



DIGITAL
VERSION



Jekel's

**EPIDEMIOLOGY,
BIostatISTICS,
PREVENTIVE MEDICINE,
and PUBLIC HEALTH**

FIFTH EDITION



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Disaster Epidemiology and Surveillance

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“We have had the lesson before us over and over again—nations that were not ready and unable to get ready found themselves overrun by the enemy.”

Franklin D. Roosevelt

1. OVERVIEW

Before discussing disaster epidemiology and surveillance, it is important to define what is meant by disaster. A **disaster** is generally considered to be an event that puts an overwhelming stress on a system such that the resources used on a daily basis are inadequate for dealing with the impact of the event. The resources may be inadequate because of the number of people affected by the event, or because the resources themselves have been damaged or limited as a result of the event. Disasters may be further categorized by *intent* or *cause*. Whereas **natural disasters** are events such as tsunamis, hurricanes, tornadoes, earthquakes, and floods, **human-made disasters** are related to human-developed technology and may be *unintentional*, such as a train crash, building collapse, or fire, or *intentional*, such as a terrorist attack, mass shooting, or the intentional distribution of a toxic agent (e.g., 1995 sarin gas release in Tokyo subway, 2011 anthrax letters sent in United States, 2017 Las Vegas concert killings, 2018 Parkland, Florida school killings). In either case, the epidemiology and surveillance needs in a disaster may be impacted by the type of event that has occurred.

Disaster epidemiology and surveillance are rooted in epidemiologic principles that apply to other diseases, but unique challenges and concerns need to be considered in the context

of disaster epidemiology. Investigators use disaster epidemiology to assess the short-term and long-term health effects (both physical and mental) of disasters. In addition, disaster epidemiology is important in allowing epidemiologists and public health practitioners to understand how to prevent deaths, injuries, and disease spread in disaster situations. Despite advances in disaster epidemiology, however, there is still a need to refine the approaches to surveillance and epidemiology in disaster situations.¹

Unlike in other types of events, when we perform epidemiologic studies and surveillance in disasters, we focus on not only the inhabitants of a community affected by the disaster but also the workers and volunteers who respond to a disaster. These responders are often at risk for injury or disease because of their involvement in the response (e.g., a New York City Fire Department chaplain responding on 9/11 was killed by a falling object). In other situations, workers may be exposed to infectious diseases or injury risks. In addition, while we routinely do not perform surveillance and epidemiology of the impact of disasters on communities and populations that are not directly affected by an event, there may be both short-term and long-term impacts on both nearby and distant communities and populations, some of which may perceive risks similar to the people and communities affected by the disaster.

1.1 BURDEN OF DISASTER

The World Health Organization (WHO) estimates that 2.6 billion people have been affected by natural disaster phenomena in the past decade.² In the United States, there has

been a steady increase in the number of official disaster “declarations” with more than 100 declarations in 2017. The Global Disaster Alert and Coordination System (GDACS) provides real-time information on disaster alerts around the globe and includes maps and other information about types of disasters that are current or past.³

2. DEFINITIONS AND OBJECTIVES IN THE STUDY OF DISASTERS

To have a basis for understanding the issues associated with disaster epidemiology and surveillance, it is important to understand the definitions commonly used in the study of disasters. First, a disaster could be considered an event that places a strain on the health or public health system such that additional resources are needed to respond. Disasters may occur within an institution, in a community, or on a broader scale. Disasters can be classified in a number of ways, but are usually described as natural or human-made, as previously noted. Natural disasters encompass a range of situations that put people at risk for significant health effects.

Disaster epidemiology is defined as the use of epidemiology to assess the short-term and long-term adverse health effects of disasters and to predict and prevent consequences of future disasters. It brings together various topic areas of epidemiology, including acute and communicable disease, environmental health, occupational health, chronic disease, injury, mental health, and behavioral health. Disaster epidemiology provides *situational awareness*—that is, it provides information that helps responders understand what the needs are, plan the response, and gather the appropriate resources.

