

On the Front Lines of Climate Health Effects in North Carolina

Lauren Thie, Kimberly Thigpen Tart

Populations across the United States are vulnerable to—and experiencing health effects from—climate change, and North Carolina is no exception. Health professionals are vital when it comes to identifying and treating such impacts, as well as serving as trusted authorities in educating and protecting communities against climate health threats.

As the Nation Changes, So Changes North Carolina

Since 2014, the US Global Change Research Program (USGCRP) has presented evidence of climate health effects occurring across the United States through national assessments, with several consistent key findings. First, changes in climate threaten the health of all Americans. Certain populations, however, are more vulnerable to such health effects. Fortunately, public health actions to adapt to changes in climate can do much to prevent or reduce many of these effects while also improving health generally [1, 2]. For example, policies that expand access to municipal water systems, which are less vulnerable than wells to contamination during extreme weather, can improve people's health overall, regardless of whether climate changes occur in the manner currently predicted [3]. The 4th National Climate Assessment, due for release by the USGCRP at the end of this year, is largely anticipated to affirm these same findings.

The USGCRP assessments are conducted on a national scale; however, their key messages are directly applicable to North Carolina. The geographic and topographic, climatic, ecologic, sociodemographic, and economic diversity of the state make it a microcosm of the nation in terms of many of the effects of climate on health (see Figure 1).

Sea levels along North Carolina's more than 300 miles of coastline are rising at some of the highest rates in the country, presenting hazards to drinking water infrastructure, tourism, and agriculture. Changes in amounts and frequency of precipitation may disrupt the production of crops and livestock, increase the need for pesticides, produce runoff from both agricultural and urban landscapes, and contaminate soil and water with chemicals and pathogens. Extreme weather events such as hurricanes, floods, wildfires, and heat waves present numerous threats to the environment and to the health of people and animals in our state.

North Carolina's sociodemographic makeup contributes to the health effects of climate-related exposures experi-

enced by residents, as well to as their ability to adapt. The state's growing population of just over 10 million is spread across 100 counties which range from 4,000 to more than 1 million residents [3]. Rural and urban areas have access to vastly different resources. North Carolina has notable proportions of age groups that are susceptible to climate health effects—in 2017, nearly 23% of residents were under the age of 18 and 15% were over the age of 65 [3] (in some counties, this latter number may reach as much as 30% by 2040 [4]). North Carolina's diverse population includes racial and ethnic groups that historically and still may experience health disparities, and has the largest American Indian population east of the Mississippi River [5], as well as significant populations of African-American, Hispanic, Asian, and many other races and ethnicities. Moreover, differences in access to financial resources influence residents' ability to act to protect their health, particularly in the face of extreme weather events; more than 15% of the state's population lives in poverty, including nearly a quarter of its children [4].

Underlying disease burdens in the state make certain populations more vulnerable to climate health effects and affect people's resilience during and after extreme events. In terms of health, almost 10% of the population has a disability, and more than 12% lack health care insurance [4], both of which affect the capacity to adapt. Climate-sensitive diseases such as cancer, heart disease, stroke, chronic lung disease, and accidental injury make up the top 5 causes of death in North Carolina [6, 7]. Other diseases endemic to the state, including diabetes, asthma, and mental illness, also increase the vulnerability of certain populations to changes in extreme temperatures and weather, air pollution, food insecurity, and other climate effects. Sociodemographic factors act in concert and the combined effects can significantly impact a person's or community's vulnerability and resilience.

