Prevalence of Lead Poisoning in a Suburban Practice

Karen B. Striph, MD
Sylvania, Ohio

Background. The purpose of this study was to determine the prevalence of elevated blood lead levels (EBLLs, lead ≥10 μg/dL [0.48 μmol/L]) in a suburban family practice setting and to assess the utility of a questionnaire as an alternative to universal screening in identifying individuals with EBLL in a low-risk population.

Methods. Parents bringing children aged 1 through 3 years into the office for any type of visit were offered the opportunity to complete a questionnaire concerning risk for lead poisoning and to obtain free blood lead testing for their child. No child in this study had previously been tested for lead toxicity. The lead levels found on testing were correlated with the questionnaire results.

Results. Two hundred thirty-two children with an average age of 20 months were tested. Blood lead levels ranged from 0 to 53 μg/dL (2.56 μmol/L). Elevated blood lead levels were found in 5.6% of the study population. The five questions suggested by the Centers for Disease Control and Prevention (CDC) were taken as a group, and any "yes" or "don't know" response was considered a risk factor. These questions had a sensitivity of 84.6% and a specificity of 41.6% in identifying children with EBLL. An additional question regarding residence in a home built before 1960 (or not knowing the age of the home) was a better screening test for EBLL (sensitivity 92.3%, specificity 57.1%) than the five CDC questions. Lower household income was associated with an EBLL, but sex, race, and home location (urban, suburban, rural) were not.

Conclusions. Risk-assessment questionnaires are useful tools in selecting children who are at risk for an EBLL from low-risk populations. Comparison of this study with similar studies suggests that the most useful questions for this purpose may vary according to location. In this and other studies to date, however, questionnaires show less than 100% sensitivity in identifying children with EBLL.

Key words. Lead poisoning; children; screening; questionnaires. (*J Fam Pract 1995; 41:65-71*)

Lead poisoning is one of the most common health problems facing children in the United States today. Like hypertension, it is clinically silent unless lead levels are extremely high. The neurobehavioral effects of lead toxicity occur in all developmental stages, with lower lead levels than previously thought, and in groups of children not originally considered at risk, resulting in long-term negative consequences.[1–10]

Based on this growing fund of knowledge, the Centers for Disease Control and Prevention (CDC) revised the guidelines for lead toxicity in 1991. Universal lead screening is now recommended for all children ages 12 to 36 months. Communities exempt from this screening are those in which a large number of children have been screened and the prevalence of elevated lead levels has been found to be low. In these communities, high-risk children, identified by history or questionnaire, should be screened.[11]

Until recently, little has been known about the prevalence of lead exposure in communities that have been traditionally considered low risk; these areas have been neither targeted by researchers nor subjected to universal screening by clinicians. Lowering the warning level of blood lead toxicity to 10 μg/dL (0.48 μmol/L) results in an increased number of seemingly low-risk children being considered at risk for neurobehavioral consequences.[12] The necessity, logistics, and costs of universal screening as

Submitted, revised, February 28, 1995.

From Family Physicians Association, Flower Hospital, Sylvania, Ohio. Requests for reprints should be addressed to Karen B. Striph, MD, 5300 Harroun Rd, Suite 304, Sylvania, OH 43560.

ISSN 0094-3509

opposed to targeted screening are still controversial, especially in low-risk areas.

The cost of lead screening per case found is highly dependent on the prevalence of lead poisoning in a community.[13,14] Recent studies have shown that communities that seem to share the same lead-exposure risk characteristics can have very different prevalences of lead poisoning; the prevalence can vary even between neighborhoods within a single city.[15] This variability would make it difficult for any community to exempt itself from universal screening. A cost-effective alternative would be to test the blood of only those children who are suggested to be at risk by their responses to a screening questionnaire. The purpose of this study was to determine the prevalence of lead toxicity in a suburban practice and to determine whether a questionnaire (or a subgroup of the questions) would effectively select at-risk children.

