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AUTHOR Kimball, Sarah L.
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ABSTRACT

This report discusses the effects of lead exposure and toxicity on children's cognitive development and school performance and addresses the role of schools in prevention of lead poisoning. Sources of lead exposure include mining, smelting and refining activities, lead paint, leaded gasoline, and industrial emissions. The results of lead poisoning are most often dealt with in school systems where, in some cases, over 50 percent of students in special education classes are lead poisoning victims. Although lead can affect every system in the body, the major organ systems affected are the central nervous system, the blood system, and the kidneys. Lead poisoning is manifested in neuropsychological problems, cognitive impairments, and behavior problems. A review of recent studies on children exposed to lead indicates deficiencies in both development and cognitive functioning. Exposure pathways of lead include inhalation of contaminated air and dust and ingestion of contaminated water, food, soil, and dust. The most common source of lead exposure for preschool children is lead-based paint produced before 1940. School systems can play a pro-active role in preventing lead poisoning by identifying and eliminating possible lead hazards in children's homes and in the school environment. In addition to local agencies, federal agencies can assist schools with the prevention of lead poisoning. These include the Centers for Disease Control and Prevention, HUD, National Lead Information Center, National Poison Control Center Hotline, and American Water Works Association. Appendices include a list of the effects of lead poisoning and a summary of studies concerning lead exposure and children. (LP)

Sarah L. Kimball
Oklahoma State University
Stillwater, Oklahoma

THE INFLUENCE OF LEAD EXPOSURE AND TOXICITY TO CHILDREN'S NEUROLOGICAL DEVELOPMENT AND SCHOOL PERFORMANCE

INTRODUCTION

Lead is a common metal with a long history of diverse uses and has been known to cause neurological damage in humans. Cases of lead exposure and subsequent poisoning are extensive as the exposure sources are myriad ranging from mining, smelting and refining activities to lead paint, leaded gasoline and industrial emissions. Although lead targets the central nervous system, the symptoms and effects of lead exposure are varied and common to other medical problems, lead poisoning is difficult to diagnose without a blood screening test. At the present time, the lead blood level of 10 ul/dL is considered harmful.

The results of lead poisoning are most often dealt with in the school systems where, in some districts, it is estimated that over 50% of the students in special education classes are lead poisoning victims. In education, the effects of lead exposure can be expensive. In other historical times, lead exposure has been catastrophic. Lead production associated with silver mining has been linked to the rise and fall of the Greek and Roman Empires. The rise of both empires was associated with the access to silver mines and the lead integrated with silver. The fall of the civilizations was associated with depletion of the mines and/or decline of the upper class and rulers due to lead poisoning induced general insanity and sterility from lead components of cosmetics, water distribution systems, cisterns and sapa production and consumption (grape juice simmered in lead kettles then added to wine) (Patterson, 1980). Lead poisoning is treatable with medication and preventable by the identification and abatement of the source and/or the exposure pathway.

EFFECTS

The individual effects of lead poisoning vary widely - from temporary dizziness to death. The extent of lead effects are dependant on duration and frequency of exposure, exposure route, the concentration of the dose and the age of the person exposed. Acute exposure effects are frequently reversible with time and/or proper treatment. These effects, listed in Table I, can be quite similar to many diseases and may not, therefore, be attributed to lead poisoning. Some acute effects are loss of appetite, headache, gastritis, malaise, irritability, and reversible kidney damage. Chronic exposure effects can be irreversible, carcinogenic, teratogenic, mutagenic and deadly. Chronic effects include sclerosis of the liver and/or vascular system and interstitial fibrosis. Low lead exposure levels may result in increased blood pressure, impaired neurotransmission and immune system function. Other low level effects include decreased stature or growth, decreased hearing acuity, reduced birth weight, decreased ability to maintain a steady posture, and diminished IQ scores. Severe toxicity from high exposure doses can lead to abortion, neonatal mortality and morbidity, sterility, coma, convulsions and death.

Although lead can affect every system in the body, the major organ systems affected are the central nervous system (CNS), blood system and kidneys. In the CNS lead poisoning leads to encephalopathy accompanied by severe cerebral edema, increase in cerebral spinal fluid pressure, proliferation and swelling of endothelial cells in capillaries and arterioles, proliferation of glial cells, neurological degeneration and areas of focal cortical necrosis in fatal cases (Sax and Lewis, 1989 page 2096).

In a school setting the results of lead exposure (other than noticeable physical disabilities) manifest themselves in several ways, usually as neuropsychological or cognitive impairments and/or behavior problems. Neuropsychological impairments include lower IQ scores and Attention Deficit Disorder. Behavior problems exhibited include improper conduct, inattentiveness, passivity and hyperactivity. While lead exposure is not always recognized as the cause of these problems, studies on children of known lead exposure have attempted to delineate the relationship between the exposure level and the level, or degree, of the manifestation of the subsequent effect. Some recent studies that address the exposure level/effect issue are presented in Table II and the following summaries.

