
Occupational Therapy in Pediatric Lead Exposure Prevention

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Environmental lead is a toxic substance that is affecting the growth and development of 3 to 4 million U.S. preschool children today, with effects ranging from learning disabilities to death. This review of environmental lead sources and effects on children provides a background for comprehensive prevention of childhood lead exposure. Prevention strategies at the child, family, and community levels allow for widespread protection of child health and development. Prevention begins with an understanding of the person–environment–occupation framework for the factors that contribute to children at risk for lead exposure. An open system model is presented with specific interventions at the child, family, and community levels, providing innovative, integrated contributions by occupational therapy practitioners for lead exposure prevention and health promotion of children who have been exposed to environmental lead.

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Lead is a toxic substance in our environment that indiscriminately affects children of all socioeconomic backgrounds. An estimated 74% of all housing nationwide is contaminated with lead (American Public Health Association [APHA], 1994). Approximately 3 to 4 million preschool children in the United States have blood lead levels that exceed the 10 µg/dL level set by the Centers for Disease Control and Prevention (CDC) (APHA, 1994). The effects of childhood lead exposure range from mild problems in school (Needleman, Gunnoe, & Levinton, 1979), including hyperactivity (Freedman, Olson, & Hoffer, 1990; Winder, 1984) and sensorimotor dysfunction, to death. Lead poisoning is also one of the few recognized fully preventable diseases affecting children (Alliance to End Childhood Lead Poisoning, 1994).

Because lead is prevalent in our environment and poses a serious health risk for children, the U.S. Department of Health and Human Services (DHHS) established a goal to reduce the prevalence of infants and young children with high blood lead levels to less than half a million by the year 2000 (DHHS, 1991). This goal requires aggressive screening and interdisciplinary prevention programs. In their interaction with children and families, occupational therapy practitioners can be active in team efforts to safeguard the health of children who are at risk for lead poisoning and can become involved in community programming and prevention.

This article reviews the sources of lead and its effects on children. It also provides the occupational therapist

with specific strategies for preventing childhood lead exposure at the child, family, and community levels.

Sources of Lead

The main source of lead is in the child's home environment, primarily from lead paint manufactured before 1960. Homes built before 1960 may have lead-containing paint chips and paint dust from walls, window sills, and woodwork, which a child may ingest (Duggan & Inskip, 1985; Olden, 1993). Lead dust accumulates on floors, countertops, furniture, and toys. This dust can also deposit in the soil of yards, gardens, and playgrounds. Therefore, children are surrounded by lead dust that can accumulate on the surface of any objects they put into their mouth, such as toys, pacifiers, and their hands. Another source of lead is drinking water that has passed through lead pipes or lead-soldered pipes; food and water also become contaminated if placed in containers such as lead-soldered cans, lead crystal decanters, and glazed pottery (Benson & Lane, 1993; Schonfeld, 1993).

Children at 18 months of age have been shown to have the highest blood lead levels (Goldstein, 1992). This age group is at the highest risk for lead exposure for several reasons that are behavioral, environmental, and physiological. Mouthing and exploratory behaviors typical of young children cause them to bring a variety of nonedible objects into their mouths—objects that can have lead dust on their surfaces (Benson & Lane, 1993). Young children also spend most of their time at home, compared with school-age children. Additionally, lead is known to compete physiologically with calcium in some of the body's biochemical processes, such as calcium absorption for bone and tooth growth (Bressler & Goldstein, 1991; Goldstein, 1992). Because of this competition of lead over calcium absorption, young children have a greater lead intake than adults because of efficient absorption and retention of calcium (and lead) during childhood growth periods (Olden, 1993; Veerula & Noah, 1990).

Understanding the sources of lead in the child's environment and knowing which children are at highest risk for exposure are the first steps in preventing childhood lead poisoning. The CDC recommends that pediatric health care providers conduct a brief interview with all parents, particularly for children younger than 72 months of age and those with "growth failure, developmental delay, hyperactivity, behavioral disorders, hearing loss and anemia" (CDC, 1991, p. 43). The occupational therapist can easily screen children at risk for lead exposure by asking parents about the following contributory environmental characteristics (CDC, 1991):

- Is the child living in or regularly visiting a house built before 1960 that is under renovation or has peeling or chipping paint?

- Does the child have a sibling who has been diagnosed with lead poisoning?
- Is the child living with an adult who is exposed to lead either on the job or during a hobby?
- Is the child living near an industry that releases lead?