Methods

Study Population

Patients aged 1 to 3 years who presented to Family Physicians Association of Flower Hospital, their affiliates, or primary care practices in their medical office building were offered an opportunity to participate in the study. Flower Hospital is a 300-bed community hospital in a suburb of Toledo, Ohio, serving a predominantly suburban population that includes some rural and urban patients in its drawing area. As in many family practices, patients of all socioeconomic and insurance types are cared for. Presumably because of the misconception that lead poisoning is a disease solely of the inner-city poor, physicians practicing here consider the area to be at low risk for lead toxicity. Some physicians indicated there was parental resistance to lead testing due to the relative lack of insurance coverage for screening. An informal survey of local physicians showed that the CDC recommendation for universal lead screening was not typically followed.

Lead Testing

Beginning June 1, 1992, and ending December 31, 1993, the parents of children of appropriate ages who presented to participating offices for an office visit were informed of the CDC's recommendation of universal screening by being given a letter by the nurse taking vital signs. Parents were asked to indicate on the letter whether they wished to enroll their child in the study. Nurses and physicians endeavored to offer participation to all age-appropriate children. Attempts were made to obtain demographic information on children whose parents refused to allow lead testing; however, many parents were unwilling to provide this information. Therefore, the exact contact and response rates are unknown. Children could be enrolled only once. Parents who chose to participate were given an informed consent document, followed by a short, multiple-choice risk-profile questionnaire.

Blood was drawn from each participating child by either venipuncture or finger stick, depending on the phlebotomist's choice and the need for additional testing as indicated by the nature of the visit. Lead levels in capillary and venous blood have been shown to be equivalent.[16] Confirmation venous testing was done for all patients with values >20 μg/dL (0.97 μmol/L). The screening test was free to the patient. All specimens were sent to Roche Biomedical Laboratories in Columbus, Ohio, for blood lead analysis. Roche is a licensed, certified laboratory that successfully participates in the CDC proficiency program using the graphite furnace atomic absorption spectrometry method of lead analysis. Each patient's primary care physician was notified of all laboratory results. The CDC's recommendations for follow-up of any patient whose lead level was found to be ≥10 μg/dL (0.48 μmol/L) were supplied to the physician. This study was approved by the institutional review board of the hospital affiliated with the study practice.

Prescreening Questionnaire

The questionnaire included five primary risk questions as outlined by the CDC (Table). Demographic information, such as zip codes and the parents' perceptions of the location of their home (urban, suburban, or rural area), were also included. The remainder of the questions solicited more specific information regarding risk factors, such as the estimated age of the home and daycare environment by decade, proximity to a major highway, and family income. Unlike the group of CDC questions, this questionnaire specifically included "don't know" as a possible response instead of only "yes" and "no." Many parents were unable to estimate the age of their homes and daycare locations.

Results

Usable questionnaires and blood results were obtained from 232 children. An elevated blood lead level (EBLL), defined as ≥10 μg/dL (≥0.48 μmol/L), was found in 13 children (5.6%). The mean level found was 4.94 μg/dL (0.24 μmol/L; standard deviation [SD], 4.43) and the levels ranged from 0 to 53 μg/dL (2.58 μmol/L). Capillary blood was used in 66.4% of the samples and

Table. Lead Screening Questions Used to Identify Children For Whom Blood Testing Would Be Appropriate

Question	% High Risk Patients*	% High Risk Patients with EBLL	Sensitivity, %	Specificity, %	Negative Predictive Value, %	*P* Value
1. Does your child live in or regularly visit a house with peeling or chipping paint built before 1960? This could include a daycare center, preschool, the home of a babysitter or a relative, etc†	40.1	11.8	84.6	62.6	99.2	.002‡
2. Does your child live in or regularly visit a house built before 1960 with recent, ongoing, or planned renovation or remodeling?†	33.6	7.7	46.2	67.1	97.2	NS
3. Does your child have a brother or sister, housemate, or playmate being followed or treated for lead poisoning (that is, blood lead ≥15 μg/dL)?†	3.9	22.2	15.4	98.6	96.9	NS
4. Does your child live with an adult whose job or hobby involves exposure to lead?†	17.2	10.0	30.8	83.6	97.1	NS
5. Does your child live near an active lead smelter, battery recycling plant, or other industry likely to release lead?†	12.1	17.9	38.5	89.5	97.6	.012
6. Was your home built before 1960?§	45.7	11.3	92.3	57.1	99.6	.001‡

