness for an incident requiring quarantine. This level of training and preparedness has dramatically changed current strategies and tactics in the management of incidents that may require quarantine. Countless lives could thus be saved.³

HISTORICAL PERSPECTIVE

The popular media have shaped lay public perceptions of quarantine. Dramatic portrayals of military personnel in personal protective equipment (PPE) and armored vehicles patrolling city streets create a sense of fear and anxiety. If not managed properly, this anxiety can evolve into panic and chaos.

For thousands of years humankind has recognized the need to isolate from the general population persons, animals, and goods that have been exposed to contagious elements. As early as 583 AD, authorities restricted the association of lepers and healthy people, building on the biblical sources in Leviticus.¹ History reveals that the use of the term quarantine only recently entered the first responder lexicon despite its having been in practice back to biblical times.⁴

In the fourteenth century, Europe endured repeated episodes of the plague, with an estimated loss of one third of the population. The plague spread rapidly throughout Europe, beginning in the south in 1347, and reaching England, Germany, and Russia within 3 years.⁵ Fear, combined with the severe impact of the plague, led to the development of intense measures to attempt to control the spread of the disease—measures we would currently call infection control. Some of the more severe measures include the abandonment of the ill in the fields outside Reggio, Italy, in 1374. By order of Viscount Bernabo, patients were left in the fields to recover or die on their own.⁶

Similarly, in the area currently occupied by the modern city of Dubrovnik, Croatia, the chief physician of the city, Jacob of Padua, advocated the establishment of an area outside of the city walls for those needing treatment for the “black death.”⁷ This separation was motivated by an early theory of contagion; however, the efforts were only modestly effective. It was this lack of effectiveness that prompted the Great Council of the city to develop more aggressive methods to prevent the spread of future epidemics.⁶

In 1377 the Great Council established a four-pillared approach to a *trentino*, or 30-day isolation period.⁶ The four pillars include the following:

1. The exclusion of citizens or visitors from plague-endemic areas from the city of Ragusa until they had been in isolation for 30 days
2. The restriction that no person from Ragusa could go to the isolation area without remaining there for 30 days
3. That any person who was not assigned by the Great Council to care for those in quarantine was not permitted to bring food or other items to someone in isolation without having to remain there for 30 days
4. That anyone who did not follow these regulations would be fined and subjected to isolation for 30 days

Similar laws were introduced in Marseilles, Venice, Pisa, and Genoa during the following 80 years,^{8,9} although during this time the period of isolation was extended from 30 to 40 days. This 40-day period was known as a *quarantino*, which was derived from the Italian *quaranta* or forty.^{3,10} Although the rationale for extending the period to 40 days is not known, it has been suggested that the shorter *trentino* period of 30 days was found to not be long enough to prevent the spread of the plague.¹¹ Others have suggested that the change was related to the 40-day period of the Christian observance of Lent⁴ or the 40-day period associated with many other significant biblical events (the great flood,

Moses' time on Mount Sinai, or Jesus' time in the desert).¹² Still others have suggested that the foundation for the *quarantino* came from the Greek doctrine of “critical days,” which stated that contagious disease occurs within 40 days of exposure.^{5,11} Regardless of the rationale, the duration embodied within *quarantino* provides the fundamental concept for our present-day quarantine.

The identification of the pathogenic agents of epidemic diseases between the nineteenth and twentieth centuries led to a turning point in the history and development of more modern quarantine. Cholera, plague, and yellow fever began to be thought of as individual pathogenic agents to be considered separately in the development of regulations. International regulations were rewritten in 1903 by the Eleventh Sanitary Conference, at which the convention of 184 articles was signed.¹³ Modern planning, identification, and response to individual pathogenic agents of concern comes out of this historical separation. Additionally with the emergence of severe acute respiratory syndrome (SARS) in the twenty-first century, traditional measures were once again utilized because a global public health crisis arose as a result of international travel of people and goods.¹⁴

CURRENT PRACTICE

First responders now have tools to rapidly and accurately identify the nature of an incident (e.g., chemical, biological, or radiological). As a result, the strategies and tactics (policies and procedures) have dramatically evolved from those of the past. First responders can rapidly test potential exposures and determine preliminary information on the nature of the offending agent. Often these rapid tests are definitive. However, most standard operating procedures call for confirmatory testing and follow-up identification procedures in specialized laboratories in order to increase accuracy and specificity. This strategy allows first responders to rapidly determine whether the incident is of a biological, chemical, or radiological/nuclear etiology and adjust quarantine recommendations accordingly. Although the first responder community continues to educate themselves, broad knowledge of signs and symptomatology has become a baseline for education and identification, even without the use of these technologies as a backup.

