REVIEW ARTICLE

Infectious Diseases Following Disasters

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Srinivas Murthy, MD, CM; Michael D. Christian, MD, FRCP(C)

ABSTRACT

Infectious diseases following natural disasters tend to occur as a result of the prolonged secondary effects of the disaster, mostly when there is an interruption of public health measures resulting from destruction of the local infrastructure. This article will review the infectious risks that occur as a result of natural disasters, with a focus on the mechanism of disease spread, infectious diseases after specific disasters, and various evidence-based interventions.

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Key Words: infectious diseases, public health, disasters

A disaster can be defined as "an event that causes adverse health impacts on a population; usually, but not always, causing wide spread destruction to the environment."[1] It can be categorized as either natural or manmade, and can be further subdivided based on whether the onset is rapid or slow.[2] Disasters with a rapid onset tend to cause most morbidity and mortality immediately as a direct result of the primary event,[3] whereas slower-onset disasters cause morbidity and mortality through prolonged, secondary effects.[4]

Infectious diseases following natural disasters tend to occur as a result of the prolonged secondary effects of the disaster, most often when there is an interruption of public health measures resulting from destruction of the local infrastructure. Despite popular belief, infectious disease outbreaks following disasters are rare, although it is crucial that programmatic implementation take infectious issues into account for the significant theoretical risk that they pose. As evidenced from prior disasters, the precise impact of this infrastructure destruction is variable and contingent upon the predisaster baseline (eg, if the preexisting level of sanitation is poor, a disaster may have little impact on baseline rates of infectious disease). The converse also is true, in that a highly developed infrastructure with a low baseline disease rate can offer a significant reserve capacity that can lessen the perceived impact of the disaster.[5] Thus, it is difficult to predict the risk of infectious disease outbreaks after a disaster simply based upon the magnitude of the disaster event itself.

More helpful in predicting the risk of postdisaster infectious diseases are the synergistic effects of 3 overlapping concerns: new pathogens introduced into a community without preexisting immunity, a change in the susceptibility of the population, or an increase in the transmissibility of local pathogens. These will be discussed in turn, followed by examples of specific types of disasters and their associated infectious risks.

PRINCIPLES OF POSTDISASTER INFECTIOUS DISEASES

New Pathogens

As many historical examples illustrate, the introduction of new pathogens into a population increases the risk of infectious outbreaks. Disasters can provide the means for the introduction of these new pathogens, bringing low-incidence endemic diseases to the forefront. The postflood environment, for example, is a prime breeding ground for fungi and mold that would previously have survival difficulties, where flooded homes and buildings newly pose infectious risks.[6] The aeration and spread of soil and particulate matter have the potential to introduce new soilborne organisms into the environment, specifically fungi such as histoplasmosis and coccidioides.[7] Collapsing wood and chaotic debris increase the risk of tetanus exposures. New vectors can be introduced postdisaster, with new mosquito habitats created in the postdisaster flotsam, increasing the theoretical risk of mosquito-borne illnesses such as malaria or dengue. Waterborne pathogens from marine water have been documented to cause wound infection in the postflood situation, notably during the response to Hurricane Katrina.[8]

An often-cited concern is the infectious risks posed by dead bodies. This has been widely examined, and there are no data to suggest that the body of a person killed in a disaster who is free of infection at the time of death will pose any risk of infection to others.[9,10] Appropriate public education is vital, with World Health Organization guidelines stating that every effort should be made to identify and bury or cremate the corpse, all the while respecting appropriate customs and laws.[11] In addition, typical universal precautions for body fluids should be observed. Concern about dead bodies will persist among

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workers and evacuees,[12,13] and reassurance should be given them by the disaster services provider or providers.

Altered Susceptibilities

Populations in movement or under stress are more vulnerable than otherwise, with an associated increased susceptibility to infectious diseases. This vulnerability comes from mechanical factors such as the compromise of personal hygiene and the presence of disaster-related wounds,[14] and biological factors such as a potentially compromised immune response due to the stress, hypothermia, or malnutrition associated with the postdisaster environment. Thus, both the likelihood of disease acquisition and the case-fatality rate are increased in the postdisaster setting.

Increased Transmissibility

Although not specific to any 1 type of disaster, populations clustering in close proximity and spending time indoors are at increased risk for a host of infections, especially respiratory and gastrointestinal illnesses. The enteric viruses, such as norovirus or rotavirus, have been implicated in outbreaks of gastroenteritis in the postdisaster setting.[15-18] The risk of tuberculosis transmission is increased with close-contact living and should be anticipated. Common respiratory virus transmission has been well documented in the close conditions of the postdisaster setting.[19] Airborne pathogens such as measles are also significant risks that need to be considered.

