

Chapter 6, Section I, entitled “ Global Impact of Lead Poisoning”

The Problem-

Lead (Pb) is the 82nd element on the periodic chart of the elements. It is the 36th most common element naturally found on earth. As early as 100 A.D. there were accounts of lead poisoning by Greek physicians. It has been used since early Roman times in pottery, glazes, soldering for pipes. Later it was used in ammunition and roofing. More recently, during the 20th century, it became widely used in batteries, paints and, in the case of tetraethyl lead, as an additive in gasoline to prevent engine knocking. Current uses include shielding from radioactive material and x-rays, as well as the continued use in lead acid batteries.

Worldwide, current sources of lead in the environment are leaded gasoline in regions where this has not yet been phased out, as a byproduct of secondary smelting of various other metals, lead mines, contaminated soil, in the solder in water pipes and food cans, utensils and in various home remedies and cosmetics.

An increasingly worrisome source of lead in the 21st century is from the “effluent of the affluent” (Grossman, 2006). The e-waste produced by unrecycled cell phones, computers, televisions, monitors and other technological equipment is being exported to the developing world, especially to China and sub-Saharan Africa. This is being done under the guise of providing developing nations with high tech equipment which can be repaired and re-used. However, there are estimates that up to 75% of the imports are irreparable and end up in unlined landfills, burned (directly releasing toxins into the environment) or in open air dumps. This then commonly gains access to the soil and groundwater. The average desktop computer contains an average of 8 pounds of lead. The scavenging of gold, copper and other valuable raw materials, without adequate safety measures or protective gear, is opening a Pandora’s box of toxic materials including lead, for the people least capable of monitoring or managing its long-term health effects.

Trends in Lead Poisoning in American Cities

Lead damage in children in the United States primarily occurs as a result of residential exposures, and dilapidated, sub-standard urban housing is a major source of childhood lead poisoning cases. In 2006, roughly 1.21% of all children screened for lead poisoning in the US were considered to have Elevated Blood Lead Levels (EBLL), and the state of Ohio alone reported nearly twice as many (2.3%) of children tested had EBLLs (CDC surveillance data). At the state level, only Rhode Island and Pennsylvania reported higher proportions of EBLLs, 2.36% and 4.46% respectively. New York City, which is calculated separately from New York state, only reported 0.85% of tested children as EBLLs (CDC surveillance data, 1997-2006).

Though documented cases of lead poisoning have decreased dramatically since the 1970’s, Cleveland continues to be one of the US cities with the highest rates of childhood lead poisoning. Cuyahoga County, which encompasses the city of Cleveland and its inner-ring suburbs, is home to the overwhelming majority of lead poisoning cases in Ohio. According to 2000 census data,

over 260,000 housing units were built before 1950, and 22% of the 10,000 children under the age of 6 live at or below poverty (CBLIS County Level Summary Data). These two residential risk factors are strongly associated with childhood lead poisoning, especially in urban neighborhoods. According to 2005 data from the Cleveland Department of Public Health, childhood lead poisoning rates within city limits hover around 10% (Environmental Health Watch “Childhood Lead Poisoning”).

Health effects of lead –

Lead’s primary target organ is the peripheral nervous system. Both children and adults are susceptible to the effects of lead, but children for many reasons, are the most vulnerable. In addition to their immature, developing nervous systems, many children in the developing world are at an even more profound risk due to poor nutritional status. Lead competes for binding sites with iron, calcium and other essential nutrients and can be stored permanently in bones in the place of calcium.

Lead crosses easily over blood-brain barrier in children and through placental barriers during pregnancy. Because lead is easily accumulated in the brain tissue, the cognitive damage is most severe in developing brains of newborns and young children. Poor growth, delayed learning and reduced intellect are well known effects of lead intoxication. Over the past several years it has become clear that behavior is also affected by lead and several papers have been written on its effects on aggression in children and adolescents (Needleman, 1996). Although the primary effects of lead are, as previously mentioned, neurological, lead can also adversely affect the renal, skeletal, reproductive and hematologic systems.

In adults, poor balance, low sperm counts, and senile dementia, hypertension and stroke have been linked to elevated blood lead levels. Moreover, recent data suggest that some of this damage can occur at blood lead levels much lower than previously expected.

Risk Factors-

Young age- The immature nervous system allows for more thorough invasion of lead across the blood brain barrier and incorporation of lead into skeletal structures where it remains as a reservoir for ongoing intoxication. Due to the fact that infants and toddlers are closer to the ground and often explore their world orally, they commonly put toys, dirt, paint chips, household dust into their mouths, thus providing a direct route of the substance into their digestive tract. It has also been shown that gastrointestinal absorption rates are inversely related to age, so that a young child will absorb up to 30-50% of ingested lead while an adult will likely only absorb 10-20% of an equivalent amount of ingested lead. Moreover, iron-deficiency will further increase intestinal absorption. Lead particles may also successfully be inhaled through the respiratory tract.

