



Extreme Weather, Flooding, and Dermatological Diseases

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Disclosures of Relationships with Industry

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F069 – Skin-Environmental Interface: Dermatologic Challenges of Our Changing Climate and Environment

DISCLOSURES

I do not have any relevant relationships with industry.

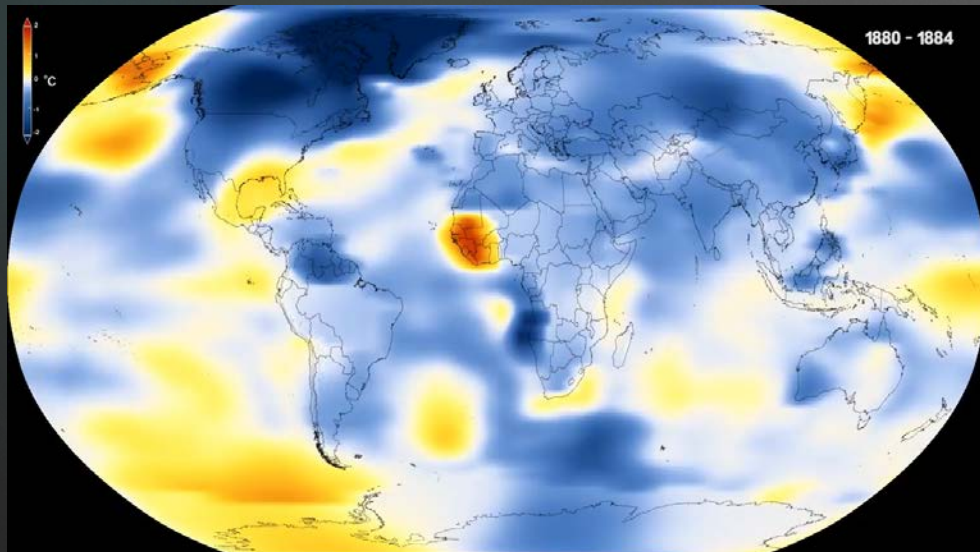
Other Disclosures

The opinions expressed within are solely those of the author(s) and do not represent an endorsement by or the views of the US Air Force, the Department of Defense, or the US Government.



Weather-related Disasters

- ▶ Background
- ▶ Relation to climate change
- ▶ Increasing incidence
- ▶ Morbidity/Mortality
- ▶ Specific consequences



Hurricane Harvey, Aug 2017, Houston

Weather-related Disasters

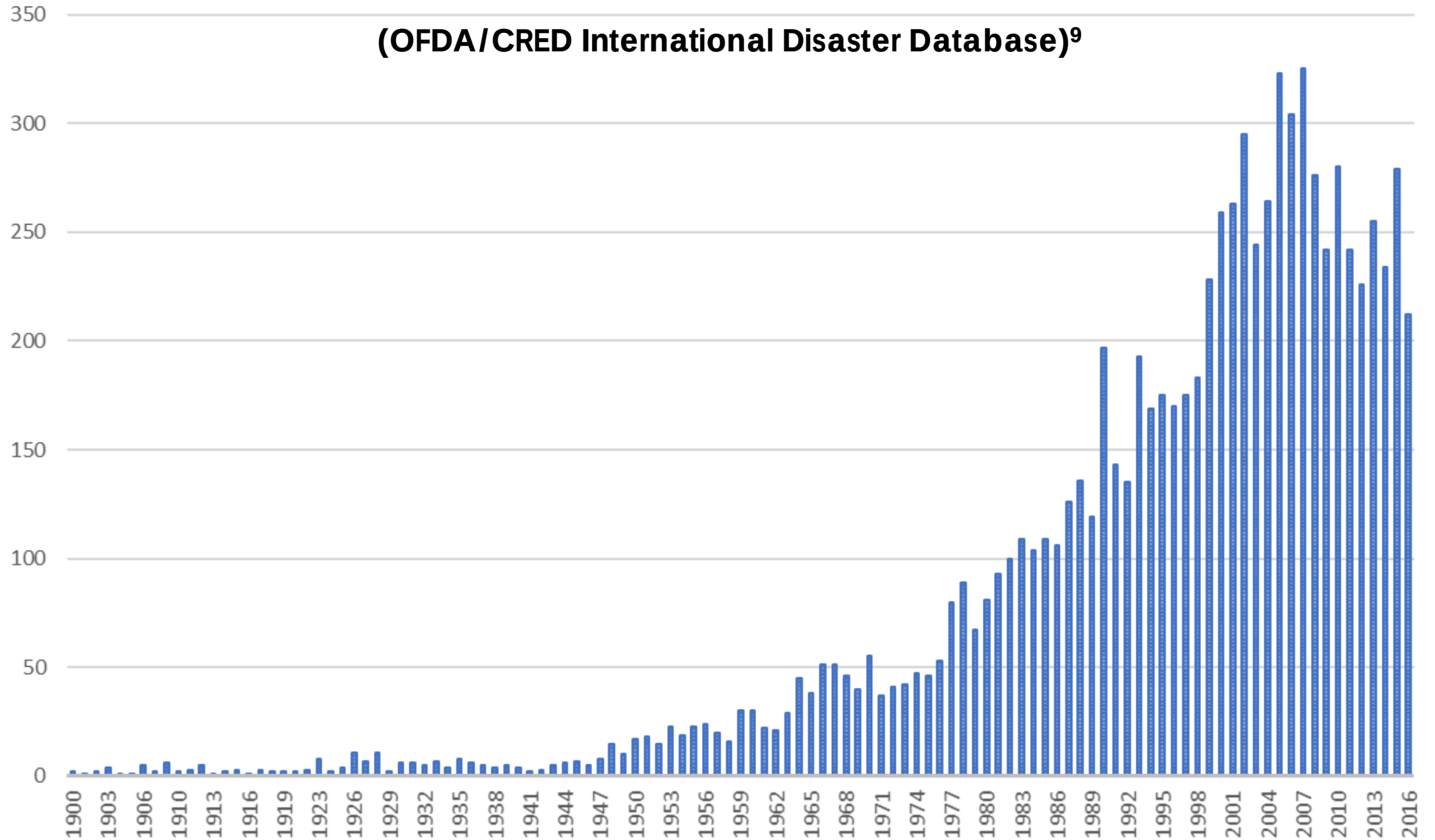
- ▶ Natural disaster rate increasing
 - ▶ 3X increase: 2000-2009 vs 1980-1989⁷
- ▶ Disastrous floods appear to be more frequent and more severe
 - ▶ Dartmouth Flood Observatory⁸
 - ▶ International Disaster Database⁹



May 2015 Houston Floods

WATER-RELATED DISASTERS

(OFDA/CRED International Disaster Database)⁹



Flooding – Reporting bias?

- ▶ Many recent disasters occurred in densely populated areas
- ▶ Worldwide media coverage has markedly increased



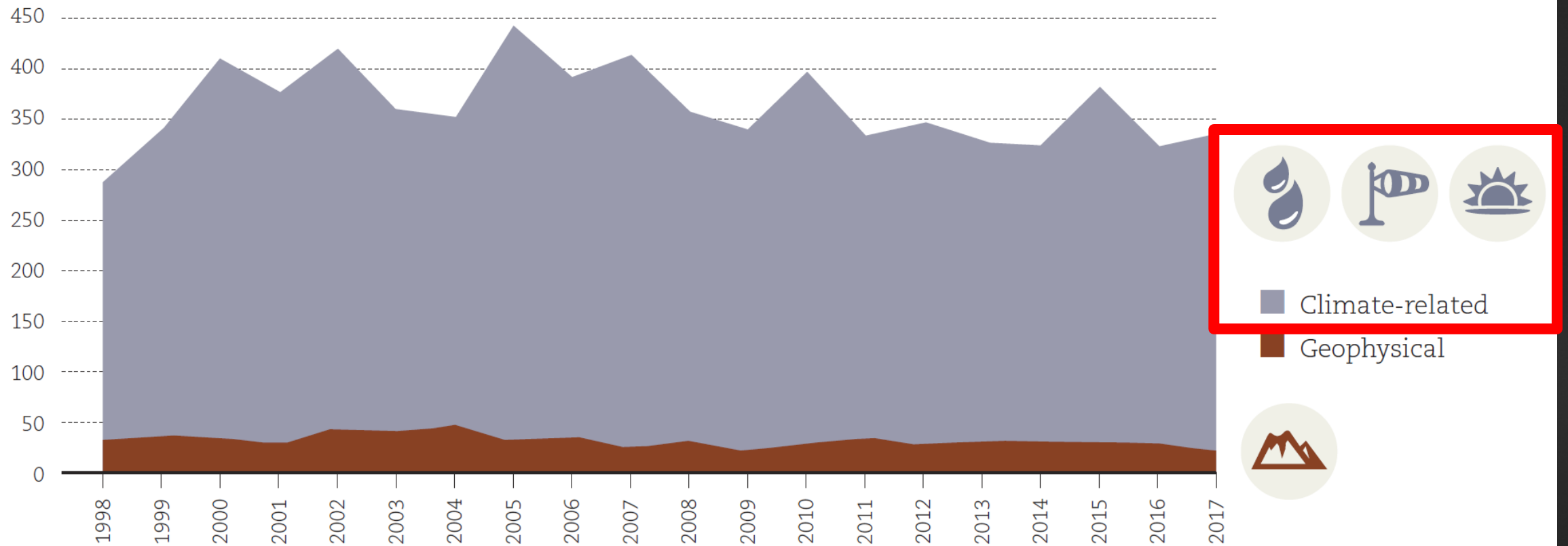
Hurricane Joaquin, Oct 2015, South Carolina

