CHAPTER 12

CLIMATE CHANGE AND DISASTER MEDICINE

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1. Introduction

The ideal temperature for the continuation of life in the world is provided by the absorption of the rays reflected from the earth's surface by greenhouse gases naturally found in the atmosphere such as carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). This effect is called the greenhouse effect. The increase in greenhouse gases causes more heat to be absorbed and consequently more warming of the earth. As a result of anthropogenic (human-induced) activities such as industrialization and the use of fossil fuels, the increase in greenhouse gases, especially CO_2, enhances the "greenhouse effect" and leads to global warming and climate change (1).

"Climate change "refers to the change observed in climatic characteristics such as precipitation, temperature, wind, and climate norms over a long period of time (2). According to the World Health Organization (WHO), climate change is "a statistically significant variation in the average state or variability of climate that lasts for a long time (typically decades or more) (3). The United Nations Framework Convention on Climate Change (UNFCCC) on the other hand, defines it as climate change that alters the composition of the global

atmosphere in addition to natural variability and is observed across comparable time periods, directly or indirectly attributed to human activities (4).

Having short, medium, and long term effects and unknown consequences on the ecosystem, the impact of climate change varies from local to the global scale. The effects of the precipitation regime and the increase in temperatures cause drought in some parts of the world and floods in coastal ocean regions (5). Although global warming brings some local benefits, such as decrease in the number of deaths due to cold in winter in the temperate climate zone and an increase in food production in certain regions, the changing climate has many negative effects on overall health (6). As a matter of fact, it causes insufficiency in many social and environmental determinants of health such as clean air and drinking water, adequate food, and safe shelter. More importantly, climate change poses a serious threat to humanity by causing many natural disasters as a result of extreme temperatures and changes in the precipitation regime (3). Disasters become more severe and frequent with climate change draws attention to the role of medical discipline in disaster management and increases the importance of disaster medicine (7).

2. Climate change

Factors that can cause climate change vary. It is possible to divide these factors into two main categories as natural processes and human-induced factors. Natural processes that lead to climate change include the hydrological cycle between the atmosphere, ocean, and land, the intensity of solar radiation reaching the earth, the earth's magnetic axis tilt, and the ongoing slow change in its orbit. Human-induced factors can be listed as human activities that change the composition of the atmosphere (use of fossil fuels, etc.) and the land surface (deforestation, etc.). The geological records contain evidence related to large-scale climate changes in the past due to natural processes (1). However, detailed analysis shows that more than 90% of climate change, the impact of which is rapidly evident today, is caused by global warming due to the increase in greenhouse gas emissions produced as a result of human activities such as forest destruction and burning of fossil fuels (8).

Global warming is the increase in the average temperature of the troposphere, the atmospheric layer closest to the earth's surface, at a level that can cause changes in global climate models. Global warming started in the late 19th century with the industrial revolution. After this period, the excessive use

of fossil fuels increased the concentration of CO_2 in the atmosphere by more than 40%, and more than half of this increase occurred after 1970 (9). According to the 2019 Global Climate Summary of the National Oceanic and Atmospheric Administration (NOAA), land and ocean temperatures have increased by an average of 0.07 ° C (0.13 ° F) per decade since 1880; and after 1981, the said average temperature increase was 0.18 ° C (0.32 ° F) (10,11).

The rise in the average temperature of the atmosphere and oceans causes the arctic glaciers to melt, the snow cover to decrease, the sea level to rise, the heat waves to become more frequent, and change of precipitation regimes (12). In this process where climate characteristics are directly affected, the occurrence frequency and severity of climate-related natural disasters are also affected (13). According to the United Nations Office for Disaster and Risk Reduction (UNDRR) report (2020), climate-related natural disasters such as heatwaves, droughts, storms, and floods have increased in numbers and caused more loss of life and property damage in the last 20 years (14).

