

# Lead Exposure

## Overview

**Prevalence** Lead exposure and contamination can come from a variety of sources, the most common being lead-based paint, lead-contaminated house dust and soil, and tap water contaminated by lead pipes. Although the prevalence of lead poisoning has decreased since State and Federal regulations were introduced in 1970,<sup>1</sup> the standards for identifying harmful amounts of lead exposure have become more stringent. Of the 27.97 million children up to 6 years old in the United States in 2006, nearly 25 percent had blood lead levels (BLLs) higher than normal (identified as between 2 micrograms per deciliter [ $\mu\text{g}/\text{dL}$ ] and 10  $\mu\text{g}/\text{dL}$ ). Males, Hispanics, Blacks, and children living in households that are below 200 percent of the Federal poverty line are disproportionately more likely to have higher than average BLLs.<sup>2</sup> As of 2011, an estimated 37 million housing units contained lead-based paint, with the highest occurrence in homes built before 1950 followed by those constructed from 1950 to 1978).<sup>3</sup> In recent years, the Centers for Disease Control and Prevention (CDC) have noted that prompt action should be taken for anyone who has a BLL of 5  $\mu\text{g}/\text{dL}$  or higher (formerly, the action level was 10  $\mu\text{g}/\text{dL}$ , having been recently changed to 5  $\mu\text{g}/\text{dL}$ ). However, no safe amount of lead exposure exists. The effects of chronic lead exposure are irreversible;<sup>4</sup> all exposure to lead should be minimized or eliminated, even for youth who have already been impacted by lead exposure.

**Characteristics** Lead poisoning and exposure can contribute to a variety of cognitive, physical, and behavioral problems. The range of disorders on the spectrum includes the following:

- **Neurological Damage.** Neurological damage often is permanent and can lead to the following:
  - Structural changes in the brain, including a reduction in brain size and function, with other effects that allow fluid to accumulate in the extracellular space (edema), swelling of the brain (herniation), and the loss of neurons and neural connections (atrophy)<sup>5</sup>
  - Seizures, comas, and sometimes death
- **Developmental Delays.** Developmental delays and associated learning difficulties contribute to a variety of deficits, such as the following:
  - Deficits in abstract thinking, attention, executive functioning, conceptual reasoning, visuospatial perception, social behavior, gross and fine motor skills, and speech and language<sup>6</sup>
  - Higher odds of performing below proficiency levels in mathematics (e.g., children with BLLs greater than 10  $\mu\text{g}/\text{dL}$  were twice as likely to underperform on mathematics assessments)<sup>7</sup>
  - Poor assessment scores, even in students not considered at high risk (i.e., those with BLLs between 5  $\mu\text{g}/\text{dL}$  and 9  $\mu\text{g}/\text{dL}$ ); even when controlling for other predictors of school performance, 13 percent of reading failure and 14.8 percent of mathematical failure can be attributed to lead exposure, even for those with BLLs in the low-risk range<sup>8</sup>
  - Behavior disorders such as attention deficit disorder and attention deficit hyperactivity disorder (ADHD)<sup>9</sup>

- **Physical Effects.** Lead exposure can lead to several physical effects:
  - Low birth weight<sup>10</sup>
  - Damage to the kidneys and nervous system
  - Irritability, sluggishness, and fatigue
  - Loss of appetite, vomiting, weight loss, and abdominal pain

## Prevention

Scholars, practitioners, and Federal agencies agree that lead exposure at any level is dangerous. Preventive measures must be taken to ensure that any exposure to lead, especially disproportionate exposure, is eliminated. Organizations issuing strong statements to this effect include the CDC, the U.S. Department of Housing and Urban Development (HUD), the National Center for Environmental Health/Agency for Toxic Substances and Disease Registry, and the U.S. Department of Health and Human Services. Emphasizing prevention is critical because the effects of moderate and high lead exposure are irreversible; successful interventions after acute lead exposure are limited at best. In addition, from an economic standpoint, much can be gained from preventing lead exposure. Each dollar invested in lead paint hazard control results in a return of \$17 to \$221, or a net savings of \$181 to \$269 billion.<sup>11</sup>

