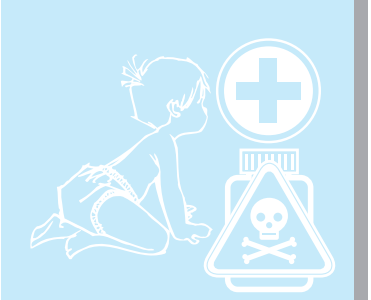

Environmental Health Hot Topics

Ann Pike-Paris, MS, RN

Nurses' Role in Children's Environmental Health Protection

Barbara Sattler
Allison Del Bene Davis

There is a growing body of evidence regarding the presence of toxic pollutants in the air, water, soil, food, and indoor environments, and the health effects of these pollutants on humans. Children have special vulnerabilities to environmental risks in their homes, schools, and communities. Children's susceptibility to environmental risks stem from biological, behavioral, and socio-economic factors. Environmental standards are not always protective of children's health, and in some instances, no standards exist. Addressing children's vulnerabilities and decreasing their exposures require a multi-faceted and multi-disciplinary approach with clinical, public health, and policy interventions. Preventing exposure to hazardous levels of pollution is largely the role of the public health community, environmental protection agencies, and the policy makers who create the enabling laws. The Institute of Medicine (IOM) (1995) has recommended the integration of environmental health into nursing practice, education, research, and policy/advocacy work. This article identifies areas in each of these categories in which nurses can enhance their practice regarding children's environmental health. In addressing children's environmental health, nurses' expanded roles can include a range of activities, such as anticipatory guidance, health education, public health interface, improved health tracking, environmental health research, and legislative/regulatory engagement.

National surveys, such as the *Third National Report on Human Exposure to Environmental Chemicals*, published by the Centers for Disease Control and Prevention (CDC), and the *Draft Report on the Environment*, published by the Environmental Protection Agency (EPA), have recently affirmed that persistent toxins in the air, water, soil, and food are also in the bodies of American adults and children (CDC, 2005; EPA, 2003a). Among the long list of invasive chemicals are lead, pesticides (including organochlorine and organophoshate pesticides), methylmercury, cotinine (a metabolite from exposure to environmental tobacco smoke), and organic solvents (CDC, 2005). There is growing concern in the scientific community about the potential health effects of these body-burdening contaminants on the immature systems of children and developing fetuses.

Barbara Sattler, PhD, RN, FAAN, is a Professor and the Director of the Environmental Health Education Center, University of Maryland School of Nursing, Baltimore, MD.

Allison Del Bene Davis, PhD, APRN, BC, is an Assistant Professor, Department of Family and Community Health, University of Maryland School of Nursing, Baltimore, MD.

The *Environmental Health Hot Topics* column focuses on issues, information, and practical guidelines related to environmental health problems, including sources of toxicants and resources for nurses to prevent, minimize, or treat adverse environmental exposures particularly as they relate to children. To suggest topics, obtain author guidelines, or to submit queries or manuscripts, contact Ann Pike-Paris, MS, RN, Section Editor; *Pediatric Nursing,* East Holly Avenue Box 56; Pitman, NJ 08071-0056; (856) 256-2300 or FAX (856) 256-2345.

Toxicological animal studies and rare epidemiological studies indicate a wide range of risks that might be associated with any given chemical. Collectively, these persistent bioaccumulative toxicants (PBTs) potentially found in children's bodies are known to be neurotoxic, immunotoxic, carcinogenic, teraterogenic, endocrine disruptors, and are associated with a range of other problems, including learning disabilities, behavioral problems, low birth weight, and asthma. There is also clear evidence that events in early life, including exposure to chemicals, can cause long-term morbidity and premature death (Stein, Stanton, & Starfield, 2005). More science is needed to better understand real-life scenarios of multiple chemical mixtures and doses, combined with a range of host factors (such as age and co-morbidities) that increase vulnerability. A more critical review of and engagement in national and state chemical policy making is also essential.

Most PBTs are chemicals that did not exist on earth before the last century. They are man-made chemicals that comprise stores of industrial chemicals, pharmaceuticals, household products, and personal care products, among others (see Table 1). With the exception of pharmaceuticals, little to no toxicity testing is required by the manufacturers before chemicals/products are brought to the market. However, in the last half century, toxicological and epidemiological research has revealed a substantial body of knowledge regarding the toxic threats that many of these PBTs present. Children are uniformly more susceptible to these risks.

Current Childhood Health Statistics

Asthma is at an all-time high, with 12-month prevalence of asthma up 74% between 1980 to 1996 (Mannino et al., 2002). In 2005, 6.5 million children in the U.S. had asthma (Akinbami, 2007). More than 1 in 10 children and young adolescents have a mental health problem, including hyperactivity disorder, anxiety, and depression (U.S. Public Health