3. Disaster Medicine

Disaster medicine is a discipline that originates from military medicine. Today, there is no internationally accepted definition of disaster medicine. However, disaster medicine is considered as a medical discipline that handles and manages situations where sudden emerging medical needs arise and the resources required to meet these needs are limited (15). Disaster medicine mainly focuses on the effects of natural or man-made disasters that endanger human life, resulting in injury or death (16). In addition, disaster medicine includes situations defined as major incident, when sufficient resources are available to solve the existing crisis, but it is difficult to deliver these resources to the right place at the right time. The main objective of disaster medicine in both disasters and major incident cases is to provide the necessary medical intervention, to minimize deaths, and to reduce the risk of both long and short term complications (7).

Disasters cause various injuries and diseases depending on the type of incident. Earthquakes lead to crush syndrome as a result of being stuck under collapsed buildings; storms result in penetrating trauma due to flying debris; outbreaks, whether natural or deliberate, can bring about different types of bacteria, viruses, and fungal diseases. While many diseases affect a certain age group and individuals with various risk factors, disasters can affect all members of society. Due to the potential variability in disaster scenarios, disaster medicine

specialists should be trained in the many patterns of injuries and diseases that can be seen in victims (17-19).

Disaster medicine defines the roles of health professionals in the general disaster preparedness and response system, in addition to making the medical role in disasters a specialty. Care responsibility for those injured in a disaster has historically been undertaken by emergency healthcare providers (20,21). The unpredictable nature of disasters obliges everyone working in emergency healthcare field to have the necessary knowledge about disaster medicine and the basics of disaster management. On the other hand, in crisis situations, healthcare professionals may be required to perform tasks that are outside of routine work, including the mass casualty triage, and the health management of special communities such as refugees and people affected by disasters. For this reason, disaster medicine is very important for all healthcare professionals in terms of providing the necessary knowledge, skills, and attitude to ensure adequate response in disaster situations (22).

4. Disasters Associated with Climate Change from the Disaster Medicine Perspective

4.1. Heathwaves

According to the World Meteorological Organization, when the daily highest temperature is 5°C (9°F) higher or more than the average highest temperature of that region for five consecutive days or further, it is called heatwave (23). In many parts of the world, there has been a rise in the frequency and intensity of heatwaves as climate change results in an increase in the global average temperature. The continent of Europe was affected by a severe heatwave during the summer of 2003. A total of more than 80,000 additional deaths were recorded in twelve European countries in 2003, due to extreme temperatures compared to 1998-2002 according to the report by Robine et al (24). Seven years later, in Russia a heatwave occurred causing 55,000 deaths and approximately 15 billion dollars in economic losses (25). From the heatwave in 2003, which seriously affected Europe, a total of 25 heatwaves occurred in different European countries, and 22 in Asian countries until 2020, and a total of 12,834 (Asia: 5804, Europe: 7030) people died due to heatwaves (26,27).

Heatwaves have many direct and indirect negative effects on human health. Exposure to heatwaves causes an increase in body temperature with

the influence of ambient temperature and metabolism. An increase in blood temperature of less than 1°C activates the peripheral and hypothalamic heat receptors and consequently, the hypothalamic thermoregulation center is stimulated. The stimulated center initiates two basic responses to lower the high temperature: sympathetic cutaneous vasodilation and sweating (28). Despite the body's response, the high heat input from the environment and body metabolism compared to the heat released from the skin by radiation, evaporation and convection causes the thermoregulation mechanism to be insufficient and, consequently, to develop temperature-related diseases. These illnesses range from minor syndromes, including heat edema and heat cramps, to heatstroke, a life-threatening emergency (Table 1) (17-20,29).

Among the pathophysiological mechanisms of heat effect on the human body are dehydration, increase in blood viscosity, and deterioration in endothelial function. In addition, in the case of exposure to high temperatures, the cardiovascular system needs to do more to ensure thermoregulation. Therefore, heat waves increase the risk of thrombo-embolic diseases and cerebrovascular events; can cause chronic lung, heart, and kidney diseases to worsen (30). The elderly, babies and those with psychiatric disorders are at more risk of being affected by heat waves (31).