In all of these situations, previously low-incident diseases increase their basic reproductive number due to the close-contact living conditions in postdisaster settings. Therefore, the threshold vaccination rate required to achieve herd immunity is increased; measles outbreaks have occurred, for example, in crowded settings with rates of immunization up to 80%.[20] This increased disease transmissibility must be taken into account when discussing any programmatic implementation, including shelter, sanitation, food distribution, and health care.

SPECIFIC TYPES OF DISASTERS

Floods

Floods are one of the most frequent of all natural disasters. Drinking water contamination is the most frequent concern from an infectious diseases perspective, with numerous historical epidemics of postflood gastrointestinal illness.[21-24] There are also examples, however, in which significant flooding and subsequent water system damage occurred without any documented outbreaks.[25-27] When outbreaks have occurred, they have typically been associated with previously endemic organisms, such as *Shigella*[23] and *Giardia*,[21] although most cases have no etiologic agent identified, with drinking water being only the assumed culprit.

A study of water quality that was being conducted when a major flood of the Mississippi River occurred provides interesting insight.[24] Source drinking water concentrations of both *Giardia* and coliform species significantly increased (330% and 270%, respectively) postflood. The 2 major factors that increased a person's individual risk of diarrhea were whether the individual house or yard was flooded and whether the person individually assisted with cleanup efforts. Active water-purifying devices had no discernible effect. This suggests that infection actually occurred through a route other then the consumption of contaminated drinking water and that source water purification may not play a significant role in attenuating outbreaks, although this is only 1 study. Similarly, following the 1998 Bangladesh floods, factors such as crowding, lack of latrine use, no lid on water storage containers, and the use of small storage containers for water were associated with increased rates of diarrheal illness.[5,22] This again illustrates that factors beyond simply a supply of clean source water are important to prevent disease, and that educational interventions regarding appropriate hygiene and infection prevention are crucial. Common causes of diarrheal illnesses postdisaster are listed in Table 1.

In addition to contaminated drinking water, flooding also raises the theoretical specter of increased vector-borne illnesses due to increased mosquito populations.[5,26] After the 1993 Iowa floods, a significant increase in the number of mosquitoes was documented, although without an accompanying increase in the endemic but sufficiently rare western equine encephalopathy.[21] Relief workers aiding the recovery efforts following Hurricane Georges in Puerto Rico did not contract the mosquito-borne dengue fever, despite its occurring during an epidemic of dengue fever.[28] Despite a lack of precedent, arthropod-borne infections pose a risk in newly formed wetlands, and a lack of evidence should not lead to complacency in education or preventive measures against such infections.

Another specific risk posed by floods is mold growth resulting from extensive water damage. After hurricanes Katrina and Rita, in New Orleans, household levels of fungal by-products were significantly higher in severely flooded homes, specifically the fungi *Aspergillus niger*, *Penicillium* spp, *Trichoderma*, and *Paecilomyces*. All of these are known to cause significant invasive respiratory and dermatological disease, especially in immunocompromised individuals. There was no significant human outbreak of these illnesses post-Katrina, although a theoretical risk exists in future disasters.[6,29]

Hurricanes, Cyclones, and Typhoons

Hurricanes, cyclones, and typhoons share a great deal in common with floods in terms of their postdisaster impact. The storm surge itself is responsible for most of the death and injury, and the postdisaster issues are similar to flooding, with similar concerns as described above.[30] Again, the pattern of outbreaks occurring where there are endemic diseases[12] and no outbreaks where diseases are not endemic[31] holds true. In 1 example, a large outbreak of diarrhea (97 934 cases) occurred following a cyclone in India.[12] Molecular analysis confirmed that this outbreak was caused by endemic strains of *Vibrio cholera*, *Escherichia coli*, and *Shigella*, although with a much lower case fatality rate compared with predisaster baseline, possibly explained by early detection and aggressive public health interventions. After Hurricane Katrina in 2005, several occurrences of primar-

