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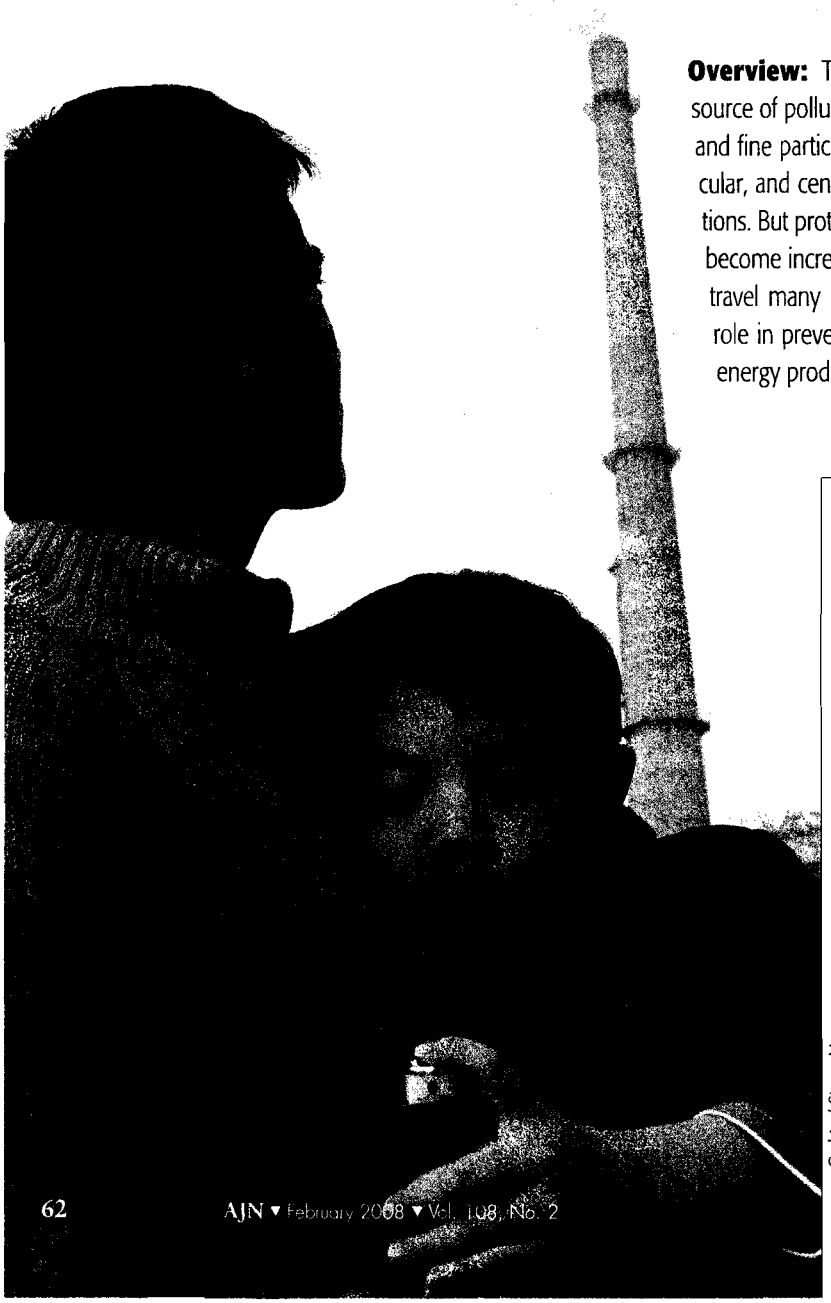
By Alane B. O'Connor, MS, APRN,BC, and Callista Roy, PhD, RN, FAAN

Electric Power Plant Emissions

Potentially harmful pollutants to be aware of and how they may affect the public's health.



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Overview: The generation of electric power is one important source of pollutants such as mercury, sulfur dioxide, nitrogen oxides, and fine particulate matter that can affect the respiratory, cardiovascular, and central nervous systems and cause pregnancy complications. But protecting people from environmental health hazards has become increasingly complex. Air pollutants are often invisible and travel many miles virtually undetected. Nurses can play a critical role in preventive strategies, as well as in the national debate on energy production and dependence on fossil fuels.

Protecting the public health is intrinsic to nursing practice,[1] but addressing the consequences of environmental pollutants can be quite complicated. For example, because many emissions are invisible, the potential for adverse health effects may not be readily apparent. Also, problems of this kind can seem so large and overwhelming that they're discouraging. But nurses can make important contributions to environmental health.

In this article we review the adverse health effects of exposure to ambient (or outdoor) air pollution, with a special focus on electric power plant emissions. We've found that for many reasons it's difficult to draw direct conclusions about the specific health effects of this one source of pollutants. Air pollution is caused by emissions from many sources: motor vehicles, heavy industry, and electric power plants are of greatest concern. Weather and other environmental factors can cause an

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Art of Nursing

By Ron Giles, PhD

Rounds with the Public Health Nurse, 1966

So remote the route, she had to drive into Georgia and double back into the north Alabama county where her patients lived in deep mountains, on gravel roads curling by cotton patches, from which the wind swept dust into trees, brown as green in the August sun. At the first house, perched on stones about five feet above the grassless yard, the nurse advised the young farmer, who didn't step down from the porch, to put screens on the windows so that the flies would not pester his family. He claimed the flies didn't bother them anyway. I waited in the yard and watched the little girl playing with a beagle. About five, she had a scar like a red button on her forehead. Her mother, coming up from the garden with turnip greens in a straw basket, stopped beside me. When I said "Hello," she said only "Allie got spurred by a rooster," and walked on, leaving the *oh* caught in my throat for the blue eye spared, bright above the beagle's tongue.