Effects of Lead Exposure

The consequences of lead exposure during childhood are systemic and can affect sensorimotor, cognitive, and neurobehavioral development (Bressler & Goldstein, 1991). At high levels of exposure (blood lead levels > 40 mg/dL), lead causes the destruction of the blood-brain barrier and encephalopathy, which can result in ataxia, headaches, convulsions, and coma (Bressler & Goldstein, 1991; Thomas, Dallenbach, & Thomas, 1971; Veerula & Noah, 1990; Winder, 1984). Hemorrhages can occur in the central nervous system (CNS), affecting critical areas such as the cerebellum and hippocampus (Thomas et al., 1971). Cerebellar dysfunction can cause motor difficulties, producing motor developmental delay (Alfano & Petit, 1982; Freedman et al., 1990), and hippocampus dysfunction relates to cognitive delays (Alfano & Petit, 1982; Fjerdingsstad, Danscher, & Fjerdingsstad, 1974). Other areas affected by lead are the kidneys (Hammond & Dietrich, 1990) and calcium-rich structures such as bones and teeth (Bressler & Goldstein, 1991; Goldstein, 1992). Lead can also contribute to fatigue by causing moderate to severe anemia (Hammond & Dietrich, 1990; Veerula & Noah, 1990).

Lead exposure alters overall electrophysiological nerve cell function, ultimately disturbing a child's normal neural development (Goldstein, 1990; Silbergeld, 1992). This can occur even at lower levels of lead exposure (blood lead levels < 40 mg/dL). Because lead competes with calcium in neurons, increased lead exposure can enhance the release of certain neurotransmitters and change the basal rate of neuronal activity (Clarkson, 1987; Veerula & Noah, 1990; Winder, 1984). An increased basal rate is thought to contribute to hyperactivity in children with lead exposure (Freedman et al., 1990; Winder, 1984). Changes in the biochemistry of neural function alter the precision with which neural networks are established and, thus, have lasting adverse effects on synaptic circuitry and CNS function (Bressler & Goldstein, 1991, Goldstein, 1992). Because synaptic connections are refined in early childhood (Kelly & Dodd, 1991), children are particularly vulnerable to the effects that lead has on overall CNS development and function.

Lead affects learning and memory at both low and high levels of exposure (Bressler & Goldstein, 1991; Clarkson, 1987; Goldstein, 1990; Kandel, 1991). Learning deficits have been identified in children exposed to

lead (Alkondon, Costa, Radhakrishnan, Aronstam, & Albuquerque, 1990; Kupfermann, 1991). Accumulated lead in the brain causes a delay in hippocampus pathway development (Alfano & Petit, 1982; Fjerdingsstad et al., 1974) and contributes to the decrease in neuronal density of the dentate gyrus and the neocortex (Winder, 1984). Neuronal loss of this type explains alterations in attention, memory, and problem solving (Goldstein, 1992).

Deficits in auditory, visual, vestibular, proprioceptive, and motor skills may also affect a child's functional performance in tasks requiring visuomotor functioning, perceptual integration, right-left orientation, and verbal abstraction, among other cognitive skills (Marecek, Shapiro, Burke, Katz, & Hediger, 1983). Table 1 summarizes documented effects of low-level lead exposure on sensory and motor performance components in young children.

Lead exposure and its resulting functional deficits can limit achievement in school. Children exposed to lead tend to score lower in tests designed to assess school performance (Bellinger, Levinton, Needleman, Waternaux, & Rabinowitz, 1986; Bellinger, Levinton, & Sloman, 1990; Winneke et al., 1985). Language and speech development has also been found to be affected by lead (Duva, 1977; Needleman, 1977; Yamins, 1977). Needleman et al. (1979) studied the classroom performance of 158 children, using the Weschler Intelligence Scale for Children, and found significant associations between tooth lead levels and low scores, particularly in verbal IQ areas for information, vocabulary, digit span, and arithmetic and in performance IQ for picture completion. Further research established a relationship between elevated lead levels and enrollment in special education (Coppens et al., 1990).

In addition to learning and attention, lead exposure in children has been attributed to behavioral problems, such as distractibility, inattention, and perseveration of inappropriate behaviors (Rice, 1993), as well as hyperactive behaviors in preschool children (David, Hoffman, Clark, Grad, & Sverd, 1983). Chelation therapy, which medically lowers the level of lead in the blood, directly

reduced hyperactive behaviors in children with known high blood lead levels (David et al., 1983), suggesting a strong relationship between lead exposure and hyperactivity. Sciarillo, Alexander, and Farrel (1992) found a similar strong relationship between low-level lead exposure (blood lead levels < 10 µg/dL) and hyperactive behaviors in 150 children 2 to 5 years of age.

In sum, lead affects the functional performance of children in areas of cognitive, perceptual, and motor development. However, lead exposure is preventable. Therefore, occupational therapy practitioners should be concerned with intervention both in the direct treatment of deficits and in the prevention of initial and continual lead exposure. In this way, practitioners promote the normal growth and development of children.