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TABLE 1

Selected Pathogens Implicated in Postdisaster Infectious Diseases

Transmission	Disease (agent)	Clinical Features	Incubation Period	Diagnosis	Treatment	Prevention/ Control
Fecal/oral	Cholera (*Vibrio cholerae*)	Profuse watery diarrhea, vomiting	2 h-5 d	Microscopic observation of organism in stool	Intensive rehydration therapy; antimicrobials based on sensitivity testing	Hand washing, proper handling of water/food and sewage disposal
	Bacillary dysentery (*Shigella* spp)	Malaise, fever, vomiting, blood and mucus in stool	12-96 h	Isolation of organism from stool	Nalidixic acid, ampicillin; hospitalization of seriously ill or malnourished; rehydration	Hand washing, proper handling of water/food and sewage disposal
	Viral hepatitis (HAV, HEV)	Jaundice, abdominal pain, nausea, diarrhea, fever, fatigue, and loss of appetite	15-50 d	Serological assay detecting anti-HAV/HEV antibodies	Supportive care	Hand washing, proper handling of water/food and sewage disposal; HAV vaccine
	Typhoid fever (*Salmonella typhi*)	Sustained fever, headache, constipation	3-14 d	Culture from blood, bone marrow, bowel fluids; rapid antibody tests	Ampicillin, trimethoprim-sulfamethoxazole, ciprofloxacin	Hand washing, proper handling of water/food and sewage disposal; vaccination in some settings
	Viral gastroenteritis (Many, including) rotavirus	Diarrhea	3-7 d	Clinical, isolation of virus in stool	Supportive, hydration	Hand washing, hygiene
Airborne	Measles (measles virus)	Fever, conjunctivitis, cough, diffuse rash	10-14 d	Clinical, serology	Supportive	Vaccination, hygiene
	Respiratory viruses	Cold-type symptoms	3-7 d	Clinical	Supportive	Hand washing, hygiene
	Meningitis (*Neisseria meningitis*)	Fever, headache, stiff neck	2-10 d	Isolation of organism in CSF	Antibiotics	Postexposure antibiotic prophylaxis, vaccination
Vector-borne	Malaria (*Plasmodium* spp)	Fever	Varies by species, 9-40 d	Visualization of organism in blood, rapid test	Antimalarial, depending on species	Mosquito control
	Dengue fever (dengue virus)	Fever, headaches, muscle pain	3-14 d	Clinical, serology	Supportive	Mosquito control

CSF, cerebrospinal fluid; HAV, hepatitis A virus; HEV, hepatitis E virus.

ily skin and soft tissue infections due to endemic species of *Vibrio* were reported.[32,33] The most widely reported case was a norovirus outbreak in a shelter, with more than 1000 cases of gastroenteritis documented.[34]

Tornadoes

Tornadoes share the ferocious power of wind with hurricanes, but they lack the storm surge and flooding that accompany hurricanes. However, tornadoes occur with greater frequency and tend to affect inland areas more then hurricanes, at times spawning from remnants of hurricanes. Although tornadoes themselves have not been reported to directly result in infectious disease outbreaks, wound infections from traumatic injuries contaminated with soil or water incurred during a tornado have been reported.[35]

Earthquakes

Earthquakes are one of the most dramatic, rapid, and destructive natural disasters that occur. The loss of life and injuries can be numerous after an earthquake, although the risk for infectious outbreaks is relatively low.[13,36,37] In fact, nearly 95% of injuries and deaths due to earthquakes occur within minutes of the quake.[36,37] Even in a situation in which significant damage has been sustained to public infrastructure and thousands of people are homeless, outbreaks have rarely occurred immediately following earthquakes.[13,38]

When outbreaks of illness do occur after an earthquake, they are typically the result of an increased incidence of endemic pathogens. Following the 1994 Northridge earthquake in California, Ventura County experienced an outbreak of 203 cases

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of Coccidioidomycosis, including 72 deaths, as a result of dust clouds created during landslides.[7,36] After an earthquake in Turkey, a large but brief outbreak of diarrhea was noted,[39] although with no significant change in the baseline rates of isolation of endemic pathogens, prompting Vahaboglu and colleagues to speculate that either emotional stress or a sudden change in the diet of displaced people or both was to account for the illnesses documented.

A unique property of earthquakes is their ability to cause tsunamis. Tsunamis combine both powerful destructive forces along with flooding, resulting in a unique disaster. Aside from drowning, the most common serious injuries reported after the southeast Asian tsunami in 2004 were large flap lacerations.[40,41] Andresen et al and Maegele et al reported that wounds were grossly contaminated with seawater, coral, or soil, causing infections by often drug-resistant organisms such as *Acinetobacter*, *Pseudomonas*, *Stenotrophomonas*, *E coli*, *Aeromonas*, and *Mucor*. These organisms are endemic in the above-listed contaminants, although otherwise rarely causing wound infections.