Heatwaves occur more slowly and over a larger area than typhoons, heavy rains, heavy snowfalls, and strong winds. While the damage caused by other natural disasters is mostly caused by external physical forces such as floods and collapses, in heat waves, health problems are mainly caused by exposure to high temperatures. Therefore, the damage caused by heat waves is also significantly affected by the health status of individuals, their housing and working conditions (32). As a result, it seems easier to take effective measures to be protected from heatwaves compared to other disasters. Disaster medicine specialists have important roles in both the training of healthcare professionals on the subject and the planning of preparations for protecting public health (33).

4.2. Drought

Drought is characterized by a shortage of water resources as a result of below average rainfall in a particular region over a long period of time (34). Climate change accelerates natural hydrological processes and causes droughts to become more intense. This situation has inevitable consequences such as the increase of forest fires, the nutritional status of the society, and a decrease in

food and water reserves (6). The latest data from EMDAT shows that more than 28 million people worldwide were affected by drought in 2019 (26).

Table 1. Disasters related to climate change and the health problems they cause

Climate related disasters	Public health effects	Diseases / Health problems
Heat waves	• Exposure to high ambient temperature • Insufficient thermoregulation mechanism	• Heat stroke • Temperature rash • Temperature edema • Temperature syncope • Heat cramps • Heat exhaustion • Kidney and heart disease
Drought	• Water and nutrient deficiencies • Poor quality of drinking water	• Increase in waterborne diseases • Increase in vectorial diseases • Food-borne diseases
	• Decrease in the amount and quality of food produced • Inadequate hygiene / sanitation due to reduction in water	• Malnutrition • Dehydration • Increase in zoonotic and vectorial diseases • Increase in water and food-borne diseases
	• Increase in the amount of dust suspended in the air due to the drying of the soil • Decrease in humidity in the air	• Respiratory diseases (allergic rhinitis and asthma) • Acute respiratory infections (bronchitis, sinusitis and pneumonia) • Fungal diseases (mycoses) • Allergic reactions
	• Change in the life cycle of vectors • Expansion of the breeding grounds of pathogens	• Poisoning • Increase in antibiotic resistance • Increase in infections
	• Drought related financial problems • Drought-induced forced migration	• Stress / mental health problems • Behavioral changes such as aggression and suicide
Storms	• Destruction of residential areas • Failure of medical equipment due to power outages, heating and feeding problems • Taking shelter in crowded groups	• Blunt, penetrating and cutting traumas, • Bone fractures • Sprain / strain • Increase in infectious diseases • Poisoning

Floods	• Exposure to floodwater • Exposure to chemical agents and biotoxins • Drinking water contamination • Mold and bacteria proliferation in affected structures • Failure of medical equipment due to power outage, heating and feeding problems • Taking shelter in crowded groups	• Trauma and injuries • Infectious diseases transmitted by water and food • Hypothermia • Exacerbation of chronic diseases • Poisoning • Mental health issues • Respiratory diseases • Allergic diseases • Increase in infectious diseases • Insect bites

The reasons such as the fact that the dates when drought starts and ends cannot be determined clearly and its effects tend to accumulate over time, making it difficult to determine the effects of drought on human health. However, drought affects human health by causing nutrient deficiency, airborne and vector-borne diseases, water and dust-related diseases, and mental health problems (35).

The most obvious effect of drought on human health is that it causes nutrient deficiency and results in death and disability (36,37). This effect is often indirect and complex. The drought disrupts the ecosystem balance, reducing both crops and animal sourced food production (38). Indeed, food production is highly dependent on water. While at least one liter of water is required to produce a one-calorie vegetable food, the production of one-calorie meat or dairy product requires ten liters of water (39). Therefore, drought poses a serious danger to adequate drinking water and food production. This can lead to a decrease in the amount and quality of consumable food and, consequently, to a vulnerability to diseases, increasing the risk of death (35).