The main objectives of disaster epidemiology are as follows:

- Prevent or reduce the number of deaths, illnesses, and injuries caused by disasters
- Provide timely and accurate health information for decision makers
- Improve prevention and mitigation strategies for future disasters by collecting information for future response preparation

As with other types of epidemiology, disaster epidemiology focuses on identifying disease and injury patterns and risk factors to the population and community affected by the disaster. This information serves as the basis for developing prevention and mitigation strategies that are driven by three contexts of disasters: *time*, *place*, and *person*. For example, hurricane season on the US East Coast, as well as in the Caribbean, is June 1 through November 30, whereas the Eastern Pacific season runs from May 15 to November 30.⁴ In addition, the geographic area generally at risk is defined. Although people who live on or near the coast are at increased risk of injury or death during a hurricane, evacuation from the hurricane zone minimizes or eliminates this risk.

In contrast to the disaster epidemiology of hurricanes, the usual season for flu occurrence is over the late fall and winter months in the United States. Flu risk is related to exposure, immunization status, and other factors such as age; generally,

elderly and very young populations, people with chronic illness or immunocompromised, and pregnant women are at increased risks for complications and mortality, depending on the flu strain that is active in a given year.⁵ Prevention strategies would focus on prioritizing immunization of highest risk populations but incorporating immunization strategies to cover as much of the population as possible, and depending on the severity of an outbreak, isolation and possible medical treatment of people who have contracted flu or who have been exposed and are likely to expose others to risk.

In a disaster situation, three types of epidemiology generally are used: descriptive, analytic, and evaluative. Each contributes to the understanding of the disaster event, as well as the prevention and mitigation of harm of future events.

2.1 DESCRIPTIVE EPIDEMIOLOGY

Epidemiologists use descriptive epidemiology to identify the distribution of disease or injury among the population groups affected by the disaster. This includes identifying the health-related issues that occur among people who are responding to the event.

After the 9/11 World Trade Center disaster, responders to the scene were exposed to various types of particulate matter, as well as larger pieces of debris, some of which fell from the collapsing towers. Other responders complained of resulting respiratory problems. The epidemiology of the health aftermath of the disaster continues to emerge; longitudinal surveys are providing information on various health outcomes. A study of 2960 nonrescue disaster workers deployed to the World Trade Center following 9/11 found that at 6 years after the event, 4.2% still exhibited symptoms of posttraumatic stress disorder (PTSD). Risk factors for ongoing PTSD included major depressive disorder 1 to 2 years after the event, history of trauma, and extent of occupational exposure.⁶ Asthma rates are increased in the 9/11 disaster responders as well, with a lifetime prevalence 6 years later that was almost twice (19% vs 10%) that of the general population.⁷ On a larger scale, the World Trade Center Health Registry at the New York City Department of Health and Mental Hygiene will provide a 20-year follow-up through periodic contact with the enrollees.⁸ To date, several research studies have provided information about the long-term effects of the disaster, including hospitalizations for asthma,⁹ heart disease and lung disease,¹⁰ parent physical and mental health,¹¹ among other topics.¹² This large disaster registry is continuing to provide information that may be helpful in planning prevention and intervention strategies (Box 27.1). The development of registries to monitor long-term effects of disasters has not been generalized to all disaster events but has the potential to inform efforts at prevention and mitigation strategies.

2.2 ANALYTIC EPIDEMIOLOGY

Analytic epidemiology can provide information about differences between people who were injured or became ill during an event and those who did not. The benefit is that analytic

BOX 27.1 World Trade Center Health Registry Projects

The current survey includes over 36,000 respondents as of October 2016 and is split between survivors (>37,000) and responders (>29,000). Through the overall survey and special surveys, the registry is being used to investigate the following:

- Cardiovascular disease
- Skin rash
- Alcohol use
- Posttraumatic stress disorder (PTSD) among police
- Unmet mental health care needs
- Cancer rates among enrollees
- Health of Staten Island landfill and barge recovery workers
- Respiratory and behavioral health of children
- Impact of 9/11 injuries on long-term enrollee health
- Coexistence, or comorbidity, of respiratory and mental health conditions experienced by many enrollees

