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Environmental Health and Developmental Disabilities

A Life Span Approach

Carl V. Tyler Jr, MD, MS; Sheryl White-Scott, MD, FACP; Shirley M. Ekvall, PhD, RD, FACN, FAAMD; Laura Abulafia, MHS

Prenatal and childhood environmental exposures are an underrecognized primary cause of intellectual and other developmental disabilities. In addition, individuals with established disabilities are vulnerable to further harm from subsequent environmental exposures. In individuals with communicative impairment or limited ability to independently escape from hazards, these subsequent exposures, too, may occur undetected or untreated. This article introduces the subject of environmental health and developmental disabilities throughout the life span. In particular, we focus on ways that families, communities, and health professionals can prevent both primary and secondary disabilities through better awareness of common environmental health issues. **Key words:** *developmental disabilities*, *environmental health*, *life span environmental exposure*, *pediatric environmental risks*

AN OVERVIEW

Developmental disabilities (DD) (see Glossary for terms in italic in the Appendix) are widespread and affect 3%–8% of the 4 million children born each year in the United States.[1] Developmental disabilities are a heterogeneous group of conditions that are present at birth, or emerge in childhood, and include such diagnoses as intellectual disability (previously called "mental retardation,") cerebral palsy, autistic spectrum disorders, epilepsy, learning disabilities, attention deficit disorder, and other neurobehavioral conditions. While the etiology of some DD is purely genetic, such as Down syndrome or fragile X syndrome, other DD are due to complex interactions between genes and environment and some are purely caused by *environmental toxicants* alone.[2] Experts convened by the National Academy of Sciences estimate that 3% of DD are directly caused by environmental toxicants and another 25% are due to interactions between environmental factors and individual genetic susceptibility.[3] For additional core information about DD and about environmental health and DD in particular, visit the Web site for the American Association on Intellectual and Developmental Disabilities (www.aaidd.org.) and read about its Environmental Health Initiative.

Many researchers believe that the incidence of DD is rising and that environmental

From the Cleveland Clinic Ambulatory Research Network, Department of Family Medicine Cleveland Clinic, and Fairview Hospital/Cleveland Clinic Family Medicine Residency Program, Cleveland, Ohio (Dr Tyler); Department of Medicine, New York Medical College, Valhalla, and St Dominic's Family Health Center/Mary Immaculate Hospital, Jamaica, NY (Dr White-Scott); Cincinnati Children's Hospital Medical Center, Division of Developmental Disabilities, and Department of Nutritional Sciences, University of Cincinnati, Cincinnati, Ohio (Dr Ekvall); and American Association on Intellectual and Developmental Disabilities (formerly AAMR), Washington, DC (Ms Abulafia).

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Corresponding author: Carl V. Tyler Jr, MD, MS, Fairview Hospital/Cleveland Clinic Family Medicine Residency Program, 18200 Lorain Ave, Cleveland, OH 44111 (e-mail: carl.tyler@fairviewhospital.org).

toxicants are partly responsible. A multisite surveillance network sponsored by the Centers for Disease Control and Prevention (CDC) reported that the prevalence of *autism spectrum disorders* among 8-year olds was an alarming 1 in 150 children.[4] While a number of susceptibility genes appear to be associated with autism, prenatal and early infancy exposure to mercury-containing compounds, halogenated aromatics, pesticides, and certain pharmaceuticals (such as thalidomide and valproic acid) are thought to be responsible for at least some of the increasing numbers of children with this disorder.[5]

One in 6 children now faces some form of *neurodevelopmental delay*.[6] Many of these are the direct consequences of maternal alcohol, tobacco, or drug use. In some children, neurodevelopmental delays are attributed to prenatal or postnatal exposure to environmental toxicants (including lead, mercury, pesticides, and solvents) or to nutritional deficiencies, either prenatally or postnatally.

Environmental toxicants are a particularly important etiology of a subset of DD termed *neurobehavioral disorders*. According to one estimate, about 10% (range 5%–20%) of neurobehavioral disorders are caused by environmental toxicants, exclusive of alcohol, tobacco, or drugs of abuse.[7] The estimated costs of neurobehavioral disorders in the United States attributed to environmental toxicants are a staggering $9.2 billion annually.[3]

The impact of environment on the health of individuals with DD extends beyond the etiology of the disability. In individuals with established DD, environmental exposures can cause additional health problems, including asthma, dermatologic conditions, headache, and certain cancers.

An additional consideration is that individuals with DD now live longer lives. In the United States alone, an estimated 641,000 adults with DD are 60 years or older.[8] There has been essentially no research on the cumulative impact of environmental toxicants on this older cohort of individuals with DD.

A united effort of self-advocates, families, and professionals in public, environmental, and community health is necessary to address the ever-expanding and complex problem of environmental health and DD. To begin, there is a widespread lack of knowledge, among lay and professional groups, about the role of environmental toxicants as both primary and secondary causes of disability. Second, it is often difficult to recognize when environmental toxicants are affecting the health of a particular individual with DD. Lastly, preventing exposure to environmental toxicants often requires individual, institutional, and community-wide action. For more information, see the "Recommendations" and "Resources" sections in the Appendix, or contact AAIDD.

