Infectious Diseases After Natural Disasters

Jason Bowling
University of Texas Health Science Center
San Antonio
Division of Infectious Diseases
Disclosures

• I have no relevant financial conflicts of interest to disclose.
Objectives

• Identify risk factors for infectious disease outbreaks following a natural disaster
• Review infections seen following natural disasters
• Discuss recommendations for response efforts to address infectious disease risks
Natural Disasters

- Catastrophic events with dramatic health, social and economic consequences
- Disruption of the ecosystem that exceeds the community’s capacity to adjust – requiring need for external assistance
- In the past 2 decades
- Millions of people killed
- At least 1 billion people adversely affected
- Enormous economic impact

http://www.healthmap.org/site/diseasedaily/article/rare-fungal-infection-strikes-joplin-tornado-survivors-61011 - accessed 4-26-16
Background

- Incidence and impact of natural disasters has increased in recent decades
- Factors:
  - Increasing global population size
  - Land shortage, poverty
  - Increased urbanization
- Increased number of people living in areas prone to natural disaster
- Increased public health impact due to higher population density
- Highly developed countries are also vulnerable to devastating consequences
  - 2005: Hurricane Katrina in U.S.
  - 2011: Great Eastern Japan earthquake

## Classification

<table>
<thead>
<tr>
<th>Hydro-meterological</th>
<th>Geo-morphological</th>
<th>Geophysical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Floods</td>
<td>Landslides</td>
<td>Earthquakes</td>
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<tr>
<td>Wave surges</td>
<td>Avalanches</td>
<td>Tsunamis</td>
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<td>Storms</td>
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<td>Volcanic eruptions</td>
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<tr>
<td>Typhoons</td>
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<tr>
<td>Hurricanes</td>
<td></td>
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<tr>
<td>Tornadoes</td>
<td></td>
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</tr>
</tbody>
</table>

Floods are the most common natural disaster worldwide
Earthquakes are second most reported

Mortality

• Majority of deaths related to natural disasters are due to:
  – Blunt trauma
  – Crush-related injuries
  – Drowning

• Deaths due to infectious diseases are fortunately less common

2010 Haiti Earthquake
Mass Casualties

https://s-media-cache-ak0.pinimg.com/736x/7b/69/b2/7b69b222d62c8d9b34c1e5835a9352af.jpg - accessed 4-26-16
Dead bodies

- Rapid presence of large number of dead bodies in a disaster-affected area raises public concern for disease outbreaks.
- However, no evidence to support this when deaths directly due to disaster.
- Survivors are more likely source of acute infections.
- No outbreaks resulting from corpses has been demonstrated.
  - Large numbers of deaths due to earthquake in Haiti, Great Eastern Japan earthquake and tsunami.

Dead bodies

• Microbial organisms involved in decay process are not pathogenic
• Only a few situations where dead bodies serve as health risk
• Pathogens persist for some time after death
  – Viral hemorrhagic fevers
    • Ebola virus, Marburg virus, Lassa virus, Crimean-Congo hemorrhagic fever virus
  – Enteric pathogens (eg, *Vibrio cholerae*)
• Precautions should be taken with these organisms

Principles for Corpse Management

• Mass management of dead bodies is often based on the false belief that they represent an epidemic hazard if not buried or burned immediately
• Burial is preferable to cremation in mass casualty situations
• Every effort should be made to identify the bodies
• Mass burial should be avoided if at all possible
• Families should have opportunity to conduct culturally appropriate funerals and burials
• When existing facilities (graveyards, etc) fill, alternative locations or facilities should be provided

Port-au-Prince Jan 13 2010
Haiti 2010

A Haitian mass grave receives unclaimed, unidentified bodies in the suburbs of Port-au-Prince January 16, 2010. (Olivier Laban Mattei/AFP/Getty Images)
Workers handling bodies should:

- Use universal precautions for blood/body fluid
- Use and correctly dispose of gloves
- Use body bags as available
- Hand wash with soap after handling bodies
- Disinfect equipment and vehicles
- Bodies do not need disinfection
  - Except: hemorrhagic fever, cholera, Shigella
- Bottom of all graves must be at least 1.5 m above water table
Risk factors for infectious disease transmission following a natural disaster
Population Displacement