We drove on into resistance, into the belief that you could not add water to powder from a box and make milk, or that the baby would die if you didn't break him out in hives. The nurse told a man loafing at a country store that it was time for him to cut a cord of firewood against November mornings when the cold caught up to the yellowing leaves, and he stretched and yawned and lit another cigarette. But the old lady dipping Tube Rose snuff and spitting into a coffee can beside her rocking chair under the oak had been taking her blood pressure pills, and the teenage mother proudly demonstrated how she remembered the right way to sterilize bottles, to test the lukewarm milk by squirting a drop on the upturned wrist. Though we couldn't find the man who the nurse feared had tested positive for TB, we met a midwife who told us about a baby she had delivered a week ago in a house that had already burned down. She heard that the family had moved on toward Rome. And she was sorry that she had forgotten her pencil to write it down, but the little girl weighed about six pounds, looked healthy, and they named her Nellie Jo or Jean. The nurse recorded the day's progress in a black book with a leather band, and we drove back into Georgia. Turning for home at the crossroads where a red barn's roof issued its command to See Rock City, we both were thinking of Nellie, hoping her father found work at the mill, and a rental house and lot without a banty rooster sidling through the sandy yard.

Ron Giles is a professor in the English Department at East Tennessee State University, Johnson City. He is the editor of *In Place: A Collection of Appalachian Writers* (Center for Appalachian Studies and Services, 1988); his poems and stories have appeared in various literary journals, including *Silk Road, Paper Street,* and *Birmingham Poetry Review.* This poem is based on the author's memories of accompanying his mother on her rounds through rural Alabama. Contact author: giles@etsu.edu.

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uneven distribution of pollutants, and different routes of exposure to emissions can cause different health problems. In addition, it can be difficult to discern the causes of specific health effects because of confounding factors, from genetics to cigarette smoking to workplace hazards. (It should also be noted that power plants in other countries are subject to different emissions standards from those in the United States; therefore, levels of exposure vary.) And because of the difficulty of distinguishing the source of specific pollutants, there are few published studies that examine the health effects of electric power plant emissions exclusively. But because populations at risk are often exposed to the same pollutants from multiple sources, we can look to a broader field of research to understand the effects of power plant emissions.

In the United States, power plants are a major source of pollutants, including mercury, sulfur dioxide, nitrogen oxides, and particulate matter.[2] The first comprehensive federal legislation to address air pollution was the Clean Air Act of 1970. Revised in 1990, it gave the Environmental Protection Agency (EPA) broad authority in reducing emissions. But more improvements are needed to reduce emissions associated with electric power production, and nurses can play an important role in this effort. (For an example of nurses' involvement in legislation, see *The Maryland Healthy Air Act,* page 64. For more on electric power plants and common pollutants, see *Electric Power Generation in the United States,* page 66.)

Public Health

THE HEALTH EFFECTS OF EXPOSURE TO EMISSIONS

A large and growing body of evidence has found various adverse health effects of exposure to mercury, sulfur dioxide, nitrogen oxides, and fine particulate matter—all components of electric power plant emissions—on the respiratory, cardiovascular, reproductive, and central nervous systems. But the relationship between pollutants and health is complex. For example, some studies show significant adverse effects in only a subset of the population studied. Also, an adverse effect of exposure is likely to become apparent only after some time—hours, days, or many years—has passed.

Effects of direct exposure. Few studies have addressed the health effects of direct exposure to power plant emissions as the result of living near them. But there is evidence that such proximity is associated with higher rates of respiratory problems, pregnancy complications, and premature death.

Respiratory problems. Peled and colleagues studied 285 children with asthma who lived near two power plants in Israel and found an inverse relationship between exposure to fine particulate matter and peak expiratory flow rate.[20] Karavus and colleagues studied 277 people who lived within five kilometers of a power plant in Turkey and found that 46% complained of chest tightness and 29% of repeated coughing attacks.[21] These rates were sharply higher than the 28% with chest tightness and 20% with coughing attacks who lived more than 30 kilometers from the plant. Several important markers of lung function in nonsmokers, including forced expiratory volume in one second (FEV_1), were significantly lower in those living near the plant than in those living farther away.

Pregnancy complications. Between 1993 and 1996, Tsai and colleagues studied the prevalence of preterm births in women living in close proximity to eight power plants that provided most of Taiwan's electric power during this period.[22] After controlling for several confounding variables, including maternal age, education, and marital status and the infant's sex, the authors concluded that women who lived less than three kilometers from a power plant were significantly more likely to deliver a preterm infant than were women who lived between three and four kilometers away. Mohorovic studied 700 women living in the district of Labin, Croatia, near a coal-fired power plant that burns coal high in sulfur (9% to 11%) and found that increased exposure to sulfur dioxide during the initial two months of pregnancy was correlated with shorter gestation and lower body mass of the newborn.[23]

Premature death. Levy and colleagues determined that if the "best available control technology" (that applied under the Clean Air Act to new or modified sources of air pollution) were implemented at two older coal-fired power plants in Massachusetts, it would prevent 124 premature deaths, as well as 1,300 ED visits, 34,000 asthma attacks, and 230,000 daily incidents of respiratory symptoms per year.[24]

Similarly, Hermann and colleagues used an EPA air-quality model to estimate the potential health effects of 29 proposed fossil-fuel power plants in

The Maryland Healthy Air Act

One activist's story of how nurses can make a difference.