Weather-related Disasters

					
Geophysical	Hydrological	Meteorological	Climatological	Biological	Extra-terrestrial
Earthquake	Flood	Storm	Drought	Animal accident	Impact
Mass Movement (dry)	Landslide	Extreme temperature	Glacial lake outburst	Epidemic	Space weather
Volcanic activity	Wave action	Fog	Wildfire	Insect infestation	

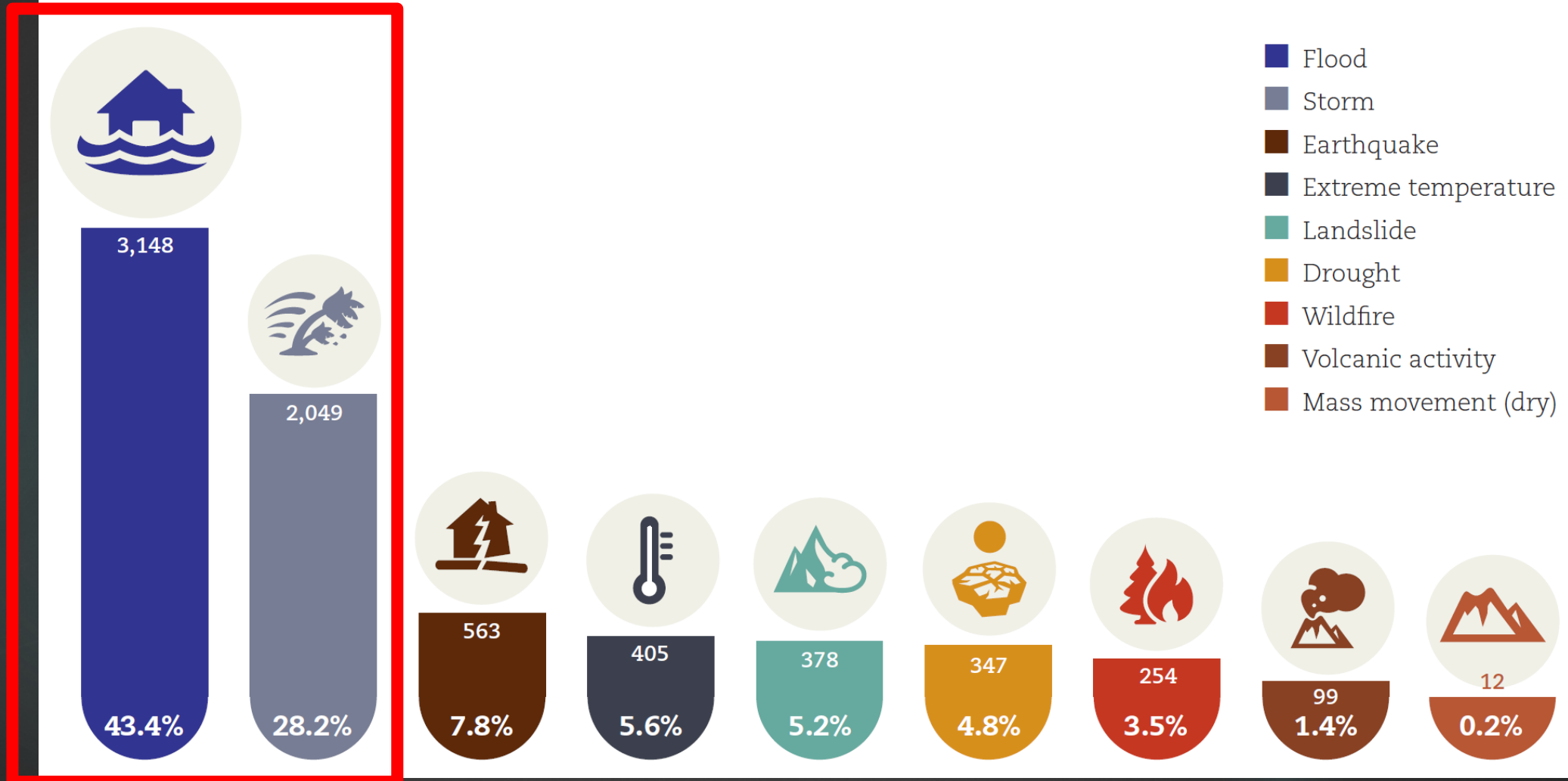
Weather-related Disasters

Number of disasters by major category per year 1998-2017



Weather-related Disasters

Numbers of disasters per type 1998-2017



Weather-related Disasters

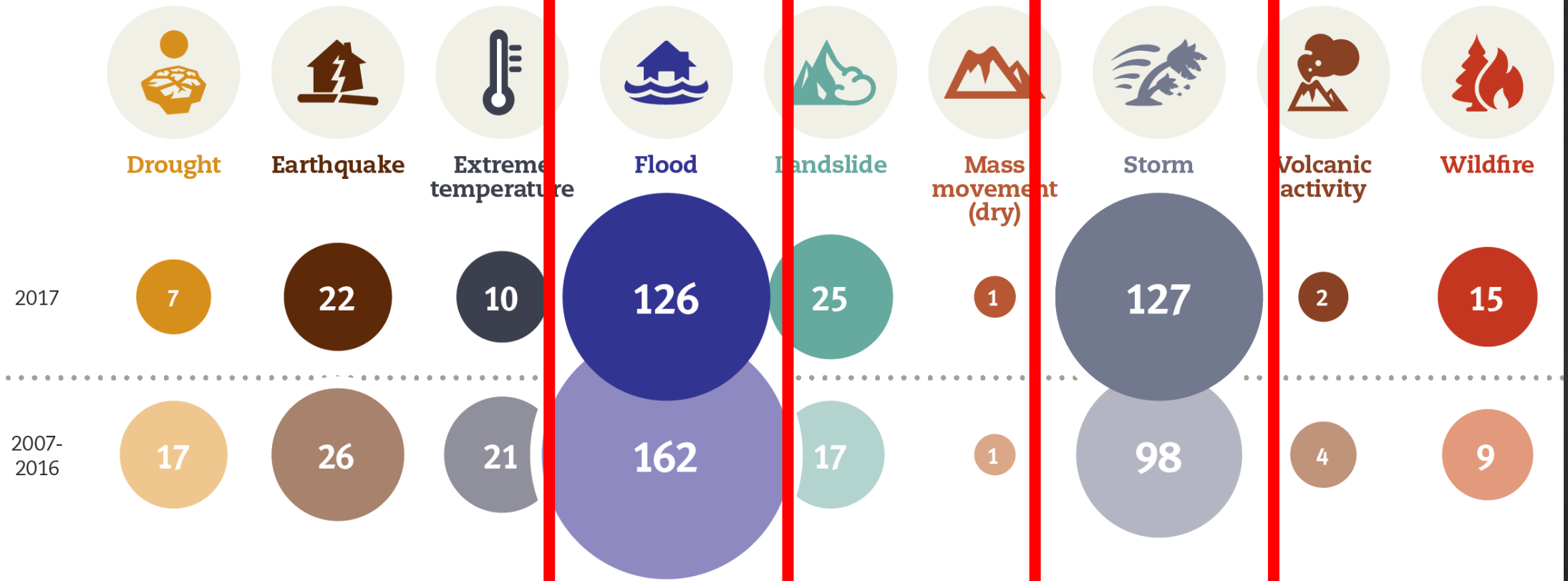
Figure 2

Occurrence by disaster type:
2017 compared to 2007-2016

354
2007 to 2016

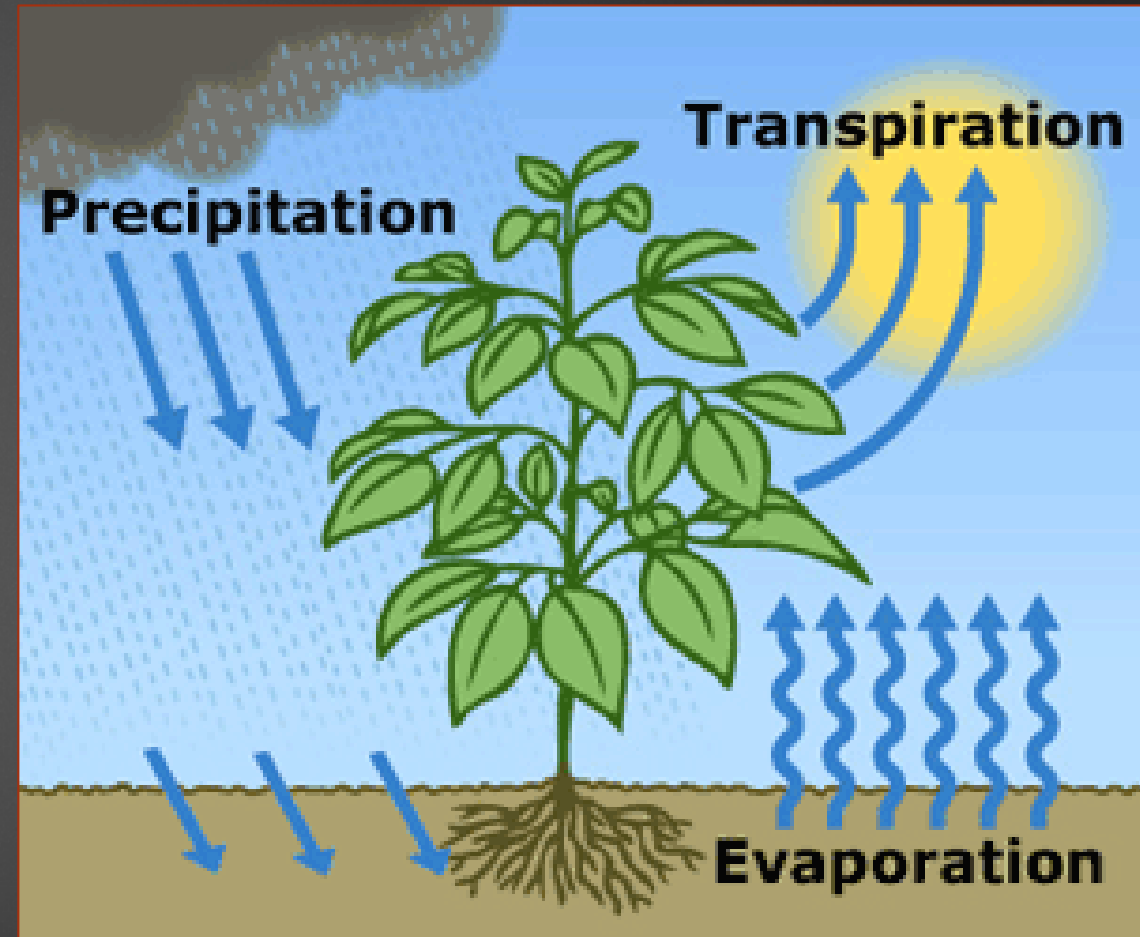
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335
in 2017



Climate Change → Flooding?