• Primary risk factor for communicable disease transmission
• Size and characteristics of displaced group
  – Proximity of safe water and working latrines
  – Nutritional status
  – Immunization status
  – Access to health care services
• Outbreaks even more common in conflict-impacted populations than disaster-affected
  – Malnutrition increases mortality risk
• Conflicts generally span longer time, more malnutrition

Clinical Phases of Infections Following Natural Disasters

- **Phase 1**
  - Impact Phase: Days 0-4
  - Victims removed, rescued and initial treatment of disaster-related wounds/injuries
  - Infections not yet emerging

- **Phase 2**
  - Post-impact Phase: Day 4 – Week 4
  - First infections emerge
  - Airborne, food-borne, water-borne

Clinical Phases of Infections Following Natural Disasters

- **Phase 3**
- **Recovery Phase**: after week 4
- Emergence of infections with long incubation periods
- During this period, either endemic infections or imported infections to the affected community can cause outbreaks and epidemics
- Outbreaks following disasters prolong the after-effects of the disaster

<table>
<thead>
<tr>
<th>Country</th>
<th>Disaster event</th>
<th>Year(s)</th>
<th>Infectious disease outbreak following natural disaster</th>
<th>Ref.</th>
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<tbody>
<tr>
<td>USA</td>
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<td>Cholera</td>
<td>[108]</td>
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<td>Dengue</td>
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<td>Malaria</td>
<td>[110]</td>
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<td>Diarrhea</td>
<td>[14]</td>
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<td>2001</td>
<td>Leptospirosis</td>
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<td>India (Mumbai)</td>
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<td>2000</td>
<td>Leptospirosis</td>
<td>[19]</td>
</tr>
</tbody>
</table>

*Summarizes natural disasters that had resulted first in substantial population displacement and then exacerbated risk factors for disease transmission and outbreaks.
ARI: Acute respiratory infection.
Infectious Diseases associated with Contaminated Water
Contaminated Water

- Natural disaster can block access to safe water
- Diarrheal diseases – leading cause of death in disaster and camp settings
- Epidemics in victims often due to contamination of water:
  - Water source (fecal)
  - Water transport and storage
  - Shared water containers and cooking pots

Diarrheal disease outbreaks

- **2004 Bangladesh**
  - After flooding, >17k cases
    - *Vibrio cholerae* and enterotoxigenic *E. coli*
- **1998 West Bengal**
  - After flooding, >16k cases of cholera
- **2004 Indonesia**
  - Following tsunami, assessment of town of Calang 2 weeks after found 100% survivors drank from unprotected wells and 85% reported diarrhea


Diarrheal disease outbreaks

• Risk is higher in developing countries than in industrialized countries but still occurs in all
• In the U.S., diarrheal illnesses documented after Hurricanes Allison (2001) and Katrina (2005)
• Norovirus, *Salmonella*, toxigenic and non-toxigenic *Vibrio cholerae* isolated

Allison – flooding in Houston

Canal Street 1 day after Katrina

Cholera Outbreak in Haiti

- 2010 Haiti population estimated at just under 10 million
  - 3 million live in Port-au-Prince
- Poorest country in Western Hemisphere
- 55% of population live below world poverty line of 1.25 dollars/day
- Sustainable water and sanitation infrastructure challenged by political instability and lack of investment
- January 12, 2010: 7.0 magnitude earthquake struck 17 km southwest of Port-au-Prince

Lantagne D et al. Current Topics in Microbiology and Immunology 2013
The cholera outbreak created increased strain on a country whose infrastructure had already been decimated in a January 2010 earthquake.

Cholera Outbreak in Haiti

- Estimated 222,650 people died and 310,930 injured
- Humanitarian response was complicated by poor pre-existing infrastructure and overwhelming scale of disaster
- Displaced population lived in spontaneous settlements
- Inadequate access to water or facilities with adequate handwashing
- Minimum agreed standard of H2O:
  - 20 L/person/day for drinking, bathing, washing, excreta disposal
- 95% residents did not have access to 10 L/day
- Only 3% had adequate handwashing facilities with soap & H2O

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
Cholera risk evaluation

- CDC wrote “Haiti Pre-decision Brief for Public Health Action Cholera”
- Cholera is extremely unlikely to occur
- While current water, sanitation, and hygiene infrastructure in Haiti would facilitate transmission, cholera is not circulating in Haiti and the risk of introduction is low
- Most relief workers are from countries without endemic cholera and they are likely to have access to adequate sanitation and hygiene facilities

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
What is cholera?

