Chapter 13
Epidemiology of Public Health Emergencies

Hong Zhu

Key Points

- Public health emergencies have enormous impact on population health.
- Public health emergencies can be divided into natural disasters, man-made disasters and disease outbreaks.
- Epidemiology plays a crucial role in the management of public health emergencies.
- Epidemiologic investigation is usually the first step when disease outbreak and disaster occurs.
- Response to public health emergencies is inextricably linked to advance preparedness.

The health impacts of public health threats, such as emerging infectious diseases (e.g., 2003 SARS epidemic, 2009 influenza A pandemic, and 2016 Zika outbreak), terrorism (e.g., 2001 World Trade Center bombing), environmental catastrophes (e.g., 2011 Fukushima Daiichi nuclear disaster), and natural disasters (e.g., earthquake), have demonstrated the importance of strengthening the public health systems and improving the community's ability to respond effectively. Epidemiology is critical for the management of public health emergencies. This chapter introduces the application of epidemiology in the investigation of, preparation for, and response to public health emergencies.

H. Zhu (✉)
School of Public Health, Tianjin Medical University, Tianjin, China
e-mail: zhuhong@tmu.edu.cn

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13.1 Basic Conception of Public Health Emergencies

Throughout 2018, altogether 484 public health events were recorded in WHO's event management system (a 16% increase from 2017), of which 352 (73%) were attributed to infectious diseases, 47 (10%) to disasters, and 19 (4%) to food safety.

13.1.1 Definition of Public Health Emergencies

A "public health emergency" refers to *a sudden-onset natural or man-made event, which poses a risk to public health,* like infectious disease outbreak, bioterrorist attack, severe food poisoning or industrial poisoning, or other significant or catastrophic events. A public health emergency, being an important part of all kinds of emergent events, seriously affects the health of a certain population and needs multisectoral cooperation co-assistance to cope.

Two terms "disaster" and "accident" are easily confused with "public health emergency." The United Nations Disaster Relief Organization (UNDRO) defines disaster as *"a serious disruption of the functioning of a society, causing widespread human, material, or environmental losses which exceed the ability of the affected society to cope using its own resources."* This definition shows that disaster has broader influences not only on health, but also on social stability and economic development. Many experts agree that the disasters which pose a threaten to human life can be called public health emergencies, while those posing danger to environment or material, rather than human health, are not public health emergencies, such as volcanic eruption in remote areas or the 1998 Asian financial crisis.

The other term "accident" means *an unpleasant event that happens unexpectedly and causes injury or damage*. Accidents can usually affect individuals or groups, while public health emergencies always affect groups. Besides, the accident cannot be anticipated or predicted. However, different from accidents, some types of public health emergencies can be predicted, for example, flood, and the activities on risk assessment, early warning, and preparation will mitigate the consequences of predictable hazards.

13.1.2 Characteristics of Public Health Emergencies

1. Public health emergency is a sudden-onset event. A public health emergency, as a kind of emergencies, has the characteristic of emergency, that is, it occurs suddenly and unpredictably, and its onset and development are hard to predict. However, now, development in science has made it possible for humans to predict more and more disasters, like early warning of floods, forest fires, and infectious diseases.

2. Public health emergency has a great impact on human health. The victims of public health emergencies are not limited to some certain individuals, but rather a large population or substantial proportion of people. The term also includes events that may pose a potential health threat, such as exposure to infectious agents, contaminated water, or food that may cause harm to humans.
3. Public health emergencies caused by different reasons have different characteristics, and correspondingly have different treatment and management strategies. For example, for the outbreak of an infectious disease, the main aim of the investigation is to identify the pathogen and transmission route; while for a natural disaster, the main aim of the investigation is to assess the situation rapidly.
4. Immediate action and unconventional measures should be taken to deal with public health emergencies. Multi-sectoral and multinational cooperation is usually needed. Health-care services, together with administrative institutes, media, military, traffic agencies, academic institutes, etc., may deal with emergencies more effectively and efficiently.

13.1.3 Classification of Public Health Emergencies

There are many different classifications of public health emergencies. The most commonly used method is based on the cause(s) of emergencies.

1. According to the nature of these events, public health emergencies can be divided into as follows:

   Biological emergencies: These include communicable diseases, biological agent-related terrorisms, and vaccine inoculation-related events.

   Chemical emergencies: These include leaks of hazardous chemicals, intentional or unintentional chemical food poisoning, and the use of chemical agents in terrorist incidents.

   Radiological emergencies: These include the release of harmful radiation caused by the explosion of a nuclear weapon or improvised nuclear device.