When a pregnant woman is afraid to eat fish because her fetus may suffer neurodevelopmental defects, when older adults don't go outdoors because polluted air might exacerbate cardiovascular conditions, and when asthma sufferers' symptoms worsen, it's time to take action against air pollution.

In 2006 coal-burning power plants in Maryland still operated without modern pollution-control technology. They're among the state's largest emitters of pollutants that harm human health and the environment: mercury, ozone- and particulate-forming nitrogen oxides, sulfur dioxide, and carbon dioxide.

A group of environmental, faith-based, and health organizations formed the Maryland Healthy Air Coalition to lobby in support of the Maryland Healthy Air Act, a law that would reduce emissions from coal-fired power plants. I was the first health care professional invited to join; I said yes immediately.

I contacted the Maryland Nurses Association (MNA) and volunteered to be their liaison to the coalition steering committee. MNA members volunteered to visit legislators and wrote letters to editors of local newspapers. We offered testimony to state Senate and House committees, often waiting for hours to tell them why the bill should pass. At Nurses Night in Annapolis, hundreds of nurses and students rallied at the State House in support of the bill. Nurses all over the state hand delivered letters to General Assembly members asking for their support.

The MNA also sponsored a report on the significant health effects of exposure to emissions from six of Maryland's coal-fired power plants on the citizens of Maryland and nearby states. The report received national attention. It found that the emissions contribute to approximately 700 deaths each year (100 in Maryland) and 30,000 asthma attacks (4,000 in Maryland), as well as other adverse outcomes. Nurses delivered a copy of the report to all members of House and Senate committees hearing the bill. (To see the report, go to www.thehastingsgroup.com/marylandrn/Levy_MD_power_plant_report_2-06.pdf).

On April 6, 2006, the Maryland Healthy Air Act was signed into law, and the regulations went into effect last July. The law—the strongest state emissions legislation on the East Coast—requires significant reductions of emissions in two phases. Using 2002 levels as a baseline, by 2010 nitrogen oxides must be reduced by almost 70% and sulfur dioxides and mercury by 80%. At full implementation in 2013, nitrogen oxides must be reduced by approximately 75% from 2002 levels, sulfur dioxides by approximately 85%, and mercury by 90%. The law also requires that Maryland become involved in a regional cap-and-trade program to reduce greenhouse gas emissions.

Together with coalition partners, Maryland nurses worked for the health of our communities—and we won.—*Brenda Afzal, MS, RN, director of health programs, Environmental Health Education Center, University of Maryland School of Nursing, Baltimore*

Virginia and determined that, over a six-year period, 104 additional deaths would occur as a consequence of operating the plants.[25]

Indirect effects of power plant emissions. Because power plant emissions may also have significant health effects in people who do not live in close proximity to them, a more comprehensive analysis is needed to understand the full extent of the effect of emissions, even at great distances from their source. For example, Zhou and colleagues modeled emissions from 29 power plants in China and found that people who live more than 500 kilometers from a plant still inhale considerable amounts of sulfur dioxide, nitrogen oxides, and fine particulate matter.[26]

Respiratory effects. Venners and colleagues studied a district of more than 576,000 people in Chongqing, China, a city with many heavy industries, including several large steel and iron smelters and power plants.[27] Coal is the main source of energy for both households and industry, and the coal available in the region is high in sulfur (4% to 12%). The researchers concluded that the risk of death from cardiovascular and respiratory causes increased significantly two days after a 100-microgram-per-cubic-meter rise in the concentration of sulfur dioxide from the baseline concentration.

Pulmonary development in children. Several studies have linked the exposure of pollutants emitted by power plants to developmental changes in respiratory

systems, exacerbations of existing pulmonary conditions, and premature death from respiratory disorders. Gauderman and colleagues followed nearly 1,800 fourth-graders in Southern California for eight years and determined that exposure to increased levels of air pollution (specifically, nitrogen dioxide, acid vapor, fine particulate matter, and elemental carbon) is linked to reduced lung development, as measured by FEV_1.[28] While the authors state that in this region the main source of these pollutants is vehicular exhaust, the same pollutants are also components of power plant emissions.

Ribeiro and Cardoso conducted two studies in São Paulo, Brazil—the first in 1986 and the second in 1998—to evaluate the effects of air pollution–control programs on children's respiratory health.[29] In both studies, they examined children living in the same neighborhoods. They found that "pollution control programs were in part neutralized by [an increase in the] number of cars and that the control of a single pollutant was not enough to protect children's health. In the area where both particulate matter and sulfur dioxide levels decreased, there was a reduction in the prevalence of respiratory symptoms." Yet they also found a higher incidence of allergies, ear and throat infections, and asthmatic episodes that required medical treatment in areas with higher levels of air pollution.

