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Lead Poisoning Risk Determination in an Urban Population Through the Use of a Standardized Questionnaire

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ABSTRACT. *Background.* **The Centers for Disease Control and Prevention (CDC) has recommended using a five-item questionnaire at every regular office visit for all children 6 to 72 months of age to identify those at risk of high-dose exposure to lead.**

Objective. **To determine how well the questionnaire identifies children with elevated lead levels.**

Research design. **Comparison of results of the questionnaire, which is intended to identify children as being low-risk or high-risk for lead poisoning, with children's blood lead levels.**

Setting. **A pediatric continuity clinic located in a major teaching hospital in Rochester, NY.**

Patients. **A consecutive sample of 476 children aged 6 to 72 months without a prior history of lead poisoning who were seen in the clinic in July and August 1992, and who had not had a lead screen in the previous 6 months (for those aged <36 months) or 12 months (for those aged 36 to 72 months).**

Measurements and main results. **Fingerstick lead samples were obtained from all children, and those ≥15 μg/dL (0.72 μmol/L) were confirmed by subsequent venous lead determinations. Twenty-eight percent had blood lead levels ≥10 μg/dL (0.48 μmol/L), 8% had levels ≥15 μg/dL (0.72 μmol/L), and 5% had lead levels ≥20 μg/dL (0.96 μmol/L). According to responses on the questionnaire, 44% were initially classified as low-risk, and 43% were high-risk. In 13% risk could not be determined because one or more items on the questionnaire had not been answered or were answered equivocally, whereas all other items were answered "No." Children for whom risk could not be determined were presumed to be at high risk and were added to that category, resulting in 56% of the study population so designated. The questionnaire was moderately effective in identifying children with elevated lead levels. Seventy percent of children having lead levels ≥10 μg/dL (0.48 μmol/L) and 82% of children having lead levels ≥15 μg/dL (0.72 μmol/L) had been classified as high-risk by the questionnaire. Children classified as low-risk were very unlikely to have elevated lead levels. Eighty-one percent of low-risk children had lead levels <10 ug/dL, and 97% had lead levels <15 ul/dL. An abbreviated questionnaire using only the first three items from the CDC questionnaire had almost identical effectiveness.**

Conclusions. **In this clinical setting, in which children are largely urban, poor, and have a moderate to high risk of developing elevated lead levels, the CDC risk assessment questionnaire is effective in identifying children with elevated lead burdens. However, an abbreviated version of the questionnaire may be as effective as the complete questionnaire. Additional questions should be added to the questionnaire to improve its overall sensitivity, and the questionnaire should be tested in other settings to see if it is effective with children having different environmental exposures to lead.** *Pediatrics* **1994;93:159–163;** ***lead, screening, risk determination.***

ABBREVIATIONS. CDC, Centers for Disease Control and Prevention; AAP, American Academy of Pediatrics.

In October 1991, citing new evidence that significant adverse effects may occur with lead burdens that were previously believed to be safe, the Centers for Disease Control and Prevention (CDC) established revised guidelines for lead screening and intervention.[1] These guidelines call for assessment of the risk of lead exposure by use of a five-item questionnaire at every regular office visit for all children in the United States aged 6 months to 6 years. Children determined to be at high risk are then to be screened frequently for lead. The five questions used to determine risk of lead exposure are:

- Does your child live in or regularly visit a house built before 1960 which has peeling or chipping paint?
- Does your child live in or regularly visit a house built before 1960 with recent, ongoing, or planned renovations or remodeling?

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- Does your child have a brother, sister, housemate, or playmate who is followed or treated for lead poisoning (that is, having a blood lead level of 15 µg/dL [0.72 µmol/L] or higher)?
- Does your child live with an adult whose job or hobby involves exposure to lead?
- Does your child live near an industry that is likely to release lead (such as a battery plant, lead smelter, or manufacturing plant where lead may be used)?