   Weather and home emergencies: These include the threats caused by abnormal meteorological conditions, like thunderstorms, flooding, tornado, and extremely hot or cold weather, and the threats from home, like kitchen fire, gas leak or explosion, and carbon monoxide poisoning.
2. According to the originating source of the disaster, public health emergencies can be divided into as follows:

   Natural disasters: Natural disasters include weather phenomena (such as tropical storms, tsunamis, avalanches, extreme temperatures, winds/typhoons/hurricanes, and floods) and geologically related disasters (like earthquakes, landslides, and volcanic eruptions).

   Man-made disasters: Man-made disasters include industrial accidents, traffic accidents, pollution incidents, terrorism, and armed wars. Natural disasters have long been considered the ones that cause the most deaths and economic losses, but man-made disasters are becoming more prominent.

Epidemic diseases: Disease epidemics or outbreaks would threaten the health of a certain population. These diseases are usually infectious or communicable, such as cholera, measles, hepatitis, influenza, malaria, SARS, H1N1, and HIV. They can spread among population through different routes of transmission, including air, food, water, direct or indirect contact, and insect or animal vectors. It is worth noting that the risk of disease outbreak usually increases following natural or man-made disaster (i.e., a flood), mainly due to poor sanitation and overly dense populations.

13.1.4 Phases of Public Health Emergencies

Emergency situations always change dynamically and require changes in response accordingly at different phases. The whole process of a public health emergency is often thought of as a cycle, which consists of six phases including preparedness phase (pre-emergency phase), warning phase, impact phase (emergency phase), response phase, reconstruction (rehabilitation) phase, and mitigating (preventing) phase. While the stages of dynamic change appear to be continuous, clearly identifying the end of each phase facilitates the adjustment of response strategies and better accommodation of new demands.

The whole process of an emergency may be divided into four phases: impact phase, response phase, recovery phase, and mitigation phase. Sometimes, it also includes a warning phase. Impact phase is the stage when the disaster causes real harm to the population. The duration of this phase depends on the number of people affected, and the type of incident. It may last for a few minutes (e.g., an earthquake), or several days (e.g., a flood), or several months (e.g., a disease outbreak). A response is made following the impact phase of an emergency. Preparedness actions taken in a timely manner prior to an emergency can be extremely helpful when facing an emergency. Relief activities (such as patients' treatment or victims rescue) occur during the response phase, which is followed by the reconstruction (rehabilitation) phase. During this phase, the focus is no longer on relief, but rather on development, which aims to help the affected people self-reliant. Besides, the lessons learned from the emergency are applied to prevent the recurrence of such disasters or to reduce the harm caused by such disasters, and to adequately prepare for such disasters should it recur.

The above process helps to formulate emergency response strategies and protocols. This concept suggests that four phases occur successively and unidirectionally. Actually, however, many things may occur at same time. The cycle concept ignores the reality that the serious consequence caused by emergencies may extend well beyond efforts at the reconstruction phase. The weakness of the efforts at reconstruction and mitigation phases can easily be magnified by subsequent emergencies (Fig. 13.1).

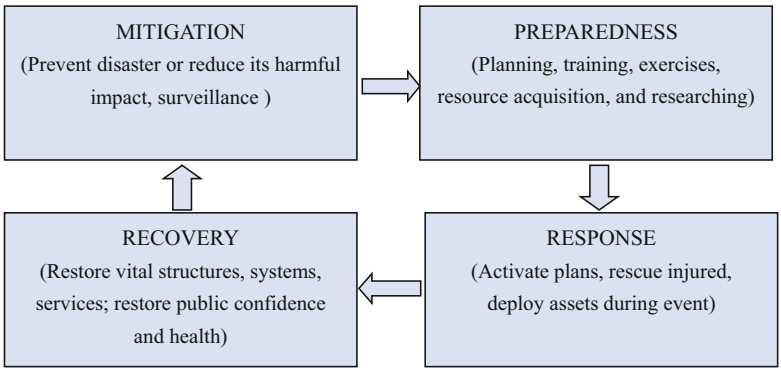

Fig. 13.1 Phases cycle of public health emergencies

13.1.5 Harm Caused by Public Health Emergencies

Public health emergencies, especially those occurring in large scales not only result in human mortality, but also cause physical, psychological, and social disabilities.