Warmer temperatures ↑ evapotranspiration
↓
Generation of more atmospheric moisture
↓
Increase in global average annual rainfall
↓
More frequent and intense floods⁶



Flooding – Prevalence

- ▶ Centre for Research on the Epidemiology of Disasters (CRED)
- ▶ CRED International Disaster Database⁹
 - ▶ **14,090** Natural Disasters from 1900-2016
 - ▶ **8,728** Water-related Disasters (62%)
 - ▶ Geophysical (e.g. tsunamis)
 - ▶ Hydrological (e.g. floods)
 - ▶ Meteorological (e.g. storms)



Hurricane Joaquin, Oct 2015, South Carolina

Flooding – Sequela

- ▶ From 8,728 Water-related Disasters⁹
 - ▶ 4.7 billion people affected
 - ▶ 8.6 million deaths
 - ▶ \$2.1 trillion in damage
- ▶ On an annual basis
 - ▶ Floods are often the most frequent and deadly natural disasters
 - ▶ 2004 – Floods accounted for 7 of the top 10 disasters by death count¹⁰



2004 Asian Tsunami

Event	Type	Year	Location	Est Population affected		Est Cost (USD)	Land involved (km²)	Comments	
				Dead	Displaced				
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Anthropogenic Flooding

- ▶ Creation of new dams
- ▶ Aswan High Dam - Egypt
 - ▶ Finished in 1964
 - ▶ Intentional flooding of farmland/villages as part of reservoir



Aswan High Dam

Anthropogenic Flooding

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 - ▶ Environmental costs to include habitat for vectors/infection
 - ▶ Rate of Schistosomiasis ↑↑



Anthropogenic Flooding

- ▶ Massive expansion of hydroelectric power planned in the Brazilian Amazon¹¹



Itaipu Dam

Anthropogenic Flooding

- ▶ Massive expansion of hydroelectric power planned in the Brazilian Amazon¹¹
- ▶ Will require intentional flooding of ~12,000 km²



Belo Monte Mega-Dam under construction





Flooding – Sequela

- ▶ Health implications of floodwater exposure
 - ▶ Traumatic injuries
 - ▶ Typical/Atypical wound infections
 - ▶ Communicable diseases
 - ▶ Exposures to pollutants
 - ▶ Malnutrition
 - ▶ Mental health disorders
 - ▶ Decreased access to care



Dec 2015 Missouri Floods

Flooding – Sequela

- ▶ Many (if not all) have dermatological manifestations
 - ▶ E.g. [2004 Asian Tsunami](#) and [2011 Thailand Floods](#)^{12,13}
- ▶ The pediatric population is particularly vulnerable to the threats of climate change and natural disasters^{1,14}



Aug 2016 Louisiana Floods

Dermatological Consequences

► Infectious

- Bacteria (Common, Atypical, Polymicrobial, Multidrug resistant)
- Mycobacterial
- Fungal
- Viral
- Parasitic/Infestation

► Non-Infectious

- Environmental
 - Miliaria
 - Immersion Foot
 - Contact dermatitis
 - Traumatic wounds
 - Animal bites
 - Insect bites
 - Electrical injuries
- Psychodermatology



2004 Asian Tsunami

★ Region, type of disaster, character of water (e.g. saltwater, freshwater, brackish water) play a role

Complicating Factors



Damaged Infrastructure

- ▶ Monsoon rains + Cyclone Komen
 - ▶ Summer 2015
- ▶ Severe flooding of Myanmar (Burma)



2015 Myanmar Floods

Damaged Infrastructure

- ▶ Typical disease, death, displacement, and damage
- ▶ 285 health facilities significantly damaged thus hampering relief efforts¹⁵



2012 Typhoon Tembin, Thailand

Disaster + Disaster = ?

- ▶ Heavy rains in Sierra Leone, West Africa → flooding of capital (Freetown)
- ▶ Thousands displaced, many sheltered in close quarters in two stadiums



Sept 2015
Freetown Floods

Disaster + Disaster = ?

- ▶ Occurred during 2014-2016 Ebola epidemic!
- ▶ Incident management systems and population flow access points with symptom/temp screening proved effective¹⁶



Sept 2015 Freetown Floods

Infectious Sequelae

PERSONS HAVING
CURRENTLY ACTIVE
DIARRHEA OR WHO
HAVE HAD ACTIVE
DIARRHEA WITHIN
THE PREVIOUS 14
DAYS SHALL NOT BE
ALLOWED TO ENTER
THE POOL WATER

Infectious Sequelae

- ▶ Common pathogens (e.g. *Staph*, *Strep*, dermatophytes)
- ▶ Exposure to water, even in recreational environments (pools, beaches), increases the risk of skin infections/problems¹⁷
 - ▶ 2010 prospective RCT in healthy individuals swimming off the Florida coast



Beach in
China

Unique Environments

- ▶ Flooding disasters create unique environments further increasing the risk
 - ▶ Traumatic open wounds
 - ▶ Flotsam
 - ▶ Sharp objects under murky water
 - ▶ Climbing trees/structures to escape rising waters
 - ▶ Contamination from sewage/waste-water
 - ▶ Vigorous churning of soil/vegetation containing atypical pathogens
 - ▶ Stagnant water



2015 North Chili Floods/Mudslide

Unique Environments

- ▶ [Hurricane Matthew](#) in Oct 2016
 - ▶ Inundation of rainfall caused miles of rural flooding in North Carolina
- ▶ North Carolina has the highest concentration of hog farms in the US
 - ▶ Smithfield Foods in Tar Heel slaughters 30,000 animals a day
- ▶ Thousands of drowned hogs, chickens, and turkeys floated/decomposed in floodwaters²¹



Unique Environments

- ▶ Bacteria-laden waste “Hog Pits” overcome by floodwaters²¹
- ▶ High risk of contaminating groundwater/wells
- ▶ Threatened the delicate ecosystem of tidal estuaries and bays





Skin Infections

- Most frequently reported medical problem in survivors and responders after the [2004 Asian Tsunami](#) and [Hurricane Katrina](#)^{12,18}



South Carolina
Flooding, 2015

Diaz and Lopez, 2015

- ▶ Reviewed infections following aquatic injuries and exposures²⁰
- ▶ Mostly polymicrobial Gram(-) organisms (particularly marine bacteria)
 - ▶ Often resistant to 1st/2nd gen penicillins and cephalosporins
- ▶ Nontuberculous, mycobacterial infections should be considered in late-onset, culture negative, and antibiotic resistant marine infections
- ▶ Seemingly superficial wounds exposed to seawater may result in deeply invasive infections and sepsis in immunocompromised



Specific Pathogens

Vibrio vulnificus



Vibrio vulnificus – Flooding

- ▶ Cases of *Vibrio* are typically sporadic and isolated

- ▶ Hurricane Katrina (2005)

- ▶ Cluster of infections in evacuees/rescue workers after large-scale exposure to the brackish floodwaters
 - ▶ CDC: 24 cases of hurricane-associated *V. vulnificus* and *V. parahaemolyticus* wound infections, with 6 deaths²³



