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Multiple Risk Factors for Lead Poisoning in Hispanic Sub-Populations: A Review

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Abstract As a result of recent media attention to lead (Pb) in consumer products, Pb exposure and toxicity to children has been placed back on the national agenda. This review presents the current literature on sources of Pb in Hispanic sub-populations in the broader context of national lead poisoning trends, sources, and exposure pathways. Pb poisoning among Hispanics is a multi-dimensional issue that is far more complex than for the general population in terms of environmental, cultural, and social dimensions. As a result, a higher percentage of Hispanic children have elevated blood lead levels compared to the general population. Given the additional risks that Hispanics face, all Hispanic children should be defined as "at risk" for lead exposure and included in targeted screening programs. This review concludes with specific public policy recommendations that directly address the increased risk of Pb poisoning to Hispanic children so that Pb will poison fewer children in the future.

Keywords Hispanic subpopulations · Lead poisoning · Environmental health · Public health

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Introduction

Environmental pollutants are among under-examined causes of racial and ethnic disparities in child health outcomes [1]. This review article focuses on lead (Pb) poisoning in Hispanic sub-populations to bring increased attention and visibility to the overlap of environmental risk assessment and preventive medicine for these groups. Recommendations to public health professionals and policy makers are drawn from key studies in the literature for this under-examined health disparity.

Health disparities in Pb poisoning are of ethical concern and have serious economic consequences. According to Landrigan et al. [2] the present value of lifetime earnings loss for today's five year olds from Pb poisoning amounts to $43.4 billion. Pb poisoning causes this loss through impairment of childhood cognitive development. As this review documents, Hispanic children are particularly susceptible to Pb exposure possibly bearing a greater lifetime earnings loss than the general population.

Currently, the US Centers for Disease Control and Prevention (CDC) recommends that action be taken when a child presents a blood Pb concentration greater than 10 μg/dl. However, neurological and behavioral effects have been documented at concentrations lower than 10 μg/dl [3–5]. Children with a blood Pb level (BLL) of 10 μg/dl scored on average 7.4 points lower on the Stanford-Binet intelligence test (IQ) than children with minimal exposure [6]. Furthermore, Pb exposure has been linked to school performance [7], attention deficit hyperactivity disorder [8], and criminal activity [9] among other things.

Blood Pb levels often begin to rise late in the first year and peak at around 2 years of age [10] when children begin to crawl and mouth objects [11]. Assessing cognitive abilities in infants is difficult; hence, much of the research has focused on school-aged children and relies on measures that provide only a single performance score, like IQ [12].

Pb poisoning is a preventable disease [2] since an infant's Pb exposure can be reduced by eliminating environmental exposure. However, outreach and education efforts to inform the general public about the threat of Pb poisoning and the simple steps to reduce this threat among infants and children is thwarted by its nature as a disease without visible symptoms. As result, intervention often comes after the irreversible damage is done.

This review article focuses on Hispanic sub-populations and the unique dimensions of exposure that increase their risk of Pb poisoning. Hispanic populations are important in this respect as compared to other high-risk groups (e.g., low income or other ethnic minorities), in that they share increased risks due to housing and have additional cultural sources of risk that other groups do not have. This risk includes occupational exposures, neonatal exposure, cultural practices (folk remedies, food preparation, etc.), and the economic status of Hispanics that increases their vulnerability (migration and housing). For a common risk factor, housing, Hispanics share, and likely have an increased risk as compared to the general population. For example, living in older rental properties may increase the risk to Pb poisoning and Hispanics are less likely to be homeowners than non-Hispanics [13]. In a national survey of housing, Hispanics had a higher probability of living in a home deemed "hazardous" due to the presence of Pb-based paint (32%) versus 24% of non-Hispanics [14]. As we discuss below, Hispanic children have elevated blood Pb levels compared to non-Hispanic children. Unique exposure routes within Hispanic populations need to be considered, alongside better-understood Pb sources such as housing, as important sources of Pb to children.

