Varying Psychological Sequelae of Lead Ingestion in Children

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DOES excessive lead ingestion permanently affect the mental development of children when ingestion is not associated with lead encephalopathy?

Most research workers agree that pica is a predisposing factor to lead poisoning in children older than 18 months. This fact raises the question that older children who have pica might be retarded or brain damaged or, before ingesting lead, have had emotional difficulties which consequently lowered intellectual functioning.

The lack of diagnostic uniformity and attention to type of patient used for study purposes were conspicuous in the studies I will review in this paper. In a recent review of lead poisoning in childhood, Chisolm and Kaplan (*1*) noted the severe effects of lead encephalopathy. Surviving children so affected were often markedly retarded.

Lead poisoning is difficult to diagnose and to grade according to severity. Blood or urine tests do not correlate perfectly with each other or with severe encephalopathy (*2, 3*). Tests for, and operational definitions of, possible lead poisoning were variable. In any research or survey regarding incidence, this definition is critical. In correlational studies aimed at establishing cause and effect relationships, however, the major research consideration is that the specific operational definitions be reliable, so that their predictive validity may be ascertained.

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Incidence of Lead Poisoning

Some inner city metropolitan areas are frequently referred to as the lead belt. These areas are usually characterized by older poorly maintained dwellings and have a poor and predominantly Negro population. Many older buildings have interior and exterior paint which contains lead pigments. Some children with pica may ingest objects painted with paint containing lead and so become poisoned. All children, however, mouth and ingest inedible objects during the first 18 months of life. Chisolm and Kaplan (*1*) reported that the rate of decline of this normal mouthing of foreign objects was small and that many children ate foreign substances when they were 3 to 5 years of age.

Chisolm and Harrison (*4*) noted that such early mouthing behavior was not dependent upon initial retardation, organic dysfunction, or emotional disturbances. Pica, as a pathological symptom, was said to have a higher incidence in older children who were emotionally disturbed as a result of absent or faulty mothering. Mothers of children with pica suffered from despair and inactivity. Chisolm and Harrison concluded that dwellers of old lead painted houses were likely to be people who rear chil-

dren with pica; even though pica, in a pathological sense of the term, is not a necessary precondition for lead poisoning, particularly in infants less than 18 months of age.

Lead Poisoning Related to Pica

Estimates of the incidence of pica and of lead poisoning vary. Lin-Fu (*5*) previously reviewed relevant studies. Gutelius and co-workers (*6*) reported that it was difficult to locate lower class Negro children without pica to use as control subjects. Other reports (*7*, *8*) suggested that the incidence of both pica and abnormally high lead ingestion was large, but specific data were not provided.

Three reports provided relatively well controlled statistical data about large numbers of children, which suggested that the incidence of pica, lead ingestion, and lead poisoning was surprisingly high among certain selected populations. Bradley and co-workers (*9*) examined 604 children who were patients at a well-baby clinic and a pediatric outpatient department. They were from low income families, 90 percent were Negro, and they were 7–60 months of age. The urine of 197 (33 percent) was positive for coproporphyrinuria, indicating chronic lead intoxication. Of these 197 children, 124 had a history of pica. Abnormally high levels of blood lead (>0.05 mg. per 100 gm.) were noted in 44 percent of 333 children. Eberlein and co-workers (*10*) reported that the urine of 113 of 829 children seen in an outpatient clinic was positive for coproporphyrinuria. The data from both of the preceding studies might be biased because the children had been brought for medical examination.

A study by Griggs and co-workers (*11*) avoided this bias. Three city blocks in Cleveland were selected in a census tract area known to be within the lead belt. A fourth sample was taken in the same area but from a new public housing project free of flaking, leaded paint. Of 801 children, 12–60 months who lived in older housing, 27 percent had abnormally high concentrations of lead or coproporphyrin, or both, in urine samples. Of 105 children living in public housing, only three had urine indicative of abnormal lead ingestion. These data suggest a surprisingly large incidence of lead ingestion and possibly of lead poisoning in a population of exposed children.