Poverty- For reasons both known and unknown, poverty is directly proportional to rates of lead intoxication, both in the U.S. and abroad. Exposure to contaminated soil, lack of access to medical care and poor nutritional status all contribute, but do not completely explain why poverty is such a potent risk factor.

Poor nutritional status (especially linked with low iron levels and anemia)- As stated above, poor nutritional status especially with respect to iron, but also calcium-deficiency predisposes individuals to greater risk of lead poisoning.

Urban living- Concentrated exposure to car exhaust, crowded conditions, older housing, close proximity to smelting plants attributes higher risks of lead poisoning. Likewise, living near, or with a person who mines lead or works in any type of salvage industry will raise an individual's likelihood of having higher blood lead levels. High risk occupation- Table 1 lists some of the high risk occupations associated with lead toxicity. Occupational safety regulations tend to be less controlled in the developing world, and as such places workers in these areas in even further danger.

Table 1

Operations that may present lead hazards for workers

Primary and secondary lead smelting	Lead mining
Welding and cutting of lead-painted metal constructions	Plumbing
Welding of galvanized or zinc silicate coated sheets	Cable making
Other welding	
Shipbreaking	Wire patenting
Nonferrous founding	Lead casting
Storage battery manufacture: pasting, assembling, welding of battery connectors	Type founding in printing shops
Production of lead paints	Sterotype setting
Spray painting	Assembling of cars
Mixing (by hand) of lead stabilizers into polyvinyl chloride	Shot making
Mixing (by hand) of crystal glass mass	
Sanding or scraping of lead paint	Lead glass blowing
Burning of lead in enamelling workshops	Pottery/glass making

Repair of automobile radiators

Why does the Urban Environment present such a High Risk?

Many American East Coast and Midwest cities, as well as others internationally, are home to an aging housing stock and many homes are in a state of disrepair. Childhood lead exposure is generally a result of residential exposure to chipping, peeling, flaking, cracking or otherwise deteriorating lead-based paint, which may still be present in homes built before the late 1970's. Over 90% of the homes in the city of Cleveland were built before 1950, making them probable carriers of lead paint. A common misconception is that children are only at risk of lead poisoning if they actively ingest paint chips; in truth, significant lead exposure occurs from inhalation of invisible lead dust particles released by chipping paint. Therefore even homes that are only in slightly bad condition may be at risk for releasing lead dust.

Lead poisoning is common in low-income neighborhoods where home maintenance may be inadequate and sub-standard. Cleveland, for example, has a significant population of low and middle income homeowners and landlords. Many have hypothesized that the burden of lead remediation has been passed down through several generations of low-income families who cannot afford to assess and remove lead paint hazards. This problem is aggravated by the high cost of remediation. Trained professionals should handle removal of lead paint; contractors in Ohio receive certification in lead removal only after completing a weeklong course in proper removal practices.

The U.S. Environmental Protection Agency publishes a useful guide with information and options for homeowners faced with the problem of lead in their homes. Generally, residents are not encouraged to attempt their own lead remediation. There are less expensive temporary solutions to protect against lead exposure, but temporary is the key word. Some temporary solutions include: painting over or blocking off access to cracking and chipping paint, "wet-cleaning" chipping surfaces with a disposable cloth and detergent solution, planting grass in bare soil near chipping paint, using High Efficiency Particulate Air vacuums in rooms where children play, frequently washing children's toys and hands, and others ("Renovation, Repair and Painting" <http://www.epa.gov/lead/pubs/renovation.htm>).

Creation of lead-safe housing is the main initiative that needs to be seriously undertaken in urban neighborhoods in order to eradicate lead poisoning. Enabling low and middle income homeowners to make necessary lead-safety changes would have a significant impact, but often there simply isn't enough money to fund assistance programs. Housing improvements are some of the most difficult problems to solve, particularly because lead-safe renovations are costly, and there is little incentive to maintain homes according to environmental standards.

Current screening methods-

Capillary and venous blood testing of serum lead levels. Blood lead levels (BLLs) are measured in micrograms per deciliter (ug/dL). Since 1991, levels above 10 ug/dL are considered toxic according to the Centers for Disease Control and Prevention and the World Health Organization.

This level has been progressively lowered over the past several decades. In 1960 the guideline was 60 ug/dL. There is currently a movement to lower the threshold even further as the CDC acknowledges “no threshold has been identified for the harmful effects of lead” (CDC,1991).

Levels above 70 ug/dL are associated with seizures, coma and death.

In workers, the allowable BLL is up to 60 ug/dL before the worker must undergo “medical removal protection”, or 30 ug/dL for any male or female planning to have children in the future (OSHA, 1978).

In the United States, average BLLs have come down over the last decades since the banning of leaded gasoline and leaded paints. The CDC reports the average U.S. BLL to be 2.2 ug/dL (NHANES, 1999-2000) but this average is much higher in certain urban populations. Even in the most affected populations in the U.S. only approximately 50% of eligible children are screened, which begs the question of what is the “real” average BLL in these populations?

