
Title

Childhood Blood Lead Levels and Symptoms of Attention Deficit Hyperactivity Disorder (ADHD): A Cross-Sectional Study of Mexican Children

Author(s)

Siying Huang, Howard Hu, Brisa N Sánchez, Karen E. Peterson, Adrienne S. Ettinger, Héctor Lamadrid-Figueroa, Lourdes Schnaas, Adriana Mercado-García, Robert O. Wright, Niladri Basu, David E. Cantonwine, Mauricio Hernández-Avila, and Martha María Téllez-Rojo

Abstract**Background**

Lead is a natural metal present below the Earth's surface. It had once been used as an additive in gasoline and in the production of paints and plumbing fixtures. Over time, enough evidence amassed to prove that exposure to lead is harmful to human health and development. Thus, in the 1970-1980's the federal government took measures to reduce human exposure to lead by removing it from gasoline as well as from household paint, solder, pipes, and brass fixtures and fittings for residential plumbing. However, lead persists in our living spaces today--in old and poorly maintained paint in homes built before 1978, in dust and soil near flaking old paint, and in some plumbing fixtures and water service lines carrying drinking water. There are also many consumer products that have been found to have high levels of lead in them. Numerous health concerns and even death have been identified at various levels of lead exposure, and scientists have not identified a safe level of exposure¹. At even very low blood lead levels in children, studies have found positive associations with Attention Deficit Hyperactivity Disorder (ADHD) and with ADHD symptoms. However, the associations between lead exposure and ADHD subtypes are inconsistent and understudied.

Objective

This study explored the association between consistent exposure to low levels of lead and three ADHD subtypes (hyperactivity, inattention and combined hyperactivity-inattention).

Methods

Two cohorts of pregnant women were recruited from Mexico City, the first in 1997 and the second in 2001, from various prenatal clinics of the Mexican Social Security Institute. However, mother-infant pairs were later excluded from the study if a child was preterm, had a low birth weight (< 2,000 grams), had an Apgar score of 6 or less at birth, been admitted to the ICU or had a serious birth defect. Of the children born to the recruited women, 1,079 were included at the start of the study. An initial questionnaire on marital status, education level, socio-economic status, smoking status, and other covariates was administered. In addition, children's growth and neurological development were assessed in 6-month intervals from birth to 5 years of age.

When the children were 6-13 years old, 578 of the 1,079 original mother-infant pairs participated in a voluntary behavioral assessment in 2008 and 2011. At that time, an updated questionnaire was administered and mothers assessed their children's behaviors using Conner's Rating Scale-Revised (CRS-R), an instrument that evaluates children's behaviors, including those associated with ADHD. The researchers used data points from specific CRS-R scales, subscales, and index scores related to ADHD symptoms and subtypes such as hyperactivity, inattentiveness, and combined hyperactivity-inattention, to assign behavior scores.

¹ Centers for Disease Control and Prevention's National Center for Environmental Health (2016, January 29). Retrieved June 16, 2016, from <http://www.cdc.gov/nceh/lead/>

Over the study period, children's blood lead levels (BLLs) were taken at 12, 18, 24, 36, 48 months for 71% of 578 participants.

Results

Fifteen percent of the children had BLLs higher than 5 ug/dL, the level at which intervention is considered necessary by the Centers for Disease Control and Prevention (CDC).

Overall, consistent exposure to lead was linked to hyperactivity and impulsivity-associated behaviors but this relationship was not linear. The CRS-R scale showed that as BLLs increased, even as little as 1 ug/dL, there were significant increases for some behavior outcomes (hyperactivity, restless-impulsive, hyperactive-impulse, and combined hyperactivity-inattention) for children with BLLs below approximately 5 ug/dL. However, this relationship did not hold above the 5 ug/dL BLL mark.

There were no signs of inattentiveness or overall ADHD symptoms associated with the children's BLLs.

Conclusion

Hyperactive and impulsive behaviors were positively associated with the BLLs of children with low lead exposure (≤ 5 $\mu\text{g}/\text{dL}$) in this Mexican cohort. There was no association with inattentive behaviors. These results contribute to the mounting evidence that very low levels of exposure may play a role in lead-associated neurodevelopmental deficits.

Policy Implications

Lead-based paint represents the largest source of human exposure to lead. Although the federal government banned consumer uses of lead-containing paint in 1978, older homes often still have old paint on both interior and exterior walls. In 1992, Congress passed the Residential Lead-Based Paint Hazard Reduction Act to protect families from exposure to lead from paint, dust, and soil. This law directed the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Housing and Urban Development (HUD) to require disclosure of known information about lead-based paint and hazards before the sale or lease of housing built before 1978². However, many people remain unaware of the hazards in their own homes, and many living in old, poorly maintained public housing are at most risk. The HUD Healthy Homes and Lead Hazard Control program addresses childhood lead-based paint poisoning and other childhood diseases associated with poor housing conditions³. This program partners with organizations and nonprofits to reduce lead exposure in housing throughout the country. It is critical that this program has sufficient funding to continue its work in eliminating lead-based paint hazards to children.