Severe drought can adversely affect air quality. During a drought, there is an increased risk for forest fires and dust storms (40). Particles suspended in the air and dust storms after forest fires can irritate the bronchial passages and lungs. This situation can lead to worsening of chronic respiratory diseases and may also cause respiratory infections such as bronchitis and pneumonia (41).

The level decrease in water resources during droughts, the stagnation of watercourses such as streams, rivers, and cascades, which increase the salinity of freshwater resources; has an effect that enables the pollution of ground and surface waters (42). In addition to the water stagnation due to drought, temperature higher than normal, causes the proliferation of harmful algae and toxin-producing bacteria, and a decrease in dissolved oxygen concentration

(43). This situation leads to negative consequences on human health in terms of both insufficiency and decrease in quality of drinking water and increase of water-borne diseases (42,43).

Insufficiency of water resources during a drought means that more users benefit from the same resource. The use of the same resources by animals and humans increases the risk of communicable infectious diseases. In addition, due to the lack of sufficient water to ensure personal hygiene and the high concentration of infectious agents, toxic, chemical and pollutants in the water, various water-borne diseases can be encountered frequently during drought periods (35).

Drying of the soil due to drought increases the amount of dust suspended in the air. The increase in the amount of dust in the inhaled air can damage the respiratory tract through two mechanisms and cause "dust pneumonia". These mechanisms are direct trauma from pathogen transport and inhaled particles. Thousands of people lost their lives due to dust pneumonia in severe dust storms caused by drought in the United States from 1930 to 1936 (44).

Climate is one of many variables that affect the frequency of vector-borne diseases. Drought leads to changes in the life cycle of vectors in various aspects such as life span, population number, behavior, distribution, and vector pathogen interactions (45). Chase and Knight, for example, found that drought reduced mosquito hunters and competitors, leading to an increase in mosquito outbreaks (46). In addition, it has been reported that there is an increase in fever, malaria, St Louis encephalitis, Schistosomiasis, Rift Valley fever virus, Japanese encephalitis, Chikungunya, West Nile virus infection, and tick-borne diseases in connection with drought. In addition, the incidence of fungal diseases such as coccidioidomycosis, whose spores are aerosolized under drought conditions, may increase (35). Drought also has many important negative effects on mental health. The main psychosocial effects of droughts include reduced quality of life, significant lifestyle changes, depression, anxiety, and post-traumatic stress disorder (47).

4.3. Storms (Cyclones)

Climate change affects storms in two ways: frequency and strength. Decrease in difference between earth surface temperature and atmospheric temperature caused by global warming has a reducing effect on storms' frequency. However, the increase in ocean surface temperature makes storms more powerful and

destructive in terms of both wind speed and precipitation intensity because storms draw energy from ocean surface waters. So it means that the more heat energy stored in ocean surface waters, the greater the energy source for storms (48,49).

In the acute phase and due to their devastating effects, storms pose a serious threat to human health (50). Storms' most severe acute effect is death due to drowning, electric shock, or physical trauma (51). Storms can also cause a range of non-fatal injuries, including blunt traumas, penetrating injuries, lacerations, sprains, injuries, motor vehicle accidents, and animal bites (52-54).

Local or regional power outages may occur after storms as a result of strong winds toppling electric poles, wire breakage, or flood disasters caused by storms damage electricity infrastructure. Widespread power outages pose a serious threat to the living conditions of patients dependent on medical equipment such as mechanical ventilators and dialysis devices (55,56). In addition, improper use of portable generators, cooking appliances, and equipment operating with various fuels in confined spaces due to power outages can result in carbon monoxide (CO) poisoning (57). Strong storm winds can also cause water accumulation along the coastal line and increase of the water level, and then coastal flooding resulting in severe damage and deaths due to the impact of large waves (58).