Wigg et al. (1988) - The Port Pirie Cohort Study. In an Australian lead smelting community, 723 infants were tested for lead blood levels antenatally, at birth, six and fifteen months and two years. Children with estimated lead blood levels of 30 ug/dL at the age of two years had a deficit of 3.3 points (3.2%) on the Bayley Mental Development Index.

McMichael et al. (1988) - The Port Pirie Cohort Study, continued. Children with estimated lead blood levels of 30 ug/dL at the age of four years had a deficit of 7.2 points (6.7%) on the McCarthy General Cognitive Index.

Baghurst et al. (1992) - The Port Pirie Cohort Study, continued. In a group of 494 of the original 723 children, seven-year-old children were administered the Weschsler Intelligence Scale for Children (WISC-R). The data indicated that for an increase in blood lead concentration from 10 ug/dL to 30 ug/dL (average concentration from fifteen months and annual reading to four years) the estimated reduction in children's IQ ranged from 4.4 to 5.3 points (4-5 %) at age seven. It was concluded that low level exposure during early childhood is inversely associated with neuropsychological development through the first seven years of life.

Sciarillo et al. (1992) - Children with lead blood levels > 15 ug/dL had significantly higher mean Child Behavior Checklist (CBCL) Total Behavior Problem Scores (TBPS) and Internalizing and Externalizing Scores than the controls. For each unit increase in blood lead levels there was a 0.18 point TBPS increase. In the high exposed group the TBPS was 5.1 points higher and the children were 2.7 times more likely to have a TBPS in the clinical range. The author concludes that the study results support the belief that undue lead exposure in early childhood may have an influence on the prevalence of juvenile delinquency.

Sachs (1981) - Contrary to previous findings, Sachs found the absence of neurological sequelae following symptomatic lead poisoning. Testing several years after diagnosed lead

poisoning revealed no hypertension, renal problems, neurological problems and anormal EEGs. Psychological tests revealed minimal differences between patients and controls.

EXPOSURE PATHWAYS AND SOURCES

Lead may enter the body through a variety of pathways and from multiple sources, thus estimating total lead intake is complex. Multiple low level inputs can result in an aggregate exposure at a significant level. Exposure of children to lead is greater than adults due to behavioral and metabolic differences and the higher frequency of pica (the craving for ingestion of non-food substances such as lead paint chips) in children (Oskarsson, 1989). Exposure pathways include inhalation of contaminated air and dust and ingestion of contaminated water, food, soil and dust. Dermal contact usually leads to inhalation of contaminated dust or ingestion of the contaminated soil from hand-to-mouth activity, not to direct dermal adsorption.

The most common source of high doses of lead exposure for preschool children is lead-based paint produced before 1940. The manufacture of paint containing more than 0.06% lead was banned in 1978 by the Consumer Product Safety Commission. Lead paint chips, flakes, dust or objects they contaminate are easily inhaled or ingested via normal hand-to-mouth activity of small children. Children who live in older houses, particularly if the houses are undergoing renovation, are at high risk for lead poisoning from various pathways.

Soil and dust contaminated with lead from paint, alkyllead fuel combustion exhaust or industrial emissions are sources of lead inhaled or ingested by children. Roadside soil, metal mine tailings, soils adjacent to old houses painted with lead-based paint and soils adjacent to smelters may have levels of 10,000 to 60,000 ppm lead. Acid rain mobilizes the lead in the soil into surrounding water bodies. Ingestion of fruits, vegetables or other food contaminated with lead is a frequent pathway of lead exposure.

In drinking water, lead contamination occurs in the distribution and storage systems more than in the supply source. Sources of lead contamination within a distribution system include lead pipes, lead-soldered joints in copper plumbing, lead-soldered joints and tanks in drinkingwater fountains and coolers, faucets and fixtures. Older buildings are more susceptible to lead contamination due to type of plumbing fixtures popular at the time of construction. Cisterns used in rural areas to collect and/or store water are susceptable to lead contamination particularly if the rain water is acidic.

Lead exposure from food can come directly from contaminated food itself or from food handling (the cooking water, utensils used to store, prepare or serve food). Acetic food or beverages can leach lead from lead glazed pottery and thus make the lead available for ingestion. The lead soldering in cans is a frequent source of lead ingestion.

PREVENTION

C.C. Patterson (1980) has warned "that the mining and smelting of lead and dispersal of manufactured leaded products within the human environment is actually a monumental

crime committed by humanity against itself" and proposed a ban on such activities. While a ban would be effective, less drastic lead poisoning prevention measures are more realistic. In light of new data which indicate significant adverse effects of lead exposure in children at blood levels previously believed to be safe, theU. S. Department of Health and Human Services, Center for Disease Control and Prevention (CDC) now promotes the goal of all lead poisoning prevention activities should be to reduce children's blood levels below 10 ug/dL (CDC, 1991).