**High risk includes the percentage of patients answerig either "yes" or "don't know" to the question.*
†Lead screening questions from the Centers for Disease Control and Prevention questionnaire.
‡Yates-corrected chi-square; other P values in this table are calculated using a one-tailed Fisher's exact test.
§The lead screening question from the local questionnaire that was determined to the the most useful.
EBLL denotes elevated blood lead level (≥10 μg/L [≥.48 μmol/L]); NS, not significant.

venous blood in 33.6%. There was no significant correlation between the type of blood drawing and the presence of an EBLL.

The average age of patients was 20 months (SD, 8.5). Parents identified their own race or ethnicity (82.3% white, 3% black, 6.9% Hispanic, 7.8% other or no response). Without receiving guidelines from the practice staff, parents also made their own judgments regarding the classification of their homes: urban (22.8%), suburban (52.6%), rural (24.6%). In retrospect, these categories were found to overlap considerably. For example, homes with nearly identical locations might be classified as either urban or suburban, depending on the parents' perceptions. Sex, age, race or ethnicity, proximity to a major highway, and home location did not correlate significantly with EBLL ($P>.05$).

About 95% of participants reported family income: 40.5% had an annual household income of less than $20,000; 34.5%, $20,000 to $40,000; and 25%, more than $40,000. Membership in the poorest group (annual family income less than $10,000) was significantly associated with EBLL ($P=.003$, two-tailed Fisher's exact test; relative risk (RR)=5.15; 95% confidence interval [CI], 1.76 to 15.1). No cases of EBLL were found in families with an annual income over $40,000. Neither home location nor ethnicity was significantly correlated with family income in this sample ($P>.05$).

The results of the five CDC questions are reported in the Table. The CDC questions require a response of either "yes" or "no." We found that many parents answered questions with "don't know." Given the purpose of the questionnaire as a screening tool, it seemed reasonable to classify "don't know" responses as "yes" to increase the sensitivity of identifying patients with EBLL. The five questions taken as a group (ie, a high-risk response to one or more of the questions classified a patient in the high-risk group) had a sensitivity of 84.6% and a specificity of 41.6% in identifying patients with EBLL. A high-risk classification carried a relative risk of 3.68 (95% CI, 0.83 to 16.22) for EBLL. The negative predictive value of the CDC questions, used in this way, was 98.7%. If the CDC questions were used as formulated (ie, with high risk defined as a "yes" response, rather than "yes" or "don't know"), they yielded a sensitivity of 76.9% and a specificity of 63.5% for identifying patients with EBLL.

Many parents could not estimate the age of their home even within a decade. By classifying children living in a home known to have been built since 1960 as low-risk and all others (including those who did not know the age of their home) as high-risk, we found that older homes

were significantly associated with EBLL (chi-square, $P<.005$). Older homes carried a relative risk of EBLL of 14.3 (95% CI, 1.9 to 107.9). This question alone had a sensitivity of 92.3% and a specificity of 57.1% in identifying children with EBLL and could have been used to avoid screening in 126 of the 232 children while missing only one child with EBLL.

Either the single question on home age or the set of CDC questions detected all children in this sample with blood lead level ≥15 μg/dL (7.2 μmol/L), the level at which the CDC recommends environmental action, such as nutritional monitoring, surveying the house for peeling paint, and household cleaning to eliminate dust.

