The environment in which we live affects our health. During the 20th century the majority of the advances in population health were the result of public health interventions focused on improving the physical environment.[1] Despite these advances, air and water pollution persist and produce negative effects on the health of the population. Air pollution has been shown to cause or worsen respiratory conditions (e.g. asthma and emphysema) and cardiovascular conditions (e.g. heart attack and stroke).[a,2] Water pollution has been linked to both acute poisonings as well as chronic effects. In addition, certain air and water pollutants have been linked to cancer.[2-5]

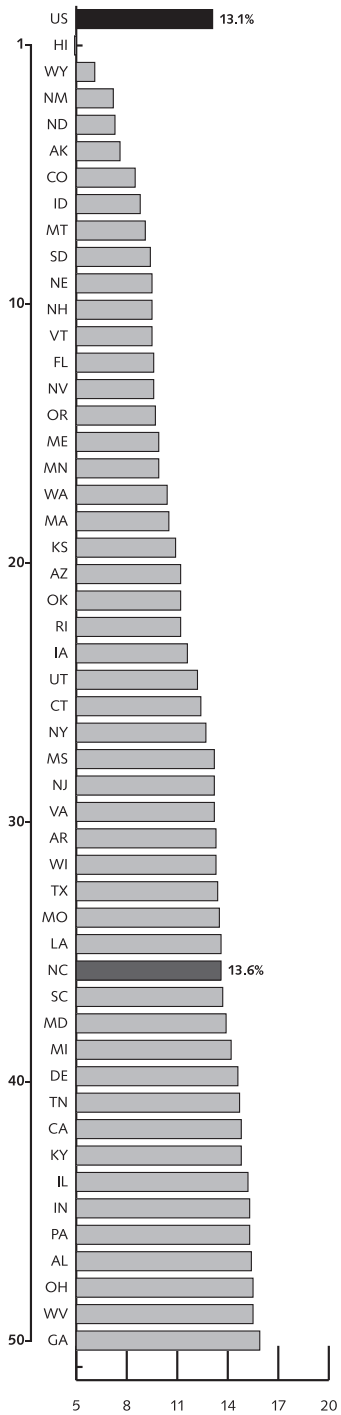
Although the term environment often refers to outdoor air and water quality, the Task Force took a broader view and incorporated other features of the space within which we live, work, and learn. The built environment influences health through differential access to sidewalks, parks, trails, and other open spaces for physical activity.[6] Homes and schools can have poor indoor air quality, affecting respiratory and cardiovascular health as well as the ability to learn.[7] The burden of environmental risks falls disproportionately on children, the elderly, and low-income North Carolinians. For example, low-income North Carolinians are more likely to live in sub-standard housing. (See Chapter 11, Table 11.2.) Even so, everyone in the state can experience the negative effects of an unhealthy environment; all North Carolinians stand to benefit from a cleaner, safer, and healthier environment.

The Outdoor Environment

Air quality

Both short-term and chronic exposure to ambient (outdoor) air pollution is a serious health risk. Such pollutants as particulate matter, ozone, carbon monoxide, lead, sulfur dioxide, and nitrogen dioxide are all linked to increased rates of death and disability.[8,9] In particular, these pollutants negatively affect respiratory and cardiovascular health.[7] Research has shown that air pollutants cause and/or exacerbate such respiratory conditions as asthma, bronchitis, emphysema, and respiratory infection.[2,10,11] Exposure to carbon monoxide has been linked to coronary heart disease, and both particulates and ozone affect cardiovascular health. Additionally, individuals with respiratory conditions, sensitive airways, and heart disease, as well as children and the elderly, are at a greater risk than others for adverse health effects due to exposure to air pollution.[2]

Micrograms of Fine Particulate Matter per Cubic Meter of Air (Fine Particulates 2.5 Micron and Smaller), 2005-2007



Source: United Health Foundation. America's Health Rankings: data tables. United Health Foundation website. http://www.americashealthrankings.org/2008/tables.html. Published 2008. Accessed December 4, 2008.

a Asthma is one of the most common health conditions for children. North Carolina's asthma rate is slightly higher than the national average (10.8% and 9.3%, respectively). (Yeats K. The environment and asthma: strategies for North Carolina. Presented to: the North Carolina Institute of Medicine Prevention Task Force; January 14, 2009; Morrisville, NC.)

Air Pollutants

Under the Clean Air Act, the Environmental Protection Agency (EPA) is required to regulate and set standards for six pollutants: particulate matter, ozone, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead.[b,c] These pollutants are considered "criteria" pollutants because they are commonly found across the United States, and they have negative effects on both public health and the environment.[9] While the EPA sets standards for each of the pollutant concentrations, states must develop the methods to attain the standards. Improvements have been made in lowering air pollution; however both North Carolina and the nation as a whole continue to experience levels of air pollution above the standards. North Carolina ranks 15th highest in the country for exposure to fine particulate matter. (See Figure page 173.)

Both short-term and chronic exposure to ambient (outdoor) air pollution is a serious health risk.

