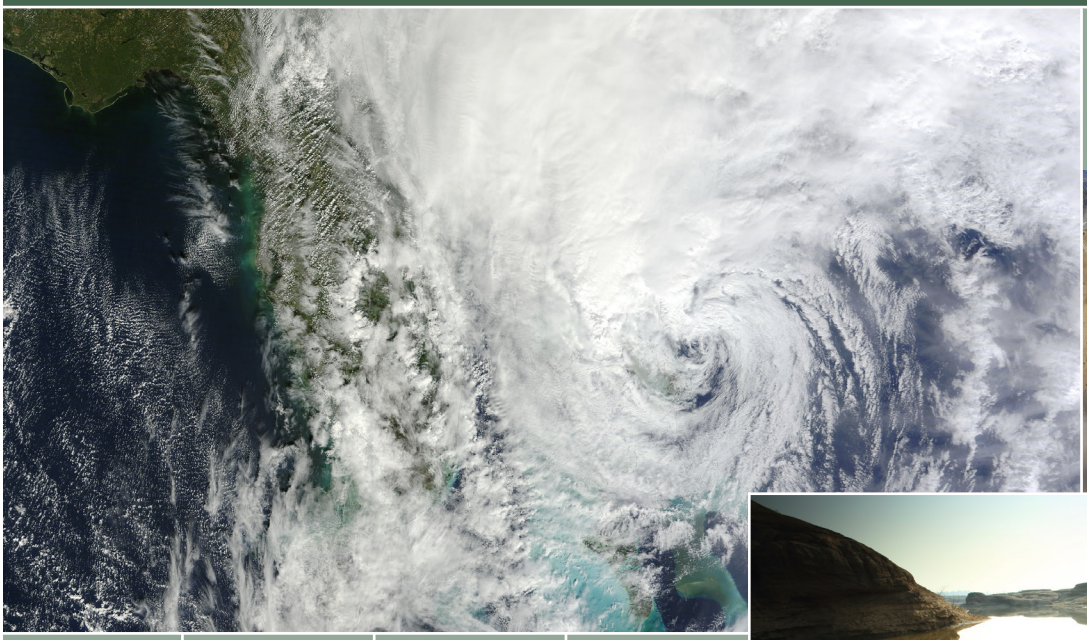
A Primer for Understanding the Principles and Practices of Disaster Surveillance in the United States



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For additional information or to obtain copies, please contact:

CDC's Health Studies Branch at 4770 Buford Highway, MS F-60, Chamblee, GA 30341
Phone: +1 770-488-3410 Fax: +1 770-488-3450

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Primary Authors:

Nicole Nakata, MPH; Amy Schnall, MPH; Amy Wolkin, DrPH; Rebecca Noe, MN, MPH; Sherry Burrer, DVM, MPH; and Tesfaye Bayleyegn, MD

Critical Reviewers:

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Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

Introduction

Disasters can significantly affect human health and seriously disrupt the functioning of society. They cause widespread human, material, or environmental losses that exceed local capacity to respond, and call for external assistance.[1] These events can be categorized as natural, human-induced, and complex. Natural events include tornadoes and earthquakes, human-induced include accidental chemical spills and terrorist events, and complex include famine and war. Disasters can severely impact a community's well-being though major infrastructure damage and severe financial losses, straining local health care and emergency response capabilities and severely affecting health and the environment.[2,3] Health risks include illness, physical injury, potential disease outbreaks, exacerbation of chronic illness, mental health issues, and death.[4]

Epidemiology plays an integral role in disaster preparedness, response, and recovery activities. During disasters, public health surveillance can provide useful information for targeted and effective public health response.[5-10] However, according to a study by the Disaster Epidemiology Subcommittee of the Council of State and Territorial Epidemiologists (CSTE), the range of disaster surveillance activities conducted across U.S. states differ significantly.[9] States varied in whether they had performed disaster surveillance in the past 10 years, had included surveillance in their jurisdiction's response plan, and had used exercises to test their surveillance systems. Those that had conducted disaster surveillance activities reported the need for flexible disaster surveillance response plans, key partnerships established, and staff trained and ready to support surveillance activities before an event.[9] This primer was developed to provide introductory information on the purpose, importance, and methods for approaching disaster surveillance in the U.S.

The audience for this primer is public health departments at state, local, tribal, and territorial levels. This document outlines how health departments can approach public health surveillance during a disaster and reviews principles and practices of disaster surveillance. It provides key concepts and challenges to consider when conducting disaster surveillance, but does not give step-by-step guidance.

The principles and practices described in this document can be useful for developing surveillance systems for disasters if existing systems do not exist, or for leveraging or modifying existing systems for disaster situations.

Disaster Epidemiology

To mitigate adverse health effects and reduce future impacts from disasters, public health officials must respond with appropriate public health actions. Those might include conducting epidemiological studies or program development and implementation throughout the disaster life cycle (i.e., preparedness, response, recovery, mitigation). Timely and accurate information is required so that actions from policy decisions during the mitigation and preparedness phases, to resource allocation during the response phase and long-term assistance in the recovery phase is appropriate and effective.

Disaster epidemiology plays a major role throughout the disaster life cycle in providing needed information. In simple terms, **disaster epidemiology** is the use of epidemiology to investigate the short- and long-term health effects of disasters and to predict the health consequences of future disasters.[11]

Disaster surveillance is a tool in disaster epidemiology that

- provides ongoing, systematic collection, analysis, and interpretation of injuries, illnesses, and deaths for use in planning, implementation, and evaluation of public health practice;
- enables public health to track and identify morbidity and mortality linked to an event; and
- provides insight into future disasters.[12-14]

Information collected from any surveillance system must serve to facilitate action, and therefore must be communicated to emergency managers, policy makers, public health staff, program leaders, and the public. Information can also be used to drive public health actions, target response activities, provide situational awareness, direct public communications, and address rumors.[5-10,14,15] Surveillance can be invaluable in understanding the totality of the disaster's human health impacts. Surveillance systems provide data on health events resulting from the disaster that are analyzed to characterize those events by person, place, and time. This information helps to identify where public health problems are, who is affected, and where and how they are affected.[16,17]

Information collected from any surveillance system must serve to facilitate action.

Purpose of Disaster Surveillance

When disasters occur, many questions will need to be answered. These include what public health problems are occurring, where and why they are occurring, who is impacted, and which are causing the greatest public health problems. Disaster surveillance is an effective way to address these questions. It provides public health staff and other decision makers with actionable health information.[15] Disaster surveillance helps to

- define and detect outbreaks and health problems early on;
- determine when, where, and how injuries, illnesses, and deaths occur;
- prepare for and prevent ongoing adverse health effects;
- estimate the magnitude of a health problem;
- identify at-risk groups or geographic areas;
- demonstrate the need for public health intervention or resources;
- inform and monitor the effectiveness of response and relief efforts; and
- assist with planning for future disasters and recommend ways to decrease the consequences of future disasters.[14]

For many conditions, surveillance is used to monitor and track morbidity (i.e., illness or disease) and mortality (i.e., fatalities) in a population or subset of a population, such as first responders.[18] Surveillance can track morbidity and mortality from communicable diseases such as norovirus and waterborne diseases, and chronic diseases such as diabetes and chronic obstructive pulmonary disease (COPD). Surveillance also might track injuries from carbon monoxide (CO) exposure, falls, and other causes; health consequences of exposure to chemicals and environmental contaminants; and behavioral and mental health issues.

Without surveillance data, decision makers' actions might not address the most urgent needs of the affected population. When implementing a disaster surveillance system, keep in mind that information must be promptly dispersed to health and government officials and emergency managers who are in a position to take action based on data-driven recommendations. This is the primary purpose of disaster surveillance: to provide timely, accurate, and relevant information to drive decisions and interventions during a disaster.[12,19-22] Surveillance also helps plan for future disasters. As issues are resolved and needs arise, continued disaster surveillance allows responders to track and redefine public health problems and priorities as the disaster progresses and moves to new phases.[12] Finally, disaster surveillance serves to highlight areas for future research and training, which will help jurisdictions better prepare for disasters.[23]

Disaster surveillance helps to identify disaster-related health problems; provides information to prevent or reduce injury, illness, or death; and helps guide prevention strategies for future disasters.

