

Reducing North Carolina's Health Care Costs Through Environmental Disease Prevention

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At a time of unprecedented pressure on the North Carolina state budget, reducing environmental risks to health may provide opportunities for substantial savings in the proportion of the state budget (24%) that is allocated for medical assistance. Recently, the Research Triangle Environmental Health Collaborative held a summit to identify options for increasing attention to environmental impacts on health in the ongoing health care and budget debates. Summit participants included not only public health and environmental experts, but also individuals (such as transportation planners, developers, and industry representatives) whose decisions can have a significant impact on environmental quality. This article summarizes key recommendations from the summit, as well as commentaries in the policy forum of this issue that further elaborate on why environmental quality matters for public health in North Carolina. Key recommendations from the summit include requiring formal health impact assessments (similar to environmental impact assessments but with an emphasis on health) in state and local transportation and land use planning processes, quantifying the total disease burden attributable to environmental hazards in North Carolina, prioritizing environmental risks to health in North Carolina, providing state technical assistance for communities disproportionately affected by poor environmental quality, establishing a new database system to link existing environmental and public health data by geographic location, undertaking North Carolina case studies to test the hypothesis that improving environmental quality also reduces medical care costs, and developing "environment matters to your health" public awareness campaigns.

Whoever wishes to investigate medicine properly, should proceed thus: in the first place to consider the seasons of the year. . . . Then the winds . . . , especially such as are common to all countries, and then such as are peculiar to each locality. We must also consider the qualities of the waters, for as they differ from one another in taste and weight, so also do they differ much in their qualities.

Hippocrates (attributed), *On Airs, Waters, and Places*

As this quotation from the Hippocratic Corpus illustrates, the belief that environmental factors are associated with preventable diseases is a long-established concept in public health. Although the past century has witnessed dramatic improvements in public health because of environmental interventions such as improved water and sanitation systems, environmental risks remain important contributors to public health problems. The World Health Organization estimates that, all told, environmental risk factors are associated with approximately 17% of the total disease burden in industrialized nations [1].

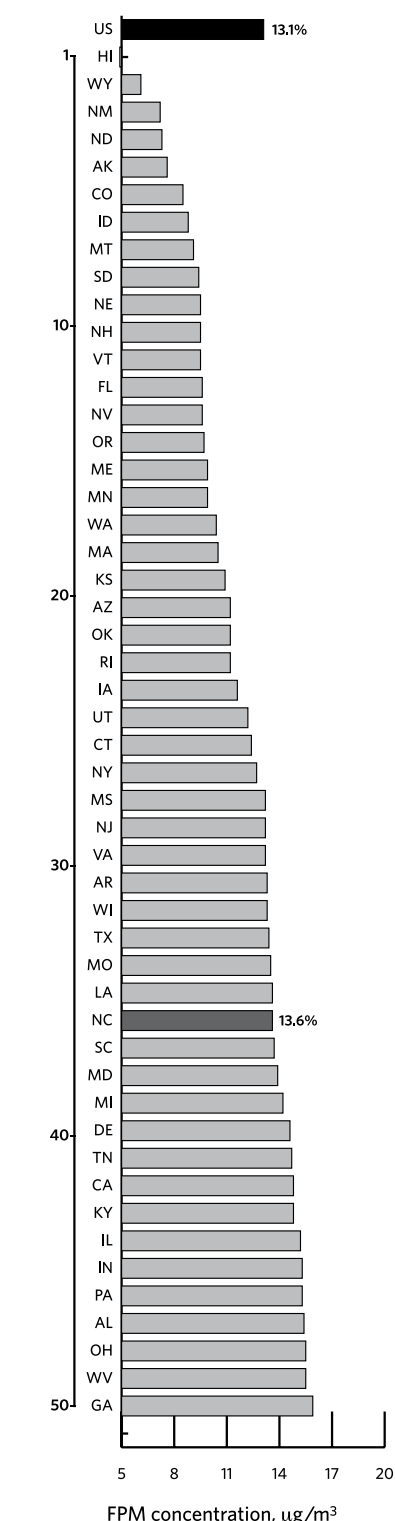
US states have not undertaken comprehensive assessments of the burden of environmental disease, so comparing North Carolina's status with that of other states on this important public health measure is not possible. However, for the limited environmental factors for which assessments have been undertaken, North Carolina scores relatively poorly. For example, North Carolina has the 15th highest concentration of fine particulate matter in air among US states, according to the North Carolina Institute of Medicine Task Force on Prevention (Figure 1) [2]. High levels of particulate matter in outdoor air contribute to high rates of respiratory and cardiovascular diseases. In North Carolina, fine particulate matter in air is a causative factor in 6,000 hospital admissions for respiratory distress and 3,000 premature deaths each year, the latter of which accounts for 3%-7% of all deaths not due to violence or unintentional injury [3]. While environmental exposures are just one cause of preventable diseases and premature deaths, North Carolina compares relatively poorly with other states in terms of indicators of disease and death. According to the United Health Foundation [2], North Carolina ranks 36th among states in overall population health (with 1 being the best) and 38th in terms of premature mortality.