1. *Physical harm*: Public health emergencies may cause deaths, injuries, and sometimes malnutrition. The impact phase is the primary phase of an emergency resulting in serious injury or death. When a public health emergency occurs, the most important and urgent task is the treatment of the wounded or patients.
2. *Psychological harm*: Psychological trauma is a unique individual mental experience caused by a serious injury event, especially when enormous pressure derived from the event is beyond one's ability to cope. Psychological effects of fear, helplessness, anxiety, depression, and terror caused by emergencies might linger for years, even decades, hence, psychological rehabilitation must be done on a long-term basis.
3. *Economic and social disabilities*: Natural disasters or terrorist attacks may lead to social disruption and infrastructure damage, such as transportation, residential building, enterprise assets, and electricity. It will directly or indirectly reduce the profits of the economy and reduce the speed of economic development, and ultimately affects social stability. Usually, developing countries are more vulnerable to emergent events than developed ones.
4. *Environmental and ecological harm*: Some kinds of emergencies, like volcanic eruptions, chemical or radiological releases, may affect the environment and disrupt the ecological balance in a certain geographic area, which in turn leads to harmful effect on human.

13.2 Basic Principles and Application of Epidemiology in Public Health Emergencies

13.2.1 Role of Epidemiology in Public Health Emergencies

Epidemiology of public health emergencies may be defined as *the application of epidemiology in public health emergency preparedness and response, with the aim of determining the nature of the events, exploring the causes and risk factors of the events, identifying the high-risk population, developing and assessing the health programs to prevent and control harmful effects caused by emergencies.*

From an epidemiological perspective, policymakers and practitioners can focus on the main issues of the entire affected population rather than on individuals, and to further develop measures to improve the health of the entire community. For public health personnel, epidemiological investigation is usually the first step when the disease or the disaster occurs.

Table 13.1 summarizes the epidemiological tools and principles applicable to responding to public health emergencies, with the aim of containing the progress of events, and reducing the harmful impacts on the whole populations.

13.2.2 Key Epidemiological Indicators

In epidemiology, the occurrence of disease or disaster is not in a random way; instead, follows a specific pattern which can be studied and predicted with respect to "what, who, where, when, how, why, whom, and what next." Hence, some indictors can be used to describe this pattern, evaluate the impact of disease or disaster, and to assess the effectiveness and efficiencies of intervention programs. Table 13.2

Table 13.1 The application and goals of epidemiology in public health emergencies

Application of epidemiology	Goals of epidemiology
Demand assessment	Evaluating the size and structure of the affect and potentially affected population, identifying the priority health issues and the health-related demands (medical devices, staffs, etc.) in the community
Population surveys	Determining the mortality and morbidity of disease (death rates and incidence/prevalence) or the number of injured; determining health status (nutrition and immunization status)
Public health surveillance	Monitoring health trends of the community; early predicting and warning
Disease outbreak investigation	Identifying the causes or risk factors of the disease; determining the source of infection, the route of transmission, and the susceptible population
Program evaluation	Assessing the coverage and the impact of health programs; economic evaluation

Table 13.2 Epidemiological indicators for evaluating emergency intervention programs

Indicator	Examples
Public strategies	Degree of protocol commitment 1. Follow the diagnostic criteria for the case and treatment protocols 2. Degree of public and community involvement 3. Degree of cooperation and coordination between inter-sectors 4. Equity and accessibility of resource allocation
Demographics	Estimated number and structure of the affected population 1. Age and sex proportion 2. Population mobility and migration 3. Proportions and characteristics of high-risk and vulnerable groups 4. Ratio of urban and rural population
Health status	Rate of disease and death 1. Incidence and prevalence of common diseases or the infectious disease to be studied, secondary attack rate 2. Death rate (crude, age- or sex-specific, infant, under-fives, maternal) and fatality rate 3. nutritional status especially among under-fives
Program inputs	Input of the following resources: 1. Government financial guarantee funds 2. Facilities and equipment (health centers, beds, medicine, sanitize devices) 3. Staff (professional staff, volunteers, army, firefighters) 4. Basic supplies (food, water, shelter material, daily necessities) 5. Ancillary resources (fuel, charcoal, transport, communication)
Program process	Access, coverage, and quality of the following services: 1. Daily necessities sanitation 2. Environmental sanitation (feces/garbage disposal, disinfection) 3. Coverage of vaccination and prophylaxis 4. Demand for and utilization of health services (two-week attendance rate, hospitalization rate)

summarizes the epidemiological indicators that can be used to evaluate an emergency intervention program's process and outcome.

13.2.3 Outbreak Investigation

13.2.3.1 Purpose of Outbreak Investigation

A disease outbreak (or epidemic) refers to the sudden occurrence of similar disease among many people in a region or a community due to the same source or carrier, with the incidence rate higher than normal expectations. Epidemiological investigations can be used to ascertain the nature of disease epidemics, for example, the cause of diseases (why), transmission routes and vectors (how), disease distribution by place, time and population (what, where, when, who), susceptible population (whom), and disease trend (what next). Determination of these natures of disease outbreak is critical to identify effective and proper clinical and public health

interventions. The objectives of outbreak investigation are to determine the existence and the severity of the outbreak, to explore the cause(s) and risk factors of the disease, to identify high-risk groups who are at higher risk of being affected and who would benefit most from interventions, and to identify and evaluate effective interventions to slow down the spread of the disease and reduce the harm caused by the outbreak.