Table 1.
Common Chemical Exposures, Sources, and Associated Health Effects

Chemical	Use	Location Found	Major Health Effects
Lead	Formerly used in plumbing, paint, gasoline.	Old paint in homes older than 1975, contaminated dust, aging pipes, hazardous waste sites. * Lead based paint was banned for interior uses in 1978.	• If not detected early, children with high levels of lead in their bodies can suffer from: – Damage to the brain and nervous system. – Behavior and learning problems (such as hyperactivity). – Slowed growth. – Hearing problems. – Headaches. • Lead is also harmful to adults. Adults can suffer from: – Difficulties during pregnancy. – Other reproductive problems (in both men and women). – High blood pressure. – Digestive problems. – Nerve disorders. – Memory and concentration problems. – Muscle and joint pain.
Mercury	Medical equipment, switches, thermometers, dental fillings.	Contaminated fish (especially large predatory types).	Methylmercury. • Fetuses, infants, and children: – Impaired neurological development. Impacts on cognitive thinking, memory, attention, language, and fine motor and visual spatial skills have been seen in children exposed to methylmercury in the womb. • All ages: – Symptoms of methylmercury poisoning may include impairment of the peripheral vision; disturbances in sensations ("pins and needles" feelings, usually in the hands, feet, and around the mouth); lack of coordination of movements; impairment of speech, hearing, walking; and muscle weakness.
		Coal, health care settings, schools (labs), thermostats, homes (thermometers), junked automobiles.	Elemental mercury: • Tremors, emotional changes (for example, mood swings, irritability, nervousness, excessive shyness), insomnia, neuromuscular changes (such as weakness, muscle atrophy, twitching), headaches, disturbances in sensations, changes in nerve responses, performance deficits on tests of cognitive. • Higher exposures – there may be kidney effects, respiratory failure, and death. People concerned about their exposure to elemental mercury should consult their physician.
Manganese	Gasoline additive, making steel, pesticide; a compound used in hospitals to test if a patient has certain types of cancer.	Many types of rock, airborne dust particles, dissolved into water, combustion from automobiles, hazardous waste sites.	• Manganese (Mn) is an essential trace element and is necessary for good health (about 1 to 10 mg manganese per day). • Neurotoxin: – Neurological symptoms characterized by severe extrapyramidal dysfunction resembling the dystonic movements associated with Parkinson's disease, also known as "manganism." People with compromised liver function may be at greater risk than the normal population to the toxic actions of Mn.
PCBs	Electrical, heat transfer, and hydraulic equipment; and as plasticizers in paints, plastics, and rubber products; in pigments, dyes, and carbonless copy paper; and many other applications.	Hazardous waste sites, incinerator releases, landfills, contaminated fish.	• Probable human carcinogens. • May suppress the immune system. • May have reproductive effects (low birth weight, lower live birth, difficult conception). • May cause neurological deficits (learning deficits and changes in activity). • Associated with decreased thyroid hormone levels. • Elevations in blood pressure, serum triglyceride, and serum cholesterol have also been reported.

Table 1. (continued)
Common Chemical Exposures, Sources, and Associated Health Effects

Chemical	Use	Location Found	Major Health Effects
Environmental Tobacco smoke	N/A	Near smoke emitted from the burning end of a cigarette, cigar, or pipe, and smoke exhaled by the smoker.	• Lung cancer, nasal sinus cancer, respiratory tract infections, and heart disease.
Bisphenol A	Used primarily to make polycarbonate plastic and epoxy resins. It is also used in flame retardants and rubber chemicals, and as a fungicide.	Digital media (CDs, DVDs), electrical and electronic equipment, automobiles, sports safety equipment, reusable food and drink containers, and many other products.	• Contact can irritate or even burn the skin and eyes. • Bisphenol A may cause a skin allergy. If allergy develops, very low future exposures can cause itching and a skin rash. • There is limited evidence that bisphenol A may damage the developing fetus and reduce fertility.
PERC (tetrachoroethylene)	Dry-cleaning and metal degreasing.	Dry cleaning operations and on clothes that have been dry cleaned, industrial emissions, water repellants, spot removers, glues, wood cleaners.	• Short-term: Dizziness, headache, sleepiness, confusion, nausea, difficulty breathing, speaking, and/or walking, unconsciousness, and possible death. • Long-term: Reasonably anticipated to be a human carcinogen.
Brominated Flame Retardants	Routinely added to consumer products to reduce fire-related injury and property damage.	Computers, electronics and electrical equipment, televisions, textiles, foam furniture, insulating foams, and other building materials.	• Limited information in humans. • Animals: Linked to thyroid hormone disruption, permanent learning and memory impairment, behavioral changes, hearing deficits, delayed puberty onset, fetal malformations, and possibly cancer. Exposure in utero or infancy leads to much more significant harm than adult exposure, and at much lower levels.
Solvents	Used to dissolve other substances.	Paints, inks, and other coatings; in cleaners and degreasers, and paint strippers; and as refrigerants and coolants. *Also in thousands of other products at work and at home.	• Have been associated with toxicity to the nervous system, reproductive damage, liver and kidney damage, respiratory impairment, cancer, and dermatitis.
Dioxin	No commercial usefulness.	Formed during combustion processes, such as waste incineration, forest fires, and backyard trash burning; and during manufacturing processes, such as herbicide manufacture and paper manufacture.	• High exposures can lead to cancer and reproductive and developmental problems, increased heart disease, and increased risk for diabetes. • Long-term low level exposure: Limited understanding.

Source: Clouse & Sattler, 2005.

Service, 2000). Autism has increased 1,000% since the mid-1980s (Byrd, 2002; Chakrabarti & Fombonne, 2001). Developmental disorders and attention deficit hyperactivity disorder (ADHD) collectively are estimated to affect 17% of school-aged children (Agency for Healthcare Research and Quality [AHRQ], 2002). Several environmental chemicals, such as lead and polychlorinated biphenyls (PCBs), affect learning and are thought to contribute to the development of ADHD (Mt. Sinai School of Medicine, 2007). Emerging science about the role of low doses of bisphenol A, found in plastics, has indicated that it might also effect neurological development in animal models (Ishido, Masuo, Kunimoto, Oka, & Morita, 2004; Lee et al., 2007).

Child and adolescent obesity has more than tripled since the 1960s (National Center for Health Statistics, 2007). Several endocrine-disrupting chemicals, such as flame retardants (polybrominated diphenyl ethers [PBDEs]), phthalates, and PCBs, are thought to interfere with weight control mechanisms through hormonal and neurotransmitter changes (Heindel, 2003). Several cancers have also increased in children, including acute lymphocytic leukemia and cancers of the brain and nervous system (National Cancer Institute, 2005). According to the American Cancer Society (2006), only 5% to 10% of all cancers can be attributed to inherited factors. Environmental exposures from cancer-causing agents in air, water, and soil currently account for 6% of all cancer diagnoses and deaths (American Cancer Society, 2006). Because of the unequal distribution of pollutants among communities, the risk of cancer from environmental pollutants is disproportionately borne by minority and low-income families and communities.

