Development of an Integrated Intervention Plan to Reduce Exposure to Lead and Other Contaminants in the Mining Center of La Oroya, Perú

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By

Centers for Disease Control and Prevention
National Center for Environmental Health /
Agency for Toxic Substances and Disease Registry
Division of Emergency and Environmental Health Services

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ABBREVIATIONS

ASARCO: American Smelting and Refining Company

ATSDR: Agency for Toxic Substances and Disease Registry

BLL: blood lead level

CDC: Centers for Disease Control and Prevention

DIGESA: Peruvian General Directorate of Environmental Health

INEI: National Institute for Informatics and Statistics

MEM: Ministry of Energy and Mines

NCEH: National Center for Environmental Health

NGO: nongovernmental organization

NIOSH: National Institute for Occupational Safety and Health, CDC

µg/g: micrograms per gram

µg/dL: micrograms per deciliter

UNES: The Union for Sustainable Development Consortium

USAID: United States Agency for International Development

USEPA: United States Environmental Protection Agency

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EXECUTIVE SUMMARY

La Oroya, Peru, is home to a metal smelter that has operated for more than 80 years. In October 2003, the United States Agency for International Development (USAID) asked the Centers for Disease Control and Prevention (CDC) to provide technical assistance in the development of an integrated plan for addressing the lead pollution problems in La Oroya. A team of scientists from CDC's National Center for Environmental Health (NCEH) visited Peru during March 13–22, 2004, to learn about the conditions and concerns in La Oroya. While in Peru, the NCEH team visited the Doe Run Peru La Oroya smelter facility and discussed smelter-related environmental public health issues with national, regional, and local government officials; the smelter operator; health-care providers; concerned citizens; and other stakeholders. The NCEH team also learned about the existing environmental public health infrastructure and government oversight of the mining industry in Peru. This report summarizes observations from meetings, highlights relevant findings from studies conducted in various parts of the world, and offers recommendations.

The situation in La Oroya is not a new environmental public health issue. Lead has become an increasingly important problem in Latin American and the Caribbean as a result of rapid industrialization. Studies conducted during the past 30 years in communities with metal processing plants throughout the world have documented the relations between blood lead levels (BLLs) and lead levels in air and soil. The effects of lead are well known and range from subtle learning and behavior impairment to seizures, coma, and death.

Major findings:

- Recent (1999–2001) BLL surveys conducted in La Oroya found all children sampled had elevated BLLs (ranging from 15 to 80 micrograms per deciliter [µg/dL]). These results indicate that the children of La Oroya are being exposed to lead in their living environment.
- Emission control had not been implemented at the lead processing plant in La Oroya.
- The extent of soil contamination has not been determined, and a soil remediation plan has not been developed for implementation.
- The environmental public health infrastructure needed to control plant emissions and oversee soil remediation efforts is fragmented and lacks resources.

Recommendations:

The most immediate priority is to reduce exposure to lead and other contaminants. This is best accomplished by building the environmental public health infrastructure needed to develop and implement a comprehensive and integrated intervention plan. Stakeholders need to unite and collaborate systemically to reduce emissions, remediate soil contamination, and operate a sustainable monitoring system. Specifically, the process should

1. Reduce air lead emissions, both stack and fugitive, to levels that protect children from having BLLs ≥10 µg/dL. Until this is accomplished no other interventions will have a great impact on lowering children's BLLs.

2. Implement interventions that have been demonstrated scientifically to reduce lead exposure from historical soil contamination.

3. Develop a scientifically robust plan to monitor the impact of emission reduction efforts.

To strengthen the overall process and plan, and to improve credibility and ensure that monitoring and other needs of affected parties are met, stakeholders should participate in reduction planning, implementation, and monitoring of lead and other contaminants.

The framework presented at the closeout meeting on March 22, 2004, in Lima, Peru, and recommendations contained in this report can guide stakeholders tasked with developing and implementing a comprehensive intervention plan.

I. BACKGROUND

A. The Mining Center of La Oroya, Peru

The City of La Oroya, located in the mineral-rich department of Junín in the central sierra of Perú, is the largest and oldest smelting and refining center for lead, copper, and zinc in the country. Production processes also exist for cadmium, silver, gold, and other metals.

The La Oroya metallurgic complex has a history of mining activities spanning 80 years. La Oroya lies along the central highway and the Central Railway, the highest railway in the world. Both transportation routes wind upward from Lima, through the mountains, before reaching La Oroya at 3,371 meters. The city is 180 km northeast of Lima and has a population of approximately 35,000. (For additional site description information, see the following documents: La Oroya No Espera [Cederstav 2003]; Situación Ambiental del Aire, Aguas, y Suelos en La Provincia de Yauli–La Oroya [UNES 2002]; Estudio de Dispersión de la Contaminación Atmosférica de la Ciudad de la Oroya [DIGESA 2001]; Estudio Socio-económico 2001, Distrito La Oroya [INEI 2001]).