Understanding Surveillance

Types of Surveillance

Passive Surveillance

Traditionally, surveillance systems are classified as passive or active. **Passive surveillance** is the regular reporting of disease data by health institutions to health authorities. In a passive surveillance system, there is no active search for cases, rather it involves passive notification by the health care facilities or practitioners.[24] For example, hospitals, clinics, public health facilities, laboratories, and other sources report pre-determined notifiable diseases to state health departments due to legal state mandates.[25] This is the basis of notifiable disease surveillance in the U.S. The National Notifiable Disease Surveillance System (NNDSS) collects information on selected infectious and non-infectious diseases and conditions, such as salmonellosis, West Nile virus, and carbon monoxide (CO) poisoning that can be used as a data source during disasters.[26]

Passive systems are useful beause they

- are relatively inexpensive,
- are cost-effective to implement,
- have a low data collection burden, and
- provide important information for monitoring a population's health.

Often data requested from passive systems are minimal. If a large area needs to be covered, passive surveillance may be used as a relatively inexpensive strategy. For example, following a widespread disaster, passive surveillance may be used to monitor vaccine-preventable disease occurrence, such as tetanus. However, because passive surveillance depends on health officials and procedures in different institutions to provide data, the quality and timeliness of those data are difficult to control.[7] Reporting can be slow, variable, or incomplete if the responsible health officials do not report regularly. Slow and irregular reporting are concerns in disaster situations where timely information is needed. These issues with passive systems might be compounded if the health care infrastructure is damaged or destroyed.[27]

Active Surveillance

Active surveillance uses designated staff members to regularly contact heath care providers, laboratories, hospitals, the population, and others to seek information about health conditions. Active surveillance is often more sensitive and may collect information that is more detailed than passive system data since staff can search or request for specific information about cases.[25]

During disasters, epidemiologists may use active surveillance systems in addition to passive surveillance. After Hurricane Andrew, for example, the Louisiana Office of Public Health, in coordination with emergency departments, public utility personnel, and coroners, used active surveillance to facilitate health impact and outcome reporting in the affected areas.[28]

Active surveillance is commonly used in disaster situations where tents, temporary shelters, mobile clinics, or other venues are established for short-term medical care by response agencies such as

Active systems are useful because they

- can complement regular reporting functions disrupted by the disaster;
- can be used in non-traditional settings, such as evacuation centers and temporary shelters, providing more flexibility than regular reporting mechanisms;
- can be targeted to determine the needs of special populations or identify groups, more at risk for adverse health events; and
- often provide more complete information than passive surveillance.

the American Red Cross and the military.[7] Whether you use active, passive, or a combination of both is determined by the specific disaster situation and available resources.

Although active surveillance provides the most accurate and timely information, it is also expensive and labor intensive. Resource scarcity in disaster settings and the cost of running active surveillance might limit its use to short periods and the investigation of specific health concerns.[27] Differences in format, methods of data collection, and reporting across sources also make it difficult to aggregate this information unless the surveillance system uses mechanisms such as standardized questionnaires to diminish such differences.

Sentinel Surveillance

Sentinel surveillance is an active or passive surveillance system that collects data from a limited number of recruited participants or providers to report on specific health events.[29] The selected sample of reporting sources may serve to estimate trends in the larger affected population.[7] Sentinel surveillance providers may include clinics, hospitals, other health care facilities, laboratories, or physicians. Providers included in the sentinel surveillance system report all cases of the conditions of interest.

Sentinel systems are useful because they

- monitor trends effectively,
- overcomes issues of underreporting,
- monitor a greater number of conditions,[27]
- are less costly than other methods,[7] and
- are flexible and can be scaled up by recruiting additional surveillance sites.

Sentinel surveillance can be established to supplement an existing surveillance system. After the 2010 earthquake in Haiti, national and international agencies collaborated to form the National Sentinel Site Surveillance System to monitor disease trends, detect outbreaks, and characterize the affected population to target relief efforts to areas of need.[30] Over the course of 3 months, 51 selected hospital and clinic surveillance sites provided daily telephone or email reports for 25 specified conditions. During that time the sentinel system did not pick up any anomalies, but was used as proof to dispel rumors about disease clusters and outbreaks.[30]

Although sentinel surveillance can be extremely useful for detecting large public health problems, it might not capture rare events, such as the early emergence of a new disease, which might occur in areas not covered in the sentinel surveillance system.[7] The sentinel sites selected also might not be representative of the larger disaster-affected area, depending on how the sample is selected.

Syndromic Surveillance

Syndromic surveillance is an active or passive system that uses case definitions or syndromes based on a group of signs and symptoms, primary complaints or presumptive diagnoses, or other characteristics of the disease, rather than specific clinical or laboratory diagnostic criteria. Data can be gathered from traditional surveillance sources, such as emergency rooms and physicians, or from non-traditional sources such as nurse hotlines and pharmacies.[31] Each source included in the syndromic surveillance system reports any case matching the syndromes being monitored to the appropriate health authority. This process can be automated for quicker turnaround of information. In instances where the health infrastructure is maintained but increased timeliness is important, syndromic surveillance can supplement existing active or passive systems. In these situations, adding or monitoring specific syndromes, such as fever

and shortness of breath, in an existing surveillance system may ensure that you capture essential data.[3] However, syndromic surveillance is often less specific and can be subject to misclassification. It might identify more people than actually have the condition of interest and might result in more complex data analyses and handling. For example, if a jurisdiction is interested in monitoring flu-like syndromes following a snowstorm, the number of true positives of influenza may be a much smaller number than the number of cases flagged by the syndromic surveillance system and would require additional data, such as laboratory confirmation, to monitor influenza trends.

Syndromic systems are useful because they

- are timely, providing early information and situational awareness, sometimes in near real time;
- do not require health care practitioners to make diagnoses, which can be time consuming and difficult;
- do not require laboratory confirmation; and
- can detect outbreaks early on.

Syndromic surveillance is particularly useful in the early stages of a disaster if routine surveillance has been disrupted or has not been established. Flexibility and timely reporting are ideal. It can be used many ways, including situations where health effects are widespread, as in wildfires or hurricanes. It can be used to rule out an illness outbreak after a disaster or to detect and monitor health impacts that affect only a few individuals.[8] In 2001, after the World Trade Center attacks, syndromic surveillance was established in New York to help quickly identifying potential outbreaks or illnesses that could be linked to a bioterrorist event.[25] Syndromic surveillance provides early identification of potential morbidity and mortality because the system can identify potential cases from doctor or emergency department visits before a person's condition is officially diagnosed.[11] In areas particularly

devastated by a disaster, syndromic surveillance provides an earlier indication of unusual increases in illnesses, injury, or death to shape early intervention efforts.

CDC's National Syndromic Surveillance Program (NSSP) BioSense Platform is a public health surveillance system that increases the ability of health officials at local, state, and national levels to efficiently, rapidly, and collaboratively monitor and respond to harmful health effects of exposure to disease or hazardous conditions. The Platform gives users access to the data and technology to conduct syndromic surveillance to track health issues and rapidly share information with others in the system. After the 2010 Deepwater Horizon Gulf oil spill, state and local jurisdictions coordinated with CDC and other federal agencies to use the BioSense Platform to monitor 21 conditions. The monitoring produced daily situational awareness reports for affected state and local responders.[32] Another example, in 2007 CDC personnel monitored data received by the Biossense Platform for evidence of health effects possibly related to wildfires in San Diego County, CA. Visits for diagnoses and chief complaints of asthma were all increased during the monitoring period.[33]

More information about the BioSense Platform and NSSP is available at http://www.cdc.gov/nssp/biosense/index.html.