Science confirms the presence of man-made chemicals in human beings and attributes potential human health risks from these chemicals. Pediatric nursing professionals need to incorporate this knowledge into their professional practice. Nurses as advocates also have a responsibility to provide the public with evidence-based information about the health effects of these chemicals, ways to reduce exposure, and routes to advocate for changes to reduce risks to health. Unfortunately for many PBTs that already persist in the body, little can be done to reduce a child's existing body bur-

den of toxic chemicals. Primary prevention and advocacy are key. The nursing community as a profession has a weighty obligation to understand the science and risks associated with environmental pollutants, and to engage in political and economic decisions regulating the environment that have a profound effect on human health, especially the health of our children. This engagement occurs in policy-making arenas, including legislative, regulatory, and international treaties. In the last decade, the nursing community has taken noteworthy steps to engage in the policy arena and will be discussed later in this article.

Special Vulnerabilities of Children

This article describes special vulnerabilities of children and young adolescents, along with several specific examples of environmental health risks. In 1995, the Institute of Medicine (IOM) issued a foundational report entitled, *Nursing, Health, and the Environment* (IOM, 1995). This guiding report, which examined environmental health implications for nursing education, practice, research, policy, and advocacy, will also be discussed. Progress toward meeting these recommendations will be discussed since they relate to each area of practice. Environmental health policies and national research initiatives will be reviewed, and a listing of valuable Web-based resources will be provided. This article attempts to raise awareness about environmental health risks to children while providing guidance to nurses regarding clinical, education, and advocacy approaches to reducing these risks. It also encourages the incorporation of environmental protection and environmentally related disease prevention into the nursing profession's lexicon.

Biological Factors

Years ago it was believed that the placenta formed a protective barrier from most harmful chemicals. This myth has been dispelled; it has since been learned that the fetus experiences the same exposures as the mother to air pollutants and pesticides (Perera et al., 2003). This results in body burdens of potentially damaging pollutants in the newborn. In addition, mothers' breast milk is now an avenue for further sharing of contaminants. While breast milk is still considered the best source of nutrition for newborns, this essential nutrient now has the potential to come with PCB, DDT, dioxin, benzene, trichloroethylene, and polybrominated diphenylethers (flame retardants) (Landrigan, Sonawane, Mattison, McCally, & Garg, 2002; Moya, Bearer, & Etzel, 2004). It is now known that childhood exposures to the well-studied contaminant – lead – can be a predictor of life-long cognitive impairment and altered behavioral patterns (Needleman, Schell, Bellinger, Leviton, & Allred, 1990).

In the first year of life, there continues to be rapid growth and activity in the central nervous system, lungs, and immune system. While tissues and organs continue to mature, they are more vulnerable to the effects of toxic chemicals. The nervous system continues to undergo migration, differentiation, and myelination through adolescence. Eighty percent of the alveoli are formed postnatally. While full function of the lungs is attained at approximately six years of age, changes continue to occur in the lungs through adolescence (Dietert et al., 2000). Children have a larger lung surface per kilogram of body weight than adults, and they breathe 50% more air per body weight than adults (Schwartz, 2004). This results in a larger "dose" of inhaled toxic chemicals from indoor and outdoor pollution per kilogram of weight. Because of children's increased intake per body weight of "air," they also receive increased doses of air pollutants.

Similarly, children eat and drink more per body weight, meaning they could be exposed to greater "doses" of the pesticide residues and other potentially harmful chemicals in food and water. As clinicians, nurses can make adjustments to pharmaceutical doses for the size and age of a child; however, there is no control over their pollutant dosage. It is also important to consider the fact that children eat and drink more fruits and fruit juices per body weight than most adults, further increasing their "dose" of potentially harmful pesticide residues that are commonly used on non-organic produce.

Infants' and young children's metabolism and renal clearance of toxic chemicals are different than those of older children and adults. This may affect the way in which chemicals are metabolized into more or lesser toxic chemicals, and the effectiveness of excretion pathways via the kidneys. Neonates have highly permeable gastrointestinal tracks, and their gastric pH is higher until about age three. Both can increase gastric absorption of toxic chemicals. These attributes particularly increase the absorption of lipophilic toxicants, such as PCBs and dioxins that may be present in breast milk, cow's milk, and other sources of sustenance (Gladen et al., 1988; Koopman-Esseboom et al., 1996). Immature immune function in early childhood, combined with environmental exposures, is the focus of current research exploring the pathogenesis of asthma.

It is the authors' understanding that early-life exposures and the resulting adult-onset of symptoms and diseases is evolving. While women's reproductive health is determined in part by the number of oocytes in the ovarian pool and the number of oocytes that are available over the lifespan – all of which are determined prenatally – it has been noted in animal models that early reductions in the number of oocytes can be caused by chemical exposures, which may ultimately result in loss of fertility (Hoyer & Sipes, 1996).

Most chronic diseases, including asthma, autism, learning disabilities, diabetes mellitus, cancer, Parkinson's disease, and Alzheimer's disease, arise from complex interactions between genes and environmental factors (Olden, 2002). Inherited predisposition to diseases can by triggered by environmental exposures that catalyze the expression of the disease. When comparing the incidence of cancer in twins, Lichtenstein et al. (2000) reported that genetics accounted for approximately one-third of the risk for developing one of 10 of the most common cancers, and environmental factors accounted for two-thirds of the risk. Powell and Stewart (2001) described the same proportion of risk attribution in the case of autoimmune diseases. With the recent mapping of the human genome, exploration of gene-environment interactions is now available. Such exploration will include how genetics, age, and stage of development influence susceptibility to disease from environmental exposures.