In the developing world, there are wide variations in screening rates of children. In many countries, average BLLs are only estimated by sporadic, focused studies that have been performed in the recent past. Due to lack of access to medical care, lack of adequate laboratory availability and lack of knowledge regarding the prevalence of the problem, testing is just not regularly performed in most of the world.

Worldwide Prevalence and Incidence-

The WHO estimates that there are 120 million people worldwide with BLLs above 10 ug/dL (Ezzati, 2004) and 240 million people with BLLs greater than 5 ug/dL.

The only Australian blood lead survey of children in 1996 found 7.3% of preschoolers were lead poisoned (and this is probably an underestimate).

Table 1 : Blood Lead Levels (BLL) of children in various countries

Country	Date	BLL (median)	BLL>10 µg/dL
South Africa ¹	2002	11.9 µg/dL	78%
Jamaica ²	2000	9.2 µg/dL	
Rural areas		16.6 µg/dL	42%
Urban areas		35 µg/dL*	71%
contaminated area, the site of a former lead ore processing plant			-
India – 1852 urban children ³	1999	-	51.4%
			[12.6%>20µg/dL]
China ⁴	2004	9.29 µg/dL	33.8%

USA ⁵	1999-2002	1.6 µg/dL	-
Europe/Urban area ⁶	N/A	-	0.1 – 30.2%
Australia ⁷	1996	5.8 µg/dL	7.3%
* reduced now by implementation of mitigation strategies			
¹ Mathee et al., 2002; ² Lalor et al., 2001; ³ George Foundation, 1999 ⁴ Wang and Zhang, 2004; ⁵ CDC, 2005; ⁶ WHO, 2004; ⁷ Donovan 1996			

Asia/Pacific:

China and India currently weigh in as the most affected in the region. See Table 1 for details. In China, 33.8% of children tested had BLL greater than 10 ug/dL. In a region along the Lianjiang River there have been measured lead levels 2,400 times WHO Drinking Guidelines (BAN and SVTC, 2002). In India, the George Foundation has been instrumental in identifying the extent of lead poisoning among both children and adults. In a study including 7 Indian cities blood lead levels were on average, elevated in over half of the children studied (George Foundation, 1999). An interesting source of lead in this region of the world is in the Kohl cosmetic used to line the eyes. This contains varying amounts of lead. As a natural health product, kohl has many uses that vary among cultures, including: use as an aid in the healing of the infant umbilical cord stump, circumcision after-care, eye infection protection, blood clotting aid, digestive aid, sunglare prevention/eyestrain reliever, and general anti-microbial treatment.

Latin America:

The majority of cases of lead poisoning stems from contaminated smelters, soil contaminated by years of leaded gasoline, and glaze used in pottery making. Often, drinking water is stored in these vessels, which then leaches the lead from the glaze. Also, lead solder in pipes and in food cans also persists as a source implicated in high blood lead levels in both children and adults.

Sub-Saharan Africa:

In just one African city Johannesburg, which may be representative of all the cities in the 43 African countries still using leaded gas at the time of the study, 78% of the children were lead poisoned as shown in Table 1 (The Lead Group Incorporated, “Green Lead”- Oxymoron or Future Vision, Nov 2005). Later in this discussion, we will cover how this prevalence is expected to decrease since all of sub-Saharan Africa has now converted to Lead Free gasoline.

What’s Working to Improve Outcomes-

The *Clean Air Act* passed in the U.S. in 1970 and updated in 1990. Under this law, EPA sets limits on how much of a pollutant can be in the air anywhere in the United States. This ensures that all Americans have the same basic health and environmental protections. The law allows

individual states to have stronger pollution controls, but states are not allowed to have weaker pollution controls than those set for the whole country.

The *Lead-Based Paint Poisoning Prevention Act* was passed in the U.S. in 1971. This was despite the fact that it was recognized as early as 1914 that lead paint was toxic and certain European countries like Belgium, France and Austria had outlawed lead-based paints as early as 1909. Ongoing efforts at lead abatement in housing and the workplace continue, and will for years to come.

Global Leaded Gasoline Phase-Out Program – Started in the U.S. in 1972 and is spreading slowly. The EPA reported average U.S. BLL drop of 37% between 1976 and 1980 and a subsequent study demonstrated a decrease in BLLs in the U.S. of 78% between the years 1978-1991. Most ambitious goal is complete phase out worldwide, by the year 2015.

Until recently, Sub-Saharan Africa was one of the most egregious offenders. Only 1 out of 49 sub-Saharan African nations (Sudan) was able to claim complete lead-free gasoline in 2002. Thanks to the work of the World Summit on Sustainable Development in Johannesburg in 2002 (WSSD), all have followed suit including South Africa in January of 2006 (Washington Post, 12/31/2005).

Currently well over 30 countries globally are still using leaded petrol, with big challenges remaining in the small and far flung islands of the Pacific including Micronesia. Other countries so far without plans to phase-out lead include Afghanistan, Algeria, Bhutan, Cambodia, Cuba, Iraq, Laos, Mongolia, Myanmar, North Korea, Tajikistan, Turkmenistan, and Uzbekistan.