Along with sources of Pb described in this paper related to unique factors within Hispanic sub-populations, Hispanic children are also burdened with risk factors related to poverty. For Mexican-American children, socio-economic factors are statistically significant predictors of elevated blood Pb, controlling for age of housing and sources of drinking water [15]. Poor neighborhoods are often situated close to industrial operations, such as smelters, and this proximity has been linked to elevated environmental concentrations of Pb [16] and elevated blood-Pb levels [17].

The research presented below includes a combination of national surveys, large-scale research and epidemiological studies, and case studies focused on one or a few subjects. Case studies are included not to draw conclusions about larger populations but to draw attention to potential Pb sources in Hispanic populations that may be important but are not well understood and/or have received little attention in the literature. These studies are presented to encourage future research efforts in under-studied areas as well as inform health care practitioners of possibly overlooked risks to Pb exposure. This review article concludes with a discussion of recommendations to improve the approach and direction of clinicians and researchers to better address this health disparity.

It is important to acknowledge that the use of the pan-ethnic term "Hispanic" ignores sub-population differences in national origin, culture, economic status, urbanization, and a wide range of other factors. This review article refers to specific sub-populations when this information is available in the cited publication.

Overview of Pb Exposure and Environmental Health

Sources of Pb

Humans have used Pb since the beginning of recorded history and this element remains a part of our daily life. For example, some computer monitors contain between 3 and 5 pounds of Pb [18] but there is no direct risk of exposure from this source in the home. Ingestion of smaller, highly concentrated sources of Pb such as charms [19], bullets and other items can occur but do so rarely. Much of the Pb in our personal environment is not likely to enter our bodies, however, diffuse urban Pb contamination is readily bioavailable; a serious issue affecting tens of thousands of children in US metropolitan areas [20]. This contamination is a result of the historical use of two products with added Pb: paint and gasoline. Pb-based paints have long been recognized as a serious problem in older communities. The deterioration of intact paint into ingestible or inhalable fine Pb paint dust contaminates the interiors of many homes built before 1978. Pb is also a significant and ongoing risk to children due to its geochemistry. While leaded gasoline was officially banned in the United States in 1986, Pb emitted in car exhaust over a 60 year period was absorbed by neighborhood soils [21]. This soil is now a source of Pb to anyone that might disturb it. Rain does not wash out Pb from soils and dry weather conditions have been associated with the dispersal of leaded soil dust and increased blood Pb concentrations [22]. In a study of 281 children in an urban area, living near traffic jams increased the probability (quadrupled the risk) that levels would be greater than 100 μg/l [23].

It is important to note that while much of the research on childhood Pb exposure is on Pb concentrations in large urban areas, rural areas and smaller communities also have older housing stock and soils that received deposits of Pb from leaded paints and gasoline [24, 25]. In addition, many rural communities lack the resources and capacity for outreach, screening, and other programs that reduce risk and exposure.

In brief, children are most likely to be exposed to Pb through inhaled or ingested Pb contaminated dust in and around the home.

Children's Unique Susceptibility to Pb Exposure and Poisoning

Childhood mouthing behavior in a contaminated environment is directly correlated with a child's blood Pb level [26]. These behaviors occur both inside and outside the home. One study found that <50% of children washed their hands after coming indoors, 42% of 1 year olds ingested soil and 1–2 year olds spend about 10% of their time playing on the floor [27]. Children absorb a greater percentage of ingested Pb than do adults [28] and they are particularly susceptible because their developing central nervous systems are a major site of toxicity, producing cognitive effects that persist throughout their entire lives [12].

Pb Poisoning in Hispanic Sub-Populations

It is imperative that Pb poisoning prevention efforts be focused on subpopulations that have a higher probability of risk to having elevated blood Pb levels. Reductions in blood Pb for all populations have occurred over the last 20 years, however, a larger percentage of Hispanic children still have elevated blood Pb levels compared to Anglo children. Despite this, in a recent review of public health issues facing Hispanic populations, Pb poisoning was not mentioned as a health disparity issue [29].

Overview of Blood Pb Concentrations in Hispanic Children in the US

The evaluation of blood Pb concentrations in Hispanic children began in the 1970s. Health disparities in Pb exposure were first noticed as soon as data began to be collected based on ethnicity. For example, a study conducted in New York City found that geometric means for blood Pb concentrations were different for different ethnic groups [30].