Short- and long-term effects in adults. A study conducted in six European cities with widely differing climates showed a correlation between exposure to air pollution and daily hospital admissions among patients with chronic obstructive pulmonary disease.[30] And Pope and colleagues studied the potential health effects of long-term exposure to air pollution and concluded that exposure to sulfur oxide–related pollution and fine particulate matter over a 16-year period is associated with a 6% increase in the risk of death from cardiopulmonary causes and an 8% increase in the risk of death from lung cancer.[31]

Cardiovascular effects. The cardiovascular system is also adversely affected by exposure to the substances emitted by power plants. Exposure to ambient air pollution is linked to cardiac rhythm disturbances, cardiac arrest, heart failure, and stroke, and the effects appear to be strongest immediately after increases in concentrations of pollutants. However, long-term exposure to ambient air pollution is also associated with adverse effects on cardiovascular health.

Liao and colleagues examined data from a population-based longitudinal study of atherosclerosis and its sequelae and data on air pollution from an EPA database.[32] The participants had been enrolled in four study centers in Maryland, North Carolina, Minnesota, and Mississippi, and sample sizes for analyses of each pollutant examined were in the range of 4,000 to 7,000 subjects. The researchers concluded that ambient air pollution is associated with poorer cardiac autonomic control as evidenced by reduced heart rate variability, especially among those with cardiovascular disease.

Over a 12-year period, Wellenius and colleagues studied more than 50,000 Medicare beneficiaries age 65 or older living near Pittsburgh and found that daily fluctuations in the ambient concentration of sulfur and nitrogen dioxide were correlated with same-day hospitalization for congestive heart failure.[33]

> One study found that 7.8% and 15.7% of the annual birth cohort are exposed in utero to potentially harmful levels of methylmercury—associated with impaired neurologic development and 'small but significant loss of IQ.'

Low and colleagues studied nearly 17,000 people admitted to New York City hospitals over a nine-year period with the diagnosis of ischemic stroke and found a small but significant correlation between stroke incidence and ambient concentration of sulfur dioxide, among other factors studied such as dry air and grass pollen, suggesting a possible link between pulmonary inflammation and stroke.[34]

Peters and colleagues studied patients living in the greater Boston area who had suffered heart attacks over a one-year period and found that the risk of the onset of myocardial infarction was directly correlated with exposure to increased concentrations of fine particulate matter in the previous two hours.[35] The authors also determined that high daily average concentrations of fine particulates were correlated with an increased risk of myocardial infarction with a 24-hour delay.

Pope and colleagues found a long-term relationship between fine particulate matter concentrations and death from ischemic heart disease as well as arrhythmias, heart failure, and cardiac arrest.[36] The authors also concluded that exposure to fine particulate matter appeared to have an "additive if not synergistic" effect with smoking.

Mercury. While the effect of mercury on the neurologic system is well established, Stern suggests that methylmercury exposure from eating contaminated fish may also be linked to adverse cardiovascular effects, particularly to myocardial infarction, and that the link may be due to an antagonistic rela-

Electric Power Generation in the United States

The United States generates almost a quarter of all electric power worldwide. In 2005 more than 16,800 U.S. power plants produced more than 4 trillion kilowatt hours of electric power—a 2% increase over the previous year and more than that of all European Union countries combined.[3,4] Half of this energy was generated by burning coal.[2] Coal-fired power plants are not only the largest producers of electricity but also among the dirtiest. Nearly 40% of the coal-fired plant capacity currently in use came on line prior to the passage of the Clean Air Act in 1970[5]—meaning that these plants do not operate under the same pollution-control standards that apply to newer power plants. Recent legislative efforts to apply stricter standards to older plants have been unsuccessful, although the Environmental Protection Agency (EPA) did issue a cap on mercury emissions, discussed below.[6]

Emissions from coal-fired power plants are linked to the majority of health problems discussed in this article, although power plants that burn natural gas and petroleum also contribute. However, the electric power generated by natural gas–fueled power plants accounts for only one-fifth of the U.S. total—roughly on a par with nuclear power (20% and 19.4%, respectively).[2] Petroleum-fueled power plants produced only 1.6% of the total. Hydroelectric power accounted for 7%. The remaining 3% of electric power was produced by other means, including renewable resources such as geothermal, solar, and wind power.

Emissions. In recent years there has been a focus on greenhouse gas emissions—primarily carbon dioxide—from power plants and other sources; they are thought to play a role in global warming and climate change. Indirect health effects may be associated with climate change, including higher rates of infectious diseases and heat-related illnesses. However, carbon dioxide emissions from electric power plants do not materially change the composition of breathable air. The current average atmospheric concentration of carbon dioxide is approximately 379 parts per million or about 0.0379%.[7] Short-term exposure to levels below 2% has not been linked to adverse health effects.[8] Therefore, greenhouse gas emissions are not discussed at length in this article. We're concerned mainly with sulfur dioxide and nitrogen oxides, fine particulate matter, and mercury.

