Does asymptomatic lead exposure in children have latent sequelae?

Seventy children who had had exposure to lead but had not had symptoms related to it were evaluated at four years of age using a series of psychological tests. Results were compared to those of similar evaluations of 72 children with comparable socioeconomic backgrounds but presumably without unusual exposure to lead. Sixty-five per cent of the control children but only thirty-five per cent of the lead-exposed ones performed normally in all areas tested (I.Q., fine motor development, gross motor development, concept formation, behavior). Deficits occurred most frequently in fine motor function and behavior. The majority of children in each group had an average I.Q.

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A LARGE percentage of children who survive acute lead encephalopathy have brain damage manifest by gross neurologic and sensory abnormalities; these include mental retardation, convulsions, hemiparesis, blindness, and severely deviant behavior.[1-3]

Many children with lead poisoning without clinical encephalopathy show subtle signs of brain injury on later evaluation. These deficits occur most frequently in the area of visual motor perception or behavior while in many instances the global intelligence remains normal.[4, 5]

It has been suspected that lead acquired in quantities insufficient to cause acute clinical symptoms may result in neurologic damage.[1, 3, 6] Controlled prospective studies have not been done to prove or refute these consequences.[6] This research was undertaken to determine if children with asymptomatic lead exposure do show latent sequelae.

MATERIALS AND METHODS

The development of 4-year-old children with proved lead exposure was compared to that of 4-year-old children with similar family background who presumably had not had undue exposure to lead.

All children were members of the Child Development Study at the Medical College of Virginia in Richmond, a participant institution of the Collaborative Study of Cerebral Palsy, Mental Retardation, and Other Sensory Disorders of Infancy and Childhood. The total population consisted of 3,46[illegible] mothers who were followed during pregnancy and delivery and whose children were postnatally evaluated by regular pediatric neurologic examinations, psychological testing, and medical interviews.

Beginning in 1963 trained interviewers

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Table I. Characteristics of children with lead exposure and of those in the control group

Characteristics	*Children with lead exposure N = 70*		*Children without lead exposure N = 72*	
Race	Black 64	White 6	Black 64	White 8
Sex	Male 32	Female 38	Male 34	Female 38
Socioeconomic index	Mean 3.2	S.D. 1.3	Mean 3.2	S.D. 1.3
Mother's SRA nonverbal I.Q.*	Mean 77	S.D. 16.7	Mean 81	S.D. 16.4
Housing density	Mean 1.5	people/room	Mean 1.5	people/room
No. of children below 6 yr.	Mean 2.1		Mean 2.2	

*Published by Science Research Associates, Inc., Chicago, Ill., 1947.

questioned all mothers at each clinic visit regarding their children's pica habits, the substance ingested, and the duration of the event. During home visits the family composition and the living conditions, including size and state of repair of the dwelling, were evaluated. This approach developed more reliable information than that usually garnered in the regular clinic.[7]

From all children with a definite history of paint and plaster intake between one and three years of age, 70 individuals were selected who lived in old dilapidated houses and had positive tests for urinary coproporphyrins.[8] The urine samples were examined for the presence or absence of fluorescence and reported as positive or negative. In addition, all 70 youngsters had a blood lead level of 0.04 mg. per cent or above (mean 0.058 mg. per cent; range 0.04 to 0.1 mg. per cent) or a lead level of at least 0.03 mg. per cent with positive radiographic findings consisting of lead lines in the long bones, metallic densities in the intestines, or both. Blood lead level determinations were performed with the United States Public Health Service dithizone procedure in the toxicology laboratory of the Commonwealth of Virginia's medical examiner. All radiographs were taken at the department of radiology of the Medical College of Virginia and interpreted by a qualified radiologist. None of these children had obvious signs of lead intoxication by examination or from the mother's report.

Fourteen children were treated with calcium versenate. All children were observed with repeated blood lead level determinations and had normal values (0.03 mg. per cent or below) on discharge from the pediatric clinic.

The control subjects were drawn from a group of children who had no history of paint or plaster ingestion on any of our six specific interviews up to four years of age. Children eating foreign materials other than paint or plaster were included in this group. Unfortunately blood lead levels or radiographic studies were not done on this sample. Thus the control subjects were selected by choosing children from an environment which provided very little opportunity for the ingestion of lead-containing substances and who had no measurable coproporphyrins in their urine. Seventy-two children, living in recently built homes in good repair, were matched for age, race, sex, and several socioeconomic variables (Table I). The socioeconomic index used takes into account education and occupation of the head of the household and family income.[9] The majority (87 per cent) of control children lived in city housing projects. Those cared for by babysitters in old neighborhoods were excluded.