13.2.3.2 Three Elemental Epidemiological Designs in an Outbreak Investigation

In the epidemiological investigation of disease outbreaks, three elemental epidemiological designs can be used:

1. Descriptive epidemiology, especially cross-sectional design, can be used to describe the characteristics of disease distribution and to identify the difference in disease frequency among different regions and populations, which provide clues to the establishment of etiological hypotheses. Multiple cross-sectional studies can also provide information on temporal trends of disease outbreak.
2. Analytical epidemiology, mainly including case-control design and cohort design, can be used to explore the risk factor (e.g., environmental and behavioral factors) of disease by comparing the exposure proportion between cases and non-cases (case-control design) or by comparing the incidence rate between those with or without a certain exposure (cohort design).
3. Experimental epidemiology, including randomized controlled trial, filed trial, and community intervention trial, can be used to assess the safety and efficacy of a certain intervention, such as a new medicine, a new vaccine, or a new public health program. For example, evaluating a cholera prevention program by comparing the incidence of cholera between two communities with or without initiating this program.

13.2.3.3 Key Steps in Carrying Out Outbreak Investigation

1. Confirm the outbreak: All reports of the suspected outbreak by health-care workers or victims themselves require an immediate response from the relevant health authorities. The first step is to confirm the existence of the outbreak by local public health teams (e.g., staffs in CDC) through field investigation. Sometimes, besides epidemiologist, other specialists, such as microbiologists, zoologist, internists, and environmentalist, are needed to cooperate with the field investigation.

   Initial investigations provide first-hand information on disease outbreaks, which is helpful for the follow-up investigation. Besides, the findings can also be used to develop diagnostic criteria for the disease, which is essential for the further investigation and clinical treatment.

2. Define a "case": The main work at this step is to define a "case." Health workers use this standard case definition to determine whether a person has a certain disease. Based on this case definition, investigators can identify how many people are cases (the numerator), and how many people are at risk of the occurrence of this disease (the denominator). Subsequently, attack rates (for disease outbreak) or incidence rate (for disease epidemic) can be calculated and compared with previous average rate level. Please note that data on the whole population is always needed as the denominators in the calculation of incidence rate or death rate.

   The definition of the case includes suspected case, clinically diagnosed case, and a laboratory-confirmed case. In the early stage of the investigation, due to the lack of laboratory equipment for diagnosis, most cases are diagnosed based on epidemiological and clinical information. At this stage, more sensitive case definition (e.g., suspected case) is helpful to find more cases. In the middle stage of investigation, more specific definition (e.g., clinically diagnosed or laboratory-confirmed case) should be used in order to identify real patients and explore risk factors of the disease through case-control study or cohort study. In the end stage of the investigation, the definition used should be feasible and proper for disease surveillance, with the aim of assessing the effect of outbreak control activities.
3. Describe the outbreak by place, time, and person: Epidemic curve, which shows the number of diseases (y-axis) in an outbreak over time (x-axis), provides key information about an outbreak, including time trend (how quickly it is growing, and whether it is ongoing), what are the potential sources of disease (single or multiple sources), and how long the incubation period is. Dotted map which graphs the location of all reported cases can help to identify regional distribution of the outbreak and disease spread direction. Rates calculated by age and sex provide information on the most susceptible subpopulations and causal clue. Investigators can access to public health surveillance system to get data for rate calculation.
4. Analyze what caused the outbreak: Explore key differences between the non-cases and cases to determine which groups or individuals are more susceptible to disease, what are the potential risk factors, and what are the possible sources of disease and routes of transmission. Biological specimens are also collected from two groups for experimental test. If there has been some evidence that certain exposure is the potential cause of the disease outbreak, historical or prospective cohort design can be used to identify whether the persons with the exposure has the higher incidence rate than those without the exposure.
5. Assess environment: If disease outbreak is speculated to be related to environmental factors, such as animals or vectors, fecal contamination, or toxic chemicals, assess environment becomes necessary. Animal hosts or vectors should be investigated and some abnormal phenomenon should be observed and reported, especially for animal-borne diseases.
6. Initiate and improve prevention and control strategies: The ultimate goal of epidemiological investigation is to prevent and control disease outbreak. Hence,

intervention strategies and programs should be developed and launched based on the available information on disease outbreak. A clear understanding of the outbreak characteristics is needed for effective prevention and control. This involves three aspects: morbidity and mortality of the diseases, three elements of disease epidemic (source of infection, route of transmission, susceptible population), and context information (the amount and availability of medical resources, administrative divisions, etc.).