Christian and co-workers (*12*) reported data for 1,000 children—half of whom lived in older sections of Chicago and half of whom lived in a control (newly built) area. Eighteen percent of the children from the older section had urine with increased coproporphyrin; only 2.8 percent of the children from the control area had increased coproporphyrin.

Nearly all infants mouth inedible substances before 18 months of age, and because paint containing lead was the preferred high-quality house paint until relatively recently, it is perhaps surprising that the incidence of reported or diagnosed lead intoxication is not higher in neighborhoods with poorly maintained or older housing.

Factors Affecting Controlled Research

Many of the previously cited reports, as well as those by Jacobziner and Raybin (*13*, *14*), have stressed the intimate relationship of pica to lead poisoning. Greenberg and co-workers (*15*) noted that a possible 48 cases of lead poisoning (blood lead >0.06 mg. per 100 gm.) were noted in 194 children who had had pica. In a more recent paper, Jacobziner (*16*) noted that 30 percent of all pica cases reported to child health stations in New York City had blood lead levels of more than 0.06 mg. per 100 gm. Siblings of such children also had elevated blood lead levels, although they were without clinical symptoms of lead poisoning.

Two studies conducted in Washington, D.C., further explored the relationships of pica to lead poisoning. Millican and co-workers (*17*) stated that the etiology of pica and lead poisoning indicate a disturbed mother-child relationship. They noted patients' mothers were immature, related poorly to their children, and actively encouraged oral habits in their children. Gutelius and co-workers (*6*) compared 30 pica-afflicted lower class Negro children with 28 controls. These authors reported no difference in IQ between the two groups of children. The families of pica-afflicted children, however, were more disorganized—there were a greater number of unmarried mothers and more frequent residential moves—than in families whose

children did not have pica. The general nutrition of the two groups of children did not differ.

The design of research studies of mental development frequently neglects the dependent variable. Attention is often given to the development quotient obtained from infants even though many psychologists feel this measure may be a poor predictor of future potential. A standard intelligence test administered to an older child may not be the most important dependent variable in studies of minimal cerebral dysfunction and may not be predictive of future emotional or academic impairment, or both. Desirable dependent measures should include, together with IQ tests in older children, measures of academic achievement and tests of perceptual-motor functioning, sensory discrimination and integration, and aphasic disturbance. Ideally, studies of post-disease effects should have some indication of premorbid functioning. When this is not possible, relevant factors affecting functioning should be controlled. These would include a variety of estimates of socioeconomic status and parental behavior. In the studies to be reviewed, attention was seldom paid to these considerations.

Diagnostic criteria suggested by Chisolm and Harrison (*4*) would seem to be one way of estimating the excessive lead ingestion. The health of the children under study would also affect experimental results and should be controlled. Possibly, anemic children might have different levels with which they are afflicted by excessive lead ingestion. Most critical are children's age and duration of exposure.

Effects of Lead Poisoning

The sequelae of serious lead poisoning associated with severe encephalopathy have been noted. In the epidemiologic studies previously cited, most children with positive laboratory findings were asymptomatic. The unanswered question is: To what extent is future intellectual impairment associated with asymptomatic lead ingestion?

Chisholm (*18*), while reviewing the incidence of lead poisoning and diagnostic criteria, raised the issue as to whether a long standing minor degree of elevation in blood lead concentration would be associated with future neurologic malfunction.

Hardy (*19*) hypothesized that amounts of lead, which are not clinically impressive, interfere with brain enzyme systems if such poisoning occurs during the period of central nervous system growth in early childhood. When such children were 6 to 7 years old, they were said by Hardy to appear in neurological clinics with a variety of behavior disorders, although these children never were reported to have suffered from acute lead intoxication.

Chisholm stated that lead was a major inhibitor of sulfhydryl enzymes and also inhibited the formation of heme. He also said that increased lead intoxication was associated with cranial capillary permeability and petechial hemorrhages causing neural destruction and cerebral edema (*20*). The brain lesions associated with lead-induced encephalopathy have been lucidly described by Blackman (*21*).