Particulate matter: Particulate matter (especially matter less than 10 μm in diameter) and ozone are the most widespread air pollutants in North Carolina.[11] Particulates are a mix of solid and liquid particles suspended in the air. These particles can contain many different chemicals, including carcinogens and metals. While the majority of larger particulates are coughed or sneezed out of the body, PM_{10} and smaller particulates infiltrate the lungs, and ultrafine particles (less than 0.1 μm in diameter) can pass from the lungs into the blood stream. Short-term increases in particle matter have been linked to increased death due to respiratory and cardiovascular events (e.g. stroke), child mortality, number of heart attacks, and severity of asthma symptoms, and decreased lung function. The body reacts to particle matter similarly to how it reacts to secondhand cigarette smoke. The responses can lead to increased hospitalization and emergency department use. In addition, chronic exposure to particulates is linked to lung damage, slowed growth in lung function in children, and increased risk of death due to lung cancer and cardiovascular disease.[2] A 2006 study of the effects of air pollution on the health of North Carolinians estimated that particulate matter causes thousands of preventable deaths and cases of illness and disability in the state each year.[7,11] (See Table 7.1.) In the past several years, the particulate levels in Catawba, Davidson, and Mecklenburg counties have exceeded the annual EPA standards (15.0 $\mu g/m^3$ for matter less than 2.5 μm in diameter).[12]

Ozone: As shown in Table 7.1, ground level ozone is also estimated to cause preventable illness and disability in North Carolina. Ground level ozone, the major component of smog, is an extremely reactive gas formed through the chemical reaction of volatile organic compounds and nitrogen oxides, fueled by sunlight and heat.[13] Because the reaction is catalyzed by sunlight and heat, ozone levels increase during the hot summer months prevalent in North Carolina. Ozone is the state's most widespread air pollutant, and more than half of the state's population lives in counties where ozone levels, at some time in the year, exceed

b 42 USC 85

c A table of the six priority pollutants and their air quality standards can be found at http://epa.gov/air/criteria.html.

Table 7.1
Particulate Matter and Ozone Lead to Considerable Death and Disability in North Carolina

	Estimated yearly cases
Particulate matter (<10 μm in diameter)	
Premature deaths (adults)	3,000
Respiratory hospital admissions	2,000
Cardiovascular hospital admissions	2,000
New cases of chronic bronchitis	2,500
Asthma attacks	200,000
Missed work days	500,000
Restricted activity days	5 million
Increased symptom days	15 million
Ozone	
Adult onset asthma	1,500
Respiratory hospital admissions	4,000
Asthma attacks	200,000
Restricted activity days	1 million
Increased symptom days	4 million

Source: Madsen T, Ouzts E; Environment North Carolina Research and Policy Center. Air pollution and public health in North Carolina. http://www.environmentnorthcarolina.org/uploads/pi/gC/pigCWFDm1vcQyslTtXzIPA/Air_Pollution_In_NC.pdf. Published February 2006. Accessed July 1, 2009.

More than half the state's population lives in counties where ozone levels, at some time in the year, exceed the EPA standard.

the EPA standard (eight-hour average of 0.075 parts per million[d] or a code orange ozone day).[12] During the summer, ozone levels in many parts of central North Carolina exceed EPA standards. In 2009, the Charlotte-Gastonia-Salisbury metropolitan area ranked the 8th most ozone-polluted city in the nation.[2] The reactivity of ozone can damage the tissues of the lungs, reducing lung function and increasing lung sensitivity and susceptibility to other irritants, even after only a short exposure.[13] Ultimately, short-term exposure to elevated ozone levels can contribute to premature death.[2]

Carbon monoxide, nitrogen oxides, sulfur dioxide, and lead: Carbon monoxide, nitrogen oxides, sulfur dioxide, and lead are also regulated by the EPA; however, they are not as prevalent in North Carolina as particulate matter and ozone. Carbon monoxide is a colorless, odorless gas, and breathing it reduces oxygen delivery to organs and tissues in the body, such as to the brain and heart. As a result, carbon monoxide can cause cardiovascular effects (e.g. chest pain) as well

d In 2008, the Environmental Protection Agency tightened ozone level standards to 0.075 parts per million. Before 2008, the standard was 0.08.(Ozone air quality standards. Environmental Protection Agency website. http://www.epa.gov/air/ozonepollution/standards.html. Update October 14, 2008. Accessed July 2, 2009)

as nervous system effects (e.g. vision problems, reduced ability to learn, and reduced dexterity). In extremely high doses, a single exposure can cause death. In addition, carbon monoxide contributes to the formation of ground level ozone.[9]

Nitrogen oxides are extremely reactive gasses and include nitrogen dioxide, nitrous acid, and nitric acid. Short-term exposure to nitrogen oxides can cause airway inflammation and increased respiratory problems for people with asthma and other respiratory problems. Higher concentrations of nitrogen oxides (30%-100% higher) are typically found near roadways. Approximately 16% of housing units in the United States are located within 300 feet of a major highway, railway, or airport.[14] However, the largest impact from nitrogen oxides in North Carolina is as a precursor to ozone, which has significant effects on health as discussed above.

Motor vehicles—especially diesel engines—are the largest source of air pollution in North Carolina.

Sulfur dioxide produces both gas and fine particulate pollution. Exposure to sulfur dioxide causes particular problems for sensitive groups (i.e. people with asthma, heart disease, and lung disease as well as children and the elderly). Short-term increases in sulfer dioxide levels can cause breathing difficulty for people with existing respiratory problems, and long-term increases in sulfur dioxide particulates can cause respiratory illness, worsen heart disease, and cause premature death.[9] Sulfur dioxide can also move over long distances without dissipating, which can cause problems in areas far from the point of origin.

Due to the removal of lead from gasoline, between 1980 and 1999 the levels of lead in the air decreased 94%. However, lead can still be present in the air. Exposure to lead can affect the nervous, immune, cardiovascular, and reproductive and developmental systems. Infants and young children are particularly sensitive to exposure to lead, which may be linked to behavioral problems and learning deficits.[15]

Sources of Air Pollution

Motor vehicles—especially diesel engines—are the largest source of air pollution in North Carolina. Nearly half of both particulates as well as precursors to ozone (i.e. nitrogen oxides and volatile organic compounds) emissions come from mobile sources (i.e. cars, trucks, buses, and off-road equipment).[11] In addition, three-fourths of carbon monoxide emissions come from cars and trucks, and nitrogen oxides and sulfur dioxide are large components of auto emissions.[16] Motor vehicle emissions are especially problematic in large cities, which have greater numbers of vehicles and levels of traffic.