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FIGURE 1.
Average Concentration of Fine Particulate Matter (FPM) in Air During 2005-2007, Nationally and by State



Note. Data are from [2]. FPM is defined as particles with a diameter of $\leq 2.5 \mu\text{m}$. Numerals in the y-axis denote state rank.

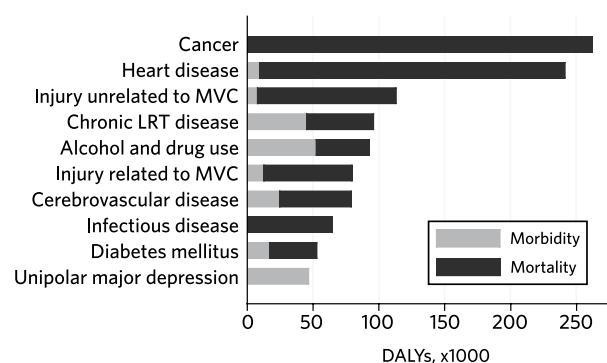
An increased burden of environmental disease translates to significant economic implications for medical care systems. Landrigan and colleagues [4] estimated that 4 environmentally mediated chronic health conditions in children (ie, lead poisoning, asthma, cancer, and neurobehavioral disorders) cost the nation \$54.9 billion per year. Several individual states have completed similar assessments on children, with state-specific total annual medical care costs for select diseases ranging from \$1.57 billion to \$5.8 billion [5-8]. North Carolina researchers have estimated that the burden of just 1 health outcome category (ie, respiratory disease) and 1 type of pollution (ie, particulate matter in outdoor air) costs the state medical system nearly \$14 million annually [3].

At a time of unprecedented pressure on the state budget, North Carolina can ill afford to continue paying for preventable disease associated with environmental factors. In fact, medical assistance programs accounted for 24% (\$10.4 billion) of the state's total budget of \$42.8 billion in 2009-2010 [9]. Given that 3 of the 4 leading causes of death and illness in North Carolina—cancer, heart disease, and chronic lower respiratory disease—are initiated or exacerbated by environmental risk factors (Figure 2), improving the environment offers substantial opportunities for North Carolina to save money through environmental initiatives that prevent disease [2]. Yet, the potential for increased environmental protection to yield health care savings for North Carolinians has received scant, if any, attention in ongoing debates over both the state budget and health care reform. In fact, the North Carolina legislature is proposing cuts of 22% in the budget for the Department of Environment and Natural Resources (DENR), the state agency chiefly responsible for ensuring environmental protection [10, 11].

The commentaries in the policy forum of this issue focus on research and practice to understand and reduce environmental impacts on the public's health in North Carolina and elsewhere. As the commentaries illustrate, North Carolina has pioneered new research methods, policies, and community engagement strategies focused on understanding and preventing environmentally mediated diseases. Actions in all of these areas—scientific research, policy improvements, and community engagement—will be necessary to reduce the state's burden of preventable disease. Such an effort by North Carolina can then serve as a model for improving similar conditions in other states across the nation.