Three National Health and Nutrition Examination Surveys (NHANES) along with a survey targeting three Hispanic groups (The Hispanic Health and Nutrition Examination Survey: HHANES1982-84) have been conducted since 1970 (1971–75, 1976–80, 1988–94). Continuous NHANES data collections have occurred since 1999. These studies have documented factors related to the health and nutritional status of children including increasing consideration of environmental health. Data is collected from thousands of in-home interviews and medical tests using mobile examination centers. These studies constitute the most comprehensive assessment of child health nationally and have documented health disparities between Hispanic and non-Hispanic children including disparities in blood Pb concentrations.

The first NHANES study did not collect blood Pb data. While NHANES II did include this data, ethnic determination of children tested was limited to black versus white [31]. The HHANES data revealed blood Pb differences among Mexican-American, Puerto Rican and Cuban children and disparities between Hispanic and white children [32]. In an assessment of the NHANES III (1988–1994) study, it was reported that 1% of 1–2 year old Mexican-American children had greater than 25 μg/dl blood Pb, twice that of non-Hispanic whites [33]. In another evaluation of the third NHANES study data, ethnic groups were compared revealing that 28% of Mexican American children had BLLs greater than 5 μg/dl compared with 19% of non-Hispanic white children [34].

NHANES 1999–2002 collections showed persistent disparities. For example non-Hispanic black and Mexican American children <1 year had higher percentages of elevated BLLs (1.4% and 1.5%, respectively) than non-Hispanic whites (0.5%) [35]. It is important to mention along with these disparity descriptions that blood Pb levels for Hispanics were also declining overall. It was reported that blood Pb levels among Mexican Americans declined from 2.96 to 1.86 μg/dl in comparing the NHANES III and NHANES (1999–2002) data [36].

Pb exposure to all children in the United States has been greatly reduced as a result of banning Pb-based paint and leaded gasoline. It is now estimated that fewer than 2% of US preschoolers overall have a blood-Pb level greater than 10 μg/dl [37]. Disparities among different ethnic groups, however, still persist. Explanations for continued disparities are likely a combination of environmental factors (e.g., condition of housing, proximity to busy highways and intersections) as well as unique cultural and behavioral dimensions within different Hispanic subpopulations [15].

Sources of Pb to Hispanic Subpopulations

Where people live, what people do and what people consume are the organizing themes for the following presentation of Hispanic Pb poisoning factors. In addition, there are additional modifying factors that can affect Pb uptake. This review begins with Pb sources determined by where Hispanics live in terms of national origin, border populations and immigration status. It continues with what some Hispanics do for a living and practices they engage in that increase Pb exposures and this section ends with a review of ethnic products that some Hispanics consume or ingest that lead to Pb poisoning. Lastly, a factor that modifies Pb uptake is presented given its potential as an important influence on Pb poisoning rates among Hispanics.

Where People Live: Pb Exposure as a Function of Location

Immigration and Pb Poisoning

For Hispanic immigrants, blood Pb levels may be a reflection of prior exposure in their country of origin where environmental risks are greater [38]. Evidence of increased risk to environmental Pb concentrations and exposures in Latin American countries has been documented in numerous review articles [39, 40] and research studies [41]. The consequences of inaction in battling diseases linked to environmental health in Latin American countries have been discussed [42] along with suggestions on how to address these environmental health issues [43].

Whether and how developing countries address environmental contamination is important because their policies are having an impact on health indicators in the US [44, 45]. Immigrants bring with them their physiological burden of Pb stored in bone [46, 47]. In addition, they bring distinctive cultural and dietary practices [48–50] that can result in the significant exposure to Pb discussed in the following sections.

Unfortunately, very few studies have been conducted on the Pb burden of newly arrived immigrants. One study found a greater percentage (20%) of Mexican-born Hispanic children had blood Pb levels greater than 10 μg/dl than did US-born Hispanic children (7%) [51]. 12% of immigrant children arriving at the Miami-Dade County Health Department from 1999 to 2001 had elevated blood Pb levels, a rate 5.5 times the general population at the time [52]. In Massachusetts, the percentage of recently arrived refugee children with elevated blood Pb levels was more than twice that of US-born children, leading the authors to suggest that clinicians should consider nativity as a risk factor [46].