Aug 2016 Louisiana Floods

Nontuberculous Mycobacteria



M. fortuitum (fast-grower)



M. marinum (slow-grower)

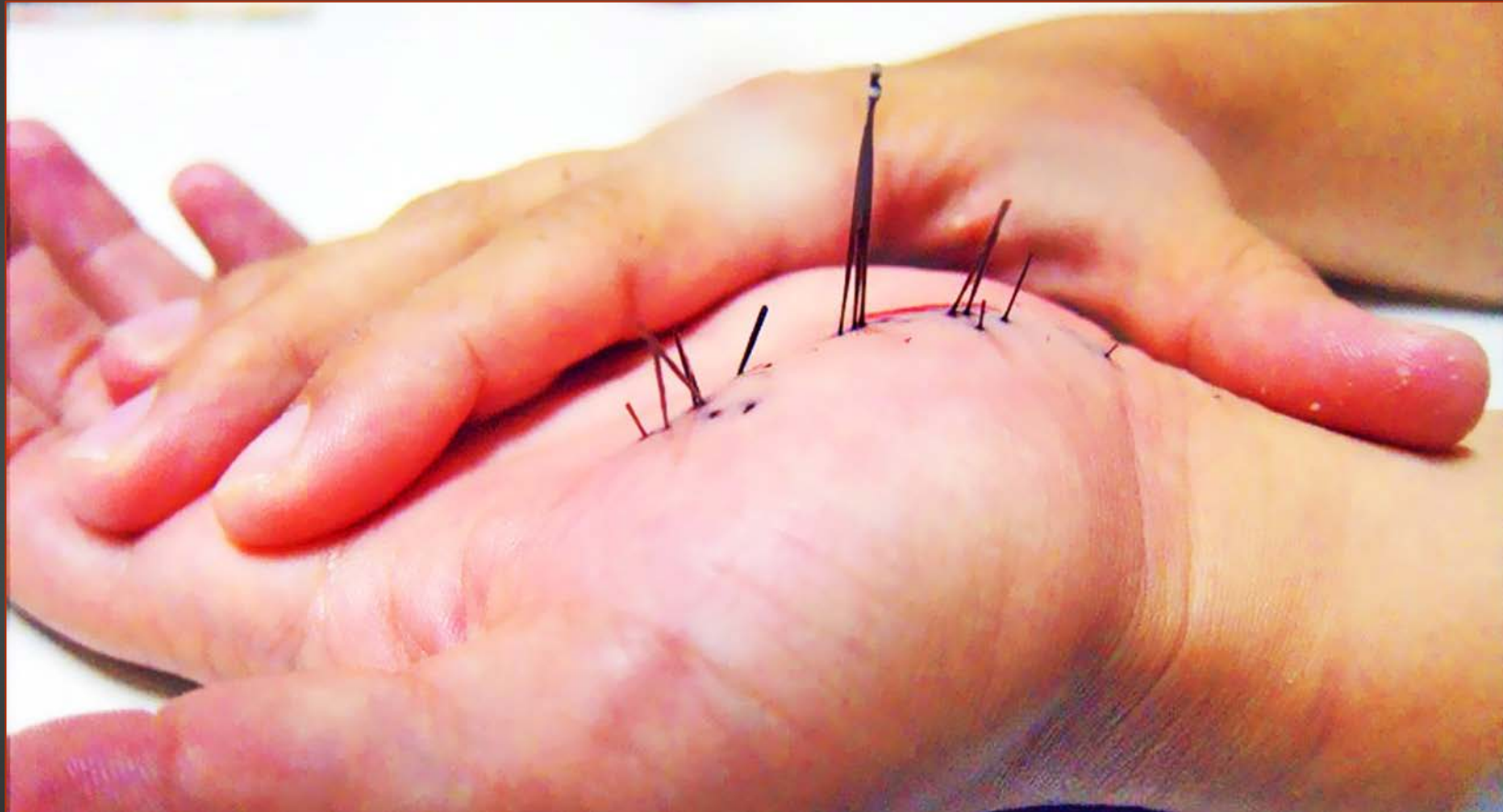
M. marinum

- ▶ *M. marinum* – well-documented association with water exposure²⁴
- ▶ Inflammatory patterns suggesting a mycobacterial infection in sea-urchin granulomas²⁶
- ▶ 41 specimens analyzed with PCR and restriction enzyme analysis
 - ▶ Enabling species identification
 - ▶ 8 with mycobacterial DNA
 - ▶ 3 speciated to *M. marinum*



M. marinum

- Deep-seated metatarsal osteomyelitis by *M. marinum* in an immunocompetent patient who stepped on a sea urchin²⁷



SPAM

- ▶ Unique NTM closely related to *M. marinum*²⁵
- ▶ Seemingly isolated to Pacific Islanders
 - ▶ Particularly Satowan (Micronesia)
- ▶ Chronic, verrucous infection called “spam” due to its resemblance of the food product
- ▶ Infection emerged after World War II
 - ▶ Exposure to taro farming or stagnant, water-filled bomb craters left after Allied bombing
 - ▶ Difficult to treat



M. Ulcerans (Buruli/Bairnsdale ulcer)

- ▶ Shares some environmental/molecular/clinical features with *M. marinum*
- ▶ Likely diverged from *M. marinum* (using comparative genomics)^{28,29}
- ▶ Acquired via contact with wet environments
- ▶ Environmental factors likely drive endemics
 - ▶ Wetland abundance along Nyong River (Cameroon) associated with ↑ incidence^{31,32}



Johnson et al, 2005.

M. Ulcerans (Buruli/Bairnsdale ulcer)

- ▶ Outbreaks in Congo temporally correlated with civil conflict and flooding³⁵
- ▶ Sprinkler/irrigation system was source of outbreak in Australia in 1997³⁶
- ▶ Mosquitos and aquatic bugs possibly play a role transmission^{37,38}



Heteroptera

NTM – Flooding

- ▶ Rapid-growing NTM infections in survivors of the [2004 Asian tsunami](#)^{39,40}
- ▶ Polymicrobial NTM infections^{41,42}
 - ▶ *Mycobacterium abscessus*
 - ▶ MRSA
 - ▶ *Burkholderia pseudomallei*
 - ▶ *Actinomyces neuui*
 - ▶ *Cladophialophora bantiana*



Dec 2015 Missouri Floods



Aeromonas hydrophila

Aeromonas – Flooding

▶ 2004 Asian tsunami

- ▶ *Aeromonas* was often the most commonly isolated organism in SSTIs (23-25%)^{47,48}
- ▶ Despite saltwater surge from tsunami, freshwater inundation from surrounding reservoirs quickly followed

▶ Hurricane Katrina

- ▶ Storm surge caused the freshwater Lake Pontchartrain to overflow
- ▶ High concentrations of *Aeromonas* detected⁴⁹
 - ▶ New Orleans Superdome
 - ▶ Local hospitals



Aeromonas-infected Fish



Hurricane Katrina, New Orleans



Hurricane Katrina, New Orleans

Melioidosis



Bipolar staining

Melioidosis – Flooding

- ▶ Can remain latent for years before presenting as unexplained fever when immunocompetence wanes (e.g. Vietnam veterans)⁵¹
- ▶ Increased incidence during heavy rains/monsoons, whether seasonal or disastrous⁵³
- ▶ 2004 Asian tsunami
 - ▶ Severe post-immersion, near-drowning, aspiration pneumonic melioidosis⁵⁴⁻⁵⁶
 - ▶ Cutaneous wound infections⁵⁷⁻⁵⁹

Leptospirosis

Leptospirosis – Flooding



- ▶ Thrives in warm freshwater, so highest incidence in tropical areas
- ▶ Many outbreaks occur after heavy rains or floods cause sewers to overflow^{64,65}
- ▶ 2009 Philippine floods⁶⁶
 - ▶ Tropical storm Ondoy + Typhoon Pepeng
 - ▶ Thousands of cases, Hundreds of deaths
- ▶ Similar cases after flooding⁶⁷⁻⁷¹
 - ▶ India, Iowa, Argentina, Mexico



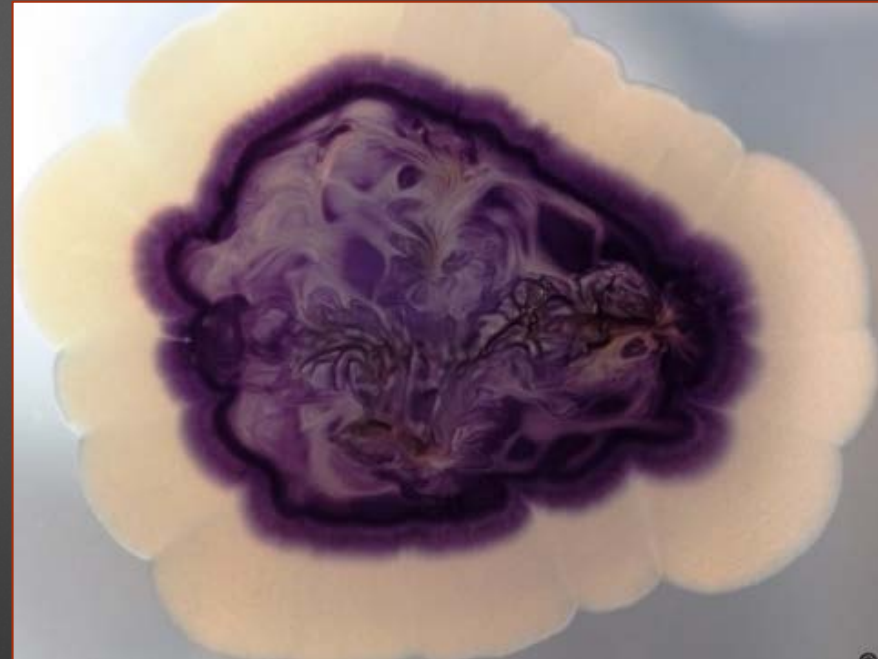
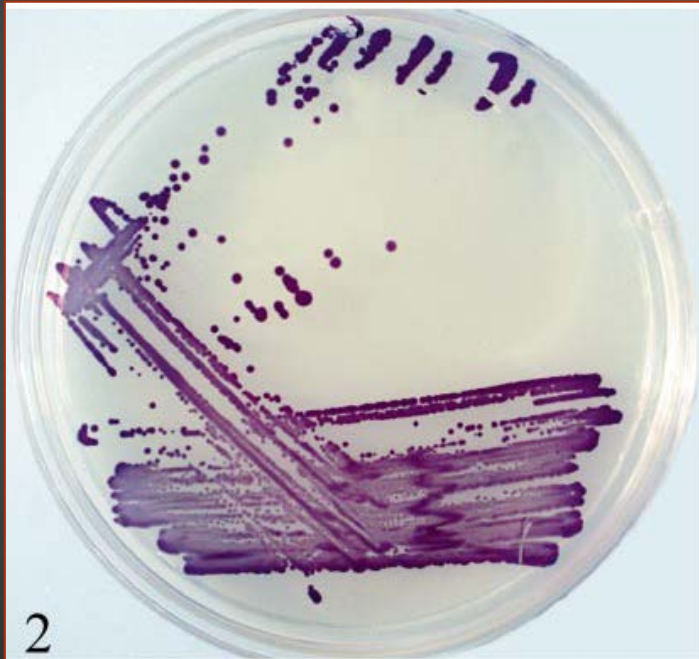
Hurricane Matthew, Oct 2016, Haiti