Quarantine is technically for those incidents involving biological exposures. However, in modern practice, the term also applies to detention, in holding areas, following exposures and prior to decontamination for chemical and radiological or nuclear events. Modern quarantine may be initiated whenever an individual or group is known or suspected to have contracted, or been exposed to, a highly contagious or dangerous disease or a chemical contamination. Public health authorities must ensure that there are resources available to provide care for those in quarantine and to implement and maintain the quarantine. It is also imperative that authorities provide for the expeditious provision of health care for those in quarantine, including coordination with the local health care delivery system, heightened surveillance and monitoring, expedited diagnosis and treatment, and preventive treatment (vaccination, prophylactic antibiotics, and PPE).^{15,16}

Within any potential circumstance in which a modern quarantine might be issued, the primary goal is to reduce disease transmission by increasing the “social distance” between persons (i.e., reducing the number of people each person comes into contact with).¹⁷ To accomplish this there are a wide variety of strategies for disease control that may be implemented individually or in combination with one another. These strategies include shelter-in-place, short-term voluntary home curfew, restrictions on public gatherings and events (including travel and mass transit restrictions), and cordoning off an area with a sanitary barrier.¹⁸ Modern quarantine can be effective in some cases even when it is only partial quarantine (i.e., where many or most, but

not all, exposed persons are quarantined).¹⁷ This partial or “leaky” quarantine, particularly when combined with a program of vaccination, has been effective in slowing the rate of the spread of disease, including SARS and smallpox.¹⁹

Distance and duration of exposure are commonly found to be important predictors of transmission. Accordingly public health authorities employ modern quarantine procedures that involve limited numbers of exposed persons in small areas. These small areas or zones are designed as “rings” or concentric circles drawn around individual disease cases.²⁰ Only those who fall within the ring of exposure duration or distance would be quarantined along with the individual disease case, with the most intensive disease control activities in the inner ring.

Implementation of modern quarantine also requires the trust and participation of the public. Compliance with quarantine is lowest in areas with little to no experience with quarantine in their recent past. In the United States, obstacles to compliance include difficulties with PPE and preventive measures, issues with compensation for lost income because of missed work, and lack of communication from trusted public officials.^{21,22} The public must be informed about the dangers of contagious diseases subject to quarantine before an outbreak or intentional release of biological agents occurs and throughout an actual event.

Authority for Quarantine

Whereas all aspects of the first responder community provide a rapid response to 911 emergencies when called upon, state and federal governments have enormous resources and jurisdictional laws, rules, and regulations that are utilized to protect and respond to incidents throughout the United States. They also respond in support of first responders, as needed. These federal, state, and local jurisdictional laws govern the specifics of incident command and control in response to a biological incident.

Federal Law

The Commerce Clause of the U.S. Constitution provides the authority for utilization of quarantine and isolation by the federal government. The U.S. Secretary of Health and Human Services is also authorized to take measures to prevent the entry and spread of communicable diseases from foreign countries into the United States and between states, as stated in section 361 of the Public Health Service Act (42 U.S. Code § 264).²³ The authority to carry out these functions is delegated to the Centers for Disease Control and Prevention (CDC), including the authority to detain, medically examine, and release persons who are suspected of carrying a communicable disease and are arriving into the United States or traveling between states (42 CFR, parts 70 and 71). Twenty U.S. quarantine stations are located at ports of entry and land border crossings, enabling the CDC to routinely monitor people at these locations for signs or symptoms of communicable disease. When necessary the CDC can institute public health practices to stop or limit the spread of disease through the use of isolation and quarantine.²¹

Although isolation and quarantine are well understood as medical functions, they are less well known as “police power” functions. These police power functions come from the right of the state to take actions affecting individuals for the benefit of society and empower the government to detain or constrain people who may be contagious with a communicable disease.

Federal isolation and quarantine are authorized by executive order of the president and currently exists for the following communicable diseases (this list may be revised by executive order of the president):

- Cholera
- Diphtheria
- Infectious tuberculosis

- Plague
- Yellow fever
- Smallpox
- Viral hemorrhagic fevers (e.g., Ebola)
- SARS
- Pandemic influenza

State, Local, and Tribal Law

Similar to the federal government, individual states have police power functions to protect the health, safety, and welfare of people within their jurisdiction and to enforce the administration of isolation and quarantine.²¹ Laws vary between states, and the authority to enforce state law can be at the state or local level, although breaking quarantine is a criminal offense in most states. In the United States, Indian tribes also have police power authority to take actions to establish and enforce their own isolation and quarantine laws within tribal lands.²¹

Who Is in Charge?

In a quarantine situation the federal government has authority over the states and tribal lands and likewise the states have authority over local governments. In addition federal authorities may either assist state and local authorities in infection control operations or request assistance from state and local authorities in enforcing federal isolation and quarantine.