Sulfur dioxide and nitrogen oxides are gas byproducts of the high-temperature combustion of coal and other fossil fuels.[9,10] Chemically active, they combine readily with other atmospheric chemicals to form particulate matter. In both gaseous and particulate forms, their implications include respiratory problems in humans and damage to soil, water, and plant and animal life. Both are involved in the formation of acid rain, and nitrogen oxides are a main ingredient in the formation of ground-level ozone, which can cause respiratory distress.

According to the EPA, 65% of all sulfur dioxide released into the air in the United States comes from electric power plants.[9] Other sources include industrial facilities such as petroleum refineries, metal processing facilities, and off-road diesel-powered vehicles and equipment, such as tractors, cranes, forklifts, and other agricultural and construction machinery.

About 22% of domestic human-made nitrogen oxide emissions come from electric power plants.[10] Motor vehicle emissions contribute 55%, and another 22% comes from other industrial, commercial, and residential sources. In 2005 ambient air emissions from electric power plants included 10.3 million metric tons of sulfur dioxide and 4 million metric tons of nitrogen oxides.[2]

Particulate matter. Both sulfur dioxide and nitrogen oxides also combine with other substances in the atmosphere to become important components of fine particulate matter.[11] The term *particulate matter* comprises hundreds of chemicals in liquid and solid forms, in a variety of shapes and sizes. Health authorities are especially concerned about particles smaller than 10 micrometers in diameter, which enter the lungs most readily. *Fine particulate matter* refers to particles that are 2.5 micrometers in diameter or smaller, most of which are not emitted directly from power plants but rather form in the atmosphere through chemical reactions among sulfur dioxide, nitrogen oxides, and other substances.

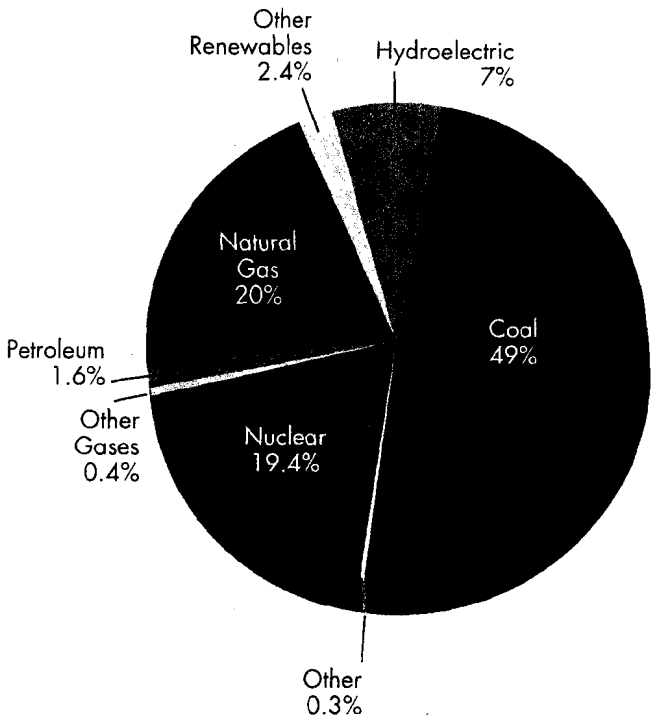
Mercury is released by power plants into the air and settles into water, where microorganisms convert it into methylmercury, a toxin that accumulates in fish, shellfish, and animals that eat fish.[12] Human exposure to methylmercury usually occurs when people eat these foods, but the health effects of mercury exposure

tionship between the toxic effects of methylmercury and the protective effects of omega-3 fatty acids.[37]

Pregnancy complications. Pollutants emitted by electric power plants are also linked to complications with pregnancy, including low birth weight infants, intrauterine growth retardation, and preterm delivery, as well as increased levels of mercury in cord blood. Liu and colleagues studied live births in Vancouver, Canada, from 1985 to 1998 and determined that infants were significantly more likely to be of low birth weight or have intrauterine growth retardation if exposed to a five parts per billion increase in sulfur dioxide during the first month of pregnancy.[38] Preterm delivery was associated with increased maternal exposure to sulfur dioxide during the last month of pregnancy.

Leem and colleagues conducted a population-based study of more than 52,000 births in Korea in

Figure 1. U.S. Electric Power Industry Net Generation, 2006



Energy Information Administration. *Electric Power Annual 2006*. U.S. Department of Energy. November 2007. http://www.eia.doe.gov/cneaf/electricity/epa/epa_sum.html.

depend upon the route, amount, and duration of exposure, as well as the person's age and health. Greater emissions from power plants and other industries in the past century have increased the amount of environmental mercury; because mercury does not break down easily into less harmful substances, it remains hazardous indefinitely.[13]

Coal-burning power plants in the United States account for about 40% of domestic mercury emissions.[12] According to the EPA, about 50 tons of mercury are emitted annually by burning coal to produce electric power.[14] The EPA estimates that approximately one-quarter of this amount, or 12.5 tons of mercury, accumulates within the contiguous 48 states, while the rest is dispersed beyond our borders. Likewise, it's thought that more than half of the mercury deposited in the United States originates from abroad.[12] Another important domestic source of mercury released into the air is the burning of hazardous wastes.