4.4. Floods

Floods causing great social and economic damage are among the most common natural disasters in the world (59). Atmospheric warming and related hydrological changes; Excessive precipitation, increased rainfall volume, coastal flooding, and melting of glaciers lead to an increase in flood disasters that severely damage human life and living space (59,60). The frequency of floods due to climate change may differ in different parts of the world depending on local climate and basin characteristics (61). Floods have many important effects on health, ranging from suffocation and injuries in the short term to infectious diseases and mental health problems in the long term (62). Drowning is the greatest risk of death from flooding. Also, debris moving along with floodwaters can cause blunt trauma. Injuries in such cases are similar to bullet injuries and are usually in the form of extremity fractures, cuts, and severe bruises. Depending on the scale of the flood and the availability of rescue personnel, people may spend hours or days in harsh weather. In this process, hypothermia may occur if the ambient temperature drops below 15 ° C (63,64).

Stagnant water and sediment remaining in flooded areas constitute a breeding ground and are a serious source of endotoxins for a variety of microorganisms, including airborne and respirable fungi and bacteria. Exposure to these microorganisms and endotoxins can increase the incidence of mycotic infections, respiratory tract, and allergic diseases by affecting particularly sensitive individuals (65). Flood disasters affecting industrial and agricultural areas pose a threat of poisoning with various chemicals for the inhabitants of the region (66).

After floods, an increase in food and waterborne infectious diseases can ocur (67). This danger is generally the result of sewage leaks mixing into the drinking water network due to infrastructure damage. Exposure to contaminated floodwater can lead to conjunctivitis, skin and ear, nose and throat infections. Stagnant puddles formed after floods become an ideal breeding ground for mosquitoes. The growth of the mosquito population in these areas is the cause of an increase in mosquito-borne vectorial diseases such as Zika virus, dengue fever, West Nile virus, chikungunya virus, and malaria (68).

The evacuation of local residents after floods can disrupt healthcare services and lead to the worsening of chronic diseases. In addition, living together in shelters poses a serious risk for infectious diseases to spread. People who are not injured during the flood can be injured by being traumatized during evacuation. Finally, as in other natural disasters, the worsening of mental problems and developing mental health problems such as post-traumatic stress disorder may happen after floods (50).

5. Conclusion

The effects of climate change on natural living conditions are increasingly felt. As the global surface temperature increases, more heatwaves emerge, and the danger of drought becomes greater. The rise in oceans temperature causes stronger storms, and the increase in the amount of evaporating water causes excessive rainfall and floods. As a result, climate change increments the frequency and severity of climate-related disasters. This situation makes it inevitable that healthcare workers will encounter more and more health problems related to climate change and disasters, which they rarely encounter in daily practice and do not receive adequate training. Health workers, especially emergency response teams, should have sufficient training on the basic principles of disaster medicine

expertise in order to manage health problems associated with climate change and disasters whose frequency increases with climate change. In addition, it is very important that disaster medicine expertise is involved in all stages of disaster management in order to anticipate health problems that may develop due to disasters and to make the necessary preparation. This understanding is important in order to respond to disasters in a global sense in coordination.