It is possible for federal, state, local, and tribal health authorities to each have legal quarantine power over the same incident at the same time. Whenever this occurs, however, federal law and authority supersede all others.²⁴

Federal Enforcement

When a communicable disease that is authorized for quarantine is suspected or identified, the CDC may issue a federal isolation or quarantine order. Enforcement of such a public health order may require assistance from police or other law enforcement. The issuing authorities may request domestic law enforcement assistance at any time in the quarantine process. U.S. Customs and Border Protection and the U.S. Coast Guard are also authorized to assist with the enforcement of federal quarantine orders.²¹ Failure to follow a federal quarantine order is punishable by fines and imprisonment, although federal law does allow for conditional release from quarantine when possible if the individuals agree to comply with medical monitoring and surveillance.²¹ Although federal authorities have the capability to declare such events, large-scale isolation and quarantine have not been initiated since the influenza (“Spanish Flu”) pandemic in 1918-1919.²¹

State and Local Enforcement

State and local authorities respond in a similar manner to federal authorities with regard to the issuance of a quarantine order. Assistance with enforcement may be requested from local law-enforcement agencies and from the federal level, when necessary. Failure to follow quarantine orders can lead to fines and/or detention, depending on the local or state statutes.

First Responders

First responders will be early on the scene and expected to initiate a response. It is critical that as they arrive, first responders have the capability to properly assess the situation and recognize the signs and indications that a potential CBRN incident has occurred. First responders have to rely on the strength of their training to guide them in their next decisions about the incident. Standard operating guidelines and procedures will likely provide the basis for much of these decisions, including a predetermined level of response to suspected

or confirmed CBRN incidents, when to initiate a public health response, how to assess the extent of damage and risk, how to determine exposure pathways and the need for mutual aid, and criteria for activating an emergency operations center (EOC) and incident command post (ICP).

Once determinations are made that there is a CBRN incident requiring the activation of an EOC/ICP and involving public health, the local resources will continue to operate using the incident command system (ICS) and remain in control of the scene for rescue and public safety. The incident commander should coordinate with local and state emergency management officials to request additional resources from state or federal assets in the event that quarantine becomes necessary. First responders may be called upon by the incident commander to assist with provision of needed services throughout the duration of the incident and/or quarantine. Scene management for the first responder requires an understanding of quarantine for potentially contaminated or infected persons, establishment of decontamination and triage areas, and isolation of contaminated areas. For each of these items, it is critical that the first responder understands the signs, symptoms, and effects of CBRN substances (weaponized or nonweaponized CBRN materials that can cause significant harm) and is familiar with HazMat management.¹

Under control of their respective governor, each state possesses assets that may be deployed to assist in the event of an incident. The National Guard Civil Support Teams (CSTs) are one of the most critical components for quarantine responses. A state's Office of Emergency Services coordinates the request for and deployment of the CSTs. When an incident exceeds the states' capabilities, they may request federal assets through their Federal Emergency Management Agency (FEMA) Regional Operations Center.

Training and Response of First Responders: Quarantine

Agencies and organizations, such as the Occupational Safety and Health Administration (OSHA), Environmental Protection Agency (EPA), National Fire Protection Agency (NFPA), and FEMA, have many different levels of training on this topic, ranging from basic awareness courses up through specialist and advanced formal courses. Current guidelines and training emphasize the need to be knowledgeable of all types of HazMat and their management. Recognition is the first line of defense in an incident. Recognition not only protects each individual and other first responders, but also enables first responders to initiate the system-wide responses necessary to manage these incidents. Most training also emphasizes the adherence to established protocols designed to detect hazardous agents on a minute level by the first arriving units. One aspect of these protocols establishes the criteria for involving the highly advanced capabilities of specialized HazMat and weapons of mass destruction (WMD) teams and state and federal resources, if necessary. Recognition that an incident is beyond the management capability of local resources and involves HazMat or WMD would be an initial reason for an incident commander to reach out through an EOC for state or federal resources. This is particularly true when combined with patients exhibiting signs and symptoms of exposure to HazMat or WMD. State resources that may be called upon include agencies such as CSTs. Federal assistance may be requested by the incident commander in coordination with an EOC at the local and state levels through the proper channels. State and federal authorities throughout a state's Office of Emergency Management and Department of Homeland Security (DHS) monitor incidents of significance and of larger magnitudes. This includes fusion centers, which serve as focal points within the state and local environment for the receipt, analysis, gathering, and sharing of threat-related information between the federal government and state, local, tribal, territorial (SLTT), and private sector partners.

Further knowledge of protocols and procedures provides guidance on protection of the scene for the purpose of limitation and/or reduction of further injuries and illness through limiting ongoing or subsequent exposure and contamination. Finally first responders' knowledge of their own agency-specific guidelines and those of other related agencies will assist in the speed of implementation of these protocols. It is this knowledge of protocols and procedures that provides a first responder with the ability to take the initial actions toward isolation and quarantine procedures. These actions must be guided by stated policies and procedures and supported by training guidelines and principles.