Children for whom any of the these five questions may be answered "Yes" are considered to be at high risk for lead exposure, and hence, for lead poisoning. Those children for whom all five questions are answered "No" are presumed to be at low risk.

The risk assessment questionnaire, originally developed by the Massachusetts Department of Health (N. Hayes, CDC, and M. J. Brown, Massachusetts Department of Health, personal communication, May 20, 1993), was subsequently endorsed for use nationally by the CDC's Advisory Committee on Childhood Lead Prevention Planning. The effectiveness of the questionnaire for identifying children with elevated lead burdens has not previously been evaluated. The present study was conducted to test this instrument in a clinical setting by comparing risk categorization, as determined by the questionnaire, with actual screening results.

METHODS

The CDC's risk assessment questionnaire was completed by the parents of all children aged 6 to 72 months who attended the Strong Memorial Hospital Pediatric Continuity Clinic in Rochester, NY, in July and August 1992, for health supervision visits, follow-up visits, or illness-related visits. The months of July and August were chosen because potential exposure to exterior sources of lead is greatest during the warm summer months. The housing stock in Rochester is old, with most of the homes built in the 1920s and 1930s. The children attending the clinic primarily live in the inner city, and approximately 75% are Medicaid recipients. Sixty-four percent are African American, 23% are white, 6% are Hispanic, 6% are of mixed racial heritage, and less than 1% are Asian.

To test the effectiveness of the questionnaire as a true screening instrument, children previously known to have a history of elevated lead levels were excluded. Also excluded were children aged less than 36 months who had been screened for lead within the preceding 6 months, and children aged 36 to 72 months who had been screened for lead within the preceding 12 months, because they would not yet be due for retesting according to the screening schedule recommended by the CDC. Before initiation of this study, children attending the clinic were routinely screened for lead once at 9 to 12 months of age; children believed to be at risk for lead poisoning were screened again at 2 years of age.

After their parents completed the written risk assessment questionnaire, the children were sent to the hospital's outpatient laboratory where fingerstick samples were obtained for blood lead determinations. All samples were run by the Monroe County, NY, Department of Health. Fingerstick lead levels of 15 µg/dL (0.72 µmol/L) or higher were confirmed by subsequent venous lead determinations.

The Statistical Package for the Social Sciences (SPSS, Inc, Chicago, IL) and Epi Info (CDC, Atlanta, GA; World Health Organization, Geneva, Switzerland) were used for analysis of the data. Relative risks were determined, and χ^2 tests were used for significance testing.

The protocol for this study was reviewed by the Research Subjects Review Board of the University of Rochester. The Research Subjects Review Board found that neither written consent of the children's parents, nor formal Research Subjects Review Board approval were required because the information obtained and the laboratory studies conducted were consistent with the lead screening guidelines of the CDC.

RESULTS

Questionnaires were completed and lead levels were obtained for 476 children. Overall, 28% had lead levels of 10 µg/dL (0.48 µmol/L) or higher, 8% had levels of 15 µg/dL (0.72 µmol/L) or higher, and 5% had lead levels of 20 µg/dL (0.96 µmol/L) or higher. These proportions underrepresent the actual prevalence of children having increased lead burdens, because children previously known to have elevated lead levels were excluded from the study. The distribution of elevated lead levels is illustrated in the Figure. None of the 122 children younger than 11 months of age were found to have lead levels of 15 or higher. The highest proportions of children with lead