Surveillance during a Disaster

Disasater Data Types

Disaster surveillance is often defined by data types: morbidity and mortality.

- **Morbidity** is the state of being ill, diseased, or injured or the incidence or prevalence of illness or injury in a population.[18]
- **Mortality** is the incidence of death in a population.[18] It is an important indicator of the gravity of a disaster.

Detecting outbreaks of infectious disease such as gastrointestinal and respiratory illness after a disaster is crucial, especially when populations are displaced and sheltering in large groups. However, data collected after Hurricane Katrina and other major disasters show that health events in disasters are not limited to infectious diseases. Chronic illness, injury, and mental health outcomes can worsen and often play a larger role than communicable disease.[17] Therefore, surveillance systems need to monitor morbidity and mortality related to non-infectious conditions such as chronic disease, mental health issues, CO poisoning, and injury, especially focusing on at-risk populations (e.g., young children, pregnant women, elderly).[17]

Morbidity Surveillance

Disaster-related morbidity surveillance helps inform decisions about allocating resources, targeting interventions to meet specific needs, triggering public health response, and planning for future disasters.[34] Morbidity surveillance collects information on

- incidence rate,
- prevalence rate, and
- stratified rates (e.g., by age, sex, geographic location).

Mortality Surveillance

The mortality (death) rate helps to measure the impact of a disaster on a population.[19] It can assist in determining the magnitude of event-related health effects, evaluating prevention policy effectiveness, and identifying preventable disaster-related deaths.[6] Important mortality-related data to collect include

- demographic characteristics,
- time and location of death, and
- cause and manner of death.

Surveillance During a Disaster

During a disaster, data collection conditions are often chaotic and unpredictable. Surveillance is time and resource intensive, so use the most efficient method of reaching your objectives.[35]

The preferred approach is to use preexisting surveillance data for baseline information and modify established epidemiologic surveillance systems for disaster settings. In the U.S., many existing public health infectious disease surveillance systems can be used or modified for use during a disaster. Many states also have systems to monitor non-infectious diseases and injuries, which might be beneficial.[15] Examples of existing state surveillance systems include NCDETECT in North Carolina, ESSENCE in Florida, and SPARCS in New York.[36-38]

A supplemental or ad hoc surveillance system will be useful

- if the area lacks a preexisting surveillance infrastructure, or
- in circumstances where populations are displaced and temporary health care facilities are established.

Planning for Surveillance

Sometimes a surveillance system has not been created. Other times the existing surveillance systems are insufficient or have been compromised because the health infrastructure is severely damaged. In such situations, you might need to conduct supplemental surveillance, create a new system, or modify one that is available.[7]

Whether you plan to use an existing surveillance system and supplement it as needed or you need to create a new system or modify an existing one, careful planning is important and should be done in the preparedness phase of the disaster cycle.[21] Determining priority conditions or indicators to monitor will help to ready jurisdictions to rapidly conduct disaster surveillance.[17] Although no one approach fits all situations, key steps to help you develop a disaster surveillance system include the following:

- Define objectives
- Select variables for data collection
- Determine data sources
- Develop a data analysis approach
- Plan for report generation and results dissemination

Disaster surveillance is a fluid process. Outcomes from previous or current surveillance activities might affect the surveillance objectives and data collection, analysis, and dissemination.[39] As with all disaster activities, surveillance should be flexible and adaptable and integrate lessons learned from previous experiences. Knowing how to adapt existing systems to your needs can help facilitate your disaster surveillance activities.

Define Objectives

Set clearly defined objectives for your system in the preparedness phase. A surveillance system may be more likely to collect the information you need to answer your questions if you create strong objectives early on. Failing to create clear objectives may result in collecting unnecessary information, wasting time and resources. The objectives describe how the surveillance information will be used to inform public health actions.

Potentially useful objectives of a disaster surveillance system include the following:

- Monitoring the affected population's health for a defined time period
- Estimating the magnitude of a health problem
- Tracking disease trends for early detection and outbreak control
- Identifying priority health needs, both immediate and long-term

- Identifying causes of event-related injury and illness
- Tracking the geographic distribution of morbidity and mortality
- Focusing resources on groups that might be more vulnerable to disaster-related impacts and other disproportionately affected populations
- Evaluating public health actions and interventions
- Identifying research needs and evaluating control strategies[5,19]

Additionally, when defining your objectives, you should plan for which phase of a disaster you will implement surveillance and how your objectives may change as you shift from one phase to another. In the response phase, for example, the main priority of surveillance is to reduce morbidity and mortality rates. In contrast, an objective in the recovery phase may be to evaluate program interventions.[19]

After establishing the objectives, use them to limit your data collection and sites to the simplest possible solution that will meet the objectives. Consider data quantity versus timeliness and simplicity. You do not want to burden or overwhelm staff, therefore, collecting only the information that is absolutely needed is important.

Select Variables to Collect

After you have developed your objectives, you will need to select variables for data collection and establish case definitions. A case definition is a set of standard criteria for classifying whether a person has a particular disease, syndrome, or other health condition. Case definitions must be simple, clearly defined, understandable, and practical for use in a disaster setting. Generally, case definitions include criteria for person, place, and time.[27]

During a disaster, time and resource constraints often will limit your case definitions to

- simple clinical signs and symptoms, and
- a few common conditions.[19]

For disaster surveillance, case definition criteria might differ from clinical criteria when diagnosing an illness, disease, or other health condition. You might be dependent on initial impressions, chief complaint, or a broad category of signs and symptoms (e.g., nausea, diarrhea, skin irritation, conjunctivitis) rather than laboratory results, discharge diagnosis, or other confirmatory information.[5,25] You might need to make a trade-off between degree of certainty in diagnosis and timeliness of reporting. Common clinical signs and symptoms could include fever alone or in combination with sore throat or cough.[40] Disaster surveillance often also includes noncommunicable conditions such as burns, chemical exposures, CO poisoning, physical trauma, and adverse mental health effects.

When developing case definitions, consider both

- **direct health effects** — caused by the disaster's actual, physical forces, or essential elements (e.g., flooding from a hurricane or flying debris in a tornado), and
- **indirect health effects** — caused by unsafe or unhealthy conditions that develop from the effects of the disaster or events that occur from anticipating the disaster (e.g., motor vehicle accidents during mandatory evacuation).[41]

Without case definitions that account for both the direct and indirect effects of a disaster, surveillance data may be incomplete or may not accurately capture the health needs of the affected population.

The information you collect will be limited by your available human and financial resources. The conditions and determinants under surveillance should not affect the system's ability to operate

throughout the extent of the disaster.[14] Remember to set your objectives and priorities for case definitions based on those considerations.

To aid with timeliness and standardization, you might use established case definitions such as those established by NNDSS (http://wwwn.cdc.gov/nndss/conditions/).

Determine Data Sources

Before creating a new form to collect data, try to find out what existing data sources are available. Whether you are using or modifying an existing surveillance system or creating a supplemental or active surveillance system, the objectives and type of surveillance system will help determine the data source(s). Consider identifying existing potential data sources and establishing working relationships with partners during the preparedness phase. For example, if you are interested in mortality surveillance it would be helpful to reach out to your partners in vital statistics, funeral directors, medical examiners and coroners, and mass fatality staff to see their electronic death registration system (EDRS) capabilities. Additionally, nongovernmental organizations (e.g., American Red Cross) and federal agencies (e.g., FEMA) may be collecting mortality information that could supplement your existing efforts.