## Interventions for Parents, Schools, and Programs

The following tables present interventions that can improve the outcomes for children of all ages impacted by lead exposure and poisoning. Because the effects of lead exposure are irreversible and the symptoms vary greatly, interventions specific to lead poisoning are few, with much of the literature focusing heavily on the importance of prevention. Even with our knowledge of the importance of prevention, hundreds of thousands of children have been exposed to levels of lead that impact academic and lifelong success; they often need tertiary interventions—strategies that help them function at the optimal level.<sup>12</sup> Also, major gaps still exist in research as to the efficacy of educational interventions in addressing problems related to lead exposure; therefore, interventions for specific effects (such as interventions for behavioral or learning delays) can be used to treat the effects of lead exposure, as long as they are individualized to support the specific needs of each child.<sup>13</sup> These interventions should be considered in terms of coexisting factors, such as the child's home environment and support system, health care screening opportunities, and community-based supports.

Table 1 presents academic interventions, and Table 2 presents behavioral interventions. Each table includes the name of each intervention or category of interventions, a brief description of the intervention, and examples of specific actions associated with the intervention. The tables also include quality indicators, which describe the changes in outcomes that can be expected when the intervention is implemented successfully, and sources of additional information on the intervention.

**Table 1. Academic Interventions for Toddlers, Children, and Youth\***

Intervention Name	Description	Example(s)	Quality Indicator(s)	More Information
ADHD-Specific Interventions <sup>†</sup>	<ul style="list-style-type: none"> <li>Children with lead exposure who exhibit difficulty with attention, impulsivity, and hyperactivity may not meet the criteria for an ADHD diagnosis but could still benefit from related interventions.</li> <li>Identify the supports needed for a student, whether during classroom instruction, testing, or transitioning, and implement a plan to be supported by all teachers and staff interacting with the child.</li> </ul>	<ul style="list-style-type: none"> <li>Divide complex tasks into manageable ones.</li> <li>Seat the student away from distractions and in a place where he or she can easily see the teacher or screen.</li> <li>Create a written schedule for daily activities to help the student feel more in control.</li> <li>Incorporate movement into lessons.</li> <li>Provide cues and prompts to remind the student to avoid impulsive behavior.</li> </ul>	<ul style="list-style-type: none"> <li>Youth behavioral controls become more consistent.</li> <li>The child learns to behave appropriately in the classroom and performs well in the classroom environment.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">ADHD Resource Center</a></li> <li><a href="#">National Resource Center on ADHD</a></li> <li><a href="#">Classroom Modifications for Children With ADHD or Concentration Issues</a></li> <li><a href="#">Team Management Plan for Child With ADHD</a></li> </ul>
Continued Developmental Surveillance <sup>‡</sup>	<ul style="list-style-type: none"> <li>Ensure developmental surveillance is in place for children exposed to lead, even if they are not considered at high risk, and continue this surveillance even if their BLLs are reduced.</li> <li>Many medical organizations recommend periodic developmental screenings at 9, 18, and 24 or 30 months, but for children exposed to lead, screening should start in early childhood and continue throughout their lives.</li> </ul>	<ul style="list-style-type: none"> <li>Perform developmental screenings in early childhood programs or during home visits.</li> <li>Be watchful when new educational demands are put on a child to ensure that he or she is transitioning successfully.</li> </ul>	<ul style="list-style-type: none"> <li>The child's needs are anticipated and addressed at home and school.</li> <li>The child reaches developmental milestones on time.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">American Academy of Pediatrics</a></li> <li><a href="#">CDC: Learn the Signs. Act Early</a></li> </ul>
Language and Literacy Interventions	<p>Assist with the mastery of literacy and language skills, including oral language, phonological awareness, and spelling, adding fluency and comprehension skills as the child masters the fundamental aspects of literacy. A focus on language and literacy is especially important for students exposed to lead who may live in environments where they are not exposed to rich language early on.</p>	<p><i>For young children:</i></p> <ul style="list-style-type: none"> <li>Regularly incorporate reading and interaction with text and language into the day.</li> <li>Use consistency and repetition, repeating the way a particular skill is taught from the first time to increase the likelihood of a lasting effect.</li> </ul> <p><i>For older students:</i></p> <ul style="list-style-type: none"> <li>Avoid asking "why" questions.</li> <li>Ask concrete who, what, where, and when questions.</li> <li>Consider students' needs and group them into collaborative reading groups based on skill level.</li> </ul>	<ul style="list-style-type: none"> <li>Students successfully identify different parts of speech and can re-create them independently.</li> <li>Students' increased fluency positively impacts comprehension and success across all subjects.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Language to Literacy Program</a></li> <li><a href="#">A Unified Model of Language-to-Literacy Intervention Approaches</a></li> </ul>