COMMON PRENATAL AND CHILDHOOD TOXICANT EXPOSURES

In the womb, the developing fetus receives nutrients from the mother via the *placenta*. To foster growth, some of the nutrient transport mechanisms involving the placenta shunt nutrients from the mother to the fetus, achieving far greater concentrations in the fetus than those in the mother. Unfortunately, certain environmental toxicants utilize these same nutrient transport mechanisms, shunting environmental toxicants from the mother into the fetus. Alcohol, lead, and mercury are examples of toxicants that selectively concentrate in the fetus.

An analogous process occurs with breast milk production. Just as some nutrients are concentrated into breast milk, so can some environmental toxicants achieve higher concentration in breast milk than in the mother's body, again exposing the developing infant to potentially greater harm.

During prenatal neurodevelopment, and in the first years of life, the brain is particularly vulnerable to neurotoxic effects of environmental exposures. *Neurotoxicants* interfere with essential developmental central nervous system processes, including cell proliferation, cell migration, formation of connections between nerve cells, programmed cell death, and myelinization.[9]

Lead

Lead is a metal that damages the nervous system, leading to decreased learning ability and behavioral deficits. It is also a reproductive toxin and a carcinogen. Lead's wide range of neurotoxic effects includes learning disabilities, hyperactivity, impaired hearing, behavioral tendencies toward violence, and even brain damage.[10] While the CDC and the American Academy of Pediatrics currently identify 10 μg/dL as a threshold blood lead level for concern, other studies suggest that even lower blood lead concentrations may impair cognition.[11] Thus, there may be no truly "safe" blood lead level that is free of adverse effects on the nervous system.

Maternal lead exposure can result from occupational or renovation-related activities, accidental dietary ingestion of lead-contaminated food or calcium supplements, or pregnancy-associated pica behavior, the ingestion of nonfood items. Preventive education to women in the childbearing years should include the following: (1) avoid work or hobby activities that may result in lead exposure, including renovations of an older home and (2) take calcium supplements distributed by well-established companies, avoiding "natural" remedies that may contain ground bone, a potential source of lead. During pregnancy, sensitive questioning about pica behavior should occur at each prenatal visit. In some women, chewing and/or ingestion of pieces of ceramic pottery has resulted in an elevated lead level in both mother and newborn.

Infants may acquire lead via breast milk; however, this is extremely rare and usually does not occur at a clinically significant rate unless the maternal blood lead level is more than 25–30 μg/dL.[12] In general, women should not refrain from breast-feeding because of any theoretical fear that their breast milk is contaminated by lead.

Infants and young children absorb lead more avidly than adults. Crawling and mouthing behaviors also predispose children to greater lead exposure. Children with autism spectrum disorder or pervasive developmental delays appear particularly vulnerable to lead poisoning.[13] As long as individuals with DD engage in pica behaviors, they remain at risk for lead exposure, regardless of chronological age.

While the average blood lead concentration of school-aged children in the United States has decreased markedly since the removal of lead from gasoline and common household paints, some children remain at disproportionately higher risk of lead exposure and poisoning. Among these are children with DD.[10] Extrapolating data from The Third National Health and Nutrition Examination Survey, an estimated 310,000 children aged between 1 and 5 living in the United States still carry lead levels of 10 μg/dL or greater.[14] The cost of lead poisoning in the pediatric population of the United States has been estimated at $43.4 billion annually.[3]

In the United States, both the CDC and the American Academy of Pediatrics recommend that all children have their blood lead levels measured at the ages of 1 and 2 years. Since these recommendations were made in 1991, median blood lead concentration has decreased among US children, although Black children and poor children tend to still have higher levels of lead concentration likely due in part to older housing conditions. Universal screening for excessive lead levels and targeted screening among these higher-risk populations remain a core part of the national strategy to reduce morbidity and mortality from lead exposure. As long as individuals with DD engage in behaviors associated with lead exposure, for example, mouthing, crawling, or eating nonfood items, they should be considered at risk for lead exposure and may require lead screening at ages exceeding general population guidelines.

Individuals working in health, education, mental health, and child care sectors all need to learn about the magnitude of the lead problem in their local community. They should seek every opportunity to educate parents, and those who work with or care for children, about common sources of lead and about

developmental behaviors predisposing to lead ingestion.[15]

Mercury

Mercury is a known *teratogen* and, like lead, it is linked to many nervous system disorders.[16] Prenatal exposures to mercury can impair many neurocognitive functions, including thought processing, memory, attention, and fine motor skills.

