



## Children's Health: Why the Environment Matters

We all want our children to thrive where they live, learn, and play. Because children are smaller than adults, their risk for harm is greater when exposed to chemicals, pollution, or drugs. They are also more vulnerable to toxic effects because their brains and other organs are still developing.

Protecting children's health is a shared responsibility, with parents being supported by their communities, public health professionals, clinicians, and local, state, and federal governments.

### What causes children's health problems?

Many factors contribute to development and overall health. Some health conditions are genetic, passing from grandparents to parents to children. Some health problems may be caused by factors in the environment. Many diseases arise from an interaction between genes and environment. Learning more about these interactions offers hope for preventing some health problems.

### What does NIEHS research tell us about children's health?

Using a variety of research approaches, the National Institute of Environmental Health Sciences (NIEHS) addresses exposures to chemicals and circumstances during all stages of development. Research conducted or funded by NIEHS leads to discoveries about how the environment affects children's health, which, in turn, become a basis for ways to reduce or stop harmful exposures.

### Environmental factors

Environmental factors can be external to your body, such as pollutants in air, water, and soil or social circumstances, or internal, such as stress.

**Air pollution** comes from vehicle, manufacturing, construction, and power generation emissions, and sources such as wildfires. A long-running, NIEHS-funded



study has linked higher levels of air pollution with increased respiratory infections and measurable lung damage. And, on the other hand, it found that children's respiratory health improved when air pollution levels declined or the children moved to less polluted areas.<sup>1</sup>

A type of air pollution exposure, particulate matter 2.5, at even relatively low levels, in children aged 9 to 10, may alter the developing brain. This effect could later increase the risk for cognitive and emotional problems in adolescence.<sup>2</sup>

**Arsenic**, a carcinogen, is a metalloid that occurs naturally in soil and groundwater. Early-life exposure to arsenic is linked to an increased risk of infection, lung and liver dysfunction, neurodevelopment and cognitive effects, and skin changes, according to the American Academy of Pediatrics. Arsenic exposure may predispose children to health problems later in life. An increased incidence of lung and bladder cancers was found in adults exposed to arsenic early in life, even up to 40 years after high exposures ceased. These findings provide rare evidence that an early-life environmental exposure can be associated with risk of cancer as an adult.<sup>3</sup>

**Fluoride** added to drinking water is a public health initiative for improving oral health. The U.S. Public Health Service recommends 0.7 milligrams (mg) of fluoride per liter (L) of water to help prevent tooth decay. But fluoridation of water has also raised concerns. The National Toxicology Program, an interagency program located at NIEHS, found that exposure to fluoride at 1.5 mg/L and higher — twice the recommended level for water — may be linked to lower IQ in children.<sup>4</sup>



**Lead** in any amount in the body can damage health. Even low lead levels in children's blood are associated with behavioral problems, delayed puberty, and decreased hearing, cognitive scores, and growth or height.<sup>5</sup> Lead exposure is also associated with autism spectrum disorder.<sup>6</sup> High blood lead levels in children are due mostly to contaminated paint dust and soil.

**Neighborhood characteristics**, particularly high poverty and unemployment, may pose an environmental risk to the developing brains of children, according to NIEHS-funded research.<sup>7</sup> Disadvantaged neighborhoods may also lack quality health services, access to nutritious foods, parks and recreational facilities, and have more pollutants.

Racial segregation may make the consequences of lead exposure worse. A study linked detailed birth records with lead screening, standardized testing, and Census data for almost 26,000 children. Among the children with higher blood lead levels, test scores decreased as racial segregation increased. This effect became more marked as blood lead levels increased.<sup>8</sup>

### Climate change and children's health

Climate change increases risks to children's health, especially through extreme heat and increased air pollution exposures. On hotter days, for example, researchers found that artificial turf reaches much higher temperatures than natural grass, raising heat stress concerns on those fields.<sup>9</sup> Emergency department visits by children in cities increase during heat waves, and asthma might be the most common cause.<sup>10</sup>

Higher temperatures can also lead to more ground-level ozone formation, a lung irritant that can set off asthma attacks and reduce lung function in children.<sup>11</sup> In parts of the U.S., a changing climate fuels wildfires, from which widespread smoke increases air pollution. Children's developing lungs are vulnerable and these exposures can lead to worsening asthma,<sup>12</sup> lower respiratory tract infections,<sup>10</sup> and chronic bronchitis.<sup>13</sup>

### Prenatal health effects

Research shows that prenatal contact with certain environmental factors influences whether some diseases may happen later in life. NIEHS researchers reported that when pregnant women improved their nutrition and reduced exposure to hazardous chemicals, they were more likely to have healthy babies, and their children were better able to cope with environmental stressors later in life.<sup>14</sup>