Results from studies conducted in Lima/Callao in 1998 and 1999 indicated that mineral concentration deposits located near homes and educational centers were the main sources of lead contamination causing elevated BLLs in children. Fifty percent of the mineral concentration deposits in Lima/Callao storage facilities originate from La Oroya. As a result of the Lima/Callao study, the General Directorate of Environmental Health (DIGESA) carried out BLL studies in selected populations in La Oroya in November 1999. Results revealed an average BLL of 33.6 μg/dL (n=346) for children 6 months to 10 years of age (Hernandez-Avila et al. 1999). More striking were results indicating that 99.1% of children examined had BLLs >10 μg/dL, the level targeted for elimination by 2010 in the United States. Given the elevated BLLs in the zone, DIGESA prioritized development of an integrated plan to improve the health of La Oroya residents.

B. Purpose and Scope of the Assessment

On October 31, 2003, the Centers for Disease Control and Prevention (CDC) received a technical assistance request developed by the United States Agency for International Development (USAID). A CDC/USAID Peru Mission interagency agreement established in 2001 allows USAID to request technical assistance from CDC on environmental and public health issues. Amendment 6 of the CDC/USAID interagency agreement Number AAG-P-00-99-00006-00 establishes the mechanism for requesting technical assistance. The request was accompanied by specific terms of reference, developed by DIGESA. The objective of the terms of reference is to support DIGESA management working to resolve health problems in the La Oroya population resulting from exposure to environmental contaminants believed to be associated with current and historical lead smelter operations. The technical assistance request specified the following activities:

- Send a CDC team to La Oroya, Peru, to assess conditions that may be contributing to reported health complaints and elevated BLLs;
- Determine pollution levels;
- Determine and assess current and planned activities to address the concerns in La Oroya by Ministry of Health officials, specifically DIGESA personnel working with mining officials, the operator of the smelter, community members, health-care providers, and nongovernmental organizations (NGOs);
- After the 10-day visit to Peru and in coordination with DIGESA, develop a work plan to address smelter-related health issues in La Oroya. The work plan

will include terms of reference for future CDC assistance and recommended actions for the ministries, mining groups, and other stakeholders.

II. CDC ASSESSMENT ACTIVITIES

In response to the technical assistance request (Appendix A) and accompanying terms of reference (Appendix B), the CDC's National Center for Environmental Health (NCEH) was assigned the task and prepared a response to USAID on December 16, 2003 (Appendix C). Dr. Sharunda Buchanan, Chief of the NCEH Environmental Health Services Branch organized and led the technical assistance team that

(1) Conducted an extensive literature review of health and environmental studies in La Oroya and other mining and mineral processing communities (Appendix D). The literature review identified 188 English-language and 15 Spanish-language documents pertinent to conditions in La Oroya. The literature review was delivered to USAID officials in December 2004. Key elements of several significant studies and notable findings are presented in the Discussion section of this report. Electronic and paper copies of lead-related documents and reports developed by U.S. government agencies were provided to DIGESA, Ministry of Energy and Mines (MEM), and USAID representatives during the March 2004 site visit. The literature review also identified the information resources listed in Appendix E.

(2) Collaborated with USAID Peru Mission, DIGESA, Doe Run Peru mining officials, and NGOs to develop a site visit agenda (Appendix F). The CDC team did not

collect human specimens or environmental samples or develop, review, or recommend an environmental sampling plan or any plans to collect and analyze human specimens.

(3) Completed technical site visits March 13–22, 2004, and met with key stakeholders in an effort to understand the complex environmental public health issues in La Oroya.

(4) Presented preliminary observations and recommendations for the development of an integrated intervention plan to Peruvian stakeholders on March 22, 2004, DIGESA Central Office, Lima, Peru (Appendix G).

(5) Developed this report as a guide for DIGESA and other stakeholders for the *Development of an Integrated Intervention Plan to Reduce Exposure to Lead and Other Contaminants in the Mining Center of La Oroya, Peru.*

III. FINDINGS FROM ASSESSMENT VISIT AND MEETINGS

A. Child Blood Lead Level Studies in La Oroya

During the site visit, findings from three previous studies of children's BLLs in La Oroya were presented to the CDC team. DIGESA surveyed BLLs of 139 children ages 3–10 years living in Old La Oroya in 1999. Old La Oroya is 650 meters from the main stack of the smelter. The DIGESA study reported BLLs ranging from 14.7 to 79.9 µg/dL. Mean

BLL was 43.5 µg/dL (DIGESA 1999). All children participating from Old La Oroya had BLLs >10 µg/dL. DIGESA also collected blood samples from 162 children aged 4–9 years living in New La Oroya. New La Oroya is approximately 2,500 meters from the main stack. BLLs ranged from 6.9 to 67 µg/dL, and mean BLL was 26.6 µg/dL. Forty-five children ages 3–9 years were enrolled in the study from Santa Rosa de Sacco, which is 8,100 meters from the main stack of the smelter. BLLs ranged from 14.6 to 52.5 µg/dL, and the mean BLL was 28.7 µg/dL.

