Is There Lead in the Suburbs? Risk Assessment in Chicago Suburban Pediatric Practices

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ABSTRACT. *Objective.* **This study was designed to determine: (1) the prevalence of elevated blood lead (BPb) levels (BPb ≥ 10 μg/dL) in Chicago suburban children attending Pediatric Practice Research Group practices at 12 and 24 months of age, and (2) the efficacy of the Centers for Disease Control and Prevention (CDC) and Illinois lead exposure risk assessment questions.**

Methods. **Parents bringing their 1- and 2-year-old children for health supervision visits at pediatric practices completed questionnaires. BPb levels were drawn on children. Both questionnaire and an analyzable BPb level were obtained on 1393 subjects (79.2%).**

Results. **Only 2.1% of our sample had a venous BPb level ≥10 μg/dL (0.48 μmol/L); no subjects had a level ≥30μg/dL (1.45 μmol/L). The CDC risk assessment questions had a sensitivity of .69 and specificity of .70. Due to the low prevalence of elevated BPb levels in this sample, CDC and Illinois screening strategies had high negative predictive values (.99) and low positive predictive values (.05 and .04, respectively). However, some of the subjects with BPb levels ≥10 μg/dL were not at high risk by CDC and Illinois screening questions; 9 of 29 subjects with elevated lead levels (31%) did not respond affirmatively to any CDC risk assessment questions. The question best predicting an elevated BPb was the determination that the house the child lives in was built before 1960 (sensitivity = .83, specificity = .67). This question is not currently included in CDC or Illinois screening strategies. Screening based on the single question "Was your house built before 1960?" would have missed only five (17%) of the children with BPb levels ≥10 μg/dL. Three of these five children were among the 17.1% of 1-year-olds and 26.3% of 2-year-olds in our sample who had moved.**

Conclusions. **In this sample, children living in houses built before 1960 should be considered at high risk for high-dose lead exposure. Due to the high mobility of our sample, phrasing the question to include lifetime exposure (ie, Has your child *ever* lived in a house built before 1960?) should also be considered. Selective BPb testing of high-risk children in low-prevalence suburban areas using this question would miss few children with elevated BPb. Useful risk assessment questions in other areas and other populations may differ.** ***Pediatrics* 1994;93:164–171;** ***lead, children, screening, risk assessment, lead poisoning.***

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ABBREVIATIONS. CDC, Centers for Disease Control and Prevention; BPb, blood lead; CI, confidence interval; RR, relative risk; PPRG, Pediatric Practice Research Group.

Because lead causes neurocognitive delay at low blood levels, the Centers for Disease Control and Prevention (CDC) recently lowered the blood lead (BPb) level considered elevated to 10 μg/dL (0.48 μmol/L).[1] The CDC statement recommends that all children have BPb testing at 12 months of age. Repeat testing at 24 months of age depends on available resources. Children at high risk for high-dose lead exposure are to be tested earlier (6 months) and biannually thereafter. Illinois law mandates BPb testing on all high-risk children and requires that all children entering a state-licensed or -regulated day care, preschool, or kindergarten have a physician or health care provider statement that the child has had BPb screening.[2,3] These recommendations and requirements have profound implications for providers of primary health care to children in our region, creating a new, time-consuming and resource-requiring routine procedure.

The Pediatric Practice Research Group (PPRG)[4] is a consortium of pediatricians in the greater Chicago area, which undertakes research on issues relevant to primary care pediatrics. In the past most suburban members of the PPRG determined BPb values on some children, such as those living in high-risk situations (eg, house renovation), with anemia, or on parental request. Physicians could recall only rare instances of elevated BPb levels.

Therefore, a study was designed to determine: (1) the prevalence of elevated BPb levels (BPb ≥ 10 μg/dL) in Chicago suburban children attending PPRG practices at 12 and 24 months of age, and (2) the efficacy of the CDC and Illinois lead risk assessment questions.