Data from New York City Department of Health and Mental Hygiene, World Trade Center Registry, Survey response rate: <https://www1.nyc.gov/assets/911health/downloads/pdf/wtc/wtc-datafile-manual15.pdf>.

epidemiology gives information about the **risk and protective factors** related to a disaster event. For example, an investigation of deaths and injuries after a tornado outbreak can provide data about where people were when they were killed or injured, the types of injuries sustained, and whether protective factors had an impact on the occurrence of injuries. These may be environmental or behavioral factors. This type of study allows informed recommendations for interventions to help protect people from injury caused by tornadoes. It is easy to imagine how information about and descriptions of risk and protective factors in disaster events can be useful to preparedness and response planners.

2.3 EVALUATIVE EPIDEMIOLOGY

In using evaluative epidemiology, investigators can determine the effectiveness of specific interventions that have been implemented and identify factors that have resulted in their success or failure. It allows them to modify strategies and develop new interventions. This allows epidemiologists to determine, for example, if specific immunization strategies are effective in preventing spread of flu, or whether environmental changes (e.g., building standards) are effective in decreasing building collapses, and therefore deaths and injuries, in earthquakes.

Consider the example of mass shooting in schools in the United States (e.g., Parkland, Florida, in February 2018). There have been numerous suggestions about how to prevent similar incidents, ranging from arming teachers or placing armed guards in all schools, to continuing to hold active shooter drills to prepare school children for possible events. Evaluative epidemiology can provide information about the use of these interventions, as well as the risk and protective factors associated with them if an event occurs. Evaluative epidemiology may add to the data needed for research across events in addition to research related to a specific event.

3. PURPOSE OF DISASTER EPIDEMIOLOGY

Disaster epidemiology allows investigators to identify the priority health problems in the community affected by a disaster. Although the primary focus is on health problems related to the disaster itself, epidemiologists can also learn about preexisting health problems that impact a community's resilience and create needs for specific services during a disaster. In a disaster or public health emergency, it is also important to identify the causes of disease and injury and associated risk factors in the context of the event. This may include examining the results of laboratory testing of biologic and other specimens to identify specific disease agents or toxic substances involved in the event.

Various methods of classifying severity of injury or illness can aid in determining priorities for health interventions. The epidemiologic assessment of health problems allows for a rapid needs assessment that leads to planning for interventions, identification of the need for additional help, and modifications as well as additional support for the infrastructure. As an event evolves, continued surveillance and epidemiology allow tracking of the course of diseases, as well as identification of emerging issues. For example, although many people were killed and injured in the 7.0 earthquake in Haiti on January 12, 2010, it took several days to identify the emergence of cholera, which presented a significant risk to the survivors. Epidemiology was used to identify cases and limit the spread of the disease. In January 2011 the Pan American Health Organization¹³ released a report on the health impact of the earthquake, highlighting lessons that could be applied to the next major disaster event. In this way, the epidemiology and surveillance from one disaster can be used to inform planning and response for future events.

3.1 FORENSIC EPIDEMIOLOGY

Forensic epidemiology is not discussed as often as it might be with respect to disaster epidemiology. The field of forensic epidemiology brings together public health and a legal investigative approach to examining a disaster or emergency situation. This is especially important in cases of suspected bioterrorism and other intentionally created events. Forensic epidemiology explores the intent, persons involved, degree of harm, and risk factors, to form a complete picture of an intentional disaster. As an example, the 1985 investigation of intentional contamination of salad bars in Oregon led to the prosecution of the religious group responsible.¹⁴ In the case of mass shootings, a forensic epidemiology approach can provide critical information to identifying commonalities and differences between the mass shooting events.

4. DISASTER SURVEILLANCE

As with other parts of epidemiologic practice, surveillance plays a critical role in epidemiologic investigations during and after a disaster. One of the major challenges of surveillance in disasters is that many routine surveillance systems may not provide the information necessary to assess needs or

identify disease or injury patterns. This occurs in both natural and human-made disasters and creates difficulty for all types of disaster epidemiology. Disasters present special circumstances in which surveillance may be difficult, and during which routine surveillance systems may not be functional or accessible because of the circumstances of the disaster. As technologies continue to emerge, the potential for using new data collection systems can increase our ability to initiate and maintain surveillance systems early in the course of a disaster.