- Severe, acute, dehydrating diarrhea
- Can kill adults and children in < 12 hr
- **Pathogen:**
  - bacteria *Vibrio cholerae*
  - Produces potent toxin: cholera toxin
- **Clinical spectrum:**
  - Asymptomatic infection to fatal disease
- **Treatment:**
  - Rehydration (oral or IV based on severity)
  - Antibiotics

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
Cholera outbreak in Haiti

- October 2010: Cholera appeared in Haiti
  - Recovery phase (Phase 3)
- First appearance in nearly 100 years
- Investigation performed
- UN Relief teams increased after earthquake
- Personnel from 22 countries deployed to Haiti
- Contingent from Nepal arrived in October
  - Cholera is endemic in Nepal
- Epidemiologic review of infections raised concern of relief team camp site near river
- ”Black water” waste from camp dumped into open pit
  - Located in area known to flood and overflow into river with rainfall

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
Relief Team Camp Site

Fig. 2 Toilet area and canal flowing into Meye Tributary
“Black” water disposal pit

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
Cholera outbreak in Haiti

- Whole genome sequencing later revealed that *V. cholerae* from Haiti outbreak and isolates from Nepal were nearly identical
- Conclusions
- >10k Haitians use the river system for washing, drinking and were exposed
- Thousands of agriculture workers exposed during labor, esp in rice paddy fields
- Haiti population lacked prior immunity
- Poor water and sanitary conditions
- Haiti had environment conducive for outbreak
- Source no longer relevant – outbreak not caused by deliberate actions

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
Cholera in Haiti

A boy diagnosed with cholera is treated at a medical center run by Medecins Sans Frontieres (Doctors Without Borders) outside of Port-au-Prince November 1, 2012.

Cholera had not been documented in Haiti in almost 100 years prior to the 2010 outbreak.

People walk across a tiny overpass as raw sewage flows beneath in Port-au-Prince, Haiti, September 2012. (Reuters / Swoan Parker)
Important Points

• Highlights risk of transmitting cholera by mobilizing diverse populations in emergency response
• Personnel from endemic areas need to be screened for colonization, receive prophylactic antibiotics, or both
• UN facilities should treat fecal waste with on-site systems
• Haiti needs improved water and sanitation

Lantagne D et al. *Current Topics in Microbiology and Immunology* 2013
Viral Hepatitis Infections

- Transmission of Hepatitis A and E: fecal-oral route
- Lack of access to safe water and food increases infection risk
- Hepatitis A endemic in most developing countries
  - Most children exposed and develop immunity at early age
- Risk for large outbreaks low in these settings
- Hepatitis E outbreaks in endemic areas follow flooding
- Usually a mild, self-limited illness BUT
- Pregnant women at risk: case-fatality rate up to 25%!
- 2005 Pakistan — earthquake
- Hepatitis E infections seen in areas without safe water
- >1200 cases of acute jaundice, many confirmed Hep E

Leptospirosis

• Zoonotic bacterial infection – *Leptospira* sp
• Broad spectrum of severity - can be fatal
• Fever, HA, conjunctival suffusion
• Can cause meningitis, acute renal failure, acute hepatic failure
• Rodents shed high quantities in urine
• Transmission: contact of skin and mucous membranes with water, damp soil, or mud contaminated with rodent urine
• Flooding facilitates spread
  – Proliferation of rodents
  – Increased proximity to people on high ground
• Outbreaks following floods:
  – 2001 Taiwan after Typhoon Nali
  – 2000 in Mumbai, India
  – 1998 Argentina

How Leptospirosis is spread?

People contract the disease by direct contact with contaminated water.

- Bacteria: Leptospira sp.
- Rodents, especially rats
- Splashing contaminated water/urine into eyes
- Swallowing contaminated water/food
- Exposing open wounds (i.e., cuts) to contaminated water/soil

Contaminated water/soil/food

Infectious Diseases associated with Crowding
Measles

- Risk of transmission after natural disaster is dependent on baseline immunization coverage of affected population
- Caused by one of the most contagious viruses on earth
- Crowded living conditions facilitate transmission
- 1991 Phillipines – Mt. Pinatubo eruption
  - Displaced population >18k cases of measles
- 2005 Pakistan - South Asia earthquake
  - Sporadic cases and clusters of measles

INFECTIONOUS DISEASES

As Ebola fades, a new threat

With health services devastated in the wake of Ebola, experts are bracing for a deadly measles outbreak in West Africa