The *Basel Convention* is a UN treaty in force as of 1992. This is a legally binding international agreement that addresses the problem of the uncontrolled movement and dumping of hazardous wastes across international boundaries, especially to non-OECD countries (BAN, 2002). Since that time 166 countries, including seven of the G-8 nations, have ratified it. The United States, along with Haiti and Afghanistan, have yet to follow suit. The rest of the world has also accepted the Basel Ban, a more recent amendment to the convention that specifically prohibits hazardous waste exports from the twenty-nine wealthiest, most industrialized nations, where 90 percent of global hazardous waste is produced, to poorer nations (The Nation, November 15, 2005).

Reduction of e-waste represents a monumental opportunity for reducing the negative health impact of lead and other hazardous substances by the fledgling cottage industries involved in “recycling” electronic equipment. There exist very few reputable recyclers for this material worldwide, even in the developed nations.

Elimination of exportation of secondary lead sources from the developed nations to the developing world. The Basel Action Network, a Seattle-based organization, has been successful in gaining commitment by the large tech firms such as Apple, Dell and Hewlett-Packard to voluntarily participate in computer TakeBack programs. These are free recycling programs which foster corporate responsibility and will, with widespread adoption, drastically curtail the vast numbers of computers being exported. BAN also publishes the names and locations of reputable recyclers in the United States for the benefit of concerned consumers.



08 March 2005

Guiyu China

A Chinese child sits amongst a pile of wires and e-waste. Children can often be found dismantling e-waste containing many hazardous chemicals known to be potentially very damaging to children's health.

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In 2006, the EU is instituting the *Restriction of Hazardous Substances (RoHS)* in electronic equipment which will limit the amount of lead used in new products to 0.1% by weight. There will be some exceptions to this, including lead content of batteries, but provisions have even been made for these. For batteries containing more than 0.4% lead, a separate waste stream must be generated and adhered to with strict recycling requirements (EU 2002b).

The United Nations Environmental Programme's (*UNEP*) *Cleaner Production Declaration* is a commitment on the part of many of the players in a product's life cycle to cooperate and create solutions to the problems that the ever increasing electronic waste stream is creating. Product stewardship on the part of the electronic and auto industries will play a key role in gaining control over the looming specter of a potential 17-20 kg/person/year of electronic waste. This represents the largest growing segment of waste today, at 3-5% per year, or more than 6 millions tons in Europe alone (EPA, 2005).

Concept of Extended Producer Responsibility (EPR) - Corporate action to reduce percentage of lead-containing components (ie. Lead solder, etc) and increase product "lifetime" to prolong the recycling phase. "Product stewardship is an all embracing term for the way we address products, their uses and management at end of life. It includes production efficiency, releases to the environment, and ecological and health risk assessments, as well as hazard classification, life cycle assessment and recyclability." (Rio Tinto 2003)

The demand for lead-acid batteries is ever increasing, especially in China where the automobile industry has recently exploded. This means that, worldwide, the need for responsible recycling efforts, what some call “Greater Than 100% Recycling” will be needed.

100% would be the recycling rate if all the batteries that were made in one year were recycled, but because so much lead is "out there" the rate of recycling must be greater than 100% for many years to come, in order to bring back all the batteries not recycled in their year of manufacture – globally this is at least 35% of batteries for many decades. That means the lead problem will continue to exist for a very long time and consequently lead poisoning and environmental degradation goes on, especially in many developing countries (GreenLead, 2005).

There are great efforts being taken by the electronics industry leaders, as well as some non-profit, environmental based companies, to develop comprehensive, global battery recycling programs. However, until legislation mandates the recycling of these batteries and a reasonable, affordable, accessible means to global recycling is available there will always exist an environmental “black hole” into which the world’s “dead” batteries will fall.

Urban Lead Poisoning Prevention and Management Strategies in American Cities

Case Study: New York City

Given the mounting evidence implicating lead as a danger to children for many reasons, why is it that we have not eliminated it from our homes, buildings and environments? Permanent lead remediation is expensive, but that doesn’t account for the entire story. Obviously, it takes more than scientific literature to tackle an environmental problem with the complexity of lead exposure. New York City is one of several exemplary examples of comprehensive childhood lead exposure prevention programs, particularly due to the cooperation of the city health departments, government, health providers and community groups.

In 1992, New York State Legislature passed the Lead Poisoning Prevention Act, which prohibits the sale of certain products containing lead-based paint, outlines abatement conditions and regulations, and delineates enforcement for these rules and regulations. The act also provides for a lead poisoning prevention program including the screening of pregnant women and children, a registry of children with elevated blood levels and a program coordinate lead poisoning prevention, exposure reduction, and identification and treatment activities with state, federal and local agencies.