DISPLACED POPULATIONS

A unifying feature of the postdisaster environment is the presence of displaced populations. People displaced due to complex emergencies such as civil unrest or political instability are discussed elsewhere.[42-44] Populations displaced to emergency shelters in the event of natural disasters have been extensively studied. As was widely publicized during Hurricane Katrina, people evacuated to emergency shelters often faced crowded living conditions that made the population vulnerable to outbreaks of communicable diseases. Outbreaks of methicillin-resistant *Staphylococcus aureus* skin infections and gastrointestinal illnesses were common in post-Katrina evacuation centers.[8] During Hurricane Hugo, for example, 10 300 people were evacuated to 161 emergency shelters, where outbreaks of head lice and influenza-like illnesses were reported frequently. People sheltered in buildings with 1 large room (eg, churches, community centers) were at significantly higher risk of contracting an influenza-like illness than those in shelters with several smaller rooms (eg, schools).[19] Following 2 hurricanes that struck the Dominican Republic in 1979, community-wide outbreaks of hepatitis, gastroenteritis, and measles occurred,[45] although disease rates did not increase significantly from already elevated baseline rates for 5 months. Small outbreaks of respiratory illnesses, scabies, and lice occurred after the 1980 earthquake in Italy.[13]

The quasipermanent nature of "temporary shelters" poses delayed infection risks, with shelter-based outbreaks of *Giardia* occurring multiple years after the disaster itself.[5,46] When populations become displaced for long periods of time, natural disasters can spawn complex emergencies that can prompt outbreaks of diseases such as malaria, meningitis, pneumonia, tuberculosis and human immunodeficiency virus (HIV).[4,43,47-50] Postdisaster crowding itself is a complex enterprise, with new pathogens, altered susceptibilities, and increased transmissibility of illnesses synergistically resulting in a significantly increased risk of a diverse spectrum of infectious diseases.

INTERVENTIONS

Most interventions should be centered upon anticipatory prevention, given the risks of a significant infectious outbreak. Vital to these interventions is surveillance, both immediately after and in the weeks following a disaster as the response continues. The ability to detect greater-than-baseline incidences of diarrhea, respiratory illness, or fevers with rash is the cornerstone of any outbreak response.

Rapid health assessments, performed as soon as possible, have been proven to be helpful in stemming any subsequent outbreak that may occur.[20] These assessments include determining any major health risks in the direct environment, visually inspecting the environment, obtaining baseline epidemiological data for the diseases listed above, and establishing a coherent health care coordinating mechanism. Subsequently, it is imperative that responders rapidly set up an effective surveillance mechanism[51] to detect any new clusters of illness so that appropriate responses can be scaled up early and appropriately. Standardized forms for this process have been created by the Centers for the Disease Control and Prevention and are freely available.[52]

Implementing appropriate infection control precautions, including universal precautions when dealing with body fluids, illness transmission–based precautions when dealing with patients suspected of carrying infection, and standard precautions in all other situations is vital for health workers' safety and outbreak control. In addition, the availability of handwashing stations, which help to ensure frequent and thorough hand cleansing, is potentially the most cost-effective intervention in the postdisaster setting to stem the spread of disease, as determined through extrapolating nondisaster setting data.[20,53] Maintaining a focus on hygiene through mandated clean food preparation and eating areas, appropriately placed lavatories, and containment of soiled areas is vital to prevent an outbreak of infection.[18,54] As mentioned above, postdisaster sheltering in many, small-size rooms is preferable to few, large-size rooms, if it is feasible to do so.

History reveals that, after natural disasters, there has often been a reflex response to undertake mass vaccination or chemoprophylaxis campaigns.[5,13,31] When such vaccination campaigns have been undertaken during disaster conditions, immunization records have not been kept, incomplete series of vaccinations have been given, and no follow-up care has been arranged.[13,31] Rapidly changing epidemiology makes each situation unique, however, and the merits of vaccinating postdisaster evacuees should be examined on a case-by-case basis.[55] In places such as Canada[56] or the United Kingdom,[57] with measles immunization rates of <90%, there may be a need to introduce measles mass-vaccination campaigns to achieve the new, higher threshold of herd immunity in postdisaster crowding, should the situa-

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tion warrant. Similarly, in settings in the developing world, the lower baseline vaccination rate coupled with increases in their basic reproductive number make preventive measles vaccination a priority in all children up to 15 years of age.[58]

