Elevated Blood Lead Levels in Children —A 27-City Neighborhood Survey—

JAMES M. SIMPSON, JOHN L. CLARK, PhD, ROGER S. CHALLOP, MD, and EDWARD B. McCABE, MD

FROM SPRING 1971 through early 1972, personnel of the Bureau of Community Environmental Management in cooperation with local health departments conducted neighborhood surveys in 27 cities. The purpose was to assess the proportion of children aged 1 to 6 with elevated blood lead levels who lived in older housing where the interior use of lead-based paint was likely.

At the time of the survey reported here, the authors were members of the staff of the Division of Community Injury Control, Bureau of Community Environmental Management, Health Services and Mental Health Administration. Tearsheet requests to Dr. John L. Clark, 8001 Federal Office Bldg., 550 Main St., Cincinnati, Ohio 45202.

Only cities which were not currently conducting a screening program for childhood plumbism were included in the survey. The 27 cities were well dispersed throughout the various regions of the nation, with 23 States being represented. The cities were: Chester, Pa.; Des Moines, Iowa; San Antonio, Tex.; Trenton, N.J.; Nashua, N.H.; Denver, Colo.; Nashville, Tenn.; Pasadena, Calif.; Toledo, Ohio; Sacramento, Calif.; Portland, Oreg.; Wilmington, Del.; Spokane, Wash.; Lexington, Ky.; Indianapolis, Ind.; Binghamton, N.Y.; Stamford, Conn.; Salt Lake City, Utah; Flint, Mich.; Wichita, Kans.; Tulsa, Okla.; Pensacola, Fla.; Dayton, Ohio; Hoboken, N.J.; Charleston, S.C.; Albuquerque, N.Mex.; and Harrisburg, Pa.

After various biological variables which might be employed in a lead screening program were considered, measurement of the blood lead concentration was chosen. A new method of trace metal analysis (*1*), anodic stripping voltammetry (ASV), was selected as the analytical method, since sufficient blood for paired determinations, 0.2 ml., could be obtained by fingerstick and the problems associated with obtaining 10 ml. samples by venipuncture from small children could thereby be avoided.

As a check on the ASV analyses, 5 percent of the children screened were to have venipuncture samples drawn for analysis by a reference laboratory. Because of an untimely death and an unexpected resignation, the laboratory originally selected was unable to provide the reference service.

Dr. J. Julian Chisolm, Jr., and his associates at Johns Hopkins University were then asked, and they agreed, to perform the reference laboratory service. However, the necessity to change reference laboratories after the survey had begun resulted in lack of monitoring of the ASV results for the first few participating cities. More seriously, inaccuracies in the ASV determinations were not recognized, examined, and corrected as quickly as desirable.

All children with an initial blood lead level greater than or equal to 40 μg. per 100 ml. whole blood were to be retested. The participating local health agencies accepted responsibility for providing necessary diagnostic services and therapy. It was also agreed that a poisoned child would either be relocated in a safe environment or that the lead paint in the home would be removed.

In conjunction with the screening of children, homes were evaluated for high concentrations of lead on painted surfaces, using K X-ray fluorescence analyzers. When obtained, this information was entered on the child's screening form.

Results

Blood lead determinations. Agreement was erratic between ASV determinations and reference laboratory determinations or the results on retesting of children with apparent elevated blood lead levels. Data analysis of the surveys in some cities indicated satisfactory agreement; data from surveys in other cities showed an inexplicable lack of agreement. Therefore, the results which follow are based on blood lead levels determined through analysis of venipuncture samples by macro atomic absorption spectrophotometry (AAS) or dithizone methods.

In two cities in which surveys were conducted, venipuncture samples as well as fingerstick samples were obtained from virtually all children screened. Besides the usual purpose of determining the proportion of children with elevated blood lead levels, these surveys were designed to uncover the kinds of difficulties encountered with mass screening using ASV determinations and to ascertain whether, after modification, the problems had been solved. Since the blood samples in these two cities were collected and analyzed differently, the results of these surveys are reported separately.