With these considerations in mind, the Research Triangle Environmental Health Collaborative (available at: <http://environmentalhealthcollaborative.org/about/overview/>) recently held a summit to identify ways to increase attention to environmental impacts on health in the ongoing health care and budget debates. One goal of the summit was to bring together individuals and organizations not traditionally associated with public health or environmental health but whose decisions can have a significant impact on health outcomes. Participants included land use and transportation

FIGURE 2.
Top 10 Causes of Morbidity and Mortality in North Carolina,
as Measured by Disability-Adjusted Life Years (DALYs)



Note. Data are from [2]. Three of the 4 leading causes (ie, cancer, heart disease, and chronic lower respiratory tract [LRT] disease) can be triggered or exacerbated by environmental pollution. MVC, motor-vehicle crash.

planners, housing developers, architects, agricultural industry representatives, and federal, state and local government personnel. This diverse array of summit participants divided into 3 subgroups and then convened in plenary sessions to develop 3 types of recommendations: policies, to prevent or reduce environmental impacts on the disease burden and the medical care system; research and analytical tools, to support existing and new policies to prevent and reduce environmental impacts on health and the medical care system; and opportunities for public outreach, education, and mobilization, to reduce the impact of environmental quality on human health and the medical care system.

This article summarizes innovative projects pertinent to each of these 3 topics in North Carolina, as described in more detail in the policy forum of this issue. It also highlights some of the key recommendations from the North Carolina Environmental Health Summit. A complete list of the presentations and recommendations is posted on the Research Triangle Environmental Health Collaborative Web site (available at: <http://environmentalhealthcollaborative.org/summit/presentations1/>).

Policies

The commentary by Ross [12], former secretary of the North Carolina Department of Environment and Natural Resources, describes North Carolina's leadership in reducing air pollutant emissions from coal-fired power plants, which has resulted in measurable improvements to air quality. A 10-year collaborative research project, the Southern Appalachians Mountains Initiative, demonstrated that North Carolina would gain substantial benefits from reducing emissions of nitrogen oxides and sulfur dioxides from the state's coal power plants. According to Ross, this research led to consensus that these emissions indeed had measurable public health impacts and therefore needed to be reduced. Subsequent negotiations between the state legis-

lature and the electric utility industry led to a new law, the Clean Smokestacks Act of 2002, that reduced air pollution and, by allowing accelerated tax write-offs for pollution controls, was financially feasible for the utility industry. Ross shows the significant decreases in air pollution levels that have resulted from this legislation, which went beyond federal mandates for power plant emissions reductions.

While the Clean Smokestacks Act represents clear North Carolina leadership in policies to reduce environmental risks to public health, many problems remain. Participants in the Environmental Health Summit emphasized the particular need for policies to reduce health disparities that result from differences in environmental toxicant exposures. The commentary in this issue by Wilson [13], president of the West End Revitalization Association (WERA; Mebane, NC), emphasizes the disproportionate exposure to environmental hazards faced by the state's minority and low-income communities. In North Carolina's low-income communities, these hazards include lack of access to basic water and sanitation services (ie, public water supplies and sewerage services) that are now taken for granted in the state's middle- and high-income communities.

Summit participants recommended as a possible policy change a new requirement to include formal health impact assessments, similar to environmental impact assessments, in state and local transportation and land use planning processes. Current federal law (ie, the National Environmental Policy Act of 1969) requires environmental impact assessments for any project that involves federal funding or permits. These environmental impact assessments focus mainly on ecosystems. Although health impact assessment is widely practiced in other parts of the world, currently the United States does not require health impact assessments for new projects. North Carolina could provide leadership in advancing health impact assessment as an evidence-based tool for supporting public policy decisions. Such assessments also could increase attention on how new projects (such as new highways or industrial facilities) affect the health of existing communities—including low-income and minority communities—and how alternative designs could decrease these impacts.

Summit participants also suggested that North Carolina policymakers initiate formal planning exercises at the county and state levels to select environmental health priorities and identify interventions that will improve the health of the largest number of people and the communities most severely affected. Community input and participation in the selection of priorities and interventions could be required. To structure the planning processes, counties and the state could consider using the methods described in the policy forum by MacDonald Gibson [14] for combining systematic community engagement with quantitative environmental burden of disease assessment by public health experts. North Carolina counties conduct community health assessments (which include limited environmental risk informa-

tion) every 4 years. Stronger, more targeted environmental health assessments could be incorporated in these ongoing community health assessments.