Many sources for morbidity and mortality data are available. These include national and state-based reportable disease systems, electronic or paper hospital records, census data on vulnerability and health predictors, disease registries, and health surveys (e.g., National Health and Nutrition Examination Survey, Behavioral Risk Factor Surveillance System).[15,17]

Health Care Facilities

Hospital and other health care facility data can provide a look at morbidity and mortality for certain conditions that are attributed to a disaster to determine increases due to the event. Hospitals in the U.S. currently use the International Classification of Diseases, 10th revision, Clinical Modification (ICD-10-CM) codes to classify diseases and health issues. The ICD alpha numeric codes allow for morbidity and mortality data to be systematically classified, compiled, and compared.[42] This coding enables searches for disaster-related ICD codes (e.g., X37 for cataclysmic storm, T58 for toxic effects of carbon monoxide) to gather morbidity and mortality surveillance data.

The ICD-10 site can be accessed at https://www.cms.gov/Medicare/Coding/icd10/.

In the U.S., many hospitals and health care providers use electronic information systems, which are a potential source for large amounts of data. Electronic health records and exchanges are valuable data sources that can help address baseline and logistical constraints on data collection.[15,43, 44]

When electronic systems are not available, paper forms can be used to collect morbidity and mortality data. Using pre-created, validated, and standardized collection instruments is ideal in disaster situations. They save time and resources and may allow for cross-jurisdictional standardization for comparison and data aggregation.[11] Abbreviated forms can be used if summary or less-detailed information is sufficient or when the burden of collecting detailed, individual information is substantial. CDC has developed multiple, ready-to-use templates for morbidity and mortality surveillance forms. You can use these templates to supplement existing surveillance, temporarily replace a system, or create an ad hoc surveillance system (e.g., in a shelter where no system previously existed).

You can access these surveillance templates on the CDC Emergency Preparedness and Response website (http://emergency.cdc.gov/disasters/surveillance/).

During a disaster, the Red Cross, if deployed, captures aggregate morbidity data, from their shelters onto a report form. Public health working with local chapters of Red Cross can develop information sharing protocols for such events.

Although using existing data sources and forms is preferred, you may need to create new surveillance forms for some disaster circumstances (e.g., severe health care infrastructure disruption, persons seeking care outside typical acute care settings) or when no forms or existing data sources are available to meet your surveillance objectives.[17]

Ideally, surveillance forms will be developed, tested, and distributed before a disaster. However, you might need to modify them depending on factors such as disaster type, available resources, and surveillance site. The forms should be easy to use and only collect the most essential information to simplify data entry.

Vital Statistics

Vital statistics (i.e., death records) are the gold standard for mortality surveillance. They provide data on demographic characteristics, geographic location, and cause of death. However, death record data can take months to obtain and might be of limited use in the response phase. Electronic death registration systems (EDRS) have been established in 38 of the 57 vital statistics jurisdictions in the U.S. EDRS allow for electronic filing of death certificates anywhere that has Internet access. They provide timely data in a more standardized manner that can be shared across jurisdictions and with federal agencies.[45]

To facilitate inter-jurisdictional data exchange, the National Association for Public Health Statistics and Information Systems developed the State and Territorial Exchange of Vital Events (STEVE) system. Jurisdictions and federal agencies can use this messaging application to electronically exchange vital event data such as death certificates.[45]

Electronic recording and sharing of death data can potentially provide a useful, timely, and streamlined source of baseline and event specific mortality surveillance data collected from various agencies and jurisdictions (e.g., Red Cross, Federal Emergency Management Agency [FEMA], state emergency operation centers).

You will face various challenges in using EDRS for disaster-related mortality surveillance. Some of these include a lack of standardized cause of death entry and coding, missing data on disaster-relatedness in a death entry, and limitations on the search capabilities within the system. Timely reporting and high quality information on cause of death and injury are required for EDRS to be beneficial in a disaster.[46] When collecting morbidity and mortality data, it helps to have the death certificate flagged as disaster-related so the record can be retrieved and tracked. It also helps to work with your local medical examiners or coroners during the preparedness phase to enlist their aid in the identification and reporting of all disaster-related deaths. CDC's "Reference Guide for Certification of Deaths in the Event of a Disaster" has information to help you with in this process.

Poison Centers

Poison centers (PCs) are a useful source of information on chemical exposures and poisonings related to disasters. PCs can provide background data and situational awareness by helping to monitor and detect outbreaks and trends and track disaster-related exposures, among other activities.[43] A network of 55 regional PCs services all parts of the country and U.S. territories through one national hotline number. Data collected from calls to PCs are uploaded into the National Poison Data System (NPDS). NPDS is a near-real time, national electronic data repository and web-based public health surveillance system. CDC uses NPDS data for surveillance of disaster-related exposures and associated illnesses (e.g., CO poisoning, foodborne outbreak). During a disaster, PCs can flag calls related

to the event with a code based on a predetermined case definition or inclusion criteria. This allows for easy, systematic tracking of all event-related calls.[43]

At the national or regional level, PC data can be used to indicate

- the extent of toxic exposures related to the disaster through call frequencies over time,
- the basic demographic distribution of toxic exposures related to the disaster and potential vulnerable populations who may be disproportionately affected,
- health communication messaging needs of the affected population, and
- the severity of toxic exposures and illness related to the disaster through a medical outcome measure used by all PCs.[47]

Local and state public health personnel can also leverage this data to supplement existing disaster surveillance systems (e.g., to track CO exposure during disasters). At the local level, public health agencies can use this information for event mapping down to the zip code level, or case-finding of high priority exposures related to the disaster. You should establish partnerships with PCs before a disaster to provide for effective surveillance at the local level. Such partnerships can help local and state public health collaborate with PCs to access and use their data and technology to conduct public health disaster surveillance activities.[43]

Affected Workers

In addition to the general public, health care and response workers can be affected by injury or illness during disasters, especially emergency responders, who often have the highest exposures. CSTE and CDC's National Institute for Occupational Safety and Health (NIOSH) have a number of resources available for assessing worker health effects and exposures. CSTE's Occupational Health Subcommittee is a useful

resource (http://www.cste.org/members/group.aspx?id=106606). Each state has an occupational safety and health contact (http://www.cdc.gov/niosh/statosh.html). NIOSH also has occupational health surveillance resources (http://www.cdc.gov/niosh/topics/surveillance/).

For assessing emergency responders, The Emergency Responder Health Monitoring and Surveillance (ERHMS) system is a multi-agency health monitoring and surveillance framework that includes recommendations and tools for protecting emergency responders. This tool can help identify potential exposures and detect and address health issues relief and response workers that may arise from their work.

More information about ERHMS is available at http://www.cdc.gov/niosh/topics/erhms/default.html.

Unstructured Data

Nontraditional sources of surveillance information that can be useful include news and media outlets. Unstructured data from these sources include information that is not part of an organized database designed to be quantitatively analyzed.[23] Access to data (e.g., media reports of disaster-related mortality) on the Internet is widespread and can help with timely detection of health events and more complete situational awareness. During Hurricane Sandy, for example, CDC evaluated the usefulness and accuracy of online media reports for disaster-related mortality surveillance. Epidemiologists used key word searches to track media reports in the affected region for Sandy-related deaths and to obtain demographics and circumstance of death. Data from the online media reports provided timely information on disaster-related mortality and could serve as a supplemental source of data in disasters.[48] Additionally, memorial websites posted after mass fatality events might list mortality data, and social media sites may identify morbidity trends or outbreaks.[19-51] These types of data may have lower specificity and reliability, but they can be valuable in a disaster situation where timely information is key. They can provide valuable information to supplement data gathered through more traditional sources such as public health and health care providers.[23]

Develop a Data Analysis Approach

After having gathered the surveillance data, you want to analyze it by person, place, and time.[14] In disaster situations, you will want to conduct analysis and reporting frequently to quickly and effectively identify potential health issues and transmit that information to decision makers so they can implement timely interventions.[19,52] During the response phase, daily analysis and reporting is encouraged.[52] As the disaster progresses and surveillance needs shift or surveillance reverts back to more passive systems, you may consider transitioning to weekly or more infrequent analysis. In the preparedness phase, determine the appropriate analytic approach. Consider the technical capacity available for analysis, level of analysis complexity, and how frequently you will tabulate data.[14,27] Data analysis is driven by your surveillance system's purpose and design.[53]

