ISSUE BRIEF

Health and the Environment in North Carolina

H. Kim Lyerly, David B. Peden

Environmental impacts on health are usually discussed from a global perspective. However, this issue of the North Carolina Medical Journal focuses on studies of health outcomes in North Carolina caused by local air and water pollution. While some people are clearly at increased risk, environmental threats to health ultimately impact all of us.

While every resident of North Carolina interacts with the environment on a constant basis, it is becoming more evident that these interactions can not only impact the quality of their lives, but also their lifespans. It is estimated that 23% of all deaths and 26% of deaths among children under the age of 5 are due to preventable environmental factors [1]. The World Health Organization (WHO) defines the environment as it relates to health as "all the physical, chemical, and biological factors external to a person and all the related behaviors [2]." These environmental factors are diverse and include exposure to hazardous substances in the air, water, soil, and food, as well as natural and technological disasters, climate change, and occupational hazards. In this issue of the North Carolina Medical Journal (NCMJ), we have collated a number of articles to frame the topic of human health and the environment, with specific emphasis on topics of particular interest to physicians in North Carolina, as well as the communities and families they serve.

The United States Healthy People 2020 Environmental Health Objectives [3] include the following 6 themes: outdoor air quality, surface and groundwater quality, toxic substances and hazardous waste, homes and communities, infrastructure and surveillance, and global and environmental health. Outdoor air quality has the broadest impact, as air quality affects everyone in a region. Water quality and exposures to toxic and hazardous substances also have broad impact, but may be mitigated by alternative sources of water, or by avoidance of known exposures. Nonetheless, unempowered segments of society are unable to avoid exposures due to a lack of alternatives, and/or unavoidable proximity to sources of contaimination. Furthermore, challenging environmental conditions may have a disproportionate impact on people whose underlying health status is already compromised, such as the chronically ill, but also elderly people, children, and pregnant women. Therefore, our view of environmental health must pay particular attention to the environmental factors affecting communities in which these at-risk populations are overrepresented.

The impact of the environment on health has long been of interest to residents of North Carolina, which is home to institutions such as the National Institutes of Environmental Health (NIEHS), the air pollution research labs of the US Environmental Protection Agency (EPA), the University of North Carolina at Chapel Hill Institute for the Environment, and the Nicholas School of the Environment at Duke University. A few years ago, Research Triangle Environmental Health Collaborative, which plans and holds meetings of organizations working in the field of environmental health, organized a summit in Research Triangle Park focused on potential research involving the nexus of environmental and health data, particularly big data sets related to actual health benefits and improved air quality [4]. This summit set the stage for a series of ongoing activites focused on the environment and health in North Carolina, many of which are detailed in this issue.

Throughout this issue, we will touch upon the 6 themes of the Environmental Health Objectives, with contributions from authorities throughout the state representing 10 different universities, government agencies, or non-profit organizations. A focus on the impact of health and the environment in North Carolina is timely, as recently leaders from the World Health Organization, the United Nations Environment Programme, and the World Meteorological Organization launched a new global coalition on health, environment, and climate change, reflecting on the opportunity to address the impact of the changing environment on many lives [5]. One of the overall goals of this international initiative is to reduce the 12.6 million annual deaths caused by environmental risks, especially air pollution. We hope that North Carolina physicians, communities, and residents can work together to address these issues in our state, and that this volume of the NCMJ can contribute by providing information on the current status of the impact of the environment on our health.

Outdoor Air Quality

In 2008, it was estimated that approximately 127 million people living in the United States were exposed to air

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Address correspondence to H. Kim Lyerly, M.D., 203 Research Drive, Suite 433, Duke University Medical Center, Durham, NC 27710

