Blood Lead Levels in Young Children: US, 2009-2015

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Objectives To evaluate trends in blood lead levels in children <6 years of age, this Quest Diagnostics Health Trends report builds on previously reported National Health and Nutrition Examination Survey data with a much larger national group and adds more detail and novel assessments.

Study design This report describes the results from a 6-year retrospective study (May 2009-April 2015) based on >5 million blood lead level results (including >3.8 million venous results) from children <6 years old living in all 50 states and the District of Columbia. We evaluated yearly changes and examined demographic categories including sex, pre-1950s housing construction, poverty income ratios (PIRs), Medicaid enrollment status, and geographic regions.

Results Among children <6 years old, 3.0% exhibited blood lead levels ≥5.0 μg/dL (high). There were significant differences in high blood lead levels based on sex, pre-1950s housing construction quintiles, and PIR <1.25 and PIR >5 (all $P < .01$). Health and Human Services regions, states, and 3-digit ZIP code areas exhibited drastically different frequencies of high blood lead levels and blood lead levels ≥10.0 μg/dL (very high). Generally, levels declined over time for all groups.

Conclusion Examination of more than 5 million venous blood lead level results in children younger than 6 years old allowed for a robust, detailed analysis of blood lead level group results by geography and other criteria that are prohibited with the narrower National Health and Nutrition Examination Survey database. Progress in reducing the burden of lead toxicity is a public health success story that is incomplete with some identified factors posing larger, ongoing challenges. *(J Pediatr 2016;175:173-81)*.

Childhood lead toxicity is a preventable environmental disease with long-lasting adverse health and behavioral effects.[1] Public health services and other health professionals throughout the US have dedicated more than 4 decades of efforts to screen children, especially those at high risk, for lead exposure and to identify primary sources of lead.[2] Federal and local environmental policies have included the removal of lead from gasoline, reduction of lead in paints, and testing of homes for lead-based paint. These efforts along with laboratory testing and case management efforts have been instrumental in significantly reducing blood lead levels in the US. The 2007-2010 National Health and Nutrition Examination Survey (NHANES) estimate of the geometric mean blood lead level was 1.3 μg/dL,[3] which is a 90% decrease compared with the 1976-1980 NHANES II 12.8 μg/dL estimate.[4]

In 1991, the Centers for Disease Control and Prevention (CDC) recommended changes for preventing childhood lead poisoning, which included a reduction for the blood lead level deemed safe (from 25 μg/dL to 10 μg/dL).[5] In May 2012, the CDC Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) identified that there is no safe blood lead level and the CDC accepted ACCLPP recommendations to remove all CDC blood lead level references to "blood lead level of concern."[6] The CDC position of "no safe blood lead level" is based on an absence of blood lead levels without effects and low blood lead levels that are associated with intellectual deficits, attention deficit behaviors, and poor academic achievement.[7,8] That these effects appear to be irreversible[9-11] emphasizes a public health care shift to primary prevention rather than secondary and tertiary prevention efforts, which are based on responses after detecting lead exposure.

In May 2012, the CDC also adopted the ACCLPP committee recommendations to use the NHANES 97.5th blood lead level percentile (5.0 μg/dL) as an upper reference interval threshold to identify children with elevated blood lead levels. The 5.0 μg/dL value is based on 2 consecutive cycles of the NHANES blood lead level data distribution among study children 1-5 years of age. Based on the 5.0 μg/dL threshold, the 2012 ACCLPP committee report estimated 450 000 children in the US as having blood lead levels greater than the new reference limit.[12] The NHANES analysis includes demographic categories with long-standing disparities of risk for elevated blood

ACCLPP	Advisory Committee on Childhood Lead Poisoning Prevention
CDC	Centers for Disease Control and Prevention
HHS	US Department of Health and Human Services
NHANES	National Health and Nutrition Examination Survey
PIR	Poverty income ratio

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lead levels, including age, sex, race/ethnicity, age of housing, poverty income ratio (PIR), and Medicaid enrollment status.

Despite the insights provided by the NHANES analysis, the study has several limitations. One such limitation is that the low numbers of NHANES-enrolled children with blood lead levels ≥10 μg/dL (only 9 children in 2007-2008; 6 children in 2009-2010) make interpretation of population estimates of very high blood lead levels unreliable. In addition, the NHANES was not designed to produce estimates at the state and local level and may not detect statistically significant disparities with important public health implications.