Water is not a major source of human lead exposure, but any exposure contributes to an individual's cumulative burden, and no safe levels have been identified. Much of the drinking water infrastructure in this country is old, and many drinking water supply and service lines contain lead. Many people also unwittingly have old lead plumbing fixtures (pre-1986) in their homes. Lead leaches from lead pipes and fixtures into the drinking water due to corrosion. All public water suppliers need to implement optimum corrosion control plans and water testing and monitoring according to regulatory standards to safeguard public health. EPA's Lead and Copper rule, issued under the Safe Water Drinking Act, is designed to prevent lead and copper corrosion in our drinking water systems⁴. Under the Lead and Copper rule, if more than 10% of tap water samples exceed the regulatory lead action level of 15 parts per billion,

² The Lead Disclosure Rule. Retrieved June 21, 2016, from http://portal.hud.gov/hudportal/HUD?src=/program_offices/healthy_homes/enforcement/disclosure

³ Healthy Homes and Lead Hazard Control. Retrieved June 21, 2016, from <http://portal.hud.gov/hudportal/HUD?src=/hudprograms/hhlhc>

⁴ Lead and Copper Rule. (Updated March 30, 2016). Retrieved June 21, 2016, from <https://www.epa.gov/dwreginfo/lead-and-copper-rule>

water systems must take action. This rule is currently undergoing revision in attempts to reduce human exposure to lead⁵.

Lead can also be found in various consumer products. The 2008 Consumer Product Safety Improvement Act (CPSIA) provided the Consumer Product Safety Commission (CPSC) with new regulatory and enforcement tools to address, among other things, lead in children's products⁶. Strict limits are set for lead content in children's products for both the total lead content (100 parts per million of total lead content in accessible parts) and for lead in paint and similar surface coatings (90 parts per million)⁷. However, imported and antique toys may not always meet these standards set by CPSIA.

The Clean Air Act requires that EPA set a national standard for lead concentration (among others) in outdoor air⁸. The standard has been updated once (in 2008) since it was first set in 1978, and is currently set at $.15\mu\text{g}/\text{m}^3$ in a rolling 3 month average period⁹. It is important that when this lead standard is periodically reviewed the latest science is used during the review process.

The Lead Contamination Control Act of 1988 authorized the Centers for Disease Control and Prevention (CDC) to create the CDC Childhood Lead Poisoning Prevention Program to eliminate childhood lead poisoning in the US. This program funds state and local childhood lead poisoning programs, provides technical assistance and training to public health professionals, and supports collaborative relationships between CDC's funded partners and other lead poisoning organizations¹⁰. Sufficient funding for CDC's Childhood Lead Poisoning Prevention Program is essential for the agency to achieve the program's mission as mandated under the law.

Policies at all levels of government, whether media-based (paint, water, air, consumer products) or place-based (housing, schools, child care facilities), should be designed to protect all children from even the lowest levels of lead exposure. Multiple routes of exposure result in greater cumulative burdens of lead in children, and greater burdens of illness and disability.

Reference

Article available in [Environmental Health Perspectives](#).

Keyword(s)

[Lead in water](#), [lead in paint](#), [lead in dust and soil](#), [ADHD](#)

⁵ Lead and Copper Rule Long-Term Revisions. (Updated May 12, 2016). Retrieved June 21, 2016, from <https://www.epa.gov/dwstandardsregulations/lead-and-copper-rule-long-term-revisions>

⁶ The Consumer Product Safety Improvement Act (CPSIA). (December 6, 2013). Retrieved June 21, 2016, from <https://www.cpsc.gov/en/Regulations-Laws--Standards/Statutes/The-Consumer-Product-Safety-Improvement-Act/>

⁷ Total Lead Content. Retrieved June 21, 2016, from <http://www.cpsc.gov/en/Business--Manufacturing/Business-Education/Lead/Total-Lead-Content/>

⁸ Lead (Pb) Standards. (Updated April 26, 2016). Retrieved June 21, 2016, from https://www3.epa.gov/ttn/naaqs/standards/pb/s_pb_index.html

⁹ Lead (Pb) Standards - Table of Historical Pb NAAQS. (Updated March 4, 2016). Retrieved June 21, 2016, from https://www3.epa.gov/ttn/naaqs/standards/pb/s_pb_history.html

¹⁰ CDC's Childhood Lead Poisoning Prevention Program. (Updated 2015). Retrieved June 21, 2016, from <http://www.cdc.gov/nceh/lead/about/program.htm>