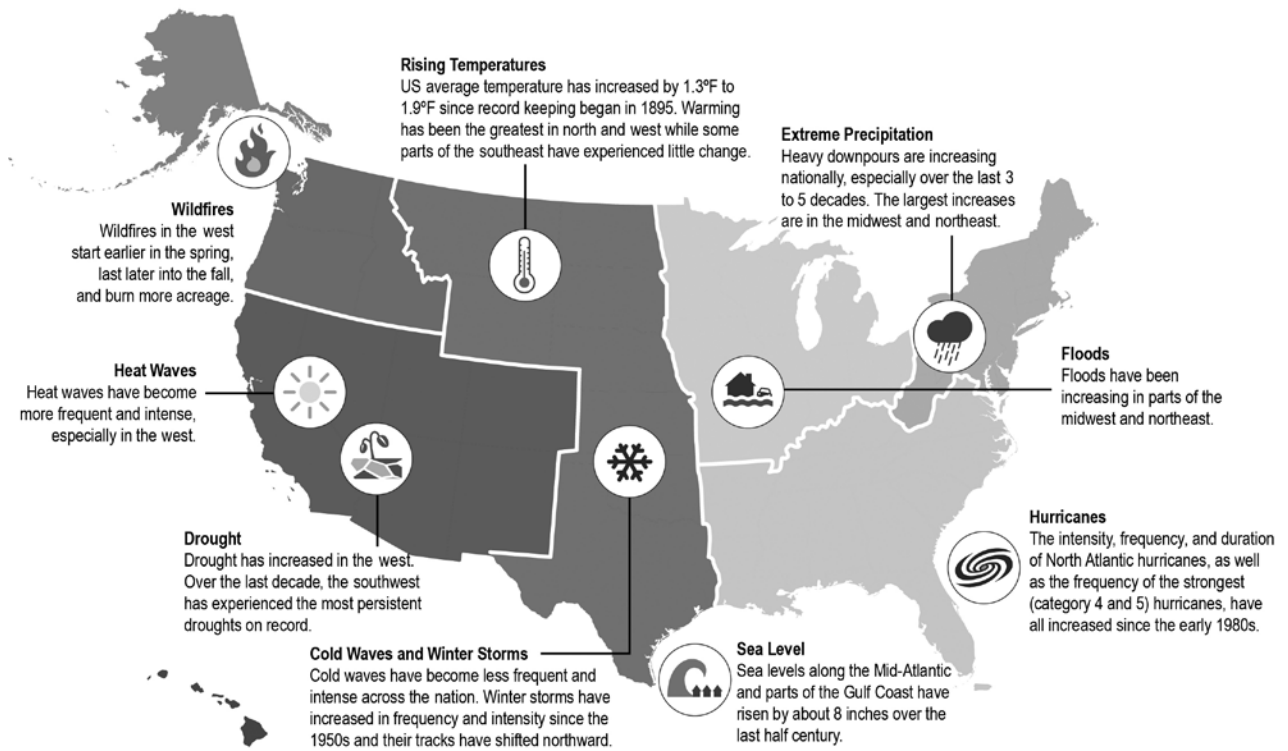
Health professionals are already encountering the health effects of extreme weather events in their practices, and therefore must prepare to take actions to protect their

Electronically published September 10, 2018.

Address correspondence to Lauren Thie, Division of Public Health, North Carolina Department of Health and Human Services, 1912 MSC, Raleigh, NC 27699 (lauren.thie@dhhs.nc.gov).

N C Med J. 2018;79(5):318-323. ©2018 by the North Carolina Institute of Medicine and The Duke Endowment. All rights reserved. 0029-2559/2018/79510

FIGURE 1.
Major US National and Regional Climate Trends



Source: Crimmins A, Balbus J, Gamble JL, et al. US Global Change Research Program. The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment. Washington, DC: USGCRP; 2016.

patients' health and that of their communities. Given their role in identifying, promoting, delivering, and ensuring health, professionals of varied backgrounds (eg, physicians, nurses, preparedness officials, hospital administrators, emergency responders) are clearly on the front lines of addressing climate health effects. These professionals are uniquely positioned to protect the health of North Carolina's residents because of their relevant training, accessibility, and high level of public trust. A 2017 East Carolina University public health symposium reflected this idea and maintained that the most effective place for health professionals to act to prevent climate health effects is in their own backyards [8].

