THE NEWS HIT like a punch in the stomach. I was producing a daily environmental broadcast for CBS News and had just finished researching a story about the effects of childhood lead poisoning. I knew what an elevated lead level could mean. Lead poisoning is far and away the greatest environmental threat our children face. The U.S. Environmental Protection Agency estimates that one of every ten preschoolers suffers from some form of lead poisoning. Even low levels of lead can block an infant’s mental development. Lead in a child’s system can lower that child’s IQ enough to cause a potential genius (my child, of course!) to drop to an average achievement level, and it can leave an average child learning disabled.

Almost as an afterthought, while working on my broadcast, I had asked our pediatrician to test Matthew for lead poisoning. My wife and I expected the results to be another “reflexes okay, weight and length about average” reassurance that everything was normal. But it wasn’t. We had an intruder in our home, an invisible thief bent on stealing our baby’s brainpower. Our little boy was being silently poisoned.

Our children live, one expert writes, in a world of lead. Matthew certainly did. A do-it-yourself lead-test kit told us that some surface paint in our home contained lead. No surprise, really; almost every
house built before 1976 contains at least some lead paint, and ours was built in the 20s. Another test showed our tap water to be a source. Plumbing is a classic source of lead poisoning, and we discovered lead-soldered copper pipes in the house and a solid lead pipe bringing water in from the street.

We had been renovating our new home while Andrea was pregnant with Matthew, and thus she was nagged by a mother's question, "Did I do this to my baby?" She was haunted by the fear that she had unwittingly exposed our unborn baby to this poison even as we worked to ready his new home. We will never know the answer for certain, but we learned that many home renovations where kids are present result in childhood lead poisoning. The risk could have been prevented, had we only known.

**SOME BASIC FACTS ABOUT LEAD POISONING**

Lead poisoning is the number-one environmental health threat our children face today. We raise our children in homes and yards and a nation contaminated with lead. Lead has no positive value to the human body and has not been shown to be safe at any level. One in ten American children—over 1.7 million kids—have unacceptable levels of lead in their blood, and what is considered acceptable today may be proven unacceptable tomorrow.

The good news is that lead poisoning is totally preventable, and there's a lot you can do yourself to protect your child. Most lead poisoning happens in and around the home. Once you identify the sources of your child's exposure to lead, you can reduce or eliminate them, sometimes with little cost and effort. There are even nutritional steps you can take to keep your child's body from absorbing lead. And certain house-cleaning precautions can reduce the threat of lead dust poisoning.

The key to preventing lead poisoning is knowledge—knowing what to do and what not to do. For example, deteriorating lead paint in a child's home is hazardous, but removing it improperly can turn the potential for low-level poisoning into the reality of acute lead poisoning.

Children are at special risk because their bodies process lead differently than adults. Children absorb up to 50 percent of the lead they ingest—adults retain only 10 percent. This high retention occurs during the early formative years when the central nervous system, including the brain, is developing. Lead interferes with that development. By the time physical symptoms are evident—headaches, nausea, weakness—significant brain damage has already occurred.

It doesn't take much lead to poison a child. An amount equal to one gram of sugar each day over a period of time will raise a child's blood lead level to 35 µg/dl, high enough to trigger intervention and treatment. According to the Centers for Disease Control (CDC), the threshold for poisoning is just 10 µg/dl (see box, p. 4).

Contact with lead is unavoidable. Nobody is immune. No class, no race, no community, no one. Half of all inner-city children suffer from lead poisoning, yet some of the highest levels of lead poisoning are found in the children of middle- and upper-class families who are renovating expensive homes. Lead poisoning is thought of as an urban problem, but people living in North Carolina and Missouri are finding that the problem is more out on the farm than it is in the city. Lead is invisible. Tasteless. Odorless. It accumulates in the body; long-term consumption of low levels can be more dangerous than a single ingestion of concentrated lead. Lead attacks the unborn child in the mother's womb, and children remain at special risk at least through age seven. Even at low levels in the blood, lead attacks the child's developing brain. At high levels, lead can kill.

We have had to change our perception of lead poisoning. For years, lead poisoning was seen as an acute disease, affecting a relatively small percentage of the population. Education, regulation, intervention, and treatment have all but eliminated lead poisoning as a killer of children in America. As a result, many people view the whole subject of lead poisoning as a problem of the past.

This notion is reinforced by the fact that average blood-lead levels in America have come down dramatically. In the past 20 years, the federal government has banned the use of lead in paint and in gasoline. The food industry has stopped using lead-soldered cans. In 1976, the average level of lead in our blood was 17 µg/dl; today it is about 4 µg/dl. However, as average blood-lead levels have come down, scientists have been better able to measure the effects of lower-level exposure to lead. We are now able to know lead poisoning to be a much less dangerous disease in terms of its severity—but a much more threatening one in terms of the size and spectrum of the population it affects.