Discussion

Universal lead screening is a controversial issue. Some feel that there is insufficient evidence that low levels of lead produce clinically significant detrimental effects, and that, therefore, large-scale screening of populations at lower risk is not warranted. The findings of several studies[17–20] conflict with the CDC's universal lead screening recommendations, suggesting that the CDC failed to consider all available data in developing current guidelines. It is unclear, however, how to define a low-risk area. Advocates of screening argue that lead toxicity is a sufficiently common, preventable disease with important public health implications and that detection and intervention have a positive cost-benefit ratio.[11, 21–24]

This sampling of children aged 1 to 3 years from a suburban (low-risk) practice setting found 5.6% of children with a blood lead level ≥10 μg/dL (0.48 μmol/L). Two children (0.8%) had a blood lead level >20 μg/dL (0.97 μmol/L); neither of the children, whose levels were 27.5 and 53.0 μg/dL (1.33 and 2.56 μmol/L), respectively, would have had lead screening had it not been for this study. Other large studies have found the prevalence of EBLL to vary between 0% and 36%.[12–15, 21, 25–29] This variability is not surprising, since the risk of lead toxicity is clearly related to the current and historical presence of lead in the local environment. It is important to recognize, however, that several groups have recently found that a given city or apparently homogeneous region can vary widely in the prevalence of EBLL between neighborhoods or other subpopulations.

Binns and associates[13] tested the patient population of a consortium of primary care pediatricians in nine suburban Chicago office sites. The range of EBLL prevalence varied from 0% to 12.4% among the different office locations. Of all the blood lead levels ≥10 μg/dL (0.48 μmol/L), only 0.1% were ≥20 μg/dL (0.97 μmol/L) and none were over 30 μg/dL (1.45 μmol/L).

Data obtained by Rooney and colleagues[15] demonstrated a wide difference in prevalences from presumably similar populations in Wisconsin. In this study, patients were screened at two major health care organizations, whose primary care offices included both family physicians and pediatricians. Clinic A had a prevalence of 5.4% of lead ≥10 μg/dL (0.48 μmol/L), whereas clinic B's rate was 16.8%. They could find no demographic differences between either the clinics or the populations studied to account for the divergent findings.

A Pennsylvania suburban family practice attempted to determine the prevalence of lead poisoning in their community[28] but were able to sample only 40 patients because private insurance did not pay for the screenings, and parents were not routinely willing to assume the expense. Therefore, the majority of children tested were insured under Medicaid. Of those tested, 20% had levels ≥10 μg/dL (0.48 μmol/L). The authors of this study doubted the generalizability of their results because of the recruitment problems. The variability in coverage between self-pay, indemnity insurance, health maintenance organizations, and welfare programs causes problems in generalizing lead study results and translating them into reasonable practice patterns.

Gellert and associates[14] felt that they practiced in a high-risk location yet determined that the prevalence of EBLL in their low-income urban children was 7.25% for lead ≥10 μg/dl (.48 μmol/L) and only 0.12% for lead >25 μg/dL (1.21 μmol/L). These values are less than some obtained from low-risk suburban populations. These results suggest that physician perceptions about lead risk for individual patients and their own vicinity may be misleading.

The results of the current study indicate that a questionnaire may be useful in selecting children for lead screening. Testing the efficacy of a questionnaire to predict which patients would have EBLLs has recently been attempted by several different groups. Tejeda et al[26] tested children from an urban, middle-class population who presented to a hospital-based general pediatric clinic or to either of two private offices located in California. The prevalence of EBLL among this group was 6%, and no patients had lead levels >19 μg/dL (0.92 μmol/L). In this population, the CDC questionnaire had a sensitivity of 87% for predicting EBLLs and a negative predictive value of 99%.[26] Questions relating to the home environment were the most sensitive predictors.

Another study by Schaffer and colleagues,[29] which included a high proportion of inner-city residents and Medicaid recipients, tested the CDC questionnaire for two summer months in 1992. Twenty-eight percent of their patients had levels of 10 μg/dL (0.48 μmol/L) or higher, and 5% had levels ≥20 μg/dL (0.97 μmol/L).

These researchers experienced difficulty interpreting the questionnaires because not all patients answered all the questions. These missing responses were presumed to indicate risk. The CDC questionnaire in the study by Schaffer et al had a sensitivity of 70% and a negative predictive value of 81% for lead ≥10 μg/dL (0.48 μmol/L).