METHODS

Risk Questions

This study evaluated the sample risk assessment questions provided in the CDC statement. These questions were designed to identify children most likely to be exposed to high-dose sources of lead. A "yes" answer to any one of the following CDC questions means the child should be considered high risk.

"Does your child—

1. Live in or regularly visit a house with peeling or chipping paint built before 1960? This could include a day care center, preschool, the home of a babysitter or a relative, etc.
2. Live in or regularly visit a house built before 1960 with recent, ongoing, or planned renovation or remodeling?

3. Have a brother or sister, housemate, or playmate being followed or treated for lead poisoning (that is, blood lead ≥15 μg/dL)?
4. Live with an adult whose job or hobby involves exposure to lead?
5. Live near an active lead smelter, battery recycling plant, or other industry likely to release lead?"[1]

Questionnaires for this study presented a list of jobs and hobbies in a table.

Illinois Department of Public Health recommended questions[3,5] differ from CDC questions; Illinois targets houses built before 1978. To examine this difference, questionnaires phrased CDC questions (1) and (2) as follows:

1. Does your child live in, or regularly visit, any houses or buildings with peeling or chipping paint, including a day care center, preschool, home of a babysitter, relative, etc built before 1978?
   a. (If *yes*) Were any of these houses or buildings with peeling or chipping paint built before 1960?
2. Does your child live in, or regularly visit, any houses or buildings with recent, ongoing, or planned renovation or remodeling built before 1978?
   a. (If *yes*) Were any of these houses or buildings with renovation or remodeling built before 1960?

Additional questions were:

1. What is the approximate year the house or building your child lives in was built? (If unsure, please guess at least the decade, such as 1930s, 1970s, etc.)
2. How many months has your child lived in this house?
3. Does your child live within 100 feet of a busy street?
4. Several questions inquired about practices (eg, using hot water for cooking or drinking) and behaviors (eg, eating paint chips) associated with lead exposure.

Blood Lead Measurement

BPb testing at no cost was offered to all participating children. Most practices obtained initial capillary BPb levels; two practices switched to all venipuncture collection. All subjects with initial capillary BPb levels ≥10 μg/dL (0.48 μmol/L) were requested to return for venous sampling. BPb was not repeated on children with initial venous sampling.

All BPb specimens were processed by atomic absorption spectrophotometry at the Illinois Department of Public Health Laboratory in Springfield, IL or at St. Margaret's Hospital in Hammond, IN.

Practice and Sample Selection

Eleven suburban practices with prior PPRG research experience were invited to participate. Several practices were selected because they were close to the Chicago border, where we assumed we would find the largest proportion of suburban children in older houses. Nine of the eleven invited practices (8 in Illinois, 1 in Indiana) comprised the study sites. Before study initiation, one investigator (H.J.B.) visited all participating offices to present in-service training on lead and explain study protocol.

Physicians and staff enrolled all suburban children having their 1- or 2-year health supervision visit who were within 2 months of their birthday, during three consecutive months (September through November 1992). The Indiana practice began and ended participation three weeks after other sites. Parents completed a survey and children had BPb testing.

Daily appointment schedules (or sign-in logs) for each practice indicating patient age and reason for visit were reviewed retrospectively.

Medical records of non-enrolled, age-appropriate children scheduled for a health supervision visit were reviewed to determine whether a child had been missed.

Treatment and follow-up of children with elevated BPb levels was at the discretion of the participating pediatricians. This study was approved by Institutional Review Boards at Children's Memorial Hospital and the University of Chicago.

RESULTS

Enrollment

During the study, 1759 suburban, age-appropriate children were brought for health supervision visits at the nine participating practices (94.0% from Illinois). Parent survey completion by practice ranged from 89.5% to 99.5%.