Intervention Name	Description	Example(s)	Quality Indicator(s)	More Information
Mathematics Interventions	Address the developmental and cognitive delays that can accompany lead poisoning by providing targeted mathematics instruction and support to students.	<ul style="list-style-type: none"> <li>For students who need more intensive mathematics instruction, explicit, carefully sequenced instruction is helpful. For students who need less support, discovery-oriented approaches are typically successful.</li> <li>Students are taught how to build schemas related to different mathematical concepts so that they can break down problems that are more difficult.</li> </ul>	<ul style="list-style-type: none"> <li>Students are able to problem-solve without fear of failure.</li> <li>Students can break down difficult problems into subproblems that are solvable.</li> <li>Students have increased working memory of mathematical concepts.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Math Interactive Learning Experience (MILE) Program</a></li> <li><a href="#">National Center on Intensive Intervention</a></li> <li><a href="#">RTI Action Network</a></li> </ul>
Multidisciplinary Continual Assessments	<ul style="list-style-type: none"> <li>Include a multidisciplinary team in assessments, such as educators, speech/language pathologists, developmental-behavioral pediatricians, neuropsychologists, neurologists, and child psychiatrists.</li> <li>A diverse team can provide a thorough diagnostic evaluation (versus a screening) and, therefore, a more comprehensive educational plan.</li> </ul>	<ul style="list-style-type: none"> <li>View the child in a variety of circumstances and at different points throughout the year.</li> <li>Continually reassess the comprehensive plan to ensure that interventions are successful or modifications can be made.</li> </ul>	The child is able to transition between subjects, grades, and learning material through a variety of learned skills.	<a href="#">Lead Poisoning Educational Interventions</a>
School Modernization	<ul style="list-style-type: none"> <li>Ensure that schools are not contributing negatively to lead exposure and that all buildings meet regulations.</li> <li>Be sure that administrators are aware of procedures and standards in your State, as well as the consequences of noncompliance.</li> <li>Schools can take this a step further and provide testing to children at back-to-school events.</li> </ul>	<ul style="list-style-type: none"> <li>Determine if buildings have lead paint or materials.</li> <li>Conduct air sampling to assess exposure.</li> <li>Perform BLL testing.</li> <li>Ensure proper cleanup and disposal, as well as training of workers for safe practices.</li> </ul>	<ul style="list-style-type: none"> <li>A safe school environment meets State and Federal lead standards.</li> <li>The identification of students with lead exposure who may benefit from interventions.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Lead Safety and School Modernization</a></li> <li><a href="#">Lead Testing—Back to School Checklist</a></li> <li><a href="#">3Ts for Reducing Lead in Drinking Water in Schools</a></li> </ul>