4.1 SYNDROMIC SURVEILLANCE

Syndromic surveillance uses indicators of population and individual health that may appear before widespread disease is confirmed through clinical or laboratory diagnosis. This type of surveillance is often set up as a routine surveillance mechanism that is in place to monitor for specific diseases. For example, a sharp increase in sales of over-the-counter cold remedies might indicate the emergence of a new respiratory virus. Across the United States, emergency departments participate in syndromic surveillance systems designed to detect clusters of events in the early phases of an outbreak, such as gastrointestinal illness caused by food poisoning or disaster. Syndromic surveillance systems may be based on existing data systems, particularly when electronic health records are available in real time. If the focus is looking for a specific disease, case criteria for surveillance are identified, whereas in a more general syndromic surveillance strategy, data may be monitored for unusual patterns that could indicate emerging disease. The Centers for Disease Control and Prevention (CDC) has developed definitions for diseases associated with critical bioterrorism agents.¹⁵ In addition, syndromic surveillance may be implemented on a short-term basis during specific events when there is a possibility of either disease transmission or an intentional act that results in illness. For example, during the 2002 Kentucky Derby Festival, 12 hospitals successfully participated in the surveillance system that was set up to quickly interpret emergency department patients' chief complaints to serve as a disease sentinel for the community.¹⁶ Syndromic surveillance is being integrated into practice in health care settings, and entire countries are now using this approach. The CDC has established a committee, Syndromic Surveillance and Public Health Emergency Preparedness, Response and Recovery (SPHERR), that helps integrate syndromic surveillance data and information into preparedness and emergency response.¹⁷

4.2 CHALLENGES IN DISASTER SURVEILLANCE AND EPIDEMIOLOGY

To perform disaster surveillance activities, it is important to predefine the variables and data points that would be of interest during a particular type of disaster. Although a core set of variables is important in any disaster event, each type of event has unique circumstances that need to be documented to understand fully the impact of the event. For example, the spread of a newly emerging strain of flu would necessitate identification of the strain causing infections in the population of interest, at least to the extent that one can assume the cases beyond a

certain point in time could be attributable to the agent that has already been identified. In the case of a tornado or earthquake, the specific location of victims, with details about the type of building, the force of the tornado or earthquake, the injuries sustained and their severity, and the outcome for each person injured are all important data to collect. In an infectious disease outbreak, the trajectory of the impact on the population is very different, and there may be more time to collect data to plan for the resources and interventions that will be needed. These are data points in addition to demographic data.

Surveillance is also important after the disaster, particularly if there are risks for the development and increased transmission of infectious diseases due to the nature of the event or other known or potential long-term health impacts. Events that disrupt water supplies and sanitation place the communities affected at risk for the spread of infectious disease from contaminated water sources. Other postdisaster outcomes of interest include recovery status of injured disaster victims. An understanding of the severity of injuries sustained, as well as long-term rehabilitation and support needs, will aid in community planning.

4.3 DESIGNING A DISASTER SURVEILLANCE SYSTEM

As much as possible, a disaster surveillance system should not require a large amount of additional resources or personnel during a disaster event. Because personnel will be consumed with responding to the disaster and implementing interventions, requirements for collecting large amounts of additional data are likely to create difficulties for the personnel involved. The number of skilled staff may be insufficient to collect the data needed, or the staff responding may not have a good understanding of basic epidemiologic principles and measurement. There may be limited access to the population of interest. If a sample of the population is surveyed, it may not be representative of the overall population affected by the disaster. Cultural and language barriers pose additional problems, along with the difficulty in investigating the long-term needs of the affected population.