The Centers for Disease Control and Prevention has issued guidelines regarding immunizations for displaced people in postdisaster settings, encouraging updating tetanus, meningococcal, and pneumococcal series for those who do not have up to date immunizations.[59] In addition, varicella, influenza, and measles, mumps, and rubella vaccines should be considered for individuals living in crowded group settings and without written documentation of having received the vaccines. Targeted vaccinations for at-risk populations can be used to control outbreaks such as meningitis and to prevent tetanus, to which people are commonly exposed during disaster cleanup activities.[60-62] Crucial to all of these vaccination recommendations is adequate documentation of any intervention to avoid costly repetition, with vaccination cards provided, if necessary.[59]

The chemoprophylaxis and vaccination needs of responders to a disaster, ideally organized before departure, should include provisions for HIV postexposure prophylaxis following percutaneous exposures. Postexposure chemoprophylaxis for documented cases of meningitis or rabies should be performed on an as-necessary basis. In addition, many patients will have chronic infectious issues, namely HIV, for which access to medications will be a likely concern.[63] It was estimated that up to 40% of people affected by Hurricane Katrina lived with a chronic illness,[64] making disease exacerbations a concern.

A crucial component of infection control and triage for people with a suspected or documented infection is a local health center where there is limited exposure to other community members and easy access to medical personnel.[65] Anticipatory preparation of these health and evacuation centers for expected outbreaks, especially of diarrheal illness, should be performed. The creation of appropriate diagnostic centers where rapid assessment of patients, including rudimentary laboratory facilities, is a reasonable step for prolonged postdisaster conditions.[34,51]

The distribution of antimicrobial medications should be done on a patient-by-patient basis by appropriately trained professionals. Table 2 lists the antibiotic-related contents of the most recent World Health Organization emergency kit, which can be used as a guide in deciding upon appropriate medications for the setting.[66]

The following lists considerations to take into account when creating an antibiotic formulary for postdisaster settings:

- Endemic organisms in the disaster area
- Resistance patterns of endemic organisms
- Ease of administration in the field (oral preferred over intramuscular preferred over intravenous)
- Storage requirements (avoid drugs that require refrigeration or are damaged by freezing)
- Expiration dates for drugs not <4 y
- Vaccines and chemoprophlyactic agents
- Drugs needed to treat people affected by the disaster and the potential needs of those responding to the disaster

Again, because of rapidly changing epidemiology, drug formulary selection should be performed on a situational basis using the criteria listed above and the specific environment, with the WHO emergency kit used simply as the backbone. Baseline rates of antibiotic resistance should be ascertained, if there are preexisting data, and antibiotic kits appropriately modified.

TABLE 2

Infectious Disease–Related Contents of World Health Organization New Emergency Health Kit 98

Basic kit

Benzyl benzoate, lotion, 25%
Chlorhexidine 5%
Chloroquine, tablet, 150 mg
Gentian violet, powder
Mebendazole, tablet, 100 mg
Oral rehydration salts
Sulfamethoxazole + trimethoprim, tablet, 400 + 80 mg
Tetracycline eye ointment 1%

Supplemental kit*

Amoxicillin, tab, 250 mg
Ampicillin, injection, 500 mg/vial
Benzathine benzylpenicillin, injection, 2.4 million IU/vial
Benzylpenicillin, injection, 5 million IU/vial
Chloramphenicol, capsule, 250
Chloramphenicol, injection, 1 g/vial
Doxycycline, tablet, 100 mg
Metronidazole, tablet, 250 mg
Nystatin, noncoated tablet, 100,000 IU/tab
Nystatin vaginal, tablet, 100,000 IU/tab
Procaine benzylpenicillin, injection 3 – 4 million IU/vial
Quinine, inj 300 mg/mL 2 mL/ampoule
Quinine, sulfate, tablet, 300 mg
Sulfadoxine + pyrimethamine, tablet, 500 mg + 25 mg

Kit does not contain

Vaccines
Drugs for tuberculosis, leprosy, specific resistant malaria strains, specific sexually transmitted infections

*Also includes all contents of basic kit.

CONCLUSIONS

Disasters, whether natural or man-made, have the potential to lead to outbreaks of infectious diseases. Despite the common portrayals by the media, outbreaks after a disaster are relatively infrequent and when they do occur, most are caused by endemic organisms as opposed to novel ones. The body of literature pertaining to infectious diseases after disasters has significant limitations, including the frequent lack of baseline data for comparison with postdisaster rates of infections and a lack

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of documentation of etiologic agents causing outbreaks. The main tools in prevention and treatment remain infection control, epidemiologic analysis, and laboratory diagnostics. By considering the type of disaster, rapidity of onset, endemic organisms, public health infrastructure, and baseline population characteristics, responders should be able to predict with reasonable certainty what infectious agents may pose a threat after a disaster, thereby allowing a tailored response. The recent movement toward including active research agendas in disaster response further solidifies our knowledge and improves the evidence-based foundation for interventions.