References

1. Sivaramanan S. Global warming and climate change causes, impacts and mitigation. Central Environmental Authority 2015;2-4.
2. Climate Change. Western Geographic Science Center Web site. https://www.usgs.gov/centers/wgsc/science/climate-change. Accessed January 1, 2021
3. Climate change and health. World Health Organization Web site. https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health. Accessed January 1, 2021
4. United Nations. United Nations Framework Convention on Climate Change. https://unfccc.int/resource/docs/convkp/conveng.pdf. Accessed January 11, 2021
5. McCann DG, Moore A, Walker M-E. The water/health nexus in disaster medicine: I. Drought versus flood. *Current Opinion in Environmental Sustainability*. 2011;3(6):480-5.
6. Bell JE, Brown CL, Conlon K, Herring S, Kunkel KE, Lawrimore J, et al. Changes in extreme events and the potential impacts on human health. *Journal of the Air & Waste Management Association*. 2018;68(4):265-87.
7. Al-Jazairi AF. Disasters and disaster medicine. *Essentials of Accident and Emergency Medicine*. 2017:93-118.
8. America's Climate Choices. Panel on Advancing the Science of Climate Change; National Research Council 2010. Advancing the Science of Climate Change. Washington, D.C. The National Academies Press 2010.
9. IPCC AR5 Working Group I Highlights. Center for Climate and Energy Solutions Web site. https://www.c2es.org/content/ipcc-ar5-working-group-i-highlights/. Accessed January 11, 2021
10. National Centers For Environmental Information. Global Climate Report - Annual 2019. https://www.ncdc.noaa.gov/sotc/global/201913. Accessed January 15, 2021

11. Annual anomalies in global land surface temperature from 1880 to 2020, based on temperature departure (in degrees Celsius)*. Statista Web site. https://www.statista.com/statistics/1048518/average-land-sea-temperature-anomaly-since-1850/. Accessed January 15, 2021
12. Global Climate Report - Annual 2019. National Centers for Environmental Information Web site. https://www.ncdc.noaa.gov/sotc/global/201913. Accessed January 15, 2021
13. Van Aalst MK. The impacts of climate change on the risk of natural disasters. *Disasters* 2006;30(1):5-18.
14. 'Staggering' rise in climate emergencies in last 20 years, new disaster research shows. UN News Web site. https://news.un.org/en/story/2020/10/1075142. Accessed January 18, 2021
15. Walsh L, Subbarao I, Gebbie K, Schor KW, Lyznicki J, Strauss-Riggs K, et al. Core competencies for disaster medicine and public health. *Disaster Med Public Health Prep*. 2012;6(1):44-52.
16. Peleg K. Disaster and emergency medicine–a conceptual introduction. *Frontiers in Public Health* 2013;1:44. doi: 10.3389/fpubh.2013.00044
17. Ciottone GR. Introduction to disaster medicine. Ciottone's Disaster Medicine. Philadelphia, PA, USA: Elsevier; 2016:2-5
18. Grubenhoff JA, du Ford K, Roosevelt GE. Heat-related illness. *Clinical Pediatric Emergency Medicine*. 2007;8(1):59-64.
19. Grigoletto JC, Cabral AR, Bonfim CV, Rohlfs DB, Silva EL, Queiroz FBd, et al. Management of health sector actions in drought situations. *Ciência & Saúde Coletiva*. 2016;21:709-18.
20. Nufer KE, Wilson-Ramirez G, Crandall CS. Different medical needs between hurricane and flood victims. *Wilderness & Environmental Medicine*. 2003;14(2):89-93.
21. Burkle Jr FM. Disaster management, disaster medicine and emergency medicine. *Emergency medicine.* 2001;13(2):143.
22. De Boer J. The future of disaster medicine. *International Journal of Disaster Medicine*. 2005;3(1-4):71-3.
23. Extreme heat/heat wave. International Federation of Red Cross and Red Crescent Societies (IFRC) Web site. https://media.ifrc.org/ifrc/messages-disaster-prevention/heatwave/. Accessed January 20, 2021