Behavioral Factors

During normal early childhood development, hand-to-mouth exploration creates risks for ingestion of potentially toxic chemicals that may be in dust, soot, and soil. This is especially true for lead-based paint dust, which is the primary source for childhood lead poisoning in the U.S. Children also play on the floor and on the ground outdoors, as well as play "in the dirt," placing them at higher risk for exposure to those chemicals that deposit on the ground. In indoor environments, household cleaning products and pesticides create potentially hazardous exposures. Finally, children's activities often increase their respiratory rate, further amplifying their intake of airborne toxicants.

Parents' behaviors can affect exposures when they bring potentially toxic, workplace chemicals home on their clothes or when they engage in recreational activities that involve toxic chemicals. Many hobbies include the use of potentially toxic chemicals, such as glues, solvents, pigments, glazes, photo-

graphic chemicals, gardening chemicals, and others. Home remodeling can create unhealthy exposures to lead-based paint, asbestos, formaldehyde, and radon (Yiin, Lu, Sannoh, Lim, & Rhoads, 2004). Use of paint strippers, adhesives, and other volatile organic compounds (VOCs) during home repairs and renovations also create health risks in the home.

Young adolescents experience adult-level, work-related exposures when they enter the work force. Adolescence is yet another time for rapid cell growth during puberty, and metabolic differences create special vulnerability. Young workers are the most apt to ignore safety and health warnings, and therefore, they experience some of the highest workplace injury rates. In high schools that have vocational training, such as "shop," "automotive,""cosmetology," and art programs, exposure to potentially hazardous chemicals can be significant. These are also places and times where safe work practices and chemical safety can be explored and adopted.

Socio-Economic Factors and Environmental Justice

Children of minority ethnicity and lower income levels in America are disproportionately affected by a range of environmental health threats, including lead, air pollution, pesticides, incinerator emissions, and exposures from hazardous waste sites (Faber & Krieg, 2002; Landrigan, Suk, & Amler, 1999; Powell & Stewart, 2001; Silbergeld & Patrick, 2005). Children of minority ethnicity are more likely to suffer and die from asthma. Although some air pollutants are relatively homogenous across large, urban areas, others are affected by place-based exposures, such as exposures associated with proximity to major traffic thoroughfares, bus routes, or selective industries.

The quintet of risks that are often associated with poverty – substandard housing, poor diet, decreased access to health care, hazardous jobs (which translates to increased risk of take-home toxins for family members), and increased environmental exposures – combine to create significant yet often preventable risks for poor children. Public health approaches are required to effectively address these combined health threats. Clinicians can engage in partnerships with public health agencies to address many of them.

Environmental Health History Taking

The key to determining a child's health risk is the identification of hazardous environmental exposures. There is no single history-taking form that will work for all children, and questions should help identify potential exposures in the child's home and school/daycare, and should include outdoor yards and playgrounds. Proxy questions can be asked. For instance, the age of a home can help predict the presence of lead-based paint, and the presence of gas-fired furnaces and appliances can help predict the risk of carbon monoxide exposure. In addition, parents'/guardians' work exposures should be considered for potential "take home" toxins from their workplaces. The National Environmental Education Foundation has an example of a pediatric environmental health screening form that can be used. This assessment tool and a primer on environmental health can be found at http://www.neefusa.org/health/PEHI/HistoryForm.htm. An example of a tool that can be used to assess home environmental health risks can be found at http://thelumniaryproject.org/downloads/Tools%20-%20HomeEnvironmentalHealthandSafetyAssessmentTool1.pdf

The National Library of Medicine has produced an excellent and fairly comprehensive source of information on assessment and identification of exposures in everyday lives and the associated health risks. The Web site, entitled ToxTown (www.toxtown.nlm.nih.gov), provides easy access to information about common exposures in the home, schools, hospitals, on farms, and in a variety of settings within the community. The National Library of Medicine's "Household Products" site (http://www.nlm.nih.gov/medlineplus/householdproducts.html) allows one to assess and consider the potential hazards in cleaning products, pet care products, pesticides commonly used in the home, cosmetics, and several other categories of common products.

More often than not, a patient or parent will have no idea about their ambient air quality or the quality of their drinking water. Local public health agencies and state departments of environmental protection can help fill in these gaps. Additionally, there is a variety of online sources for this information. Environmental Defense, a national environmentalist organization, provides a user-friendly Web site (www.scorecard.org) for EPA data on select air emissions and discharges that are required to be reported under the community right to know laws. This helpful site provides zip code-specific information about the human health risks associated with emission and discharge data for 600 common and potentially dangerous chemicals. Drinking water information can be derived from *Consumer Confidence Reports*, described later in this article. The critical point to remember about environmental health history taking is that it is important to collect data from various sources in order to create a comprehensive picture of the potential exposures of an individual child or group of children in a certain school, day care center, or community.

Figure 1.
Lead Testing

The "equipment" for dust sampling – a Ziplock® storage baggy, a pen that will write on a plastic bag, a baby wipe (without aloe), and something with which to measure a 12" square. The baby wipe is swiped in one direction and then the other on a 12" area of floor, placed in the baggie, marked with the location within the home and date, as well as the name and address of the home owner or tenant. This sample is then sent to an environmental lab that will analyze it (for a very modest fee), and results will be returned that will indicate whether or not it exceeds EPA's lead dust standards.

Environmental Health Risks

A range of environmental health risks have been selected to illustrate several key elements of environmental health, including scientific underpinnings, assessment strategies, practice implications, and policy issues. Table 1 contains information on the health effects of common environmental health exposures.

Lead. Despite the fact that more is known about the health hazards of lead than any other chemical exposure, hundreds of thousands of American children continue to have elevated blood lead levels, placing them at risk for a host of health threats. In addition to crossing the placenta, lead easily crosses the blood brain barrier, where it can damage the brain. It is also toxic to the peripheral nerves, the kidneys, and the heme-synthesis system, and it creates a risk for hypertension and a multitude of cognitive and behavioral problems. Anticipatory guidance to the parent (even before the birth of a child) can help to avoid unhealthy lead exposures. Homes should be tested, and any exceedences of lead should be reduced or eliminated (see Figure 1).