In addition to these studies of urban populations, several groups have examined lead levels and prescreening questionnaires in suburban locations. Binns and colleagues[13] used the CDC questionnaire with some additional questions in their suburban Chicago study and found a sensitivity of 69% and a negative predictive value of 99%. One of the additional questions ("Was your house built before 1960?") improved their sensitivity to 83% in detecting children with levels ≥10 μg/dL (0.48 μmol/L). In a large midwestern health maintenance organization, Nordin et al[30] tested children at routine well visits at 9 months and 2 years of age. Including both urban and suburban clinics, an average of 2.5% of the children had lead levels ≥10 μg/dL (0.48 μmol/L). The item with the best predictive value asked parents if their child lived in or visited a house built before 1950. For blood lead levels ≥10 μg/dL (0.48 μmol/L), this questionnaire, which included the CDC's and other questions, had a sensitivity of 75% and a negative predictive value of 98.1%.

The study by Rooney and associates[15] included both CDC and community-based questions. Their own questions were formulated to determine the age of the home, its degree of disrepair, presence of co-residents who smoked, and whether the patient received Medicaid. Sensitivities and predictive values varied between clinics in this study. In the clinic with the lowest prevalence, the sensitivity and negative predictive values of the entire questionnaire were both 100%. Using their data, almost 40% of the study patients would have been considered low risk and, therefore, might not have been screened. In the clinic with the higher prevalence, the sensitivity and negative predictive values of their community-based questionnaire were 90.9% and 95.9%, respectively. The CDC questions alone did not fare as well, with sensitivities in the low- and high-prevalence clinics of 76.9% and 63.6%, respectively.

No two of the previously mentioned studies found the same questions to be equally predictive. Tejeda et al[26] found that "questions about chipping paint and remodeling, when used together, were as effective a screening tool as using all five [CDC] questions." An abbreviated questionnaire that included only the first three of the CDC questions was almost identical in effectiveness to the complete CDC questionnaire for Schaffer's group.[29] Rooney et al[15] found that their own five questions were more effective than the CDC's set of five. The present study found that a single question on the age of the child's home was more sensitive than the CDC's set of questions in predicting EBLL.

It was difficult to overcome physician and parental attitudes to enlist cooperation and study participation. Many believed that our study locale was a low-risk area, in spite of the lack of evidence to support this assertion and the general difficulty in estimating a region's EBLL prevalence, as demonstrated in the other studies cited. Informal surveys of our physicians and their local colleagues initially found that lead screening was rarely performed, despite knowledge of CDC recommendations. This informal survey is comparable to the one performed by Bar-on[31]: of more than 500 pediatricians responding, only 12% were practicing universal screening.

These attitudes contributed to the largest weakness of this study: the participation rate and its corresponding small sample size. Although we attempted to enroll or offer the test to all children who presented to the office sites for care, the physicians and nurses sometimes were "too busy" or "forgot" to offer the test to their patients. Others were also reluctant to offer the screening to children who presented for "sick" visits, even though they could have scheduled the testing for a future time. This problem eventually lessened, as a growing number of practices incorporated the screening test into their routines (typically obtaining a lead level at the same time as the 1-year hemoglobin test). Despite the recent publicity in the national media and local newspapers about the hazards of lead exposure, parents also frequently considered their children's risk too low to warrant the time required to complete the questionnaire, or were unwilling to subject their child to the discomfort that would result from the phlebotomy. Both medical personnel and parents considered the CDC recommendation to be just that: a recommendation rather than a mandate for blood testing. Since the screening was cost-free, it is apparent that the recommendations of the CDC did not enhance parents' willingness to have their children screened for lead. Another potential weakness of the study was the limited age range included. The ages chosen were recommended in the universal screening guidelines of the CDC for patients without known risk factors.[11]

Additionally, many parents responded to a number of the questions with "don't know," limiting the usefulness of a questionnaire intended to identify patients for whom testing would be appropriate. In keeping with the spirit of screening, patients answering "don't know" should probably be considered at risk, thus raising sensitivity but lowering specificity. Another interesting problem was that neither parents nor physicians agreed about whether certain homes were "urban," "suburban," or "rural." Many believe that an "urban" home location is a

risk factor for EBLL. This study found a trend to support this but it was not statistically significant ($P>.05$). This trend may reflect broad overlap in parents' identification of their homes as urban vs suburban, similarity in housing age between the suburban and urban drawing area of the practices, or some unknown factor.