Atmospheric mercury from industrial sources is converted into methyl mercury and becomes bio-concentrated as it moves up the food chain. The most common maternal mercury exposure is methyl mercury, acquired through dietary sources, primarily larger fish (swordfish, shark, king mackerel, and tilefish). Methyl mercury then accumulates in the fetus achieving concentrations in the fetus that are greater than those in the mother. In adults, following a single exposure, whole body elimination of mercury requires 70–80 days.[17]

Like lead, mercury is able to cross the placenta from the maternal circulation into the fetus. Mercury is also found in breast milk but at concentrations that are one third of the mother's blood levels. Mercury levels of breast-fed infants are highest immediately after birth, declining significantly by 2–3 months age.[18] Women who are pregnant (or who might become pregnant, given the long time required to eliminate mercury) can avoid mercury ingestion by avoiding consumption of those larger fish listed above. Instead, they should consume seafood that is typically lower in mercury: ocean perch, haddock, shrimp, canned light tuna, wild salmon, pollock, and catfish. Albacore "white" tuna usually contains more mercury than canned light tuna. Fish ingestion should be limited to 12 oz per week, typically 2 average servings.[19]

Less commonly, mercury exposure occurs through vapor inhalation of elemental mercury from broken equipment gauges, thermometers, blood pressure gauges, or other electrical/industrial devices, such as broken fluorescent light bulbs. Even in small amounts, an elemental mercury spill on carpeting may emit fumes for years. Exposure to elemental mercury can be diminished through avoidance of contact with liquid mercury that has spilled, adequate ventilation of the room(s) where a spill has occurred, and prompt reporting of broken gauges or thermometers to local hazardous waste/environmental agencies.

Smoking

Whereas other toxicants directly injure the developing fetal brain, nicotine causes fetal harm, in part, by constricting the placental vessels that provide nutrients, including oxygen, to the fetus. There is also evidence that maternal tobacco use is directly neurotoxic. Fetal nicotine exposure occurs through maternal tobacco use and through maternal exposure to environmental tobacco smoke (ETS), more commonly known as *secondhand smoke*. Infant exposure to nicotine occurs through inhalation of ETS and through breast milk.

Infants born to mothers who smoke are more likely to be small for gestational age, with a lower birthweight and smaller head circumference.[20] The risk of sudden infant death syndrome is 5 times greater among infants whose mothers smoked during their pregnancy.[20] Children born to mothers who smoked during their pregnancy have higher rates of learning disorders, attention-deficit/hyperactivity disorders, and disruptive behaviors.[21] A systematic review of the literature regarding smoking cessation programs targeting pregnant women confirmed that such programs effectively reduce the proportion of pregnant women who smoke, reduce low birthweight, and reduce preterm birth.[22]

Beyond the smell, cigarette smoking releases tiny particles that attach to curtains, upholstery, carpets, and walls. These particles are eventually inhaled. Postnatal ETS has been linked to many adverse health outcomes in children, including decreased lung growth and increased rates of asthma, respiratory tract infections, and otitis media

(ear infections).[23] Even low levels of ETS exposure is associated with reduced cognitive abilities among children and adolescents.[24]

In a study conducted by the CDC, more than half of all nonsmokers in the United States older than 3 years had detectable amounts of cotinine, a metabolic by-product of nicotine, in their blood.[25] Alarmingly, nonsmoking children and teenagers carry even higher levels of cotinine than nonsmoking adults.[24]

If exposure to ETS is unavoidable in the home, it is advisable to keep the smoke outdoors so that it does not collect in carpeting, fabrics, and other household items that absorb the toxicants present in tobacco smoke.

Alcohol

Alcohol consumption during pregnancy remains the foremost preventable cause of DD in the United States today.[26] Prenatal exposure to alcohol can produce a wide range of structural, behavioral, and neurocognitive anomalies termed *fetal alcohol spectrum disorders*.[27] These include fetal alcohol syndrome, alcohol-related birth defects, and alcohol-related neurodevelopmental disorder.

In the fetal brain, alcohol interferes with the genesis, proliferation, migration, maturation, and programmed death of nerve cells. In addition to its nervous system injury, fetal alcohol exposure can cause anomalies of the face, kidneys, heart, and skeleton. The exact pathophysiologic mechanism is unknown, but alcohol and its metabolites are known to disrupt cellular differentiation and growth, DNA and protein synthesis, and cell migration. Alcohol interferes with the placental transfer of many nutrients, including amino acids, glucose, folic acid, and zinc.

Fetal alcohol spectrum disorders are thought to affect between 1% and 3% of children in the United States.[28] Despite these risks to the fetus, national Behavioral Risk Factor Surveillance System data indicate that among pregnant women in the United States, 10% use alcohol, 2% drink 7 or more alcoholic drinks per week, and 2% engage in binge drinking, defined as 5 or more drinks on any 1 occasion.[26]

Screening for alcohol use in pregnancy and brief interventions to reduce alcohol use have been shown to decrease the percentage of alcohol-exposed pregnancies.[28] Two screening measures specifically targeting alcohol use in pregnant women have been developed, the T-ACE and TWEAK. Questions about tolerance: "How many drinks does it take before you feel high?" and "How many drinks can you hold?" (ie, "How many drinks does it take before the alcohol makes you fall asleep or pass out?") are particularly helpful in uncovering pregnant women who might otherwise deny or underreport their alcohol use. Screening for alcohol use alone, without additional intervention, reduces prenatal alcohol consumption.[29]

Brief interventions to decrease alcohol exposure during pregnancy are sessions typically lasting 15 minutes in duration or less and may be single or multicontact. The content of these sessions includes education about alcohol abstinence, goal setting, and brainstorming; these often incorporate techniques derived from motivational interviewing models. In one study, brief intervention for alcohol use in pregnancy was most effective among the subgroup of heavier drinkers, whose partners were involved in the brief treatment.[30]

There is no established safe level of alcohol consumption during pregnancy. Pregnant women are advised to refrain from drinking any alcohol whatsoever throughout the pregnancy.