Intervention Name	Description	Example(s)	Quality Indicator(s)	More Information
Supportive Home Environments <sup>§</sup>	<ul style="list-style-type: none"> <li>Promote a child-rearing environment that consists of a variety of age-appropriate educational opportunities and early intervention services.</li> <li>Provide parents with training in developmentally appropriate activities and information on their legal rights under the Individuals with Disabilities Education Act (IDEA) and the Americans with Disabilities Act (ADA) so that they are prepared to engage with schools.</li> </ul>	<ul style="list-style-type: none"> <li>Provide guidance for safe and healthy infant care.</li> <li>Focus on skills that foster child development and parenting skills.</li> </ul>	<ul style="list-style-type: none"> <li>The child engages in positive and age-appropriate play.</li> <li>Parents can identify and respond to a child's emotional and physical needs.</li> <li>The child feels secure and engaged at home.</li> <li>Parents are engaged with the school.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Circle of Security</a></li> <li><a href="#">U.S. Department of Health and Human Services: Child Welfare Information Gateway</a></li> <li><a href="#">Collaborative for Educational Services</a></li> </ul>
Visuospatial Perception Supports	Ensure that students are processing visual information properly (i.e., they can interpret words, symbols, pictures, and distances, and they are not impacted socially or emotionally by any difficulties in processing information).	<ul style="list-style-type: none"> <li>Use simple testing accommodations, such as allowing students to write answers directly on tests/test booklets instead of separate scoring tools, such as scantrons.</li> <li>Use verbal instructions instead of pictures and allow extra time for students to copy information.</li> <li>Provide materials that can be handled and manipulated when teaching and testing concepts related to spatial relationships.</li> </ul>		<ul style="list-style-type: none"> <li><a href="#">The Elementary Teachers' Federation of Ontario</a></li> <li><a href="#">Association for Supervision and Curriculum Development</a></li> <li><a href="#">Understanding Visual Processing Issues</a></li> </ul>

\* Because the bulk of research and corresponding interventions related to lead exposure focuses on intake that occurs postnatally, these tables do not include interventions targeted at infants.

† Although behavioral in nature, these interventions are designed to help students benefit from the academic setting.

‡ Continued Developmental Therapy is both an academic intervention and a behavioral intervention. Thus it is included in both tables.

§ Supportive Home Environments is both an academic intervention and a behavioral intervention. Thus it is included in both tables.

**Table 2. Behavior Interventions for Toddlers, Children, and Youth\***

Intervention Name	Description	Example(s)	Quality Indicator(s)	More Information
Continued Developmental Surveillance <sup>†</sup>	<ul style="list-style-type: none"> <li>Ensure developmental surveillance is in place for children exposed to lead, even if they are not considered at high risk and continue this surveillance, even if their BLLs are reduced.</li> <li>Many medical organizations recommend periodic developmental screenings at 9, 18, and 24 or 30 months, but for children exposed to lead, screening should start in early childhood and continue throughout their lives.</li> </ul>	<ul style="list-style-type: none"> <li>Perform developmental screenings in early childhood programs or during home visits.</li> <li>Be watchful when new educational demands are put on a child to ensure that he or she is transitioning successfully.</li> </ul>	<ul style="list-style-type: none"> <li>The child's needs are anticipated and addressed at home and school.</li> <li>The child reaches developmental milestones on time.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">American Academy of Pediatrics</a></li> <li><a href="#">CDC: Learn the Signs. Act Early</a></li> </ul>