Coal-fired power plants are another source of air pollution, emitting 67 different pollutants and toxins, including particulates, precursors to ozone (including nitrogen oxides), lead, carbon monoxide, and sulfur dioxide.[17] Coal-fired power plants also release mercury, which settles into the water supply (discussed further in the section on water quality).[e] There are 14 major coal-fired power plants across

e Coal-fired power plants are the largest source of mercury emissions (33%), followed by municipal/medical waste incinerators (29%) and commercial/industrial boilers (18%). (Palmer RF. Blanchard S, Wood R. Proximity to point sources of environmental mercury release as a predictor of autism prevalence. Health and Place. 2009;15:18-24)

North Carolina.[18] In 2002 the North Carolina General Assembly passed the Clean Smokestacks Act, which required coal-fired power plants in the state to reduce their emissions of nitrogen oxides by 77% by 2009 and sulfur dioxide emissions by 73% by 2013.[f] Nitrogen oxides are a main cause of ozone—one of North Carolina's most prevalent air quality problems—and sulfur dioxide is the main cause of fine particle pollution. Measures used to reduce nitrogen oxides and sulfur dioxide emissions are also expected to reduce mercury emissions; the North Carolina Division of Air Quality estimates that the Clean Smokestacks Act will reduce total mercury emissions by 50%.[19] While steps have been taken in North Carolina to reduce power plant emissions, the state cannot regulate emissions in neighboring states, whose pollutants can migrate across state lines.

There are also several new and growing sources of air pollution. These include poultry waste incineration, hog waste, medical waste incineration, and waste from energy incineration. While the emissions produced from these sources have not been well-characterized, some (e.g. poultry manure incineration) could be worse than coal-fired power plants.[7] Living in close proximity to hog operations has been associated with heightened levels of certain reported health problems, including headaches, runny nose, sore throat, excessive coughing, diarrhea, asthma, and burning eyes.[20] These findings are consistent with a later study conducted in 16 North Carolina communities which found that levels of hydrogen sulfide particulate matter, pollutants produced by hog operations, were elevated at times when community residents reported hog odor.[21] Another study found higher prevalence of wheezing symptoms and doctor-diagnosed asthma reported by children attending North Carolina public middle schools where staff noticed livestock odor inside school building twice per month or more.[22] In North Carolina, industrial swine operations are located disproportionately near low income schools and schools attended by students of color, meaning that local air pollution from these sources has the greatest potential to impact populations of children that suffer from higher rates of asthma and have poor access to medical services.[23]

In North Carolina, industrial swine operations are located disproportionately near low income schools and schools attended by students of color, meaning that local air pollution from these sources has the greatest potential to impact populations of children that suffer from higher rates of asthma and have poor access to medical services.

Indoor air quality also influences health. Mold, radon, carbon monoxide, humidity, and other indoor pollutants can cause or worsen asthma, allergic reactions, the ability to concentrate and learn, and lung cancer.[7] Indoor air quality in homes and school-based risks are discussed in more detail below.

Water Quality

Water pollution is caused by both naturally occurring contaminants (e.g. arsenic in bedrock and algal toxins) and human activities (e.g. use of petroleum, agriculture, and industry) and can affect both groundwater and source water.[7] Drinking water in North Carolina comes from both groundwater (through private wells and aquifers) and source water (from lakes, rivers, and streams). More than half of North Carolinians rely on groundwater for drinking, through both private wells and public aquifers.[24] The water quality of public water systems is regulated

f SL 2002-4

by the North Carolina Department of Environment and Natural Resources, Division of Environmental Health. In contrast to public water supplies, private wells are not subject to inspection. As a result, North Carolinians using privately supplied drinking water are at a greater risk for drinking contaminated water. This is a considerable population in our state: according to the US Geological Survey, there are approximately 2.7 million people in North Carolina that rely on private wells for their drinking water. A higher percentage of people in North Carolina rely on privately supplied drinking water than nationally (34% and 15%, respectively).[25]

In contrast to public water supplies, private wells are not subject to inspection. As a result, North Carolinians using privately supplied drinking water are at a greater risk for drinking contaminated water.

Arsenic and algal toxins are naturally occurring contaminants. Algae blooms of blue-green algae (i.e. cyanobacteria) in freshwater lakes and ponds can release toxins into the water, which can cause illness and death in humans if ingested.[26] Arsenic is an element found in many geological formations and is released into groundwater as water flows across rocks and soil containing arsenic. Geological events and stresses, such as earthquakes and droughts, can cause the release of excess levels of arsenic.[27] Regular consumption of high levels of arsenic in water has been linked to bladder, lung, skin, liver, kidney, and prostate cancer.[3,5] Arsenic exposure can also cause skin lesions, stomach pain, nausea, vomiting, diarrhea, numbness of the hands and feet, partial paralysis, and blindness. There is some evidence that low levels are associated with cardiovascular health, diabetes, and adverse reproductive outcomes.[28] Arsenic is also used in pesticides and other agricultural products as well as in wood treatment. Run-off from pesticides can introduce arsenic into groundwater; arsenic in treated wood can leach into the soil and seep down into groundwater. The EPA's maximum contaminant level for arsenic is 0.010 parts per million.[g] Due to the geological rock formations in the North Carolina Piedmont, this area has the greatest probability of increased arsenic levels in groundwater, with several areas experiencing arsenic levels in water above the EPA standard.[29] The Charlotte-Mecklenburg area has some of the highest levels of groundwater arsenic concentrations in the state.[30]