In the other 25 of the 27 cities where neighborhood surveys were conducted, a total of 499 macro determinations on venipuncture samples were reported on 2,043 children screened. These determinations, which were either AAS analyses or dithizone analyses, were made either as part of the 5 percent sample for the reference laboratory or as confirmatory determinations on children whose blood lead level was greater than or equal to 40 μg. according to the original ASV result. Of those 499 determinations, 124 were greater than or equal to 40 μg.; therefore, of 2,043 children screened in 25 cities, at least 6 percent had an indicated elevated blood lead level. The 499 determinations included 335 samples from black children; 109 (32.5 percent) were greater than or equal to 40 μg. For 154 nonblack children, 15 (9.7 percent) determinations were greater than or equal to 40 μg. The color of 10 additional children was not known.

In 23 of the 25 cities, at least one child was found to have a blood lead level greater than or equal to 40 μg., through analysis of a specimen obtained by venipuncture. Reports of two analyses of venipuncture specimens have been received from one of the other two cities. No reports of venipuncture specimen analysis have been received from the other city.

In the surveys in the two cities where venipuncture samples were obtained from substantially all those screened, more than 95 percent of the children were black; thus, no useful information could be obtained about the prevalence of elevated blood levels in nonblack children. A total of 266 children were screened in these cities, and 87 (32.7 percent) had levels greater than or equal to 40 μg.

The ASV results in the first of the two cities, before any substantial changes were made in sample collection or laboratory procedures, were in general lower than AAS results. The mean difference in paired venous samples was more than 11 μg.

Of those children in all 27 cities who had venipuncture samples analyzed and whose ages were reported, 25.8 percent of those under 3 years of age had blood lead levels greater than or equal to 40 μg. The percentage for children age 3 and over was higher, 31.4 percent.

History taking. Two questions asked on the child's screening form related to possible exposure: "Does child eat nonfood substances?" and "Is there loose, flaking paint in the house?"

To the question on the eating of nonfood substances, an affirmative answer was given about half of the time for children under age 3. For children age 3 and over, an affirmative answer was given about one-third of the time. There was little difference in the responses for black and nonblack children.

Answers to the query about loose flaking paint were affirmative 56 percent of the time. Again, there was little difference in the responses for black and nonblack children, nor was there any appreciable difference associated with the children's ages.

Pearson chi-square tests for association were made for elevated blood lead levels and reported eating of nonfood substances and for elevated blood lead levels and reported loose flaking paint. Testing at an alpha level = 0.1, the null hypothesis of no association could not be rejected in either case.

Home inspections for lead paint. The amount of lead paint which a child may ingest regularly without peril is so minute that the K X-ray fluorescence analyzers used lack sufficient sensitivity to determine that any painted surface tested would be free of a dangerous quantity of lead (*2*). The analyzers were used to ascertain (*a*) which surfaces almost certainly had lead paint—criterion, a mean of 3 readings greater than or equal to 2.0 mg. Pb per cm.^{2}, (*b*) which surfaces probably had lead paint—criterion, a mean of 3 readings between 1.0 and 1.9 mg. Pb per cm.^{2}, and (*c*) which surfaces were inconclusive as to the presence of lead paint—criterion, a mean of 3 readings less than or equal to 0.9 mg. Pb per cm.^{2}.

A total of 1,256 homes were inspected. In 74.3 percent of these homes, at least one interior surface almost certainly had lead paint. An additional 13.9 percent of the homes had at least one interior surface which probably had lead paint. The range by cities of homes inspected which had at least one interior surface almost certainly covered with lead paint was 48 to 100 percent.

A Pearson chi-square test for association was made for elevated blood lead levels and the presence of an interior surface with a mean reading greater than or equal to 2.0 mg. Pb cm.^{2}. Testing at an alpha level = 0.1, the null hypothesis of no association could not be rejected.