Roberts L. Science 2015 347(6227)
Measles in post-Ebola outbreak setting

- Liberia, Guinea, Sierra Leone at risk even before Ebola outbreak
- Only 62-79% of children vaccinated 2012-2013
- Need 95% of pop. vaccinated with 2 doses for effective herd immunity
- Liberia scheduled measles campaign in fall of 2014 – cancelled due to Ebola outbreak
- Statistical projection – regional measles epidemic post-Ebola would affect about twice as many people as pre-Ebola outbreak
  - 227k compared to 127k, and cause extra 2k-16k deaths
- At high end, this would exceed the number killed by Ebola

Roberts L. Science 2015 347(6227)
Other crowding-associated infections

- *Neisseria meningitidis* meningitis
- Person-person, esp. in crowded situations
- Cases and deaths have been reported in displaced populations in Pakistan, Indonesia
- Prompt antimicrobial prophylaxis can halt
- Acute respiratory infections
- Major cause of illness and death, esp. <5 yrs
- Lack of access to health care and antibiotics increases risk of death
- Displaced persons – crowding, malnutrition

Vector-borne infectious diseases
Vector-borne diseases

• Heavy rains, hurricanes, flooding might first wash away some mosquito-breeding areas
• Residual standing water creates new breeding sites
• Usually some weeks delay
• Risk factors that increase likelihood:
  – Increased vector population
  – Crowding of infected and susceptible people
  – Inadequate public health support
  – Halt in vector control programs
Vector-borne diseases

- **Malaria**: vector *Anopheles* mosquitoes
- Outbreaks well-documented after floods
- 1991 Costa Rica earthquake – caused habitat changes that increased breeding – rise in malaria
- **Dengue**: vector *Aedes* mosquitoes
- Interruption in water supply, solid waste disposal can lead to increased containers


Infections associated with wounds and injuries
Infections associated with wounds and injuries

- Not transmitted from person to person but pose a serious risk to those infected
- Tetanus – caused by *Clostridium tetani*
- Associated with crush injuries and contaminated wounds
- Pre-disaster tetanus vaccination rate affects risk
- Cases of tetanus seen:
  - 2004 Indonesia following tsunami
    - Case fatality rate of 18% (20/106) in Banda Aceh province
  - 2005 Pakistan earthquake

Fungal soft tissue infections

• May 22, 2011: Joplin, Missouri struck by tornado with winds >200 mph
• Approx 1000 injured, 159 deaths
• June 3: Physician notified Health dept of 2 people hospitalized with suspected necrotizing fungal infection
• (Phase 2 time frame)
• June 10: 8 patients had been identified
• June 17: last of 13 patients reported
• Pathogen identified:
  – Mucormycete *Apophysomyces trapeziformis*

Benedict K et al *MMWR* 2011; 60(29)
Joplin, Missouri

http://www.healthmap.org/site/diseasedaily/article/cluster-deadly-fungal-infection-investigated-post-tornado-joplin-missouri - accessed 4-26-16
Cutaneous mucormycosis

- Rare fungal infection
- Mucorales fungi – in soil, decaying wood
- Often opportunistic infection in patients with immunocompromise – heme malignancy, solid organ transplant
- Can see in immunocompetent after traumatic implantation of fungal spores
- Case fatality rate: 29-83%
- Treatment:
  - Early diagnosis, surgical debridement, systemic antifungals

Benedict K et al MMWR 2011; 60(29)
13 confirmed patients

- Median age: 48 yrs old (13-76 yrs)
- 7 were female
- No infections found in people cleaning up debris
- Injuries included lacerations, fractures, and blunt trauma
- Average of 4 wounds on initial exam
- All 13 had surgical debridement
  - 6 had foreign object removed
  - Wood splinters were most common foreign object
- No patients were immunocompromised
- All 13 received systemic antifungal therapy
  - Initial antifungal therapy in 6 pts did not cover Mucorales
- 10 required ICU admission
- 5 died

Benedict K et al *MMWR* 2011; 60(29)
Figure 2. Locations of Case Patients at the Time of the Tornado and Genotype Groups.

