The American Red Cross - Centers for Disease Control and Prevention Health Impact Surveillance System for Natural Disasters

by

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ABSTRACT

Since 1987, the American Red Cross and the Centers for Disease Control and Prevention have collaborated on the Health Impact Surveillance System for Disasters, which collects data on morbidity and mortality related to disasters in the United States and its territories. We describe the surveillance system and present an analysis related to 104 disasters occurring from 1994 to 1996. Associated with these disasters were 426 fatalities, 9,846 cases of morbidity in the disaster-affected populations, and 2,752 cases of morbidity among 45,066 American Red Cross personnel. Injuries were the most frequent cause of death in 1994 and 1995, whereas drowning were the most common in 1996. The percentage of disaster-related deaths that were due to drowning increased from 32.9% in 1994 to 52% in 1995; however, the distribution of disaster types also changed. The use of motor vehicles was heavily implicated in drowning deaths. Injuries and illnesses in the disaster-affected population occurred with greater frequency during the impact phase of acute-onset disasters such as tornadoes and hailstorms and during the post-impact phase of floods and tropical cyclones. The estimated risk for morbidity among ARC staff members was greatest for tropical cyclones. Illnesses exceeded injuries among ARC staff members for every disaster type except wildfires across the 3 study years. We recommend that prevention efforts focus on preventing deaths by drowning and those caused by motor vehicle-related injuries.

KEYWORDS: earthquakes; epidemiology; floods; hurricanes; natural disasters; public health surveillance; tornadoes

1. INTRODUCTION

The public health importance of natural disasters -- defined as ecological disruptions causing human, material, or environmental losses that exceed the ability of the affected community to cope using its own resources and that often require outside assistance -- have been documented worldwide (1). During 1971 to 1995, approximately 141.5 million people worldwide were killed, injured, made homeless, or otherwise affected by an estimated 5,240 natural disaster events; economic damages were estimated at $439.3 million (2). In the United States, economic losses of $70 billion were incurred from 15 major weather-related disasters between August 1992 and January 1995. Human vulnerability to natural disasters has increased with population growth, increased urbanization, and increased population concentration in hazard-prone areas (3). The post-disaster setting is often characterized by deteriorating environmental conditions that can compromise sanitation and hygiene. The risks for increased mortality and morbidity are potentiated by: 1) changes in pre-existing levels of disease, 2) ecological changes as a result of the disaster, 3) population displacement, 4) changes in population density, 5) disruption of public utilities, and 6) interruption of basic public health services. In addition, disasters may also lead to an exacerbation of psychological problems in the community, as the

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normal routines of people are disrupted. Common health hazards after disasters have been 1) exacerbation of chronic illness; 2) psychological effects; 3) a lack of food, water, and shelter resulting from population displacement; and 4) climatic exposure (4).

Responding to natural disasters in a timely and appropriate manner requires epidemiologic tools that can rapidly provide information upon which public health decisions may be made. These tools may be used to control epidemics; monitor rates of preventable deaths, illness, and injuries; monitor health care needs among the affected population; and identify appropriate interventions.

A commonly used epidemiologic tool following a disaster is surveillance. Surveillance is the ongoing and systematic collection, analysis, and interpretation of outcome-specific data for use in planning, implementing and evaluating public health practice (5). Data from surveillance systems are used both to determine the need for public health action and to assess the effectiveness of programs.

In the post-disaster setting, surveillance provides information that can serve as the basis for action during the immediate disaster and also for planning of future activities. Such information is used to answer the following questions (6):

- What problems are occurring? Why are they occurring?
- Where are problems occurring?
- Who is affected?
- What problems are causing the greatest morbidity and mortality?
- What problems are increasing or decreasing?
- What problems will subside on their own? When?
- What problems will increase if unattended?
- What relief resources are available?
- What relief activities are in progress?
- Are relief activities meeting relief needs?
- What additional information is needed for decision-making?

Such systems for collecting the above information must be flexible to changes in the definitions of health outcomes; acceptable to users of the data; sensitive and specific for capturing valid and reliable information; timely in collection, analysis, and response; accurate, representative, and ethical (7).