When referring to CBRN incidents, there are continual changes in the management of these incidents based on improvements in education, training, experience, and, most significant of all, technology. Best practices have also led to advances in management. However, the United States is a diverse country, and scenarios in different parts of the country have to be managed based on their locale and its related procedures. Many different factors, such as weather, population, location, infrastructure, and nature of the incident, come into play in different locations. However, the basic facts of exposure and contamination remain constant. Below is a short summary of exposures and contaminations that have relevance to quarantine and isolation.

Types of Quarantine

Following an exposure or contamination, the greatest concern for the first responder is to limit the number of people already affected or who could potentially be affected. The nature of the agents and the methods of exposure determine the risk level and the actions necessary to mitigate that risk. Quarantine and isolation are the most extreme actions for risk mitigation. Technically quarantine most closely fits biological exposures due to the method of transmission, incubation, and infection by biological agents. However, quarantine is also used when detaining exposed or contaminated personnel for decontamination following a chemical, radiological, or nuclear exposure (Boxes 82-1 to 82-4).

Biological

There are many biological agents that are pathogenic and can cause harm. Rapid identification of potentially infected persons and the biological agents involved increases the effectiveness of methods to control the spread of disease (isolation, quarantine, barrier methods [gloves, filter masks, and eye protection], and hand washing). When quarantine is

BOX 82-1 Examples of Vaccine-Related Quarantine Measures

- Unimmunized children exposed to measles are excluded from school until one full incubation period after the last case. Children who accept immunization with live virus vaccine within 72 hours of exposure or with immune globulin within 6 days of exposure may return to school. Children immunized outside these time frames are excluded from school until a full incubation period from the last exposure of that child has passed.
- Persons exposed to smallpox without fever or exanthemata may be vaccinated and continue normal activity while being monitored until a vaccine "take" is ensured (discharge from quarantine) or until fever and/or skin lesions appear (isolation required).
- Immunized domestic and farm animals exposed to rabies are revaccinated and confined for observation if owners are willing and able to restrict the animal's contact with other animals and humans until an incubation period has expired. Unimmunized pets have to be quarantined in a controlled facility for 10 days, observed for onset of illness, and, if well, vaccinated before being released from quarantine.

BOX 82-2 Examples of Prophylactic Treatment as Quarantine Measures

- Persons with household and face-to-face contact to pneumonic plague and those exposed through a terrorist act should receive prophylactic antibiotics as quickly as possible and be placed under surveillance for 7 days. If unprotected exposure continues, prophylaxis may need to be extended. Those who refuse or cannot receive prophylactic antibiotics must be placed in strict isolation and monitored closely for 7 days.
- Persons with tuberculosis may be required to remain isolated until antibiotics have effectively sterilized the sputum, at which time isolation ceases, but directly observed therapy continues for the full course of treatment.

BOX 82-3 Examples of Travel-Related Quarantine Measures

- A child on a long airplane trip may develop symptoms suspicious of measles. Data must be collected on the immunization status and current health status of all travelers. Data on the seating arrangements and movements within the plane of the child and other occupants are useful. Immunization can be provided to any unimmunized person. If immunization is unavailable or refused, detailed contact information for the next 3 weeks for any susceptible person is collected, as is precautionary information.
- In a more complex scenario, the diagnosis of measles is made after the debarkation and airline manifests must be used to find and notify fellow passengers.
- Travelers with suspected SARS provide recent examples. Temperature screening at embarkation and debarkation of travelers from areas with reported cases provide an opportunity to detect cases before passengers are dispersed to many destinations. The quarantine officers need data to decide whether to detain any passengers if there is a suspected case. Data are collected on the body temperature, current health status, seating arrangements, and movements within the plane of all travelers. Detailed travel plans and contact information for all nonfebrile travelers for the next 10 days are obtained in some instances. Before being released from quarantine, travelers receive "fever watch" instructions and directions to report to medical care if fever develops.

BOX 82-4 Useful Resources

- Selected Federal Legal Authorities Pertinent to Public Health Emergencies. Prepared by the Public Health Law Program, U.S. Department of Health and Human Services. Centers for Disease Control and Prevention. Updated February 2014. <http://www.cdc.gov/php/docs/ph-emergencies.pdf>.
- Centers for Disease Control and Prevention. U.S. Department of Health and Human Services. <http://www.cdc.gov>.
- Federal Emergency Management Agency. U.S. Department of Homeland Security. <http://www.fema.gov>.

necessary it is critical that there is continuity of provision of care and command and control in order to ensure the best possible outcomes.

Chemical

Following a chemical exposure, first responders often need to detain exposed people in a quarantine area to isolate them from nonexposed people and areas and to provide rapid decontamination and medical treatment. By treating exposed people according to their clinical syndrome, rather than waiting on the identification of the specific chemical involved, first responders can provide the most rapid, aggressive, and

clinically relevant care.²⁵ This alignment of treatment modalities based on syndromic categories is believed to provide for better outcomes and faster release of exposed persons.