The CDC's recommendation for drawing childhood blood-lead levels has evolved from no recommendation, to recommendations for every child being tested, to its current recommendation calling for a more targeted approach – any child who may have a risk for exposure should be tested. This determination is left to the health care provider. The American Academy of Pediatrics recommends that targeted

screening be done through a combination of risk assessment via a questionnaire during all well-child visits and targeted screening in areas where there is older housing or known elevated blood lead levels in children. In several states, blood lead levels are required for entrance into grammar school. Elevated blood lead levels, usually greater than 10 µg/dl, are a reportable finding and generally will initiate a public health response.

While lead-based paint is the most common source of childhood lead exposure, "take home" lead-dust from adult workplaces, art sources (such as lead solder for stained glass), and lead sinkers used for fishing are examples of other sources. When a child has an elevated blood lead level, a complete risk assessment of his or her environment should be performed.

Water pollution. Given that 70% of the human body is water, it is vital for health providers to know the quality of the drinking water in their communities. Gathering this information has been made easier in areas where there is a public water supply. All public water suppliers are required to regularly test the water that they distribute and to provide an annual summary of the test findings to their consumers. They test the water for chemical, biological, and radiological contaminants. This summary, which is required under the Safe Drinking Water Act, is called a *Consumer Confidence Report*. Nurses can access this information directly from the water distributor. Many distributors place the reports on their Web sites, and many provide reports to the EPA, which in turn, places them on the EPA EnviroFACTS Web site. They are also sometimes distributed in the water bill on an annual basis.

For households that depend on private well water, there is no statutory requirement to test the water, other than when the well is initially drilled. Therefore, it is important for nurses to remind their patients and families to periodically test their wells. This becomes increasingly important in agricultural areas where pesticides and fertilizers are used, as well as areas where there are hazardous waste sites, manufacturing plants, and other potentially polluting entities. When drinking water quality is compromised, alternative sources of water should be considered or appropriate control devices (filters, etc.) should be applied. It should be noted that some chemical contaminants, such as solvents, can enter the body through the skin, thus enabling exposure during showers and baths.

Nurses should consult with local health departments about the drinking water quality (and the recreational water quality) in their communities and the communities they serve. Source water protection (for ground and surface water) is an important component in protecting the health of children and adults.

Food. Many PBTs enter the body from food sources (for example, mercury in fish, pesticide residues on food). Pesticides, such as DDT, chlordane, aldrin, methoxychlor, and dieldrin are stored in body fat decades after the exposure (Roberts & Silbergeld, 1995). Current agricultural practices have resulted in a wide range of environmental health risks. Concentrated Animal Feed Organizations (CAFOs) are "industrial strength" farms. They create unsustainable use of the land due to extraordinary amounts of animal waste (urine/manure) that cannot be accommodated in the same way that smaller farming operations can absorb and recycle them. In CAFOs, livestock is highly likely to receive non-therapeutic levels of antibiotics that are routinely supplied to animals in their feed. Many antibiotics are the same or similar to those used therapeutically for humans. This practice is creating conditions for the development of antibiotic-resistant strains of pathogens. Because of this, the American Nurses' Association (ANA) passed a resolution calling for banning the use of non-therapeutic antibiotic in animal feed.

Air pollution. Air pollution presents a particular risk to children due to the biological differences that distinguish them from adults; in early childhood, their lungs are not fully developed, and the size of the airways makes them particularly susceptible to inflammatory processes and more vulnerable to harmful pollutants, particularly irritants like ozone. Children breathe more per body weight, causing them to have increased exposure to toxic chemicals that constitute air pollutants; at the same time, their ability to metabolize, detoxify, and excrete toxicants is diminished. Finally, children spend on average five times the amount of time outdoors than adults.

Air quality in the U.S. is characterized by a set of 6 *Criteria Air Pollutants* (see Figure 2). In 2002, 146 million Americans lived in counties in which pollution levels exceeded the National Ambient Air Quality Standards for at least one of the 6 criteria pollutants (EPA, 2003b). In a study of children with asthma in New Haven, CT, increased ozone levels were a predictor of increased asthmatic episodes and increased use of rescue medications (Gent et al., 2003). Further, a dose-response could be plotted, such that each incremental rise in ozone levels created an increased likelihood for wheezing. Several recent studies have found an association between air pollution (especially particulate matter) and infant death and/or sudden infant death syndrome (Diaz, Linares, Garcia-Herrera, Lopez, & Trigo, 2004; Romieu et al., 2004; Tong & Colditz, 2004).

In addition to the criteria pollutants, the EPA regulates 188 pollutants and chemical groups known or suspected to cause serious health effects, such as cancer, birth defects, and respiratory and neurological illnesses. These include solvents used for dry cleaning, asbestos, diesel exhaust, benzene (from gasoline), and PCBs.

The health risks that are considered when the EPA formulates its "health-based standards" for air pollutants may not be protective of children. Adverse health effects have been observed in children when air pollution levels are at or even below the standards for ozone, particulate matter, and nitrogen dioxide, indicating that current air standards are not protective of children's health (Kim, 2004). Average health risks to children from exposure to power plant combustion wastes could be up to 10,000 times higher than the EPAs allowable risk levels for cancer and other illnesses (Hill & Keating, 2002).

In clinical settings, information can be shared about the Air Quality Index, allowing parents to monitor their children's outdoor activities vis à vis daily air quality reports. For example, on high ozone days, outdoor physical activities should be halted in the middle of the day. School nurses should be engaged in the decision-making regarding outdoor physical education.