Intervention Name	Description	Example(s)	Quality Indicator(s)	More Information
Executive Function Therapy	<ul style="list-style-type: none"> <li>Encourage self-talk, allowing youth to understand how their thinking impacts emotions and actions.</li> <li>Help youth identify their behavioral state and develop techniques for optimizing that state to adapt to situations.</li> </ul>	<ul style="list-style-type: none"> <li>Focus on one to three behaviors to work on at a time and include the child in setting the goals for these behaviors.</li> <li>Provide a variety of visual reinforcements (e.g., prompts, lists, and notes).</li> <li>Provide supports for emotional previewing to help students anticipate emotional reactions and think through how they will respond.</li> <li>Provide training in mindfulness to increase awareness of the connection between mind and body.</li> </ul>	<ul style="list-style-type: none"> <li>Supports fade across time as the student begins to succeed independently.</li> <li>The student is better able to organize and manage time.</li> <li>The student has increased meta-cognition (knowledge about when and how to use particular strategies for learning or problem solving).</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Classroom Interventions for Executive Functions</a></li> <li><a href="#">Understood: For Learning and Attention Issues</a></li> <li><a href="#">Executive Functioning: Concepts, Educational Impact, and Intervention Strategies</a></li> </ul>
Gross and Fine Motor Skills Interventions	Provide opportunities for children to learn and refine gross and fine motor skills in various settings. Start out with gross motor skills and work through fine motor skills as the child becomes more efficient.	<ul style="list-style-type: none"> <li>Provide a variety of materials—both hard and soft—for children to practice working with so that they can develop skills working with a variety of materials.</li> <li>Encourage students to use both hands when working with materials.</li> <li>Use assistive technology supports to individualize interventions.</li> <li>Allow for extended periods of motor and physical activity.</li> </ul>	<ul style="list-style-type: none"> <li>The child is able to adapt to the physical environment and independently succeed in the environment with self-help tasks, such as getting dressed and washing hands without assistance.</li> <li>The child experiences more success in other academic areas, such as mathematics, reading, attention, speech and language processing, and behavior.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Teaching Strategies That Support Fine-Motor Skills</a></li> <li><a href="#">Technical Assistance and Training System – Developmentally Appropriate Practice</a></li> </ul>
Supportive Home Environments <sup>‡</sup>	<ul style="list-style-type: none"> <li>Promote a child-rearing environment that consists of a variety of age-appropriate educational opportunities and early intervention services.</li> <li>Provide parents with training in developmentally appropriate activities and information on their legal rights under the Individuals with Disabilities Education Act (IDEA) and the Americans with Disabilities Act (ADA) so that they are prepared to engage with schools.</li> </ul>	<ul style="list-style-type: none"> <li>Provide guidance for safe and healthy infant care.</li> <li>Focus on skills that foster child development and parenting skills.</li> </ul>	<ul style="list-style-type: none"> <li>The child engages in positive and age-appropriate play.</li> <li>Parents can identify and respond to a child's emotional and physical needs.</li> <li>The child feels secure and engaged at home.</li> <li>Parents are engaged with the school.</li> </ul>	<ul style="list-style-type: none"> <li><a href="#">Circle of Security</a></li> <li><a href="#">U.S. Department of Health and Human Services: Child Welfare Information Gateway</a></li> <li><a href="#">Collaborative for Educational Services</a></li> </ul>

\* Because the bulk of research and corresponding interventions related to lead exposure focuses on intake that occurs postnatally, these tables do not include interventions targeted at infants.

<sup>†</sup> Continued Developmental Therapy is both an academic intervention and a behavioral intervention. Thus it is included in both tables.

<sup>‡</sup> Supportive Home Environments is both an academic intervention and a behavioral intervention. Thus it is included in both tables.



## Resources

[American Academy of Pediatrics: Lead Exposure and Lead Poisoning](#): This webpage provides links to a variety of information applicable for both parents and pediatricians. Pediatricians play a key role in preventing lead exposure, identifying and treating lead poisoning, and advocating for public health measures to address the problem.

### CDC

- [Managing Elevated Blood Lead Levels Among Young Children](#): This webpage offers guidelines from public health practitioners, physicians, educators, and psychologists who provide research-based interventions and recommendations for children who have been exposed to lead.
- [Educational Interventions for Children Affected by Lead](#): This updated report presents current information on educational interventions, as well as information on how to get support for children with lead poisoning under both IDEA and ADA.
- [Lead Poisoning Prevention and Treatment Recommendations for Refugee Children](#): This fact sheet provides simple directives on how to identify, test, and treat lead exposure. It includes specific information about the threshold for identifying excessive lead levels and how to intervene.