UNES also surveyed BLLs of 30 children, from birth to age 3 years in 1999. Children were enrolled in the study from Old La Oroya and Santa Rosa de Sacco. BLLs ranged from 15.8 µg/dL to 64.7 µg/dL, with a mean of 41.8 µg/dL (UNES 1999). BLLs in all children surveyed were >10 µg/dL.

Doe Run Peru surveyed BLLs of 252 children from birth to age 3 years in 2000–2001. Mean BLL was 26.1 µg/dL. (PERU 2002). Mean BLLs for specific locations in the La Oroya area were 36.7 µg/dL in Old La Oroya, 27.1 µg/dL in Buenos Aries/Huaymanta, and 22.8 µg/dL in Santa Rosa de Sacco. Doe Run Peru did not report BLL ranges for children aged 0–3 years in the respective study areas.

Review of results from these three BLL studies in the La Oroya zone indicates that BLLs are elevated in the population living near to the Doe Run smelter. BLLs in La Oroya are consistent with those studies in Mexico, the United States, and other countries, which demonstrate that BLLs increase as distance to smelting activities decreases (See three case studies in Appendix H). BLL studies provide evidence that the smelting facility in La Oroya is the main source of lead contamination in the zone.

B. Environmental Contamination

At the time of the CDC site visit (March 2004), the responsible parties had not agreed on plans to control air emissions, nor had remediation efforts needed to address historical soil contamination been implemented. In addition, the extent of contamination in the area and the magnitude of impact on surface and groundwater quality, air quality, vegetation, agricultural and ecologic systems, and human health had not been fully assessed. The geographic distribution of lead and other contaminants of concern does not appear to be well understood. No efforts have been made to remediate historical contamination. More information is necessary to develop an effective plan to remediate historical contamination

Accumulated lead resulting from the long history of smeltering activities in La Oroya is evident by numerous, large slag piles. The impact of slag waste storage practices on human health has not been fully investigated. How storage practices continue to contribute to the historical contamination in the zone is unclear. Additionally, the impact on health from transportation of material associated with smelter operations (truck, train, conveyor belt system) has not been adequately assessed.

At the time of the CDC assessment visit, the wastewater stream emanating from the smelter facility was untreated. The impact of the wastewater on drinking water supplies, surface water and groundwater, the watershed ecosystem, and downstream activities is not well understood.

C. Coordination of Activities

No one group appears to be responsible for or to manage assessment, monitoring, and remediation activities. A comprehensive plan to evaluate the environmental impact of environmental lead reduction interventions in the La Oroya zone does not exist. Similarly, no long-term coordinated plan exists to monitor BLLs as remediation efforts reduce human exposure to lead and other contaminants. Implementation activities, data collection efforts, and monitoring plans often are fragmented among agencies, incomplete, and not ongoing. These activities appear sometimes to be managed outside of the responsible governmental agency, and may not focus on the most important priorities: reduce emissions and remediate historical contamination. Data collection efforts are not coordinated and may be redundant. No one group has taken responsibility for coordinating, collecting, reviewing, and summarizing environmental and health data. Monitoring plans and data collection have not been agreed to, and the results from existing assessments and investigations do not appear to be consistently shared with stakeholders. Whether laboratory capacity exists within DIGESA for monitoring activities is not clear; lack of such capacity may limit efforts to develop effective monitoring systems for BLLs and remediation efforts.

D. Hygiene

A hygiene education program is being implemented in La Oroya. Some local officials thought hand washing and house cleaning would protect children from lead poisoning. However, studies conducted around the world have demonstrated that efforts focused solely on hygiene and behavior change will not yield significant results until reduction of emission levels and remediation of historical contamination are prioritized.

E. Communication

A health risk communication plan does not exist for the La Oroya zone, and no process is in place to develop a plan for communicating risk. The La Oroya community, national and local government officials, Doe Run Peru management, and health-care providers do not appear to have reached consensus on potential health impacts from exposure to smelter operations. Limited public health infrastructure at the national and local levels may impede collection and generation of information needed to clearly and promptly communicate health status to authorities, decision makers, Doe Run Peru, and community residents.

Health-care providers in La Oroya and Huancayo appear to place more priority on curative measures than preventive measures. Health authorities may not have sufficient information about measures that can significantly prevent and control human exposure to lead and other contaminants from mining activities. Without the appropriate information and participation in active programs health-care providers support curative care more than preventive care. The specific issue of chelation was addressed during the CDC visit to the Regional Health Directorate in Huancayo. CDC's recommendations are located in Appendix I.