NUTRITION AS A PROTECTIVE FACTOR AGAINST TOXICANTS

Specific nutritional deficiencies may be the primary cause of some DD, as exemplified by the relationship between folate deficiency and myelomeningocoele.[31] However, for the purposes of this article, discussion is limited to the protective effect of specific nutrients against specific environmental toxicants.

Zinc deficiency acts as a coteratogen with alcohol.[32] In alcohol-exposed pregnancies,

low birthweight, malformation, and growth depression are more common when both alcohol exposure and zinc deficiency are simultaneously present. Suboptimal zinc intakes appear to be common in pregnancy.[33]

Optimum zinc, calcium, iron, and vitamin C intakes are relevant to lead exposure. Individuals of all ages consuming diets that are adequate in iron, calcium, vitamin C, and zinc absorb less lead from the intestinal tract and suffer less injury from what lead is absorbed.[34] Therefore, families whose children are at higher risk for lead poisoning should be counseled about dietary sources of these critical nutrients. Additional information regarding dietary sources of these nutrients is available online through the National Institutes of Health, Office of Dietary Supplements. (http://ods.od.nih.gov/Health_Information/Vitamin_and_Mineral_Supplement_Fact_Sheets.aspx).

TOXIC EXPOSURES IN AND AROUND THE HOME AND SCHOOL

Environmental toxicants accumulate in the developing fetus prior to birth and continue to accrue throughout childhood, representing a "body burden" for each child.[35] These exposures occur in the home, in the school, and in other community settings.

It is important to identify toxic exposures in and around the home because there may be a sizable cumulative effect of these exposures. Many exposures, such as cleaning products and pesticides, can be easily avoided or limited. Alarmingly, an estimated 3–4 million children and adolescents live within 1 mile of a federally designated *Superfund site*.[36] While families may have limited resources to control where they live, they do exert significant control over critical aspects of their home environment.

Potential sources of toxicants in the home include cleaning products, pesticides, paints and varnishes, building materials, pet care products, plastics, and hobby materials. Cleaning products, air fresheners, and personal care products (such as soaps, shampoos, hand lotion, nail polish, perfumes, and cosmetics) may also contain toxic chemicals, such as phthalates, a class of oily chemical compounds used in plastic to improve flexibility and durability that are linked with cancer, hormonal disruption, and birth defects.[37] Practices such as washing plastic baby bottles or drinking bottles made out of polyvinyl chloride plastic, or microwave heating food in plastic containers, may leach dangerous chemicals such as dioxin and bisphenol A out of plastics.[38]

Pesticides and herbicides can be found on food, in chemical tick- and flea-collars, flea baths or dips for pets, in lawn and garden weed killers and bug sprays, and in indoor products such as rat poison and ant traps. Carpets, furniture, and house dust can serve as reservoirs for pesticides. Indoor pesticide levels are most concentrated in the air just above floor level.[39]

While healthcare providers may readily recognize acute poisoning by *organophosphate pesticides*, they may fail to identify the more subtle manifestations of chronic exposure.[39] Children repeatedly exposed to high levels of pesticides in the home or in schools have been shown to display hyperactivity and other behavioral disorders and to suffer impairments in short-term memory and eye–hand coordination.[40] To minimize indoor contamination with outdoor pesticides, remove shoes worn outside when entering indoors, dry off pets when they return indoors, and damp mop the floor frequently.

Children and adults may be exposed to toxicants such as pesticides, cleaning chemicals, and poor indoor air quality (IAQ) in schools and vocational training sites.[41] Exhaust from buses can easily travel indoors and be circulated along with other indoor contaminants throughout the school. Toxicants in solvents may be found in paints, model building, furniture refinishing, and auto repair. Potentially harmful art supplies include rubber cement, permanent felt-tip markers, pottery glazes and enamels, and spray fixatives.[42]

The US Government Accountability Office released a report finding that more than

half of schools in the United States have IAQ problems in at least some part of their campuses.[41] Poor IAQ in schools can impact the comfort and health of students and staff, which, in turn, can affect concentration, attendance, and student performance. Moreover, if schools fail to respond promptly to poor IAQ, students and staff are at an increased risk of short-term health problems, such as fatigue and nausea, as well as long-term problems like asthma.[43] A child with DD may be especially vulnerable to these outcomes. Table 1 lists common toxicants and ways to minimize exposure.

ENVIRONMENTAL HEALTH IN ADULTHOOD AND LATE LIFE

Following completion of their educational program, employed adults with DD may encounter potentially injurious environmental toxicants in the workplace.[44] They may not recognize such exposures as potentially harmful or may not link their symptoms or health problems to their work environment. Even if they suspect an environmental health problem, they may be reluctant to report it for fear of losing their employment, given the scarcity of job opportunities.

Persons with DD are commonly exposed to ETS from their families, peers, and support persons at residential and work environments. Environmental tobacco smoke not only measurably increases the risk of lung cancer in nonsmokers but also increases the risk of heart disease. Nicotine in particular is also linked to acute increases in heart rate and blood pressure. Environmental tobacco smoke exposure nearly doubles the risk of myocardial infarction. Nonsmokers who have high blood pressure or high blood cholesterol level are at even greater risk of developing heart diseases from ETS.[25] Persons with DD and their advocates need to recognize the health value of tobacco-free work and residential environments.