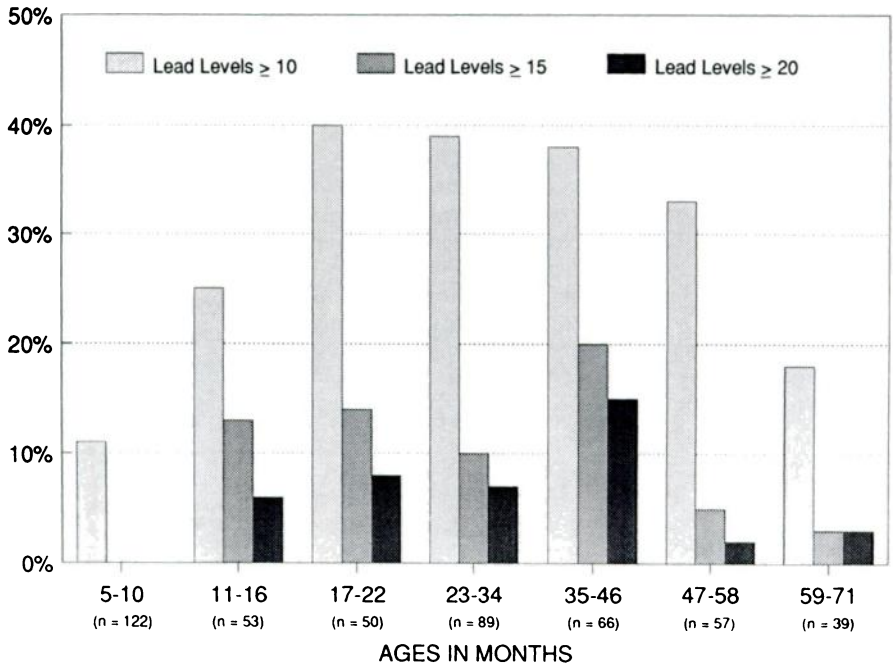

Figure. Distribution of elevated lead levels by age group. Lead levels are expressed as micrograms per deciliter.

TABLE 1. Responses to Items on Risk Assessment Questionnaire

Questionnaire Item	No (%)	Yes (%)	Unsure/Blank (%)
Home built before 1960, with peeling or chipping paint	67	26	7
Home built before 1960, with recent or planned renovations	71	23	6
Friend or sibling with lead poisoning (lead level ≥15 μg/dL)	82	13	5
Adult in household who has job or hobby involving lead	93	3	4
Live near an industry that is likely to release lead	89	6	5

levels of 10 or higher were aged 11 to 46 months. Children 35 to 46 months old were significantly more likely to have lead levels of 20 or above than were children either aged 11 to 34 months ($P = .03$) or 47 to 71 months ($P = .002$). Little variation was noted between venous and fingerstick lead levels.

According to responses on the questionnaire, 26% of the children in the study lived in homes built before 1960 which have peeling or chipping paint, 23% lived in homes built before 1960 with recent or planned renovations, and 13% had friends or siblings who have lead poisoning. There were few children reported as living with adults whose jobs or hobbies involved the use of lead and few who lived near industries that were believed by their parents to possibly release lead (Table 1).

Overall, using the CDC's criteria, based on responses to the questionnaire, 44% of the sample population would be considered to be at low risk for lead poisoning, 43% would be considered at high risk, and in 13% risk could not be determined, because one or more of the items on the questionnaire either had not been answered or had been answered equivocally whereas all other items on the questionnaire were answered "No." Routine lead screening is recommended by the CDC according to a timetable which depends on designation of children as either being at high risk or at low risk for lead poisoning. Therefore, those children for whom risk could not be determined by using the questionnaire were presumed to be at high risk and were added to that category, resulting in 56% of the study population so designated.

Affirmative responses to only two of the five items on the questionnaire were associated with a significantly increased percentage of children having actual elevated lead burdens. Those items related to whether the child lives in a home built before 1960 which has peeling or chipping paint, and to whether the child has a sibling, housemate, or playmate with lead poisoning (defined as a lead level of 15 μg/dL [0.72 μmol/L] or higher). Children whose parents acknowledged that the family lives in an older home which had peeling or chipping paint had a 1.4 times greater relative risk of having a lead level of 10 μg/dL (0.48 μmol/L) or higher ($P = .04$, 95% confidence interval = 1.0 to 1.8) and a 1.6 times greater relative risk of having a lead level of 15 μg/dL (0.72 μmol/L) or higher (which was not significant because of relatively small numbers). Children having siblings, housemates, or playmates with lead poisoning were themselves 1.9 times more likely to have a lead level of 10 or higher ($P < .0001$, 95% confidence interval = 1.4 to 2.6) and 2.4 times more likely to have a lead level of 15 or higher ($P = .01$, 95% confidence interval = 1.3 to 4.4).