It should be noted that the Committee on the Environment of the American Academy of Pediatrics articulates in their Policy Statement that "[t]he assurance of healthy air for children to breathe is beyond the control of an individual pediatrician" (Kim, 2004). Their recommendations apply incontrovertibly to the nursing community:

- Work within state chapters of one's professional association to play a role in advocating for children's environmental health.
- Work within community coalitions in support of strong pollution control measures.
- Speak to the local and state policy-makers regarding the harmful effects that the environment can have on children's health.

Figure 2.
Criteria of Air Pollutants Under the EPA's National Ambient Quality Standards

Sulfur dioxide is produced during combustion and industrial processes.

- Sulfur dioxide is a major contributor to acid rain.
- It is associated with respiratory illness, alterations in pulmonary function, aggravation of existing cardiovascular disease, and asthma.

Nitrous dioxide is produced during combustion; it affects the lungs, immune function, and asthma.

Health Effects: Respiratory effects, including increased allergy and asthma exacerbations, reduced lung function.

Carbon monoxide is produced during the burning of fossil fuel.

- Carbon monoxide is substantially produced by motor vehicles.
- Carbon monoxide binds very effectively with hemoglobin, precluding the binding of oxygen, resulting in anoxia; the most sensitive populations are those with cardiovascular diseases.

Health Effects: Particulate matter (PM) consists of liquid and solid aerosols from fuel combustion, motor vehicle exhaust, high temperature industrial processes, and incineration.

Particulate matter includes dust, dirt, soot, smoke, and liquid droplets.

- The lungs are a prime site for damage and exacerbation of underlying disease; the size of the particle determines the deposition in the lungs.

Health Effects: Respiratory effects – Acute bronchitis and chronic cough, also associated with increased risk for infant death, including sudden infant death syndrome.

Lead in the aerosolized particulate matter is from industrial processes and incineration.

Health Effects: Nervous, immune, cardiovascular, reproductive systems, as well as damaging to heme synthesis and to the kidneys. Associated with cognitive impairment, behavioral problems, and hypertension.

Ozone is an odorless, colorless gas composed of three atoms of oxygen. Ozone occurs both in the earth's upper atmosphere and at ground level. Ozone can be good or bad, depending on where it is found. Ozone is categorized as "good" ozone or "bad" ozone.

- The "good" ozone occurs at a layer in the stratosphere about 10 to 25 miles above the earth, and it serves to protect us from the most damaging UV rays. It has been significantly damaged by chlorofluorocarbons [CFCs].
- The "bad" ozone is ground level ozone that is created by reaction of hydrocarbons, which include volatile organic compounds (VOCs) and nitrogen oxides in the presence of sunlight.
  - VOCs are emitted from a wide range of sources: Dry cleaners, cars, chemical manufacturers, paint shops, and many others.
  - The prime target organ for ozone is the lung, where it causes damage, diminishes lung function, and sensitizes the lung to other irritants.
  - The burning of fossil fuel (for example, in diesels, industrial boilers, and power plants) and waste incineration are two other major contributors.
  - Bad, ground-level (man-made) ozone can irritate the respiratory system, aggravate asthma, reduce lung function, inflame and damage the lung epithelium.

Health Effects: Powerful respiratory irritant (this effect can occur at levels frequently found in urban areas), decreased lung function, shortness of breath, chest pain on inhalation, wheezing/coughing, and exacerbations in asthma.

- Participate in discussions about land use and transportation issues.
- Advocate for energy-saving (and pollution-minimizing) lifestyles to patients' families.
- Participate in discussions about the placement of new schools – review potential sites for proximity to major roads, airports, and other pollution sources (as well as the properties previous usages to determine the possibility of contaminated soil).

Indoor air quality (IAQ) is another key concern in children's environmental health. The EPA is a good source of information regarding indoor air with its IAQ/Tools for Schools Kit. The National Association of School Nurses has been actively involved in educating nurses about health risks associated with indoor air pollutants, including molds, pesticides, environmental tobacco smoke, volatile organic compounds, and other exposures that occur in schools, the home, and daycare centers.

Environmental Health and Nursing Practice

In the IOM's seminal 1995 report, *Nursing, Health, and the Environment*, a road map was created for the integration of environmental health into all aspects of the nursing profession (see Figure 3). Recommendations include integration into education, practice, research, and policy/advocacy. In basic and advanced nursing education, environmental health is beginning to be found in texts and curricula. Teaching about assessment of the environment and environmental health risks is being incorporated into basic undergraduate nursing education courses, such as health assessment and community health. Nursing students are being taught to use environmental health indicators to assess the health of a community. In basic health assessment courses, adding environmental health to history taking has helped nurses identify potential etiologies that had not been considered previously. In addition, nurse researchers are becoming principle investigators on environmental health inquiries and are assisting communities in the translation of environmental health science into practices that protect health. In the policy arena, nurses have been affecting changes at the institutional, local, state, national, and international levels, and are valued by law makers as reputable sources of information on the effects of the environment on human health.

Highlighting Practice

In the practice arena, nurses with knowledge about the environmental effects on health are helping bridge the gap between primary acute care and public health. In the Baltimore City Health Department, public health nurses have partnered with emergency room clinicians to make follow-up home visits for children admitted to the emergency room with an asthmatic event. During the home visit, nurses

Figure 3.
Institute of Medicine Report: *Nursing, Health, and the Environment*

Nurses' Roles in Environmental Health

The following summarizes the recommendations from the Institute of Medicine report, *Nursing, Health, and the Environment* (IOM, 1995).

General Environmental Health Competency for Nurses

All nurses should have the following competencies:

A. Understand the scientific principles and underpinnings of the relationship between individuals or populations and the environment, including:
   1. The basic mechanisms and pathways of exposure to environmental health hazards.
   2. Basic prevention and control strategies.
   3. The interdisciplinary nature of effective interventions.
   4. The role of research.