Health Effects in North Carolina

Although North Carolina is likely to see many of the climate health effects expected nationwide, some climate events and their outcomes—including those related to extreme weather—present particularly pressing problems. The health costs of extreme weather events can be high; from 2000 to 2009, 6 extreme weather events caused an estimated \$14 billion in health costs nationally [9]. Major adverse health outcomes associated with climate change in North Carolina include heat-related illness and exacerbations of respiratory and cardiovascular disease from wildfire smoke.

Extreme Heat Exposure

North Carolina experiences many days with dangerously hot temperatures, and this pattern is expected to intensify. Over the next 30 years, most areas of North Carolina are likely to experience an additional 10 to 30 days annually that reach 95°F [10]. A study found that emergency department visits for heat-related illness increase substantially between 98°F and 100°F, with an additional ~16 visits for each 1°F increase in temperature in this 2°F range [11]. High heat days are associated with adverse outcomes including heat exhaustion, heat stroke, cardiovascular disease, and diabetes complications. A predictive model of North Carolina heat illness anticipates additional cardiovascular mortality related to increasing temperatures [12].

Heat-related illness also increases in North Carolina at temperatures considered normal or even mild, possibly due to longer exposures experienced by outdoor workers or those living without access to adequate cooling. A study found that above 60°F, the overall rate of heat-related illness emergency department visits increased incrementally by 1.43 for every additional temperature increase of 2°F [13]. For outdoor workers, the reality is that many days of the year may be dangerously hot. Two studies reveal the toll of heat on worker health and safety. One found that from 1992 to 2006, North Carolina had the highest rate in the United States of

Sugg sidebar

heat-related deaths (2.36 per 100,000 workers) among crop workers [14]. Another found that North Carolina heat-related fatality rates increase with summer temperature average as well as annual number of days with a high of 90°F or higher. Among occupational heat-related fatalities during 1977 to 2001, farm laborers constituted half of the deaths, and many of the deaths occurred without the decedent receiving medical attention or other employer attention [15].

Heat does not impact all of the state's residents equally across age groups, with those over the age of 65, those between the ages of 19 and 44, and those between the ages of 15 and 18 all showing unique vulnerabilities. Being over age 65 is a risk factor for heat-related illness emergency department visits [11, 16]. Studies of the incidence of heat-related illness in North Carolina have revealed some differences when compared with other regions. For example, high rates of heat-related illness emergency department vis-

its have been found in 19- to 44-year-olds, possibly related to work outdoors or in hot environments, and among 15- to 18-year-olds, related to playing outdoor sports [11, 13, 16].

Heat-related illness varies geographically in North Carolina, with the highest incidence rates for heat-related illness emergency department visits occurring in rural counties and the Sandhills region [13, 17]. Risk factors for heat-related illness in rural areas include living in mobile homes, being a non-citizen, and working in labor-intensive agriculture. In urban areas, risk factors include having less than a high school education, living in a mobile home, and having an income below the federal poverty level [16, 17]. Energy poverty, or difficulty affording heating and cooling, increases vulnerability to heat-related illness [18]. Increasing frequency of extreme heat in North Carolina will require both the medical and public health communities to be vigilant for symptoms and engaged in interventions to prevent such illness.

Sugg sidebar continued

Wildfire Exposure

In addition to heat, North Carolina residents also experience significant health effects from wildfires. Wildfires are a frequent occurrence in North Carolina, and research suggests that higher temperatures and drier climates are contributors. In the past 10 years, there have been multiple large wildfires in the state. In 2011, a wildfire in the Alligator National Wildlife Refuge burned 5,000 acres of pocosin forest and sent smoke plumes across Eastern North Carolina [19]. In 2016, more than 2 dozen wildfires in Western North Carolina burned over 50,000 acres [20].