Questionnaire and analyzable BPb results were obtained on 1393 children (79.2%), who are the subjects of this report. Children were excluded from the analyses for the reasons outlined in Table 1. Of the 106 children lacking both questionnaire and BPb, 77 were missed and 29 refused. Blood drawn on 73 children with questionnaires was unanalyzable due to insufficient quantity or labeling error. BPb results on seven children were considered unanalyzable because capillary BPb was ≥10 μg/dL (range 11.0 to 17.0 μg/dL), and the child did not return for venous BPb testing. The potential impact of failure to return for venous confirmation on prevalence is calculated below.

Of children with both questionnaire and analyzable blood results, 777 and 616 children were having their 1- or 2-year health supervision visit, respectively. Subjects were 52.6% male and 94.5% white. Most (92.0%) had non-Medicaid medical insurance coverage. Only 2.2% had Medicaid coverage. Almost all mothers (97.9%) were high school graduates; many mothers (59.9%) had a college degree.

Capillary BPb Level Elevation

We had 1296 children with an analyzable fingerstick capillary BPb level. Of these, only 47 (3.6%) had a capillary BPb ≥ 10 μg/dL. A majority (70.2%) had values ≤5.0 μg/dL.

Of the children with capillary BPb ≥ 10 μg/dL returning for venous sampling, 31.9% had a confirmed elevated BPb. Based on this ratio, we estimate 2.2 additional children (95% confidence interval (CI) 1.3 to 3.1) with capillary BPb ≥ 10 μg/dL would have had venous BPb ≥ 10 μg/dL if all subjects had returned for retesting.

Prevalence of Elevated BPb Levels

Only 29 (2.1%, 95% CI 1.4 to 2.8) of 1393 subjects were found to have a venous BPb ≥ 10 μg/dL; of these, only 2 (0.1%) had a venous BPb ≥ 20 μg/dL; no children had a venous BPb >30 μg/dL. Based on estimates described above, inclusion of children not returning for venous sampling would have raised the prevalence of children with BPb elevation to 2.3%. There was an equal prevalence of elevated BPb among 1- and 2-year-olds.

The proportion of children with elevated BPb levels varied by practice (Table 2). Slightly more than one third (37.9%) of all the children we found with elevated BPb levels were at a single practice adjacent to

TABLE 1. Study Participation

Participation	n (%)
Total eligible	1759 (100.0)
Exclusions	
Questionnaire, blood not drawn	166 (9.4)
Questionnaire, blood drawn but unanalyzable	80 (4.5)
No questionnaire, analyzable blood	14 (0.8)
Missed or refused	106 (6.0)
Study subjects	1393 (79.2)

TABLE 2. Prevalence of Elevated Blood Lead (BP) Levels by Practice

Practice	N	Children With BPb ≥10 μg/dL Venous BPb ≥10 μg/dL, n (%)	Mean Decade House Built	Houses Built Before 1960, %
A*	89	11 (12.4)	1920	88
B*	62	3 (4.8)	1940	78
C†	194	4 (2.1)	1970	23
D	110	2 (1.8)	1960	29
E	130	2 (1.5)	1960	39
F	156	2 (1.3)	1960	32
G	252	3 (1.2)	1960	28
H	324	3 (0.9)	1960	27
I‡	76	0 (0.0)	1960	26
Overall	1393	29 (2.1)	1960	34

* Practices serving communities which border the city of Chicago.
† Practice C has three sites. One site, with significantly older houses (analysis of variance, $P < .01$), had three of the four children with elevated BPb.
‡ Northwest Indiana practice.

the city; 12.4% of children with analyzable BPb at this practice had an elevated BPb level. This practice was one of two using initial venous sampling. One practice had no children with an elevated level. Practices serving children where the mean decade of house construction was before 1960 were more likely to have children with elevated BPb levels ($P < .001$).