On March 15, 2005, the EPA issued a federal rule that will permanently cap and reduce these emissions.[15] The first goal is to reduce domestic mercury emissions to 38 tons per year by 2010 and to 15 tons per year by 2018.[15]

How dirty is coal? Coal-fired power plants emit more than 100 times more sulfur dioxide and three and a half times more nitrogen oxides than natural gas–fired plants per megawatt hour of electricity generated.[16] (Also, in generating the same amount of electricity, coal-fired plants emit twice as much carbon dioxide as do natural gas–fired plants.) In addition to air emissions, coal-fired plants produce more than 115 million tons per year of "coal combustion wastes" such as fly ash that contain metal oxides and alkalis, which typically are buried in landfills. While not federally regulated as hazardous waste, they have raised concerns about their effect on groundwater quality. Opportunities to recycle fly ash do exist in the manufacture of concrete and asphalt.[17] In comparison, natural gas–fired plants do not produce any waste ash.

Nuclear energy is another much-discussed source of electric power that presents complex environmental concerns. Using nuclear fuel to generate electric power does not contribute to ambient air pollution or to the build-up of atmospheric greenhouse gasses (atomic fission produces no notable carbon dioxide, sulfur oxides, nitrogen oxides, particulates, or ash).[18] But nuclear waste differs from fossil-fuel waste, remaining radioactive for thousands of years. Substantial costs and significant security concerns are associated with the transportation and long-term disposal of such waste. The U.S. Department of Energy (DOE) is responsible for the disposal of spent nuclear fuel from nuclear power plants, most of which is stored at each facility. The transport and disposal of this spent fuel have been strongly debated. Under the DOE's "best achievable repository construction schedule," Yucca Mountain, a disposal site in Nevada, could begin receiving spent nuclear fuel in 2017.[19] The operation and eventual dismantling of nuclear power plants also necessitates disposal of lower-level waste at various commercial sites across the country.

2001 and 2002 and found a dose-dependent relationship between preterm delivery and exposure to sulfur dioxide during the first trimester.[39]

Neurologic effects have also been shown to result from power plant emissions. This is particularly true of methylmercury (as noted in *Electric Power Generation in the United States*, page 66, the primary health effects don't come from direct exposure to the mercury emitted but from the methylmercury that accumulates in fish and shellfish that people eat). Costa and colleagues concluded that the pathologic changes in the brain from exposure to methylmercury depend upon the age of the person exposed.[40] For example, neurologic damage in adults exposed to methylmercury is localized in the visual cortex of the cerebrum and the granule layer of the cerebellum. But methylmercury exposure either in utero or at a young age causes damage throughout the central nervous system.

Resources

- A list of environmentally friendly products for health care facilities can be found at [illegible].
- For more ideas on how you can help your hospital or workplace do no harm, see Health Care Without Harm at [illegible] and Hospitals for a Healthy Environment at [illegible].
- The Nature Conservancy is one of many organizations working to reduce another kind of air pollutant, greenhouse gasses. Go to [illegible] to learn more, and see [illegible] to calculate your own carbon footprint.

This is particularly alarming in light of the findings of Trasande and colleagues, who used Centers for Disease Control and Prevention data on the prevalence of mercury in maternal blood and determined that in the United States between 316,588 and 637,233 infants (or 7.8% to 15.7% of the annual birth cohort) each year are exposed in utero to potentially harmful levels of methylmercury, with cord blood amounts greater than 5.8 micrograms per liter, which has been associated with impaired neurologic development, as evidenced by "small but significant loss of IQ."[41] The lower end of the range represents an estimate based on the conservative assumption that the concentration of mercury in cord blood is equivalent to maternal blood concentrations. However, studies have shown that the concentration of mercury in cord blood may be 70% greater than in maternal blood; if this is true, the upper limit of the range would represent a more accurate estimate. (According to current standards, only cord blood levels of mercury less than 5.8 micrograms per liter are without recognized adverse effects.[42]) Further, the researchers estimated that the lower economic productivity of those affected would cost society $8.7 billion annually and that $1.3 billion of the total "is attributable to mercury emissions from American power plants."[41]

Debes and colleagues found that children who had been exposed to high levels of methylmercury in utero had, at the age of 14, significant deficits in reaction time, cued naming, and finger-tapping speed.[43] In a subsequent study, Trasande and colleagues concluded that the mercury released from coal-fired power plants in the United States likely accounts for 231 additional cases of mental retardation each year.[44]

THE ROLE OF NURSES

Despite the complexity of the problem and the adverse health effects associated with air pollution, nurses can make significant contributions toward solutions that would help to reduce the public's exposure to ambient air pollution and improving health.

Awareness. First, it's important to be aware of the sources of pollution within your community and the potential pathways of exposure. Depending on the pollutant, exposure may occur through breathing contaminated air, drinking contaminated water, being exposed to contaminated soil, or eating contaminated fish. Information about pollution and hazardous waste sites by ZIP code is available at the EPA's Envirofacts (go to www.epa.gov/epahome/commonsearch.htm). This site can help nurses identify important sources of pollutants in their communities. Armed with this information, nurses can then be vigilant in identifying disease clusters that may result from exposure to certain pollutants.

Risk reduction. Nurses can make an important contribution in the area of risk reduction. For example, an air-quality index as well as information on particulate pollution is available from AIRNow at [illegible]. This site can help nurses identify conditions under which those with existing pulmonary or cardiovascular diseases may be at particularly high risk. Avoiding strenuous activities when levels of particulate pollution are high can reduce exposure. Patients who know when and where to spend time outdoors are better equipped to reduce risk. In general, air quality is better earlier in the day and away from busy roads and can be especially bad on hot summer days when the weather is calm (see www.epa.gov/air/emissions and www.epa.gov/airnow//health-prof/Asthma_Flyer_Final.pdf).