2. BACKGROUND

To improve the reporting of health events related to disasters -- defined as any death, injury, or illness occurring during the pre-impact, impact, or post-impact phase of a disaster -- the American Red Cross (ARC) and the Centers for Disease Control and Prevention (CDC) developed the Health Impact Surveillance System for Natural Disasters (HISSD) under a memorandum of agreement in 1986. The objectives of HISSD were:

- To estimate the magnitude of morbidity and mortality associated with major disasters in the United States and its territories.
- To characterize the impact of each disaster type.
- To identify risk factors for disaster-related injury, illness, or death among disaster-affected populations.
- To monitor health and identify risk factors for injury and illness among ARC personnel involved in relief operations.
- To stimulate epidemiological research aimed at preventing or mitigating morbidity and mortality associated with disasters.

The role of the ARC in this surveillance system is to determine the need for emergency and preventive health services by documenting the number of deaths, illnesses, and missing persons related to a disaster event (defined as disasters costing $50,000 or more for ARC operations). The role of CDC is to analyze the data collected

by the ARC, to assess the adverse health effect of the disaster event, and to advise the ARC on response and prevention.

From 1988 to 1993, the ARC summarized and forwarded disaster-related morbidity and mortality statistics to CDC for compilation (8, 9). In 1996, CDC conducted a survey to assess the usefulness of the system, improved collection instruments, field-tested new forms, and evaluated the flow of information from ARC service centers and shelters, to its headquarters, and finally to CDC (10, 11).

3. COMPONENTS AND OPERATION OF THE SYSTEM

The population under surveillance is the entire population in the disaster area, who seek assistance in ARC shelters or service centers, including the ARC staff members who are paid employees or volunteers for relief operations.

Information about deaths is population-based and is collected by ARC volunteers and nurses who query their clientele, local hospitals, doctors' offices, medical examiners or coroners, and local authorities, such as sheriffs' offices. Information about injuries and illnesses is provided by the ARC health services based on visits for these services. The flow of health information is generated and processed in ARC field disaster-relief facilities. From these field facilities, the flow of the mortality and morbidity data is traced through the field operations headquarters to the ARC national office, and finally to CDC (see Figure 1.)

Such information is organized by year to include:

- The number of fatalities, injuries, and illnesses per individual event.
- The number of fatalities, injuries, and illnesses by type of disaster.
- The geographic location at which these health conditions occurred.
- Demographic information on individual clients, including decedents.
- Causes of injuries, illnesses, and deaths.
- Descriptions of circumstances in which individual cases of injuries, illnesses, and deaths occurred.
- The number of ARC volunteers and staff who are injured, ill, or die during relief operations.

The results of the analysis are presented in a preliminary report to the ARC and CDC. A final report is subsequently produced and disseminated to the disaster community (12). The reports serve the following objectives:

- To recommend ways of preventing deaths in future natural disasters based on the systematic description of past events.
- To describe disaster-related morbidity in the disaster-affected population and among ARC staff members.
- To provide the descriptive epidemiology needed to generate hypotheses for further analytic studies.
- To evaluate the surveillance system's performance for the years under study and to recommend ways of improving the system.

4. ANALYSES FROM THE SURVEILLANCE SYSTEM

In this section, we present surveillance data from the years 1994, 1995 and 1996.The number of disaster events by natural hazard, state, and year when the event occurred are shown in Figures 2-4.

4.1 Mortality Results

4.1.1 Causes of death

A larger number and greater variety of disasters occurred in 1995 and 1996 than in 1994, but fewer fatalities were associated with these disasters. The Northridge earthquake was perhaps the most severe disaster of 1994 and accounted for the largest number of fatalities. Injuries and drowning remained the leading

causes of death across the 3 study years. Injuries were the leading cause of death in 1994 and 1995 and accounted for most of the deaths associated with earthquakes and tornadoes. Crushing injuries and unspecified multiple injuries were the leading causes of death in all 3 years. Motor vehicle-related injuries may have been under represented.