Descriptive analyses are useful in disaster situations because they are often simple, quick to calculate, and provide information for concrete public health action in an understandable manner. This approach involves calculating rates and identifying high-risk population groups. It involves answering questions of person, place, and time, such as "How much injury is occurring in a population?" and "Is one part of the population more negatively affected by the disaster than another?"[12,25,27] For unexpected results, you can conduct more in-depth analysis or research to identify factors contributing to those outcomes.[53] For example, Alabama and Texas analyzed morbidity and mortality data focusing on carbon monoxide exposure following Hurricanes Katrina and Rita in 2005. After conducting general descriptive statistics, they conducted more in-depth data analysis on specific results, including determining correlation between generator placement and carboxyhemoglobin (COHb) levels found in patients.[54]

Additionally, the Sphere Project* recommends stratifying data based on sex, age, individual vulnerability, affected and host populations, and context (e.g., shelter and non-shelter) when possible.[55] After the 2010 Haiti earthquake, epidemiologists stratified data from the sentinel surveillance system by location, identifying the regions which accounted for a majority of reported conditions, as well as by age, identifying the morbidity of those under 5 years of age.[30] It might also help to disaggregate by community member and response or relief workers. Stratifying data in this manner can help to identify potentially vulnerable groups and those disproportionately affected by the disaster. It can also help identify the occurrence of morbidity and mortality during the disaster. Relief workers and community members may be affected by the same disaster differently because their roles and exposures may differ.[56,57] However, detailed disaggregation may be difficult during the early stages of a disaster.

Frequencies

Common and useful measures for analyzing injury or illness frequency include incidence and prevalence.[53] **Incidence** measures the occurrence of new cases of death, disease, or injury in a population. **Prevalence** measures the existing cases of death, disease, or injury .[19,53] When providing case counts, clearly define whether the counts are related to new (incident) cases or current (prevalent) cases in the period.

Incident cases or prevalence counts are usually simple and easy to understand. They can be useful for identifying clusters of disease and for health planning. An example is identifying needs, such as the number of beds or doses of vaccine required in a shelter.[25] However, counts alone may not provide all of the information needed nor allow you to compare events in population groups of differing sizes or in different locations.[19] For example, you cannot compare the 10 cases of illness in one shelter to the 20 cases of illness in another shelter without knowing the population of each shelter. As a shelter's population fluctuates widely, a system (e.g., "heads in beds") can help keep track of the denominator as the response situation evolves. For surveillance data to be useful, case counts must be related to the population size.[25] You can do this by calculating incidence, prevalence, and other morbidity and mortality rates.[19,25]

Rates are measures of risk that allow you to compare the frequency of morbidity and mortality in different places, times, or population groups.[25] Usually, a calculation of the number of cases and rates includes a description of the population (person), location (place), and the period (time) for the condition.[25]

- You could analyze data by person to identify subgroups (e.g., age, sex) that may be at increased risk for negative health outcomes by comparing instances of morbidity and mortality in various groups (e.g., general population, women, children, disabled, elderly).
- You could analyze data by place by adjusting for differences in the size of the population in the assigned geographic areas. For instance, you could compare rates of injury in the disaster affected population to the rates occurring in a non-disaster affected population in the same region.
- You could analyze data by time to describe trends and detect changes in disease occurrence or frequency. This can help determine if you have an outbreak of diarrheal illness in a shelter or if death among children younger than 5 years have increased as a result of the disaster.[25]

* The Sphere Project is a multi-agency, nongovernmental organization initiative to improve humanitarian actions during disaster response. The Sphere Handbook presents a Humanitarian Charter and a set of minimum standards for humanitarian response to disasters. It provides concepts for planning, implementation, monitor, and evaluation in responses and supports disaster preparedness activities and contingency planning. More information is available at http://www.spherehandbook.org/.

For example, after Hurricane Opal, surveillance data for 20 conditions were analyzed by time, comparing the proportional morbidity rates of ED visits for these conditions for 6 days after the hurricane to the ED visits 6 days before the hurricane.[58] Although calculating rates such as these can be beneficial, denominator or baseline data may not be available to make these calculations in the disaster setting. Analysis may then be limited to calculating incident cases or prevalence only. Basic analysis such as providing incidence or prevalence rates is commonly done in surveillance and provides a quick picture of what is going on in the field.[59,60]

The analysis you conduct depends on the objectives of your surveillance and the design of your system, as well as the availability of resources. Table 1 lists some common parameters for analyzing morbidity and mortality surveillance data in disaster situations.[19,55]

Before data analysis, consider the audience for your information and how you will present this information to them. By drafting your table shells early on, you will be prepared to insert your results into the shells for quick reporting turnaround.

Monitoring Anomalies

When interpreting your surveillance data, first think of the limitations of your information and of the specific type of surveillance system and data collection methods used. Different systems have inherent strengths and weaknesses; be familiar with those before analyzing and interpreting your data.[53] Doing so will help you determine whether any anomalies in data patterns are the result of bias (e.g., recall, sampling) or are important health events that need to be addressed. In addition, you want to keep in mind the objectives of your surveillance system and key questions you are trying to address. Other useful questions to consider when monitoring for anomalies include the following:

- What are potential areas where you expect an increase in frequency of reports?
- What are the alert thresholds or signal detection levels for your surveillance system?
- Is there an increase in frequency of a reported health condition? If so, is it related to the disaster and does this increase signify a need for response?
- Are cases clustered by time or geographic location?
- Have there been any changes to surveillance system or data collection over time?[53]

Monitoring for anomalies in your surveillance data will help determine whether or not public health action is required. For example, a spike in the incidence and 30-day mortality from myocardial infarctions and stroke were found after Hurricane Sandy in New Jersey.[61] To help interpret your surveillance data and make decisions, the Sphere Project recommends using supplementary data from other sources (e.g., surveys, baseline data, BRFSS, NHANES, health department surveys).[55] If the expertise and resources are available, consider building algorithms into the surveillance system and analysis to identify statistical anomalies in the data. However, this may not be practical for disaster situations.[62] To better detect anomalies, it may be helpful to analyze certain data more frequently in the initial phases of a disaster.[53] This can provide a more immediate picture of the ongoing changes in morbidity and mortality in the affected population. It also might reveal biases in the data that need to be investigated.

Table 1. Definitions and formulas for surveillance parameters.

Measure of Frequency	Measure	Definition
Counts	Incident cases†	The occurrence of new cases of death, disease, or injury in a population over a specified period
	Prevalent cases†	The existing cases of death, disease, or injury in a population over a specified period
Morbidity and mortality rates	Incidence rate (new cases)‡	The number of new cases of a disease or injury that occur during a specified period per unit of person-time at risk (can be stratified by age and sex)
	Prevalence or prevalence rate (total existing cases)†	The proportion of people in a population who have a particular health condition at a specified point in time or over a specified period
	Crude mortality rate (CMR)‡	The rate of death in the entire population (includes all people, regardless of sex or age)
	Cause-specific mortality rate§	The mortality rate from a specified cause for a population in a specified period
	Age-specific mortality/morbidity rate (<5 years, >5 years)‡	A mortality/morbidity rate limited to a particular age group (e.g., under-5 mortality rate [U5MR] is the rate of death among children younger than 5 years in a population)
	Incidence proportion (attack rate, generally used for infectious conditions)†	The proportion of an initially disease-free population that develops disease, becomes injured, or dies during a specified (usually limited) period
	Proportional morbidity/mortality§	The proportion of all deaths/new or existing cases in a specified population over a period attributable to a specific cause
	Case fatality rate (CFR)‡	The proportion of people with a health condition in a specified period who die from it
Program process rates	Health facility utilization rate‡	The number of outpatient visits per person per year (if it is possible, distinguish between new and old visits and use new visits to calculate the rate)
	Number of consultations per clinician per day‡	The average number of total consultations (new and repeat cases) seen by each clinician per day