Nurses can also counsel patients about fish consumption during pregnancy, specifically the types of fish to avoid and those that are considered safe to consume in moderation (see http://americanpregnancy.org/pregnancyhealth/fishmercury.htm).

Environmental health assessments. Nurses, particularly community health nurses, may consider performing environmental health assessments. The University of Maryland School of Nursing's *EnviRN* provides information on the intersection between environmental health and nursing. A variety of databases and assessment tools can be found at http://envirn.umaryland.edu/resources. The organization also produces the Environmental Health Assessment Guide for a Home and Family, an excellent screening tool for identifying risks in and around patients' homes, available online at http://envirn.umaryland.edu/files/1_HHDP_Family_Assessment.pdf.

Activism. Nurses' role in public-health debates can be extensive. For example, nurses can support increased use of emission-control technology at power

plants, in tandem with efforts to reduce emissions from other major sources, including automobiles.

Renewable resources. Nurses can also support legislation that promotes or requires the use of low-sulfur coal and the increased use of renewable resources to generate power cleanly. For example, wind power generates electricity without creating pollution and without consuming fuel that must be mined, transported, and stored. Other possible renewable energy alternatives include solar and geothermal energy, landfill gas, and biomass.[45] Though many bills pertaining to energy use and production were introduced in the U.S. House of Representatives during 2007, few were voted on. However, HR 2776, the Renewable Energy and Energy Conservation Tax Act of 2007, passed the House in August and currently awaits a vote in the Senate.[46] The primary emphasis of the bill is to encourage production of energy using renewable resources by providing federal tax credits, effectively lowering the cost of energy production from such resources. The electricity produced by renewable resources can then be transmitted via the electrical grid and sold to customers. Among other items, the bill extends the renewable energy credits from 2009 to 2013 and expands the definition of renewable resources. ▼

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REFERENCES

1. American Nurses Association. Section 8.1: Health needs and concerns. In: *Code of ethics for nurses with interpretive statements.* Silver Spring, MD: The Association; 2001. p. 23.
2. Energy Information Administration. U.S. Department of Energy. *Basic electricity statistics.* 2007. http://www.eia.doe.gov/neic/quickfacts/quickelectric.html.
3. Energy Information Administration. U.S. Department of Energy. *Summary statistics for the United States. Electric power annual with data for 2006.* Washington, D.C.; 2007 Oct 22. http://www.eia.doe.gov/cneaf/electricity/epa/epates.html.
4. Central Intelligence Agency. Rank order—electricity—production. In: *The World Factbook.* Washington, D.C.: Potomac Books; 2004. https://www.cia.gov/library/publications/the-world-factbook/rankorder/2038rank.html.
5. Energy Information Administration. U.S. Department of Energy. Existing generating units in the United States by state, company and plant, 2005. Washington, D.C. 2006.
6. Clean Air Council. *Clear the air campaign.* 2006. http://www.cleanair.org/Air/clearTheAir.html.
7. Intergovernmental Panel on Climate Change (IPCC). Summary for policymakers. In: Solomon S, et al., editors. *Climate change 2007: the physical science basis. Contribution of Working Group I to the fourth assessment report of the Intergovernmental Panel on Climate Change.* New York: Cambridge University Press; 2007. http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf.
8. Canadian Centre for Occupational Health and Safety. *2-health effects of carbon dioxide gas.* 1997. http://www.ccohs.ca/oshanswers/chemicals/chem_profiles/carbon_dioxide/health_cd.html.
9. Environmental Protection Agency. *Six common air pollutants. Sulfur dioxide: what is it? Where does it come from?* 2007. http://www.epa.gov/air/urbanair/so2/what1.html.
10. Environmental Protection Agency. *Six common air pollutants. NOx: what is it? Where does it come from?* 2007. http://www.epa.gov/air/urbanair/nox/what.html.
11. Environmental Protection Agency. *Particulate matter.* 2007. http://www.epa.gov/oar/particlepollution/.
12. Environmental Protection Agency. *Mercury: basic information.* 2007. http://www.epa.gov/mercury/about.htm.
13. Davidson PW, et al. Mercury exposure and child development outcomes. *Pediatrics* 2004;113(4 Suppl):1023-9.
14. Environmental Protection Agency. *Controlling power plant emissions: overview.* 2007. http://www.epa.gov/mercury/control_emissions/index.htm.
15. Environmental Protection Agency. *Revision of December 2000 Clean Air Act section 112(n) finding regarding electric utility steam generating units: and standards of performance for new and existing electric utility steam generating units: reconsideration;* 2005. EPA-HQ-OAR-2002-0056; FRL-8180-4. http://www.epa.gov/air/mercuryrule/pdfs/camr_recon_fr_final_053106.pdf.
16. Environmental Protection Agency. *Clean energy. Air emissions.* 2006. http://www.epa.gov/cleanenergy/emissions.htm.
17. Turner-Fairbank Highway Research Center. *Coal fly ash.* Federal Highway Administration. U.S. Department of Transportation, http://www.tfhrc.gov/hnr20/recycle/waste/cfa51.htm.
18. Energy Information Administration. U.S. Department of Energy. *Nuclear issues paper. Nuclear power and the environment.* Washington, D.C.; 2003. http://www.eia.doe.gov/cneaf/nuclear/page/nuclearenvissues.html.
19. U.S. Department of Energy. *Civilian radioactive waste management: Yucca Mountain repository.* 2007. http://www.ocrwm.doe.gov/ym_repository/about_project/index.shtml.
20. Peled R, et al. Fine particles and meteorological conditions are associated with lung function in children with asthma living near two power plants. *Public Health* 2005;119(5):418-25.
21. Karavus M, et al. Respiratory complaints and spirometric parameters of the villagers living around the Seyitomer coal-fired thermal power plant in Kutahya, Turkey. *Ecotoxicol Environ Saf* 2002;52(3):214-20.
22. Tsai SS, et al. Increased risk of preterm delivery in women residing near thermal power plants in Taiwan. *Arch Environ Health* 2004;59(9):478-83.
23. Mohorovic L. First two months of pregnancy—critical time for preterm delivery and low birthweight caused by adverse effects of coal combustion toxics. *Early Hum Dev* 2004;80(2):115-23.
24. Levy J, et al. *Estimated public health impacts of criteria pollutant air emissions from the Salem Harbor and Brayton Point power plants.* Boston, MA: Clean Air Task Force; 2000 May. http://www.airimpacts.org/documents/local/plant.pdf.
25. Hermann RP, et al. Predicting premature mortality from new power plant development in Virginia. *Arch Environ Health* 2004;59(10):529-35.
26. Zhou Y, et al. The influence of geographic location on population exposure to emissions from power plants throughout China. *Environ Int* 2006;32(3):365-73.
27. Venners SA, et al. Particulate matter, sulfur dioxide, and daily mortality in Chongqing, China. *Environ Health Perspect* 2003;111(4):562-7.
28. Gauderman WJ, et al. The effect of air pollution on lung development from 10 to 18 years of age. *N Engl J Med* 2004;351(11):1057-67.
29. Ribeiro H, Cardoso MR. Air pollution and children's health in Sao Paulo (1986–1998). *Soc Sci Med* 2003;57(11):2013-22.
30. Anderson HR, et al. Air pollution and daily admissions for chronic obstructive pulmonary disease in 6 European cities: results from the APHEA project. *Eur Respir J* 1997;10(5):1064-71.