Based on this study and others, it seems that a prescreening risk questionnaire could be useful in identifying children at risk for lead poisoning who otherwise would not be perceived to be at risk by their primary care provider.[13,15,26,30] Selecting a higher risk subpopulation from a low-risk general community would decrease the health care dollars spent on screening by reducing the number of children subjected to blood lead determination. This option, however, is based on the possibility that some children with EBLL will not be identified. The CDC's group of questions may not be the most useful screening tool in all locales. To maximize sensitivity, communities may wish to develop screening questions appropriate for their own region or consider combining the CDC questions with those found to be useful in other studies, such as the age of the child's home or the family income. In the studies cited, however, even the best community questionnaires might miss up to 14% of children with EBLL. If this rate of omission were considered worthy of concern and worth the screening costs, universal screening for lead toxicity would be warranted.

Conclusions

The CDC recommends universal blood lead screening for toxicity unless a community has determined that its own prevalence of elevated blood lead levels is acceptably low (without actually defining this acceptable level). Studies have shown a wide variability in EBLL prevalence between "similar" communities and even within communities. Without a period of local universal screening, it may not be possible to know a specific community's prevalence of EBLL. If the costs, monetary and otherwise, of universal screening are to be avoided, physicians may wish to select high-risk patients for screening with a questionnaire. Whether this is a cost-justified trade-off or proof that universal screening is still necessary depends on the reader's viewpoint in the controversy about management of low lead levels. A community-specific questionnaire or the addition to the CDC questionnaire of questions that are specific to a given area can improve sensitivity in detecting patients with EBLL.

Acknowledgments

This work was supported, in part, by funding from the Ohio Academy of Family Physicians and the Centers for Disease Control and Prevention.

Statistical assistance was provided by Cheryl Bourguignon, PhD, of Toledo, Ohio. The author wishes to thank the physicians, nurses, laboratory technicians, and office personnel who assisted in this study.

References

1. Dietrich KN, Krafft KM, Bornschein RL, et al. Low-level fetal lead exposure effect on neurobehavioral development in early infancy. Pediatrics 1987; 80:721–30.
2. Bellinger D, Leviton A, Waternaux C, Needleman H, Rabinowitz M. Longitudinal analyses of prenatal and postnatal lead exposure and early cognitive development. N Engl J Med 1987; 316:1037–43.
3. Wigg NR, Vimpani GV, McMichael AJ, Baghurst PA, Robertson EF, Roberts RJ. Port Pirie cohort study: childhood blood lead and neuropsychological development at age two years. J Epidemiol Community Health 1988; 42:213–9.
4. Needleman HL, Gunnoe C, Leviton A, et al. Deficits in psychologic and classroom performance of children with elevated dentine lead levels. N Engl J Med 1979; 300:689–95.
5. Bellinger D, Needleman H, Bromfield R, Minty M. A follow-up study of the academic attainment and classroom behavior of children with elevated dentine lead levels. Biol Trace Elem Res 1984; 6:207–23.
6. Needleman HL, Schell A, Bellinger D, Leviton A, Allred EN. The long-term effects of exposure to low doses of lead in childhood, an 11-year follow-up report. N Engl J Med 1990; 322:83–8.
7. Baghurst PA, Tong S-L, McMichael AJ, Robertson EF, Wigg NR, Vimpani GV. Determinants of blood lead concentrations to age 5 years in a birth cohort study of children living in the lead smelting city of Port Pirie and surrounding areas. Arch Environ Health 1992; 47:203–10.
8. Lyngbye T, Hansen ON, Trillingsgaard A, Beese I, Grandjean P. Learning disabilities in children: significance of low-level lead-exposure and confounding factors. Acta Paediatr Scand 1990; 79: 352–60.
9. Needleman HL, Bellinger D. The health effects of low level exposure to lead. Ann Rev Public Health 1991;12:111–40.
10. Bellinger DC, Stiles KM, Needleman HL. Low-level lead exposure, intelligence and academic achievement: a long-term follow-up study. Pediatrics 1992; 90:855–61.
11. Centers for Disease Control. Preventing lead poisoning in young children. Atlanta, Ga: Department of Health and Human Services, 1991.
12. Blatt S, Weinberger H. Prevalence of lead exposure in a clinic using 1991 Centers for Disease Control and Prevention recommendations. Am J Dis Child 1993; 147:761–3.
13. Binns HJ, LeBailly SA, Poncher J, Kinsella TR, Saunders SE, Group PPR. Is there lead in the suburbs? Risk assessment in Chicago suburban pediatric practices. Pediatrics 1994; 93:164–71.
14. Gellert GA, Wagner GA, Maxwell RM, Moore D, Foster L. Lead poisoning among low-income children in Orange County, California. JAMA 1993; 270:69–71.
15. Rooney BL, Hayes EB, Allen BK, Strutt PJ. Development of a screening tool for prediction of children at risk for lead exposure in a midwestern clinical setting. Pediatrics 1994; 93:183–7.
16. Schlenker TL, Fritz CJ, Mark D, et al. Screening for pediatric lead poisoning: compatibility of simultaneously drawn capillary and venous blood samples. JAMA 1994; 271:1346–8.
17. Cooney GH, Bell A, McBride W, Carter C. Low level exposures to lead: the Sydney lead study. Dev Med Child Neurol 1989; 31: 640–9.