In low-level lead poisoning (10 µg/dl), there are no symptoms and there is no treatment. The only answer is prevention—eliminating sources of lead before the child is further poisoned. In acute lead poisoning (60 µg/dl), there are overt symptoms, and the primary concern
THAT µG/DL TECHNICAL STUFF

Unless you are a scientist, the µg/dl's, ppm's, and ppb's that you will encounter could make your eyes glaze over. Unfortunately, we need to use these units of measure occasionally so we know when we're talking about apples and when we're talking about oranges. Don't try to memorize what they mean; the important thing to know is that 60 apples is more than 10 apples.

µg/dl is used to describe the amount of lead in blood. It's shorthand for micrograms (µg) per deciliter (dl). A microgram is one millionth of a gram, and there are 28 grams in an ounce. A deciliter is a tenth of a liter, equal to about half a cup. You'd get a concentration of 1 µg/dl if you flooded a football field with two feet of water and tossed in one tablespoon of sugar.

ppm, used to measure levels of contamination, stands for parts per million. A big truck overturns and spills one million oranges. Workers cleaning up the mess discover one apple. That's one part per million.

ppb, used the same way, stands for parts per billion. One hundred dollar bills overturn and spill one billion oranges. Workers find one apple. That's one part per billion, which also equals one microgram per deciliter (1 ppb = 1 µg/dl).

AND THEN THERE ARE ALL THOSE ACRONYMS

ATSDR, CDC, EPA, HHS . . . what would government agencies be without acronyms? One thing I do know is that without them, this book would include a lot more pages! Whenever an agency is referred to for the first time, I'll use the full name, along with its acronym. After that, it's alphabet soup. If you forget, you can look it up in appendix A.

is treatment. Common symptoms include headaches, stomachaches, cramps, or vomiting. The child may be tired, cranky, clumsy, or lose interest in playing. Diagnosis can be difficult since those symptoms also occur in any number of childhood maladies.

Low-level lead poisoning reduces intelligence, causes reading and learning disabilities, and has been linked to later failure to graduate from high school and to criminal behavior. It can also cause such behavioral problems as hyperactivity and reduced attention span. Physical effects include low birth weight and size, loss of hearing, and delayed physical development. Signs of possible lead poisoning include delayed developmental milestones like standing, walking, and talking, but by the time these are noted, damage has been done. A blood lead test is the only reliable way to diagnose lead poisoning.

There is a lot more to learn about the effects of lead at the lowest levels, but it is becoming clear that lead at any level poses a threat to children. As we learn more about the effects of low-level lead poisoning, the so-called action level—the point at which we say a person is lead poisoned—keeps moving down. In the mid-1960s, people weren't considered poisoned until their blood-lead level hit 60 µg/dl. The number was cut in half in 1978, dropped again in 1985, and lowered to the present 10 µg/dl in October 1991.

PRENATAL EXPOSURE TO LEAD

Exposure to lead starts even before conception. The body stores lead. Its half-life (the length of time it takes to reduce the concentration of lead by 50 percent) in blood and soft tissue is about a month. Lead's half-life in bone is some thirteen years for adults. (The figure is unknown for children.) In times of stress, including pregnancy, the lead stored in bones is released into the blood stream. Lead easily crosses the placental barrier throughout the gestation period, including the critical period during which the central nervous system is formed.

By reducing lead intake for at least two months prior to conception, the mother-to-be can lower the amount of lead stored in her body. This in turn will reduce the amount of lead her baby is exposed to once she conceives. Reducing exposure to lead while pregnant is especially important because pregnant women absorb much more of the lead they ingest than do other adults.

We learned of the danger of in-utero poisoning long after Matthew was born, after Andrea had seemingly spent her entire pregnancy either
Bone analysis — bones store 95 percent of the lead in an adult body — shows that our early ancestors had virtually no lead in their bodies. Lead is an element; it doesn’t break down, burn up, biodegrade, or dissipate. Lead poisoning is the by-product of industry. Researchers studying sediment layers from the bottoms of Swedish lakes have been able to trace lead pollution back 2,600 years, to lead dust released when the ancient Greeks began refining silver. Concentrations of lead pollution peaked 600 years later at the height of the Roman Empire, then faded away for almost two millennia, only to soar again with the advent of the Industrial Revolution in the 1800s. Every microgram of lead that has been released into the environment is still there. And there’s a lot of it.