A core set of data points can be used in surveillance in most disaster events. Demographic data as well as simple outcome data for both victims and responders are useful in tracking the impact of the disaster as well as identifying the need for resources. A data system design that allows for a *modular* approach, which adapts the data to be collected depending on the type of event as well as the phase of the event, may be useful. System design requires consideration of the data collection methods that are routinely available and that may be available after the disaster. In addition, it is important to consider the burden that data collection will present to an already-stressed system. When possible, it is important to use existing data systems rather than creating new systems that have not been tested or accepted by those involved in a disaster response; the simpler the data collection, the better. It is also possible to collect postdisaster data and interview people who were at the scene, but this is not always optimal because of the potential for *recall bias* and for data to be missing from patient records. Data collection during and after a disaster

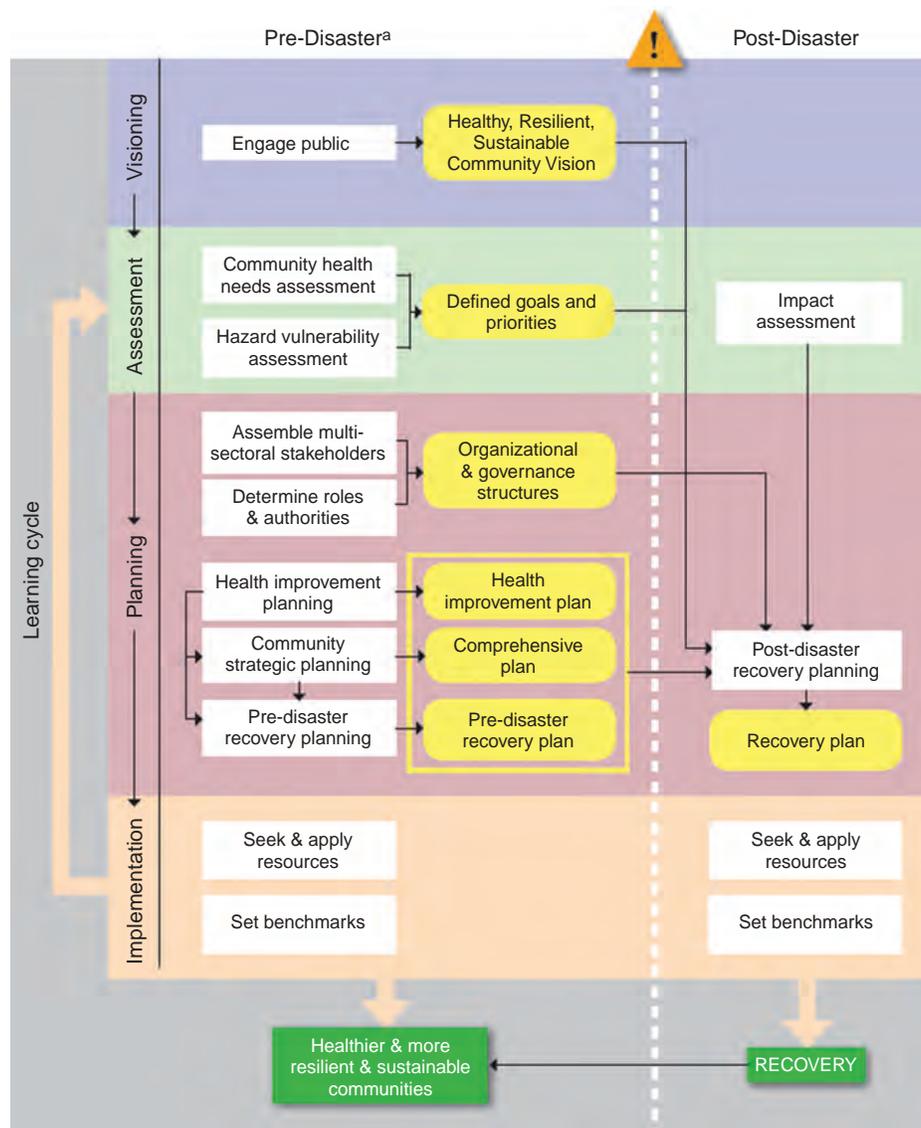
must take into account existing data sets and information; the size, demographics, and baseline health status of the population affected; and available resources. Geographic mapping can be useful in examining the impact of environmental factors in a disaster. Consideration should be given to collecting data that will be, or are likely to be, used.