In summary, one may speculate that young children may be neurologically affected by excessive lead absorption because of interference with enzyme production and interference with the biosynthesis of heme. In more severe cases, excessive absorption may cause neurological lesions of varying degrees.

In April 1964, J. E. Bradley, chairman, department of pediatrics, University Hospital, Baltimore, Md., in an oral communication, reported that 41 of 116 children of varying ages diagnosed as having blood lead levels greater than 0.05 mg. per 100 gm. were compared with 69 children whose blood lead levels were less than this. Differences between groups were not obtained. Bradley noted that his selection of 41 children with high blood lead might have been biased. In an earlier report, Bradley and coworkers (*2*) followed 10 surviving children who had had convulsions and a blood lead level of more than 0.04 mg. per 100 gm. Only two had IQ scores above 90.

Bradley and Baumgartner (*3*) studied 18 children seen when 2 to 5 years of age, after they had been treated for lead encephalopathy. They discovered that the children's IQs were not notably impaired compared with normative scores, but that the children's responses to the Draw-A-Person and Bender-Gestalt Visual-Motor Test (both of which contain perceptual and motor coordination factors) were impaired.

Of 45 children studied by Byers (*22*), 40 were followed after being treated for lead poisoning. Twenty-one of these were normal, 15 had psychologic defects, and four had died. Thirty-nine of the 45 children were normal before they became ill with lead poisoning. Seventeen of the original sample had encephalopathy, but data were not given on the psychological outcome of the encephalitic group compared with the children without encephalopathy.

Byers and Lord (*23*) reported 20 nonencephalitic cases of lead poisoning in children and observed that 19 of the 20 were educationally retarded. Fourteen of these 20 children had recurrent acute plumbism. Byers and Lord stressed that impairment involved perceptual-motor functioning.

Cohen and Ahrens (*7*) followed 10 children who were not encephalitic but who had other symptoms of lead poisoning. Five had moderate residual mental defects. A high proportion of the siblings of these patients who were without clinical symptoms had laboratory indications of lead ingestion.

Mellins and Jenkins (*8*) rated 15 children after they had been treated for lead poisoning. Prepoisoning status was estimated by interviews with the afflicted child's parents or guardian. Before lead ingestion, three of the 15 were retarded in at least one area of mental functioning compared with 14 after treatment. Immature motor and perceptual-motor behavior, language skills, and personality traits were specifically mentioned as impaired. These children were considered by their mothers as somethat whiny, balky, and cranky.

Jenkins and Mellins (*24*) associated lead poisoning with impaired IQ, speech, and fine motor coordination. Twenty-seven of 32 children were impaired in at least one of these areas after lead poisoning, compared with seven of 32 before lead poisoning.

Smith and co-workers (*25*) studied 40 children by using EEG records 5 years after lead poisoning. These children varied in their likelihood of having had lead poisoning and in the severity of their symptoms. Six of 10 children with lead poisoning associated with encephalopathy had EEG records that showed abnormalities as compared with two of 30 other children.

In a later paper, Smith (*26*) reported that a group of children with lead encephalopathy had a mean IQ of 80, 5 years after initial diagnosis. Another group of children who had lead poisoning without encephalopathy had a mean IQ score of 87. Children with and without pica, who had no symptoms of lead poisoning, had mean IQs of 98. Unfortunately, Smith does not give the number of cases or social status, age, and statistical information regarding the significance of his findings. His study, however, was one of the few which reportedly controls for the independent effects of the degree of lead poisoning and also for pica.

Thurston and co-workers (*27*) followed 11 of 19 survivors of lead poisoning and noted no correlation between the severity of the lead poisoning and degree of mental defect.