Agriculture can introduce multiple types of pollutants into the water. Pesticides used on crops can run-off or seep into water supplies. Industrial animal farming generates large amounts of animal waste which harbors pathogens and chemical contaminants. Animal waste can be a source of groundwater contamination when used as sprayed fertilizer or when it is improperly disposed.[31] The health effects of drinking contaminated water depend on the contaminant. Some pesticides may irritate the skin or eyes, some affect the nervous system, and some have been linked to cancer.[4] Nitrates from agricultural fertilizers, as well as human and animal waste, can seep into groundwater or run-off into surface waters. Ingestion of nitrates (levels exceeding about 10%) reduces the ability of red blood cells to carry oxygen, a condition known as methemoglobinemia (or blue baby syndrome, as babies are particularly susceptible to developing the condition). This acute effect

g In 2001, the Environmental Protection Agency adopted a new standard for arsenic in drinking water at 10 parts per billion (ppb), replacing the old standard of 50 ppb.

can be serious and can even result in death. Nitrates are also the precursor to N-nitroso compounds (NOC), a class of cancer causing agents. Several studies have linked drinking nitrate contaminated water with increased levels of certain types of cancer; however, results are mixed.[32]

Old, unlined solid waste facilities (i.e. landfills) can also be sources of groundwater contamination. Hazardous substances can leach from the waste and seep into groundwater. In North Carolina, many of these older sites have a house, school, day care, church, or drinking water source within 1,000 feet of the landfill or a well within 500 feet.[33] Studies of the effect of contaminated water supplies on health have been mixed and depend on the contaminant. However, in 1991 the National Research Council concluded that contamination of drinking water from solid waste facilities could lead to adverse health effects.[34]

Industry, such as power plants and pharmaceutical manufacturers, can dump pollutants into the water supply as well. Mercury naturally occurs in coal, and when coal is burned in power plants, it is released into the air and can settle into surrounding water formations. The mercury is absorbed by fish and shellfish, which can accumulate very high levels of mercury (methylmercury in fish). Consumption of high levels of methylmercury can cause adverse health effects in the brain, heart, kidneys, lungs, and immune system.[35] In addition, high levels of methylmercury can impair the development of the nervous system in children. Mercury has been linked to increased rates of autism in children living in close proximity to power plants.[36] Pharmaceuticals can enter the water supply through both industrial waste from pharmaceutical manufacturers and individual waste. Some research suggests that certain pharmaceuticals in the water supply can produce ecological harm.[37] However, further research is needed to determine if pharmaceutical contamination has negative effects on human health.

In addition, underground gasoline storage tanks can leak and contaminate groundwater. Methyl-t-butyl ether (MTBE) is a volatile organic compound added to gasoline to reduce carbon monoxide and ozone caused by auto emissions.[38] While the health effects of exposure to MTBE are still being examined, the EPA is considering drinking water standards for MTBE. Benzene, a known carcinogen, is also a component of gasoline which can seep into and contaminate groundwater.[39]

Built Environment

The built environment—including neighborhood design, land use patterns, and transportation systems—affects health, because it influences the levels of physical activity that people engage in.[6] Physical activity is an important part of a healthy lifestyle. Regular physical activity reduces the risk of premature death, prevents against feelings of depression, and helps to prevent obesity. Even small amounts of regular exercise are beneficial to health and produce financial savings by reducing medical expenses.[40]

Access to more places for physical activity, particularly sidewalks, trails, and parks, has been shown to increase activity levels.[41] In North Carolina, it is important to make the built environment more conducive to physical activity, as nearly 60% of

The built environment—including neighborhood design, land use patterns, and transportation systems—affects health, because it influences the levels of physical activity that people engage in.

North Carolinians report they would increase their physical activity if their community had more accessible trails for walking or bicycling.[42] As such, the Task Force recommends building active living communities and expanding the Community Grants Program. A more thorough discussion of the built environment and physical activity, as well as the recommendations in this area, can be found in Chapter 4.

Reducing Environmental Risks

Reducing environmental risks is an important component to preventing death and disability. North Carolina needs to address the major pollutants and causes of pollution in the state, as well as the built environment, to build healthy, active communities. Promoting healthy communities requires creating solutions for all of these environmental risks. Improving the built environment will provide people with increased access to areas to participate in physical activity. However, if the air is polluted and unhealthy, people will not utilize the improved built environment to the extent possible. In addition, the state should emphasize the protection of vulnerable populations such as children, the elderly, and low-income and minority North Carolinians. Children and the elderly are more susceptible to the negative health effects of an unhealthy environment, and low-income and minority individuals are disproportionately exposed to some environmental risks.[10] For example, both solid waste facilities and intensive hog operations are more likely to be located in minority and low-incomes communities than non-minority, higher income communities. Minority and low-income populations may be at greater risk for consuming nitrates as solid waste facilities are 2.8 times more likely to be located in majority-minority communities (i.e. communities with more than 50% minority populations) than in communities with less than 10% people of color. This group is also 1.5 times more likely to live in communities with median household values of less than $60,000, as compared to communities with median household values of $100,000 or more.[h,43] A North Carolina study found that there are 7.2 times as many intensive hog operations in communities in the highest quintile of poverty compared to the lowest; communities in the three highest quintiles of percentage non-white population have approximately five times as many intensive hog operations as compared to the lowest quintile.[h,44] In addition, people living near major highways, railways, and airports are more likely to be low-income and minorities.

North Carolina needs to address the major pollutants and causes of pollution in the state, as well as the built environment, to build healthy, active, communities.