Radiological and Nuclear

Radiological and nuclear incidents are often confused with one another. For the purposes of emergency management and disaster medicine, a nuclear incident involves a nuclear detonation, whereas all other radiation incidents are called radiological incidents.²⁶

Although the sources may differ between the two, the exposure requiring isolation, quarantine, decontamination, and treatment is the same for both incidents. With radiological and nuclear exposures, first responders will need to detain exposed people in a quarantine area to provide rapid assessment of injuries. Injured people should receive immediate medical treatment and transportation to a hospital facility for additional treatment and appropriate decontamination. The noninjured will be assessed for level of contamination for determination of type of decontamination process (emergency decontamination on site or at hospital or delayed decontamination at home).²⁷

Execution of Quarantine

Control of Individual, Animal, and Environmental Movements

The actual conditions and stipulations of any quarantine depend on a variety of factors. In particular the type, natural history, contagious period, environmental spread, and specific routes of transmission will all influence the type and variety of restrictive measures that may be necessary. Typically these decisions will arise from state or federal public health authorities, but only after careful review of the currently available clinical data. A multidisciplinary approach will include physicians, nurses, law enforcement officers, and likely military personnel for adequate containment and restriction enforcement. Although the United States has predetermined exposures that do not require additional federal approval to instigate a local quarantine, many jurisdictions require a court order to initiate or enforce movement restrictions or property confiscation.

Implementing a proper quarantine to separate the unexposed from exposed populations, a variety of measures may be useful. Within the quarantine area, unexposed individuals can utilize personal protective measures, including face masks and gloves. Removing individuals from a nuclear quarantine area is obviously ideal; however, preventing additional radiation exposure with both personal and regional decontamination methods can help to limit the number of exposures. Unexposed individuals within a quarantine zone may benefit from immunization or prophylactic therapies. These prophylactic measures do not have to include the entire at-risk population; however, as evidenced by the 2009 U.S. H1N1 and oseltamivir programs, it may be of benefit to prophylactically treat vulnerable populations, including those with high risk of exposure and immunocompromised individuals, depending on the agent of concern.²⁸ The decision to offer prophylaxis to some members of the population must be done carefully and with clear dissemination of public information to avoid confusion and unnecessary treatments. For example, the public fear of radiation exposure and misguided rush for iodine tablets following the 2011 Fukushima nuclear disaster caused undue stresses and unnecessary treatments even in distant European nations.²⁹

Close, at-home observation remains a viable option, as does the performance of serial examinations on those with known exposure to a contagion or environmental toxin. Individuals who develop signs and symptoms may be hesitant to seek care, especially with knowledge that this may lead to isolation. Every effort must be made to ensure that a quarantined population is well informed and understands that treatment and social support are readily available during this stressful time.

Those who develop evidence of infectivity may qualify for additional restrictive measures, including isolation. However, depending on the type of exposure it may be acceptable to enforce at-home isolation with relief of work duties and other activities that would place a known contagious individual in public spaces. Depending on the natural history of the disease, any isolative measures should be lifted as soon as possible once a contagious period has passed to avoid any further public distrust.¹

Restricting movement in any capacity will likely displace individuals from their homes, as may already be the case in any large-scale disaster associated with nuclear or airborne toxins. Shelter provisions should clearly be provided to those displaced by circumstance, though front-line medical care teams must remain vigilant for signs of communicable exposures. If water sources and other sanity conditions decline, the ease of disease transmission will exponentially increase. As a result disaster response teams should consider ways to quarantine and potentially isolate infectious individuals under even the worst conditions, if at all possible, to help reduce new cases in a refugee shelter situation.

Events involving highly contagious strains of influenza demonstrate the potential impact of movement restrictions. For example, during the 2009 H1N1 outbreak, the United States and Canada instigated voluntary home quarantine of sick individuals and closed public meeting places, including schools and malls, with moderate success. In comparison China enacted a strict quarantine lasting 60 days in many major urban areas, including Beijing, with military enforcement to restrict personal movement until the quarantine period was cleared.³⁰ Although differences in governmental policies and ability to rapidly restrict travel and public space usage exist, restricting the movement of individuals in and out of a quarantine zone will be critical to help prevent additional spread of the targeted exposure. In particular, careful screening of major air and seaport passengers will likely become necessary, again depending on the type of contagious material and natural history of the disease. Travel restrictions can be especially effective in the early phases of a quarantine to help limit the rapid spread of undetected cases, though sensitive measures are difficult to discern early in a disease process, as evidenced by the questionably ineffective efforts during the 2009 H1N1 outbreak to fever screen airport passengers at airports.^{31,32} Restriction of clearly symptomatic individuals from making both local and international travel can be a method to help prevent rapid spread, though as with any restrictive measure this must be carried out in an evidence-based method and tailored to the pathogen at hand.