Individuals requiring more personal assistance and who have limitations in mobility may be particularly subject to environmental tobacco exposure or other environmental toxicants. Fragrances, indoor air sprays, fabric softeners, and fumes from cleaning products may cause discomfort or more serious symptoms such as irritation to the eyes, nose, or throat, and individuals may experience nausea, dizziness, or headaches. Persons with limited mobility or verbal skills are less able to escape from these exposures, thus placing them at higher risk for secondary health concerns.

Adults who engage in pica are at additional risk for exposure to hazardous toxicants in the environment. Cleaning products, personal care products, and other potentially harmful items should be kept secure from adults who engage in pica. Contact information for local poison control centers should be prominently displayed at home, school, and workplace and they should be contacted immediately if a potentially harmful ingestion has occurred. "Green cleaning," involving the use of cleaning products with less toxicity, can minimize adverse health outcomes from these exposures.[45]

Many individuals, with and without DD, take imported health remedies or consult traditional, complementary, and alternative medicine practitioners without their healthcare provider's knowledge. Increasingly, it is recognized that some of the products obtained through these sources may contain lead, mercury, heavy metals, or other potentially harmful toxicants. Healthcare providers should carefully inquire about nonprescription substances when examining individuals for illness due to possible toxic exposures.

Individuals diagnosed with "sentinel health conditions" such as asthma, contact dermatitis, bladder cancer, or peripheral neuropathy should undergo a careful evaluation of their occupational and home environments for potential exposures that may have initiated or contributed to these conditions. Unexplained signs and symptoms, such as cough, eye irritation, itchy or sensitive skin, runny nose, or behavioral problems should prompt consideration of possible environmental factors. Consultation with a local occupational medicine

Table 1. Common environmental toxicants and how to avoid them

Toxicant and where is it found?	What does it do?	How do I avoid it?	Alternatives? What can I do?
Alcohol Wine Beer Liquor Some medications Some folk or traditional medicines	Leading known preventable cause of intellectual disability in the United States Low birthweight, small head circumference, failure to thrive, developmental delay, organ dysfunction, epilepsy, poor coordination/fine motor skills *Facial abnormalities*: smaller eye openings, flattened cheekbones, and indistinct philtrum (an underdeveloped groove between the nose and upper lip) Poor socialization skills, such as difficulty building and maintaining friendships and relating to groups, lack of curiosity or imagination *Learning difficulties*: poor memory, inability to understand concepts such as time and money, poor language comprehension, poor problem-solving skills *Behavioral problems*: anxiety, hyperactivity, inability to concentrate, social withdrawal, stubbornness, impulsiveness	Fetal alcohol spectrum disorders (FASD) is 100% preventable. If you are pregnant or plan to become pregnant, do not drink any alcoholic beverage. There is no known safe level. To ignore the facts does not change the facts Studies suggest that drinking a large amount of alcohol at any 1 time may be more dangerous to the fetus than drinking small amounts more frequently Unfortunately, women sometimes wait until a pregnancy is confirmed before they stop drinking. By then, the embryo/fetus has gone through several weeks of critical development, a period during which exposure to alcohol can be very damaging. Therefore, the Division of Alcohol and Drug Abuse urges women who are pregnant or anticipating a pregnancy to abstain from drinking alcoholic beverages	Alternatives to alcohol consumption may vary and could include substituting the beverage with water, tea, juice, and other such beverages Speak with your healthcare provider to assist you with interventions to abstain from alcohol during pregnancy If you are planning to get pregnant and are concerned about your ability to stop drinking alcohol, see a healthcare provider for assistance Check contents of nonalcoholic beverage to ensure that it is alcohol free
Lead Leaded paints Some imported jewelry (especially metal toy jewelry)	Lead is a heavy metal that is found naturally in the earth and in many common products Impacts brain development, fetal	Avoid old painted toys, avoid lead and pewter figurines Use wood toys, especially untreated wood (or treated with oil or wax)	Nova Natural Toys and Crafts, the Bingo Bed, the Wagon of Blocks, the Beka Starter Block Set, wood puzzles, etc

(*continues*)

Table 1. Common environmental toxicants and how to avoid them (*Continued*)