The legislation created the New York State Advisory Council on Lead Poisoning Prevention, the multi-disciplinary body in charge of overseeing the activities of the city. The Advisory Council, in conjunction with the local health departments have the authority to enforce regulations and recommend changes to the legislature (*NY State Dept. of Health, “Physicians Handbook on Childhood Lead Poisoning Prevention” 2002*). These provisions address many different aspects of lead poisoning prevention as well as medical management for children with probable exposures and diagnoses. Health screening, commerce and sale of lead based paint products, medical intervention for exposed young children, medical guidelines for pregnant women, and some lead abatement enforcement issues combine to make this legislation thorough. Many states

have similar lead poisoning prevention legislation, but the New York legislation was particularly effective due to the cooperation from many different sources and authorities.

Part of what New York City's success is due to the fact that providers have taken these recommendations seriously. Recognizing the progress that providers have made to increase screening and provide education and care, the Attorney General of the New York Health Care Bureau commissioned an inquiry in September 2005 to compile a report on the practices and strategies area HMOs found most useful in complying with state laws regarding childhood lead screening and treatment. An earlier "Compliance Profile", compiled in 2004, demonstrated that many Medicaid and Child Health Plus health plans have failed to screen children for lead poisoning at an adequate rate. These health plans were not only failing to comply with law, but also failing to address the needs of the communities they serve. The best practices report was intended to provide support for health insurers struggling to comply with recommendations they were given.

Among the recommendations, the Best Practices report suggests that other health insurance plans: increase efforts to screen 1-year-olds (in order to screen as early as possible), monitor network provider compliance (especially in areas where satellite clinics and pediatric offices are smaller and not closely monitored. The report even recommends maintaining lists of providers who have not screened eligible children), provide incentives for providers to comply with screening, provide incentives for families whose children receive screening (aimed at empowering families to ask for and demand lead testing and be proactive about their children's health), conduct regular internal assessments of screening effectiveness, explore ways to increase screening at small primary care clinics and doctor offices, engage in member outreach (especially to parents of young children and pregnant families, as early as possible, to begin the discussion of lead issues, make all medical materials available in Spanish and other applicable languages for the community, provider education (evidence shows that many providers are unaware of the lead problems in their communities. Medical education curricula often don't cover lead issues in detail). The Best Practices guide was written not as an admonishment for failures in screening rates, but was distributed as a useful guide in helping plans better guarantee screening services. (NYC Best Practices "An Ounce of Prevention: Best Practices for Increasing Childhood Lead Screening by New York's Managed Care Plans").

The New York regulations demand that all children are screened at age 1 and 2, not just high-risk children. National policies, set forth by the CDC, stipulate that providers should engage in "targeted" screening (AAP Policy Statement, 2005) Under a targeted screening program, lead screening is recommended for "high risk" children, who are identified as such by their zipcode or other demographic information, insurance status (all Medicaid eligible children should receive lead tests), positive response to living in a house over 50 years old or recent home remodeling, presence of a lead poisoned sibling or family member, and various other key target questions (AAP Policy Statement, 2005). However many providers are not specifically educated about lead exposure assessment and they are unsure of appropriate qualifications that indicate high risk of lead exposure. The NY regulations handle this provider uncertainty by publishing its own lead risk assessment (~10 question interview) to be conducted at six months for every child to help identify likely candidates for lead exposure. This effectively is a universal screening program, rather than a targeted screening program, and it ensures that no child falls through the cracks

because he or she does not meet the criteria of demonstrating high-risk. Additionally, the New York City Department of Health and Mental Hygiene recognizes that lead levels below 10 can be damaging, and the department recommends education, re-testing, and lead risk assessment for children whose lead tests fall below the action level of 10.

Another significant provision of local and state policy is the action required for pregnant women. Pregnant women are not required to be tested for lead, but providers are encouraged to conduct a lead risk assessment (similar to the child risk assessment) on these women to determine if further action is warranted. According to the Dept of Health and Mental Hygiene, over 90% of pregnant women with lead exposures are foreign born, so screening in foreign populations should be a priority, and local clinics serving international populations should do internal assessments to determine whether mandatory lead testing should be implemented (“City Health Information” Vol. 26(3):15–22).

New York, like many old cities, continues to struggle with the challenge of providing lead safe housing. In an opinion article from 1993, Goodman et al., proposed that “we must not be deterred, however, from beginning this effort in the communities and dwellings that need intervention the most: deteriorated, older housing units in which young children reside,” (Goodman et al., 1993). In a report on the health status of New York City residents in 2005, it was reported that rates of lead poisoning had significantly decreased (Perez-Pena, NYTimes, June 21, 2006).

Case Study: City of Cleveland

The City of Cleveland has legislation and organizational support essentially similar to New York City, and Cleveland is also making significant progress in addressing lead poisoning, albeit at a slower pace than New York City. As directed by federal requirements, Ohio state law requires any lead abatement worker of any kind to be licensed by the state (ORC, 3742.05). A lead-certified official must actually *do* the lead abatement and cannot supervise or instruct non-trained persons to conduct this kind of work (ORC, 3742.05). According to Wayne Slota, Director of the Lead Poisoning Prevention Program at the CDPH, enforcement of licensing laws is not often a problem; the biggest problem is that there are too few certified workers because the work is costly and dangerous and (personal communication, Wayne Slota). Even though profits from lead abatement are potentially high, there are not enough incentives for contractors to complete training for an expensive procedure that few homeowners actually take advantage of.