The proportion of deaths by drowning increased across the study years, accounting for 32.9%, 43.4%, and 52.3% of all deaths in 1994, 1995, and 1996, respectively. The use of a motor vehicle was heavily implicated in disasters associated with drowning, such as floods, flash floods, and Tropical Storm Alberto. The results are consistent with the use of a motor vehicle being a risk factor for death by drowning. Whether these motor vehicle deaths were entirely preventable is unknown, but at least eight of the deaths were known to have occurred during floods when drivers ignored "road closed" signs or when "road closed" signs were not used properly. Other deaths by tree fall injuries and structural collapse of roadways could have been prevented if drivers stayed off roads during tropical cyclones and floods. These deaths point to the need for better communication of prevention messages.

Heart attacks were the third most frequent cause of death in the earthquake year, 1994, but were not as frequent in other disaster years except during the clean-up phase of tropical cyclones and floods in 1996. These findings point to the need for hospitals to be ready to treat patients who have heart attacks precipitated by earthquakes, tropical cyclones, or floods. The proper operation of backup electrical power in hospitals during and after an earthquake is important in critical care facilities; three fatalities were associated with failure of mechanical ventilators. Fires resulting from candles and stoves being lit during power outages were a preventable cause of death.

4.1.2 Demographic characteristics

During studied years, more men than women have died from disaster-related causes. The number of deaths among men consistently exceeded the number among women in every phase of tropical cyclones, and male sex is a risk factor for death during these events. It may be that men are more likely than women to be engaged in high-risk clean-up activities, such as cutting tree limbs, or that men are more likely to engage in risk-taking behaviors that involve motor vehicles. Men may also be more likely to be exposed to risks as a result of employment on power crews and other occupationally related activities.

The consistent finding across 3 years that more than half of deaths occurred in persons 60 years or older during disasters indicated the greater physical vulnerability of this population. The results may demonstrate the need for preventive messages, improved evacuation efforts, and an identification of risk factors among older people.

4.1.3 Place of death and place of injury

For the 3 years studied, most deaths occurred outdoors, in single-family homes, or in motor vehicles. The distribution of place of injury was not consistent over the 3 years, mainly because the data were skewed by the 1994 Northridge earthquake, in which fatal injuries occurred mainly in multi-family dwellings, and by a church roof collapse in the same year, in which a number of fatal injuries also occurred.

The two fatalities among ARC staff members were due to cardiovascular events. Further circumstances are unknown; the deaths may have been brought on by the physical activity associated with disaster relief.

4.2 Morbidity Results

Morbidity occurred more frequently during the post-impact phase of floods and tropical cyclones than during the impact phase, a pattern also noted in previous years (8, 9). In contrast, in disasters with sudden acute onset, such as tornadoes, morbidity was more likely to occur during the impact phase. Our finding that

illnesses were more common than injuries among field personnel may be somewhat useful in planning health assistance to staff members, but further study of disaster-related morbidity is necessary.

5. DISCUSSION

The ARC-CDC Health Impact Surveillance System is the only known surveillance system in the U.S. that systematically collects morbidity and mortality data related specifically to natural and technological disasters. As the nation's designated relief agency, the ARC is in a unique position to collect data as disaster-relief operations are conducted. The surveillance information helps the ARC to target resources for future disaster assistance, and it helps CDC, as the nation's prevention agency, to better focus prevention efforts. The system also collects valuable information on the circumstances of each case of illness, injury, or death among personnel specifically trained in disaster relief.

Like most surveillance systems, the ARC-CDC Health Impact Surveillance System has limitations that analysts should keep in mind when interpreting the data. For example, as with most surveillance systems, a number of limitations arose with interpretation of the data. Whereas the difference between disaster categories such as "earthquake" and "tornado"is straightforward, the difference between others, such as floods vs flash flood, may be more difficult to distinguish. There also may be additional floods with tornadoes that were not characterized as such. Because of this lack of standard definitions for disaster types, the analysis of mortality and morbidity within disaster types is most useful for those categories that are clearly distinct from one another, such as earthquakes and hurricanes.