While requiring health impact assessments for new projects and county-level environmental health assessments are top-down approaches to focusing attention on the linkages between environmental quality and public health, Environmental Health Summit participants also emphasized the need for political support of bottom-up approaches that are focused on education and technical assistance for communities. Participants recommended a state commitment to provide technical assistance to communities facing disproportionate environmental disease burdens.

Research and Analytical Tools

The commentaries in this issue's policy forum highlight exciting new opportunities for research to improve understanding of the complex links between environment and health, to support evidence-based policy making.

Olden and colleagues [15] write about the potential for new research tools in genetics to shed light on the interplay between environmental and genetic factors in disease initiation and progression. Olden is former director of the National Institute of Environmental Health Sciences, the nation's premier federal environmental health research agency, located in Research Triangle Park, North Carolina. Olden and colleagues recommend developing a database of epigenetic markers (ie, observed changes in human cellular factors other than DNA sequence that affect cellular function) gathered in parallel with environmental and genetic information from populations in different neighborhoods. Such a database could serve as a platform for transdisciplinary research to understand the complex gene-environment interactions thought to be major factors in the etiology of diseases that contribute disproportionately to the nation's health care costs.

Miranda and Edwards [16], researchers at Duke University's Nicholas School of the Environment, provide several examples of how new geographic information system (GIS) and statistical tools have already been used in North Carolina to improve understanding of the links between environmental risk factors and public health. As examples, GIS tools have been used to identify homes most at risk for lead contamination and to target blood lead screening to those at-risk neighborhoods, using the maps as powerful tools to communicate risks to the affected communities. Similarly, GIS tools have been used to inform policies concerning arsenic testing of private wells, which provide drinking water for more than 2 million North Carolinians. North Carolina's universities have developed some of the most powerful tools, now used worldwide, for such geospatial analysis [17].

Summit participants stressed the potential for research on a variety of fronts to provide a stronger information base to support policy making. Participants recommended that North Carolina researchers pursue a variety of case studies that could test the hypothesis that improving environmen-

tal quality also reduces medical care costs. For example, researchers could compare health status in counties that have different environmental risk factors. Similarly, public health researchers could analyze health data before and after legislation (such as smoking bans or reductions in permissible air emissions) to improve environmental quality.

An additional recommendation was to conduct case studies in North Carolina to quantify the local and regional burden of disease due to different environmental factors and to estimate the medical care cost savings that might accrue with decreased exposures to environmental risk factors. For some environmental risk factors, such as exposure to air and water pollution, data are already routinely collected, and relevant health and health care expenditure data can be gathered from existing sources, including various data sets available from the North Carolina Center for Health Statistics, making such efforts possible at relatively low cost.

Summit participants also recommended that North Carolina pursue a number of activities to restructure existing data, to facilitate research on the connections between environment and health. For example, one recommendation was to develop the spatial architectures needed to integrate existing data on environmental exposures, health, and pollutant concentrations. The new database technologies should be able to combine spatially resolved environmental data with health records at the individual and population levels, while protecting the privacy of personal health data. Such data structures would facilitate low-cost research to understand linkages between environmental exposures and health.

Community Outreach

While disparities in exposure to environmental risk factors remain pervasive in North Carolina, the state also has produced examples of successful, community-based, collaborative decision making on development projects with potential environmental and health impacts.

Wilson [13] describes WERA's work to engage community members, local university science experts, and government agencies to identify and reduce environmental hazards in low-income communities. The Environmental Protection Agency recently named WERA as a prototype model for engaging communities in reducing the local health effects of environmental hazards associated with transportation corridors.

Contrary to a commonly held belief that environmental protection is detrimental to economic development, improved environmental stewardship can benefit not only community health but also local economic development, contends Levine [18], professor in the Department of Epidemiology and Public Health at North Carolina State University, in the policy forum. Levine presents several examples of cooperation among businesses, local community members, state agencies, and environmental groups to craft plans that enable strong local economic development

TABLE 1.
Select Resources in North Carolina for Addressing Environmental Risks to Health