[Green and Healthy Homes Initiative](#): The Coalition to End Childhood Lead Poisoning, founded in 1986, together with the Green and Healthy Homes Initiative launched by the White House Office of Recovery in 2008, work to promote policies and programs to eradicate childhood lead poisoning and support the creation of healthy homes.

[Lead Exposure in Children: Prevention, Detection, and Management](#): This article provides evidence-based guidance for managing children with increased lead exposure. It also provides a research foundation for continuing to invest in safe and lead-free housing to limit lead exposure for all children.

### HUD

- [Office of Lead Hazard Control and Healthy Homes \(OLHCHH\)](#): This Federal department provides funds to State and local governments to develop strategies for reducing lead-based paint hazards and enforce HUD's lead-based paint regulations. The group also provides public outreach and technical assistance and conducts technical studies to help protect children and their families from health and safety hazards in the home.
- [Lead Regulations](#): This webpage outlines the regulations and statutes pertaining to lead-based paint hazards.
- [Simple Steps to Protect Your Family From Lead Hazards](#): This pamphlet offers simple and easy-to-follow guidelines for protecting one's family from lead exposure in the home.

[U.S. Environment Protection Agency \(EPA\)](#): The EPA provides guidelines for renovating homes, schools, and facilities that were constructed before 1978 to ensure that certified renovators are being used. The EPA also offers information on National Lead Poisoning Prevention Week and other national campaigns to raise awareness of the effects of lead poisoning and exposure.

[World Health Organization \(WHO\): Childhood Lead Poisoning](#): WHO provides a comprehensive report on what is known about the effects of lead on neurobehavioral development and guidelines on how lead poisoning and exposure can be prevented.

## Endnotes

1. Centers for Disease Control and Prevention. (2005). Preventing lead poisoning in young children. Atlanta, GA: Author. Retrieved from <http://www.cdc.gov/nceh/lead/publications/PrevLeadPoisoning.pdf>
2. Gould, E. (2009). Childhood lead poisoning: Conservative estimates of the social and economic benefits of lead hazard control. *Environmental Health Perspectives*, 111(7), 1162–1167. Retrieved from <http://ehp.niehs.nih.gov/wp-content/uploads/117/7/ehp.0800408.pdf>
3. AAP Council on Environmental Health. (2016). Prevention of childhood lead toxicity. *Pediatrics*, 138(1). e20161493. Retrieved from <http://pediatrics.aappublications.org/content/pediatrics/early/2016/06/16/peds.2016-1493.full.pdf>
4. Rosen, J. F., & Mushak, P. (2001). Primary prevention of childhood lead poisoning: The only solution. *The New England Journal of Medicine*, 344(19), 1470–1471.
5. Gould (2009).
6. Rosen & Mushak (2001).
7. Evens, A., Hryhorczuk, S., Lanphear, B. P., Rankin, K. M., Lewis, D. A., Forst, L., & Rosenberg, D. (2015). The impact of low-level lead toxicity on school performance among children in the Chicago Public Schools: A population-based retrospective cohort study. *Environmental Health*, 14(21). doi:10.1186/s12940-015-0008-9
8. Ibid.
9. AAP Council on Environmental Health. (2016).
10. Ibid.
11. Gould (2009).
12. Educational Services for Children Affected by Lead Expert Panel. (2015). *Educational interventions for children affected by lead*. Atlanta, GA: U.S. Department of Health and Human Services. Retrieved from [https://www.cdc.gov/nceh/lead/publications/educational\\_interventions\\_children\\_affected\\_by\\_lead.pdf](https://www.cdc.gov/nceh/lead/publications/educational_interventions_children_affected_by_lead.pdf)
13. Ibid.

This document was produced under U.S. Department of Education, Office of Special Education Programs (OSEP) contract no. GS-10F-0112J. The views expressed herein do not necessarily represent the positions or policies of the U.S. Department of Education. No official endorsement by the U.S. Department of Education of any product, commodity, service, or enterprise mentioned on this website is intended or should be inferred.