If an exposure is suspected to involve any animals responsible for producing food or other goods, public health officials must also seek to establish livestock quarantines. Although this may be difficult in the early stages of a previously unknown or undetected pathogen, many novel diseases are ultimately found to be harbored or spread via animal vectors toward humans. For example, given initial suspicions that the SARS pandemic of 2002 and 2003 may have originated in civet cats sold in public markets, China quickly moved to ban the sale or transport of these animals. Civet farms were closed until additional information became available, to prevent any further animal-borne spread of SARS cases.³³ In the present-day, globalized economy, this prospect can be especially difficult, making strict port-of-entry precautions, including freight examination, testing, and quarantine, necessary to combat a given zoonotic exposure.³⁴ These policies will certainly come with economic consequences and the decision to enact mandatory culling, isolation, or trade restrictions on a specific animal or animal product must not be taken lightly, but instead enacted with clear intentions and clear public information regarding necessity.

Regardless of the source, in any unfolding epidemic or mass exposure, controlling the movements of populations is challenging but can

be of tremendous benefit for preventing additional spread of the contagion. However, inappropriate quarantine is likely to create civil distrust and unrest. In addition a poorly planned quarantine, which unintentionally exposes healthy individuals or animals with the infected or afflicted, can have disastrous consequences and spark further distrust. Actions intended for the greater good of a society can be easily perceived as inequitable if poorly understood, and every effort must be made to encourage voluntary compliance and reduce panic with equitable means of population control. Trust becomes a vital commodity during times of crisis, and it will become the duty of front-line medical professionals and public health officials to minimize novel cases after an event by providing reasonable yet effective methods of controlling the movements of people and their property following an exposure disaster.

Management and Protection of Community Assets

As with any significant natural disaster or terrorist attack, management of community assets in the immediate post-event period is critical for effective exposure control. When considering a quarantine or isolation, health care officials must take into account any limitations on existing health care and community assets. It is also possible to instigate voluntary and less-invasive means, such as closure of public schools and transportation, to help alleviate the spread of a concerning pathogen. With this in mind, one can best utilize existing infrastructure for triage and treatment of the exposed, while looking to minimize exposure of healthy individuals by best managing public facilities.

Health Care Assets

Following a mass-exposure event, protecting and managing health care assets in a given community is of utmost importance. Decontamination (discussed in [Chapters 83 and 84](#)) will certainly be the initial and primary strain placed on hospitals and emergency departments after a mass-casualty event. Once these patients are triaged and decontaminated, proper management and placement within the health care system can help to minimize secondary exposures. In addition to standard hospital policies already in place for infection isolation and environmental decontamination, quarantine measures may include cohorting of patients and health care workers among institutions to reduce the exposure spread to all institutions. Should the number of infected or exposed individuals overwhelm the isolation capacity of regional hospitals, setting up separate temporary facilities to care specifically for disaster victims can be an effective means to simultaneously treat and quarantine populations. This strategy does require significant resources and predetermined disaster management plans.

Measures to protect and maintain the availability of medical care following an exposure are also of utmost importance. Basic means, including hand washing and equipment disinfection, gloves and masks, and spatial separation of suspected or confirmed victims, can assist with intrahospital quarantine. Effective infection isolation within a care facility can maintain the overall function of that clinic or hospital. It is important to remember that more typical emergencies and community health care demands will continue despite a recent exposure event, and all efforts must be made to maintain normal function while also preventing exposure spread. Additional strategies, including measures to avoid patient-to-patient exposures entirely by nonfacility care, can also be effective, and include telephone screening, home visits, and public-place examination clinics. With growing public fears people may seek out unnecessary health care visits, only furthering the risk of contamination. As a result, aggressive public communication and clear reasoning are necessary to help alleviate these fears and prevent unnecessary health care access.

Schools

In any crisis schools become a source of significant anxiety for parents and students. Because of close contact with their peers and family members, school children are a rapid means of spreading infection. An immediate local school closure following an exposure event can be of tremendous benefit to help prevent novel cases and also prevent unnecessary travel and further public exposure to a given pathogen. Schools can also be temporarily repurposed as shelters, outbreak clinics, or government rally points for further management after a major disaster. The decision to close individual or entire systems of schools should be based on the nature of the exposure and the need for facility repurposing. Simulated influenza pandemic models also suggest that school closures can alleviate strain on local health care assets by reducing new cases in both children and adults.³⁵

After schools are reopened it is prudent to instruct school officials regarding signs and symptoms of exposure-related illness in order to detect any new cases early and prevent further spread. School events, including sports and social gatherings, should be treated like other mass gatherings after a major disaster with quarantine rules extending to these events as well. Isolation measures within schools could help to facilitate ongoing educational concerns; however, the logistics of effective isolation inside of most schools are likely near impossible. It is likely of greater benefit to reopen schools only once a threatening pathogen or exposure has been adequately controlled and new cases have already started to subside.