To reduce air pollution, the state needs to examine ways to reduce emissions from mobile sources—particularly those with diesel engines—such as the development and improvement of mass transportation systems in urban areas, strengthening of vehicle emissions standards, increasing the use of alternative energy/fuel sources, and decreasing vehicle idling. The use of alternative energy sources and stricter emissions standards could also further reduce emissions from coal-fired power plants. Water quality can be improved by reducing the release of pollutants into the water supply and by improving the detection and treatment of already contaminated water. The American Recovery and Reinvestment Act of 2009

h These findings adjust for population density.

provides funding for states to reduce environmental risks, promote sustainability, and support "green" initiatives.[i] As of July 13, 2009, North Carolina has received over $148 million in funding through the EPA.[45] (See Table 7.2.) However, North Carolina needs a statewide plan for how to use these and other resources to promote healthy communities, minimize environmental risks, and promote sustainability and "green" initiatives that will support and improve the public's health and safety. Agencies and stakeholders across disciplines need to work together to devise and implement evidence-based, workable strategies for reducing environmental risks in North Carolina.

Agencies and stakeholders across disciplines need to work together to devise and implement evidence-based, workable strategies for reducing environmental risks in North Carolina.

Table 7.2
American Recovery and Reinvestment Act Funding to Reduce Environmental Risks in North Carolina (July 13, 2009)

Project	Funding
Reduce underground petroleum leaks	$7.5 million
Reduce school bus diesel emissions	$509,000
Improve water quality	$714,400
Clean up brownfields	$1.6 million
Reduce emissions from diesel engines	$1.73 million
Drinking water infrastructure	$65.5 million
Clean water infrastructure	$70.7 million

Source: Environmental Protection Agency. Region 4: EPA Southeast information related to the American Recovery and Reinvestment Act of 2009 (Recovery Act). Environmental Protection Agency website. http://www.epa.gov/region4/eparecovery/newsroom.html. Updated July 10, 2009. Accessed July 13, 2009.

Therefore, the Prevention Task Force recommends:

Recommendation 7.1: Create an Interagency Leadership Commission to Promote Healthy Communities, Minimize Environmental Risks, and Promote Green Initiatives

The Governor or the North Carolina General Assembly should create an Interagency Leadership Commission to develop a statewide plan to promote healthy communities, minimize environmental risks, and promote sustainability and "green" initiatives that will support and improve the public's health and safety. The Interagency Leadership Commission should create an implementation plan that includes the roles that each agency will play in implementing the plan, the costs of the plan, and potential funding sources. The plan should emphasize local sustainability, environmental justice, protection of vulnerable populations, and precaution. Contents of the plan should include, but not be limited to, statewide efforts to promote active, walkable, livable

i Pub L. 111-005

communities; reduce environmental exposures and risks that negatively impact population health; promote clean, renewable energy, green technology, and local production of food, energy, goods, and services; and increase opportunities for mass transportation.

a) **The Interagency Leadership Commission should include senior level agency staff from the North Carolina Department of Transportation, Department of Health and Human Services, Department of Public Instruction, Department of Environment and Natural Resources, Department of Commerce, State Board of Education, Board of Transportation, Department of Insurance, North Carolina Community College System, and University of North Carolina System. The Commission should also include representatives from the League of Municipalities, North Carolina Association of County Commissioners, North Carolina Association of Metropolitan Planning Organizations, North Carolina Association of Local Health Directors, North Carolina Recreation and Park Association, North Carolina State Society for Human Resource Management, the North Carolina Chamber, and at-large members of the public.**

b) **The Interagency Leadership Commission should oversee the environmental assessment described in Recommendation 7.2 and should lead the development of a communications campaign to educate and inform North Carolinians of the findings and implications and actions being taken as a result of the assessment.**

c) **The Interagency Leadership Commission should present the plan to the Governor and the Joint Legislative Commission on Governmental Operations no later than January 1, 2011, and should report progress on implementation of the plan at least once annually thereafter.**

It will be hard to create a statewide plan without sufficient data on environmental risks in North Carolina and their effects on health. The Department of Environmental Sciences and Engineering in the University of North Carolina (UNC) Gillings School of Global Public Health is currently the lead institution working to produce an environmental health strategy for the United Arab Emirates (UAE), including a systematic assessment of environmental risks in the country and the effects on health. UNC is building a model to quantify the public health effects of the top environmental risks in the UAE, which will be later used to determine the public health benefits of strategies to control the key risk factors.[46] This project provides a science-based model that North Carolina can use to develop an environmental health strategic plan. Therefore, the Task Force recommends:

Recommendation 7.2: Develop an Environmental Assessment for North Carolina that Links Environmental Exposures to Health Outcomes

The Department of Environmental Sciences and Engineering in the University of North Carolina (UNC) Gillings School of Global Public Health should collaborate with the North Carolina Division of Public Health, North Carolina Department of Environment and Natural Resources, North Carolina Department of Agriculture and Consumer Services, and North Carolina Agromedicine Institute (East Carolina University, North

Carolina State University, and North Carolina Agricultural and Technical State University) to develop an environmental assessment for the state that links environmental exposures/risks and health outcomes and includes strategies to address the exposures/risks. This environmental assessment should be conducted to address the priorities and needs of the state as identified by the Recommendation regarding an Interagency Leadership Commission. The North Carolina General Assembly should appropriate $3 million in non-recurring funds in SFY 2011 to the UNC Gillings School of Global Public Health to support this effort.