The main countermeasures against disease outbreak include controlling the source of infection (isolation and treatment of confirmed cases, management of asymptomatic carriers and animal hosts), curb disease spread (personal hygiene, environmental disinfection, health education, avoid gatherings, vector control, and entry-exit health quarantine) and protecting susceptible individuals (vaccination, nutrition, personal protection, and chemoprophylaxis). All these control measures should be established in accordance with national disease control regulations and policies.

Note: Taking control measures as early as possible is the most effective way to prevent the spread of disease. Hence, the process of outbreak investigation and intervention must be conducted rapidly and simultaneously. When little is known about the cause of disease, nonspecific measures for control of communicable diseases can be taken, such as isolation of the suspected patients, environmental disinfection, and personal protection. With the further understanding of the disease, prevention and control strategies will be improved correspondingly, and more targeted measures can be introduced (e.g., immunization).

7. Summarize an outbreak investigation and write a report:

Summarizing the whole process of the investigation and sharing the experience with all involved is the last step when the outbreak ends. The report should include the source of infection and possible routes of transmission, possible causes of the outbreak, case characteristics and clinical symptoms, geographical distribution, time trends, and lessons learned from epidemic control.

13.2.4 Disaster Investigation

13.2.4.1 Purpose of Disaster Investigation

In contrast to disease outbreaks, the cause and the harmful effects of most disasters (natural or man-made) are relatively easy to identify and diagnose. Hence, the objectives of investigation in disease outbreak and disaster are different. In the event of disasters, investigation is conducted mainly for identifying the amount and the trend of harmful impact, and corresponding demands for staff, materials, and services. For example, it is important to understand the need for intervention and to determine the size and type of the intervention as soon as possible. Unfortunately, several weeks are usually needed to collect and organize precise and reliable data. Hence, the urgent work for disaster investigation is to conduct a rapid needs

assessment to get less-precise and less-reliable data, based on which crucial decisions are made. Besides rapid needs assessment, further investigation is also needed to collect more detailed, precise, and complete information, which is essential for the reconstruction of the community.

A rapid needs evaluation should be initiated as soon as possible, preferably within the first 3 days after the event. The objectives of rapid needs assessment are to assess the amount of affected population, disaster situation, local rapid response capacity, secondary disaster risk, resources needed, and the recommended actions.

13.2.4.2 Key Steps in Carrying Out Disaster Investigation

1. Preparing for rapid health needs assessment
   Prior to rapid assessment, adequate preparation is required, such as collect background information about the emergency location, inspect safety conditions at the site of disaster, contact with local authorities and relevant organizations, and prepare essential equipment and supplies. Besides, a plan for the field assessment should be made to determine the order and manner of information collection, the forms for recording and analyzing the collected information, time schedule, and tasks assignment to each team member.
2. Making checklists for rapid needs assessment
   Making a list of information to be collected during the preparation phase ensures the quality and comprehensiveness of needs assessment. A number of rapid assessments checklists are available. The checklist chosen should be adapted to the specific culture and background of the emergency.
3. Identifying methods and sources for collecting data
   The main sources of information include health records at local health facilities; satellite maps; local pictures and videos; news media and social media information; vital statistics; medical insurance records; and field interviews with local health workers, health officials, or affected population. Please note that the interviewees should be selected from different demographic characteristics, such as gender, age, and race.
   The method of data collection is determined by the type of the emergency, financial, material, and staff resources for the assessment as well as time requirements. Both qualitative and quantitative methods can be used, such as reviewing past records, observation, focus group discussions, key informant interviews, patient narratives, and questionnaire.
4. Conducting rapid health needs assessment
   The following steps may provide a logical approach to rapid health needs assessment:(a) Conduct preliminary observation when approaching the site to evaluate the extent of population displacement and the damage caused by the disaster. (b) Interview local authorities and personnel, such as local government leaders, public health workers, volunteers, as well as people in affected communities to identify water and food supplies, medical services, and demographic characteristics. (c) Review existing records, such as maps, census data, and

surveillance system data (d) Conduct detailed visual inspection, like field surveys around affected communities to collect information on the structure of camps, living conditions and sanitation, population movement and migration, social influences and reactions, damage to transportation and communication systems, epidemic risk of infectious diseases, and priority health issues.

Rapid needs assessment is usually conducted through cluster or convenience sampling methods. The results are useful for planning follow-up interventions; hence, the main findings of needs assessment and corresponding recommendations should be reported to policy-makers or related agencies as soon as possible.