† CDC 2012c
‡ The Sphere Project 2011
§ Abdallah and Panjabi 2008

Plan for Report Generation and Results Dissemination

Information gathered from the surveillance system is most useful if quickly shared with stakeholders to use for public health action.[7,12] You should identify stakeholders during the preparedness phase. They may include public health agencies, government officials, relief and response workers, the affected community, and the media. Establishing reporting and communication plans during the preparedness phase helps ensure this information is transmitted appropriately. The format in which results are presented will depend on your audience. In general, provide results in a clear and concise manner that can be understood by nontechnical audiences.[12,19,35] When communicating or reporting data, include the following:

- Sources of data, including potential limitations
- Your findings
- The meaning or interpretation of the findings
- Actions to take[63]

Decision makers, stakeholders, and partners at all levels must understand the data results so they can readily act on the recommendations your data support. Evidence-based reports provide details to support those actions, but a summary statement can help provide focus. That statement, a single overriding communication objective (SOCO), provides actionable items based on the data.[63] In short, make sure that you communicate a clear public health message rather than simply relaying data.[14] The SOCO provides a response for the following questions:

- What is new?
- Who is affected?
- What works best?[63]

Graphs, tables, and maps are useful tools that assist in rapid data review and comprehension.[12,7,19] When creating visuals, ensure they are simple and clear so they are easier to understand. Epidemic (epi) curves can be created to give a visual display of the onset of health problems associated with the disaster. The epi curve displays the time trend or distribution over time, pattern of spread, outliers, scope, and magnitude of health problem.[64]

Finally, make sure that all stakeholders receive your surveillance summary reports. Before you implement a surveillance system, determine your reporting protocol. Decide who will receive information and how often you will report surveillance results to your stakeholders. Examples of mechanisms for sharing your information include

- daily or weekly summary reports (e.g., emergency operation center situational reports) and
- in-depth briefing meetings.

After the disaster has transitioned to the mitigation phase, publishing your surveillance results in journal articles or other documentation is important so others can benefit from the lessons you have learned from the disaster.

Challenges of Surveillance in Disasters

Disasters are often challenging situations, even when the response is well planned, understand the issues that complicate surveillance in disaster situations. Disaster surveillance challenges discussed in this section include timing constraints, competing priorities, missing baseline data, difficulty obtaining denominator data, lack of standardized data collection and reporting, lack of representative information and underreporting, resource considerations, and infrastructure damage.

Surveillance challenges in disaster situations include the following:

- Time constraints
- Competing priorities
- Missing baseline data
- Difficulty obtaining denominator data
- Lack of standardized data collection and reporting
- Lack of representative information and underreporting
- Resource consideration
- Infrastructure damage

Time Constraints

Timely information is a key component in responding effectively to disasters. Without timely data, it becomes more difficult to detect and address public health issues present during a disaster. Data must be collected and analyzed rapidly, under challenging conditions, with forces outside your control impeding efforts to perform disaster-related morbidity and mortality surveillance. Because disasters often have a sudden onset, quickly implementing a system is difficult, unless one is already in place.[21] Timeliness differs in various stages of the disaster. In the response phase of a disaster, for example, time and resources for data collection, analysis, and reporting are often limited.[19] In contrast, more time may be available to conduct more comprehensive surveillance in the recovery phase.

Keep in mind that setting up flexible surveillance systems in advance or building surveillance systems into existing infrastructure using existing systems, partnerships, and resources allows you to implement disaster surveillance more swiftly during a disaster response.[15] Surveillance activities that rely on existing systems function more smoothly because the capacity to collect and analyze data is already in practice. During the response phase of a disaster you may end up collecting and analyzing a wide range of unnecessary data. You can minimize wasted time and effort by prioritizing the indicators collected based on what is most essential and practical for use.[19]

Competing Priorities

During a disaster, the various stakeholders have differing and often competing priorities. Government agencies may focus on restoring infrastructure, whereas health agencies work to provide medical care. Differing priorities can affect resource availability for surveillance. Prioritizing data and information needs and tailoring indicators to the disaster phase, type of disaster, and potential impacts of the disaster will be important.[5]

Begin with clear surveillance objectives. This will also help you prioritize necessary information that will be collected by the surveillance system and facilitate decision making. Establishing cross-agency coordination (e.g., between disaster management officials and departments of health) will streamline disaster surveillance activities and increase efficiencies.[5,65]

Missing Baseline Data

You need baseline health information to determine if you have a true increase in a disease or worsening health status in the affected population and to assess population risk and vulnerability.[5] However, the needed data are often missing or non-existent. This can occur when large portions of the population are displaced, the health care infrastructure is severely damaged, or no previous surveillance system collected the information you need.

Baseline health information is available from multiple sources. These include previously established surveillance systems, such as the Behavioral Risk Factor Surveillance System. Published data are also available from CDC WONDER, the Web-Based Injury Statistics Query and Reporting System (WISQARS), census records, and surveys.[14,65]

Difficulty Obtaining Denominator Data

Gathering denominator data to calculate rates of morbidity and mortality also may be difficult. The population under surveillance may change frequently and residents may have evacuated an area or been displaced. Traditional census or population data may not adequately reflect the current population in the affected area. As a result, the population denominator may not be accurate or stable.[65] Alternative sources of denominator data include shelter population counts, hospital admissions, and special surveys or assessments during the disaster.

Lack of Standardization in Data Collection and Reporting

The need to collect information across multiple sites is challenging, especially if data collection and reporting are not standardized. Aggregating data across jurisdictions is important to target disaster response and relief, implement interventions, and evaluate intervention effectiveness.[3,5]

Ideally, data collection and reporting will be standardized during the preparedness phase. The process should be simple, flexible, and acceptable to the multiple organizations operating the surveillance system and using the results.

Pre-existing standardized surveillance templates and case definitions are available for use (http://emergency.cdc.gov/disasters/surveillance/).[5]

Lack of Representative Information and Underreporting

When underreporting occurs, the surveillance system may not be representative or may fail to identify significant health issues.[27] During disasters, underreporting can be a significant hurdle. Even in non-disaster circumstances, you may see substantial underreporting of cases. This is especially true for illnesses that are difficult to diagnose and where case definitions are overly complex. Logistical challenges, misconceptions about the need for surveillance, and a lack of disaster surveillance specific training can also lead to underreporting.

The timing, location, and methodology of your data collection might affect how representative the data are of the affected population. For instance, information gathered from surveillance in facilities such as shelters or emergency clinics may not be representative of the larger population. The data gathered will instead represent the populations present in those locations, but not the larger affected geographic area.[5,65]

Having health care workers familiar with disaster surveillance, and a simple and efficient surveillance system for data collection, can help address these issues. Remember that a lack of reporting does not mean the absence of morbidity and mortality. Similarly, do not assume an increase in reporting represents an actual increase in cases. When reporting data, remember to take into account these considerations and any potential biases in results.[5,65]

Resource Considerations

Some of the direct and indirect costs related to surveillance include

- data collection, entry, management, and analysis;
- information dissemination;
- staff time, investment, and travel; and
- collecting, testing, and, transporting specimens (e.g., environmental samples, laboratory case confirmations).[20]

Conducting surveillance may be considered too costly if it takes resources from other response and relief efforts.[5] Design surveillance systems to minimize their cost and burden, while still meeting identified information needs.[27] This may involve determining trade-offs between the cost of data collection and the value of the information. Try to limit data collection to only the most essential information and use the least labor-intensive method possible that still maintains the needed quality, scope, and detail to meet your objectives.[14] Creating strong objectives, using an existing surveillance system, and educating stakeholders about the value of surveillance may also help to sway decision makers to conduct disaster surveillance.[5]

Infrastructure Damage

Disasters can severely damage or destroy local hospitals and health care systems. When that happens, health care services are interrupted or

limited and established health care surveillance systems (e.g., hospital surveillance) may stop working. In such instances, outside relief and health organizations, such as the American Red Cross, provide temporary medical assistance and care, but they may not have the same surveillance capacity as hospitals. Additionally, the few operating medical care facilities are likely to be overwhelmed and unable to conduct surveillance.