Childhood Lead Exposure as an Open System

Childhood lead exposure follows a developmental person-environment-occupation framework where the child, the home environment, and the community environment are interconnected (Starr, 1985). Viewed as an open system, the child is surrounded by an environment with which he or she interacts and which can either directly or indirectly affect development. When lead is present in this environment, the system is disrupted, thereby affecting the child's health, personality, behavior, developmental status, nutrition, and biological integrity as well as how he or she relates to his or her environment. When lead is present in the home environment where the child interacts through normal exploratory play, ingestion occurs when objects covered with lead dust are placed in the mouth. This initial interchange with the home environment will, in turn, affect how the child will be able to interact with the environment in the future because absorbed lead will interfere with his or her motor, sensory, and perceptual abilities. In terms of prevention, interventions at any one of these levels (child, home, community) feeds into other levels and has the potential to produce an effect on the entire system, creating both a healthier envi-

Table 1
Effects of Low-Level Lead Exposure on Sensory and Motor Performance of Young Children

Sensory or Motor Area	Effect	Reference
Auditory	Decreased central auditory processing abilities and hearing thresholds	<ul style="list-style-type: none"> • Otto et al. (1985) • Robinson et al. (1985) • Schwartz and Otto (1987, 1991)
Visual	Retinal rod degeneration and decreased visual-evoked potentials at blood lead levels > 25 µg/dL	<ul style="list-style-type: none"> • el Azazi, Krisrensson, Malm, and Wachmeister (1987) • Fox and Chu (1988) • Fox, Katz, and Farber (1991) • Lilienthal, Winneke, and Ewert (1990) • Reuhl, Rice, Gilbert, and Maller (1989)
Vestibular	Postural disequilibrium	<ul style="list-style-type: none"> • Bhattacharya, Rakeah, and Dietrich (1993) • Bhattacharya, Shukla, Bornsheim, Dietrich, and Keith (1990)
Fine and gross motor	Motor development delay	<ul style="list-style-type: none"> • Dietrich, Berger, and Succop (1993)

ronment with which the child will interact and a healthier child.

Prevention

Major national initiatives, such as *Healthy People 2000* (DHHS, 1992) and *Healthy America: Practitioners for 2005* (Shugars, O’Niel, & Badger, 1991), invite health professionals to become more involved in health-oriented practice and prevention of disease. Table 2 summarizes how occupational therapy practitioners can use lead prevention strategies in their roles as direct providers of treatment, monitors of treatment, and consultants about treatment. The following are suggestions for prevention strategies that therapists can use at the child, home, and community levels of the open system model. Combinations of strategies can also be used.

Child

Intervention at the child level can take the form of encouraging the child to decrease his or her risk for lead intake through the following:

- *Frequent hand and toy washing:* Ideally, toys should be washed before play and every hour during play (Lead Free Kids, Inc., 1991), before meals, and at bedtime to reduce accumulated lead dust on hands. Hand and toy washing can be achieved during play activities, such as floating a toy in a bucket of water.
- *Use of pacifiers:* Younger children and infants should be encouraged to suck on pacifiers that the caregiver can wash frequently, instead of sucking on their thumb, fingers, or other objects (finger and object sucking are the leading contributors of lead exposure among this age group).
- *Good nutrition:* A healthy diet reduces both the intake and absorption of lead. A diet rich in iron, calcium, and vitamin C reduces the absorption of

lead into the body. Behaviorally, a child with a balanced diet is less likely to eat nonnutritious objects, such as paint chips, which are sweet and palatable.

Encouraging the child to participate in lead exposure prevention during interventions with occupational therapy practitioners and other health professionals helps transfer these activities to the home rather than the parents being the only active participants in prevention.

Home

Prevention intervention at the family level must consider factors in the family—the family unit; parent–child interactions; parental factors, such as child-rearing practices; and socioeconomic status—in addition to factors in the physical home environment (Starr, 1985). Family socio-demographic factors, such as poverty, poor housing conditions, and lack of social and financial support, increase the likelihood that lead will be in the home (Benson & Lane, 1993). Other family environmental factors such as inadequate nutrition, limited parental supervision, disturbed mother–child relationship, and cultural acceptance of oral gratification increase the likelihood that the child will ingest lead (Stark, Quah, Meigs, & Delouise, 1982). Therefore, strategies for prevention at the home level include changes in the physical home environment and in the parent–child relationship. For example:

- *Housekeeping:* Prevention techniques include dusting and mopping at least once a week, using a wet rag or mop and a cleaning solution containing 5% to 8% phosphate or trisodium phosphate (available in hardware stores) mixed in water (CDC, 1991), and regular wet wiping of window sills and baseboards. Vacuuming and dry dusting are discouraged because these activities only disperse lead dust. Occupational therapy practitioners can suggest organizing the home in a manner that makes clean-