Children designated as being at high-risk for lead poisoning using the five-item questionnaire were significantly more likely to have elevated lead levels than were children who were considered to be at low risk. High-risk children had a 1.8 times greater risk of having a lead level ≥10 μg/dL (0.48 μmol/L) ($P < .001$, 95% confidence interval = 1.3 to 2.5) and a 3.6 times greater relative risk of having a lead level of 15 μg/dL (0.72 μmol/L) or higher ($P = .001$, 95% confidence interval = 1.6 to 8.0) than did low-risk children.

To evaluate the effectiveness of any screening test for identifying a condition or illness in a population, one must evaluate the test's sensitivity, specificity, positive predictive value, and negative predictive value. Of particular importance are the sensitivity, the measurement of how well the test identifies those with the condition, and the negative predictive value, a measure of the proportion of those having normal results on the screening test who do not actually have the condition. The effectiveness of the CDC questionnaire in either identifying children having lead levels ≥10 μg/dL (0.48 μmol/L) or ≥15 μg/dL (0.72 μmol/L) is illustrated in Table 2. Eighty-two percent of children with lead levels of 15 or higher were identified by the questionnaire as being at high risk, and fully 97% classified as low-risk had lead levels <15.

Table 3 illustrates the effectiveness of using an abbreviated version of the questionnaire which includes only its first three items, the questions which relate to whether or not the child either lives in or regularly visits a home built before 1960 which has peeling paint, or recent or planned renovations, or whether the child has a sibling or playmate with lead poisoning. The abbreviated questionnaire's effectiveness (ie, sensitivity and negative predictive value) is almost identical with that of the complete CDC questionnaire.

DISCUSSION

Since their implementation in 1991, the CDC lead screening guidelines have engendered much controversy.[2,3] In April 1993, the American Academy of Pediatrics (AAP) released a policy statement on screening and primary prevention of lead poisoning which

TABLE 2. Effectiveness of the Risk Assessment Questionnaire in Identifying Children With Elevated Lead Levels

	Lead Levels	
	≥10 μg/dL	≥15 μg/dL
Sensitivity	.70	.82
Specificity	.49	.46
Positive predictive value	.35	.12
Negative predictive value	.81	.97

TABLE 3. Effectiveness of an Abbreviated Risk Assessment Questionnaire in Identifying Children with Elevated Lead Levels

	Lead Levels	
	≥10 μg/dL	≥15 μg/dL
Sensitivity	.69	.82
Specificity	.54	.50
Positive Predictive value	.37	.13
Negative predictive value	.82	.97

generally supports the CDC's screening recommendations.[4] The AAP policy statement notes that studies have clearly shown that lead poisoning is not a disease of poor or minority children alone.[5–9] It suggests the screening of all children at 9 to 12 months of age and again at 24 months of age, and proposes that a history of possible lead exposure be assessed regularly at health supervision visits between 6 months and 6 years of age using the questions from the CDC questionnaire. The AAP also suggests that further evaluation and refinement of the risk assessment questionnaire be pursued.

The results of the present study illustrate that in an inner-city, urban population which has a moderate to high risk of lead exposure, regular lead screening until 6 years of age can identify many asymptomatic children with elevated lead levels. The high proportion of children aged 35 to 46 months with lead levels of 20 μg/dL (0.96 μmol/L) or above among the children in this study contrasts with the widely held belief that toddlers have the greatest risk of lead poisoning because of their high degree of hand-mouth activity.[1] Although other studies confirm that children aged 25 to 48 months are as likely as toddlers to have increased lead burdens,[9,10] the current AAP and CDC guidelines do not call for routine screening of children in this age group unless they are classified as high-risk. Risk determination, therefore, cannot be overemphasized. Nevertheless, not all the 35- to 46-month-old children noted to have elevated lead levels in the current study were classified as high-risk by the questionnaire. Some of these children may have been exposed to lead at an earlier age. They would not now have been designated as high-risk because the CDC questionnaire deals only with current and recent exposure to lead without addressing past exposure. Alternatively, they may have been recently exposed to a source (eg, soil, ceramics, water, lead-containing toys) not listed in the questionnaire.