Toxicant and where is it found?	What does it do?	How do I avoid it?	Alternatives? What can I do?
Diesel exhaust or leaded gasoline (tetraethyl lead, TEL) Dust and soil contaminated with the above Drinking water (from lead pipes and solder) Incinerated products (printing inks and paper) Batteries Smelter and industrial emissions Radiation shields Hair dyes Lead weights used to balance motor vehicle wheels	development, and reproductive system; damages the nervous system Linked to birth defects, intellectual disability, attention deficit disorder (ADD), and other behavioral disorders Long-term exposure is linked to anemia (low red cell count), kidney disease, Alzheimer's disease, and death	Check paints used for windows and windowsills, doors/doorframes, stairs, railings, banners, porches, and fences If you rent or own a home built before 1978, notify your landlord of peeling/chipping paint; homeowners should complete removal and repairs Wash hands often, especially before eating, before nap time, and bed time Keep children's play areas clean Wash bottles, pacifiers, toys, and stuffed animals regularly	Buy unleaded paints (read label) for your home Buy unleaded gasoline and diesel Eat nutritious, low-fat meals high in iron and calcium, such as red meat and dairy products. Children with diet high in iron and calcium absorb less lead Change lead plumbing/piping Alternatives include zinc, steel, stainless steel, some plastics, aluminum, silicone rubber, tin, copper, brass, ceramics In childbearing years, women should check occupation, hobby, or renovation-related repairs that could result in lead exposure
Mercury Most mercury comes from coal-fired power plants and other industrial sources Fish and seafood Thermometers Dental amalgams Elemental mercury vapors from spills Auto exhaust Batteries	Like lead, mercury is a naturally occurring heavy metal and can be found in certain foods and can be inhaled as a vapor or ingested through food *Neurologic development*: impaired cognitive function, memory, attention, language, fine motor skills, visual spatial skills, insomnia, tremors, mood swings, headaches, changes in nerve responses	Avoid eating if pregnant or nursing a child any large fish or predator fish, such as albacore tuna, shark, Chilean sea bass, swordfish, king mackerel, tilefish Avoid eating fish caught from areas in close proximity to coal-fired power plants/other industrial sources *Note*: fish consumption is beneficial to health in the long-term and	Seafood, usually lower in mercury are recommended, for example, ocean perch, haddock, shrimp, canned light tuna, wild salmon, pollock, catfish People concerned about their exposure to inorganic mercury should consult their healthcare provider Check the EPA fish consumption advisories and/or state fish

(*continues*)

Table 1. Common environmental toxicants and how to avoid them (*Continued*)

Toxicant and where is it found?	What does it do?	How do I avoid it?	Alternatives? What can I do?
Pesticides and fertilizers Drinking water Bleached flour Processed foods Fabric softeners Calomel (talc, body powder) Paint pigments, solvents Cinnabar (used in jewelry) and cosmetics: some mascaras Floor waxes, polishes, wood preservatives Plumbing piping Air conditioner filters	Neuromuscular changes (such as weakness, muscle atrophy, twitching) Emotional changes (mood swings, irritability, nervousness, excessive shyness) Performance deficits on tests of cognitive function Kidney disorders Skin rashes and dermatitis	has been related to reduced coronary heart disease risk If elemental mercury is spilled, contact local hazardous waste collection programs	advisories; for additional information see EPA links: http://www.epa.gov/waterscience/fish/advice/ For disposal and cleanup programs, see EPA links: http://www.epa.gov/mercury/disposal.htm*
Nicotine Cigarettes Tobacco products Secondhand smoke exposure, also called environmental tobacco smoke (ETS)	Nation's leading preventable cause of death Dioxins are present in cigarette smoke *Maternal cigarette smoking*: spontaneous abortions, low birthweight, neonatal intensive care unit admissions, 50%–500% increased incidence of sudden infant death syndrome (SIDS), learning disorders, ADD, disruptive behaviors *Nicotine in fetus*: perinatal morbidity and mortality, growth retardation, behavioral anomalies *Cell damage*: loss of synaptic function; brain areas involved in learning, memory, and mood	Quit smoking Avoid exposure to ETS or secondhand smoke Smoke outdoors or away from pregnant women and children to reduce exposure to ETS Prenatal nicotine exposure predisposes the brain to nicotine addiction in adolescence: nearly all smokers begin as adolescents, 75% become daily smokers by 20 years of age, lower quit rate, females smoke more than males and health effects are worse for females	Nicotine replacement therapy (NRT) products are available as gum and patches over the counter, prescription nasal spray and puffer ("inhaler") Self help booklets Telephone counseling through "quit lines" Work with your healthcare provider to assist in smoking cessation For more information, visit: www.americanheart.org or www.lungusa.org

(*continues*)

Table 1. Common environmental toxicants and how to avoid them (*Continued*)

Toxicant and where is it found?	What does it do?	How do I avoid it?	Alternatives? What can I do?
Toxic or brominated flame retardants (eg, PBDEs) Animal fats House dust Furniture Bedding Foam padding Electronics High-impact plastic products Some textiles	PBDEs help reduce threat of fire because they are highly flame resistant PBDEs are linked to brain development and thyroid problems—they are a known neurotoxicant Health effects appear to be permanent	Broil meat and fish, trim away fats Eat leaner meats and avoid high-fat dairy foods Maintain a heart-healthy diet with plenty of fruits, vegetables, and whole grains Choose PBDE-free furniture (see Alternatives) Choose reduced PBDE electronics and computers	Sony, Intel, and Motorola have PBDE-free equipment HP monitors are PBDE free Canon, Apple, Hitachi, Panasonic, NEC, and Toshiba have reduced PBDEs IKEA, Galam, Abundant Earth, Organic Cotton Alternatives, Berkeley Mills, Lifekind, Ecobaby have PBDE-free products
Perfluoro-chemicals (PFCs)[†] Teflon and Gore-Tex Stainmaster Found in armor-piercing bullets, body armor, electrical insulation, moving parts like bearings and industrial lubricants to frying pans, household lubricants Stain-resistant fabrics, firefighting foams, film	Compounds that have been used in making nonstick stain-resistant coatings, repel water and oil, and are resistant to heat and chemical stress Animal studies show damage to the immune system, brain, pituitary gland, thyroid, and sex glands; birth defects; and death Decreased birthweight and head circumference	The Green Guide urges people to stop using Teflon pans You will have to check with the manufacturer regarding the specific function of the Teflon lubricant, but you should be able to substitute a food-grade and/or a nonpetroleum bio-lubricant	3M stopped using this in its Scotchguard for carpets and materials Return to old-fashioned cast iron or lead-free ceramic-coated pans For more information, visit: www.ewg.org/reports/pfcworld/es.php