24. Robine J-M, Cheung SL, Le Roy S, Van Oyen H, Herrmann FR. Report on excess mortality in Europe during summer 2003. EU Community Action Programme for Public Health, Grant Agreement. 2007;2005114:28.
25. Barriopedro D, Fischer EM, Luterbacher J, Trigo RM, García-Herrera R. The hot summer of 2010: redrawing the temperature record map of Europe. *Science*. 2011;332(6026):220-4.
26. EM-DAT The International Disaster Database. https://public.emdat.be/data. Accessed January 6, 2020.
27. Organization WH. Preventing harmful health effects of heat-waves. World Health Organization (WHO); 2006.
28. McGregor GR, Bessmoulin P, Ebi K, Menne B. Heatwaves and health: guidance on warning-system development: WMOP; 2015.
29. Zacharias S, Koppe C, Mücke H-G. Climate change effects on heat waves and future heat wave-associated IHD mortality in Germany. *Climate*. 2015;3(1):100-17.
30. Weir E. Heat wave: first, protect the vulnerable. *Cmaj*. 2002;167(2):169-.
31. Kim DW, Kwon C, Kim J, Lee JS. Characteristics of Heat Waves From a Disaster Perspective. *J Prev Med Public Health*. 2020;53(1):26-8.
32. Kovats RS, Kristie LE. Heatwaves and public health in Europe. *Eur J Public Health*. 2006;16(6):592–599
33. Matthies F, Menne B. Prevention and management of health hazards related to heatwaves. International Journal of Circumpolar *Health,* 2009;68(1): 8-12.
34. McCann DG, Moore A, Walker M-E. The water/health nexus in disaster medicine: I. Drought versus flood. *Current Opinion in Environmental Sustainability*. 2011;3(6):480-5.
35. Stanke C, Kerac M, Prudhomme C, Medlock J, Murray V. Health effects of drought: a systematic review of the evidence. PLoS currents. 2013;5.
36. Delbiso TD, Altare C, Rodriguez-Llanes JM, Doocy S, Guha-Sapir D. Drought and child mortality: a meta-analysis of small-scale surveys from Ethiopia. *Scientific reports*. 2017;7(1):1-8.
37. Yusa A, Berry P, J Cheng J, Ogden N, Bonsal B, Stewart R, et al. Climate change, drought and human health in Canada. *International Journal of Environmental Research and Public Health.* 2015;12(7):8359-412.

38. Cheeseman J. Food security in the face of salinity, drought, climate change, and population growth. *Halophytes for Food Security in Dry Lands*. 2016. p. 111-23.
39. Wahlquist AK. Water and its role in food and health security-the importance of water to food production. *Asia Pacific Journal of Clinical Nutrition.* 2009;18(4):501.
40. Wang W, Peng C, Kneeshaw DD, Larocque GR, Luo Z. Drought-induced tree mortality: ecological consequences, causes, and modeling. *Environmental Reviews*. 2012;20(2):109-121.
41. Kalis MA, Miller MD, Wilson RJ. Public health and drought. *J Environ Health*. 2009;72(1):10-1.
42. Mosley LM. Drought impacts on the water quality of freshwater systems; review and integration. *Earth-Science Reviews*. 2015;140:203-14.
43. Chapra SC, Boehlert B, Fant C, Bierman Jr VJ, Henderson J, Mills D, et al. Climate change impacts on harmful algal blooms in US freshwaters: a screening-level assessment. *Environmental Science & Technology*. 2017;51(16):8933-43.
44. Schubert SD, Suarez MJ, Pegion PJ, Koster RD, Bacmeister JT. On the cause of the 1930s Dust Bowl. *Science*. 2004;303(5665):1855-9.
45. Brown L, Medlock J, Murray V. Impact of drought on vector-borne diseases–how does one manage the risk? *Public Health*. 2014;128(1):29-37.
46. Chase JM, Knight TM. Drought-induced mosquito outbreaks in wetlands. *Ecology Letters* 2003;6(11):1017-1024.
47. Petkova EP, Celovsky AS, Tsai W-Y, Eisenman DP. Mental Health Impacts of Droughts: Lessons for the US from Australia. Climate Change Adaptation in North America: Springer; 2017. p. 289-304.
48. Emanuel K. A statistical analysis of tropical cyclone intensity. *Monthly Weather Review*. 2000;128(4):1139-52.
49. Wing AA, Sobel AH, Camargo SJ. Relationship between the potential and actual intensities of tropical cyclones on interannual time scales. *Geophysical Research Letters*. 2007;34(8).
50. Lane K, Charles-Guzman K, Wheeler K, Abid Z, Graber N, Matte T. Health effects of coastal storms and flooding in urban areas: a review and vulnerability assessment. *Journal of Environmental and Public Health*. 2013;2013.