Current and culturally appropriate procedures for assessing children's behavior and symptoms for signs of lead poisoning are not widely and consistently used in La Oroya. Access to appropriately designed tools to measure the chronic behavioral changes associated with lead intoxication may afford local health-care providers a clearer understanding of the extent of human health and contamination problems in La Oroya, as well as in other mining communities. All children with elevated BLLs—virtually the entire childhood population—should be evaluated for developmental delay, speech and reading difficulties, and cognitive development at school entry.

Local residents receive conflicting educational material on environmental contaminants, health effects, and risk levels. Some community members also expressed concern that they were not fully participating in discussions and decision-making regarding health impacts from exposure to contaminants.

IV. DISCUSSION

A. Importance of Lead

Lead is a toxic metal that occurs naturally in the environment. The production and use of lead in industry and in consumer products has exposed people to lead. Because lead is a basic element, it cannot be degraded or broken down into a less toxic substance. Therefore, when lead is found near human settlements by either naturally occurring or anthropogenic processes, it may threaten public health until removed. Effective technology exists to control lead in the environment. The best way to minimize introduction of lead into the environment from industrial activities is to control emissions.

The lead industry plays an important role in the economy of La Oroya and Peru. The growing economies of other Latin American and the Caribbean countries also benefit from the collection, transportation, and processing of lead-containing ore (Romieu et al. 1997). Lead has been used for hundreds of years in industrial and manufacturing processes, and it is found in many products used today. Lead production increases with demand for this natural resource. The mining and processing of lead containing ore can release harmful contaminants into the environment. Even at low concentrations, exposure to lead can be detrimental to human health. The processing of lead ore also can emit other metals of concern, such as arsenic and cadmium (Baghurst et al. 1992; Landrigan et al.

1975; McMichael et al. 1985; Roels et al. 1980; Diaz-Barriga et al. 1997; Benin et al. 1999).

B. Lead and Human Health

Lead is not a natural constituent of the human body. Lead may enter the body by ingestion and inhalation. Exposure pathways include industrial emissions, auto emissions, lead-based paint, ambient air, indoor and outdoor dust, and soil (Figure 1). In communities where lead is processed, air emissions are a primary concern. Airborne lead from smelter operations accumulates in soil. Lead particles can be resuspended by wind and human activities. Particles <10 µg, and especially those <2.5 µg, can bypass the body's respiratory defense systems and enter the lung. Particles >10 µg can be deposited on food, and in soil and water, and ingested. Young children who commonly engage in hand-to-mouth activities are more likely than older children or adults to ingest lead contained in soil. Studies conducted around smelters suggest that direct inhalation of airborne lead is the principal route of lead absorption for adults (Roels et al. 1980; Yankel et al. 1977). In children the common route of exposure is ingestion of lead contaminated soil (Yankel et al. 1977) and dust (Roels et al. 1980).