Affiliation type, organization	Web site	Major activities
University		
Dept of Environmental Sciences and Engineering, GSGPH, UNC-CH	http://www.sph.unc.edu/envr/	Conducts interdisciplinary research and teaching of the effects of environmental contaminants on human health and the effects of human activity on the environment
UNC-Chapel Hill Dept of Epidemiology, GSGPH, UNC-CH	http://www.sph.unc.edu/epid/	Conducts research and teaching to understand the patterns and causes (environmental and other) of health and disease
Institute for the Environment, UNC-CH	http://www.ie.unc.edu/	Coordinates environmental research and outreach across departments and centers of UNC
Nicholas School of the Environment and Earth Sciences, DU	http://www.nicholas.duke.edu/	Conducts research and outreach on environmental issues
Dept of Civil, Construction, and Environmental Engineering, NCSU	http://www.ce.ncsu.edu/	Conducts research on new technology for emerging environmental problems
State		
Dept of Environment and Natural Resources	http://portal.ncdenr.org/web/guest	Administers programs to protect air quality, water quality, and public health
Div of Public Health, Dept of Health and Human Services	http://publichealth.nc.gov/	Administers disease prevention, health services, and health promotion programs in collaboration with local health departments, hospitals, community health centers, practitioners, and community agencies
Federal		
National Institute of Environmental Health Sciences	http://www.niehs.nih.gov/	Supports research to understand how the environment influences the development and progression of human disease
Environmental Protection Agency	http://www.epa.gov/rtp/	RTP campus is the primary center for air pollution research and regulation; also houses National Health and Environmental Effects Research Laboratory, National Center for Computational Toxicology, and other research centers focused on environmental impacts on health
Other		
NC Environmental Health Collaborative	http://www.EnvironmentalHealthCollaborative.org	Connects organizations; links research and policy; and joins government, academia, industry, and public interest groups to mutually consider, discuss, and debate the future of environmental health on a regional, national, and international level
RTI International	http://www.rti.org/	Provides government and private-sector clients with environmental and public health expertise
The Hamner Institutes for Health Sciences	http://www.thehamner.org	Fosters translational research in environmental health sciences and chemical risk assessment
Note. Dept, department; Div, division; DU, Duke University; GSGPH, Gillings School of Global Public Health; NCSU, North Carolina State University; RTP, Research Triangle Park; UNC-CH, University of North Carolina-Chapel Hill.		

and environmental protection. As an example, he cites a committee of developers, builders, community members, and environmental groups that conceived of a plan to allow major new residential developments in Wake County, North Carolina, while also meeting requirements for the protection of Falls Lake. The committee devised local ordinances that specified landscape design features to minimize surface water runoff to the lake by dispersing rainwater over natural areas, to support infiltration and evapotranspiration.

The need for community engagement in local decisions that affect environmental quality and, thus, public health was one of the most prevalent themes at the Environmental Health Summit. The participants' primary recommendation was to enlist marketing experts to develop "Environment Matters to Your Health" campaigns, using North Carolina as a test case and local foundations to provide funding. The

campaigns would be designed to educate and mobilize the public around pertinent environmental health issues. When an environmental health issue of concern is identified, each affected community includes individuals with different views of the problem. Some people care passionately about the potential health impacts of environmental exposures, possibly because they have been directly affected; others are indifferent or uninformed; and others oppose action to protect the environment. In addition, some community members have more political influence than others. Messages need to be tailored differently, to target groups with different viewpoints and levels of influence. The marketing campaigns would target 4 different audiences, with a separate messaging strategy for each: individuals who care about the environment (ie, the "public that cares"), people of influence, communities affected by environmental risks,

and individuals who do not hold strong views about environmental protection (ie, the “neutral public”).

In the short term, the “Environment Matters to Your Health” campaigns should focus on messages that concern policies and individual actions that are most readily implementable and feasible. In the longer term, the campaigns should encompass policies and actions that will contribute the most to reducing environmental impacts on health.

Next Steps

North Carolina has demonstrated important leadership in policies, research, and community engagement to protect public health from environmental risk factors. Furthermore, North Carolina is home to some of the leading research institutions focused on understanding and reducing environmental impacts on health (Table 1). Nonetheless, the state’s poor scores on important public health and environmental indicators suggest that much work remains. The North Carolina Environmental Health Summit produced a menu of options that the state can pursue toward the goal of preventing diseases of major importance that are triggered or exacerbated by environmental exposures. Reducing the prevalence of these preventable diseases has the potential to substantially decrease state health care spending over the long term. North Carolina can serve as a national model for reducing the prevalence of preventable diseases and decreasing state health care.