51. Diakakis M, Deligiannakis G, Katsetsiadou K, Lekkas E. Hurricane Sandy mortality in the Caribbean and continental North America. *Disaster Prevention and Management: An International Journal*. 2015;24(1):132–148. doi:10.1108/dpm-05-2014-0082
52. Warner GS. Increased incidence of domestic animal bites following a disaster due to natural hazards. Prehosp Disaster Med. 2010;25(2):188-90.
53. Shultz JM, Russell J, Espinel Z. Epidemiology of tropical cyclones: the dynamics of disaster, disease, and development. *Epidemiologic Reviews*. 2005;27(1):21-35.
54. Control CfD, Prevention. Surveillance for illness and injury after Hurricane Katrina--three counties, Mississippi, September 5-October 11, 2005. MMWR: *Morbidity and Mortality Weekly Report*. 2006;55(9):231-4.
55. Beatty ME, Phelps S, Rohner C, Weisfuse I. Blackout of 2003: public health effects and emergency response. *Public Health Reports*. 2006;121(1):36-44.
56. Kile JC, Skowronski S, Miller MD, Reissman SG, Balaban V, Klomp RW, et al. Impact of 2003 power outages on public health and emergency response. *Prehospital and Disaster Medicine*. 2005;20(2):93-7.
57. Waite T, Murray V, Baker D. Carbon monoxide poisoning and flooding: changes in risk before, during and after flooding require appropriate public health interventions. *PLoS Currents.* 2014;6.
58. Woodruff JD, Irish JL, Camargo SJ. Coastal flooding by tropical cyclones and sea-level rise. *Nature*. 2013;504(7478):44-52.
59. Kundzewicz ZW, Kanae S, Seneviratne SI, Handmer J, Nicholls N, Peduzzi P, et al. Flood risk and climate change: global and regional perspectives. *Hydrological Sciences Journal*. 2014;59(1):1-28.
60. Andersen TK, Marshall Shepherd J. Floods in a changing climate. *Geography Compass*. 2013;7(2):95-115.
61. Tabari H. Climate change impact on flood and extreme precipitation increases with water availability. *Scientific Reports*. 2020;10(1):1-10.
62. Lowe D, Ebi KL, Forsberg B. Factors increasing vulnerability to health effects before, during and after floods. *International Journal of Environmental Research and Public Health*. 2013;10(12):7015-7067.
63. Du W, FitzGerald GJ, Clark M, Hou X-Y. Health impacts of floods. *Prehospital and Disaster Medicine*. 2010;25(3):265-72.

64. Ohl CA, Tapsell S. Flooding and human health: the dangers posed are not always obvious. *British Medical Journal* Publishing Group; 2000.
65. Brown L, Murray V. Examining the relationship between infectious diseases and flooding in Europe: A systematic literature review and summary of possible public health interventions. *Disaster Health.* 2013;1(2): 117-127.
66. Fox M, Chari R, Resnick B, Burke T. Potential for Chemical Mixture Exposures and Health Risks in New Orleans Post–Hurricane Katrina. *Human and Ecological Risk Assessment*. 2009;15(4):831-45.
67. Watson JT, Gayer M, Connolly MA. Epidemics after natural disasters. *Emerging Infectious Diseases*. 2007;13(1):1.
68. Ligon BL, editor Infectious diseases that pose specific challenges after natural disasters: a review. Seminars in Pediatric Infectious Diseases; 2006: Elsevier.