Prevalence of Risk Responses for Lead Exposure

Questionnaire responses for children with analyzable BPb are presented in Table 3. A parental hobby or job involving lead and renovation of a house built before 1960 were the most commonly reported CDC risk factors. Although each risk assessment item had a "don't know" response, 4.1% and 7.0% of parents failed to indicate any response to the CDC peeling/chipping paint or renovation questions, respectively. Nine percent of parents indicated they did not know if they lived near an industry likely to release lead.

The Illinois decision to consider houses built 1960 to 1977 with peeling or chipping paint or renovation as high-risk exposures increased the percentage of children considered high-risk. An additional 2.1% of children were exposed to peeling or chipping paint; an additional 6.4% to renovation.

In this sample of young suburban children visiting pediatric practices, 33.7% lived in houses built before 1960, and 29.9% in houses built 1960 to 1977. Only 1.9% of parents did not list when their house was built.

Because CDC questions inquire only about current housing, we obtained information on family mobility. Parents reported that 17.1% of 1-year-olds and 26.3% of 2-year-olds had moved.

Parents were also surveyed regarding other behaviors and practices associated with lead exposure (Table 4). In response to the question "Does/did your child eat outside dirt or sand?" 1.5% of parents responded "often" and 42.1% responded "sometimes." Many parents had prepared formula with boiled tap water. Most parents reported using hot tap water for drinking or cooking.

Study subjects with blood results did not differ on age or sex from children excluded. There were no significant differences between 1- and 2-year-old study subjects in demography or risk factors. To assess bias due to sample loss from no blood, questionnaire responses of subjects were compared with those for children with parent-completed questionnaires, but without blood samples (ie, with either no BPb or an

TABLE 3. Individual Risk Questions: Response and Relative Risk

Risk Questions	Response %			"Yes" Response = High Risk		"Yes", "Don't Know," or Missing = High Risk	
	Yes	Don't Know	Missing	RR*	95% CI	RR	95% CI
CDC†							
Peeling or chipping paint (before 1960)	7.4	4.7	4.1	6.3	2.9, 13.9	4.2	2.0, 8.6
Renovation (before 1960)	14.6	3.2	7.0	6.0	2.8, 12.8	4.3	2.1, 8.9
Hobby/job	17.4	2.3	1.5	1.8	0.8, 4.0	1.7	0.8, 3.6
Illinois							
Peeling or chipping paint (before 1978)	9.5	4.6	3.9	4.8	2.2, 10.7	4.3	2.1, 9.0
Renovation (before 1978)	21.0	1.9	7.3	4.4	2.1, 9.3	3.4	1.5, 7.6
Additional questions							
Live within 100 feet of a busy street	24.7	0.9	1.1	3.6	1.7, 8.5	3.5	1.6, 7.8
House built before 1960	33.7	NA‡	1.9	9.2	3.5, 23.9	8.7	3.3, 22.7

* Abbreviations used are: RR, relative risk; CI, confidence interval; CDC, Centers for Disease Control and Prevention.
† Other child with lead poisoning—0.4%, 2.6%, 0.6% response (yes, don't know, missing, respectively). Live near lead industry—0.8%, 9.0%, 0.9% response (yes, don't know, missing, respectively).
‡ Not applicable.

TABLE 4. Behaviors and Practices: Response and Relative Risk

Risk Item	Response %		"Often," "Sometimes" = High Risk		"Often," "Sometimes," or Missing = High Risk	
	Often or Sometimes	Missing	RR*	95% CI	RR	95% CI
Eat paint chips	2.1	1.0	5.6	1.8, 17.5	5.0	1.8, 13.8
Eat dirt or sand	43.6	1.9	1.2	0.6, 2.6	1.3	0.6, 2.6
Swallowed object, such as coin, toy, or battery, or placed in ear or nose	10.3	1.4	0.7	0.2, 2.8	0.9	0.3, 2.8
Used boiled tap water for making child's formula	40.0	2.0	1.2	0.6, 2.4	1.1	0.5, 2.3
Hot top water for drinking/cooking	72.0	0.9	3.3	1.0, 10.7	3.2	1.0, 10.6

* Abbreviations used are: RR, relative risk; CI, confidence interval.

unanalyzable BPb). Of these, 11.0% had a parent with job or hobby involving lead, compared with 17.7% of study subjects ($P < .05$), and 23.8% lived in a house built before 1960, compared with 34.3% of study subjects ($P < .01$). No other risk responses varied significantly.