The CDC (1991) outlines several mechanisms for prevention of lead poisoning in young children which school officials need to be aware of to determine their role and participation. Public health agencies should:

1. provide blood screening services
2. identify exposure patterns and high-risk populations
3. implement a primary prevention plan
4. coordinate prevention activities with other agencies
5. provide followup services for poisoned children

The CDC recommendations for public housing agencies are as follows:

1. provide housing and environmental services to affected families
2. enforce lead hazard code requirements
3. assist public health agencies in lead hazard education of all concerned with housing
4. use regulations and abatement techniques to increase safe housing

The CDC recommendations for environmental agencies are as follows:

1. participate in interagency efforts to prevent lead poisoning
2. address environmental lead hazards with a multimedia approach
3. monitor, regulate, license and enforce activities to reduce environmental exposure to lead

School systems can play a pro-active role in lead poisoning prevention by identifying and eliminating possible lead hazards in the children's home and school environment. Many of the hazard identification and elimination actions can be performed by existing state and federal agencies upon request. Such actions may include the following:

1. test water fountains for lead components
2. test water in fountains for lead concentrations and compare with municipal water supplies
3. determine if lead-based paint has been used in older school buildings as well as homes in the area
4. determine if your geographic area has metal mining, smelting, processing or other related activity now or in the past
5. determine if school playgrounds have been contaminated by metal activities
6. educate children and parents concerning the sources, pathways, hazards, effects and prevention of lead poisoning
7. communicate with health, housing and environmental officials concerning lead hazard identification, treatment and elimination programs in your area

8. encourage good personal health habits, especially frequent hand washing
9. discourage children from putting objects in their mouths
10. be aware of the symptoms and effects of lead exposure to assist in diagnosis and treatment with the assistance of health professionals

CONTACTS FOR ADDITIONAL INFORMATION

Many federal, state, county and local agencies can provide information, educational material and services pertaining to lead sources, exposure and poisoning. For your convience, some are listed here.

U. S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, Atlanta, Georgia 30333
404/329-3235
404/639-3311
404/488-7330
404/332-4559 - Traveler's Hotline

RCRA/Superfund Hotline - 1-800-424-9346
They are concerned with identification, location and remediation of contaminated soil and water and will answer questions and/or send information requested.

HUD Hotline - 1-800-RID-LEAD (1-800-743-5323)
They will provide information about sources, identification, location and abatement of possible lead-contaminating products in houses.

National Lead Information Center - 1-800-LEAD FYI (1-800-532-3394)
They will provide information about lead paint removal.

National Poison Control Center Hotliné (24 hour) - 1-800-522-4611
They will provide literature, including a compliation of references and abstracts, or give information over the telephone on consumer protection, lead poisoning hazards and prevention.

American Water Works Association - 1-800-926-7337
They will provide information on water testing, regulations, treatment, standards etc. Their Small Systems Program may be especially useful to rural communities.

Local, county and state health agencies.

County or state extension programs.

SUMMARY

Although preventable, lead poisoning is an all too frequent cause of renal, blood system and neurological damage in children which may be treated but may, also, have

permanent effects. There are many lead sources and various exposure pathways. The school system is involved with lead poisoning symptoms and effects in special educational settings for neuropsychological and behavioral problems. Many agencies can provide educational material, information and services to schools concerning lead exposure problems. Schools systems can play a pro-active role in lead poisoning prevention by identifying and eliminating possible lead hazards in the childrens' homes and school environment. School personnel should be familar with the symptoms of lead exposure to assist in diagnosing and treatment of the disease as early as possible.

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TABLE I EFFECTS OF LEAD POISONING

EXPOSURE	EFFECT
Acute	Headache
	Gastritis
	Malaise
	Irritability
	Reversible kidney damage
Chronic	Sclerosis of the liver
	Sclerosis of the vascular system
	Interstitial fibrosis
Low Level Exposure	Increased blood pressure
	Impaired neurotransmission
	Impaired immune system function
	Decreased stature or growth
	Decreased hearing acuity
	Reduced birth weight
	Diminished IQ scores
High Level Exposure	Abortion
	Neonatal mortality and morbidity
	Coma
	Convulsions
	Sterility
	Death

TABLE II STUDIES OF LEAD EXPOSURE EFFECTS ON CHILDREN

STUDY	CHILDREN'S AGE	LEAD LEVELS (ug/dL)	ASSESSMENT TOOL*	RESULTS
Sciarillo et al., 1992	2 -5	> 15	CBCL-TBPS	0.18 point increase/lead unit increase
Sciarillo et al., 1992	2 -5	> 15	CBCL-TBPS	5.1 points higher
Sciarillo et al., 1992	2 -5	> 15	CBCL-TBPS	2.7 times more likely to be in clinical range
Wigg et al., 1988	2	30	BMDI	3.3 point deficit (3.2 %)
McMichael et al., 1988	4	30	MGCI	7.2 point deficit (6.7%)
Baghurst et al., 1992	7	10 - 30	WISC-R	IQ reduction of 4.4 - 5.3 points (4-5%)

* Assessment Tools
CBCL-TBPS = Child Behavior Checklist - Total Behavior Problem Scores
BMDI = Bayley Mental Development Index
MGCI = McCarthy General Cognitive Index
WICS-R = Wechsler Intelligence Scale for Children