Table 2
Pediatric Occupational Therapy Service Delivery Models and Approaches for Children With Lead Exposure

Model	Approach		
	Provide Direct Treatment	Monitor Treatment	Provide Consultation About Treatment
Remedial	Use tilt board activity in occupational therapy clinic to increase balance and equilibrium.	Supervise teacher in facilitating use of fine motor skills in writing.	Give parents strategies to increase interactive behaviors in play.
Compensatory	Give child adaptive devices, such as elastic shoe laces, because of decreased fine motor skills.	Supervise daily activity scheduling so that child will be more attentive in classroom.	Advise teacher to limit environmental stimuli in classroom.
Prevention and intervention	Teach child to wash toys (and hands) before and after play.	Monitor parents in nutritional program for child.	Teach community lead prevention group about program development and advocacy.

Note. Models and approaches from Dunn and Campbell (1991).

ing easy, for example, ridding clutter items on a kitchen counter for easier wiping, dusting toy storage areas frequently, and choosing washable toys.

- *Meal preparation:* Prevention techniques include storing food in clean containers instead of cans (one in five cans are soldered with lead [Benson & Lane, 1993]), avoiding ceramic containers because their glazes can be lead based, and protecting food from lead dust by storing dishes upside down and rinsing them before use.
- *Clean drinking water:* Prevention techniques include flushing water from lead pipes for 5 min before use, particularly when making infant formula, and avoiding boiled water for drinking because boiling concentrates lead levels in water (Schonfeld, 1993).
- *Urban gardening:* Occupational therapy practitioners can discourage families from planting vegetable gardens in urban areas because the soil can be contaminated with lead.
- *Education and referral:* Occupational therapy practitioners can educate parents about reducing lead in the child's environment by explaining its importance in preventing functional deficits. Education is particularly important when the child is experiencing developmental delays resulting from lead poisoning. Local groups or clinics that inform parents and communities about lead poisoning, safe lead abatement, and funding for lead abatement usually have pamphlets to give to parents. The National Lead Information Center will mail information directly to parents and can provide resources for local lead prevention groups. Other health care practitioners may offer additional referral sources.

Community

Prevention intervention at the community level can involve raising the community's consciousness of lead problems by screening for lead exposure during clinical interviews. For example:

- *Screening:* A simple and brief interview with parents can help identify children who are at risk for lead exposure in a particular community. Therapists are encouraged to screen children as suggested by the CDC (1991) in its report *Preventing Lead Poisoning in Children*.
- *Program planning:* The occupational therapy practitioner can help plan a community education and prevention program. Education and awareness of the problem of lead in a community can prompt the community to plan appropriate programs and prevention strategies.

- *Legislation:* The occupational therapy practitioner can become involved, and encourage community members to participate, in legislative action. Legislative involvement assists in promoting healthy environments, protecting safe housing, and encouraging financial support to families and communities dealing with lead as an environmental hazard.
- *Empowerment:* Community action can lead to community empowerment (Townsend, 1991). The occupational therapy practitioner can help the community identify its strengths and increase its consciousness about solutions to problems of lead exposure. It is important that the community understands, first, that lead is a problem that affects everybody and, second, that lead poisoning is preventable. Communities need to be informed about the major sources of lead and the effects lead can have on child development. Citizens need to be informed about their rights, available housing loans for safe lead abatement, and the importance of having their children tested for lead. Some city lead clinics provide blood lead screening and home testing. Most importantly, the practitioner must emphasize the community's important contribution to preventing lead poisoning and creating a safer, healthier environment for its members.

Conclusion

Pediatric lead exposure prevention is multifaceted, and the levels of intervention are interconnected. At a basic level, children who wash their hands often and refrain from chewing nonedible objects learn to prevent lead poisoning. At the next level, the home environment for growing and exploring children should be safe yet stimulating. Toys that are developmentally appropriate, continuously positive parent-child interactions, and good housekeeping strategies linked with knowledge of parental rights and community services are all factors that can better prepare families and communities to reduce lead in the child's environment. At a broader level, advocacy and information support families and communities in implementing strategies to build safe environments for children.

Occupational therapy practitioners are encouraged to use these lead exposure prevention strategies at all levels—child, home, and community—and to share them with other members of treatment and prevention teams. Lead is affecting the healthy development and functional performance of children; occupational therapy practitioners should be informed of its effects and contribute toward the national task force to reduce pediatric lead exposure. Using and teaching prevention strategies of screening and intervention, occupational therapy practi-

tioners can, and should, contribute to a lead-free environment that protects and encourages the healthy development of children nationwide. ▲

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Health care practitioners can contact Physicians for Social Responsibility at 202-785-3777 or The National Lead Information Center at 1-800-LEAD-FYI for more information on lead poisoning prevention.

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