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containing pollutants that exceeded the National Air Quality Standards [6]. Consequently, outdoor air quality, which has been linked to premature deaths, cancer, and long-term damage to the respiratory and cardiovascular systems, is a major topic in this issue of the NCMJ. Most people are aware that bad air quality can lead to respiratory diseases such as asthma, but an additional critical aspect of air pollution is its effects on the heart. In fact, it is cardiovascular disease which causes the most morbidity, mortality, and cost of any medical condition related to air pollution [7]. The well-established causal associations between active and passive smoking with heart disease and stroke support the plausibility of an adverse effect of air pollution, including particulate matter, on the cardiovascular system. Collectively, a number of scientific studies suggest that air pollution may accelerate the development of coronary atherosclerosis and worsen its sequelae. As Dr. Wayne Cascio, acting director of the National Health and Environmental Research Lab for the EPA, writes, some of these effects may occur over time, as with acceleration of the progression of atherosclerosis, while others occur rather abruptly, as with the triggering of an arrhythmia or myocardial infarction by acute inflammatory responses, altered platelet adhesiveness, or perhaps vascular endothelial dysfunction [7]. This is particularly a problem in areas dealing with wildfires.

In addition to respiratory and cardiovascular disease, there are a number of unexpected health effects from pollution and particulates in the air that have been linked to other health conditions including depression, osteoporosis, and even autism, which Dr. David Peden, director of the Center for Environmental Medicine at the University of North Carolina at Chapel Hill (UNC-CH), addresses in a sidebar article [8].

Surface and Ground Water Quality

High-quality water is also a critical factor for health and the environment, as contamination by infectious agents or chemicals can cause a variety of illnesses. Protecting our water sources and minimizing exposure to contaminated water are important aspects of water quality in North Carolina that are addressed in this issue. Most significantly, a review by Drs. Julia Kravchenko and H. Kim Lyerly of the Environmental Health Scholars Program at Duke University describes the reported health risks associated with exposure to water that may have been contaminated by coal ash [9]. Additional challenges to water quality in North Carolina include contamination due to a variety of environmental exposures including lead, chemicals such as GenX, and contaminants from concentrated animal feeding operations (CAFOs). An original resarch article describing the poor health outcomes for a variety of conditions found in communities in proximity to CAFOs was generated by Dr. Kravchenko and colleagues at Duke [10]. In an accompanying article, Dr. Virginia Guidry of the NIEHS and colleagues discuss the concept of environmental justice, present the impact of large-scale hog production as an example of environmental injustice in North Carolina, and make suggestions for how clinicians can address environmental injustices affecting their patients [11].

Toxic Substances and Hazardous Waste

The specific assessment of toxic substances such as hazardous waste features significantly in this issue. For example, there is a need for enacting a health-based standard for lead in drinking water to improve children's health even though there is no safe level of exposure to lead, especially for children, who may suffer lifelong developmental defects. As Dr. Jennifer Hoponick Redmon of the Research Triangle Institute (RTI) and colleagues write [12], a health-based drinking water standard has never been set. In 2017, a study by RTI International tested participating North Carolina child care centers and schools for lead in the water and found that 3 out of 4 tap water samples contained lead above the 0.1 parts per billion laboratory detection limit, yet few (< 1%) of these samples exceeded the EPA's treatment-based action level of 15 parts per billion [12]. The questions of what is an acceptable level of lead in drinking water and what are the policies needed to implement this type of monitoring remain. In this issue, Drs. Ann Chelminski and Kim Gaetz of the North Carolina Department of Health and Human Services also run the numbers on trends in lead poisoning prevention among North Carolina children aged 6 and younger [13].

The term "contaminant of emerging concern," or CEC, describes a collection of chemical compounds found in water sources in recent years that may cause adverse effects to human health and aquatic life. One such contaminant that has emerged to be of importance to North Carolina residents is GenX, based on potential pollution from the Chemours Plant at the Cape Fear River and the surrounding water supplies. In a sidebar about GenX, Dr. Stanley Meiburg of the Graduate Program of Sustainabilty at Wake Forest University writes that sampling beginning in 2012 detected GenX in surface water in the Cape Fear River and the North Carolina Department of Environmental Quality (NCDEQ) later detected GenX in groundwater and well water near the Chemours facility [14].

Emerging contaminants result from products we depend on, but there is a lot we don't know know about their effects. Meiburg asks readers to consider an important question [14]: "How much risk, in exchange for what benefits and under conditions of uncertainty, are we willing to tolerate?"

Homes and Communities

The homes and communities that are affected by environmental hazards create an opportunity to address environmental justice issues. Clinicians with a better understanding of how the environment affects their patients' health are better poised to recognize symptoms and conditions associated with known sources of pollution [11].