B. Assess and refer, using the following strategies:
   1. Successfully completing an environmental health history.
   2. Recognizing potential environmental hazards and sentinel illnesses.
   3. Making appropriate referrals for conditions with probable environmental etiologies.
   4. Accessing and providing information to patients and communities, and locating referral sources.

C. Demonstrate knowledge of the role of advocacy (case and class), ethics, and risk communication in patient care and community intervention with respect to the potential adverse effects of the environment on health.

D. Understand the policy framework and major pieces of legislation and regulations related to environmental health.

IOM Recommendations on Nursing Practice, Education, Research, and Advocacy

A. Environmental health should be re-emphasized in the scope of responsibilities for nursing practice.
   1. Resources to support environmental health content in nursing practice should be identified and made available.
   2. Nurses should participate as members and leaders in interdisciplinary teams that address environmental health problems.
   3. Communication should extend beyond counseling individual patients and families to facilitating the exchange of information on environmental hazards and community responses.
   4. The concept of advocacy in nursing should be expanded to include advocacy on behalf of groups and communities, in addition to advocacy on behalf of individual patients and their families.
   5. Research regarding ethical implications of occupational and environmental health hazards should be conducted and findings incorporated into curricula and practice.

B. Environmental health concepts should be incorporated into all levels of nursing education.
   1. Environmental health content should be included in nursing licensure and certification examinations.
   2. Expertise in various environmental health disciplines should be included in the education of nurses.
   3. Environmental health content should be an integral part of life-long learning and continuing education for nurses.
   4. Professional associations, public agencies, and private organizations should provide more resources and educational opportunities to enhance environmental health awareness in nursing practice.

C. Multidisciplinary and interdisciplinary research endeavors should be developed and implemented to build the knowledge base for nursing practice in environmental health.
   1. The number of nurse researchers should be increased to build the knowledge base in environmental health as it relates to the practice of nursing.
   2. Research priorities for environmental health nursing should be established and used by funding agencies for resource allocation decisions and to give direction to nurse researchers.
   3. Current efforts to disseminate research findings to nurses, other health care providers, and the public should be strengthened and expanded.

D. Nurses should have the skills to work with the community, environmental groups, and local government, including the following activities:
   1. Legislative lobbying.
   2. Reporting community hazards.
   3. Advocating for safer environments.
   4. Policy implementation.

Source: Institute of Medicine, 1995.

engage in several activities, such as assessing the home for environmental triggers to asthma (for which recommendations are made), assessing the child's and parent/ guardian's understanding of asthma and the associated medicines and use of medical devices, providing health education, determining the health insurance status of the child and enrolling the child in a public insurance scheme as necessary, and connecting the child to a primary care provider when appropriate. This combination of services has been shown to decrease subsequent emergency room visits (personal communication, Mary Harris, Baltimore City Health Department, 2005). In the absence of these activities, many risk factors would persist, including asthma events triggered by preventable environmental exposures.

While it is essential to include questions about environmental exposures when taking a history, it is equally critical to understand the limitations of the clinical setting for addressing environmental health risks and the ways in which to connect to public health and community-based services where environmental health issues may be more effectively addressed. Another imperative reason to connect to the public health world is lead poisoning. Clinicians have limited choices, beyond guidance and health education, that they can do to reduce elevated blood lead levels in children exposed to lead poisoning. This often requires a combined public health and housing solution. As such, clinicians must be aware of the mechanism to initiate the public health response and the requirements for reporting elevated blood-lead levels. This varies by state and locality, and a call to the local health department is the first step.

In almost every instance, reduction or elimination of the environmental exposure is the key to affecting the related health effect. Public health practices and policies are generally the path to this end. After lead was taken out of gasoline in the 1970s, there was a noteworthy reduction in the average blood lead level in the U.S. The reunification of Germany has resulted in greater environmental protection efforts, and there has been a marked reduction in the rates of chronic cough and bronchitis symptoms in a study cohort of children (Heinrich, Hoelscher, & Wichmann, 2000).

Highlighting Research

There are substantial data gaps regarding the understanding of human health threats associated with the chemical soup that compromise our air and water, as well as the environmental exposures associated with energy production, manufacturing, and consumer products, such as household cleaners and personal care products. There are many national and local research initiatives that provide a forum for nurses to voice their concerns about health and environment in a multidisciplinary arena. About 100,000 chemicals are used in the industrialized world. Almost all are man-made, 15,000 are produced annually in quantities greater that 10,000 pounds, and 2,800 of them are produced in quantities greater than one million pounds a year (Goldman & Koduru, 2000). Of the 2,800, only 7% have been tested for developmental effects, and only 43% have been tested for any human health effects. The trend in European chemical policies is toward increased testing requirements, but the U.S. is not yet on this same policy trajectory. Instead, the U.S. has relied on voluntary testing efforts by the manufacturers – the results of which are not often required to be made public.

The federal research agencies have however, funded several Children's Environmental Health Research Centers. Additionally, for each of the 10 federal regions of the U.S, there is a Pediatric Environmental Health Specialty Unit in which pediatric specialists in environmental health provide advice and consultation for health professionals and others who have questions of an environmental health nature. The role of nurses in these centers is also advancing as nurses work toward defining a framework for nursing practice in this arena. The EPA is helping to expand these centers internationally, first in Mexico, with others being planned in South America.

National Children's Longitudinal Study

Several federal agencies have partnered to carry out a National Children's Study, authorized by the Children's Health Act to create a national longitudinal study of environmental influences (including physical, chemical, biological, and psychosocial) on children's health and development. It will include 100,000 children across the U.S. who will be identified early in pregnancy and followed through birth, childhood, and into young adulthood. This study is led by a consortium of the following federal agencies – the U.S. Department of Health and Human Services (DHHS) (including the National Institute of Child Health and Human Development [NICHD], the National Institute of Environmental Health Sciences [NIEHS], and the CDC) and the (EPA) (see Figure 4). This study will provide invaluable data on the relationship between the environment and children's environmental health.