Ohio state law, unlike New York’s regulations, requires that only some children be tested for lead; testing is mandatory for those in high-risk zip codes and those covered by Medicaid. Despite this mandate, there is no proposed monitoring of non-compliance of this rule. Similar to other states, health care providers are required by state law to report any elevated BLL to the local or county health department where the screening took place (ORC 3742.30). Any child determined to have a EBLL is reported to the local health department and the department is responsible for conducting an environmental risk assessment of the home.

In 2003 the Ohio legislature created the Lead Poisoning Prevention Fund under ORC 3742.51, with the purpose of “providing financial assistance to individuals who are unable to pay for ... [the] costs associated with obtaining lead tests and lead poisoning treatment for children under

six years of age[and]....Costs associated with having lead abatement performed” (ORC 3742.51). This fund never received any money and currently has no operational budget. Supporting lead remediation endeavors with grant monies for families and financial bonuses for contractors and construction firms could potentially encourage a great deal more lead repairs to be undertaken.

The Ohio Dept of Health (ODH), the Cleveland Department of Public Health (CDPH) and the Cuyahoga County Board of Health (CCBH) all have taken a proactive role in lead poisoning surveillance in order to track trends and make resources available to residents. The largest adult-focused lead program is the Nationwide ABLES- Adult Blood Lead Epidemiology and Surveillance – Program, which conducts research into occupational risk, adult lead exposures, conducts blood testing, and provides education on the management and of high BLL in adults. The ODH facilitates the implementation of the ABLES program in Ohio through targeted interventions in high-risk occupational settings.

The Cleveland Department of Public Health and the Cuyahoga County Board of Health have joined forces to formulate the Greater Cleveland Plan to Eliminate Childhood Lead Poisoning, which outlines specific goals and hopes to eradicate childhood lead poisoning by the year 2010. The plan has six main foci: Community Infrastructure and Stability, Outreach and Advocacy, Integration (of programs and organizations), Environment/Property Owners, Workforce, Health Care. Each of the six components serves some piece of the overall goal, which is enforced and implemented by the “oversight entity called the Greater Cleveland Lead Advisory Council that formally directs all resource identification, utilization, need prioritization, and points of accountability in the community” (Greater Cleveland’s Plan to Eliminate Childhood Lead Poisoning by 2010). The Greater Cleveland Lead Advisory Council (GCLAC) is the executive body overseeing the Plan (similar to the NYC Advisory Council) and is comprised of nearly 100 volunteers from a broad spectrum of community organizations, universities, state agencies, local advocacy groups and charity groups. However there are over 20 other entities working in conjunction with the GCLAC to implement Greater Cleveland’s Plan, including the Cleveland Metropolitan Housing Authority, the Cleveland Department of Community Development, the Lutheran Metropolitan Ministry and many others (Greater Cleveland’s Plan to Eliminate Childhood Lead Poisoning by 2010). The GCLAC is multi-disciplinary and offers opinions from the academic, education, health, government, housing, and business fields.

In general, the Cleveland Department of Public Health is involved in several small local projects and programs, but these programs are often limited in funding and scope. For instance, the CDPH and the Lead Safe Living Campaign recently received a small grant from the EPA to fund Project IMPACT (Increasing Methods of Prevention for At-Risk Children Today) which will train local early child care workers to conduct blood lead testing using finger pricking kits. While this program will potentially screen 2000 at-risk children, it cannot address prevention with the time and money available. Small programs are useful to meet small, specific goals, but ideally, many small programs could be incorporated to fund large comprehensive programs covering many different needs of families.

The Lead Safe Living Campaign is another Cleveland-area lead abatement and prevention program, and is a subset of the GCLAC. The Lead Safe Living Campaign is accountable to its

private grant funding agency (the Cleveland-based St. Luke's Foundation), the steering committee of the GCLAC which oversees the Campaign, and an outside evaluator. The Campaign organizes advertisements, distribution of educational brochures, radio spots, press conferences, and community events in an effort to engage the community in prevention efforts.

Emerging Evidence of the Social Implications of Early Childhood Lead Exposure

Lead exposure at varying levels has been associated with cognitive development problems for several decades, and current literature continues to support this association. Questions remain, however, surrounding the degree to which lead is a causal factor in cognitive impairment in children. Almost all studies acknowledge that there are many potential confounding factors, which are biological and social, that may influence the extent of damage caused by lead exposure. Figure 1 provides a basic diagram of the links between lead, behavior, and "covariates" (i.e. genetic, physiological, environmental, social factors, etc.) as they relate to IQ (Figure 1 from Chen et al., 2007). Lead is certainly not the only issue affecting decreases in cognitive development in children; nevertheless, researchers continue to conclude that early childhood exposure to lead is associated with various developmental problems and argue that lead exposure should not be overlooked when assessing a child's overall environment.