Chromobacterium violaceum

C. violaceum – Flooding

- ▶ Correlation with muddy/stagnant water exposure well-established⁷⁵
 - ▶ 7 yr old healthy boy swam in a pond near Georgia home – Fatal⁷³
 - ▶ 9 yr old healthy waded in drainage ditch near home – Fatal⁷³
 - ▶ 42 yr old healthy man fell from bike into drainage canal – Nonfatal⁷⁶





Teen in Chiang Mai, Thailand



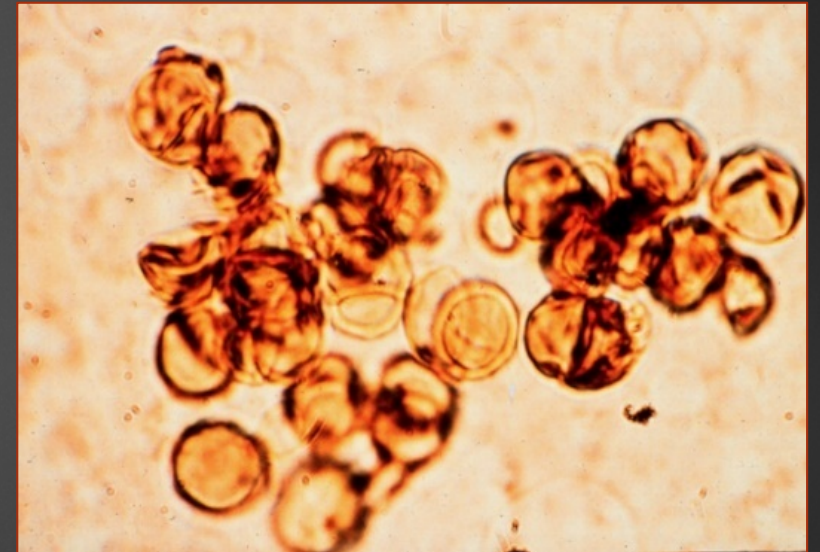
Teen swimming in
Hope Mills Lake, NC



Fungal Infections

Chromoblastomycosis

- Cases reported in aid workers in Thailand after the [2004 Asian tsunami](#)⁷⁷



Troncoso et al, NEJM 2009.⁷⁸

Mycetoma

- ▶ Often co-infected with chromoblastomycosis species^{79,80}
- ▶ Presentation may occur many years after a flooding disaster^{81,82}



Mucormycosis

- ▶ Sinus/brain infections in severe DM2 or immunocompromised
 - ▶ *Mucor*, *Rhizopus*, or *Absidia* common in soil
- ▶ Skin infections after traumatic wound is exposed to soil/mud/water^{86,87}
 - ▶ [1985 Nevado del Ruiz Volcano Eruption](#) in Columbia
 - ▶ Melting of mountain's icecap → massive volcanic "lahar" mudslide → trauma/immersion
 - ▶ One report of 38 victims w/ necrotizing fasciitis, 8 w/ concomitant mucormycosis⁸⁸
 - ▶ [2004 Asian tsunami](#)
 - ▶ Mucormycosis causing necrotizing fasciitis reported in victims^{89,90}





Nevado del Ruiz Volcano Eruption, Columbia, 1985

Parasitosis

Parasitosis

- ▶ Parasitic infections are often ↑ after flooding due to ↑ opportunity for:
 - ▶ Contact with contaminated water
 - ▶ Ingestion of contaminated water
 - ▶ Habitat expansion of vectors due to stagnant water
 - ▶ Crowded living conditions



Hurricane Matthew, Oct 2016, Haiti

Parasitosis

- ▶ Pythiosis (*Pythium insidiosum*)⁹⁵
 - ▶ Formerly a fungus, now considered a parasitic oomycete “protist” – Thailand
 - ▶ Zoonotic infection after exposure to stagnant water (e.g. swimming, agriculture)



Noninfectious Sequelae



Miliaria

Miliaria

- Reported in aid/relief workers by the CDC after [Hurricane Katrina](#)²³



Miliaria crystallina



Miliaria rubra



Immersion Foot

Immersion Foot

- ▶ Cutaneous injury/pain due to prolonged exposure to wet environments
- ▶ Four distinct syndromes delineated by water temperature and time¹¹²
 - ▶ Cold water – Direct vascular injury, three phases (Pre/Hyperemic/Post), +/- perniois
 - ▶ Trench foot – Insidious (days/weeks) process of wet but not fully immersed feet
 - ▶ Immersion foot – Quicker process (15-24hrs) of prolonged and complete water immersion
 - ▶ Warm water
 - ▶ Tropical Immersion foot – Several days of continuous immersion
 - ▶ Warm-water Immersion foot – Shorter, intermittent immersion



Perniosis



Polymicrobial
toe-web infection



Pitted Keratolysis

Contact Dermatitis

Contact Dermatitis

- ▶ Floodwaters often polluted with irritant chemicals and substances
 - ▶ Damaged sewage/water supply systems
 - ▶ Agricultural run-off of fertilizers and pesticides
 - ▶ Flooding of chemical factories/warehouses
- ▶ Exposure to wild foliage
 - ▶ While escaping rising floodwaters
 - ▶ Living in outdoor refugee camps post-flood
- ▶ Both survivors and rescue workers at risk



Contact Dermatitis

▶ [Hurricane Katrina](#)

- ▶ Increase in toxic exposures to gasoline, lamp oil, and carbon monoxide¹¹³
- ▶ 44 offshore oil facilities spilled > 7M gal of crude oil, some entered residential areas¹¹⁴

▶ [2005 Matsu typhoon](#) in Shanghai, China

- ▶ Flooding of a dry alkaline chemical storehouse created NaOH and NH_4Cl solutions¹¹⁵
- ▶ 100+ workers suffered alkali chemical burns ranging from 0.5% to 25% total BSA
- ▶ 68 cases of deep partial-thickness burns; 45 cases of full-thickness burns

Traumatic Wounds

Traumatic Wounds

- ▶ Initial cause of morbidity/mortality is typically trauma-related



Jan 2017 Thailand Floods

Traumatic Wounds

- ▶ Minor cuts/lacerations/puncture wounds should not be overlooked
 - ▶ Occur in both flooding victims and relief workers¹²⁰
- ▶ May devolve into the polymicrobial “Tropical ulcer”¹²¹
 - ▶ Phagedenic/Aden/Malabar ulcer or “Jungle rot”; Malnourishment may increase risk
 - ▶ Inflammatory papule → painless, undermined ulcer mimicking Buruli ulcer or Leish



Electrical Injuries



Electrical Injuries

- ▶ Flooding disasters place victims at risk of environmental electrical injury
 - ▶ Lightning strikes
 - ▶ Victims climbing tall structures
 - ▶ Downed powerlines or exposed wiring
 - ▶ Conduction properties of water
- ▶ [Hurricane Hugo \(1989\)](#)
 - ▶ 7 fatal electrocutions reported by the CDC in Puerto Rico^{128,129}
 - ▶ 4 similar cases reported in South Carolina¹³⁰



Animal/Snake Bites

Animal/Snake Bites

- ▶ During/after flooding, there is an increase in wild/domestic animal bites
- ▶ Rising flood levels cause wild populations to shift to higher ground
 - ▶ Compete with domestic animals and humans for space



Animal/Snake Bites

- ▶ [Hurricane Ike \(2008\)](#)

- ▶ “Animal bite” was 3rd most common trauma complaint recorded by a medical response team deployed to Webster, Texas¹³⁵

- ▶ [2010 Pakistan floods](#)

- ▶ > 700 dog bites in the first 3 weeks⁹³
 - ▶ Hundreds of snake bites
 - ▶ Local antivenin stores quickly depleted



Insect Bites

Insect Bites

- ▶ Insect bite/stings often increase after severe storms/floods¹³⁶
 - ▶ Tormenting both victims and responders
- ▶ [Hurricane Hugo \(1989\)](#)
 - ▶ Among 7 North Carolina EDs
 - ▶ 21% of all “injuries” were due to insect stings¹⁰⁷
 - ▶ 26% causing a generalized reaction
- ▶ [Hurricane Katrina \(2005\)](#)
 - ▶ Papular urticaria in construction workers from previously flooded, mite-infested temporary lodging¹⁰⁸



Insect Bites

- ▶ Natural hosts (rodents/birds) flee area
 - ▶ Insects seek alternative hosts (humans)¹³⁹
- ▶ Natural predators killed by flooding
 - ▶ Population overgrowth
- ▶ [Hurricane Gilbert \(1989\)](#)
 - ▶ Population overgrowth → outbreak of urticarial dermatitis in 100s of hotel employees¹⁴⁰



Insect Bites

- ▶ Insects also move to avoid rising floodwaters
 - ▶ Egyptian factory “attacked” by staphylinid (rove) blister beetles after 1994 flash flood
 - ▶ Dermatitis/conjunctivitis in ~40 workers¹⁴¹
 - ▶ Similar outbreak in US military unit training in Arizona desert after heavy rain/flooding¹⁴²



Insect Bites

- ▶ [Hurricane Harvey \(2017\)](#) – Fire Ant Flotillas





Psychodermatology

Psychodermatology

- ▶ Disaster victims lose family, friends, shelter, possessions, land, livelihood
 - ▶ Suffer severe psychoemotional consequences
- ▶ Psychological/physical stress may play a role in cutaneous disease^{144,145}
- ▶ Exacerbate/Unmask
 - ▶ Atopic dermatitis
 - ▶ Seborrheic dermatitis
 - ▶ Psoriasis
 - ▶ Alopecia areata
 - ▶ Lupus
- ▶ Induce/Trigger
 - ▶ Delusions of parasitosis
 - ▶ Neurotic excoriation
 - ▶ Factitial dermatitis
 - ▶ Trichotillomania



Summary

- ▶ Major flooding events occurring with increased frequency/severity
 - ▶ Likely related to climate change/global warming
- ▶ Many of the deleterious effects have dermatological manifestations
- ▶ Dermatologists are uniquely skilled to aid in the relief efforts





Adis Drug Evaluation
Ivermectin: A Review in Rosacea

Dermatitis

Moisturizers in Atopic Dermatitis and Related Disorders
Association Between Atopic Dermatitis and Autism Spectrum Disorders
Oral Itraconazole Efficacy in Seborrheic Dermatitis

General Interest

The Infectious and Noninfectious Dermatological Consequences of Flooding
The Dermatological Manifestations of Postural Tachycardia Syndrome

Papulosquamous Diseases

Mucosal Lichen Planus and Metabolic Syndrome

Psoriasis

Treatment of Psoriasis During Pregnancy

Sweat Gland Disorders

Treatment of Primary Craniofacial Hyperhidrosis



Bandino JP, Hang A, Norton SA.