Author Affiliations: Dr Murthy is in the divisions of infectious diseases and critical care at the Hospital for Sick Children in Toronto, Ontario. Dr Christian is in the divisions of infectious diseases and critical care at Mount Sinai Hospital and University Health Network in Toronto, Ontario, and is a Major, 1 Canadian Field Hospital (Canadian Forces).

Correspondence: Address correspondence and reprint requests to sgmurthy @gmail.com.

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REFERENCES

1. Binder S, Sanderson LM. The role of the epidemiologist in natural disasters. *Ann Emerg Med*. 1987;16(9):1081-1084.
2. Lechat MF. Disaster epidemiology. *Ann Soc Belg Med Trop*. 1976;56(4-5):193-197.
3. Emergency care in natural disasters. Views of an international seminar. *WHO Chron*. 1980;34(3):96-100.
4. Shears P. Epidemiology and infection in famine and disasters. *Epidemiol Infect*. 1991;107(2):241-251.
5. The risk of disease outbreaks after natural disasters. *WHO Chron*. 1979;33(6):214-216.
6. Adhikari A, Jung J, Reponen T, et al. Aerosolization of fungi, (1– >3)-beta-D glucan, and endotoxin from flood-affected materials collected in New Orleans homes. *Environ Res*. 2009;109(3):215-224.
7. Schneider E, Hajjeh RA, Spiegel RA, et al. A coccidioidomycosis outbreak following the Northridge, Calif, earthquake. *JAMA*. 1997;277(11):904-908.
8. Centers for Disease Control and Prevention (CDC). Infectious disease and dermatologic conditions in evacuees and rescue workers after Hurricane Katrina—multiple states, August–September, 2005. *MMWR*. 2005;54(38):961-964.
9. Morgan O. Infectious disease risks from dead bodies following natural disasters. *Rev Panam Salud Publica*. 2004;15(5):307-312.
10. Gionis TA, Wecht CH, Marshall LW Jr, Hagigi FA. Dead bodies, disasters, and the myths about them: is public health law misinformed? *Am J Disaster Med*. 2007;2(4):173-188.
11. de Ville de Goyet C. Stop propagating disaster myths. *Lancet*. 2000;356(9231):762-764.
12. Chhotray GP, Pal BB, Khuntia HK, et al. Incidence and molecular analysis of *Vibrio cholerae* associated with cholera outbreak subsequent to the super cyclone in Orissa, India. *Epidemiol Infect*. 2002;128(2):131-138.
13. Alexander D. Disease epidemiology and earthquake disaster. The example of Southern Italy after the 23 November 1980 earthquake. *Soc Sci Med*. 1982;16(22):1959-1969.
14. Ligon BL. Infectious diseases that pose specific challenges after natural disasters: a review. *Semin Pediatr Infect Dis*. 2006;17(1):36-45.
15. Schmid D, Lederer I, Much P, Pichler AM, Allerberger F. Outbreak of norovirus infection associated with contaminated flood water, Salzburg, 2005. *Euro Surveill*. 2005;10:E050616.3.
16. Phanuwan C, Takizawa S, Oguma K, Katayama H, Yunika A, Ohgaki S. Monitoring of human enteric viruses and coliform bacteria in waters after urban flood in Jakarta, Indonesia. *Water Sci Technol*. 2006;54(3):203-210.
17. Nomura K, Murai H, Nakahashi T, et al. Outbreak of norovirus gastroenteritis in elderly evacuees after the 2007 Noto Peninsula earthquake in Japan. *J Am Geriatr Soc*. 2008;56(2):361-363.
18. Centers for Disease Control and Prevention (CDC). Norovirus outbreak among evacuees from hurricane Katrina—Houston, Texas, September 2005. *MMWR*. 2005;54(40):1016-1018.