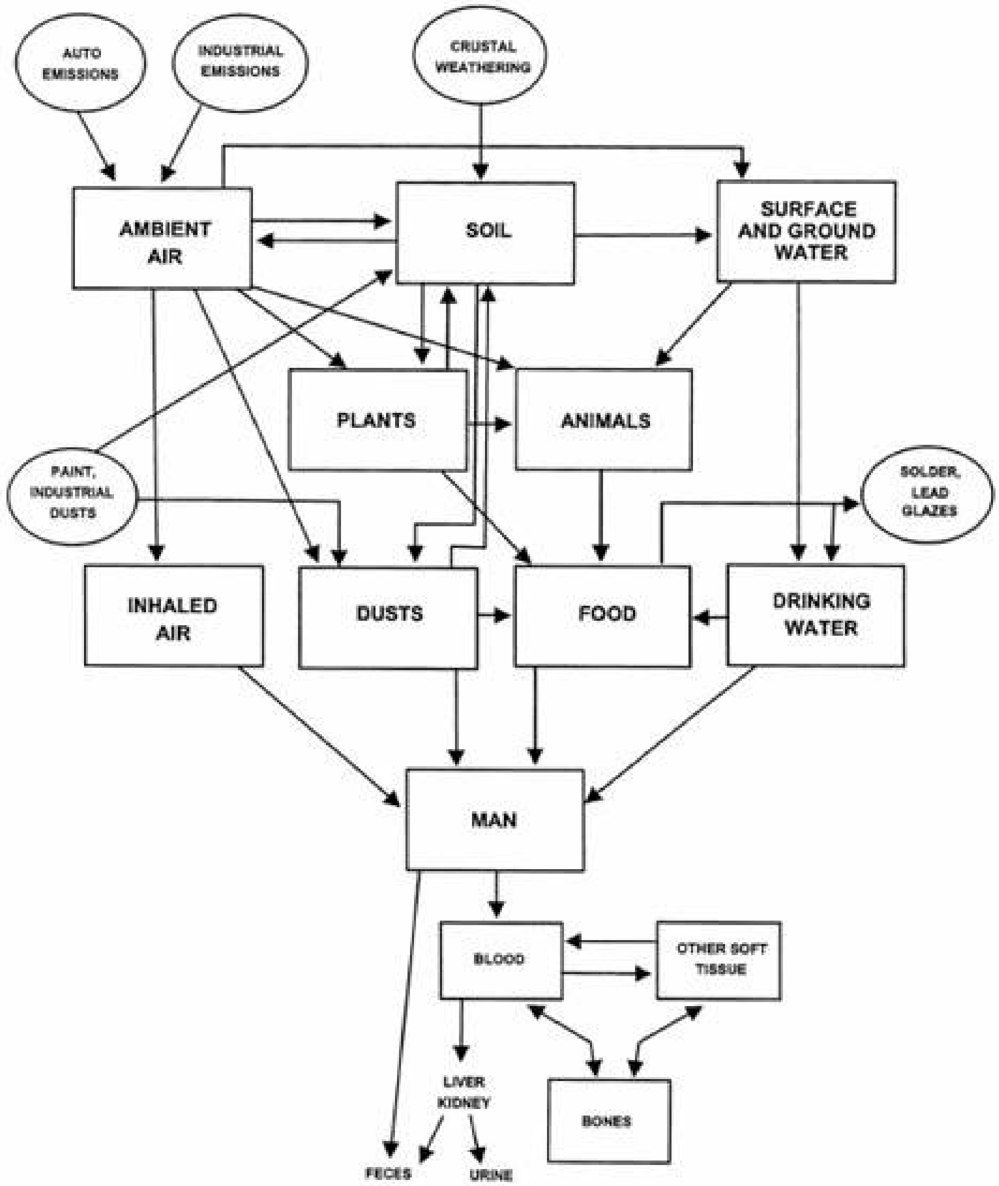
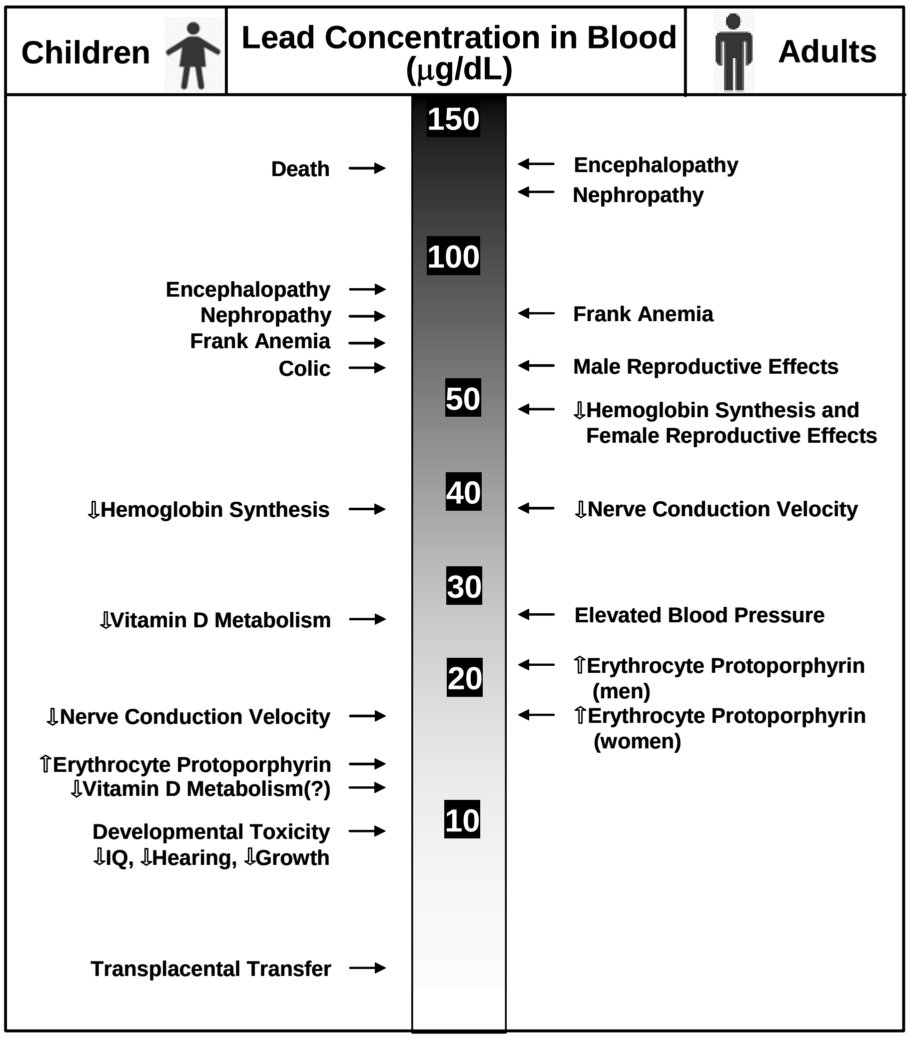


