Blood Lead Levels in Mexico and Pediatric Burden of Disease Implications

Jack Caravanos, DrPH, CIH, Russell Dowling, MPH, Martha María Téllez-Rojo, Dra, Alejandra Cantoral, ScD, Roni Kobrosly, PhD, MPH, Daniel Estrada, Manuela Orjuela, MD, ScM, Sandra Gualtero, MSc, Bret Ericson, MSc, Anthony Rivera, and Richard Fuller

ABSTRACT

Background: Although there has been success in reducing lead exposure with the phase-out of leaded gasoline, exposure to lead in Mexico continues to threaten the health of millions, much of which is from lead-based glazes used in pottery that leaches into food.

Objectives: An extensive historical review and analysis of available data on blood lead levels in Mexican populations was conducted. We used a calculated geometric mean to evaluate the effect of lead on the pediatric burden of disease.

Methods: An extensive bibliographic search identified 83 published articles from 1978 to 2010 with blood lead level (BLL) data in Mexican populations representing 150 data points from more than 50,000 study participants. Values from these publications were categorized into various groupings. We then calculated the incidence of disease and disability-adjusted life-years resulting from these BLLs using the World Health Organization's burden of disease spreadsheets for mild mental retardation.

Results: Reviewing all relevant studies, the geometric means of Mexican BLLs in urban and rural areas were found to be 8.85 and 22.24 ug/dL, respectively. Since the phase-out of leaded gasoline, the mean in urban areas was found to be 5.36 ug/dL and the average in rural areas is expected to be much higher. The U.S. Centers for Disease Control and Prevention's (CDC) upper limit of blood lead in children under the age of 6 years is 5 ug/dL and the current U.S. average is 1.2 ug/dL. Our results indicate that more than 15% of the population will experience a decrement of more than 5 IQ points from lead exposure. The analysis also leads us to believe that lead is responsible for 820,000 disability-adjusted life-years for lead-induced mild mental retardation for children aged 0 to 4 years.

Conclusion: Lead continues to threaten the health of millions and remains a significant cause of disability in Mexico. Additional interventions in reducing or managing lead-based ceramic glazes are necessary to protect the public health.

Key Words: lead, blood lead level, burden of disease, children, DALY, disability-adjusted life-year, pottery, Mexico

 Annals of Global Health 2014;80:269-277

INTRODUCTION

Mexico, with its extensive lead ore deposits and widespread use of lead-glazed pottery, has a long and unique history of lead exposure. Through technology and tradition, lead continues to threaten the health of millions living in the country. In 1990, Mexico began phasing out leaded gasoline and introduced unleaded fuels.[1] Leaded gasoline was completely phased out in Mexico by 1997. The reduction of leaded gas has been linked to improved health outcomes,[2,3] however other means of exposure still burden the people of Mexico.

Mining and secondary smelting also pose occupational and environmental health risks. Mexico is the fifth largest producer of lead worldwide at 220,000 metric tons in 2013 and has reserves of more than 5.6 million tons.[4] Three mining companies process lead ore from 13 mines operating in the states of Chihuahua, Coahuila,

2214-9996/

From the Environmental and Occupational Health Sciences Program, City University of New York, School of Public Health, New York, NY (JC); Blacksmith Institute, New York, NY (JC, RD, RK DE, SG, BE, AR, RF); Instituto Nacional de Salud Pública, Universidad No. 655 Colonia Santa María Ahuacatitlán, Cerrada Los Pinos y Caminera C.P. Cuernavaca, Morelos, México (MMT-R, AC); Department of Preventive Medicine, Icahn School of Medicine at Mount Sinai, New York, NY (RK); Departments of Pediatrics and Environmental Health Sciences, Columbia University, New York, NY (MO). Address correspondence to J.C.; e-mail: jcaravan@hunter.cuny.edu

All authors declare they have no conflicts of interest.

Funding for this article was provided by Blacksmith Institute, New York, NY.

Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

http://dx.doi.org/10.1016/j.aogh.2014.08.002

Durango, Guererro, Hidalgo, San Luis Potosi, Sinaloa, Sonora, and Zacatecas.[5] Mexico is also one of the world's top 5 exporters of silver, often mined alongside lead ore, and is a large producer, exporter, and recycler of lead-acid storage batteries commonly used in automobiles and lories.[6,7]

Leaded paints are a persisting health problem. The Comex Group, North and Central America's fourth largest architectural paint manufacturer, and Sherwin Williams S.A. de C.V., operate in Mexico's large paint and coatings production industry.[8] A 2008 study revealed that all tested samples of enamel paint contained lead concentrations greater than 90 ppm (the regulatory limit in China and the United States); plastic paints on average contained 6 ppm.[9]

A secondary source of general lead exposure in the population is ceramic glazes used in traditional earthenware. Leaded glazes were first introduced by the Spanish in the 16th century and are still used widely.[10] Unfortunately, the vast majority of Mexican ceramic kilns are wood-fired, as opposed to gas found elsewhere in the world, and do not reach the fusing/sintering temperatures necessary to vitrify lead glazes to where they are unleachable (temperature >1200°C). According to the only census to date, at least 10,000 pottery workshops use leaded glazes in wood-fired kilns.[11] The problem is compounded because many workshops are connected to living and cooking areas, making area contamination prevalent. These workers and their families are most acutely at risk for lead poisoning and related illnesses. A much broader exposure occurs with the use of lead-glazed ceramics in the home, for meal preparation and food storage. Lead can easily leach from the glaze into food, where it is ingested. This situation is aggravated by the Mexican diet, as lead is made more leachable by the presence of heat or slight acidity such as that of lime juice.[12] Although lead-glazed pottery is abundant in Mexico, poorly constructed, low-fired glazes are especially a problem in rural areas where resources are scarce. Low-income communities often are disproportionately affected.

Measuring the scope of lead contamination in Mexican communities is essential to fully characterize the country's burden of disease. This in turn helps define interventions to mitigate exposures and alleviate adverse health outcomes. In the United States, the National Health and Nutrition Examination Survey (NHANES) of the Centers for Disease Control and Prevention regularly monitors blood lead levels (BLLs). Mexico has no comparable program. In the absence of comprehensive data, we conducted an extensive historical review, cataloging those studies that incorporate BLL testing in Mexican communities. To our knowledge, this is the first such literature survey of BLL tests in Mexico.

The literature on health effects from lead exposure is extensive and definitive. Lead toxicity has been linked to various cognitive impairments, lowered IQs, cardiovascular effects, low birth weight, added economic costs, overall diminished life expectancy, and possibly even increased rates of violent crime.[13-19] The second component of this paper calculates the pediatric burden of disease from lead using methods developed by the World Health Organization (WHO). Using values from the literature review, we generated the attributable disability-adjusted life-years (DALYs) for pediatric exposure to lead in Mexico. We also estimated the effect on IQ, broadly providing a comparison against the United States, a country that does not have extensive exposure to lead-glazed pottery.

METHODS

Historical Review and Data Selection

As of January 2014, a PubMed search for *lead AND levels AND Mexico* yielded 484 articles. Various permutations were tested to ensure a large capture with these final search terms selected. We reviewed articles in English and Spanish, including only those most relevant to the study. Our selection criteria retained 83 papers as eligible for meta-analysis. A study was included in our analysis if the authors 1) collected BLL data from populations within Mexico; 2) upheld lead as a main focus; 3) included at least 30 participants; and 4) reported BLL data from either venous, capillary, or umbilical cord samples.

Studies ineligible for our meta-analysis met one or more of the following exclusion criteria: 1) did not report any BLL data and exclusively sampled from bone, organs, or other tissues; 2) lead was not the main focus of the study; 3) BLL data were reported for Mexican populations existing outside of national Mexico; 4) the study was not directly human health related; 5) the number of study participants was less than 30; 6) the paper was out of print and/or irretrievable; and 7) the study did not contain a statistical mean or SD for the original data set. Figure 1 summarizes the inclusion and exclusion criteria for studies in our analyses. Exclusion criteria removed 82% of the studies from our initial search. Because many of the publications we selected included multiple unique samples (each with a unique estimated BLL), we hereafter refer to these individual estimates as "samples."

Subgroup Rationale

Mean and SD data from the 83 studies were separated into subgroups for BLL analysis based on demographic and sampling information. Means were collected based on the initial year of data collection, not the study publication year. In cases where data was collected over a period of time, we used the middle year. In instances where no collection year was provided, we used the year before article submission. The meta-analysis included data for the following subgroups: sex (male and female), age, urbanicity, workforce exposures, and blood sample source (umbilical cord—hereinafter referred to as cord samples—and venous/capillary; see Fig. 1).