Another limitation is that the accuracy of whether a fatality was truly disaster-related was a function of how well the circumstances of the fatality were described. Responses varied widely from a few words (e.g., "died by drowning") to detailed descriptions providing all circumstances, including the date, time, and location of death, and details regarding events leading up to the death. Some deaths recorded by the system and included in the analysis were probably not actually disaster-related, and other deaths may have been indirectly related to disasters even though they are not classified as such because of a lack of detail provided. Particularly suspect are deaths by chronic disease processes or because of pre-existing medical conditions, which may or may not have occurred in the absence of the disaster.

As with disaster-relatedness, the determination of whether a death occurred before or after impact or whether it was related to a secondary disaster was largely a function of the level of detail provided in the form. As a result, there may be significant under reporting of deaths related to a secondary disaster and of deaths occurring during the pre- and post-impact periods, as well as an over estimate of the number of deaths that occurred during the impact phase.

A fourth limitation is that even though the system asks that the cause of death be ascertained from the death certificates of the victims, many fatality forms list the information source as nonmedical, such as the police or a family member. Furthermore, many deaths are listed with a circumstantial rather than a medical cause, such as "car accident." Conversely, injuries sustained in car accidents may not be noted as such, and there is likely to be some overlap between the injury and the motor vehicle categories. The causes of death presented in this report should therefore be interpreted as broad categories describing a general circumstance of death rather than specific physiological events.

The consistent difficulties with morbidity reports described above, have led to the development of a new form on which to report morbidity. This form provides information individually rather than as an aggregate tally. The new form will improve the quality of data by providing pre-existing categories of injuries and illnesses, as

well as by prompting for the location, time, and circumstances of the injuries. After 1997, the year in which this form was first implemented, an improved analysis of the morbidity associated with disasters will be possible.

6. RECOMMENDATIONS FOR THE PREVENTION OF DISASTER-RELATED MORTALITY AND MORBIDITY

In addition to pointing to the need for improved weather forecasting and for dissemination of weather information to at-risk populations, the above analysis indicates that the following could help reduce disaster-related mortality and morbidity in disaster-affected communities.

- Make the avoidance of deaths in motor vehicles during flooding or heavy rains a major focus of prevention efforts. The National Weather Service, meteorologists, and local emergency management authorities should coordinate their announcement of warnings and establish safe detour routes in communities affected by severe flooding. During a flood watch, for example, public advisories should be broadcast to caution people to observe existing barricades and avoid routes that authorities have declared unsafe. Moreover, people in cars should be advised not to attempt to outrun the flood, but to seek shelter in a nearby public building.

- Make the prevention of deaths and injuries following the impact of a tropical cyclone a major focus of disaster-related health education. Health education should emphasize tree-cutting safety, power-line safety, the avoidance of candles as a light supply following power outages, and the proper use and ventilation of generators.

- Make the avoidance of deaths and injuries among people 60 and over a major focus of prevention efforts. In educational campaigns, people in the community should be encouraged to keep in touch as much as possible with elderly neighbors and family members over the course of a disaster so that they can provide assistance when necessary.

- Focus disaster-response plans for acute-onset disasters on mass-casualty preparedness and the immediate care of victims under disaster conditions (e.g., search and rescue, triage, and transportation). Large numbers of casualties may be expected during the impact phase of tornadoes and earthquakes. The hospital deaths associated with power loss following the Northridge earthquake demonstrate the need for constant vigilance.

7. CONCLUSIONS

The Health Impact Surveillance System for Disasters provides a basis for case definitions of injuries and illnesses associated with disasters; documents disaster-related mortality and morbidity; and provides data with which to perform cost analyses. Further improvements include a revision of the ARC's data collection training manual and in procedures used by with ARC staff, implementation of standardized case definitions for injuries and illnesses under International Classification of Diseases-9 coding, computerization of the ARC field collection, and the Centers for Disease Control collaboration with the ARC to gather information from emergency rooms and other health providers in disaster sites.