Figure 1. Pathways of Lead from the Environment to Humans, Main Organs of Absorption and Retention, and Main Routes of Excretion. (Sources USEPA, 1986; USEPA, 1996a)

The effects of lead are well known and range from subtle learning and behavior impairment to seizures, coma, and death (Figure 2). Children are vulnerable to lead's adverse health effects. At very high blood lead concentrations (≥80 µg/dL in children), lead can cause encephalopathy (brain damage), coma, or death. At levels <60 µg/dL distinctive symptoms may not be evident; however, children still can experience long-term adverse health effects. Studies have found low to moderate BLLs in children are related to learning and behavior problems. Even BLLs <10 µg/dL have adverse health effects in children. No safe level of lead is known. Because most children with elevated BLLs do not have symptoms that would prompt their families to seek medical care for them, lead poisoning has been called the "silent epidemic".

In adults, high BLLs are related to hypertension and cardiovascular disease. Lead can be carried from maternal to fetal circulation through the placenta and enter the growing fetal brain. That exposure of the fetus to lead, even at maternal blood levels <10 µg/dL, adversely affects fetal brain development. (For additional information about the health effects of lead exposure see Appendix D).

Figure 2. Blood lead levels associated with adverse health effects



Note: ⇧ = increased function and ⇩ = decreased function.

Source: Adapted from case studies in Environmental Medicine: Lead Toxicity, 1990, ATSDR

C. Global Lead Reduction Studies

The following series of studies summarize activities to identify and reduce human exposure to contaminants generated by mining and metal processing activities. The interventions implemented to protect human health are similar. Responsible authorities in each community focused on control of emissions, and remediation of historical contamination. These essential interventions also should be implemented in La Oroya. The CDC technical assistance team emphasized the importance of developing an intervention plan that integrates these lead reduction and control measures during their presentation of preliminary observations and recommendations to Peruvian stakeholders on March 22, 2004, in Lima, Peru (Appendix G).

The following studies and others (Appendix D) clearly show uncontrolled air emissions from smelting activities to be correlated with high BLLs in populations residing near smelter operations. High lead levels have been measured in air, soil, and dust near smelters, and lead levels are highest closest to smelters for soil (Landrigan et al. 1975; Landrigan et al. 1976; Garcia-Vargas et al. 2001; Díaz-Barriga et al. 1997), air (Roberts et al. 1974; Roels et al. 1980; Landrigan et al. 1975; Garcia-Vargas et al. 2001), and dust (Landrigan et al. 1975; Benin et al. 1999; Vargas et al. 2001). Lead concentrations in air, soil, and dust are highly correlated with each other (Roels et al. 1980).

Elevated BLLs in children are related to high levels of lead in soil (Yankel et al. 1977; Brunekreef et al. 1981; Hertzman et al. 1991; Cook et al. 1993; Kimbrough et al. 1995; Lanphear BP 1998, Mielke and Reagan 1998), and lead in air (Landrigan et al. 1976). Consequently, children living closest to smelters have higher BLLs than children living farther away (Yankel et al. 1977; Letourneau and Gagne 1992; Landrigan et al. 1975; Roels et al. 1980; Hertzman et al. 1991; Gagne 1994; Kimbrough et al. 1995; Albalak et al. 2003; Maynard et al. 2003).

Table 1. Blood lead levels (BLLs) by distance from ASARCO smelter, El Paso, Texas, August 1972.

Distance from smelter	Age range (years)	Number tested	Percentage with BLL 40–59 µg/dL*	Percentage with BLL>59 µg/dL
<1 mile	1–4	49	55%	14%
	5–9	101	34%	11%
	10–19	109	25%	6%
	≥20	98	16%	0
1–3 miles	1–4	83	23%	4%
	5–9	124	12%	0
	10–19	292	3%	1%
	≥20	513	3%	1%

*Concentration of lead in micrograms per unit whole blood in deciliters (µg/dL whole blood)

Source: Landrigan, et al. (1975). Epidemic lead absorption near an ore smelter. The role of particulate lead. N Engl J Med 292:123–9.