When there is an urgent need for information or acquisition of resources, a rapid survey may be done. In this scenario, only the minimum information necessary to meet the surveillance goals is collected. Only information that is not already available or cannot be collected in another way is obtained, and the goal becomes to collect as representative a sample as possible to ensure generalizability to the population affected. This type of survey is sometimes repeated and refined over the course of the event and postevent period.

In the postdisaster period, surveys of persons who were present during the event may be helpful, as may surveys of those who were injured or who became ill during the event. Key informant interviews can provide information about risks and mitigating factors experienced in the community and can help identify approaches to planning for future events. As previously described, longitudinal surveys of survivors and responders provide information about long-term health and social impacts.

5. ROLE OF GOVERNMENT AGENCIES AND NONGOVERNMENTAL ORGANIZATIONS

Preparedness for and response to disasters and pandemics require a coordinated effort from multiple agencies and organizations. Although an in-depth discussion is beyond



^a Although the committee strongly encourages communities to undertake these activities in the pre-disaster period to maximize the opportunities to leverage the post-event recovery process for the purpose of creating healthier, more resilient and sustainable communities, in the event that they have not been undertaken beforehand, there is still benefit to incorporating them into post-disaster recovery planning.

Fig. 27.1 Building healthy, resilient, and sustainable communities before and after disasters. (From National Academies: <http://nap.edu/resource/18996/Post-Disaster-Report-Brief-Insert.pdf>)

the scope of this chapter, a brief summary of the role of federal agencies and nongovernmental organizations (NGOs) is helpful in understanding the multifaceted nature of preparedness and response.

Public health focuses on overall population health and ensuring that population-based measures are in place for disaster preparedness and response. Surveillance activities are in the realm of public health, as is disease reporting and investigation of disease and injury occurrence. **Emergency management** agencies, which exist at various governmental levels, focus on the overall management of a disaster response and coordination of recovery services, and may be responsible for allocation of resources. The US Federal Emergency Management Agency (FEMA), now in the Department of Homeland Security, works to plan for disasters and terrorism, makes recommendations to the public on how to prepare for events, provides education for responders, and reviews disaster declaration requests from governors to ensure that resources are appropriately allocated and distributed.¹⁸

Various other agencies are involved in preparing for and responding to disasters at the local, state, and federal levels. The private sector and NGOs, such as the American Red Cross,¹⁹ have an important role as well, providing services such as shelter, food, and clothing. NGOs also respond to disasters that occur around the world, providing emergency and long-term shelter, health care, food, clothing, and other services.

6. SUMMARY

Disaster epidemiology and surveillance are critical components of a disaster response and can contribute to understanding the nature of an event as well as the implications for planning for future events. There are unique challenges presented in performing surveillance during disasters, but the efforts made at surveillance using epidemiology principles provide valuable contributions to our understanding of disasters and planning for future events. Efforts to build healthy, resilient and sustainable communities after disasters can be addressed both predisaster and postdisaster (Fig. 27.1).

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REVIEW QUESTIONS

- Which of the following is an objective of disaster epidemiology?
 - Prevent or reduce the number of deaths, illnesses, and injuries caused by disasters
 - Provide timely and accurate information for decision makers
 - Improve prevention and mitigation strategies for future disasters by collecting information for future response preparation
 - Identify disease and injury patterns and risk factors to the population and community affected by the disaster
 - All of these