Pb, once absorbed into the body, is stored in bone and slowly leeches into the blood over the course of a lifetime–a process that accelerates during pregnancy [53]. Pb absorbed into bone while in the native country accounted for blood Pb levels among immigrant women in samples taken in the US [54]. In another study, 1,428 pregnant immigrants in South-Central Los Angeles had a significantly higher blood Pb level mean of 2.3 μg/dl compared to 1.9 of 504 pregnant non-immigrants. Blood Pb levels of immigrants were related to time spent in the US with each natural log increase in years translated to a 19% decrease in blood Pb [55]. Generation status has been shown to affect blood Pb concentrations in immigrant families. First-generation Mexican-American children had higher BLLs than third-generation children [15].

In brief, these findings document the impact of nativity and prior environmental exposure. Addressing the economic losses associated with elevated blood Pb levels for these new Americans and their children should be a public health priority. This can be done by focusing on testing immigrant children and women of child-bearing age and developing programs to minimize the negative effects of Pb through nutrition and education programs.

National Origin Differences

Generalizations regarding the environmental health of different national origin groups are difficult to make due to the confounding effects of differences in environmental and socio/behavioral risk factors [56]. Health disparities, however, do exist among national-origin subpopulations and ignoring race and ethnicity can lead to an underestimation of health disparities, for example as seen in the case of asthma [57].

In an examination of Hispanic subpopulation differences in Pb concentrations, Puerto Rican children presented the highest mean blood Pb levels (11.5 μg/dl), followed by Mexican-American children (10.4 μg/dl) and Cuban children (8.6 μg/dl). Puerto Rican children had the highest percent of elevated blood Pb defined as greater than 25 μg/dl (2.7%) as compared to 1.6% of Mexican-American children and less than 1% (0.9%) of Cuban children. [32].

Differences in blood Pb levels as a function of national origin may be linked to other factors. One researcher determined that working and housing conditions among poor workers were distributed based on nativity, citizenship, and indigenous background [58]. Other findings have revealed discriminatory practices related to occupational safety and health issues for indigenous farm workers [59]. These findings suggests that national origin as a subpopulation criteria is limited and that considering both underlying class structure and immigration status issues may better account for understanding Pb exposures.

Border Populations and Pb

The US-Mexico border merits special attention with regard to environmental health and Hispanics. The highest poverty rates are found on the US-Mexico border. Gonzalez, et al. [60] document that Pb is “a transborder problem which, if unaddressed, will lead to adverse long-term economic, social, and health consequences on both sides of the border”. Proximity to Mexico affects residents in the US as some types of pollution and environmental contamination flow freely across the border. Many residents also cross the border frequently, have family on the other side of the border, and maintain Mexican cultural traditions longer than Mexican immigrants away from the US-Mexico border.

A comparison study of blood Pb levels of children living directly on the US or Mexican sides of the border found mean BLLs were higher among children living on the Mexican side of the border (4.3 µg/dl) compared to those on the US side (2.2 µg/dl) [61]. In another example in Anapra, Mexico across the border from El Paso, Texas, Pb concentrations were found to be a function of distance from a smelter located in the US, which was closed in 1985. In an area closest to the border, 43% of children tested had blood Pb concentrations greater than 10 µg/dl. A decreasing percentage of children with blood Pb levels >10 µg/dl was found as a function of distance from the smelter. [17].

Colonias are unincorporated, unplanned settlements in proximity to urbanized areas along the border. There is little research on Pb exposure in colonias although these communities have the same diseases and debilitating health conditions that exist in the general population [62]. One case study looking at the potential for Pb exposures from home-based occupations suggested that increased risk for Pb poisoning in colonias should be investigated. In this study, two children had blood Pb levels of 32.4 and 16.6 µg/dl with household dust as the only identifiable source of Pb [63]. Colonias are typically rural in nature with dusty indoor areas where old, painted building materials are typically found and a lack of sanitary conditions is common. Increased potential for Pb exposure may be present here as this environment mirrors that of old and poorly maintained housing found throughout the US where there is an increased risk for Pb exposure. Among the many health risks associated with poverty and low quality of infrastructure, policy makers and health officials should consider Pb poisoning of potential concern along the US Mexico border given the general increased risk found in older, poorly maintained housing compounded by the lack of infrastructure.