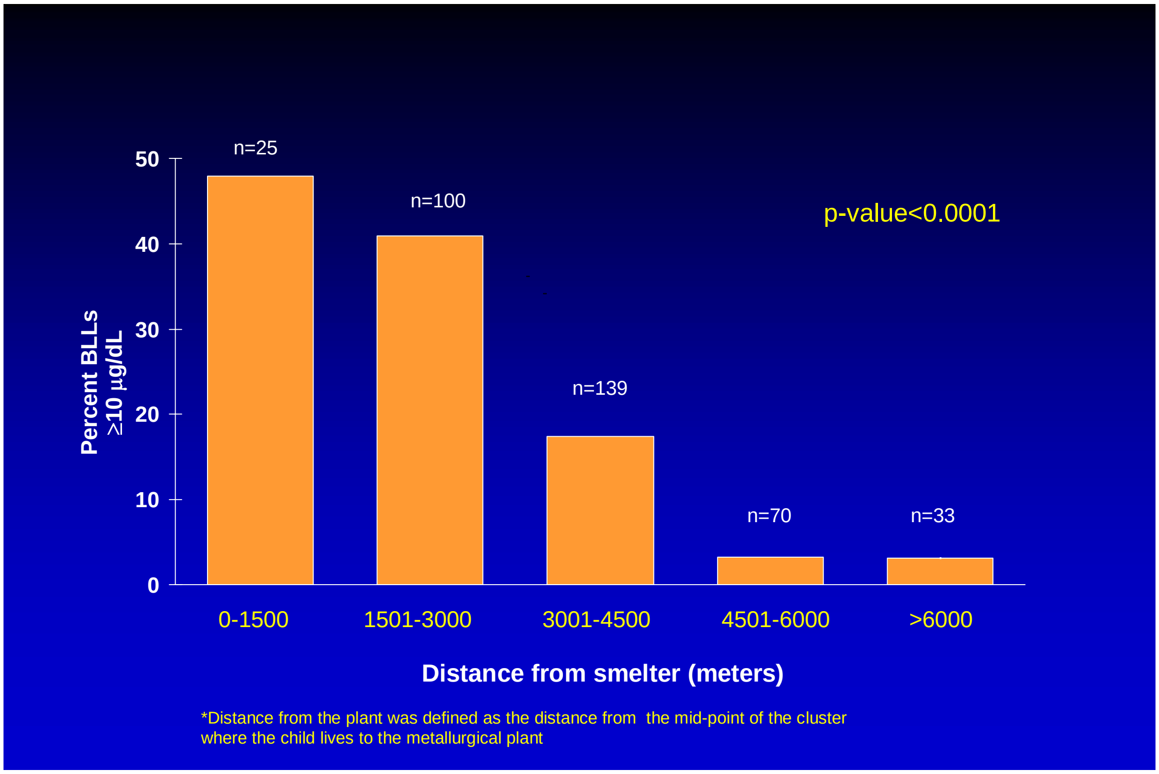
When the principal pathway of lead exposure, air emissions, is controlled, BLLs decrease. Soil then replaces air as the primary source of lead exposure. A significant portion of the population can be exposed to soil lead at concentrations that may elevate BLLs to >10.0 µg/dL, the CDC-recommended action level for children. Young children can be exposed to lead in indoor dust, especially when they exhibit hand-to-mouth activities. Higher lead concentrations in indoor dust result in elevated lead concentrations in nearby soil (Kimbrough et al. 1995; Louekari et al. 2004) and higher BLLs among children (Brunekreef et al. 1981; Hertzman et al. 1991; Kimbrough et al. 1995). Studies conducted around smelters after closure (Diaz-Barriga et al. 1997) or after a reduction in emissions (Morse et al. 1979) show lead-contaminated soil to be an important source of lead exposure for young children. This demonstrates the persistence of lead in the environment, even after the source of contamination is controlled or removed.

Table 2. Distribution of BLLs in children living in different sectors of the Anapra Neighborhood, Ciudad de Juarez, Mexico, 1997.

	Blood Lead Levels (µg/dL)		
Sector	**<10.0**	**10.0–15.0**	**>15.0**
I (within 600 meters of smelter; n=7)	57%	29%	14%
II (600–1200 meters from smelter; n=19)	79%	16%	5%
III (1200–1800 meters from smelter; n=18)	89%	6%	5%

Source: Diaz-Barriga, F., Bates A, Calderon J, Lugo A, Galvao L, Lara I, et al. (1997). The El Paso Smelter 20 years later: residual impact on Mexican children. Environ Res 74:11–16.

Figure 3. Percentage of blood lead levels (BLLs) ≥10 µg/dL by distance from the Met-Mex Peñoles metal processing plant, Torreón, Coahuila, Mexico, 2003



Source: Albalak, R, McElroy, R, et al. (2003). Blood lead levels and risk factors for lead poisoning among children in a Mexican smelting community. Arch Environ Health 58:172–183.

The feasibility of reducing children's lead absorption near smelting facilities is well established. When smelters are closed, air lead levels (TACB 1992) and children's BLLs (Diaz-Barriga et al. 1997) decrease dramatically. However, effective technology exists that can reduce dangerous lead emissions without closing smelters (Prpic-Majic et al.