19. Centers for Disease Control and Prevention (CDC). Surveillance of shelters after Hurricane Hugo–Puerto Rico. *MMWR*. 1990;39(3):41-42, 47.
20. Connolly MA. *Communicable Disease Control in Emergencies: A Field Manual*. Geneva: World Health Organization; 2005.
21. Centers for Disease Control and Prevention (CDC). Outbreak of diarrheal illness associated with a natural disaster—Utah. *MMWR*. 1983;32(50):662-664.
22. Kunii O, Nakamura S, Abdur R, Wakai S. The impact on health and risk factors of the diarrhoea epidemics in the 1998 Bangladesh floods. *Public Health*. 2002;116(2):68-74.
23. Shears P. The Khartoum floods and diarrhoeal diseases. *Lancet*. 1988;2(8609):517.
24. Wade TJ, Sandhu SK, Levy D, et al. Did a severe flood in the Midwest cause an increase in the incidence of gastrointestinal symptoms? *Am J Epidemiol*. 2004;159(4):398-405.
25. Centers for Disease Control and Prevention (CDC). Morbidity surveillance following the midwest flood—Missouri, 1993. *MMWR*. 1993;42(41):797-798.
26. Centers for Disease Control and Prevention (CDC). Public health consequences of a flood disaster—Iowa, 1993. *MMWR*. 1993;42(34):653-656.
27. Setzer C, Domino ME. Medicaid outpatient utilization for waterborne pathogenic illness following Hurricane Floyd. *Public Health Rep*. 2004;119(5):472-478.
28. O'Leary DR, Rigau-Perez JG, Hayes EB, Vorndam AV, Clark GG, Gubler DJ. Assessment of dengue risk in relief workers in Puerto Rico after Hurricane Georges, 1998. *Am J Trop Med Hyg*. 2002;66(1):35-39.
29. Rao CY, Riggs MA, Chew GL, et al. Characterization of airborne molds, endotoxins, and glucans in homes in New Orleans after Hurricanes Katrina and Rita. *Appl Environ Microbiol*. 2007;73(5):1630-1634.
30. Noji EK. Analysis of medical needs during disasters caused by tropical cyclones: anticipated injury patterns. *J Trop Med Hyg*. 1993;96(6):370-376.
31. Lee LE, Fonseca V, Brett KM, et al. Active morbidity surveillance after Hurricane Andrew—Florida, 1992. *JAMA*. 1993;270(5):591-594.
32. Centers for Disease Control and Prevention (CDC). *Vibrio* illnesses after Hurricane Katrina—multiple states, August–September 2005. *MMWR*. 2005;54(37):928-931.
33. Centers for Disease Control and Prevention (CDC). Two cases of toxigenic *Vibrio cholerae* O1 infection after Hurricanes Katrina and Rita—Louisiana, October 2005. *MMWR*. 2006;55:31-32.
34. Yee EL, Palacio H, Atmar RL, et al. Widespread outbreak of norovirus gastroenteritis among evacuees of Hurricane Katrina residing in a large "megashelter" in Houston, Texas: lessons learned for prevention. *Clin Infect Dis*. 2007;44(8):1032-1039.
35. Millie M, Senkowski C, Stuart L, Davis F, Ochsner G, Boyd C. Tornado disaster in rural Georgia: triage response, injury patterns, lessons learned. *Am Surg*. 2000;66(3):223-228.
36. Centers for Disease Control and Prevention (CDC). Earthquake-associated deaths—California. *MMWRp*. 1989;38(45):767-770.
37. De Bruycker M, Greco D, Lechat MF, Annino I, De Ruggiero N, Triassi M. The 1980 earthquake in Southern Italy—morbidity and mortality. *Int J Epidemiol*. 1985;14(1):113-117.
38. Lora-Suarez F, Marin-Vasquez C, Loango N, et al. Giardiasis in children living in post-earthquake camps from Armenia (Colombia). *BMC Public Health*. 2002;2:5.