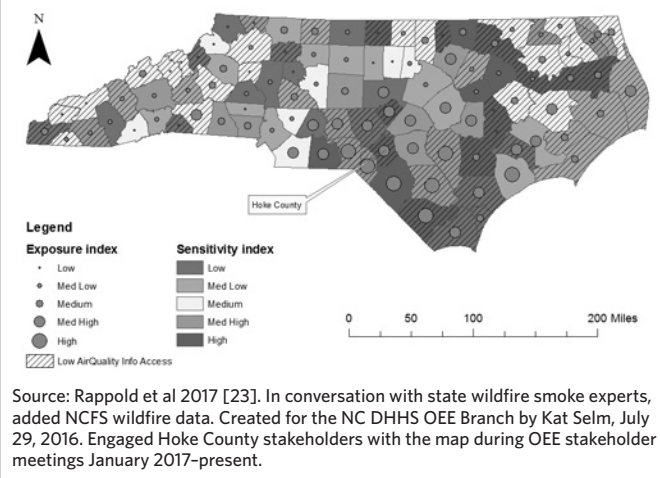
Overall, future climate scenarios predict that fine particulate matter and related mortality will decrease in the long term, however, wildfire smoke mortality is projected to increase due to increases in wildfire smoke [21]. A recent study suggests that by 2060, North Carolina may see a 74% increase in lightning-caused wildfire statewide, although the increase varies according to ecosystem type. Within the more vulnerable southeastern ecosystem of the state,

an additional 22% lightning-caused and an additional 10% human-caused wildfires are expected [22]

North Carolina experiences a mid-range level of vulnerability compared to the rest of the United States, in terms of average concentrations of fine particulate matter, number of days with high fine particulate matter, and amount of community risk factors for landfire smoke exacerbations from cardiopulmonary disease or other illnesses. Landfire includes fires from wildfires, prescribed burns, and agricultural burns. Within North Carolina, the southeast part of the state experiences the highest levels of these exposures and presence of risk factors such as underlying respiratory and cardiovascular disease [23] (see Figure 2).

Research describes specific health impacts of wildfire smoke exposure. During the 2008 Evans Road fire in Eastern North Carolina, emergency department visits in smoke-exposed counties increased significantly for cardiopulmonary symptoms and heart failure, as well as for asthma, COPD, pneumonia, and acute bronchitis [24]. Fine

FIGURE 2.
Smoke Vulnerability in North Carolina



particulate matter exposure also negatively affects the function of the vascular systems of diabetics [25]. In addition to effects related to smoke, wildfires also pose a risk of injury to residents and responders, and of harm to people’s mental health and well-being due to loss of homes, businesses, and schools, as well as from fear and stress, including as a result of evacuation and relocation.

Poised and Ready

North Carolina has a number of professional training programs that make the state well-poised to address climate health effects. The state’s universities educate, train, and deploy some of the best medical and public health researchers and providers in the world, and regularly generate innovations in agriculture and food production, energy technology, transportation and planning, natural resource management, and other fields relevant to addressing climate effects on health.

Health professionals working at every level—from the individual patient, to communities, to state and national levels—can address these effects by providing climate-informed care, education on adaptation interventions, and input to health-protective policies. For example, clinicians can counsel their patients on how to prevent heat-related illness by hydrating, limiting outdoor activity, seeking cool spaces, and discussing their medications, some of which can impede the body’s ability to regulate temperature [26]. At the community level, heat health alert systems that use trigger-alert levels and health education are being implemented with some success [27]. And many clinicians are routinely advising at-risk patients, including those with COPD, asthma, and diabetes, on how to protect themselves from wildfire smoke-related effects. At an even broader level, health professionals can participate in research to provide clinical understanding of the ways people are exposed to changes in climate and resulting health outcomes, which

could greatly aid adaptation efforts and contribute to practices and policies that decrease environmental health impacts and improve the sustainability of health care systems across the state.