The Agency for Toxic Substances and Disease Registry (ATSDR) reports that four million tons of lead used in gasoline remains in our dust and soil. The Department of Housing and Urban Development (HUD) estimates that three million tons of lead (not lead paint; lead) remain on the walls of almost 60 million private housing units — that’s three-quarters of all the housing in America. The various bans on the use of lead simply mean we’re not adding even more lead pollution to the environment. Unfortunately, there’s plenty there already, and lead poisoning is going to be with us for quite a while.

On a ladder or sitting on the floor scraping and painting as we rushed to complete renovations before the baby was born. Everyone worried about her falling off the ladder, or breathing in paint fumes. No one knew or thought to question the lead dust and lead fumes we were generating by stripping and scraping layers of paint from our woodwork.

The child exposed to lead in utero is often born prematurely. The risk of delivery before the 37th week of pregnancy if the mother’s blood-lead level is 14 µg/dl or higher is almost nine times the risk at levels up to 8 µg/dl. Birth weight, chest circumference, and length/height may all be reduced. Lead’s effect on stature has been observed at concentrations as low as 4 µg/dl. Lead poisoning also causes a loss of hearing, with the ability to hear high frequencies affected first.

Babies who are exposed to even low levels of lead in the womb also have been found to have mental and behavioral impairments. Studies in Cincinnati and Boston showed that scores on two key intelligence tests were inversely related to prenatal lead exposure. When six-month-olds were tested, there were significant differences in the scores of low (1.8 µg/dl) and high (14.6 µg/dl) children on the Bayley MDI (Mental Development Index). The Cincinnati study showed a drop of eight points for every 10 µg/dl increase in blood-lead level. The studies indicate that prenatal exposure to lead may have an even greater impact than an equal level of exposure in the first few months after birth.

**HOW LEAD AFFECTS EARLY CHILDHOOD DEVELOPMENT**

A child’s blood-lead levels remain relatively constant for the first six months of life, then begin a sharp increase, which continues until the child is 24 months old. The greatest accumulation of lead occurs in the second year of life. Dr. Julian Chisholm of the Kennedy Krieger Institute in Baltimore, one of the pioneers in the field, says the best indicator of how well a child will do on standardized tests given at age 10 will be that child’s blood-lead level at 24 months. Dr. Chisholm believes there is a reason.

He explains that during the second year of life, the human brain reorganizes itself. It makes new connections, called synapses, in the nerve pathways. Nerve pathways, along which the brain sends its information, are not unbroken trails. They stop and start, and synapses bridge the gaps. Information is handed over at the synapse, like a relay runner’s baton. Lead interferes with building the bridges. The information-baton cannot be passed. Chisholm believes this is the period when the child is most vulnerable to the effects of lead.

Unfortunately, this is also the time when a baby’s normal behavior—gumming, teething, and excessive hand-to-mouth activity—makes ingesting lead more likely. Infants crawl. They pick up lead dust from the floor, from their toys, and from pets. Then they put their hands in their mouths, they eat with their hands, they suck their thumbs.

If you ever ran your hand over the outside of a house as a child and happened to taste the white chalk residue, you may recall that the lead compound used in paint tastes sweet, encouraging small children to lick or chew it.

Lead’s greatest impact is on the developing child’s brain and central nervous system. There have been at least 14 studies, in a number of
countries, all measuring lead's impact on the child's intelligence quotient (IQ). There are some inconsistencies in the findings, in part because the negative effect of lead can be offset by what researchers call "confounding factors," but the weight of all the evidence clearly indicates that lead interferes with a child's ability to learn. As you would expect, studies indicate that the more lead the child is exposed to, the more the child's IQ is lowered.

Cultural nourishment during the developmental years can offset the negative effects of both pre- and postnatal lead exposure. It's one of those confounding factors that researchers have to consider in measuring the impact of low-level lead poisoning. Stimulation during these early years—interplay between the parent and child, the availability of toys, reading and talking to the child—directly improves the child's intelligence and later performance in school. I used to tease Andrea that she belonged to the Ben and Jerry School of Child Development because of all the black-and-white shapes she used to decorate Matthew's room. She had read that infants don't recognize colors but are stimulated by black-and-white objects and designs.

It turns out that everything that enriches your child becomes especially important if the child has been exposed to lead. But keep in mind that the best you can do is offset the effects of lead as long as the child remains exposed. The sooner you stop your child's intake of lead, the greater effect cultural enrichment can have.