5. Conducting thorough investigation

When the efforts of disaster rescue are more focused on the reconstruction or rehabilitation of the community, more precise and complete information or data are needed, such as detailed data on death and injury, nutritional status of the residents, the damage of health-care services and other public facilities, and long-term effect of the disaster on physical and psychological health. Such information plays an important role in guiding after-disaster reconstruction. Besides, the information can also be used as evidence for determining legal responsibility in man-made accidents.

13.3 Public Health Emergency Preparedness

It is generally believed that managing public health emergencies is about how to respond to the occurrence of it. However, this is but a corner of the picture. The management of public health emergencies must cover all the four phases of emergency: pre-emergency phase, response phase, recovery phase, and mitigating phase. In every phase, some certain measures should be taken, that is, preparedness, response, and recovery. Efforts conducted in all these phases are essential and valuable. For example, in preparedness phase, we take measurements to prevent the occurrence of emergencies or carry out researches to achieve precise prediction and early alarming of harmful events. When these events occur unavoidably, we can minimize the harm they cause. Previous experience has illustrated the important role of adequate preparation in advance on the successful management of public health emergencies, no matter natural or man-made. Hence, without adequate preparation, it is difficult to respond effectively and successfully, even with sufficient resources.

13.3.1 Definition of Public Health Emergency Preparedness

Public health emergency preparedness (PHEP) is the ability to prevent, prepare for, rapidly respond to, and recover from public health emergencies in coordination with local government, health-care system, health-related institutes, communities, and individuals, especially when big threatens occur that exceed the normal scale.

Preparedness involves a continuous and long-term process of planning and implementation, and its success depends on proper planning, corrective actions, coordination, and selfless dedication of many people and institutes concerned. Public health preparedness requires the collaboration of government and community leaders to ensure that the community are adequately prepared to respond to a possible emergency, do their best to mitigate its damage and recover from the emergency as quickly as possible if they cannot prevent it.

13.3.2 Significance of Public Health Emergency Preparedness

Organizing responses to emergencies ensures adequate access to mental, medical and all other health-related services for the affected population. Emergency preparedness cannot completely eliminate all hazards, but it is a strong prerequisite for ensuring rapid and effective response to emergencies, thereby minimizing morbidity, mortality, and other damages. For example, governments can develop food security programs to ensure that food is protected from pests to avoid food crises, meteorological warnings and material reserves help residents to withstand extreme heat and extreme cold weather, and wide-coverage immunization procedure and systematic surveillance system help communities prevent from outbreaks of infectious diseases.

13.3.3 The Main Activities of Public Health Emergency Preparedness

Preparedness is reflected both in the ability to prevent possible public health emergencies and in the ability to respond adequately when emergencies occur. The main activities of public health preparedness are as follows:

1. Establishing an emergency management agency

   Preparedness activities must be undertaken jointly by the many relevant health sectors in order to respond more quickly and effectively to an emergency or disaster. Hence, an effective national emergency management system is needed to organize and coordinate various departments to deal with emergencies effectively and efficiently. However, there is still no such comprehensive national emergency management system in many developing countries. Instead, the military is in charge of the relief effort by default. In China, a three-level emergency management system has been set up since 2003, which include national-, provincial-, and city-level agencies, with Prime Minister as the top leader. In 2006, Emergency Management Office of the State Council was set up, which is a significant milestone representing the building of complex emergency response system in

China. In April 2018, Ministry of Emergency Management of the People's Republic of China was set up. As the national-level agency for emergencies management, it coordinates emergency response in China.

2. Developing laws and regulations

   In the event of the SARS outbreak (2003), the Chinese government realized the necessity of legalization in emergency management, and then issued *Regulations on Preparedness for and Response to Emergent Public Health Hazards* on May 7, 2003. After that, another law was issued on August 30, 2007, which was *Law of the PRC on Response to Emergencies*. Besides, there are some other related laws or regulations, such as *Law of the PRC on the Prevention and Treatment of Infectious Diseases; Law of the PRC on Prevention and Control of Occupational Disease; Hospital Infection Management Measures; Management of Information Report on Monitoring of Public Health Emergencies and Infectious Diseases; etc.* These laws and regulations identify the specific obligations and responsibilities of each related institute and individual.

3. Establishing action protocols

   The purpose of establishing action protocols is to facilitate a prompt, efficient, coordinated response in the case of an emergency. Detailed protocols should be set up for all kinds of emergencies. Given the wide scope of emergencies, there are a corresponding number of different types of emergencies. Plans and protocols are developed and established to mitigate adverse impacts of emergency events and train the team to keep them ready.

4. Simulating emergency events to improve readiness

   Planning, preparation, and practice are the keys to achieving success in the case of an actual emergency. One kind of practice is a simulation program, like a fire drill, or earthquake drill, which is focused on training departments and residents in the timely recognition and appropriate intervention for critical emergency events.