State-level organizations, such as Clean Air Carolina, offer training for health professionals on climate, air quality, and health topics. And North Carolina itself is one of 16 states funded by the CDC’s Building Resilience Against Climate Effects grant, which seeks in part to describe the disease burden of health impacts and risk factors for future climate change, and to determine effective and suitable public health interventions for such risks [28]. Health professionals can also engage in efforts within their own organizations, such as those of the American Academy of Pediatrics, the Alliance of Nurses for A Healthy Environment, the Medical Society Consortium on Climate & Health, and the North Carolina Public Health Association. By integrating awareness of climate impacts on health throughout their practices, and by using their public credibility to promote climate adaptation, health professionals can greatly improve North Carolina’s resiliency against climate impacts and create a healthier future for the state. **NCMJ**

Lauren Thie, MSPH environmental program consultant, Division of Public Health, Occupational & Environmental Epidemiology Branch, North Carolina Department of Health and Human Services, Raleigh, North Carolina.

Kimberly Thigpen Tart, JD, MPH health science policy analyst, National Institute of Environmental Health Sciences, National Institutes of Health, U.S. Department of Health and Human Services, Research Triangle Park, North Carolina.

Acknowledgments

Financial support. This publication was supported by the Grant or Cooperative Agreement Number 5 N01EH001316-02, funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the Department of Health and Human Services.

This publication was supported, in part, by the NIH, National Institute of Environmental Health Sciences. The statements, opinions,

or conclusions contained therein do not necessarily represent the statements, opinions, or conclusions of the NIH, its component Institutes and Centers, or the United States government.

Potential conflicts of interest. L.T. and K.T.T. have no relevant conflicts of interest.