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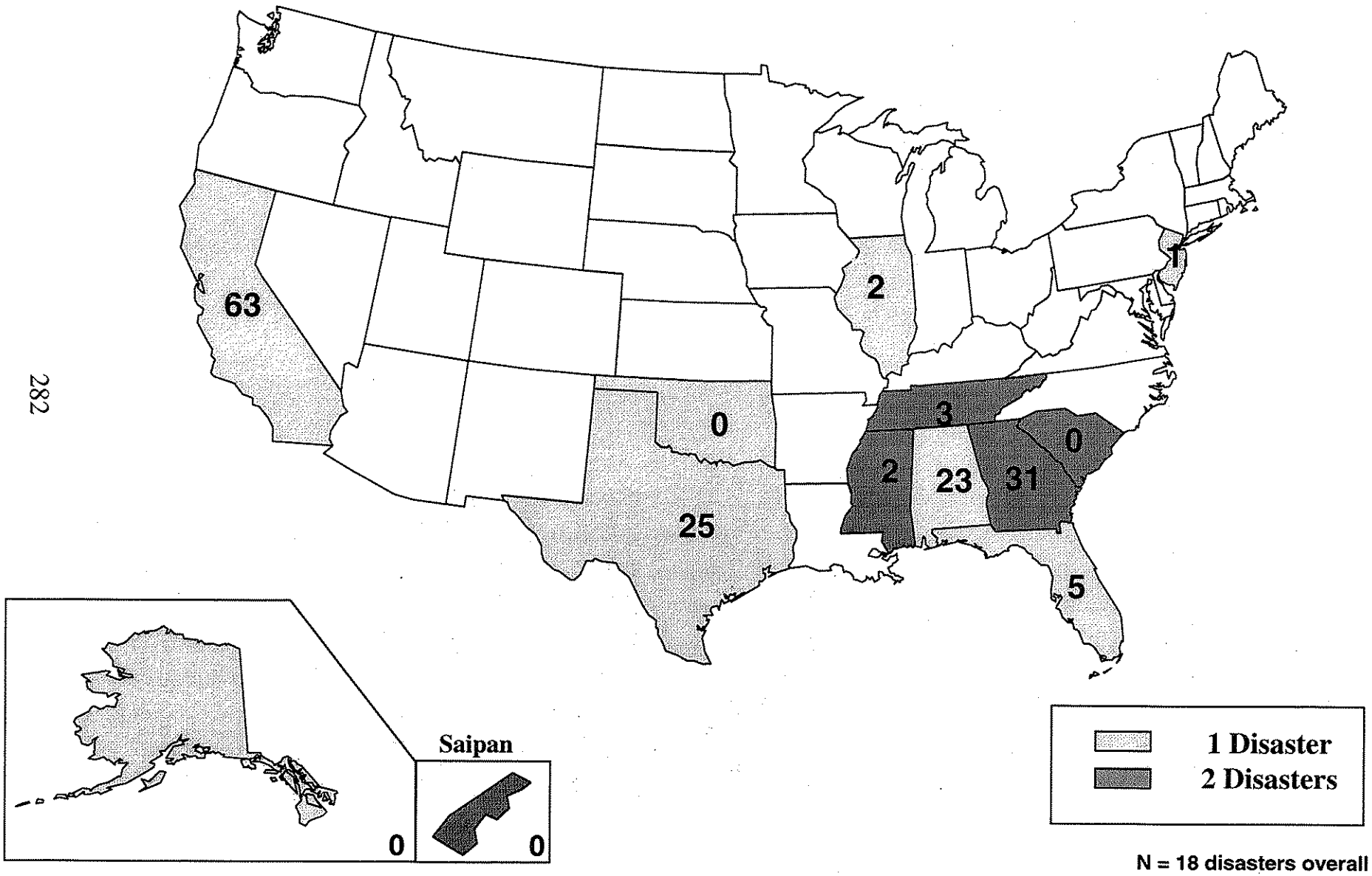