5. Training public and professional personnel

   On the one hand, professional training on the knowledge and skills related to emergency preparedness and response should be given to emergency-related personnel, such as public health professionals, emergency physicians, clinicians, other health-care workers, and even firefighters or military soldiers. On the other hand, appropriate training and education to community residents in advance is also relevant, which helps public know basic knowledge on common infectious diseases, emergency rescue skills, and proper response to a public health emergency.

   Various ways of training can be used, including lectures, courses, and network training provided by universities, Centre for Disease Control and Prevention, and academic health centers. Moreover, emergency drills and exercises are important part of training, familiarizing the personnel with the practical application of emergency procedures, systems, and facilities.

6. Reserving supplies and staffs

   Disaster relief goods and materials should be prepared in advance and specially used for the rescue, transfer, and arrangement of the affected population in

the emergency. These materials may be provided by governments at all levels or donated by public or private institutions/organizations and individuals. Till 2010, the Chinese government has set up 17 central-level lifesaving disaster relief materials storage warehouse, including foods, drinking water, medical goods, and daily necessities. Besides, some specific warehouses are building for certain kinds of emergencies, like fire, flood, earthquake. In addition, prophylactic medicines, such as antitoxins, antibiotics, chemical antidotes, and vaccines should be reserved. Professional staffs should also be cultivated by school education or on-the-job training.

7. Monitoring and early warning

   Continuous and systematic monitoring, also called "surveillance," public health data, as well as analyzing and interpreting these data, provides policy-makers critical information for planning, implementation, and evaluation of public health interventions. As the foundation of emergency preparedness, surveillance is to monitoring any health-related changes or patterns. Based on monitoring system, abnormal signs and changes which may adversely affect communities can be detected promptly, thereby, there is enough response time for emergency systems to adequately prepare for possible disasters and minimize their harmful effects. Especially, for certain events, like disease outbreaks, local armed conflicts, and floods, the authorities may issue warnings to alert people to the impending dangers. This can reduce the material and economic losses and prevent loss of life. Different colors can be used to represent different threat alert levels. For example, in American green means low threat, blue means general threat, yellow means significant threat, orange means high threat, and red means severe threat. The main responsibilities of a comprehensive monitoring and early warning system includes data monitoring, risk analysis, event detection, warning release, communication, and feedback, with the aim of realizing complete surveillance, accurate prediction, and timely warning.

8. Risk assessment

   Risk assessment is a risk analysis of predefined vulnerabilities and hazards based on systematically collected data. In a broader sense, risk assessment includes daily risk assessment and specific risk assessment. The former is conducted in the pre-emergency phase to assess the hazard vulnerability in an area, and the latter is carried out after the onset of an emergency to assess the potential further risk caused by this event. In a narrower sense, risk assessment only refers to daily risk assessment.

   Daily risk assessment involves gathering information about the most common risk factors affecting the area, the likelihood and risk of emergencies, the extent of damage to infrastructure, emergency response capacity and weaknesses of public facilities, and the amount and characteristics of vulnerable populations.

   Specific risk assessment would be conducted once an emergency is detected or notified, and then confirmed. Specific risk assessment takes into account the actual site conditions and address only the relevant hazards, and then results in grading the event, which determines the level of response that needs to be taken and activating the appropriate emergency response. Event grading is based on

five criteria: scale, severity, urgency, respond ability of local or national government, and government's reputational risk.

13.4 Public Health Emergency Response

13.4.1 Definition of Public Health Emergency Response

Public health emergency response refers to the actions, which are taken immediately following an emergency, to save lives, provide assistance, minimize economic damage, and accelerate post-disaster reconstruction, so as to mitigate the adverse impact on the public and society.

13.4.2 Significance of Public Health Emergency Response

Rapid and proper response to an emergency is important with respect to life safety (which is usually the Number 1 Goal), stabilizing the emergency and protecting the environment and property.

13.4.3 The Main Activities of Public Health Emergency Response

Emergency response is a dynamic process. The response actions should be initiated during the first 24 h of an incident. Specialized rapid-response teams are needed to respond quickly to new disasters and disease outbreaks.

13.4.3.1 Ensuring Availability of Preventive and Emergency Medical Treatment

When disease outbreak or disaster occurs, the top priority of any public health response is to save lives and control the spread of disease. Many resources are required, including isolation treatment hospital (for communicable diseases), medical supplies (antitoxins, antibiotics and chemical antidotes, laboratory agents, and equipment), staff (medical workers, health-care workers, public health personnel, volunteers, and psychological counselor), guidelines for diagnostic and treatment, transport, and stationery. Countermeasures for communicable diseases must be administered to patients, prophylactics must be provided to high-risk groups when necessary, like vaccine or prophylactic antibiotics, and psychological canceling must

be provided alongside treatment. Please note that medical workers must attach enough importance to personal protection, patients isolation, and environment and items disinfection to avoid nosocomial infections.