(*continues*)

Table 1. Common environmental toxicants and how to avoid them (*Continued*)

Toxicant and where is it found?	What does it do?	How do I avoid it?	Alternatives? What can I do?
PVC and CPVC plastics (Polyvinyl chloride) Many plastic containers—food and drink container (No. 3 plastics) Process applications including tanks, scrubbers, and ventilation systems *Building materials*: cables, window frames, doors, walls, paneling, water, and wastewater pipes *Consumer products*: credit cards, records, toys *In home*: vinyl flooring, vinyl wallpaper, window blinds, and shower curtains *In office*: furniture, binders, folders, pens *Car industry*: underseal *In hospitals*: medical disposables, as cable and wire insulation Imitation leather Garden furniture	*By-products of PVC plastics*: dioxins and PCBs Dioxins are created when PVC plastic is burned in incinerators, household stoves, open trash burning, and accidental fires in buildings and vehicles Dioxins are created during the manufacture of PVC so that production wastes are rich with dioxins and other highly toxic contaminants Toxic chemical additives are incorporated within PVC products PVC production is increasing worldwide and is now the world's single largest use of industrial chlorine	Avoid purchasing No. 3 plastics Avoid using PVC plastic containers in the microwave, or to heat up foods Beware of cling wraps for microwave use Avoid plastic packaging and plastic bottled water Contact baby bottle manufacturers and urge them to replace polycarbonate in baby bottles with safer alternatives Use cloth, wood, or bio-based plastics For more information on alternatives, visit: http://www.besafenet.com/pvc/, www.pvcinformation.org	Wal-Mart; Glad, non-PVC cling wrap; Lego company Little Tikes of the US; Prenatal and Giochi Preziosi of Italy; Ambi Toys of the Netherlands; Tolico of Denmark; Babelito of Argentina and Chicco *Bottles*: Evenflo glass or pastel polyethylene plastic, Gerber polypropylene opaque plastic, Medela breast milk polypropylene storage bottles and polyethylene milk storage bags, disposable bottle systems with polyethylene plastic inserts (eg, Playtex Nurser, Playtex Drop-Ins) "Sippy" cups made of polypropylene or polyethylene: Avent Magic Cup; Evenflo cups (inner lining); First Years Take & Toss Gerber Color Change, Sport Fun Grip and Soft Starter; Playtex Sipster, Big Sipster & Quick Straw

*For latest mercury sources, see http://www.cfsan.fda.gov/~frf/sea-mehg.html

†Includes PFOA (also called C8), PFOS, PFBA.

specialist or a pediatric environmental health specialty unit (see the resources given below) may prove helpful.

There is a dearth of information about environmental health and the aging adult with DD. In the general elder population, air pollution worsens the severity of asthma and chronic obstructive pulmonary disease and can trigger hospitalization for congestive heart failure and cardiac arrhythmias.[46] Given the high frequency of comorbid conditions and frailer health, it is likely that aging adults with DD are even more susceptible to environmental stressors than the general elder population. Thus, when there are community-wide alerts about environmental hazards, such as air pollution involving carbon monoxide, sulfur dioxide, or airborne particulate matter, elders with DD should be carefully observed for possible adverse health effects.

CONCLUSION

Environmental toxicants affect the health of individuals with DD across the life span. To begin with, one quarter of DD are wholly or partially attributable to environmental exposures. Furthermore, compared to the general population, persons with established DD are more vulnerable to additional injury from subsequent exposures in part because they have less control over their exposure to and escape from toxicants. Much more research is necessary to better understand environmental health issues in persons with DD, particularly the aging adult.

This review describes some of the more common environmental health hazards for individuals with DD throughout the life span and offers strategies to minimize their health impact.

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Appendix

Recommendations

- *For individuals*

  Know what toxicants you may be exposed to at work, through gardening and other hobbies, and through household cleaning, home remodeling, and other indoor household activities.

  Consider environmental risks according to the developmental level of your child, not his age. For example, if your older child often puts nonfood items in his mouth and spends much of his time on the floor, his risk for lead poisoning may be more like that of a toddler.

  Consider how optimum nutrition can ameliorate some of the environmental health hazards facing your family member.

  Remember that family members may not be able to communicate symptoms from environmental exposures. They may not be able to report shortness of breath from exposure to flowers or cleaning products, or headaches from carbon monoxide.