2. Which contexts of disasters must be taken into consideration to develop prevention and mitigation strategies to prevent disasters?
 - A. Costs, time, place
 - B. Time, place, person
 - C. Person, costs, time
 - D. Costs, place, person
 - E. None of these
3. Forensic epidemiology refers to the:
 - A. Identification of the distribution of diseases or injury among the population groups affected by a disaster
 - B. Analysis of risk factors associated with a disaster
 - C. Evaluation of the effectiveness of an intervention to prevent disasters
 - D. Analysis of the protective factors associated with a disaster
 - E. Assessment of intent, persons involved, degree of harm, and risk factors associated with an intentional disaster
4. Emergency management agencies function to:
 - A. Make recommendations on how to prepare for disaster events
 - B. Provide short-term shelter, health care, food, clothing, and other services
 - C. Review disaster declaration requests
 - D. Provides education for responders
 - E. Perform all of these
5. Which of the following is *not* a challenge associated with designing a disaster surveillance system?
 - A. Limited access to the population of interest
 - B. Cultural and language barriers
 - C. Difficulty in assessing the long-term needs of the affected population
 - D. Lack of public interest in identifying disaster trends
 - E. Insufficient number of staff available to collect the data needed
6. An investigation of death and injuries after a hurricane identifies the environmental and behavioral factors that affected the occurrence of injuries. This is an example of:
 - A. Analytic epidemiology
 - B. Descriptive epidemiology
 - C. Evaluative epidemiology
 - D. Forensic epidemiology
 - E. None of these
7. The 1972 investigation of intentional *Salmonella typhi* contamination of Chicago's municipal water system led to the arrest of two college students involved. This is an example of:
 - A. Ecologic epidemiology
 - B. Descriptive epidemiology
 - C. Analytic epidemiology
 - D. Forensic epidemiology
 - E. Evaluative epidemiology

ANSWERS AND EXPLANATIONS

1. E. Disaster epidemiology assesses the short-term and long-term adverse health effects of disasters to predict and prevent consequences of future disasters. It brings together various topic areas of epidemiology, including acute and communicable disease, environmental health, occupational health, chronic disease, injury, mental health, and behavioral health. Disaster epidemiology focuses on identifying disease and injury patterns and risk factors to the population and community affected by the disaster.
2. B. Three contexts—time, place, and person—drive the development of prevention and mitigation strategies. Cost (A, C, and D) is not a contextual factor that drives how prevention and mitigation strategies are implemented.
3. E. Forensic epidemiology integrates public health and a legal investigative approach to examining a disaster situation. Identification of the distribution of diseases or injury among the population groups affected by a disaster (A) characterizes descriptive epidemiology. Analysis of the risk (B) and protective factors (D) is conducted under analytic epidemiology. Evaluation of the effectiveness of an intervention to prevent disasters (C) is the primary purpose of evaluative epidemiology.
4. E. The US Federal Emergency Management Agency (FEMA) makes recommendations on how to prepare for disasters (A), reviews disaster declaration requests from governors to ensure proper allocation of resources (C), and provides education for responders (D). NGOs respond to disasters by providing both short-term and long-term shelter, health care, food, clothing, and other services (B).
5. D. Limited access to the population of interest (A), cultural and language barriers (B), difficulty in assessing the long-term needs of the affected population (C), and insufficient number of staff available (E) are factors that are likely to create difficulties for personnel involved.
6. A. Analytic epidemiology involves the assessment of risk and protective factors associated with a disaster event. Descriptive epidemiology (A) is used to identify the distribution of disease or injury among the population groups affected by a disaster. Evaluative epidemiology (C) allows investigators to determine the effectiveness of interventions that have been implemented; forensic epidemiology (D) explores the intent, persons involved, degree of harm, and risk factors to form a complete picture of an intentional disaster.
7. D. Forensic epidemiology brings together public health and a legal investigative approach to examining a disaster situation. This is especially important in bioterrorism cases, such as the one described here, to identify the intent, persons involved, degree of harm, and risk factors of the intentionally created event.

Abstract: This chapter is about disaster epidemiology and surveillance.

Keywords: disasters, burden, burden of disaster, resources, natural disasters, human-made disasters, epidemiology, descriptive epidemiology, analytic epidemiology, evaluative

epidemiology, forensic epidemiology, disaster surveillance, syndromic surveillance, challenges in disaster surveillance and epidemiology, designing a disaster surveillance system, government agencies and nongovernment, nongovernment organization (NGO)