Several authors in this issue focus on hog production

not because it is the only source of environmental injustice in North Carolina, but because it impacts vulnerable populations disparately. As Guidry et al. write, "Low-income communities and communities of color can be disproportionately exposed to environmental pollution compared to higher-income, white communities [11]." Their hope, and the hope of many authors in this issue, is that as clinicians receive better education and training about environmental issues, they will be able to better engage with patients and communities around the impacts of CAFOs and other environmental injustices [11].

Infrastructure and Surveillance

The need for environmental monitoring to detect environmental hazards is addressed in several articles in this issue, including a review of the Clean Smokestacks Act. Drs. Kravchenko and Lyerly of Duke and Bill Ross, former secretary of the NC Department of Environment and Natural Resources, write about the impact of this policy on improving environmental conditions in North Carolina including the reduction in mortality from respiratory disease and cardiovascular disease [15]. In addition, there has been a Medical Advocates for Healthy Air (MAHA) initiative to reduce idling and diesel exhaust fumes caused by construction. Rachel McIntosh-Kastrinsky, manager at MAHA, and Dr. Tom Zweng, formerly of Novant Health, write about how hospital systems are working together to improve air quality to protect both patients and workers from construction pollution [16].

In another article, McIntosh-Kastrinsky highlights Dr. Bob Parr's efforts to track pollution using individual air quality monitors and describes the potential impact of these types of activities on the health of patients [17].

Global and Environmental Health

Populations across the United States are vulnerable to and experiencing health effects from changes to climate, and North Carolina is no exception. Health professionals are vital to identifying and treating such impacts, but also to serving as trusted authorities in educating and acting to protect communities against climate health threats. Dr. Greg Kearney of East Carolina University provides an original article on this topic titled Climate Change and Public Health through the Lens of Rural, Eastern North Carolina [18]. Also in the theme of global and environmental health, the impact of climate change on North Carolina's health, particularly regarding natural disasters, is described by Lauren Thie, environmental program consultant at the North Carolina Division of Public Health, and Kimberly Thigpen Tart, health science policy analyst at the NIEHS [19]. In a sidebar article, Dr. Margaret Sugg of Appalachian State University describes how extreme heat events are some of the most dangerous climate-change-related disasters and how they affect health in ways one might not expect [20].

Conclusions

It is clear that the environment in North Carolina contributes to the enjoyment many residents experience living here. Nonetheless, the environment does play a role in our health, and pollutants not only reduce our enjoyment of the outdoors but can also accelerate sickness and death. The realization that our environment can negatively affect our quality of life and health is a major driver for the focus of this issue.

In addition to the local issues facing North Carolina residents, such as coal-fired powerplants, coal ash impoundments, CAFOs, and emerging pollutants like Gen X, the health effects of global warming may be of particular significance to our state. Climate change over the coming decades is likely to increase rates of allergies, asthma, heart disease, and cancer, among other illnesses [19]. Also, diseases that were previously found only in warmer areas of the world may show up increasingly in North Carolina, where residents have limited opportunities to develop natural defenses. Given the association between our environment and human health, the significant up-front costs of cleaner environmental policies may well be a bargain when we see our overall health care costs go down and we live longer, more productive, and healthier lives.

It is a privilege to conclude this issue with a brief recognition of 2 of the leading environmental philanthropists in North Carolina, whose support has enabled studies of the environment and health-related research. In a philanthropy spotlight, June Blotnick, executive director of Clean Air Carolina, and Dr. Lyerly highlight the contributions provided by Salisbury natives Fred and Alice Stanback [21]. NCMJ

H. Kim Lyerly, MD director, Environmental Health Scholars Program; George Barth Geller Professor of Cancer Research; professor, Departments of Surgery, Immunology, and Pathology, Duke University School of Medicine, Durham, North Carolina.
David B. Peden, MD, MS Andrews professor of pediatrics, senior associate dean for Translational Resarch, director, Center for Environmental Medicine, Asthma and Lung Biology, The School of Medicine, The University of North Carolina at Chapel Hill, Chapel Hill, North Carolina.

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