There are few studies that have looked at the impact of Pb contamination on the border. Given the increased risk to this subpopulation suggested by the limited information available, these Hispanic subpopulations should be investigated as a potential focus of Pb poisoning prevention.

Migratory Farmworkers

In 1989, there were 840,000 migrant farmworkers across the US with 409,000 children [64]. In Texas alone, it was estimated that during the 2000–2001 school year, there were 71,656 migrant students in 223 school districts [65]. Migratory farmworkers have been shown to live in crowded conditions in inadequate housing lacking basic facilities such as vacuum cleaners [66]. Because of mobility, migratory farmworkers and their families face unique conditions that can potentially exacerbate health disparities including inconsistent health care and exposure to a constantly changing environment.

Schaffer and Kincaid [24] found that children living in rental property and belonging to a family of migrant farmworkers were more likely to have elevated blood Pb levels. Children and adults moving from place-to-place into different substandard housing units as well as nutritional deficiencies caused by an inconsistent diet were likely factors.

What People Do: Pb Exposure as a Function of Activity

Occupational Exposure to Pb

Workers exposed occupationally in Pb industries constitute another at-risk Hispanic sub-population. Pb registries beginning in the 1980s document overrepresentation of Hispanics in Pb industries [67]. From 1987 to 90, the California Department of Health Services received 17,951 blood Pb reports for 4,069 workers employed by at least 328 Pb producing and processing companies. Hispanic workers represented 46% of the 232 incident case subjects with severe Pb toxicity, defined as greater than 29 µg/dl [68].

Pb exposure is not limited to traditional Pb industry employment. The renovation of older housing is a common source of occupational exposure. In an evaluation of 664 cases reported to the Massachusetts Occupational Lead Registry in 1991–1995, construction workers, in particular licensed de-leaders and house painters, accounted for almost 70% of occupational cases involving blood Pb levels more than 40 micrograms of Pb per deciliter of blood. [69]. This is particularly relevant as Hispanics make up the fastest growing population among the US construction workforce [70]. These workers may have minimal training in lead-safe work practices. Foreign-born migrant construction workers have a poor understanding of supervisory relationships and do not understand the importance of safety training, and are more likely to believe that risky situations and behaviors are just part of the job [71].

The urgent need for increased demolition as a result of natural disasters has placed many more Hispanic families at risk [72]. For example, a first-hand account of an undocumented worker from Nicaragua working in post-Katrina New Orleans described a work environment consisting of no safety training, no safety equipment and subsequent severe health problems that could have been prevented [73]. There is evidence that worker safety education is not followed by Hispanic workers [74]. Linguistically and culturally appropriate training must be conducted for workers who are occupationally exposed to Pb.

Exposure to Pb Through Food Preparation

Pb glaze is used as an inexpensive and simple method for finishing the surface of pottery. As a result, inexpensive and imported pottery from developing countries can be a major source of Pb to Hispanic families. In fact, use of Pb-glazed pottery is a virtual guarantee for increasing an individual's blood Pb level. Acidic foods such as tomato-based products stored in these containers exacerbates the leaching of Pb into the food [75].

The significance (in terms of prevalence of use, sources of importation, manner of usage) of leaded pottery in the US is unknown. A search for articles documenting importation and use of these products in the US produced no results. In an evaluation of 99 women living in southern Mexico, the only significant source of Pb that could be found was Pb-glazed pottery [76]. In another study of 220 8–10 year old children in southern Mexico, use of Pb glazed pottery was the most important predictor of elevated blood Pb level [77]. Given the strong evidence of the role of Pb-glazed pottery has in Pb poisoning in other countries, this is a critical area that needs further investigation here in the US.