Perhaps the most careful research reported has been that of Moncrieff and co-workers (*28*). They compared a sample of 80 nonretarded children who were without pica with several different groups. In the normal group all but two subjects had less than 0.037 mg. per 100 ml. blood lead. One group of 120 subjects were mentally retarded or had had behavioral disturbances or speech defects. Fifty-five of the children had more than 0.038 mg. per 100 ml. blood lead. A second group of 40 children were diagnosed as having encephalitis. Twelve of those children had greater concentrations of lead than 0.038 mg. per 100 ml. A third group consisted of 50 children with anemia, pica, vomiting, or abdominal pain. Twenty-eight of these children had concentrations of more than 0.036 mg. per 100 ml. blood lead.

In a replication of the method used by Moncrieff and co-workers, Gibson and co-workers (*29*) compared the diagnostic indications of lead poisoning of three groups of children. The three groups (20 subjects in each) were classified as normal, retarded with known etiology not related to lead poisoning, and retarded with unknown etiology. The children were between 2–11 years of age and matched for age within groups. An index of housing standards, which was applied in an attempt to control for socioeconomic status, did not discriminate between

groups. Results indicated that raised blood lead levels (>0.03 mg. per 100 ml.) were noted in six of the children with retardation of unknown etiology and in three of the normal children. None of the other children had lead poisoning using this criteria. These results are not significant.

Calculations made from the data provided by Gibson and co-workers, however, indicated that within the normal group, 17 children without raised blood lead levels had a mean IQ of 101.50. The three normal children with raised blood lead levels had a mean IQ of 91.36. Again, numbers were small and controls for relevant variables were not adequate. But this promising methodology suggests further, more comprehensive research would be rewarding.

Perlstein and Attala (*30*) reported data from 425 patients of various ages and cultural backgrounds (white, Negro, private and clinic patients). They noted that 405 of these had pica for paint and plaster. They reported neurological sequelae in about 30 percent of those children where the presenting symptoms were gastrointestinal. Control cases or IQ scores for these patients were not provided.

Conclusions

All but two of the preceding studies reported some degree of mental impairment caused by lead poisoning. Yet it seemed clear that none of the studies provided a definitive answer to the question: Is mental deficiency associated with lead ingestion which is asymptomatic or which produces symptoms less severe than encephalitis?

Those reports which claimed positive findings had either used too few cases from which to generalize or had not provided for controls for relevant variables such as social class, pica, or premorbid status. A rigorous statistical and experimental approach has been conspicuously absent. Further, the variations in diagnostic procedures and definitions lead to unclear conclusions regarding the degree of lead ingestion which may or may not be important for later development.

Questions such as the subjects' age or health status, including anemia, had been avoided most of the time. Age is critical because mouthing of foreign substances is nearly universal before 18 months and also because the first 18 months of life is a critical period of neurological and mental growth.

The necessity for controlling the subjects' sociocultural background, age, nutritional status, premorbid emotional state, and level of intellectual functioning, while varying the degree of lead ingestion, poses difficult research problems. Research using animals could avoid many of these difficulties, but generalizations from comparative research, although frequently fruitful, are also tenuous.

Despite the lack of definite research, there is reason to suspect that undiagnosed and, therefore untreated, lead poisoning is a cause for concern. The frequency of lead poisoning in neighborhoods with older buildings may be greater than generally realized.

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Tearsheet Requests

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Federation of Associations of Schools of the Health Professions

A new organization, the Federation of Associations of Schools of the Health Professions, has been formed. The federation's functions are to improve communication among the professional educational groups, to expand educational opportunities and recruitment of minority groups in all the health professions, and to plan interdisciplinary educational programs. The federation evolved when representatives from professional associations met to review common objectives and possibilities for cooperation in meeting the nation's health manpower requirements.

The 10 associations which form the federation represent about 500 schools, colleges, and programs of dentistry, medicine, nursing, public health, osteopathy, hospital administration, allied health professions, pharmacy, optometry, and veterinary medicine. Representatives from each association sit on the council of the federation.

Dr. Myron E. Wegman, dean of the University of Michigan School of Public Health, is the organization's first chairman. Dr. Hamilton Robinson, dean of the School of Dentistry, University of Missouri, is vice chairman, and Dr. Mary Dineen of the National League of Nursing in New York is secretary.