The disaster setting also presents logistical problems or obstacles to surveillance. For example, power and telephone outages may disrupt communication networks. Damaged or destroyed roads or transportation systems may slow or stop data collection. Such problems interrupt the usual reporting mechanisms, leading to an underreporting of health events. Infrastructure damage and illness and injury among health care workers may keep them from responding to a disaster and conducting surveillance. In these cases, alternative or outside volunteers with limited surveillance experience may be trained for the specific event and used. This could affect data collection quality.[5]

During times of damaged or destroyed infrastructure, working within your incident management system (IMS) is beneficial to aid with resources, logistics, and coordination. Flexibility is also important. You may need to use pencil and paper to collect data if electronic recording is unavailable. You also may need to conduct surveillance activities from a location other than your health department. Think about creative ways to gain information from resources not affected by the disaster. For example, satellite imagery, such as the overhead photos of the tsunami area in the Indian Ocean, can be used to identify the extent of a disaster. FEMA or the Army Corps of Engineers may also have estimates of damage. For damaged healthcare systems, working with temporary onsite healthcare providers (e.g., American Red Cross), outside workers trained in surveillance, and community leaders to collect data is a potential solution.[5,65]

Disaster surveillance has many uses, but data must be collected rapidly under less than ideal conditions. The data must be compiled quickly and in a logical format. Various forces outside of your control also might limit or prevent you from performing disaster-related morbidity and mortality surveillance. A lesson learned from conducting public health surveillance of Hurricane Katrina evacuees was the need to establish surveillance systems and federal, state, and local partnerships before a disaster occurs.[3]

Key Considerations in Conducting Surveillance

Disasters are unpredictable and do not uniformly affect all areas. Because public health action in disasters often occurs at the local level, surveillance systems need to be flexible and adaptable to the needs at hand. As you plan disaster surveillance activities, consider whether your existing or proposed system includes those characteristics. To prevent complicating the system and overtaxing scarce resources, consider limiting the number of conditions under surveillance to those most relevant to your situation's objectives.

Answering the following questions can help you anticipate and address some of the unique difficulties you may face as a result of the challenging circumstances surrounding surveillance during disasters.

Are your existing systems flexible and can you adapt them?

Choosing an appropriate strategy for surveillance will depend on what systems and other health and data collection resources are already present in an area.[20] Before setting up a new, ad hoc surveillance system, check whether any existing systems are available that will meet your information needs or that can be modified to address disaster information gaps. Typically, existing surveillance systems will need to be modified. More than half of the jurisdictions that reported conducting disaster surveillance activities in the past 10 years required modifications to meet disaster needs.[9] Surveillance systems also need to be flexible and easily adaptable.[9]

Working with existing surveillance resources has many benefits. By using or modifying an existing system, you eliminate the need to develop a surveillance system from scratch, saving time and resources that are often severely limited in disaster situations. In addition, health workers will not need to be retrained to use a new surveillance system. They will be familiar enough with the existing systems to easily adapt to small modifications in data reporting or collection methodology. Health care workers experienced in using the systems can aid and instruct field responders who are less familiar with the system. This helps ensure data collection and reporting quality. Finally, using existing surveillance systems allows for data that are more easily compared with those collected in non-disaster surveillance, providing a baseline for comparisons.

If using or modifying an existing system is not an option, consider creating one that has the flexibility and potential to continue to be useful beyond the disaster. Such a system can be used to both conduct disaster surveillance and help build surveillance capacity in an area that may have lacked it previously. Disaster surveillance forms can be created during the preparedness phase and then used or modified to meet the specific needs of your situation. As noted previously, CDC has developed standardized morbidity and mortality forms that can be modified to suit your needs.

You can access those forms at http://emergency.cdc.gov/disasters/surveillance/.

What are the start and stop triggers/thresholds?

When planning your disaster surveillance system, knowing when to start surveillance, what factors will trigger investigations, and when to stop disaster surveillance activities is useful. Knowing your thresholds will help systematically start and stop your investigation at the appropriate times. These thresholds will vary depending on a disaster's severity and scope. Some triggers for starting disaster surveillance include the following:

- Information needs (e.g., suspected outbreaks of infectious disease, reports of high rates of mental illness, controlling rumors)
- Impact on the population (e.g., whether or not people have been displaced or are in shelters)

- Resource availability (e.g., status of the public health and health care infrastructure, capacity to conduct surveillance)
- Opening of multiple or long-term evacuation shelters (e.g., whether or not people have been displaced or are in shelters, potential for spread of illness)

Be flexible during a disaster and know when to prioritize your actions. For instance, if you are unable to conduct surveillance in every shelter opened during a hurricane response, you could potentially prioritize them by size, how long they will be open, or population movement into and out of the facility. Plan for stopping surveillance or transitioning back to more routine surveillance systems. Defining the span of time an initial surveillance system will cover is useful for determining when surveillance should stop. At the end of the predetermined time, the data gathered from a surveillance system can be assessed to determine whether surveillance activities need to be extended.[25] Factors relating to the event itself or the affected populations could signal a good stopping or transitioning point. For instance, when people begin returning to their homes, shelter surveillance may no longer be necessary or relevant. However, in instances where the extent of the damage and level of displacement persist for an extended period, surveillance activities may need to be continued for a longer time span. For example, mortality rates remained elevated long after Hurricane Katrina passed, and high rates of chronic illness and morbidity continued for years after the storm.[65-6] In most circumstances, after a situation has become more stable, routine surveillance is functional again, or information needs have shifted, you will work to transition out of surveillance entirely or back to a passive system.

Can existing surveillance forms capture disaster-relatedness?

Even when your jurisdiction is not directly affected by a disaster, large-scale events elsewhere can result in short- and long-term displacement of affected populations across the country. Having data

collection instruments that can flag disaster-related health effects will be valuable for tracking victims no matter where they disperse. For instance, after Hurricane Katrina many evacuees were sheltered in Colorado where the state conducted health surveillance on evacuees, notifying emergency departments to identify and report evacuee visits through a Health Alert Network (HAN) message.[67] Including a way to flag disaster-relatedness on forms such as death certificates can also help to address some of the challenges related to using EDRS as surveillance for disaster-related mortality.[45] Medical examiners, coroners, physicians, and others participating in routine surveillance or working with surveillance forms and other certificates of morbidity and mortality should be given guidance and training on recording and certifying disaster-related deaths so that this process is done in a standardized manner.

Who are the relevant stakeholders?

As part of surveillance planning, you should identify the relevant stakeholders. This includes persons who requested the surveillance or information, field responders, emergency managers, officials across multiple disciplines and levels of government, non-governmental organizations, data providers, and those funding your surveillance activities. Partnerships and collaboration are key to a successful surveillance system; establish them before a disaster occurs.[39] Stakeholders will also determine the information needs of a situation and access to available types of resources. Each health care setting may have a distinct data reporting style and various information needs.[3]

In working with government officials, health care organizations, relief agencies, and other stakeholders and partners, take into account the political, financial, and human resources needed to successfully implement a disaster surveillance system. Having the support of high ranking government officials is important to ensure political commitment and funding to mobilize resources.[7] Similarly, federal, state, and local partnerships may help provide coordination capacity and financial and other resources.

How is surveillance information going to be used?