Pica Behavior

Pb glazed pottery is also of a concern in an unexpected way. Hispanic women have been known to engage in ingestion of bits of Pb-glazed pottery, often during pregnancy [78–80]. This consumption of non-nutritive materials is known as pica. According to one study, 31% of women interviewed in Southern California engaged in pica. Many of these women believed pica was beneficial to the baby [81]. Another reason given for ingestion of ground up pottery is the satisfaction of a craving [82]. Although these case studies are illustrative, it is not clear how extensive this practice is in the US. One study investigating Pb poisoning found that 15 women had been treated for severe Pb poisoning and of these women, 70% were Hispanic and all had Pb poisoning due to pica [83].

Pica behavior should be more prominently discussed and researched as the US continues to receive immigrants and migrants who may be more likely to engage in this practice.

What People Consume: Pb Exposure as a Function of Ethnic Products

Exposure to Pb Through Folk Remedies

Adults and children are exposed to Pb through traditional folk remedies. Some of these remedies contain a shocking amount of Pb. For example, a study evaluating the folk remedy known as *greta*, which is ingested in powder form and given to children for upset stomachs, was found to be 14% Pb by weight [84]. In a study conducted over 25 years ago, it was revealed that *greta* was distributed in the US [85]. During the same time among Texas farm workers, 7% of children surveyed had been given *greta* or *azarcon*, another Pb-based product [86]. These remedies may still be important in some Hispanic sub-populations. More recently, in an interview of 100 Hispanic mothers with at least one child younger than 5 in rural central California, 81% admitted to using folk remedies including 11% who used *azarcon* or *greta* [87].

Litargirio, also a Pb-based product used as a deodorant, was according to one case study 79% Pb. Incidental exposure in a home where this formulation was being used caused Pb poisoning in children [88]. In light of the data presented, the use of *Litargirio* and other folk remedies in many Hispanic populations is largely unknown. There is enough information about the use of these products; however, to indicate a strong need for additional research efforts and incorporation of new questions into screening tools used by clinicians.

The use of folk remedies may not necessarily be tied to traditional practices. Some Mexican-American women report economic necessity as a reason for using less expensive alternative treatments [89]. Many Hispanic women have been found to seek alternative medicines before seeking medical assistance possibly due to both structural (e.g., health access) and nonstructural (e.g., tradition) reasons [90]. More research must be done to determine economic and cultural reasons for using these dangerous products so that better outreach and education approaches can be developed. Public health education approaches need to walk a fine line between respecting cultural practices, but still be bold enough to point out the long term health consequences of using these Pb–based products.

Imported Candy and Other Products

Imported candy from Mexico is a potential source of lead to children. One study conducted in California found that 15% of Pb poisoning cases were linked to Pb contaminated candy from Mexico [91]. Pb has also been found in candy packaging. In one study, the Pb content of cellophane wrappers was measured in the parts per thousand range [92].

Other ethnic products have also been identified as sources of Pb to children. In Monterey, CA an outbreak of Pb poisoning cases led researchers to link consumption of imported dried grasshoppers (*chapulines*) to Pb poisoning. An analysis of *chapulines* revealed a concentration of 2300 mg/kg Pb [49] exceeding the FDA limit of 0.5 mg/kg Pb.

The introduction of contaminated products into an area may be a function of whether the Hispanic population is large enough to support a local ethnic market. Examples of contaminated foodstuffs and candy have been reported across the country. For example, Pb contaminated candy was found in Iowa [92] illustrating the potential nationwide scope of the problem. A recent article listed 76 different Mexican candies with elevated Pb [93].

A Modifying Factor in Hispanic Populations Affecting Pb Uptake: Diet

Increased intake of calcium and iron reduces Pb absorption as iron, calcium, and Pb compete for uptake in the stomach. The link between anemia and Pb poisoning in Hispanic communities should be a focus of Pb poisoning prevention. A recent NHANES report (1999–2002) showed that iron deficiency prevalence was 12% among Hispanics versus 6% in whites and 6% in blacks [94]. In 100 migratory and seasonal farmworker households located on the US–Mexico border, food insecurity was found in 82% of the homes and hunger in 49% [95]. Hispanic subpopulations facing food insecurity are at heightened risk for Pb poisoning.