The Indoor Environment

Reduce Environment Hazards in Homes

Damp houses with poor ventilation and/or water or plumbing leaks provide a fertile environment for mold growth as well as for insect or rodent infestations. Mold has been found to be associated with asthma and other chronic respiratory problems, as well as such conditions as chronic headache and sore throat.[47-49]

Uncontrolled pest infestations can aggravate asthma and increase the risk of hospitalization for asthma symptoms, particularly in children.[50]

Low-income households and older homes have been found to have the highest concentrations of mouse and cockroach allergens.[51] Studies have also shown that children with asthma who are allergic to cockroaches and live in cockroach-infested homes have a 3.4 times heightened risk of hospitalization compared to children with asthma exposed to other allergens, such as dust mites or cat dander.[52]

Old dirty carpeting, which is often found in substandard housing, can also contain dust, allergens, or other toxic chemicals which can cause allergic, respiratory, neurological, or hematological illnesses.[53] Research suggests that nationally almost 40% of the asthma diagnosed in children younger than age six is due to environmental health risks from the home.[54] In North Carolina, a statewide survey of parents reported that 14.2% of children under the age of 18 had at some point been diagnosed with asthma, and 8.2% have a current asthma diagnosis.[55] More than 15% of children with a current asthma diagnosis have missed one or more weeks of day care or school within the past 12 months due to their asthma.

Exposure to lead, through both lead-based paint and lead in water pipes, is another health risk present in housing, especially in older homes. Exposure to lead and lead contamination is particularly problematic for very young children. A single high-dose exposure to lead can cause serious health problems, but more commonly, the harm occurs from repeated exposure to low levels of lead.[56,57] Exposure to lead can result in behavioral, cognitive, and developmental problems. It can also lead to seizures and, in some instances, death.[58,59] Although lead pipes were banned for use for drinking water in 1986, and lead solder was banned by the North Carolina Building Code Council in 1985, many older homes still contain lead.[60] Lead paint can be found in houses built before 1978, which includes about

Damp houses with poor ventilation and/or water or plumbing leaks provide a fertile environment for mold growth as well as for insect or rodent infestations… Research suggests that nationally almost 40% of the asthma diagnosed in children younger than age six is due to environmental health risks from the home.

44% of the housing stock in North Carolina.[j,61] Older homes are the most likely to have lead paint; about 87% of homes built before 1940 have lead paint, as do 69% of houses built between 1940 and 1960, and 24% of homes built between 1960 and 1978.[62] The US Department of Housing and Urban Development (HUD) estimates that 27% of American homes and 34% of those with one or more children under age six, have significant lead-based paint hazards.[63] The North Carolina Division of Public Health operates a lead abatement program that tests children for potential lead poisoning. Lead abatement is generally required when a child less than age six, living in housing with lead poisoning hazards, has a blood lead level of 20 µg/dL (micrograms per deciliter) or greater.[k,l] Of the more than 650,000 children tested between 2003-2007, 1% were determined to have elevated blood lead levels of more than 10 µg/dL, and one-tenth of one percent (877 children) were found to have blood lead levels of greater than 20 µg/dL. In 2008, out of nearly 150,000 children tested for lead poisoning (>20 µg/dL) in North Carolina, 38 children were confirmed to have lead poisoning.[m] Abatement must be conducted by certified contractors, and a permit for abatement must be obtained from the North Carolina Division of Public Health's Occupational and Environmental Epidemiology Branch. While the property owner is responsible for remediating lead hazards, the Division of Environmental Health implements the Lead Hazard Control grant from HUD to address lead hazards in pre-1978 housing.[n] These funds may also be used to help address lead hazards for low-income property owners. In addition, children with blood lead levels of 45 µg/dL or higher, and adults with levels approximately 70-80 µg/dL or greater, may need to undergo chelation therapy (i.e. a chemical treatment to flush lead out of the body) to reduce blood lead levels.[o]

Exposure to airborne toxic substances in the home is also a well-established risk factor for health problems.

Exposure to airborne toxic substances in the home is also a well-established risk factor for health problems.[57] These toxic substances can come from a number of sources, including poisons released from building materials, toxic gases that enter through the basement or are emitted from appliances, and exposure to household chemicals.[64-66] Carbon monoxide and asbestos are two notable toxic substances. Carbon monoxide poisoning is a significant health risk, particularly for homes with poor ventilation. This odorless, colorless gas is one of the leading causes of death by poisoning in the United States. Eighty-six North Carolinians are known

j Lead paint for residential use was banned in 1978.

k N.C.G.S. 130A-131.9C(a)

l An environmental investigation is conducted once a lead-poisoned child is identified. The investigation is conducted by the local health department and a regional specialist from the Division of Environmental Health, North Carolina Department of Environment and Natural Resources. If lead contamination is present, either abatement or interim controls to address deteriorated surfaces is conducted. Interim controls require annual monitoring.(Norman E. Division of Environmental Health, North Carolina Department of Environment and Natural Resources. Written (email) communication. June 26, 2009.)

m Norman E. Division of Environmental Health, North Carolina Department of Environment and Natural Resources. Written (email) communication. June 26, 2009.

n The Lead Hazard Control grant was awarded in 2006. It is a three-year, $3 million grant for the remediation of 202 homes in North Carolina. (Norman E. Division of Environmental Health, North Carolina Department of Environment and Natural Resources. Written (email) communication. June 26, 2009.)

o Langley R. Division of Public Health, North Carolina Department of Health and Human Services. Written (email) communication. June 23, 2009.

to have died from accidental, non fire-related carbon monoxide poisoning between 1999 and 2004, although the true number may be higher since carbon monoxide deaths are not required to be reported to authorities.[67] Chronic exposure to carbon monoxide can also lead to health issues.[68] Asbestos is a group of naturally occurring minerals comprised of small fibers and is used in many different building supplies, including those used in homes. These small fibers can cause cancer when inhaled into the lungs.[69] Many other building materials, furnishings, and paint can also be sources of harmful indoor air pollution.[70]

Radon, a naturally occurring radioactive element, can also invade homes, typically through soil or groundwater.[p] It is estimated that one in ten North Carolina homes has an airborne radon level above the EPA action level. Extended exposure to radon can increase the risk of lung cancer.[71,72] Because of the potential health risks, the EPA recommends that people make changes to their homes to reduce the radon levels if the indoor levels are four or more picocuries per liter of air (pCi/L). According to the EPA, there are eight North Carolina counties that have a predicted indoor radon level of greater than four pCi/L: Alleghany, Buncombe, Cherokee, Henderson, Mitchell, Rockingham, Transylvania, and Watauga. There are an additional 31 counties with an elevated risk of between two and four pCi/L.[q,73] North Carolina also recommends that homes with radon levels above the EPA action level seek radon mitigation. Abatement and mitigation should be performed by a certified radon contractor. As with lead abatement, the homeowner is required to pay for radon mitigation and abatement.