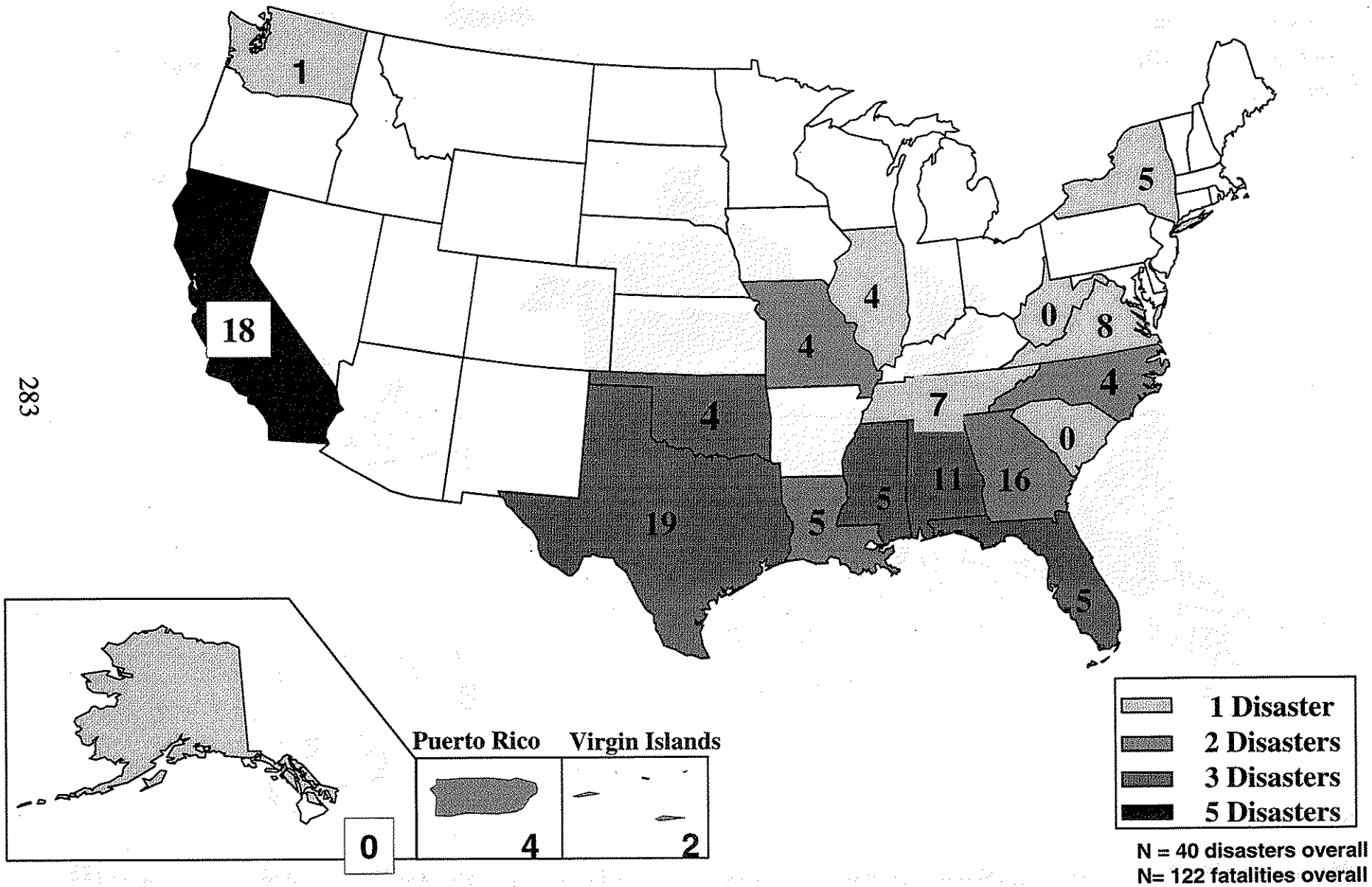
Figure 2. Frequency of disasters and related fatalities by state, 1994