In an era of severe budget constraints, costly new state initiatives are unlikely to be pursued. Therefore, as a next step, the Environmental Health Summit participants recommended that the Research Triangle Environmental Health Collaborative convene an interagency work group that includes community representatives and agency personnel to prioritize the many possible activities represented in the Environmental Health Summit’s menu of recommendations. This work group also could determine potential funding sources for the priority initiatives, to prevent short-term state budget increases while recognizing the substantial potential for these initiatives to decrease costs to the state budget over the long term. **NCMJ**

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References

1. Prüss-Üstün A, Corvalán C. Preventing Disease Through Healthy Environments: Towards an Estimate of the Environmental Burden of Disease. Geneva, Switzerland: World Health Organization; 2006. http://www.who.int/quantifying_ehimpacts/publications/preventingdisease.pdf. Accessed May 8, 2011.
2. North Carolina Institute of Medicine (NCIOM) Task Force on Prevention. Prevention for the Health of North Carolina: Prevention Action Plan. Morrisville, NC: NCIOM; 2009. <http://www.nciom.org/wp-content/uploads/NCIOM/projects/prevention/finalreport/PreventionReport-July2010.pdf>. Revised July 2010. Accessed May 8, 2011.
3. Madsen T, Ouzts E. Air Pollution and Public Health in North Carolina. Brevard, NC: North Carolina Research and Policy Center; 2006.
4. Landrigan PJ, Schechter CB, Lipton JM, Fahs MC, Schwartz J. Environmental pollutants and disease in American children: estimates of morbidity, mortality, and costs for lead poisoning, asthma, cancer, and developmental disabilities. *Environ Health Perspect*. 2002;110:721-728.
5. Schuler K, Nordbye S, Yamin S, Ziebold C. The Price of Pollution: Cost Estimates of Environment-Related Childhood Disease in Minnesota. St. Paul, MN: The Minnesota Center for Environmental Advocacy; 2006.
6. Davies K, Hauge D. Economic Costs of Diseases and Disabilities Attributable to Environmental Contaminants in Washington State. Seattle, WA: Collaborative for Health and Environment, Washington Research and Information Working Group; 2005.
7. Massey R, Ackerman F. Costs of Preventable Childhood Illness: The Price We Pay for Pollution. Boston, MA: Global Development and Environment Institute, Tufts University; 2003.
8. Glaser A. The Price of Pollution: Cost Estimates of Environment-Related Childhood Disease in Michigan. Ann Arbor, MI: Michigan Network for Children’s Environmental Health and the Ecology Center; 2010.
9. Perdue BE. The North Carolina State Budget: Post-Legislative Budget Summary, 2009-2011. Raleigh, NC: Office of State Budget and Management, Office of the Governor; 2011. http://www.osbm.state.nc.us/files/pdf_files/PLS09_11.pdf. Accessed May 8, 2011.
10. Bonner L. DENR weights effect of cuts. *The News & Observer*. April 19, 2011.
11. Natural balance [editorial]. *The News & Observer*. April 20, 2011.
12. Ross WG Jr. The North Carolina Clean Smokestacks Act. *N C Med J*. 2011;72(2):128-131 (in this issue).
13. Wilson O. Lack of basic amenities: indicators of health disparities in low-income minority communities and tribal areas. *N C Med J*. 2011;72(2):145-148 (in this issue).
14. MacDonald Gibson J. A burden of disease approach to prioritizing environmental policy initiatives: a case study in the Middle East. *N C Med J*. 2011;72(2):136-140 (in this issue).
15. Olden K, Isaac L, Roberts L. Neighborhood-specific epigenome analysis: the pathway forward to understanding gene-environment interactions. *N C Med J*. 2011;72(2):125-127 (in this issue).
16. Miranda ML, Edwards SE. Use of spatial analysis to support environmental health research and practice. *N C Med J*. 2011;72(2):132-135 (in this issue).
17. Christakos G, Bogaert P, Serre ML. Temporal GIS: Advanced Functions for Field-Based Applications. New York, NY: Springer-Verlag; 2002.
18. Levine JF. Integration of environmental stewardship and local economic development to enhance community health. *N C Med J*. 2011;72(2):141-144 (in this issue).