Another test was made for the association between reported loose flaking paint and the presence of an interior surface with a mean reading greater than or equal to 2.0 mg. Pb per cm.^{2}. The null hypothesis of no association was rejected, testing at an alpha level = 0.1. In fact, the calculated chi-square value of 19.136 with 1 degree of freedom would result in rejection of the null hypothesis at an alpha level = 0.001. In part, the large calculated chi-square value is attributable to the large sample size (N=1,104), but there appears to be some useful predictive power in the question. In instances where an affirmative answer was given to the query, "Is there loose flaking paint in the house?", a mean reading on an interior surface greater than or equal to 2.0 mg. Pb per cm.^{2} was reported in 62.8 percent of the homes examined. In instances where a negative answer was given to the question, the mean high reading on an interior surface was reported in only 47.7 percent of the homes examined.

Discussion

Since children and families were included in the screening program on a voluntary basis, no random sampling was done. Therefore, any inferences to a generalized population should be tempered with caution. Furthermore, there are lacunae in the results which make interpretation difficult. Even so, some observations may be made.

Elevated blood lead levels. It is evident that children with elevated blood lead levels, that is children with levels greater than or equal to 40 μg. per 100 ml. whole blood, may be found in many cites throughout the United States. Of the 27 cities in which surveys were made, children with elevated levels were not reported in only two cities; in these two cities, the lack of recorded elevations was likely due to the dearth of venipuncture specimens analyzed.

In the 25 cities where limited venipuncture samples were obtained, the 6.1 percent rate of elevated blood lead levels probably understates the prevalence of elevations. Two observations support this conclusion: (*a*) in the two cities where extensive venipuncture sampling was done, the elevated rate was much higher, 32.7 percent, and (*b*) in the first city where extensive venipuncture sampling was done to evaluate ASV results under field conditions, the ASV results were markedly lower than comparable AAS determinations, which suggests that some children who actually had blood levels greater than or equal to 40 μg. had been missed and thus did not have a confirmatory analysis of a venipuncture sample.

The higher rate of elevations observed for children age 3 and over compared with younger children indicates that undue lead absorption in children is not limited to the toddler teething on a lead painted surface. A number of children past the primary teaching age must be voluntarily eating lead paint and possibly other leaded substances.

The elevated rate for black children was more than 3 times the rate for nonblack children who had venipuncture specimens analyzed. In addition, the rates for black children in the 25 cities and in the 2 cities where extensive venipuncture sampling was done are virtually identical. Obviously., black and nonblack children were not matched for socioeconomic characteristics or for possible sources of lead paint. However, similar results have been reported elsewhere (*3*). Further investigation is needed to determine whether there is in fact a racial difference, and, if so, the causal factors involved.

History taking. Both questions relating to possible exposure proved nonproductive in terms of predicting which children would have elevated blood lead levels, even though significant testing was done at an alpha level = 0.1 rather than the more conventional level of 0.05 in order to increase the power of the test. Furthermore, the responsible adult who brought the child in for screening did so voluntarily, with the understanding that testing was for the purpose of finding children poisoned through the eating of lead paint. The purpose of the questions should have been clear.

The responses to the questions were essentially the same for black and nonblack respondents; therefore, if there is a true difference in blood lead elevations by race, the responses concerning eating nonfood substances and the presence of loose, flaking paint do not help to explicate the difference.

Lead paint in the house. In the homes inspected in every city, lead paint was widely found on interior surfaces accessible to children. Indeed, the inability to show an association between the presence of lead paint in the home and blood lead elevations can be explained by the ubiquity of lead paint.

The association between an affirmative reply about loose, flaking paint and the detection of lead paint in the home may be due to a more thorough investigation of homes with paint in poor condition, since the investigators were instructed to give special attention to peeling or flaking surfaces which had paint easily accessible to children. If this is the case, then there is an implication that the surfaces in poor condition contain lead, which accents the potentially hazardous character of the housing.

ASV blood lead determinations. As has been noted, there were difficulties with the ASV determinations. Such difficulties are to be expected. In the words of one team of investigators (*4*): "The problems that are connected with Pb-B analyses are too well known to be repeated here." We might add that there are special problems associated with sampling in many different locations and with analyzing many samples in a short period.

In our opinion, the factors contributing to the low reported ASV results were corrected, and the method was shown to provide satisfactory results in the second city where extensive venipuncture sampling was done. The field trial design used and the results obtained are properly the subject of a separate report, however, and do not belong in a summary of neighborhood surveys.

REFERENCES

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