The infectious and noninfectious dermatological consequences of flooding: A field manual for the responding provider.

***Am J Clin Dermatol.* 2015 Oct;16(5):399-424.
DOI 10.1007/s40257-015-0138-4**

~25 pages, 200 references, 20 figures

References

1. Ahdoot et al. Pediatrics. 2015;136:e1468-e1484
2. IPCC. Climate change 2014: synthesis report. In: Core Writing Team, Pachauri RK, Meyer LA editors. Contribution of working groups I, II and III to the fifth assessment report of the intergovernmental panel on climate change. Geneva: IPCC; 2014. p. 1–151.
3. <https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally>
4. <http://www.gallup.com/poll/182150/views-climate-change-stable-extreme-winter.aspx>
5. <http://climatecommunication.yale.edu/publications/public-perceptions-of-the-health-consequences-of-global-warming/>
6. 3. Allan RP, Soden BJ. Atmospheric warming and the amplification of precipitation extremes. Science. 2008;321:1481–4.
7. 4. Leaning J, Guha-Sapir D. Natural disasters, armed conflict, and public health. N Engl J Med. 2013;369:1836–42.
8. 5. Dartmouth Flood Observatory. Community surface dynamics modeling system. University of Colorado. <http://floodobservatory.colorado.edu>. Accessed 10 April 2015.
9. 6. EM-DAT. The OFDA/CRED International Disaster Database. Centre for Research on the Epidemiology of Disasters, Université Catholique de Louvain, Brussels. <http://www.emdat.be>. Accessed 6 June 2015.
10. 7. Llewellyn M. Floods and tsunamis. Surg Clin North Am. 2006;86:557–78.
11. 11. Nobre CA, Sampaio G, Borma LS, et al. Land-use and climate change risks in the Amazon and the need of a novel sustainable development paradigm. Proc Natl Acad Sci USA. 2016;113(39):10759–68.
12. 8. Lee SH, Choi CP, Eun HC, et al. Skin problems after a tsunami. J Eur Acad Dermatol Venereol. 2006;20:860–3.
13. Thongtaeparak W, Pratchyapruit WO, Kotanivong S, et al. Prevalence of and risk factors for skin diseases among Army personnel and flood victims during the 2011 Floods in Thailand. Disaster Med Public Health Prep. 2016;10(4):570–5.
14. 9. Disaster Preparedness Advisory Council. Pediatrics. 2015 Nov;136(5):e1407–17.
15. Burki T. Floods in Myanmar damage hundreds of health facilities. Lancet. 2015;386(9996):843.
16. Ratto J, Ivy W 3rd, Purfield A, et al. Notes from the field: Ebola virus disease response activities during a mass displacement event after flooding—Freetown, Sierra Leone, Sept–Nov 2015. MMWR. 2016;65(7):188–9.
17. 10. Fleisher JM, Fleming LE, Solo-Gabriele HM, et al. The BEACHES Study: health effects and exposures from non-point source microbial contaminants in subtropical recreational marinewaters. Int J Epidemiol. 2010;39:1291–8.
18. 11. Tak S, Bernard BP, Driscoll RJ, et al. Floodwater exposure and the related health symptoms among firefighters in New Orleans, Louisiana 2005. Am J Ind Med. 2007;50:377–82.
19. 12. Epidemiological bulletin: flood response in Pakistan. 1(2); 2010. http://www.who.int/hac/crises/pak/sitreps/pakistan_epi_30august2010.pdf. Accessed 5 April 2015.
20. Diaz JH, Lopez FA. Skin, soft tissue and systemic bacterial infections following aquatic injuries and exposures. Am J Med Sci. 2015;349(3):269–75.
21. Hernandez AR, Fritz A, Mooney C. Washington Post. October 17, 2016. Spill risk for N.C. hog farm waste pits amid flooding. Also available at: https://www.washingtonpost.com/news/capital-weather-gang/wp/2016/10/16/factory-farming-practices-are-under-scrutiny-again-in-n-c-after-disastrous-hurricane-floods/?utm_term=.3b5c76691cb7
22. 13. Bennett JE, Dolin R, Blaser MJ, editors. Mandell, Douglas, and Bennett's principles and practice of infectious diseases. 8th ed. Philadelphia: Elsevier Saunders; 2015.
23. 14. 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 Morb Mortal Wkly Rep. 2005;54:961–4.
24. 15. Tappeiner G. Tuberculosis and infections with atypical mycobacteria. In: Wolff K, Goldsmith LA, Katz SI, Gilchrist B, Paller AS, Leffell DJ, editors. Fitzpatrick's dermatology in general medicine. 7th ed. New York: McGraw Hill; 2010.
25. 16. Lillis JV, Ansdell VE, Ruben K, et al. Sequelae of World War II: an outbreak of chronic cutaneous nontuberculous mycobacterial infection among Satowanese islanders. Clin Infect Dis. 2009;48:1541–6.
26. De la Torre C, Vega A, Carracedo A, et al. Identification of Mycobacterium marinum in sea-urchin granulomas. Br J Dermatol. 2001;145(1):114–6.
27. Lopez-Zabala I, Poggio-Cano D, Garcia-Elvira R, et al. Mycobacterium marinum osteomyelitis of the first metatarsal. Eur J Orthop Surg Traumatol. 2012;22 Suppl 1:225–8.
28. Walsh DS, Portaels F, Meyers WM. Buruli ulcer: Advances in understanding Mycobacterium ulcerans infection. Dermatol Clin. 2011;29(1):1–8.
29. Doig KD, Holt KE, Fyfe JA, et al. On the origin of Mycobacterium ulcerans, the causative agent of Buruli ulcer. BMC Genomics. 2012;13:258.
30. Fyfe JA, Lavender CJ, Handasyde KA, et al. A major role for mammals in the ecology of Mycobacterium ulcerans. PLoS Negl Trop Dis. 2010;4(8):e791.
31. Garchitorena A, Ngonghala CN, Texier G, et al. Environmental transmission of Mycobacterium ulcerans drives dynamics of Buruli ulcer in endemic regions of Cameroon. Sci Rep. 2015;5:18055.
32. Landier J, Constantin de Magny G, Garchitorena A, et al. Seasonal patterns of Buruli ulcer incidence, Central Africa, 2002–2012. Emerg Infect Dis. 2015;21(8):1414–7.