Families in both experimental and control groups lived in the same general area of Richmond and came from the same basic population. From the group of children with lead exposure as well as the control group all individuals were excluded who showed signs of neurologic abnormality or developmental lag on pediatric and neurologic examinations during the newborn period and at four months or at the eight-months developmental test (Bayley scale). Also excluded were children who had confirmed or suspected

Table II. Performance of 4-year-old children with lead exposure and of the control children on selected psychological tests

Item	Children with lead exposure		Children without lead exposure	
	No.	%	No.	%
I.Q. (Binet)*	69		71	
Borderline	11	16.0	7	9.8
Mentally defective	6	8.7	0	0.0
Fine motor area†	69		70	
Performance suspect	29	42.0	18	25.7
Performance abnormal	2	2.9	0	0.0
Gross motor area‡	69		71	
Performance suspect	10	14.5	5	7.0
Performance abnormal	1	1.4	0	0.0
Concept formation§	67		71	
Performance suspect	10	14.7	6	8.4
Performance abnormal	0	0.0	1	1.4
Behavior profile‖	69		72	
Performance suspect	18	26.1	7	9.7
Performance abnormal	3	4.3	0	0.0

*$\chi^2 = 5.38$, $P < 0.05$
†$\chi^2 = 5.62$, $P < 0.05$.
‡$\chi^2 = 2.74$, N.S.
§$\chi^2 = 0.88$, N.S.
‖$\chi^2 = 9.50$, $P < 0.01$.

disease or injury of the central nervous system before four years of age.

A series of psychological tests was administered to all children between the ages of $3\frac{11}{12}$ and $4\frac{3}{12}$ years (majority at $4\frac{9}{12}$). This evaluation was done by experienced examiners, following uniform rules for test administration and coding without knowledge of any prior history of the patient.[10]

The test series included the Stanford-Binet Short Form L-M. Fine motor development was assessed with the Wallin peg board, copy forms, stringing beads, and Porteus mazes III and IV. It was coded normal if the child passed three items, suspect if only one or two items were passed, and abnormal if none of the four items was passed. Gross motor development was assessed with line walk, hopping, and ball catch. It was coded normal when two subtests were passed, suspect when one was passed, and abnormal when none of the three items was passed. Some aspects of concept formation were examined with a modification of the Graham-Ernhart block sort test. Included was a behavior profile consisting of ten 5-point rating scales for the child's behavior during the psychological test situation. Interinstitutional quality control trials of the Collaborative Project have shown tester-observer ratings for these scales to be in complete agreement in 91 per cent of 118 cases.

Table III. Results of the psychological evaluation of 4-year-old children with lead exposure and of those in the control group*

Psychological evaluation	Children with lead exposure		Children without lead exposure	
	No.	%	No.	%
Normal I.Q. All other areas of the test battery† normal	24	34.8	46	64.9
Normal I.Q. Failure in one or more of the other areas of the test battery†	28	40.7	18	25.3
Low I.Q.‡ All other areas of the test battery† normal	3	4.2	1	1.4
Low I.Q.‡ Failure in one or more of the other areas of the test battery†	14	20.3	6	8.4

*$\chi^2 = 13.23$, $P < 0.01$.
‡See Table II.
‡Low I.Q. combined for a 2×3 contingency table due to low cell frequency of low I.Q. only.

RESULTS

Findings for the major areas of the psychological evaluations of children with lead exposure and those without are shown in Table II.

Testing with the Stanford-Binet revealed a mean I.Q. of 89 (S.D. 13.1) for patients with lead exposure and a mean I.Q. of 94 (S.D. 10.5) for the control subjects. Both samples had large numbers of children with average intelligence (lead-exposed children 75.3 per cent, control subjects 88.8 per cent). Fine motor tests were most frequently failed in both groups, but failure occurred almost

twice as often in lead-exposed children. Failure in the gross motor category was apparent to a lesser degree. There was no significant difference on the Graham-Ernhart block sort test.

Deviations in our over-all behavior ratings occurred almost three times as often in children with lead exposure compared to the control subjects. The most frequent combination of behavior characteristics was extreme negativism, distractibility, and constant need for attention. This triad occurred in 18 children with lead exposure (25.7 per cent) compared to four control subjects (5.5 per cent) (χ^2 11.17, $P < 0.01$).

Table III, representing the outcome of the entire test series, shows that children with lead exposure compared to the control subjects had a significantly greater chance to have a deficit in one or more of the areas tested.

DISCUSSION AND SUMMARY

Psychological evaluation at four years showed the performance of lead-exposed children to be inferior to that of youngsters who in all likelihood were not exposed to increased quantities of lead. A large number of lead-exposed children had normal intelligence but failed in one or more of the other areas tested. The most significant difference between both groups was found in the fine motor and behavior areas. Since the group of lead-exposed children contained more mentally subnormal children, low I.Q. might have biased these results. When only children with normal I.Q. were evaluated, the difference in the behavior area remained significant.

The presented results are considered preliminary. Lead levels in the control group were not done. The selection of control children was based on their presumably lead-free environments and was further supported by negative coproporphyrin urine tests. Therefore, definite statements regarding comparative differences in lead burden in the two groups cannot be made. Admittedly, the differences found may be due to environmental factors other than lead. More rigidly controlled prospective studies should be done to clarify whether subclinical amounts of lead do have measurable sequelae.

The deficits found may be reflected in the child's later development or they may improve or disappear if, for example, they had resulted from an increased lead burden at the time of testing.[11] We hope to shed some further light on this issue by re-examining the same groups of children at seven years of age.

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