Both the CDC and the AAP recommend that risk assessment be initiated at 6 months of age, and that children at high risk be screened at that time. The CDC recommends that lead screening be started at 12 months of age for children at low risk, whereas the AAP suggests initial screening at 9 to 12 months of age for low-risk children. In the present study no children younger than 11 months of age had lead levels of 15 or above. Initiation of routine lead screening at either 9 or 12 months would therefore seem to be reasonable.

Many parents were unsure of how to answer specific items on the risk assessment questionnaire. This was especially so regarding the questions relating to whether the family lived in a home built before 1960 with either peeling or chipping paint or recent, ongoing, or planned renovations. The uncertainty occurred because the age of the family's home was often unknown, especially if the home was rented. Many parents also were unsure if industries located near their homes released lead, and therefore found it difficult to respond with certainty to the last item on the questionnaire. The need for simplification and revision of the questionnaire is clear. A simpler questionnaire should result in fewer children whose risk cannot be determined.

Several limitations affected the generalizability of this study. It was performed during a single season of the year, was restricted to a lone practice site primarily serving children living in inner-city areas, and was limited to children who were not screened within the previous 6 to 12 months. Overall, however, the CDC risk assessment questionnaire seems to be effective in identifying children with increased lead burdens in communities where children have a moderate risk of developing elevated lead levels. In localities where environmental lead is less prevalent, and the prevalence of elevated lead levels of children is lower, the effectiveness of the questionnaire would be expected to be lower as well.

In the present study, an abbreviated version of the questionnaire, which contains only its first three questions, was found to be as effective as the complete questionnaire. Questions relating to parental exposure to lead and potential exposure to lead from industrial sources were omitted in the abbreviated version because very few children lived in homes in which adults had a job or hobby involving lead, and few parents acknowledged living near an industry that is likely to release lead. Additional studies to evaluate the utility of using an abbreviated questionnaire should be conducted in other communities.

The risk assessment questionnaire should be refined by adding additional questions which may improve its overall sensitivity. In geographic areas or localities where specific sources of lead may be identified (eg, where tap water contains high concentrations of lead,[6] or where use of ceramic pottery is prevalent[1]), questions concerning exposure to these lead sources should also be included.

Strategies for identifying children with increased lead burdens should reflect local conditions. Public health agencies need to undertake further studies to estimate the prevalence of lead poisoning in individual localities and regions of the country. Selective screening based on risk assessment may then be appropriate in localities where few children are found to have increased lead levels. Until that time, universal screening, assisted by risk assessment with questionnaires such as the one developed by the CDC, is indicated.

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AGGRESSION IN PRESCHOOLERS: ITS RELATION TO SOCIALIZATION

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Abstract. The present article discusses developmental changes of aggression seen in preschool children and reports on an 18-month short-term prospective study of three preschool populations: a group referred for aggressive behavior problems, a normal control group, and a group of youngsters who had lived in violent homes, but showed no aggressive behaviors. Results indicate that the aggressive children, in comparison with the other two groups at age 4, showed a significant delay in their interpersonal awareness and perspective taking ability. However, although the aggressive children caught up with their peers in the course of the study period, there was no accompanying decrease in their aggressive behavior. The theoretical and clinical implications of these findings are discussed. *J Am Acad Child Adolesc Psychiatry*. 1992;31(5):853–862. **Key Words:** aggression, preschool, follow-up.