Evaluation of Risk Assessment Questions, Behaviors, and Practices

Table 3 shows the relative risk (RR) of an elevated BPb for the risk assessment questions. RR calculations are presented for two definitions of high risk: (1) any "yes" response only and (2) any "yes", "don't know," or missing response. RR could not be calculated for the questions "other child with lead poisoning" and "live near lead industry" because no children with an elevated BPb had these risk factors.

Questions about peeling/chipping paint, renovation, living near busy street, and house built before 1960 all identified children with elevated BPb. House built before 1960 is the single best question with a RR of 9.2.

Although only 2.1% of parents reported that their children "often" or "sometimes" ate paint chips, eating paint chips is significantly associated with an elevated BPb (RR = 5.6) (Table 4). Other behaviors and practices were not able to correctly identify children with elevated BPb.

Evaluation of Screening Strategies

The results of this survey were used to analyze the utility of several possible risk assessment questionnaire screening strategies (Table 5). Two screening strategies, CDC risk assessment questions and Illinois revision of the CDC questions are each presented, considering only those with a "yes" answer as high risk. In addition, evaluation of proposed strategies, including house age is presented. A brief description of each strategy is followed by the percent of children identified as high-risk by the strategy, the positive predictive value (the probability of an elevated BPb among high-risk children), the negative predictive value (the probability that children not at high risk will not have an elevated BPb), the sensitivity (the probability that children with an elevated BPb will be assessed as high-risk), and specificity (the probability that children without an elevated BPb will be assessed as not high-risk).

Due to the low prevalence of elevated BPb in this sample, all positive predictive values are low and negative predictive values are high. Sixty-nine percent of children with an elevated BPb were assessed as high-risk by answering "yes" to at least one CDC question (sensitivity = .69). If only children at high risk by this strategy had BPb screening, nine children with an elevated BPb level would have been missed.

The Illinois guidelines, including children in houses with peeling or chipping paint or renovation built before 1978, did not increase the sensitivity appreciably over the CDC level; identifying one additional child with an elevated BPb level. Eight children with elevated BPb would have been missed if only children at high risk by Illinois questions had BPb testing. Only one of these eight children lived in a house built between 1960 and 1977. This child had a BPb level of 13.0 μg/dL.

We also evaluated CDC and Illinois risk assessment questions when "yes," "don't know," or missing responses were considered high-risk. Positive predictive value, negative predictive value, and sensitivity

TABLE 5. Screening Strategies*

Strategy	High Risk, %	Positive Predictive Value	Negative Predictive Value	Sensitivity (95% CI)	Specificity
CDC questions					
"Yes" to any item	31	.05	.99	.69 (.52, .86)	.70
Illinois questions					
"Yes" to any item	37	.04	.99	.72 (.56, .89)	.64
House age					
Live in house built before 1960	34	.05	.99	.83 (.69, .97)	.67
House age and CDC questions					
House built before 1960 or "Yes" to any CDC question	48	.04	.99	.86 (.73, .99)	.53

* Abbreviations used are: CI, confidence interval; CDC, Centers for Disease Control and Prevention.

change little, but the percent of children considered high-risk increases from approximately one third to one half.

We next tested the ability of the single question "Was your house built before 1960?" to identify children with elevated BPb. This single question would have missed only five children with elevated BPb. These five children had BPb values of 11.0 μg/dL to 26.4 μg/dL; only one had a BPb >13.5 μg/dL. Three of these children (including the one with a BPb of 26.4 μg/dL) had recently moved; the other two had values of 11.0 μg/dL and 13.0 μg/dL. However, the CI for the sensitivity of this strategy overlaps with sensitivities of all other screening strategies due to the low frequency of elevated BPb in this population.