Lead's attack on intelligence is just one facet of its impact on the developing child. As noted earlier, it also causes behavioral problems, including irritability and hyperactivity. There may be attention deficit disorders, in which the child is unable to control his or her impulses and is easily distracted. If unrecognized and unmanaged, the behavioral problems often exacerbate the learning problems, leading to negative reinforcement that almost guarantees academic failure.

**RELATIONSHIP BETWEEN LEAD AND ACADEMIC PERFORMANCE: THE NEEDLEMAN STUDY**

Lead poisoning has a direct effect on a child's success in school. Dr. Herbert Needleman, another pioneer in the field, studied some 12,000 children in Boston, comparing their careers in school with the amount of lead found in the baby teeth they had shed in early grade school. (Since we know that lead is stored in teeth, examining baby teeth is one way to measure early lead exposure.) Dr. Needleman's study shows that a student's success in school is inversely related to the level of lead exposure; the more lead the preschool child absorbed, the worse the child did later in school. Lead levels in teeth that exceeded 20 ppm were linked with a sevenfold risk of becoming a high school dropout. There was a sixfold risk of having a reading disability, vocabulary deficits, problems with attention, and loss of fine motor coordination. Predictably, there was greater absenteeism and lower class ranking. (A recent Danish study has found higher rates of learning disabilities among students with even lower tooth-lead levels.)

Dr. Needleman's study found a downward shift of four to six IQ points. When the individual scores were plotted on a graph, the enormity of the loss became apparent. Not one child achieved superior function, meaning a verbal IQ score of greater than 125. At the other end of the scale, there was a marked increase in the number of kids with severe deficits, meaning a score of less than 80. A four-point downward shift in IQ scores results in a 50 percent increase in the number of retarded children. This lowering of intelligence of an entire generation has significant implications for the future of our society.

**CUMULATIVE FREQUENCY DISTRIBUTION OF VERBAL IQ SCORES IN CHILDREN WITH HIGH AND LOW TOOTH LEAD LEVELS**

![Cumulative Frequency Distribution](image)

Source: Needleman et al., 1979.
LEAD POISONING AND CRIMINALITY

Brace yourself for a new defense of Court TV. Lead poisoning. Law professor Deborah Denno of Fordham University in New York City was studying patterns of criminality and discovered a striking connection between lead poisoning and male criminality. Her exhaustive study tracked almost one thousand individuals of both sexes from birth (at the same Philadelphia hospital) until they were twenty-four years old. The size of the study allowed her to test many different theories of crime. "Particularly striking," she wrote, "among males, lead poisoning, a factor related to the urban environment, was among the strongest predictors of crime, even though numerous biological and psychological factors were also considered." And when Professor Denno tracked the major predictors of criminality across the progression from disciplinary problems in school to juvenile crime to adult crime, lead poisoning was the only factor common to all three.


HOW LEAD ATTACKS THE BODY

Other physical ramifications for the young child include anemia and, at higher levels, kidney damage. Lead interferes with the child's ability to produce and use vitamin D, essential for the building of normal teeth and bones, and it inhibits the formation of red blood cells. Children with elevated blood-lead levels may have slowed reaction times, problems with their balance and posture, and may be delayed in the age at which they first sit up, walk, and achieve other developmental milestones.

Lead accumulates in the human body. The level of toxicity depends on how much lead you—or your child—or both—are exposed to and how long the exposure continues. Lead tricks the body. It bonds to red blood cells in the same way that iron does. It also mimics calcium, and so is taken up and stored in teeth and bones. Almost 95 percent of the body's total accumulated lead is stored in its bones. Bones are the body's calcium warehouse. When calcium levels in the body drop, bones recycle calcium back into the bloodstream for distribution to the liver, brain, and other soft tissue organs. Bones do the same with stored lead. As the blood-lead level goes down, the bone warehouse puts lead back into the bloodstream. Purging the body of lead toxicity can take a long time.

Predictably, iron or calcium deficiencies increase the amount of lead the body absorbs. Iron deficiency has long been recognized as a major factor in the high level of lead absorption among the children of poor, inner-city families. Sickle cell anemia is another complicating factor in the inner city. Sickle cell causes a deficiency in zinc, which increases both the absorption and toxicity risk of lead. Deficiencies in protein and phosphorus also increase the rate of lead retention.

Your child's ability to absorb ingested lead can be limited by making sure she or he gets enough iron and calcium. A diet high in iron and calcium (especially iron) can play a critical role in limiting low-level lead poisoning.

The relationship between cause and effect—how much ingested lead results in how high a blood-lead level—is affected by a number of variables. The body absorbs different forms of lead at different rates. Different parts of the body absorb lead at different rates. And, as we've seen, nutrition affects absorption rates. However, the most important variable is age, and there are two factors working against kids.