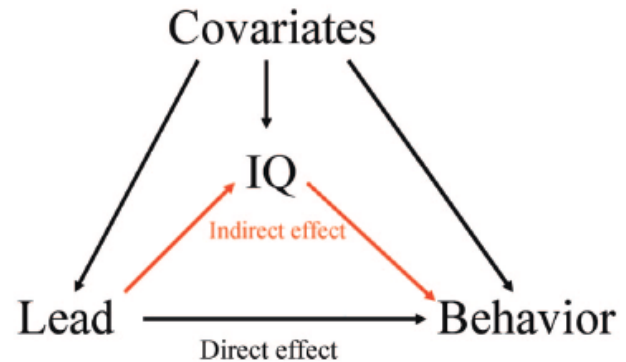


FIGURE 1
Path diagram of direct and indirect effects of blood lead level on behavior.

Recently, an emerging body of scientific literature has focused on examining the effects of low levels of lead exposure. The Center for Disease Control and Prevention (CDC) National action level of lead in blood for children is 10 µg/dL, meaning that any health care provider who identifies a child level of 10 or higher must report this case as an Elevated Blood Lead Level (EBLL) to the local and state health departments for potential further action.

Many academic researchers and experts in the childhood lead exposure field argue that the childhood action level should be reduced to 5 or even 2 µg/dL. At the least, there is increasing scientific evidence of the detrimental effects of lead levels less than 10. In a pooled analysis of seven international studies, Lanphear et al., (2006) found that the most significant lead-associated intellectual impairments were observed in children whose BLL tests revealed lead concentrations at or below 7.5 µg/dL. The study estimated that approximately 3.9 IQ points were lost on average when lead levels fell between 2.4 to 10 µg/dL, but IQ continued to fall only an additional 1.9 points for children whose BLL was between 10 to 20 µg/dL, and 1.1 points for blood lead levels between 20 to 30 µg/dL. (Lanphear et al., 2006).

Several studies have investigated the link between lead exposure and childhood IQ. In a prospective study of nearly 200 children, Canfield et al., (2003) followed children from birth to 5

years of age and collected regular blood lead levels and age-appropriate IQ assessments at both 3 and 5 years into the study. They found that children's BLLs significantly decreased IQ. They estimated that each incremental lifetime BLL increase of 10 $\mu\text{g}/\text{dL}$ was associated, on average, with a 4.6-point decrease in IQ. The investigators also found that low lead levels were associated with the largest decreases in IQ (Canfield et al., 2003).

Lead exposure has been identified as a risk factor for diagnosis of Attention Deficit Hyperactivity Disorder (ADHD) in a number of urban and general population studies. Braun et al., (2006) suggested that early childhood lead exposure may account for up to nearly 300,000 cases of ADHD in the United States. In a follow-up study to previous research, Chen et al., (2007) found mixed results on cognitive tests and behavioral tests in children 5-7 years of age who had previously had EBLLs. Even despite the uncertainty of the results, the authors maintained that "if lead exposure is affecting behavior in 5-year-olds, it is doing so mostly through IQ, and direct effects have not emerged or are not measurable with the methods we used" (Chen et al., 2007). Their conclusion supports the claim that effects of lead may not be completely understood, but it is clear that the implications of lead exposure in early childhood are potentially destructive to a child's educational future.

Lead and School Performance

Early childhood lead exposure has been implicated as a major factor in academic underperformance, as well as increases in school-related violence. Prospective studies of children exposed to lead early in life have associated lead poisoning with poor academic performance in high school, high rates of absenteeism, lower vocabulary and grammatical-reasoning scores, and poorer hand-eye coordination relative to other children (Needleman et al., 1996). In a recent study by Miranda et al. (2007), archived childhood lead level data were obtained from the city health records and linked to scores from each child's fourth grade end-of-grade test, which are standardized tests given to all fourth graders in the state. Their group found a linear dose-response relationship between lead exposure and test performance on both the reading and mathematics test sections, with the steepest decreases found at lead levels below 5 $\mu\text{g}/\text{dL}$ (Miranda et al., 2007).

Reduced academic performance and cognitive function leads many lead-poisoned children to be placed in special education classes. Schwarz (1994) estimated that as many as 20% of children with elevated blood lead levels in the U.S. will need some consistent form of special education, in the form of supplementary teaching assistance, psychology services, or services from other kinds of education specialists. As far as this author is aware, there have been no school-sponsored or educational based studies providing lead-specific case management or special education interventions for lead-exposed children, but perhaps this will be a direction school systems might pursue in the future. As special education programs continue to grow, it is important for educators and schools to be aware of the potential challenges and needs of the children.

Lead and Crime, Violence, and Anti-social Behavior

Lead exposure has consistently been associated in scientific literature with delinquency, aggression, violent crime, impairments in social functioning and behavioral problems. In a prospective longitudinal study, Dietrich et al., (2001) observed a linear relationship between both prenatal (maternal) and postnatal lead levels and self-reported delinquency behavior. Unlike the associations between lead and IQ, delinquency increased as lead exposure increased, and low lead levels were not associated with very high delinquency (Dietrich et al., 2001).