Combining house built before 1960 with answering "yes" to any of the CDC questions provided only minimal advantage over house built before 1960 alone; identifying one child with a parental job or hobby exposure while increasing the percent considered high risk from 34 to 48%.

Cost/Benefit

The cost of detecting children with elevated BPb was calculated based on an estimated cost of $25 per test. This is the amount currently charged by the Illinois Department of Public Health Laboratory and is also approximately the amount many of the practices charge their patients for BPb tests sent to other laboratories. For the 1393 subjects included in this sample, the cost to detect the 29 children with an elevated BPB level was $1245 per case found. The practice with the 12.4% prevalence rate drew almost all initial venous BPb tests. Therefore, each case at this practice was detected at a cost of only $252. The practice with a 4.8% prevalence performed capillary and venous sampling, detecting their cases at a cost of $550 per elevated BPb found. The cost of detecting the 16 children with elevated BPb levels at all other practices was $2015 per case found. If only children living in houses built before 1960, or who had moved, had BPb testing, the cost of detecting the 27 cases found would have been $618 per case. The additional cost of missing two children with elevated BPb is unknown.

DISCUSSION

In this sample of suburban children, predominantly white, insured, with well-educated mothers, and seen in private practice settings, only 2.1% of children had a BPb level ≥10.0 μg/dL. Preliminary analysis of 1990 Census data indicates that 50% of the US population now resides in suburban communities (*The New York Times*, December 18, 1991:A24). The low prevalence of elevated BPb levels in these suburban children and the large number of children living in suburbia, suggest that the applicability of recent federal and state screening guidelines should be questioned.

Prevalence of Elevated BPb Levels

Published reports estimate higher prevalence of elevated BPb levels than we found in this study. The second National Health and Nutrition Examination Survey, conducted between 1976 and 1980, estimated that 83.9% of white and 99.7% of black children 6 months through 2 years of age had BPb levels in excess of 10 μg/dL.[6]

By 1990, US Environmental Protection Agency program office staff using information from a 1988 Agency for Toxic Substance and Disease Registry report to Congress[7] and other recent information on lead occurrence, estimated that only 15.0% of US children younger than 6 years of age had BPb levels ≥10 μg/dL.[8] Among children not living in deteriorating lead-painted houses, and not exposed to highly contaminated soils, they estimated that approximately 3.5% would have a BPb level >10 μg/dL. This 1990 Environmental Protection Agency estimate is close to what we actually found.

Prevalence rates of elevated BPb at specific sites have been widely variable. Clinics, private practices, and geographic areas have reported prevalence rates from 2% to 76%.[9–20] Estimates and prevalence rates of elevated BPb levels at specific sites differ from ours due to the inclusion of urban children, and a higher percentage of economically disadvantaged children. Urban and economically disadvantaged children have traditionally been the focus of BPb screening programs because they have been found to have high rates of elevated BPb levels.

We believe our results are a nonbiased reporting of the prevalence of elevated BPb levels in our sample. We were able to have parents complete questionnaires on nearly 93% of children in our study population. The only differences found between subjects with analyzable BPb and those with parent-completed questionnaires only was in the prevalence of exposure to a parent with a possible lead-related job or hobby and the likelihood of living in a house built before 1960. We believe the potential for a strong selection bias is unlikely. However, families who are aware of their child's potential risk for elevated BPb may have been more likely to agree to the blood draw. This is an issue in studies with lower response rates; we have analyzable BPb on 79.2% of children. Nevertheless, this might have resulted in a slight overestimate of older housing in the suburbs and overestimate of prevalence of elevated BPb.