18. Ernhart CB, Morrow-Tlucak M, Wolf AW, Super D, Drotar D. Low level lead exposure in the prenatal and early preschool periods: intelligence prior to school entry. Neurotoxicol Teratol 1989; 11: 161–70.
19. Greene T, Ernhart CB. Dentine lead and intelligence prior to school entry: a statistical sensitivity analysis. J Clin Epidemiol 1993; 46:323–39.
20. Sayre JW, Ernhart CB. Control of lead exposure in childhood. Am J Dis Child 1992; 146:1275–7.
21. Agency for Toxic Substances and Disease Registry. The nature and extent of lead poisoning in children in the United States: a report to Congress. Atlanta, Ga: Department of Health and Human Services, 1988. DHHS document No. 99–2966.
22. Schlenker TL. Lead poisoning in children, the ramifications and the road to prevention. Postgrad Med 1992; 92:69–74.
23. Rosen JF. Health effects of lead at low exposure levels. Am J Dis Child 1992; 146:1278–81.
24. Mahaffey KR. Exposure to lead in childhood, the importance of prevention. N Engl J Med 1992; 327:1308–9.
25. Rifai N, Cohen G, Wolf M, et al. Incidence of lead poisoning in young children from inner-city, suburban, and rural communities. Ther Drug Monit 1993;15:71–4.
26. Tejeda DM, Wyatt DD, Rostek BR, Solomon WB. Do questions about lead exposure predict elevated lead levels? Pediatrics 1994; 93:192–4.
27. San Francisco Department of Public Health. Childhood lead poisoning surveillance, San Francisco, 1991. Bureau Epidemiol Dis Control Epidemiol Bull 1992; 9:9–14.
28. Kirchner JT, Kelley BA. Pediatric lead screening in a suburban family practice setting. J Fam Pract 1991; 32:397–400.
29. Schaffer SJ, Szilagyi PG, Weitzman M. Lead poisoning risk determination in an urban population through the use of a standardized questionnaire. Pediatrics 1994; 93:159–63.
30. Nordin JD, Rolnick SJ, Griffin JM. Prevalence of excess lead absorption and associated risk factors in children enrolled in a midwestern health maintenance organization. Pediatrics 1994; 93:172–7.
31. Bar-on ME, Boyle RM. Are pediatricians ready for the new guidelines on lead poisoning? Pediatrics 1994; 93:178–82.