- *For communities*

  Schools have many hazards. When a child with DD sits at a desk that has been treated with disinfectants and is in environmental conditions with poor ventilation systems, the child may be more vulnerable to adverse health outcomes. Poor indoor air quality (IAQ) can impact the comfort and health of students and staff, which, in turn, can affect concentration, attendance, and student performance. In addition, if schools fail to respond promptly to poor IAQ, students and staff are at an increased risk of short-term health problems, such as fatigue and nausea, as well as long-term problems like asthma.[41,43] A child with DD may be especially vulnerable to these outcomes.

  Superfund sites: Learn whether your community is near a Superfund site, what are the potential health risks, and how you can help mobilize your community to remove the hazard.

- *State and federal activities*

  Policies can be made at the state level to be more protective of public health. To find out more about your state's activities, visit your local representative's Web site or search your governor's Web site for information pertaining to legislative activities on chemical policies. Local public health or environmental organizations may also have information regarding state level activities that are aimed at protecting public health.

  The nation's toxic chemical regulatory law, the Toxic Substances Control Act was passed in 1976 and has never been amended since. Toxic Substances Control Act is widely regarded as the weakest of all major environmental laws on the books today. For more information on federal chemical policies, visit the Environmental Working Group (www.ewg.org).

  On May 20, 2008, Senator Frank Lautenberg (D-NJ) and representatives Hilda L. Solis (D-CA) and Henry Waxman (D-CA) introduced legislation aimed at protecting Americans from hazardous chemicals in consumer products called the Kid Safe Chemical Act. Press release can be found on Senator Lautenberg's Web site at http://lautenberg.senate.gov/newsroom/record.cfm?id=298072&.

Glossary of Terms

Autism spectrum disorders: A family of developmental disabilities characterized by abnormalities in social interaction and communication, highly repetitive behaviors, and severely restricted interests. The 3 main conditions belonging to autism spectrum disorders are autism, Asperger syndrome, and pervasive developmental disorder. Some autistic spectrum disorders are attributed to environmental toxicants.

Developmental disabilities: Defined by the federal government, a chronic disability whose onset is before age 22, resulting in substantial functional limitations in areas of self-care; receptive and expressive language; learning; mobility; self-direction; capacity for independent living; or economic self-sufficiency. Common developmental disabilities include intellectual disability (previously termed *mental retardation*), autism, cerebral palsy, and seizure disorders. Most, but not all, developmental disabilities involve some type of dysfunction of the nervous system.

Environmental toxicants: Substances, either natural or man-made, present in the environment that have the potential to harm living things.

Neurobehavioral disorders: Neurological conditions associated with behavioral difficulties. Examples include autism spectrum disorder, Tourette syndrome, learning disabilities, and attention-deficit/hyperactivity disorders. Some individuals with intellectual disabilities or with epilepsy have associated neurobehavioral disorders.

Neurodevelopmental delay: In infancy and childhood, deviation from the usual course of neurological development. Delays may occur in the development of motor skills, speech and language, cognition, learning, social behavior, and self-regulation of mood and behavior.

Neurotoxicant: A substance, found in nature or manufactured by humans, that can cause injury to the nervous system. Examples include alcohol, lead, mercury, pesticides, and carbon monoxide.

Organophosphate pesticides: A subgroup of pesticides that inhibit the action of the neurotransmitter acetylcholine on nerve cells. They are a common cause of both acute and chronic poisoning in humans.

Placenta: An organ that develops within the uterus of a pregnant woman that brings nourishment to the fetus and removes waste products from it. It provides an interface between the maternal and fetal circulations without physical comingling of their blood supplies. The placenta can function as a protective barrier to prevent some substances from entering the fetus, or it can allow some substances to become more concentrated in the fetus.

Superfund site: One of more than 1,000 areas in the United States designated under federal law as contaminated with toxic wastes that endanger public health. Federal funds are available to decontaminate these areas.

Teratogen: A chemical or physical agent that can cause malformation or injury prior to birth. Examples include environmental toxicants, such as alcohol, lead, and mercury; medications such as diphenylhydantoin (Dilantin) and isotretinoin (Accutane); and extremes of temperature, such as maternal fever and hot tub use.

Additional Informational Resources Regarding Environmental Health and Developmental Disabilities

Web-based resources

- American Association on Intellectual and Developmental Disabilities (www.ehinitiative.org)
- American Association of Occupational Health Nurses (www.aaohn.org)
- American Academy of Pediatrics (www.aap.org)
- Birth Defect Research for Children, Inc (www.birthdefects.org)

- Healthy Schools Network (www.healthyschools.org)
- Institute for Children's Environmental Health (www.iceh.org)
- National Resources Defense Council (www.nrdc.org).
- Oregon Environmental Council: Children at Risk (www.orcouncil.org)
- Pediatric Environmental Health Specialty Units (www.atsdr.cdc.gov/HEC/natorg/pehsu.html)
- Physicians for Social Responsibility (www.psr.org)

Suggested Reading

- Ekvall S, Ekvall VK, eds. *Pediatric Nutrition in Chronic Diseases and Developmental Disorders*. 2nd ed. New York, NY: Oxford University Press; 2005.
- *Pediatric Clinics of North America*. 2007; 54. (The entire issue is devoted to environmental health.)