Methodologic Considerations

Our data are not drawn from a random sample of children from Chicago suburbs. We therefore cannot assume that the rate of 2.1% having elevated BPb is generalizable. Nevertheless, our results, which include more children living in older homes than in many Chicago suburban areas, are considerably lower than estimates and studies in many other selected areas.

Because we accepted capillary sampling (only) to define low levels, our values may not be a true reflection of venous levels. However, only 15.2% of our confirmation venous samples were higher than the corresponding capillary sample. Several other studies have reported close correlation between venous and fingerstick capillary sampling methods[21,22] and that venous testing is generally lower.[19,21–23] In consideration of these findings, and with the majority of our

sample having capillary BPb <5 μg/dL, we believe the capillary BPb levels in these children adequately reflect the very low levels found in this sample.

We have no reason to suspect that we have missed the age of the expected BPb peak for children at these practices. BPb level peaks in three recently published longitudinal studies were found between 12 months and 2 years,[24–26] although new cases of BPb elevation may continue to be identified throughout the preschool years.[27]

Seasonal patterns that are not always consistent have been demonstrated for BPb levels.[28–30] This is unlikely to be a significant factor in determining the prevalence rate for our sample.

Behaviors and Practices Associated With Lead Exposure

The association of pica with elevated BPb prompted a recommendation for physicians to use questions of pica as a case-finding mechanism.[31] Charney[32] found that mouthing toys, chewing pencils, eating paint chips, and eating outside dirt were behaviors found more frequently in a group of children with high BPb than a group with low BPb. Although eating paint chips did pose an increased risk in our sample, the low prevalence of this behavior in the elevated BPb group makes this question more useful to identify the mechanism of ingestion for those with known elevated BPb than as a criteria by which to screen.

We found eating outside dirt or sand to be equally prevalent in both risk groups. In our study 43.6% of parents reported that their child does/did this often or sometimes, whereas only 20% of parents in Charney's low BPb group[32] reported this behavior. Barltrop's study[33] of the prevalence of pica in a 2-week period reports lower percentages for any form of pica than we found for the single question regarding dirt or sand. Our phrasing of the question most likely included children ever eating dirt or sand which may account for our higher prevalence. A history of foreign body ingestion or entrapment was not a useful predictor of elevated BPb in children going to pediatric practices at a time remote from the event.

We were surprised at the frequency with which tap water was boiled to make the child's formula, a practice recommended on formula labels,[34] although found in some cases to increase the lead contamination of water.[34] Although hot tap water is known to have an increased risk for lead contamination due to increased leaching of lead from pipes and solder,[1] the majority of families surveyed continue to use hot tap water for drinking or cooking.

Published Data Evaluating the CDC Questionnaire

Several other studies are assessing the efficacy of the CDC questionnaire. Schaffer et al,[12] surveying a pediatric continuity clinic at a major teaching hospital in Rochester, NY, found the CDC questions to have a .64 sensitivity for BPb levels ≥10 μg/dL, .77 sensitivity for levels ≥15 μg/dL, and a lower negative predictive value than ours (.81 vs .99) for the CDC questions. They concluded that the CDC lead exposure risk assessment questionnaire is of limited benefit.

A study at a hospital general pediatric clinic and two private practices in San Francisco, CA[18] achieved a sensitivity of .90 based on the combination of the chipping paint and remodeling questions alone. A significant proportion (55%) of CDC questionnaire responses were completed retrospectively by phone interview of the primary caretaker, but preliminary analysis indicates this may not have been a factor in their success rate (D. Tejeda, MD, personal communication, May 5, 1993).

Individual Risk Assessment Questions

We found we could have improved the sensitivity of risk assessment screening by asking the single question, "Does your child live in a house built before 1960?" A risk assessment questionnaire for a suburban population should include this question. It is an easy question to ask, versus the more personally sensitive question, "Is your home in disrepair (ie, peeling or chipping paint)?", can be answered by most suburban parents, and is not dependent on parents perception of the condition of their house or their willingness to admit its condition to their doctor. Our phrasing of the question requesting the approximate year their current house was built may have been key to the high response rate for this question. Only 2% of parents were unable to comply with our instructions to at least guess the decade.