Before conducting surveillance, you should know how the information you are collecting is going to be used. Are you characterizing disease or injury in the displaced population? Are you interested in looking at mental health issues? Are you monitoring for outbreaks of infectious disease in shelter populations or gastrointestinal illness in flooded areas? Knowing why you are collecting information will help to determine your surveillance strategy and will guide development of your objectives. If surveillance information will be used to monitor disaster-associated reproductive health impacts, for example, you will include these in your objectives and include questions or components in your reporting system for pregnancy and other related factors.

What information do you have about the affected population?

As part of the planning and preparation process, gather background data on the geographic areas that may be affected by a disaster, the major disease risks in those areas (e.g., vector-borne illness, high dependence on supplemental oxygen), and the at-risk and affected populations.

To help identify at-risk groups in your population, you can use tools available online from CDC at http://www.cdc.gov/nceh/hsb/disaster/atriskguidance.pdf, http://stacks.cdc.gov/view/cdc/7552, and http://svi.cdc.gov/.

The scope of a surveillance system, including the geographic area and population covered, can be narrowed using background information.[25] For instance, looking at high risk areas for flooding or earthquakes helps you narrow the geographic area within which you conduct surveillance.[21] Background information helps you determine the extent of your surveillance system. The information may indicate a need for universal coverage, where an entire population or representative sample is selected to conduct surveillance for the condition of interest (e.g., food poisoning, bioterrorism agents). Perhaps, instead, you could use a system in which sentinel sites (e.g., a few hospitals in an oil spill impact area), or health care providers are selected. In addition to information provided by the health system, relief workers, and local community groups, consider gathering information from unconventional sources such as newspapers, the Internet, or social media, which can provide important early warnings.[68] Background information focuses your efforts. It helps you avoid gathering unnecessary data and wasting limited resources.

What issues of security and confidentiality need to be considered?

Ideally, potential security issues and confidentiality concerns are addressed in the planning phase. The ability to protect patient information will vary with the policies, regulations, and statutes in your jurisdiction. Consider issues resulting from having small numbers of cases that could result in patient identification, even if names, addresses, and other personal identification information are protected or not collected. Consider how you can maintain confidentiality for organizations and those reporting to the surveillance system. For example, the need to name particular locations should be balanced against the negative effects of naming those locations. Public health organizations should be familiar with their institutional review board policies to determine whether review and approval or exemption is required before developing the surveillance system.

What phase of the disaster is it?

Finally, knowing what phase of the disaster you need to or plan to implement surveillance in will affect the goals and objectives of your surveillance. In the response phase, for example,

- surveillance may be conducted for a shorter period;
- data collection methods may be simpler, more observational, and involve active surveillance methodologies;
- case definitions may be simpler, involve a few critical conditions, and may not require laboratory confirmation; and
- information will be used for immediate action and mortality reduction.

On the other hand, during the recovery or mitigation phase,

- surveillance can be transitioned to a passive system;
- data collection methods may be more complex and involve entire populations;
- instead of sentinels, data collection may be incorporated into the established health care or health information infrastructures;
- case definitions may be more complex, involving laboratory diagnosis and a larger number of conditions; and
- information may be used for a wider range of long-term health and monitoring needs, addressing less urgent information needs, and assessing quality of care and intervention effectiveness.[19]

Additionally, deaths can be characterized according to whether they occur before, during, or after impact of a disaster to provide more detailed information on how to prevent injuries and death.[6]

Figure 1. *The Disaster Cycle (Source: FEMA)*

Conclusion

Whether you already have a system for conducting disaster surveillance or are just beginning, evaluating these systems regularly is important. Evaluation is the periodic assessment of a surveillance system for its quality, efficiency, and usefulness toward achieving the overall objectives of the system.[12,69,70] This process ensures that the system is effectively monitoring disaster-related health events.[69] To help in guiding such evaluations, CDC has published "Updated guidelines for evaluating public health surveillance systems" (http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm).[69] The guidelines outline a systematic method for approaching surveillance system evaluations. It has been used to evaluate several disaster-related mortality surveillance systems including Hurricane Ike in 2008.[71,72]

Conducting surveillance during disasters is a necessary but often complicated task. How you conduct disaster surveillance will be influenced by many factors and challenges. You can use the various existing tools and resources described in this primer to help address these challenges and effectively track disaster-related morbidity and mortality. The data you collect can provide decision makers with the information to make informed decisions. We hope the information presented here prompts public health departments to consider and begin conducting disaster surveillance and further enables such activities.

Glossary

Active surveillance — A surveillance system in which public health staff members regularly contact health care providers, laboratories, hospitals, the public, and others to seek information about health conditions for a limited period, usually weeks or months.

Case definition — A set of standard criteria for classifying whether a person has a particular disease, syndrome, or other health condition. A case definition frequently includes criteria for person, place, and time.

Disaster — A serious disruption of the functioning of society, causing widespread human, material, or environmental loss that exceeds the local capacity to respond, requiring external assistance.

Disaster epidemiology — The use of epidemiology to measure the short- and long-term health effects of disasters and to predict the consequences of future disasters.

Disaster related health effects — Direct and indirect effects:

Direct – Health effects caused by the actual physical forces or essential elements of the disaster.

Indirect – Health effects caused secondarily by anticipation of the disaster or by unsafe or unhealthy conditions that develop in connection with the disaster.

Disaster surveillance — An epidemiologic tool that provides ongoing, systematic collection, analysis, and interpretation of data on injuries, illnesses, and deaths. The information is used in planning, implementation, and evaluation of public health response. It enables public health agencies to track and identify morbidity and mortality linked to an event and provides information for future disaster response.

Incidence — The occurrence of new cases of disease or injury in a population over a specified period (e.g., total number of head and neck injuries in one week).

Morbidity — The state of being ill or diseased, or the incidence or prevalence of illness in a population.

Mortality — The incidence of death in a population relating to many different types of conditions.

Passive surveillance — Regular reporting of disease data by health institutions that see patients and are part of a reporting network. There is no active searching for cases. Cases are reported through passive notification by health care facilities or practitioners

Rates — Measures of risk that allow comparison of the frequency of morbidity and mortality in different geographic locations, times, or population groups.

Sentinel Surveillance — An active surveillance system that collects data from a limited number of recruited participants or providers to report on specific health events to estimate trends in the larger affected population.

Syndromic Surveillance — An active or passive surveillance system that uses signs and symptoms, primary complaints or presumptive diagnoses, or other characteristics of a disease to define cases, rather than using specific clinical or laboratory diagnostic criteria.

Links

The following are links to tools mentioned in this primer.

BioSense Platform
http://www.cdc.gov/nssp/biosense/index.html

ICD-10
http://www.cms.gov/Medicare/Coding/icd10/

CDC Ready-to-Use Morbidity and Mortality Surveillance Form Templates
http://emergency.cdc.gov/disasters/surveillance/

CDC "Updated Guidelines for Evaluating Public Health Surveillance Systems"
http://www.cdc.gov/mmwr/preview/mmwrhtml/rr5013a1.htm

CSTE Occupational Health Subcommittee
http://www.cste.org/members/group.aspx?id=106606

CDC List of Occupational Safety and Health Contacts at State and Territorial Health Departments
http://www.cdc.gov/niosh/statosh.html

CDC Occupational Health Surveillance Resources
http://www.cdc.gov/niosh/topics/surveillance/

Emergency Responder Health Monitoring and Surveillance (ERHMS)
http://www.cdc.gov/niosh/topics/erhms/default.html

CDC "Planning for an Emergency: Strategies for Identifying and Engaging At-Risk Groups"
http://www.cdc.gov/nceh/hsb/disaster/atriskguidance.pdf

ATSDR "The Social Vulnerability Index (SVI)"
http://svi.cdc.gov/

CDC "Public Health Workbook to Define, Locate, and Reach Special, Vulnerable, and At-Risk Populations in an Emergency"
http://stacks.cdc.gov/view/cdc/7552

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Notes

Centers for Disease Control and Prevention
Division of Environmental Hazards and Health Effects
National Center for Environmental Health
Health Studies Branch

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