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https://doi.org/10.1001/dmp.2010.hcn10005 Published online by Cambridge University Press

39. Vahaboglu H, Gundes S, Karadenizli A, et al. Transient increase in diarrheal diseases after the devastating earthquake in Kocaeli, Turkey: results of an infectious disease surveillance study. *Clin Infect Dis*. 2000;31(6):1386-1389.
40. Andresen D, Donaldson A, Choo L, et al. Multifocal cutaneous mucormycosis complicating polymicrobial wound infections in a tsunami survivor from Sri Lanka. *Lancet*. 2005;365(9462):876-878.
41. Maegele M, Gregor S, Steinhausen E, et al. The long-distance tertiary air transfer and care of tsunami victims: injury pattern and microbiological and psychological aspects. *Crit Care Med*. 2005;33(5):1136-1140.
42. Lautze S, Leaning J, Raven-Roberts A, Kent R, Mazurana D. Assistance, protection, and governance networks in complex emergencies. *Lancet*. 2004;364(9451):2134-2141.
43. Connolly MA, Gayer M, Ryan MJ, Salama P, Spiegel P, Heymann DL. Communicable diseases in complex emergencies: impact and challenges. *Lancet*. 2004;364(9449):1974-1983.
44. Salama P, Spiegel P, Talley L, Waldman R. Lessons learned from complex emergencies over past decade. *Lancet*. 2004;364(9447):1801-1813.
45. Bissell RA. Delayed-impact infectious disease after a natural disaster. *J Emerg Med*. 1983;1(1):59-66.
46. Oztürk CE, Sahin I, Yavuz T, Ozturk A, Akgunoglu M, Kaya D. Intestinal parasitic infection in children in post-disaster situations years after earthquake. *Pediatr Int*. 2004;46(6):656-662.
47. Aghababian RV, Teuscher J. Infectious diseases following major disasters. *Ann Emerg Med*. 1992;21(4):362-367.
48. Heyman SN, Ginosar Y, Niel L, et al. Meningococcal meningitis among Rwandan refugees: diagnosis, management, and outcome in a field hospital. *Int J Infect Dis*. 1998;2(3):137-142.
49. Moore PS, Toole MJ, Nieburg P, Waldman RJ, Broome CV. Surveillance and control of meningococcal meningitis epidemics in refugee populations. *Bull World Health Organ*. 1990;68(5):587-596.
50. Santaniello-Newton A, Hunter PR. Management of an outbreak of meningococcal meningitis in a Sudanese refugee camp in northern Uganda. *Epidemiol Infect*. 2000;124(1):75-81.
51. Murray KO, Kilborn C, DesVignes-Kendrick M, et al. Emerging disease syndromic surveillance for Hurricane Katrina evacuees seeking shelter in Houston's Astrodome and Reliant Park Complex. *Public Health Rep*. 2009;124(3):364-371.
52. Centers for Disease Control and Prevention. Public health assessment and surveillance after a disaster. http://www.bt.cdc.gov/disasters/surveillance. Accessed April 13, 2010.
53. Pittet D, Sax H, Hugonnet S, Harbarth S. Cost implications of successful hand hygiene promotion. *Infect Control Hosp Epidemiol*. 2004;25(3):264-266.
54. Watson JT, Gayer M, Connolly MA. Epidemics after natural disasters. *Emerg Infect Dis*. 2007;13(1):1-5.
55. Howard MJ, Brillman JC, Burkle FM Jr. Infectious disease emergencies in disasters. *Emerg Med Clin North Am*. 1996;14(2):413-428.
56. Avis K, Tan L, Anderson C, Tan B, Muhajarine N. Taking a closer look: an examination of measles, mumps, and rubella immunization uptake in Saskatoon. *Can J Public Health*. 2007;98(5):417-421.
57. Lamden KH, Gemmell I. General practice factors and MMR vaccine uptake: structure, process and demography. *J Public Health (Oxf)*. 2008;30(3):251-257.
58. Salama P, Assefa F, Talley L, Spiegel P, van Der Veen A, Gotway CA. Malnutrition, measles, mortality, and the humanitarian response during a famine in Ethiopia. *JAMA*. 2001;286(5):563-571.
59. Centers for Disease Control and Prevention. Interim immunization recommendations for individuals displaced by a disaster. http://www.bt.cdc.gov/disasters/disease/vaccrecdisplaced.asp. Published September 12, 2008. Accessed August 14, 2009.
60. Ahlawat S, Kumar R, Roy P, Varma S, Sharma BK. Meningococcal meningitis outbreak control strategies. *J Commun Dis*. 2000;32(4):264-274.
61. Weekly Morbidity and Mortality Report Ministry of Health Pakistan; 2006 01 May 06. http://www.reliefweb.int/rw/rwb.nsf/db900sid/KHII-6PQ3KG?OpenDocument&query=pakistan. Accessed May 24, 2010.
62. Morgan O, de Ville de Goyet C. Dispelling disaster myths about dead bodies and disease: the role of scientific evidence and the media. *Rev Panam Salud Publica*. 2005;18(1):33-36.
63. Clark RA, Besch L, Murphy M, et al. Six months later: the effect of Hurricane Katrina on health care for persons living with HIV/AIDS in New Orleans. *AIDS Care*. 2006;18(Suppl 1):S59-S61.
64. Miller AC, Arquilla B. Chronic diseases and natural hazards: impact of disasters on diabetic, renal, and cardiac patients. *Prehosp Disaster Med*. 2008;23(2):185-194.
65. Centers for Disease Control and Prevention. Infection control after a disaster. http://emergency.cdc.gov/disasters/infectioncontrol.asp. Accessed September 14, 2009.
66. World Health Organization. Standard health kits—new emergency health kit 98. http://www.who.int/hac/techguidance/ems/new_health_kit_content/en/index.html. Accessed April 13, 2010.

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