31. Pope CA, 3rd, et al. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA* 2002;287(9):1132-41.
32. Liao D, et al. Association of higher levels of ambient criteria pollutants with impaired cardiac autonomic control: a population-based study. *Am J Epidemiol* 2004;159(8):768-77.
33. Wellenius GA, et al. Particulate air pollution and the rate of hospitalization for congestive heart failure among medicare beneficiaries in Pittsburgh, Pennsylvania. *Am J Epidemiol* 2005;161(11):1030-6.
34. Low RB, et al. The relation of stroke admissions to recent weather, airborne allergens, air pollution, seasons, upper respiratory infections, and asthma incidence, September 11, 2001, and day of the week. *Stroke* 2006;37(4):951-7.
35. Peters A, et al. Increased particulate air pollution and the triggering of myocardial infarction. *Circulation* 2001; 103(23):2810-5.
36. Pope CA, 3rd, et al. Cardiovascular mortality and long-term exposure to particulate air pollution: epidemiological evidence of general pathophysiological pathways of disease. *Circulation* 2004;109(1):71-7.
37. Stern AH. A review of the studies of the cardiovascular health effects of methylmercury with consideration of their suitability for risk assessment. *Environ Res* 2005;98(1):133-42.
38. Liu S, et al. Association between gaseous ambient air pollutants and adverse pregnancy outcomes in Vancouver, Canada. *Environ Health Perspect* 2003;111(14):1773-8.
39. Leem JH, et al. Exposures to air pollutants during pregnancy and preterm delivery. *Environ Health Perspect* 2006; 114(6):905-10.
40. Costa LG, et al. Developmental neuropathology of environmental agents. *Annu Rev Pharmacol Toxicol* 2004;44:87-110.
41. Trasande L, et al. Public health and economic consequences of methyl mercury toxicity to the developing brain. *Environ Health Perspect* 2005;113(5):590-6.
42. Environmental Protection Agency. *Methylmercury: exposure and effects*. 2007. http://www.epa.gov/mercury/methylmercury.htm.
43. Debes F, et al. Impact of prenatal methylmercury exposure on neurobehavioral function at age 14 years. *Neurotoxicol Teratol* 2006;28(3):363-75.
44. Trasande L, et al. Mental retardation and prenatal methylmercury toxicity. *Am J Ind Med* 2006;49(3):153-8.
45. Environmental Protection Agency. *Electricity from non-hydroelectric renewable energy sources*. 2006. http://www.epa.gov/cleanenergy/renew.htm.
46. GovTrack.us. *H.R. 2776—110th Congress (2007): Renewable energy and energy conservation tax act of 2007*. GovTrack.us (database of federal legislation). 2007. http://www.govtrack.us/congress/bill.xpd?bill=h110-2776.

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