This Quest Diagnostics Health Trends report describes the results of a 6-year retrospective study based on a large national clinical laboratory database with more than 5 million results from children younger than 6 years of age. Our analysis builds upon previously reported NHANES data and includes insights into yearly trends and the distributions of blood lead levels by specimen type (venous and capillary), sex, payer type, US Department of Health and Human Services (HHS) region, residence state, PIR, and pre-1950s housing construction.

Methods

The specimen requirement for venous blood lead level analysis is whole blood collected into an evacuated collection tube certified for lead testing, such as tan-top and royal blue-top tubes containing the anticoagulant EDTA. For the capillary collection method, the specimen collection container is the lavender-top capillary tube.

The blood lead level analyses were performed by the use of either inductively coupled plasma/mass spectrometry or the Zeeman graphite furnace atomic absorption spectroscopy. Instrument calibrations are performed with standards traceable to the National Institutes of Standards and Technology. Performance for all methods is in compliance with the ± 4 μg/dL (or 10%, whichever is greater) CDC accuracy standards.[13] The blood lead level results were evaluated with a 3.0 μg/dL lower reporting threshold. The laboratory analysis of venous specimens is consistent with the CDC definition for "confirmed elevated blood lead level" when indicated.[14]

The blood lead level data set includes deidentified results of testing performed for children <6 years of age, from May 2009 through April 2015 (3 years before and after the 2012 CDC change from the 10 μg/dL "level of concern" to the 5.0 μg/dL reference interval threshold). Instances of blood lead level results reported as a specimen submitted in a tube/container not certified for lead testing were excluded from the study. This study was deemed exempt by the Western Institutional Review Board.

To avoid duplication of patient data, when 2 or more tests were associated with the same individual, only the first venous result (or the first capillary result if there were no venous results) within the data set was included in this study. The 3.0 μg/dL reporting threshold precluded our ability to estimate the mean blood lead level for the study with sufficient precision. Instead, analyses focused on the proportions of the population falling into each of 4 blood lead level groups: ≤3.0 μg/dL (below the reporting limit); 3.1-4.9 μg/dL (above the reporting limit and below the CDC 2012 reference interval threshold); 5.0-9.9 μg/dL (between the 2012 reference interval threshold and the previous 1991 CDC "level of concern"); and ≥10.0 μg/dL.

Patient data were limited to patients <6 years of age, corresponding to the CDC age definition for high risk. Blood lead levels results missing patient sex were excluded from sex analysis.

Data from the US Census Bureau's 2009-2013 American Community Survey 5-Year Estimates[15] were used to determine the proportion of housing constructed before 1950 by ZIP code. According to the CDC, "houses built before 1950 pose the greatest hazard to children because they are much more likely to contain lead-based paint than newer houses."[16] Quintiles were defined as the percentage of the housing category by ZIP code. Quintile thresholds for pre-1950s housing were defined as <3.6%, 3.6%-12.9%, 13.0%-29.9%, 30.0%-50.9%, and ≥51.0%. All quintile thresholds were chosen to provide approximately equal numbers in each quintile group. Demographics were divided into quintiles to demonstrate trends in blood lead level proportions. ZIP codes are based on patient residence, not the site of the blood collection.

Data from the United States Census Bureau's 2008-2012 American Community Survey 5-Year Estimates[17] were used to determine PIR of children's area of residence by ZIP code. Quintiles were defined as the percentage of PIR <1.25 (low income) and PIR >5 (high income) by ZIP code. Quintile ranges were defined as <16.0%, 16.0%-27.9%, 28.0%-38.9%, 39.0%-51.9%, and ≥52.0% for PIR <1.25, and <2.8%, 2.8%-6.9%, 7.0%-13.9%, 14.0%-27.9%, and ≥28.0% for PIR >5.

This study included specimens submitted for blood lead level testing from all 50 states and the District of Columbia. Data were grouped for analysis by HHS region, state, and 3-digit ZIP code region. We limited our state analyses to those with at least 2000 children and our 3-digit ZIP code analysis to areas with at least 1000 children. The proportion of housing that was constructed before 1950 in various geographical regions also was analyzed. These data were weighted by the number of patients with specimens from individual ZIP codes.

Statistical Analyses

The Cochran-Armitage test was used to analyze trends in proportions of children with blood lead levels ≥5.0 μg/dL (high blood lead level) and ≥10.0 μg/dL (very high blood lead level) for various groups. Testing for statistical significance between the 2 groups was conducted with the χ^2 test. Multivariable logistic regression models to determine characteristics associated with high blood lead level and very high blood lead level also are reported. Variables in both models were chosen based on plausibility and/or statistical significance in previous studies.[3] Living in ZIP codes associated with the greatest quintile of pre-1950s housing, low income, and high income were included as binary variables. Living in