Health Tracking

Though the environment is considered a significant determinant of health, few systems exist at the state or national level to track environmental exposures and health effects in a way that can help determine associations between the two. Tracking systems that do exist are not mutually compatible, making data linkages extremely difficult or impossible. The CDC is building a "national integrated environmental and public health information system that supports national efforts to standardize and facilitate the electronic exchange of information. Linking environmental and health data will enable a timely response to potential public health problems related to the environment" (Gerberding, 2004).

The goal of the tracking initiative is to improve the health of communities through the identification of risks and the development of more effective strategies to prevent or control acute and chronic diseases linked to environmental exposures. It is also intended to help health care providers to provide better care, with a particular emphasis on targeted preventive services, which will once again rely heavily on the interaction between clinical practitioners, public health professionals, and those involved in environmental protection.

Moving Policy and Advocacy

Ken Olden, Past Director of the National Institute of Environmental Health Sciences, stated that "prevention of disease has proven to be the most cost-effective means of

Figure 4.
The National Children's Study

What is the National Children's Study?

The National Children's Study will examine the effects of environmental influences on the health and development of more than 100,000 children across the United States, following them from before birth until age 21. The goal of the study is to improve the health and well-being of children.

The study defines "environment" broadly and will take a number of issues into account, including:

- Natural and man-made environment factors.
- Biological and chemical factors.
- Physical surroundings.
- Social factors.
- Behavioral influences and outcomes.
- Genetics.
- Cultural and family influences and differences.
- Geographic locations.

Researchers will analyze how these elements interact with each other and what helpful and/or harmful effects they might have on children's health. By studying children through their different phases of growth and development, researchers will be better able to understand the role of these factors on health and disease. Findings from the study will be made available as soon as possible as the research progresses.

The study will also allow scientists to find differences that exist between groups of people in terms of their health, health care access, disease occurrence, and other issues so that these differences or disparities can be addressed.

The National Children's Study will be one of the richest information resources available for answering questions related to children's health and development and will form the basis of child health guidance, interventions, and policy for generations to come. It is anticipated that the preliminary results from the first years of the study will be available in 2008-2009.

Source: National Institutes of Health, 2008.

Figure 5.
1996 Food Quality Protection Act

The Food Quality Protection Act was the first environmental protection statute to require that:

- Standards for pesticide residues in food must be health-based. They must be set at levels that ensure a "reasonable certainty of no harm."
- Exposure and vulnerabilities specifically of infants and children must be considered in establishing pesticide residue standards.
- When insufficient data exist to assess the special exposures and/or vulnerabilities of infants and children, an additional 10-fold safety factor must be considered in setting standards.
- Consideration of the potential benefits of pesticides must be limited.
- Endocrine effects of pesticides must be systematically evaluated in toxicity testing.
- All pesticide standards must be reviewed every 10 years.

Source: EPA, 2007.

reducing health care costs" (Olden, 2002). During the Clinton Administration, an Office of Child Health Protection was established at the EPA (www.epa.gov/children). Its presence has served to remind the regulatory branches of the agency about the special vulnerabilities of children and the need to take children into account during regulatory deliberations. This was supported by the requirements articulated in the 1996 Food Quality Protection Act (FQPA), which provided the first statutory requirement to consider childrens' special needs. It calls for protection from pesticides (see Figure 5).

Several national organizations have been very effective in advocating for children's environmental health, the most visible of which are the American Academy of Pediatrics (whose *Green Book* is a helpful primer on pediatric environmental health) and the Children's Environmental Health Network, which has an online manual for nurses and physicians (www.cehn.org). The National Association of School Nurses is also funded by the EPA to provide training and education on this issue. In addition, several national environmentalist organizations have focused their attention on children's environmental health issues. The National Conference of State Legislators has created a primer on children's environmental health that includes examples of state policies and legislation that have been introduced throughout the country (Farquar & Anderson, 2004).

Sometimes policy change does not require "an act of Congress," but rather, it changes within our own institutions. When nurses in the Neonatal Intensive Care Unit (NICU) discovered there were reproductive health risks associated with the chemical di-ethylhexyl phthalate (DEHP) in their IV tubing and bags, they became agents of change. There is evidence that DEHP, the chemical added to IV bags to make the plastic malleable, is associated with risk of damage to the male reproductive track. The Food and Drug Administration has warned that neonates, particularly baby boys, should avoid exposure to DEHP, and it has encouraged hospitals to reduce use of DEHP-containing devises on certain patients, particularly male infants. Infants in NICUs treated with DEHP-containing products have high levels of its metabolite in their bodies, and investigators have directly linked the DEHP metabolite excreted in urine with the use of DEHP-containing products in patients' treatment (Green et al., 2005). Nurses in NICUs around the country have been taking the lead in changing hospital purchasing policies so that DEHP-free IV tubing and IV bags are available. This combined micro-policy and market-force approach has characterized the Health Care Without Harm campaign (www.noharm.org), a coalition effort that is working on DEHP concerns, as well as a broad range of occupational and environmental health issues, in order to help hospitals become model stewards of the environmental and proponents of environmental health.

Conclusion

Since the IOM's report on Nursing and the Environment was released, there have been many successful efforts to achieve this goal of full integration. The ANA has now adopted principles of environmental health nursing practice and multiple continuing nursing education modules on environmental health. Many state nurses associations and specialty organizations now house environmental health task forces. The National Association of Pediatric Nurse Practitioners has pledged its support of the National Environmental Education and Training Foundation's position statement on health professionals and environmental health education. These groups are affecting change in hospitals, communities, and in the legislature, and these changes improve the health and quality of life of children and their families. Individual nurses at the basic and advanced practice levels, nursing professional organizations, nursing academics, and researchers all have been pioneering ways in which to combine their passion about human health with their concern about environmental protection, thus caring for the earth while caring for their patients – and learning that the two are inextricable.

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