Discussion and Conclusions

Reducing childhood exposure to Pb is problematic. Proximity to a potential risk is not necessarily related to how individuals assess that risk [96]. For example, risk judgments by people living near a metal processing plant were not a function of the actual risk present [97]. Logically, risks from non-visible environmental threats such as leaded dust would be of even less concern.

Most people do not understand sources of Pb in their environments and they do not take steps to prevent exposure to their children. Childhood exposure to leaded dust can be reduced by monitoring and encouraging hand washing and other behavioral changes. However, parents have limited awareness of their child's outdoor behaviors [26].

Underestimated risk among minority and immigrant populations leads to increased health disparities. Many Hispanic immigrants come from areas that are far more contaminated with Pb and may perceive the US as a "cleaner" environment for their children thereby reducing their vigilance.

There is little doubt that Pb poisoning is a critical issue for Hispanic and immigrant health. A recent estimate determined that 310,000 children ages 1–5 in the US have blood Pb concentrations greater than 10 μg/dl and that Hispanic children <1 year old are 3 times more likely to have elevated blood Pb [35]. The problem may be even worse due to evidence that would lower the definition of elevated blood Pb [98].

Determining the relative risk and importance of the described factors is beyond the scope of this review article. This review of Pb sources unique to Hispanic families however is intended to emphasize the importance of family-specific risk assessments by health care workers. This family-specific assessment for Hispanics should take into account cultural and other factors rather than making assumptions about the relative importance of factors within the population. For example, it is without a doubt that families who use Pb-glazed pottery are likely directly ingesting Pb. We simply do not know who uses these pots, how often they use the pots, or how these pots are used beyond a few case studies. In the absence of a nationally representative study, public policy and clinicians should err on the side of caution and consider all Hispanics at increased likelihood of using Pb-glazed pottery.

The Centers for Disease Control and Prevention has established guidelines for states in their development of screening plans with a focus on geography rather than population [99]. While there are recommendations with regard to targeted screening as a function of family income and racial/ethnic background, the overwhelming message is that older housing (e.g., housing built before 1950), is the most significant source of Pb to children. An example provided to states in their development of screening plans even suggests determining whether to test children in an area according to whether 27% of housing is older than 1950. While other sources of Pb are mentioned, a recent broadcast by the CDC again emphasized Pb-based paint being the major source of exposure for Pb for US children [100]. Not only are there other sources of available Pb just as important as paint [101], but a long list of myriad sources that non-universal (targeted) screening plans will ultimately miss.

This review article reveals that cultural and behavioral factors unique to Hispanic populations may be as important as age of housing and exposure to leaded paint for thousands of Hispanic children. The CDC recommends universal screening for states without a state-specific plan. For states that do not have universal screening plans, we strongly recommend that these states designate children with Hispanic origin as high risk.

Based on the unique challenges described that Hispanic subpopulations face, we recommend the following specific actions in order to reduce Pb poisoning among these high-risk groups:

Placing more emphasis on sending blood Pb data to state and national repositories to facilitate case management and epidemiological and social research to insure progress of long-term Pb poisoning reduction.

Including blood Pb level test results on vaccination reports to encourage long-term management of blood Pb levels for children of migratory farm workers who may see multiple doctors.

Testing of all newly arrived immigrants especially children and women of child-bearing age. Children that move back-and-forth between Mexico and the US should be tested regularly.

Fostering interdisciplinary collaboration on Pb research and increasing funding to facilitate effective determination of sources of Pb unique to Hispanics due to culture.

Encouraging local governments to adopt ordinances to increase the number of Pb-free homes and support training in Pb safe work practices. Education and training materials to support this are readily available from the Environmental Protection Agency and the US Department of Housing and Urban Development.

Passing legislation that allows appropriate Federal Government agencies to certify that imported pottery and food products are Pb free.

Classifying all Hispanic children as at-risk for lead poisoning in lead testing programs, given the multiple and unique risk factors to Hispanic children.

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