Travel

Travel management of exposed or infected patients is critical to any adequate quarantine process. Unfortunately this will also likely become a major point of social contention, given concerns of government oppression of a specific population. The modern, globalized era has made rapid international travel both easy and affordable, a major risk for ongoing infection spread. In the immediate post-event phase, grounding all air travel to and from areas of concern can help to prevent contagion transmission; however, this will likely be met with significant amounts of public fear as unexposed individuals attempt to rapidly leave the area. As discussed previously, effective quarantine requires the close management of population movement. Depending on the variety of disaster exposure, screening methods may be effective to still allow travel while preventing additional spread. The same principles can be applied to roadways, seaports, and other means of public transportation.

Once a quarantine or travel stoppage is ordered, there will be individuals previously traveling through the area or visiting that cannot leave as previously planned. Providing a safe shelter for these travel refugees is not only ethical, but also important to help manage the travel quarantine. If screening methods are effective at ruling out exposure or infection, these individuals can be safely moved back to their home regions. It is also important for neighboring areas to establish their own quarantine and screening practices to help evaluate and manage people leaving from a contaminated area. As mentioned previously, traveler quarantine and isolation has been a recurrent theme throughout human history and is an effective means to prevent introduction of pathogens to a new area. Management of private vehicle movements can certainly be a daunting task, but if an infection or environmental exposure is allowed to enter a new geographic region, the ultimate containment process will become exponentially more difficult. As with all forms of quarantine or isolation, clear explanations and equitable treatment of all impacted by the restrictive measures will help to alleviate any growing public distrust.

Business and Agriculture

Businesses and other places of work that are fundamental level areas of community gathering are capable of expediting the spread of a contagious material. In times of quarantine, many businesses will voluntarily close based on school closures, which can be a helpful means to limit person-to-person interaction. Despite this, some daily business will certainly continue, and every effort should be made to encourage worker safety and special precautions should be made to identify and prevent infected individuals from exposing their coworkers. Business closures and mandatory sick days can be difficult to enforce, especially in open-market settings with many small business owners operating independently. As evidenced by China's actions to ban the sale or transport of civet cats during the SARS pandemic, direct interventions on commerce can help to alleviate further exposure spread during a quarantine.³³

It is also important to note the impact of quarantine measures on local business and commerce. Areas highly dependent on tourism and international travel can be dramatically impacted by public fears associated with voluntary or mandatory quarantine. Some estimates place Beijing at a U.S. \$1.4 billion loss with regards to tourism alone as a result of the SARS outbreak of 2003.³⁶ Ideally, rapid action and site control can help to minimize the spread of a radiological, nuclear, or biological agent, with hopes to minimize the spread initially and prevent any need for long-term quarantine with significant financial impact. As a quarantine continues, business will suffer from supply shortages and product stagnation—things that must be considered and will certainly account for ongoing financial losses. Imposing mandatory embargos and trade restrictions can help both sides of a trade agreement prevent the introduction of HazMat within their borders. An effective quarantine will also look to utilize existing business resources to better understand and control the movement of goods, animals, and individuals to minimize contagion spread.

Food production and agricultural supply are not only necessary for ongoing exposure dissemination, but also for providing a quarantined population with adequate goods of daily living. Many agents of biological terrorism can compromise food production without directly impacting humans, as can effects of nuclear fallout if water supplies are contaminated. Initial decontamination and rescue efforts will appropriately focus on humans, but the surrounding livestock exposed to hazardous or contagious materials can also spread disease and radioactive material if their products are not removed from circulation. Guidance from public health officials will be critical in the management of agricultural resources, and importing in sufficient supplies during a quarantine is a critical action for effective societal support. Plants and other crops may exhibit long-term, though silent, contamination and ultimately require destruction. Restricting the movement of livestock in and out of a quarantined area should follow that of humans, with special attention in situations where asymptomatic animals may pass disease to their human counterparts.

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- *Balancing civil liberty with quarantine:* Any quarantine or isolation will fundamentally restrict certain civil liberties. In the health care setting, specific policies regarding patient isolation are at the discretion of the treating facility, but in the public sphere, isolation measures become ethically challenging. As previously emphasized, the principle of utilizing the least restrictive means possible to accomplish public protection must be at the forefront of any quarantine planning. This strategy will ideally optimize voluntary compliance, which in turn will yield an overall higher protection rate than an overly aggressive quarantine with very poor public compliance. As with any public health crisis, every effort should be made to

maintain personal privacy, especially regarding infectious status, whenever possible. Throughout history, quarantines and restriction of societal rights have been utilized in ethical atrocities, and this must be guarded against with well-defined checks and balances to prevent any unintended consequences of a public health effort.