**Autism spectrum disorder** rates are lower in children whose mothers took a prenatal vitamin with folic acid during early pregnancy.<sup>15</sup> Additionally, when mothers of children with autism spectrum disorder took prenatal vitamins with folic acid beginning in the first month of subsequent pregnancies, the occurrence of autism in those children was reduced by about half.<sup>16</sup>

**Cancer**, particularly leukemia and cancers of the brain and central nervous system, is the second leading cause of death among children under 14, according to the Centers for Disease Control and Prevention. Its incidence may be affected by prenatal nutrition or exposure to chemicals. For example, the children of women who took vitamins, including folic acid, before and during pregnancy had a reduced chance of developing childhood leukemia.<sup>17</sup> Other research showed a greater chance of leukemia developing in children whose mothers were exposed to pesticides during pregnancy, or whose fathers were exposed to pesticides around the time of conception.<sup>18</sup>

### Childhood health effects

**Asthma**, a chronic disease in lung airways, is triggered by mold, air pollution, pest allergens, tobacco smoke, and other exposures. NIEHS-funded research shows vitamin D appears to have a protective effect for children with asthma. Children with asthma who had low blood levels of vitamin D had worse asthma than children with higher vitamin D levels.<sup>19</sup>

**Neurodevelopmental disorders**, such as symptoms of attention deficit hyperactivity disorder, problems with fine motor coordination, and lower cognition, were found in children exposed to high levels of flame retardants, polybrominated diphenyl ethers.<sup>20</sup> Flame-retardant chemicals are often applied to upholstered furnishings, mattresses, carpets, electronics and electrical devices, and construction materials.

Air pollutants called polycyclic aromatic hydrocarbons (PAHs) come from burning fossil fuels and other combustion. Studies have found consistent evidence that lower IQ scores and behavior problems are associated with exposure to PAHs.<sup>21</sup>

**Puberty** in girls is changing. Girls in the U.S. appear to be getting their first menstrual periods earlier, about six months sooner on average than decades ago.<sup>22</sup> Early onset puberty is a concern because of



links to diabetes, heart issues, breast and endometrial cancers, fertility issues, and mental health, according to the Endocrine Society.

Puberty may be affected by chemicals known as endocrine disruptors. These chemicals can mimic, or interfere with, the body's hormones and alter the balance needed for proper development and good health. Small hormonal disruptions can cause significant biological effects.

- NIEHS and other researchers are seeing early onset puberty tied to endocrine disruptor exposures. To advance understanding of this connection, certain chemical structures were identified that may cause the body to release puberty-related hormones earlier than it would otherwise.<sup>23</sup>
- During puberty, frequent use of personal care products that contain endocrine disruptors is associated with an increased chance of developing breast cancer later in life.<sup>24</sup> Some of the commonly found endocrine disruptors are chemicals called phthalates, parabens, and phenols.

### Protecting children's health

The American Academy of Pediatrics provides guidance for "Promoting Healthy Environments for Children." Topic areas include air pollutants, arsenic, climate change, lead, personal care products, and pesticides.

<https://www.aap.org/en/patient-care/environmental-health/promoting-healthy-environments-for-children>

## NIEHS children's health research

### NIEHS Children's Environmental Health

**Translation Centers:** These centers collaborate and translate key research findings into clinical and public health practice. Examples of research translation may include communication and risk management strategies, public health interventions and practices, clinical guidelines, and curriculums and educational activities.

### NIEHS Pediatric and Reproductive Environmental

**Health Scholars:** This program trains pediatricians, obstetricians, gynecologists, and others to create a network of professionals who tackle the complexities of pediatric and reproductive environmental health.

### National Institutes of Health Environmental Influences on Child Health Outcomes (ECHO):

Researchers focus on pre-, peri-, and postnatal outcomes; upper and lower airway health; obesity; neurodevelopment; and positive health, such as a sense of well-being. NIEHS contributes to ECHO studies.



For more information on the National Institute of Environmental Health Sciences, visit <https://www.niehs.nih.gov>.