References

33. 21. Szaire V, Nackers F, Comte E, et al. *Mycobacterium ulcerans* infection: control, diagnosis, and treatment. *Lancet Infect Dis*. 2006;6:288–96.
34. 22. Williamson HR, Benbow ME, Nguyen KD, et al. Distribution of *Mycobacterium ulcerans* in buruli ulcer endemic and non-endemic aquatic sites in Ghana. *PLoS Negl Trop Dis*. 2008;2:e205.
35. 23. Suykerbuyk P, Wambacq J, Phanuz DM, et al. Persistence of *Mycobacterium ulcerans* disease (Buruli Ulcer) in the historical focus of Kasongo Territory, the Democratic Republic of Congo. *Am J Trop Med Hyg*. 2009;81:888–94.
36. 24. Veitch MG, Johnson PD, Flood PE, et al. A large localized outbreak of *Mycobacterium ulcerans* infection on a temperate southern Australian island. *Epidemiol Infect*. 1997;119:313–8.
37. 25. Carolan K, Ebong SM, Garchitorena A, et al. Ecological niche modeling of Hemipteran insects in Cameroon; the paradox of a vector-borne transmission for *Mycobacterium ulcerans*, the causative agent of Buruli ulcer. *Int J Health Geogr*. 2014;13:44.
38. 26. Wallace JR, Gordon MC, Hartsell L, et al. Interaction of *Mycobacterium ulcerans* with mosquito species: implications for transmission and trophic relationships. *Appl Environ Microbiol*. 2010;76:6215–22.
39. 17. Uckay I, Sax H, Harbarth S, et al. Multi-resistant infections in repatriated patients after natural disasters: lessons learned from the 2004 tsunami for hospital infection control. *J Hosp Infect*. 2008;68:1–8.
40. 18. Garzoni C, Emonet S, Legout L, et al. Atypical infections in tsunami survivors. *Emerg Infect Dis*. 2005;11:1591–3.
41. 19. Appelgren P, Farnebo F, Dotevall L, et al. Late-onset posttraumatic skin and soft-tissue infections caused by rapid-growing mycobacteria in tsunami survivors. *Clin Infect Dis*. 2008;47:e11–6.
42. 20. Petrini B, Farnebo F, Hedblad MA, et al. Concomitant late soft tissue infections by *Cladophialophora bantiana* and *Mycobacterium abscessus* following tsunami injuries. *Med Mycol*. 2006;44:189–92.
43. 27. Ashdown LR, Koehler JM. The spectrum of *Aeromonas*-associated diarrhea in tropical Queensland, Australia. *Southeast Asian J Trop Med Public Health*. 1993;24:347–53.
44. 28. Semel JD, Trenholme G. *Aeromonas hydrophila* water-associated traumatic wound infections: a review. *J Trauma*. 1990;30:324–7.
45. 29. Janda JM, Abbott SL. The genus *Aeromonas*: taxonomy, pathogenicity, and infection. *Clin Microbiol Rev*. 2010;23:35–73.
46. 30. Monaghan SF, Anjaria D, Mohr A, et al. Necrotizing fasciitis and sepsis caused by *Aeromonas hydrophila* after crush injury of the lower extremity. *Surg Infect (Larchmt)*. 2008;9:459–67.
47. 31. Hiransuthikul N, Tantisirawat W, Lertutsahakul K, et al. Skin and soft-tissue infections among tsunami survivors in southern Thailand. *Clin Infect Dis*. 2005;41:e93–6.
48. 32. Kespechara K, Koysombat T, Pakamol S, et al. Infecting organisms in victims from the tsunami disaster: experiences from Bangkok Phuket Hospital. Thailand. *Int J Disaster Med*. 2006;3:66–70.
49. 33. Presley SM, Rainwater TR, Austin GP, et al. Assessment of pathogens and toxicants in New Orleans, LA following Hurricane Katrina. *Environ Sci Technol*. 2006;40:468–74.
50. 34. Blaney D. Melioidosis. In: Heymann DL, editor. *Control of communicable diseases manual* [online version]. 20th ed. Washington, DC: American Public Health Association and Unbound Medicine, Inc; 2015.
51. 35. Ngaay V, Lemeshev Y, Sadkowski L, et al. Cutaneous melioidosis in a man who was taken as a prisoner of war by the Japanese during World War II. *J Clin Microbiol*. 2005;43:970–2.
52. Gibney KB, Cheng AC, Currie BJ. Cutaneous melioidosis in the tropical top end of Australia: a prospective study and review of the literature. *Clin Infect Dis*. 2008;47(5):603–9.
53. 36. Peacock SJ. Melioidosis. *Curr Opin Infect Dis*. 2006;19:421–8.
54. 37. Othman N, Ismail IH, Yip R, et al. Infections in post-tsunami victims. *Pediatr Infect Dis J*. 2007;26:960–1.
55. 38. Chierakul W, Winothai W, Wattanawaitunechai C, et al. Melioidosis in 6 tsunami survivors in southern Thailand. *Clin Infect Dis*. 2005;41:982–90.
56. 39. Athan E, Allworth AM, Engler C, et al. Melioidosis in tsunami survivors. *Emerg Infect Dis*. 2005;11:1638–9.
57. 40. Svensson E, Welinder-Olsson C, Claesson BA, et al. Cutaneous melioidosis in a Swedish tourist after the tsunami in 2004. *Scand J Infect Dis*. 2006;38:71–4.
58. 41. Nieminen T, Vaara M. *Burkholderia pseudomallei* infections in Finnish tourists injured by the December 2004 tsunami in Thailand. *Euro Surveill*. 2005;10(E050303):4.
59. 42. Ciervo A, Mattei R, Cassone A. Melioidosis in an Italian tourist injured by the tsunami in Thailand. *J Chemother*. 2006;18:443–4.
60. 43. Abgueguen P, Delbos V, Blanvillain J, et al. Clinical aspects and prognostic factors of leptospirosis in adults. Retrospective study in France. *J Infect*. 2008;57:171–8.
61. 44. Gochenour WS Jr, Smadel JE, Jackson EB, et al. Leptospiral etiology of Fort Bragg fever. *Public Health Rep*. 1952;67:811–3.
62. 45. Serratrice J, Ene´ N, de Roux-Serratrice C, et al. Icteric Fort Bragg fever: a case report with nosological discussion [in French]. *Rev Med Interne*. 2004;25:663–6.
63. Worth BD. *Fort Bragg Fever. Volume II: Infectious Disease. Internal Medicine in World War II Series.* US Army Medical Department, 1963.c
64. 46. Centers for Disease Control and Prevention (CDC). Leptospirosis after flooding of a university campus—Hawaii, 2004. *MMWR Morb Mortal Wkly Rep*. 2006;55:125–7.
65. 47. Phraisuwan P, Whitney EA, Tharmaphornpilas P, et al. Leptospirosis: skin wounds and control strategies, Thailand, 1999. *Emerg Infect Dis*. 2002;8:1455–9.
66. 48. National Disaster Coordinating Center, Department of Health, Republic of the Philippines. Final report on tropical storm ONDOY and typhoon PEPENG. <http://reliefweb.int/report/philippines/philippines-ndcc-update-final-report-tropical-stormondoy-and-typhoon-pepeng>. Accessed 12 April 2015.
68. 49. De A, Varaiya A, Mathur M, et al. An outbreak of leptospirosis in Mumbai. *Indian J Med Microbiol*. 2002;20:153–5.
69. 50. Fuortes L, Nettleman M. Leptospirosis: a consequence of the Iowa flood. *Iowa Med*. 1994;84:449–50.
70. 51. Vanasco NB, Schmeling MF, Lottersberger J, et al. Clinical characteristics and risk factors of human leptospirosis in Argentina (1999–2005). *Acta Trop*. 2008;107:255–8.
71. 52. Leal-Castellanos CB, Garcí’a-Sua´rez R, Gonza´lez-Figueroa E, et al. Risk factors and the prevalence of leptospirosis infection in a rural community of Chiapas. Mexico. *Epidemiol Infect*. 2003;131:1149–56.

References

72. 53. Mamlok RJ, Mamlok V, Mills GC, et al. Glucose-6-phosphate dehydrogenase deficiency, neutrophil dysfunction and *Chromobacterium violaceum* sepsis. *J Pediatr*. 1987;111:852–4.
73. 54. Ponte R, Jenkins SG. Fatal *Chromobacterium violaceum* infections associated with exposure to stagnant waters. *Pediatr Infect Dis J*. 1992;11:583.
74. 55. Lee J, Kim JS, Nahm CH, et al. Two cases of *Chromobacterium violaceum* infection after injury in a subtropical region. *J Clin Microbiol*. 1999;371:2068–70.
75. 55. Sirinavin S, Techasaensiri C, Benjaponpitak S, et al. Invasive *Chromobacterium violaceum* infection in children: case report and review. *Pediatr Infect Dis J*. 2005;24:559–61.
76. 56. Kumar M. *Chromobacterium violaceum*: A rare bacterium isolated from a wound over the scalp. *Int J Appl Basic Med Res*. 2012;2(1):70-2.
77. 57. Wiebels D. Chromomycosis: late sequela of the tsunami of 2004. *Dermatol Pract Concept*. 2008;14(1):8.
78. Troncoso A, Bava J. Images in clinical medicine: Chromoblastomycosis. *N Engl J Med*. 2009;361(22):2165.
79. 58. Murthy R, Swain JP. Concurrent mycetoma and chromomycosis. *Indian J Med Microbiol*. 2011;29(4):437-9.
80. 59. Wortman PD. Concurrent chromoblastomycosis caused by *Fonsecaea pedrosi* and actinomycetoma caused by *Nocardia brasiliensis*. *J Am Acad Dermatol*. 1995;32(2 Pt 2):390-2.
81. 60. Chaney S, Gopalan R, Berggren RE. Pulmonary *Pseudoallescheria boydii* infection with cutaneous zygomycosis after near drowning. *South Med J*. 2004;97:683–7.
82. 61. Verma SB, Nayak S, Pasale RK, et al. Late complication after tropic storm accident: subcutaneous and intracranial actinomycetoma. *Int Wound J*. 2008;5:655–9.
83. 62. Saccente M, Woods GL. Clinical and laboratory update on blastomycosis. *Clin Microbiol Rev*. 2010;23:367–81.
84. 63. Klein BS, Vergeront JM, DiSalvo AF, et al. Two outbreaks of blastomycosis along rivers in Wisconsin. Isolation of *Blastomyces dermatitidis* from riverbank soil and evidence of its transmission along waterways. *Am Rev Respir Dis*. 1987;136:1333–8.
85. 64. Szeder V, Ortega-Gutierrez S, Frank M, et al. CNS blastomycosis in a young man working in fields after Hurricane Katrina. *Neurology*. 2007;68:1746–7.
86. 65. Spellberg B, Edwards J Jr, Ibrahim A. Novel perspectives on mucormycosis: pathophysiology, presentation, and management. *Clin Microbiol Rev*. 2005;18:556–69.
87. 66. Cocanour CS, Miller-Crotchett P, Reed RL 2nd, et al. Mucormycosis in trauma patients. *J Trauma*. 1992;32:12–5.
88. 67. Patino JF, Castro D, Valencia A, et al. Necrotizing soft tissue lesions after a volcanic cataclysm. *World J Surg*. 1991;15:240–7.
89. 68. Andresen D, Donaldson A, Choo L, et al. Multifocal cutaneous mucormycosis complicating polymicrobial wound infections in a tsunami survivor from Sri Lanka. *Lancet*. 2005;365:876–8.
90. 69. Snell BJ, Tavakoli K. Necrotizing fasciitis caused by *Apophysomyces elegans* complicating soft-tissue and pelvic injuries in a tsunami survivor from Thailand. *Plast Reconstr Surg*. 2007;119:448–9.
91. 70. Centers for Disease Control (CDC). Outbreak of diarrheal illness associated with a natural disaster—Utah. *MMWR Morb Mortal Wkly Rep*. 1983;32:662–4.
92. 71. Wu XH, Zhang SQ, Xu XJ, et al. Effect of floods on the transmission of schistosomiasis in the Yangtze River valley. People's Republic of China. *Parasitol Int*. 2008;57:271–6.
93. 72. World Health Organization. Communicable disease situation update flood affected districts, Pakistan. 18 August 2010. <http://reliefweb.int/report/pakistan/communicable-disease-situationupdate-floodaffected-districts-pakistan-18-august>. Accessed 12 April 2015.
94. 73. Gauker ED, Covey DC, Emens-Hesslink KE, et al. A descriptive analysis of patient encounter data from the Fleet Hospital FIVE humanitarian relief mission in Haiti. *Mil Med*. 2000;165:337–45.
95. 74. Krajaejun T, Sathapatayavongs B, Prachartam R, et al. Clinical and epidemiological analyses of human pythiosis in Thailand. *Clin Infect Dis*. 2006;43:569–76.
96. 75. Caillouet KA, Carlson JC, Wesson D, et al. Colonization of abandoned swimming pools by larval mosquitoes and their predators following Hurricane Katrina. *J Vector Ecol*. 2008;33:166–72.
97. 76. Kondo H, Seo N, Yasuda T, et al. Post-flood-infectious diseases in Mozambique. *Prehosp Disaster Med*. 2002;17:126–33.
98. 77. Anyamba A, Small JL, Britch SC, et al. Recent weather extremes and impacts on agricultural production and vector-borne disease outbreak patterns. *PLoS One*. 2014;9(3):e92538.
99. 78. Chretien JP, Anyamba A, Small J, et al. Global climate anomalies and potential infectious disease risks: 2014-2015. *PLoS Curr*. 2015;7. pii:ecurrents.outbreaks.95fbc4a8fb4695e049baabfc2fc8289f
100. 79. Medlock JM, Vaux AG. Impacts of the creation, expansion and management of English wetlands on mosquito presence and abundance – developing strategies for future disease mitigation. *Parasit Vectors*. 2015;8:142.
101. 80. Thomas EA, John M, Kanish B. Mucocutaneous manifestations of Dengue fever. *Indian J Dermatol*. 2010;55:79–85.
102. 81. Inamadar AC, Palit A, Sampagavi VV, et al. Cutaneous manifestations of chikungunya fever: observations made during a recent outbreak in south India. *Int J Dermatol*. 2008;47:154–9.
103. 82. Bandyopadhyay D, Ghosh SK. Mucocutaneous manifestations of Chikungunya fever. *Indian J Dermatol*. 2010;55:64–7.
104. Kutsuna S, Kato Y, Takasaki T, et al. Two cases of Zika fever imported from French Polynesia to Japan, Dec 2013 to Jan 2014. *Euro Surveill*. 2014;19(4) pii:20683.
105. Stamm LV. Zika virus in the Americas: An obscure arbovirus comes calling. *JAMA Dermatol*. 2016;152(6):621–2.
106. Chen L, Hafeez F, Curry CL, et al. Cutaneous eruption in a US woman with locally acquired Zika virus infection. *N Engl J Med*. 2017;376(4):400–1.