The letters A through D denote the subtype groups of *Apophysomyces trapeziformis* clinical isolates from 11 patients; for 2 patients, data on the subtype group were not available (NA). On this map, the locations of case patients at the time of the tornado have been randomly shifted from 0.2 to 0.4 km (0.1 to 0.25 mi) in order to protect patient confidentiality. Data are from the U.S. Army Corps of Engineers and Esri.
Figure 1. Necrotizing Cutaneous Mucormycosis.
Panel A shows a left-arm wound with areas of tissue necrosis visible in subcutaneous tissue, with some extension to the muscle layer. Panel B shows the same wound the next day, after surgical débridement, with visible tissue necrosis and soft-tissue extension into muscle layers. Panel C shows a left-flank wound in another case patient, with macroscopical fungal growth (a white, fluffy appearance) and necrotic borders before repeated surgical débridement. Immunohistochemical staining in Panel D shows mucormycetes (arrows) in the vascular wall and lumen of a necrotic vessel with inflammatory microthrombi (immunoalkaline phosphatase staining with naphthol–fast red substrate and a light hematoxylin counterstain).
<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Admission to ICU</th>
<th>Clinical Description of Incident Wound†</th>
<th>No. of Days from Injury to First Positive Culture</th>
<th>No. of Days from Injury to First Surgical Débridement</th>
<th>Initial Antifungal Treatment</th>
<th>No. of Days to Treatment‡</th>
<th>Other Fungi Isolated from Incident Wound</th>
<th>Subsequent Antifungal Treatment</th>
<th>Death</th>
<th>No. of Days to Death§</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>4-cm curved laceration on flank</td>
<td>11</td>
<td>3</td>
<td>Amphotericin B</td>
<td>0</td>
<td>Posaconazole</td>
<td></td>
<td>No</td>
<td>—</td>
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<tr>
<td>2</td>
<td>Yes</td>
<td>Foreign body on scalp, according to CT</td>
<td>10</td>
<td>10</td>
<td>Amphotericin B</td>
<td>1</td>
<td><em>Candida glabrata</em> and <em>geotrichum</em></td>
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<td>5</td>
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<tr>
<td>3</td>
<td>Yes</td>
<td>Avulsion of skin and muscle on legs</td>
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<td>16</td>
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<tr>
<td>4</td>
<td>Yes</td>
<td>6-cm wound on cheek</td>
<td>9</td>
<td>6</td>
<td>Echinocandin</td>
<td>0</td>
<td><em>Candida species</em></td>
<td>None</td>
<td>Yes</td>
<td>0</td>
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<tr>
<td>5</td>
<td>Yes</td>
<td>Wound on right side of chest</td>
<td>6</td>
<td>1</td>
<td>Amphotericin B</td>
<td>3</td>
<td><em>C. tropicalis</em> and <em>aspergillus</em></td>
<td>Posaconazole</td>
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<tr>
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<td>Yes</td>
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<td>1</td>
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<td>Yes</td>
<td>4</td>
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<tr>
<td>7</td>
<td>Yes</td>
<td>Lacerations on scalp and face with underlying fractures</td>
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<td>4</td>
<td>Fluconazole</td>
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<td><em>C. albicans, C. tropicalis, and fusarium</em></td>
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<td>18-cm laceration on flank</td>
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<td><em>C. tropicalis</em></td>
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<td>Amphotericin B</td>
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</tr>
</tbody>
</table>

* CT denotes computed tomography.
† Information on the clinical description of the wound was obtained from a hospital-chart review.
‡ The number of days to treatment was defined as the number of days before the initial antifungal treatment began and after the first positive mucormycete culture was sent. Negative numbers indicate that the case patient was receiving antifungal treatment before the first positive mucormycete specimen was documented.
§ The number of days to death was defined as the number of days from the date that the first positive mucormycete culture was documented.
Conclusions

• Clinicians should consider environmental fungi as a potential cause of soft tissue infection in injured patients following disasters
• Early recognition, debridement, and treatment with appropriate anti-fungal can improve outcomes
• Likely spores were aerosolized in tornado, carried with debris, and inoculated along with debris during penetrating trauma
• Consider public health surveillance for cutaneous mucormycosis after disasters with penetrating trauma

Others

- 1994 Southern California earthquake
- Unusual outbreak of coccidiomycosis
- *Coccidioides immitis* is fungus found in soil in southwestern U.S.
- Landslides increased levels of dust in air
- 2003 New York massive power outage
- Increase numbers of diarrheal illness
- Case-control study linked cases to meat and seafood consumption after power outage
  - Refrigeration was widely interrupted
Response Approach to Prevent Communicable Diseases after Natural Disasters
Risk Assessment