1992, Hilts et al. 2003, Louekari et al. 2004). Controlling air emissions and remediation of contaminated soils have proven to substantially reduce BLLs.

Soil remediation efforts lower lead concentrations in soil (Gagne 1994; Lanphear et al. 2003), dust (Lanphear et al. 2003) and children's BLLs (Von Lindern et al. 2003; Lanphear et al. 2003). Children who place contaminated fingers, thumbs, or objects in their mouths can ingest soil and dust containing lead. This childhood behavior is an important source of exposure and highlights the need to reduce lead emissions to the air while simultaneously removing lead-contaminated soil and dust (Roels et al. 1980).

Removing lead-contaminated dust from the living environment is difficult, especially when lead emissions continue and lead-contaminated soil remains around the home. Smelter workers also may bring lead dust into the family living environment. Without reduction of air emissions and remediation of soil, home hygiene and clean neighborhood campaigns are of little value in decreasing elevated BLLs. An evaluation of a dust reduction effort that consisted of High Efficiency Particulate Air (HEPA) vacuuming once every 6 weeks for 1 year found no effect on children's BLLs and is not recommended as the main intervention strategy in a community with high smelter lead emissions (Hilts et al. 1995). Lead in house dust was decreased when lead soil remediation and air pollution controls were implemented (Von Lindern et al. 2003).

Public health education and hygiene efforts alone are of little benefit in reducing elevated BLLs. Educational interventions may help reduce BLLs after implementation of major source-control measures, such as control of fugitive emissions and construction of new state-of-the-art smelters (Hilts et al. 1998) or smelter closure (Kimbrough et al. 1995) and soil and dust remediation (Goulet et al. 1996).

V. CONCLUSIONS

1. *Minimal lead control exists*. The Ministry of Energy and Mines, Directorate of Environmental Health, Ministry of Health, Regional Environmental Council of the Central Andean National Environmental Commission, Doe Run Peru, and NGOs recognize the need to reduce the release of lead and other contaminants from the Doe Run Peru smelter in La Oroya. However, lead reduction interventions have been delayed. No action has been taken to remediate lead-contaminated soil. An independent government authority does not monitor the effectiveness and impact of implemented interventions. The presence of lead in soil, dust, water resources, and ambient air probably will continue to keep BLLs elevated in people in and around La Oroya. Ongoing discussions delay the protection young children need in La Oroya

2. *Authorities for lead control are fragmented*. A fragmented multiagency system exists to monitor and manage the environmental public health risks associated with lead smelter operations in La Oroya. Agencies act independently. DIGESA staff report they do not have the resources or authority to address the issues in La Oroya. Several organizations, including Doe Run Peru, have requested

establishment of a multisectoral work team with active participation by the Municipality, Ministry of Health, Ministry of Energy and Mines, Ministry of Transportation, and Centromín Peru and others to develop and implement a La Oroya Environmental Health and Hygiene plan.

3. *Many stakeholders feel unrepresented*. Concerned members of the community and critical stakeholders are not part of this team. Some community members believe their opinions and concerns are not considered by Doe Run Peru management or government decision-makers. Community members and stakeholders do not have a safe and open forum to express concerns and offer solutions.

4. *No comprehensive list exists of lead health and environmental issues*. A comprehensive list of problems, issues, and concerns associated with the La Oroya metallurgic complex does not exist. Scientific literature indicates that multiple metals often coexist, and these and other waste products of the smelting process can adversely affect health. Metals and contaminants likely to affect health include arsenic, cadmium, particulate matter, sulfur dioxide, and zinc.

5. *Environmental and health impacts have not been established*. Baseline environmental and human health measures and impacts have not been established for the region. Wastewater management practices at the Doe Run La Oroya smelter are not adequately monitored by an independent government authority.

The lack of information about the impacts of wastewater may make development of a plan to manage wastewater ineffective.

VI. RECOMMENDATIONS

The most immediate priority is to reduce exposure to lead and other contaminants. This is best accomplished by building the environmental public health infrastructure needed to develop and implement a comprehensive and integrated intervention plan. (The detailed framework of such a plan is outlined in Appendix J). Stakeholders must unite and work together systematically to reduce emissions, remediate soil contamination, and operate a sustainable monitoring system. Specifically, the process should address the following areas:

1. Reduce air lead emissions, both stack and fugitive, to levels that protect children from having BLLs ≥10 μg/dL. Until this is accomplished, no other interventions will have a great impact on lowering children's BLLs.
2. Implement interventions demonstrated scientifically to reduce lead exposure from historical soil contamination.
3. Develop a scientifically robust plan to monitor the impact of emission reduction efforts.

To strengthen the overall process and plan, and to improve credibility and ensure that monitoring and other needs of affected parties are met, stakeholders should participate in reduction planning, implementation, and monitoring not only of lead, but also of other contaminants as well.

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