References

107. Derrington SM, Cellura AP, McDermott LE, et al. . Mucocutaneous findings and course in an adult with Zika virus infection. *JAMA Dermatol.* 2016;152(6):691-3.
108. Brasil P, Pereira JP Jr, Raja Gabaglia C, et al. Zika virus infection in pregnant women in Rio de Janeiro. *N Engl J Med.* 2016;375(24):2321-34.
109. Honein MA, Dawson AL, Petersen EE, et al. Birth defects among fetuses and infants of US women with evidence of possible Zika virus infection during pregnancy. *JAMA.* 2017;317(1):59-68.
110. Muller WJ, Miller ES. Preliminary results from the US Zika pregnancy registry: untangling risks for congenital anomalies. *JAMA.* 2017;317(1):35-36.
111. 83. Wenzel FG, Horn TD. Nonneoplastic disorders of the eccrine glands. *J Am Acad Dermatol.* 1998;38:1–17.
112. 84. Adnot J, Lewis CW. Immersion foot syndromes. In: James WD (ed). *Military dermatology.* Department of the Army, Office of the Surgeon General, Borden Institute; 1994.
113. 85. Cox R, Amundson T, Brackin B. Evaluation of the patterns of potentially toxic exposures in Mississippi following Hurricane Katrina. *Clin Toxicol (Phila).* 2008;46:722–7.
114. 86. Environmental Protection Agency. Murphy oil spill. <http://www.epa.gov/katrina/testresults/murphy/>. Accessed 4 April 2015.
115. 87. Ma B, Wei W, Xia ZF, et al. Mass chemical burn casualty: emergency management of 118 patients with alkali burn during a Matsa typhoon attack in Shanghai, China in 2005. *Burns.* 2007;33:565–71.
116. 88. Palao R, Monge I, Ruiz M, et al. Chemical burns: pathophysiology and treatment. *Burns.* 2010;36:295–304.
117. Shaw CM, Brodie J, Mueller JF. Phytotoxicity induced in isolated zooxanthellae by herbicides extracted from Great Barrier Reef flood waters. *Mar Pollut Bull.* 2012;65(4-9):355-62.
118. 2. Campbell C, Bahrami S, Owen C. Anagen effluvium caused by thallium poisoning. *JAMA Dermatol.* 2016;152(6):724-726.
119. 89. Brennan RJ, Rimba K. Rapid health assessment in Aceh Jaya District, Indonesia, following the December 26 tsunami. *Emerg Med Australas.* 2005;17:341–50.
120. 90. Sullivent EE 3rd, West CA, Noe RS, et al. Nonfatal injuries following Hurricane Katrina-New Orleans, Louisiana, 2005. *J Safety Res.* 2006;37:213–7.
121. 91. Robinson DC, Adriaans B, Hay RJ, Yesudian P. The clinical and epidemiologic features of tropical ulcer
122. 92. Lammers RL. Principals of wound management. In: Roberts JR, Hedges JR, editors. *Clinical procedures in emergency medicine.* 5th ed. Philadelphia: Saunders Elsevier; 2010.
123. 93. Haury B, Rodeheaver G, Vensko J, et al. Debridement: an essential component of traumatic wound care. *Am J Surg.* 1978;135:238–42.
124. 94. Hollander JE, Singer AJ. Laceration management. *Ann Emerg Med.* 1999;34:356–67.
125. 95. Berk WA, Osbourne DD, Taylor DD. Evaluation of the "golden period" for wound repair: 204 cases from a Third World emergency department. *Ann Emerg Med.* 1988;17:496–500.
126. 96. Prasarithra T, Tungsiripat R, Warachit P. The revisit of 2004 tsunami in Thailand: characteristics of wounds. *Int Wound J.* 2008;5:8–19.
127. 97. Waldrop RD, Prejean C, Singleton R. Overuse of parental antibiotics for wound care in an urban emergency department. *Am J Emerg Med.* 1998;16:343–5.
128. 98. Centers for Disease Control. (CDC). Deaths associated with Hurricane Hugo-Puerto Rico. *MMWR Morb Mortal Wkly Rep.* 1989;38:680–2.
129. 99. Centers for Disease Control. (CDC). Update: work-related electrocutions associated with Hurricane Hugo-Puerto Rico. *MMWR Morb Mortal Wkly Rep.* 1989;38(718–20):725.
130. 100. Centers for Disease Control and Prevention. (CDC). Medical examiner/coroner reports of deaths associated with Hurricane Hugo-South Carolina. *MMWR Morb Mortal Wkly Rep.* 1989;38(754):759–62.
131. 101. Zafren K, Durrer B, Herry JP, et al. Lightning injuries: prevention and on-site treatment in mountains and remote areas. Official guidelines of the International Commission for Mountain Emergency Medicine and the Medical Commission of the International Mountaineering and Climbing Federation (ICAR and UIAA MEDCOM). *Resuscitation.* 2005;65:369–72.
132. 102. Ritenour AE, Morton MJ, McManus JG, et al. Lightning injury: a review. *Burns.* 2008;34:585–94.
133. 103. Resnik BI, Wetli CV. Lichtenberg figures. *Am J Forensic Med Pathol.* 1996;17:99–102.
134. 104. Maghsoudi H, Adyani Y, Ahmadian N. Electrical and lightning injuries. *J Burn Care Res.* 2007;28:255–61.
135. 105. Warner GS. Increased incidence of domestic animal bites following a disaster due to natural hazards. *Prehosp Disaster Med.* 2010;25:188–90.
136. 106. Diaz JH. The impact of hurricanes and flooding disasters on hymenopterid-inflicted injuries. *Am J Disaster Med.* 2007;2:257–69.
137. 107. Brewer RD, Morris PD, Cole TB. Hurricane-related emergency department visits in an inland area: an analysis of the public health impact of Hurricane Hugo in North Carolina. *Ann Emerg Med.* 1994;23:731–6.
138. 108. Noe R, Cohen AL, Lederman E, et al. Skin disorders among construction workers following Hurricane Katrina and Hurricane Rita: an outbreak investigation in New Orleans, Louisiana. *Arch Dermatol.* 2007;143:1393–8.
139. 109. Steen CJ, Carbonaro PA, Schwartz RA. Arthropods in dermatology. *J Am Acad Dermatol.* 2004;50:819–42 (quiz 842–4).
140. 110. Fernandez G, Morales E, Beutelspacher C, et al. Epidemic dermatitis due to contact with a moth in Cozumel, Mexico. *Am J Trop Med Hyg.* 1992;46:560–3.
141. 111. Morsy TA, Arafa MA, Younis TA, et al. Studies on *Paederus alfieri* Koch (Coleoptera:Staphylinidae) with special reference to the medical importance. *J Egypt Soc Parasitol.* 1996;26:337–51.
142. 112. Claborn DM, Polo JM, Olson PE, et al. Staphylinid (rove) beetle dermatitis outbreak in the American southwest? *Mil Med.* 1999;164:209–13.
143. 113. Maegele M, Gregor S, Steinhäusen 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;33:1136–40.
144. 114. Gupta MA, Gupta AK. Psychodermatology: an update. *J Am Acad Dermatol.* 1996;34:1030–46.
145. 115. Brown GE, Malakouti M, Sorenson E, et al. Psychodermatology. *Adv Psychosom Med.* 2015;34:123–34.

Thank you!