At the individual level, delinquency has been linked to biomarkers of chronic lead exposure. A case-control study completed by Needleman et al. (2002) concluded that adjudicated (not necessarily incarcerated) males were statistically more likely to have lead accumulated in their bones, according to x-ray analyses. This type of analysis cannot tell researchers when exposure occurred, but it implies that exposure was chronic and experienced over a significant portion of time. These results indicate that lead poisoning is associated with an increased risk of juvenile delinquency (Needleman et al., 2002). It is logical that we can expect the population of incarcerated persons to be significantly affected by lead poisoning, though studies directly investigating the current prison population are few in number.

Most of our information about the relationship between childhood lead exposure and criminality come from general population studies. In a national population-level analysis, Stratetky and Lynch (2001) examined multiple cities with respect to reported lead exposure and crime. The investigators found an association between air lead concentrations and homicide rates using county air sample data from all US counties in 1990, though they could not conclude that their results displayed a causal relationship. They suggested that the results of their study “contribute to the emerging and controversial issue concerning the role of lead exposure in predisposing some individuals to committing crime and displaying violent behaviors,” also indicating that further research should be pursued to understand better the role lead plays in community crime rates.

In a controversial analysis of population-wide lead poisoning rates and crime rates, Nevin (2007) indicated that blood lead levels early in life are proportionally associated with crime rates in nine different industrialized countries. In a separate US analysis, Nevin concluded that more violent crime (most notably murder) may be associated with the highest blood lead levels (Nevin, 2007). In an earlier study, Nevin (2000) reported that in recent decades lead in air samples (mainly due to leaded gasoline), was strongly correlated with increases in trends in violent crime, unwed pregnancy, and murder. Given the links between lead exposure and decreased IQ, the findings on violent crime and unwed pregnancy raise questions about whether lead directly affects aggression and crime, or whether lead indirectly influences these outcomes via changes in IQ and social functioning, exacerbated by the community and social environment (Nevin, 2000).

It is currently unexplained why lead exposure leads to violence and social problems. In a 1996 study, childhood lead exposure was significantly associated with higher self-reported anti-social behavior, as well as acts of misdemeanor crime and delinquency (Needleman et al., 1996). Needleman (1990) postulated that lead poisoning is associated with ADHD, which itself is associated with social isolation and antisocial behavior, but this link is only an estimate and the true pathways are not known.

Future scientific research needs are many. Many of the studies on which conclusions are drawn are observational studies that cannot draw causal conclusions about the role of lead poisoning. Dr. Herbert Needleman, one of the countries most published researchers in the childhood lead poisoning field, warned against drawing conclusions from studies of small sample size, underestimating the importance of moderate (barely statistically significant) results, as well as failing to discern causal associations from “accidental” associations (Needleman, 1990). Pocock et al., (1994) reviewed lead-related epidemiological studies and concluded that low level lead exposure may be linked to IQ deficit, but the authors raised uncertainty about the power if sample size, study design flaws and potential for unadjusted confounding. As lead exposure continues to be a well-publicized environmental exposure hazard, future examinations of childhood poisoning may be able to expand their study populations and conduct more thorough evaluations of a broad spectrum of potential effects of lead. Furthermore, the interaction between lead exposure and systemic health disparities should be closely investigated. A recent New Zealand observational study linking lead levels in teeth to adolescent delinquency concluded, “the results of the present study suggest that, while lead exposure was associated with criminal behaviour, the associations were somewhat weak, and were largely explained by linkages between lead exposure and educational underachievement” (Fergusson et al., 2008). Obviously we have much more to learn about the interactions of various biological and social factors that influence health, education and fulfilled participation in society.

Summary

Lead is one of the world’s most ubiquitous elements. It persists in the environment permanently as it cannot be broken down. Research continues to implicate lead as an exposure that is hazardous to the health, welfare and future of children everywhere. Our only hope in the efforts to control and contain the harmful effects it can have on both vulnerable children and adults is to responsibly manage the products we use everyday at the end of their useful life. Given the uncertainty surrounding interactions between lead exposure and the social environment, it would most likely be beneficial to focus efforts on improving overall disparities in health , education and social welfare to reduce the breadth of damage caused by early childhood lead poisoning.

Nations have taken great strides in eliminating the centralized sources of lead such as leaded gasoline and in paints, but much work remains to completely eradicate leaded gasoline from large pockets of the world where it remains the main source of fuel. Also, cleaning up the 82-plus years worth of environmental lead that leaded gasoline use left behind near our roadways and refineries still remains a task. City and state governments in the U.S. have demonstrated that legislative support, cooperation with other agencies, and organization of multi-disciplinary lead poisoning prevention collaboratives can have a meaningful impact in reducing environmental lead exposure.

Lastly, strong and enforceable laws governing the exportation of hazardous e-waste will be one of the largest tasks ahead of us. The developed world has a responsibility to manage its own hazardous waste streams and to ensure that its refuse does not become the developing world’s health crises of tomorrow.

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