References

1. Luber G, Knowlton K, Balbus J, et al. Human Health. In: Melillo JM, Richmond TC, Yohe GW eds. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Washington, DC: U.S. Global Change Research Program; 2014:220-256.
2. Crimmins AJ, Balbus JL, Gamble CB, et al. U.S. Global Change Research Program. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. <http://dx.doi.org/10.7930/JOR49NQX>. Accessed June 11, 2018.
3. U.S. Census Bureau. Quick Facts: North Carolina. U.S. Census Bureau website. <https://www.census.gov/quickfacts/fact/dashboard/NC/PST045217>. Accessed May 28, 2018.
4. Weldon Cooper Center for Public Service Demographics Research Group. National Population Projections. Weldon Cooper Center for Public Service website. <https://demographics.coopercenter.org/national-population-projections>. Accessed May 28, 2018.
5. North Carolina Administration. Commission of Indian Affairs. North Carolina Administration website. <https://ncadmin.nc.gov/about-doa/divisions/commission-of-indian-affairs>. Accessed May 28, 2018.
6. North Carolina Department of Health and Human Services. Chronic Disease and Injury Section. North Carolina Department of Health and Human Services website. <http://publichealth.nc.gov/chronicdiseaseandinjury/>. Accessed May 28, 2018.
7. Portier CJ, Thigpen Tart K, et al. Environmental Health Perspectives, National Institute of Environmental Health Sciences. Research Triangle Park, NC: Environmental Health Perspectives, National Institute of Environmental Health Sciences; 2010.
8. Clabby C. Local Knowledge Key in Responding to Climate Change. *northcarolinahealthnews.org*. <https://www.northcarolinahealthnews.org/2017/03/23/local-knowledge-key-responding-climate-change/>. Published March 23, 2017. Accessed May 25, 2018.
9. Knowlton K, Rotkin-Ellman M, Geballe L, Max W, Solomon GM. Six climate change-related events in the United States accounted for about 14 billion in lost lives and health costs. *Health Aff*. 2011;30(11), 2167-2176.
10. Carter LM, Jones JW, Berry L, et al. Southeast and the Caribbean. In: Melillo JM, Richmond TC, Yohe GW eds. *Climate Change Impacts in the United States: The Third National Climate Assessment*. Washington, DC: U.S. Global Change Research Program; 2014: 396-417.
11. Rhea S, Ising A, Fleischauer AT, Deyneka L, Vaughan-Batten H, Waller A. Using near real-time morbidity data to identify heat-related illness prevention strategies in North Carolina. *J Community Health*. 2012;37(2),495-500.
12. Becker D, et al. The human health impacts of future changes in air quality and temperature in the United States: master's thesis. The University of North Carolina at Chapel Hill. UNC Libraries website. <https://library.unc.edu/>. Accessed May 25, 2018.
13. Lippmann, SJ, Fuhrmann CM, Waller AE, Richardson DB. Ambient temperature and emergency department visits for heat-related illness in North Carolina, 2007-2008. *Environ Res*. 2013;124:35-42.
14. Centers for Disease Control and Prevention (CDC). Heat-related deaths among crop workers – United States, 1992-2006. *MMWR Morb Mortal Wkly Rep*. 2008;57(24):649-653.
15. Mirabelli M, Richardson DB. Heat-related fatalities in North Carolina. *Am J Public Health*. 2005;95(4):635-637.
16. Kovach MM, Konrad CE, Fuhrmann CM. Area-level risk factors for heat-related illness in rural and urban locations across North Carolina, USA. *Applied Geography*. 2015;60:175-83.
17. Sugg MM, Konrad CE 2nd, Fuhrmann CM. Relationships between maximum temperature and heat-related illness across North Carolina, USA. *Int J Biometeorol*. 2016;60(5):663-675.
18. Harrison C, Popke J. 'Because you got to have heat': The networked assemblage of energy poverty in Eastern North Carolina. *Annals of the Association of American Geographers*. 2011;101(4):949-961.
19. U.S. Fish and Wildlife Service, Southeast Region. FY2011 Fire Division Report. Atlanta, GA: U.S. Fish and Wildlife Service; 2011.
20. Off G. Mountain blazes claim over 55,300 acres. *CharlotteObserver.com*. <http://www.charlotteobserver.com/news/local/article11491183.html>. Published November 15, 2016. Updated November 25, 2016. Accessed May 21, 2018.
21. Zelasky S, et al. Quantifying future health effects due to changes in US wildfire frequency. Poster presented at: North Carolina BREATHE Annual Conference; March 8, 2018; Winston-Salem, NC.
22. Prestemon J, Shankar U, Xiu Aijun, et al. Projecting wildfire area burned in the south-eastern United States, 2011-60. *International Journal of Wildland Fire*. 2016;25:715-729.
23. Rappold A, Reyes J, Pouliot G, Cascio WE, Diaz-Sanchez D. Community vulnerability to health impacts of wildland fire smoke exposure. *Environ Sci Technol*. 2017;51(12):6674-6682.
24. Rappold A, Stone SL, Cascio WE, et al. Peat bog wildfire smoke exposure in rural north carolina is associated with cardio-pulmonary emergency department visits assessed through syndromic surveillance. *Environ health Perspect*. 2011;119(10):1415-1420.
25. Schneider A, Neas L, Herbst MC, et al. Endothelial dysfunction: associations with exposure to ambient fine particles in diabetic individuals. *Environ Health Perspect*. 2011;116(12):1666-1674.
26. Hajat S, O'Connor M, Kosatsky T. Health effects of hot weather: from awareness of risk factors to effective health protection. *Lancet*. 2010;375(9717):856-863.
27. Anderson H, Brown C, Lorraine LC, et al. National Center for Environmental Health, Division of Environmental Hazards and Health Effects, Centers for Disease Control and Prevention. *Climate and health intervention assessment: Evidence on public health interventions to prevent the negative health effects of climate change*. Atlanta, GA: Centers for Disease Control and Prevention; 2017. https://www.cdc.gov/climateandhealth/docs/ClimateAndHealthInterventionAssessment_508.pdf. Accessed June 11, 2018.
28. Centers for Disease Control and Prevention. CDC's Building Resilience Against Climate Effects (BRACE) Framework. Centers for Disease Control and Prevention website. <https://www.cdc.gov/climateandhealth/BRACE.htm>. Published January 22, 2015. Accessed May 31, 2018.