- <sup>1</sup> University of Southern California, Childrens Health Study. Available: <https://healthstudy.usc.edu>. [Accessed Aug. 30, 2024].
- <sup>2</sup> Cserbik D, et al. 2020. Fine particulate matter exposure during childhood relates to hemispheric-specific differences in brain structure. *Environ Int* 143:105933.
- <sup>3</sup> Steinmaus C, et al. 2014. Increased lung and bladder cancer incidence in adults after in utero and early-life arsenic exposure. *Cancer Epidemiol Biomarkers Prev* 23(8):1529-38.
- <sup>4</sup> National Toxicology Program (NTP). 2024. NTP monograph on the state of the science concerning fluoride exposure and neurodevelopment and cognition: a systematic review. Research Triangle Park, NC: National Toxicology Program. NTP Monograph 08. <https://doi.org/10.22427/NTP-MGRAPH-8>.
- <sup>5</sup> Renzetti S, et al. 2017. The association of lead exposure during pregnancy and childhood anthropometry in the Mexican PROGRESS cohort. *Environ Res* 152:226-232.
- <sup>6</sup> Arora M, et al. 2017. Fetal and postnatal metal dysregulation in autism. *Nat Commun* 1;8:15493.
- <sup>7</sup> Hackman DA, et al. 2021. Association of local variation in neighborhood disadvantage in metropolitan areas with youth neurocognition and brain structure. *JAMA Pediatr* e210426.
- <sup>8</sup> Bravo MA, et al. 2022. Racial residential segregation shapes the relationship between early childhood lead exposure and fourth-grade standardized test scores. *Proc Natl Acad Sci USA* 119(34):e2117868119.
- <sup>9</sup> Massey R, et al. 2020. Artificial Turf Infill: A comparative assessment of chemical contents. *New Solut* 30(1):10-26.
- <sup>10</sup> Helldén D, et al. 2021. Climate change and child health: a scoping review and an expanded conceptual framework. *Lancet Planet Health* 5(3):e164-e175.
- <sup>11</sup> Ahdoot S, et al. 2024. Climate change and children's health: Building a healthy future for every child. *Pediatrics*, 153 (3).
- <sup>12</sup> Zanobetti A, et al. 2024. Early-life exposure to air pollution and childhood asthma cumulative incidence in the ECHO CREW Consortium. *JAMA network open* 7(2), e240535.
- <sup>13</sup> Dhingra R, et al. 2023. Wildfire smoke exposure and early childhood respiratory health: a study of prescription claims data. *Environmental health: a global access science source* 22(1), 48.
- <sup>14</sup> Heindel JJ, Vandenberg LN. 2015. Developmental origins of health and disease: a paradigm for understanding disease cause and prevention. *Curr Opin Pediatr* 27:248-53.
- <sup>15</sup> Brieger KK, et al. 2022. The Association of Prenatal Vitamins and Folic Acid Supplement Intake with Odds of Autism Spectrum Disorder in a High-Risk Sibling Cohort, the Early Autism Risk Longitudinal Investigation (EARLI). *J Autism Dev Disord* 52(6):2801-2811.
- <sup>16</sup> Schmidt RJ, et al. 2019. Association of maternal prenatal vitamin use with risk for autism spectrum disorder recurrence in young siblings. *JAMA Psychiatry* 1;76(4):391-398.
- <sup>17</sup> Metayer C, et al. 2014. Maternal supplementation with folic acid and other vitamins and risk of leukemia in offspring: a childhood leukemia international consortium study. *Epidemiol* 5(6):811-822.
- <sup>18</sup> Bailey HD, et al. 2014. Parental occupational pesticide exposure and the risk of childhood leukemia in the offspring: findings from the childhood leukemia international consortium. *Int J Cancer* 135(9):2157-2172.
- <sup>19</sup> Bose S, et al. 2019. Vitamin D status modifies the response to indoor particulate matter in obese urban children with asthma. *J Allergy Clin Immunol Pract* 7(6):1815-1822.e2.
- <sup>20</sup> Eskenazi B, et al. 2013. In utero and childhood polybrominated diphenyl ether exposures and neurodevelopment in the CHAMACOS study. *Environ Health Perspect* 121(2):257-262.
- <sup>21</sup> Perera FP, et al. 2018. Combined effects of prenatal exposure to polycyclic aromatic hydrocarbons and material hardship on child ADHD behavior problems. *Environ Res* 160:506-513.
- <sup>22</sup> Wang Z, et al. 2024. Menarche and time to cycle regularity among individuals born between 1950 and 2005 in the US. *JAMA Netw Open* 1;7(5):e2412854.
- <sup>23</sup> Yang S, et al. 2024. Identification of environmental compounds that may trigger early female puberty by activating human GnRH and KISS1R. *Endocrinology* 165(10):bqae103.
- <sup>24</sup> Goldberg M, et al. 2024. Personal care product use during puberty and incident breast cancer among Black, Hispanic/Latina, and white women in a prospective US-wide cohort. *Environ Health Perspect* 132(2):27001.