• Communicable diseases risk assessment should be performed by public health responders within 1st week
• Identify disaster impact and health needs
• Determine priority diseases for inclusion in surveillance system
• Displaced population without access to basic needs is at highest risk
### Risk factors and onset of communicable diseases following natural disasters

<table>
<thead>
<tr>
<th>Major risk factors following natural disasters</th>
<th>Water-borne diseases</th>
<th>Air-borne/droplet diseases</th>
<th>Vector-borne diseases</th>
<th>Contamination from wounded injuries</th>
<th>Clinical phase of natural disasters</th>
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<tbody>
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<td>Population displacement from nonendemic to endemic areas</td>
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<td>Overcrowding (close and multiple contacts)</td>
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<td>Stagnant water after flood and heavy rains</td>
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<td>Insufficient/contaminated water and poor sanitation condition</td>
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<td>High exposure and proliferation to disease vectors</td>
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<td>Insufficient nutrient intake/malnutrition</td>
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<td>Low vaccination coverage</td>
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<td>Injuries</td>
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- **Water-borne diseases**: Diarrhea (diarrhea, dysentery), Leptospirosis, Acute respiratory infections (pneumonia, influenza), Meningococcal meningitis
- **Air-borne/droplet diseases**: Influenza, Measles, Tuberculosis
- **Vector-borne diseases**: Malaria, Dengue fever, Rift Valley fever, Cutaneous leishmaniasis, Chagas disease
- **Contamination from wounded injuries**: Tetanus, Post-exposure phase (0-4 days), Post-exposure phase (5-4 weeks), Recovery phase (>4 weeks)
1. Safe water, Sanitation, Site planning

- Must establish protected access to safe drinking water
- Most important preventive measure after a natural disaster
- Chlorine is cheap, easy, and effective against most water-borne pathogens
- Settlement sites must have H2O access and provide for sanitation needs

World Health Organization 2006 *Communicable diseases following natural disasters: risk assessment and priority interventions*
2. Access to primary health care

- Early diagnosis and treatment of diarrheal illness and acute respiratory illness
  - Esp. in children < 5 yrs
- Early diagnosis and treatment of malaria in endemic areas
- Use treatment protocols for main disease threats
- Proper wound cleaning and care
  - Use tetanus toxoid vaccine with wound care
- Have appropriate drugs available
  - Oral rehydration salts, antibiotics
- Health education messages
  - Good hygiene, safe food and H2O prep, educate on when to seek treatment
- Vector control interventions – tailor to local context

World Health Organization 2006 *Communicable diseases following natural disasters: risk assessment and priority interventions*
3. Surveillance system

- Rapid identification of epidemic-prone disease is critical
- Infectious disease risk assessment will prioritize diseases to include
- Confirm that health care providers are trained
  - Detect priority diseases
  - Promptly report to lead health organization
- Need to have sampling and transport materials available for providers

World Health Organization 2006 *Communicable diseases following natural disasters: risk assessment and priority interventions*
4. Immunization

- Mass measles immunization (with vitamin A supplement) is an immediate health priority depending on pre-disaster immunization.
- If baseline coverage of people < 15 yrs is <90%, should initiate vaccination.
- Target group age 6 months – 5 yrs **FIRST**, then up to 15 yrs if possible.
- Typhoid, Hepatitis A, Cholera vaccines generally not used in mass vaccine approach.
- Safe H2O and sanitation is more effective focus.

World Health Organization 2006 *Communicable diseases following natural disasters: risk assessment and priority interventions*
5. Prevention of malaria and dengue

- Generally a delay prior to increase in mosquitoes
- Institute vector control program
- Distribute bed nets
- Add diseases to surveillance system as indicated by risk assessment
- Periodic lab confirmation with rapid tests to track rate
- Health education messages
  - Cover all stored H2O containers
  - Remove solid debris where H2O can collect
Conclusions

• Risk of infectious disease outbreaks following a natural disaster is related to the displaced population
  – Size
  – Pre-disaster health status
  – Living conditions
• A risk assessment should be performed following a natural disaster to prioritize the infectious diseases to include in the surveillance system
• Response teams should implement recommended preventive measures to reduce risk
Questions?

Flooding in Houston after Allison

https://www.hcfcd.org/media/1247/ts-a_downtownaeriallksouth.jpg?width=616&height=470 – accessed 4-26-16