N = 18 disasters overall
N= 155 fatalities overall
Fatalities are represented by the number in each state

ARC-CDC Health Impact Surveillance System for Disasters

Figure 3. Frequency of disasters and related fatalities by state, 1995



N = 40 disasters overall
N= 122 fatalities overall

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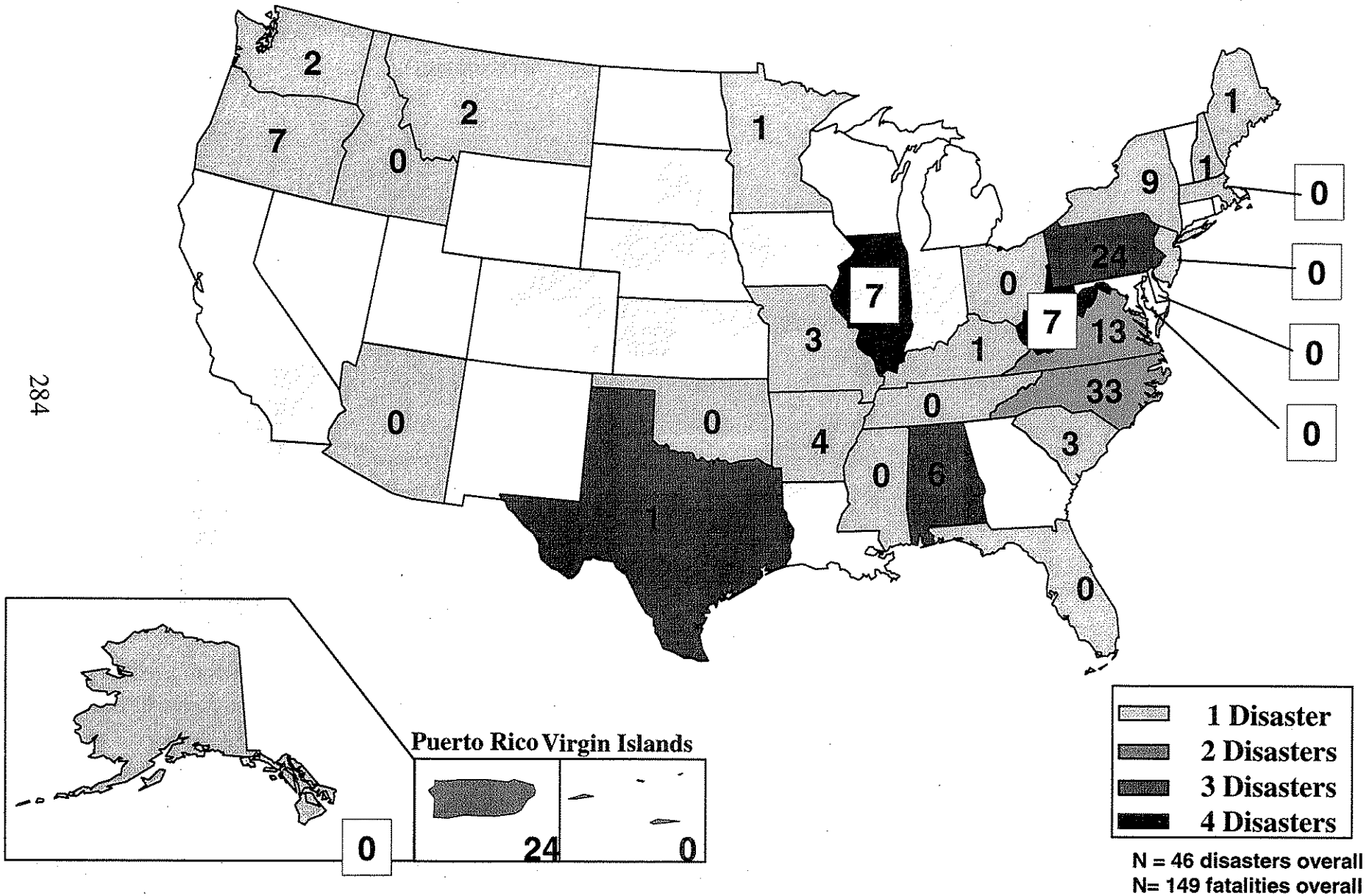
Fatalities are represented by the number in each state

Figure 4. Frequency of disasters and related fatalities by state, 1996



N = 46 disasters overall
N= 149 fatalities overall

Fatalities are represented by the number in each state

ARC-CDC Health Impact Surveillance System for Disasters

Figure 1. Flow Chart of Client and Health Information in Disaster Relief Operations,
American Red Cross - CDC Health Impact Surveillance Systems for Natural Disasters