Although the question on parental hobby or job alone was not an accurate predictor of elevated BPb levels in our sample, if such a question were used in assessing risk, it would be helpful to include a table. Exposure of children to lead transported into the home has been well documented,[35] and physicians should consider parental hobbies or jobs if selective BPb testing is practiced.

In this sample with a very low prevalence of elevated BPb, the question about "other child with lead poisoning" was not helpful. Therefore, it should be dropped.

The question regarding lead industries was not answered by 9.9% of parents. A map or list of local industrial lead release sites may be helpful to orient parents to environmental exposure.

The Illinois requirement to also consider exposure to houses built from 1960 to 1977 with peeling or chipping paint or renovation as high risk did not substantially improve the rates of identification of children with an elevated BPb in our sample. Further study should be pursued to see if this is true in other settings. The most recent Illinois revision of risk assessment questions, published after this study was in progress, considers children who live near a major highway at high risk.[3] We did not evaluate the merits of this question.

Because three of the five children missed by the single question "Was your house built before 1960?" had moved, consideration should be made to phrase risk assessment questions, "Has your child ever lived...." versus the current, "Does your child live....". The high mobility of these families with young children suggests that the current wording will fail to place children recently moved from a high-risk home in the high-risk group. Failing to consider past exposure at this young age will miss some children with unacceptable BPb levels.

Cost/Benefit

It is clear that the cost of detecting children with elevated BPb levels in this suburban setting is practice-specific; practices serving children living in older homes had a higher prevalence of children with elevated BPb. The practice with the highest prevalence fortuitously helped keep the cost down by doing venous sampling only, as has been found by others to be cost-effective.[36] Preventing a 1 μg/dL increase in BPb has been calculated to increase the net present value of a child's lifetime earnings by $1147.[37] Estimates of savings from detecting children with elevated BPb in the range we found are not available. Individual children may benefit if parents are able to decrease lead exposure, thereby minimizing duration and degree of BPb elevation.

Recommendations

The CDC statement recommends universal BPb lead screening "unless it can be shown that the community in which these children live does not have a childhood lead poisoning problem."[1] Development of risk assessment questionnaires for use in low-prevalence areas, especially if resources are limited, will help concentrate resources on children at highest risk and reduce the number of children needing BPb tests. In our sample, selective BPb screening of children at high risk by the CDC risk assessment questionnaire would have missed some children with unacceptably high BPb levels. Selective BPb screening may be an alternative in practices or communities that have examined what risk assessment questions are most sensitive in their population.

We believe that in some suburban areas, as in Practices A and B, all children should have BPb tests. Other suburban practices should focus on testing children whose parents respond affirmatively to the following question:

> Has your child **ever** lived in or regularly visited a house **built before 1960?** This could include a day care center, preschool, the home of a babysitter or a relative, etc.

Useful risk assessment questions in other areas and other populations may differ.

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SEX DIFFERENCES IN THE INTERACTION BETWEEN TEMPERAMENT AND PARENTING

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Abstract. Temperament and parent-child relationships were measured in a random sample of 776 children followed over a 10-year period. The goal was to determine whether temperament evolves differently for boys versus for girls, and if so, whether parenting influences gender-specific development. Gender-specific parenting effects on the evolution of difficult temperament were found: low father-daughter closeness, and high mother-son punishment and control led to an increase in difficult temperament, whereas comparable father-son and mother-daughter effects were not present. A possible explanation for these findings is proposed. The contribution of these findings to understanding biology-environment interactions in causing sex differences in development is discussed. *J Am Acad Child Adolesc Psychiatry*. 1992;31(5):790–801. **Key Words:** temperament, parent-child relations, sex-differences, epidemiology, longitudinal.