- Restricting personal movement and travel capabilities can quickly lead to civil unrest and social stigma. It is important to differentiate and remove any growing blame on infected individuals and redirect focus toward treatment and prevention of further spread. A study of the 2003 SARS outbreak quarantine in Toronto demonstrated that those entering an enforced quarantine were especially concerned with their ability to maintain work wages, obtain groceries, and continue their prior way of life after the quarantine was lifted. All of these concerns are certainly legitimate and are exacerbated by the intentional interruption of daily routine and removal of routine civil rights. Regardless, during times of significant natural disaster, nuclear fallout, or biological terrorism, civil rights may need to be temporarily restricted to help protect the interests of society as a greater whole. The challenge for public officials will be to ensure that this is done in an equitable and reasonable fashion, with allowances and appropriate support for those placed within a quarantine zone, and removal of restricted measures as quickly as the situation permits.
- *Obtaining compliance:* Whenever rights or activities are restricted by a governing body, a significant amount of civil unrest can result. This can be especially problematic following a major disaster when societal fears and media frenzy have reached maximum levels. Utilizing quarantine as a means of greater public defense and disaster response must always take the forefront of any restrictive efforts with careful attention to ensure that it is not being utilized as a punishment or political tool against a specific population. Clear public communication forums to reinforce that the goal of any isolation or restriction is to prevent the spread of disease and minimize the overall impact of a natural or terrorist-driven exposure.
- Unified and consistent statements and stances regarding the best methods for preventing new cases, treating those already exposed, and minimizing civil disruption are critical for the front-line physicians and public health officials. Issues of compensation for lost wages, care for family members, and similar concerns of persons subject to quarantine cannot be ignored. As evidenced by the North American influenza pandemics of 2008 and 2009, education and communication with the public are key components to encourage voluntary cooperation. Public health officials must ensure that restrictive measures are appropriate and proportional for the targeted exposure, implemented uniformly across all socioeconomic statuses, and followed with highly transparent official communications to maintain public engagement.¹ Just as careful planning is required to set up an appropriate and effective quarantine, health policy makers must be equally prudent as they deescalate any restrictive measures. Emphasis on resumption of normal routine and the importance of continued monitoring throughout all levels of the health care system can assist in this transition and help to reduce the chances of post-event turmoil.
- *Attention fatigue:* Constant vigilance is necessary to maintain quarantine, isolation, and infection control measures following a mass-exposure event. Initial disbelief, even if scientifically justified, can lead to a low index of clinical suspicion. This is especially true in the early phase of a major disaster when the exact details and etiology behind a patient's symptoms may be unclear. In the modern era of sophisticated biological weapons and the potential for multiple-modality terrorist events, clinicians cannot allow tunnel vision to prevent them from noticing and differentiating pathology. It is also worth noting that even during a mass-exposure disaster, there will

still be more typical medical problems requiring emergency intervention. As a result, front-line physicians and other health care providers must maintain attention to clinical details and prevent diagnostic momentum from building based on recent local events. That being said, erring on the side of caution is likely prudent given an unexplained clinical picture with undifferentiated terrorist or natural exposures and with an accepted number of false positives receiving treatment or isolation for precautionary measures.

- *Conflicting goals:* Physicians and other medical professionals are already accustomed to placing the needs of their patients first. This becomes especially difficult when a specific diagnosis mandates additional isolative measures. After any anxiety-provoking disaster, there will be a significant number of patients seeking reassurance following the development of suspected symptoms. Making decisions that will require treatment can be compounded by additional ethical dilemmas given a patient's entire socioeconomic sphere, in particular if removing a breadwinner from standard duties. It becomes difficult for the front-line physician to protect an entire population from further exposures while also advocating for their individual patients. Preexisting relationships with patients and community members can also exacerbate a clinician's ethical dilemma, especially when a particular diagnosis holds isolating repercussions.
- This conflict between medical responsibility to individuals and entire populations creates many of the pitfalls surrounding a mass-exposure event. It is especially difficult to maintain professional relationships with patients when trust is questioned following instigation of restrictive measures. Clinicians must communicate clearly and provide effective education to their patients, especially regarding prophylaxis and treatment options. In the initial phase of a mass-exposure event, the front-line provider will be faced with difficult decisions, only further compounded by often conflicted goals of individual and community protection.
- *Communication:* Communication between health care professionals (including first responders) and law enforcement, between the health care professionals and the community, and between governmental authorities and the public require honesty, clarity of message, and frequent updating. Trust, consistency, and credibility are essential. Professional public information officers (PIOs) should manage all communication strategies.

CONCLUSION

There are many options for a CBRN incident response, and quarantine is the most extreme of these options. For this reason the criteria for initiating quarantine is clearly delineated in federal, state, and local laws, regulations, and policies. Although states may differ regarding their laws on quarantine and emergency response and operations, each state has established laws regarding quarantine. Federal laws and regulations outline parameters by which they would supersede state law in support of a local incident. It is incumbent on all disaster medicine providers to know and understand these laws, regulations, and policies, including local and agency-specific procedural guidelines and how they interact with one another.

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