13.4.3.2 Preventing Secondary Public Health Emergencies After Disaster

The primary cause of mass casualties from terrorist attacks or natural disasters may not be chemical or biological in nature, but be the subsequent secondary hazards, such as infectious diseases (such as cholera and plague) epidemic, leakage and spread of toxic gas, destruction of lifeline supplies (communications, transportation, water supply, power supply, etc.), and social unrest (robbery). For instance, World Trade Center explosion, which caused severe damage to urban facilities and high levels of social panic may further lead to secondary infectious diseases and poisoning. Another example is that on March 11, 2011, the earthquake in Japan triggered a tsunami, causing a nuclear leak at the Fukushima nuclear power plant. Hence, in emergency situations, priority should be given to preventive measures to avoid further deaths or more health threatens. Local public health managers protect the affected and surrounding areas from secondary health threats caused by pest or rodent infestations, ensure adequate water, food, and living space, dispose garbage and human feces, promote hygiene practices, handle dead bodies appropriately, etc.

13.4.3.3 Interrupting the Route of Transmission

Public health authorities should take measures to prevent further spread of the disease as soon as the source of the disease is identified. Measures taken include isolating sources of outbreak, such as closing contaminated restaurants or water supply, isolating and treating communicable disease patients, and enclosing buildings. When a disaster is severe enough, the government has the right to declare a lockdown in the affected areas. In addition, there must also be an adequate contact tracing workforce to track and trace cases and contacts to prevent the spread of outbreaks.

13.4.3.4 Remediating of Environmental Health Conditions

The role of public health authorities also includes decontamination and disinfection of affected site and facilities. Decontaminating is the neutralization, removal or destruction of toxic or hazardous substances, such as toxic substances, radioactive materials, or disease pathogens, in order to avoid harm to other patients and health-care providers, and prevent secondary pollution and nosocomial infection. The manner and extent of decontamination mainly depends on the nature of the hazardous substance and its viability (microorganisms) and degradation rate (radiation).

13.4.3.5 Performing Laboratory Analyses to Support Epidemiology and Surveillance

Laboratory tests can strongly support epidemiological survey and surveillance. In many instances, laboratory work is inseparable from the discovery of pathogens or chemical poisons, the diagnosis of patients, and the determination of harmful substances in environment. In some special cases, new disease pathogens must be detected through more sophisticated laboratory analysis such as RT-PCR and high-throughput DNA sequencing. In addition, laboratory techniques can be used for the development of vaccines or new drugs, as well as for the study of pathogen resistance or homology.

13.4.3.6 Communicating with Media and Delivering Message to the Public

Information about the emergency must be communicated to the public through the media, telling them the good, the bad, the ugly, and what we do not know yet. This communication can also be called risk communication. As one of the key countermeasures for emergencies, risk communication is the timely exchange of information, knowledge, attitude, and advice between government or health officials or relevant experts and the affected people. Effective risk communication reduces mortality and morbidity by promoting good personal and home hygiene and improving self-rescue and self-care ability, it also helps government maintain political and economic stability of the country. Therefore, all countries should regard risk communication as a core part of their efforts to respond to emergencies. The ultimate goal of risk communication is to enable people at risk to respond correctly when a risk occurs to mitigate the effects of a hazard. The message delivered in risk communication must be simple, timely, accurate, relevant, credible, and consistent. In addition, more emphasis should be placed on effective public education and two-way conversation, as well as timely communication of risks to the public.

13.5 Summary

In the management of public health emergencies, epidemiology has the ability to monitor, detect, and investigate potential hazards, and to maintain and improve the systems necessary to support this capability. Epidemiological functions would be especially important to address hazards that are environmental, radiological, toxic, or infectious in nature. Epidemiological functions are one of several core public health capabilities as being critical for public health emergency preparedness.

For public health emergencies, preparedness and response are inextricably linked. Preparedness is based on lessons learned from both actual and simulated response

situations. An effective response is all but impossible without extensive planning and thoughtful preparation. Public health emergency management conveys the important idea that protecting populations and property involves the estimation of risks, preparation, and activities which will mitigate the consequences of predictable hazards and post-disaster reconstruction in a way that will decrease vulnerabilities. An important goal is building a culture of awareness that preparation is not only possible but also will greatly reduce the consequences of disasters in terms of human and economic loss. In these, public health is an important partner with engineers, planners, elected leaders, and community organizations.