The sources of unhealthy household environments are many and varied. Natural factors, often exacerbated by older or substandard homes, contribute to household health problems. Poorly designed and maintained homes can also increase injury risk due to falls, burns, and poisonings (as described more fully in Chapter 8). Those who experience these acute problems often require costly, long-term care.[74-76]

The sources of unhealthy household environments are many and varied. Natural factors, often exacerbated by older or substandard homes, contribute to household health problems.

The Centers for Disease Control and Prevention (CDC), HUD, and EPA are all working together to improve housing conditions and create healthier homes.[51] The goal of the Healthy Homes Initiative is to "identify health, safety, and quality-of-life issues in the home environment and to act systematically to eliminate or mitigate problems."[s] As part of this initiative, CDC and its partner agencies are working to broaden the capacity of the different professionals who inspect homes to address multiple housing problems that can affect health or safety, including mold, lead, allergens, asthma, carbon monoxide, home safety, pesticides, and

p Radon is a naturally occurring gas that comes from the decay chain of uranium or thorium founds in some soil, rocks or water.

q Alexander, Ashe, Avery, Burke, Caldwell, Caswell, Catawba, Clay, Cleveland, Forsyth, Franklin, Gaston, Graham, Haywood, Iredell, Jackson, Lincoln, Macon, Madison, McDowell, Polk, Rutherford, Stokes, Surry, Swain, Vance, Wake, Warren, Wilkes, Yadkin, Yancey

r Rosfjord C. Western Radon Coordinator, North Carolina Radon Program. Oral communication. June 29, 2009.

s Centers for Disease Control and Prevention. Healthy Homes Initiative. http://www.cdc.gov/healthyplaces/healthyhomes.htm. The Healthy Housing Reference Manual is available at: http://www.cdc.gov/nceh/publications/books/housing/housing.htm

radon. The federal agencies have also identified low-cost strategies that families and home owners can use to reduce health and safety risks in substandard housing. (Substandard housing is discussed more fully in Chapter 11, and injuries are covered in Chapter 8.) For example, some falls can be prevented through home modifications, including the installation of grab bars in bathtubs or showers or adding lighting or railings to stairwells. The number of fire or burn-related injuries that occur in the home can be reduced through the installation of smoke alarms or reducing the temperature of hot water heaters. Carbon monoxide poisoning can be averted through the installation of a carbon monoxide monitor. In addition, some unintentional poisonings can be averted by safe storage of hazardous household products.

The goal of the Healthy Homes Initiative is to "identify health, safety, and quality-of-life issues in the home environment and to act systematically to eliminate or mitigate problems."

As part of the Healthy Homes initiative, the CDC, HUD, and EPA are helping state centers provide interdisciplinary training for housing, health, environmental, and other professionals. For example, the North Carolina State University Cooperative Extension/Advanced Energy Healthy Homes Training Center for North Carolina was established in 2008 to offer the Essentials Healthy Homes Practitioners Course. The course was developed by the CDC, HUD, and EPA and leads to a national certification.[t]

The Task Force on Prevention supports the goals of the Healthy Homes Initiative. There are many different types of health, environmental, or housing inspectors who work in North Carolina homes and who could be cross-trained to identify and help mitigate multiple health, environmental, and safety risks while in a home. For example, the Division of Public Health runs the childhood lead abatement program, which helps reduce lead contaminants in households when elevated blood lead levels have been detected in children. Most houses are also inspected before they can be sold.[u] Housing inspectors are licensed by the North Carolina Home Inspector Licensure Board. These inspectors could be trained to comprehensively examine household environmental and health risks when they inspect homes. Similarly, public health professionals sometimes visit homes to identify asthma triggers for children or to eliminate fall risks for older adults, and fire marshals may visit homes to reduce fire risks. These professionals could be cross-trained to identify all housing hazards when they are in the home and to help families reduce these health risk factors.

Recommendation 7.3: Ensure Healthy Homes

The North Carolina Division of Public Health, the North Carolina Division of Water Quality, the North Carolina Department of Environment and Natural Resources, Office of the State Fire Marshal, and North Carolina Department of Insurance should expand

t The Essential Health Homes Practitioners course is a 2- day training. People need to pass a national certification exam. The course fee is $75 for nonprofit, government and $245 for private, for- profit. An additional fee for the National Environmental Health Association's (NEHA) Healthy Homes Specialist credential is $150 for NEHA members and $200 for non members.

u Warner D. Executive Director, North Carolina Home Inspector Licensure Board, North Carolina Department of Insurance. Oral communication. July 7, 2009.

and enhance efforts to create healthy homes. These efforts should address, but not be limited to, the following: indoor air quality, mold and moisture, carbon monoxide, lead-based paint, radon, asbestos, drinking water, hazardous household products, pesticide exposure, pest management, and home safety (includes injury prevention of falls, etc). As part of this initiative:

- **a) The Building Code Council should revise the state building code to require all residences with fossil fuel burning appliances or attached garages to have carbon monoxide alarms.**
- **b) The North Carolina Home Inspector Licensure Board should require licensed home inspectors to have the National Environmental Health Association's Healthy Homes Specialist Credential and to inspect homes comprehensively for environmental health and safety hazards any time the home is required to be inspected.**
- **c) Individuals such as state and local public health and fire marshal staff and building inspectors, who regularly visit homes to provide advice regarding health and safety and to conduct building inspections and environmental inspections, should have the National Environmental Health Association's Healthy Homes Specialist Credential. Agency staff who are so certified should conduct comprehensive health and safety assessments when visiting homes and provide families with information about existing environmental or safety hazards and how identified hazards can be abated. Building inspectors and staff of state and local public health departments and the fire marshal should have their Healthy Homes Specialist Credential certification by the end of 2012.**

Reduce School-Based Risks

As mentioned above, children are especially sensitive to environmental pollutants and toxins. Children and adolescents spend a large proportion of their time in school.[77] In addition, in North Carolina, nearly 9,000 young children are enrolled in Child Care Centers and Family Childcare Homes.[78] Approximately 1.6 million children in North Carolina are enrolled in school, nearly 89% in public schools.[79] However, about one-third of schools in the United States are believed to have significant environmental risk issues and are in need of extensive repair or renovation.[80,81] Studies have shown that these school-based environmental risks are linked to decreased performance; students attending schools in poor condition (i.e. with environmental hazards) score approximately 11% lower on standardized tests than students who attend schools in good condition.[81,82]

Studies have shown that these school-based environmental risks are linked to decreased performance.

Schools can have indoor air quality problems similar to those in homes. Mold and mildew thrive in buildings with moisture and ventilation issues and can accumulate in the building heating, ventilation, and air conditioning (HVAC) systems.[83] Poorly operating HVAC systems can also result in overly hot or cold buildings that are uncomfortable for students and staff. Pest infestations are also common in damp buildings. Infestations can aggravate asthma symptoms, and pesticides used to reduce infestations can irritate the skin or eyes, affect the nervous system, or cause cancer.[4,50]

In addition, schools may have problems with exposures to toxic substances such as radon, arsenic, asbestos, carbon monoxide, and lead-based paint. A nationwide survey of radon levels in schools estimates that approximately one in five schools have at least one room with a short-term radon level above the action level of 4 pCi/L (picoCuries per liter).[84] Arsenic from treated wood (such as wood used for playground equipment) can leach from the wood and be picked up by children. Arsenic exposure can cause skin lesions, stomach pain, nausea, vomiting, diarrhea, numbness of the hands and feet, partial paralysis, and blindness.[28] While the EPA banned the use of arsenic in wood treatments in 2003, children can still be exposed to wood structures treated prior to 2003. Asbestos are used in building materials such as floor tile, linoleum, sheet vinyl, cement siding, roofing, pipe insulation, sprayed-on fireproofing, and decorative ceiling treatments. If inhaled due to damage of asbestos-containing products, asbestos can cause cancer.[69] Carbon monoxide may be a particular problem for schools with poor ventilation. In addition, chronic exposure to lead dust, from buildings with lead-based paint, can cause behavioral, cognitive, and developmental problems.[58,59]

The EPA has created the *Indoor Air Quality Tools for Schools* Program as a means of reducing exposure to indoor environmental contaminants in schools by identifying, correcting, and preventing indoor air quality problems.

In 2006, the North Carolina General Assembly passed the School Children's Health Act to reduce student and staff exposures to several pollutants in schools: pesticides, mercury, arsenic, diesel fumes, and mold/mildew.[v] The bill require schools to use integrated pest management to reduce the use of pesticides in schools; seal arsenic treated wood; reduce exposure to idling school bus diesel emissions; prevent mold and mildew; and prohibits the use of bulk elemental mercury in science classrooms. However, more can be done to improve indoor air quality in schools. The EPA has created the *Indoor Air Quality Tools for Schools (TfS)* Program as a means of reducing exposure to indoor environmental contaminants in schools by identifying, correcting, and preventing indoor air quality problems. The program works through the voluntary adoption of indoor air quality management practices and uses existing staff to execute simple and inexpensive improvement measures. Schools can use the *TfS Action Kit* (available from the EPA at no charge), which outlines best practices, industry guidelines, sample policies, and a sample indoor air quality management plan. Schools that have implemented the *TfS Action Kit* have seen increases in comfort levels and reductions in absenteeism, headaches, stomach aches, bronchitis, asthma inhaler use, visits to the school nurse for asthma symptoms, and symptoms of other respiratory illnesses.[85] In addition, the costs to implement the program have been minimal. Decreasing environmental risks in schools will support the NC Healthy Schools Initiative (discussed in Chapter 12). To further improve the indoor air quality in schools, the Task Force recommends:

v S.L. 2006-143

Recommendation 7.4: Reduce Environmental Risks in Schools and Child Care Settings

The North Carolina Division of Public Health (DPH), in conjunction with the North Carolina Department of Public Instruction (DPI), North Carolina Department of Environment and Natural Resources (DENR), and North Carolina Cooperative Extension, should train elementary and secondary school staff to conduct inspections and identify potential environmental hazards in accordance with the US Environmental Protection Agency's Tools for Schools Program. The North Carolina General Assembly should appropriate $400,000 in recurring funds beginning in SFY 2011 to DPH to support this effort.

a) **DPH and the North Carolina Division of Environmental Health, in conjunction with the North Carolina Division of Child Development, should adapt the Tools for Schools assessment for child care centers and include the assessment in the child care center inspection by local environmental health specialists. The North Carolina General Assembly should appropriate $28,000 annually for four years beginning in SFY 2011 to DPH to support this effort.**

b) **DPI and the North Carolina Division of Child Development, in collaboration with DPH and DENR, should develop an implementation plan to phase in the Tools for Schools assessments in all schools and licensed child care centers over a four-year period. Child care centers would be required to complete the assessment as part of child care center licensure requirements.**

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