Children retain a far greater percentage of the lead they're exposed to than do adults. This starts before birth and continues up to age...
seven, when the retention rate falls off quickly. Older children and adults can be exposed to four times as much lead as a young child before they will reach the same blood-lead level. This high rate of lead retention comes at the same time the child is developing, both mentally and physically. As a result, even low levels of lead have a greater effect. Whereas lead affects young children at blood levels as low as 10 µg/dl, the first measurable effects on adults occur at about 30 µg/dl.

The Food and Drug Administration (FDA) has put together a chart that relates daily lead ingestion to lead poisoning in children and adults (see table). The figures represent total intake, not just intake from food or water or some other source; lead poisoning is cumulative. These are estimates of the amount of lead that will push the lead concentration in blood to the CDC action levels. There’s a separate line for pregnant women because the fetus shares the mother’s blood-lead level and so the mother’s blood-lead level must not exceed 10 µg/dl. You want to stay as far below these intake levels as possible.

The most dangerous form of lead pollution is airborne lead. This includes lead-paint dust and lead vapors created by burning off old paint, burning lead-painted wood, soldering and melting lead for use in various hobbies. It also includes out-of-the-home industrial sources. Your lungs absorb between 30 and 50 percent of the lead you breathe in. Children’s lungs absorb at the same rate as adults, but kids have a higher metabolic rate. That means they breathe in more air, relative to their body size and weight, than adults. It’s estimated that children’s lungs absorb two to three times as much lead as adults.

Burning material contaminated with lead is extremely hazardous. During the Depression, junkyards recycling lead gave discarded battery casings to poor people to be used as fuel. The practice led to an outbreak of lead poisoning in Baltimore that came to be called the “Depression Disease.” The Depression ended, but poverty did not, and lead poisoning from this source has been reported into the 1980s. Burning colored newsprint or wood coated with lead paint can also release lead into the air.

The high rate at which airborne lead enters the body explains why leaded gasoline was such a hazard. As cars burned the gas, the entire lead content passed out through the exhaust and into the atmosphere. Air became one of the primary paths by which lead entered people’s bodies. After the EPA ordered the phasing out of leaded gasoline in 1976, researchers charting blood-lead levels found a startlingly close correlation between the reduction in use of leaded gasoline and a decline in the levels of lead in blood.

Animal research shows that the smaller the particles of lead, the more easily they’ll be absorbed. In experiments with rats, when the size of the ingested lead dropped from 150 to 8 microns—a micron is one millionth of a meter—the rate of absorption increased 500 percent. This explains why lead-paint dust that you can’t see may be even more dangerous than lead-paint chips. While both the particle size and the chemical form of the lead in dust affect the rate at which it’s absorbed, the EPA estimates that for every 1,000 ppm increase in the amount of lead in dust, there is a 3 to 7 µg/dl rise in the level of lead in the blood.

### Daily Levels of Lead Ingestion Resulting in Lead Poisoning

<table>
<thead>
<tr>
<th>POPULATION</th>
<th>LEAD INGESTED (µg/day)</th>
<th>CONVERSION FACTOR</th>
<th>BLOOD-LEAD LEVEL (µg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children ages 0-7</td>
<td>60</td>
<td>0.16</td>
<td>10</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>250</td>
<td>0.04</td>
<td>10</td>
</tr>
<tr>
<td>Adults</td>
<td>750</td>
<td>0.04</td>
<td>30</td>
</tr>
</tbody>
</table>

*The conversion factor represents the relative rate at which lead is absorbed by the body. As a quick rule of thumb, every 6 µg of lead that a child ingests will raise his or her blood-lead level by 1 µg/dl.

### Take the Initiative in Protecting Your Child

The decision of the CDC to set 10 µg/dl as the “threshold of concern” was based on practicality. The ability to measure at lower levels is imprecise. The research is so new that scientists haven’t identified and evaluated ways to deal with lead at these low levels. And the CDC admits we would be overwhelmed by the sheer numbers of affected children if the threshold were lowered farther. The government is practicing preventive triage. It’s focusing attention and resources first on those with the most serious problems. Even so, the CDC sees 10 µg/dl
as a start, not a finish. Prevention activities, it says, should work to reduce children's blood-lead levels at least to below 10 µg/dl.

The government is dealing with almost two million kids; you and I are dealing only with our own. The government has a 20-year society-wide plan to eliminate lead poisoning; you and I can't wait. Unlike Uncle Sam, we have the opportunity to remove every possible source of lead exposure and to get our children's blood-lead levels as low as possible... right now.