



## *Project Summary*

# Studies in Children Exposed to Low Levels of Lead

Herbert L. Needleman

Two separate studies were conducted with the overall objective of examining the impact of lead at low dose on the neuropsychological function of children.

In the first study, a sample of children identified as having elevated lead levels in the dentine of shed deciduous teeth (N = 19) were compared to children with low dentine lead (N = 22) on electroencephalograms and a panel of 8 auditory and speech processing tasks.

Quantitative electroencephalograms were obtained from 20 sites under 4 conditions in these subjects. The spectrum from 0.5 - 32 Hz was examined; four bands were studied (alpha, beta, delta, and theta) under four conditions. Of the 320 comparisons, 10 differed at P = 0.025 or less (Wilcoxin-Mann, Whitney two sample test). These 10 features, nine behavioral measures previously obtained, and maternal I.Q. were then submitted to multivariate analysis. A stepwise linear discriminant function analysis showed that adding the EEG to behavioral analysis in the model increased the discriminating power from P = 0.015 to P = 0.001.

The most useful diagnostic features were EEG slowing (delta) over the parietal cortex and decreased full scale I.Q.

Of the 8 speech and auditory outcomes studied, significant differences favoring the low lead group were found on three measures of auditory processing: (1) Goldman-Fristoe-

Woodcock Auditory Selective Attention Test, (2) Staggered Spondaic Word Test (Left noncompeting), (3) Speech Discrimination.

*This Project Summary was developed by EPA's Health Effects Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).*

### Introduction

While the toxicity of lead at high dose is widely acknowledged, considerable controversy exists as to whether lesser doses produce adverse health effects. Lead is known to inhibit certain enzyme systems at extremely low concentrations. Among those most sensitive are D-aminolevulinic acid dehydrase, adeny cyclase, and ferrochelataase. It is not, however, universally accepted that these biochemical changes and other changes represent adverse health effects.

For the purposes of the investigations described below, an adverse health effect is defined as "an alteration in the functioning of an organism which diminishes its ability to adapt to a changing environment. As a result, the organism's longevity, vigor, or reproductive capacity is reduced." In a changing environment, the ability to register change and then make decisions based upon the data is essential to survival. The organ in which these executive

functions primarily reside in the central nervous system. The organizing principle of these investigations is that the child's CNS is a candidate site for the early expression of adverse effects of lead exposure. The Lead Exposure Program at Children's Hospital Medical Center has focused on CNS performance. Earlier studies by the group had reported that children thought to be undamaged by lead, but who had elevated dentine levels, were less able on a number of measures of CNS function when compared to controls. Among the performances which appeared sensitive to lead were verbal intelligence, auditory and speech processing, attention and classroom behavior.

This study examines the electrophysiology of the CNS of a subsample of high and low lead subjects, and also compares them on a number of other measures of auditory and speech processing. A separate sample of children from another city were evaluated by teacher ratings, family history, and their dentine lead levels measured. This offered an opportunity, not only to replicate our previous observations, but to evaluate the effects of lead on classroom performance while controlling more completely for other covariates which could be confounding.

## Conclusions

### Study I

Alterations in neuropsychologic function were demonstrated in electroencephalograms of asymptomatic children with elevated body lead burdens. These changes tended to be located in midline brain structures. The addition of EEG analysis to a battery of psychologic outcomes sharpened diagnostic precision remarkably.

Statistically significant decrease in function was found on three of nineteen speech processing outcomes. Outcomes tended to favor low lead subjects generally. The relatively small sample size may be responsible for the failure of certain outcomes to reach statistical significance.

### Study II

Teachers' Behavioral Ratings as a Function of Lead Burden.

The proportion of negative teachers' reports of classroom behavior tended to increase with increasing dentine lead concentrations. The items most sensitive to lead were distractibility, disorganization, ability to follow a sequence of

directions, and overall classroom functioning.

After data reduction by cluster analysis, the cluster containing the items "distractible" and "disorganized" was found most sensitive to lead exposure. The impact of lead was evaluated by stepwise multiple logistic regression. A significant ( $p = 0.013$ ) lead effect was found, controlling for major covariates. This study replicated in part a previous investigation from this laboratory which shows that teachers' assessments of classroom behavior are sensitive to lead exposure. It goes further than that study by controlling for a number of covariates that could be related to outcome. The ability of the child to inhibit irrelevant stimuli is critical to the task of academic learning. The item "distractible" which evaluates that ability is consistently sensitive to lead exposure. It is reasonable to expect that this deficit is related to the impaired performance on speech processing measured here.

## Recommendations

These studies add to the weight of those which report lead effects at low dose, and demonstrate that the threshold for appearance of adverse behavioral effects is a function of the sensitivity of the methods brought to bear on measuring outcome.

The findings of alterations in EEG, speech processing, and classroom behavior in samples clinically assumed to be free of frank toxicity supports the prudence and hygienic utility of reducing lead in the environment available to children.

Studies of lead effects in children should attend to those behaviors which are expressions of the organism's ability to focus attention.

---

*Herbert L. Needleman, formerly with Children's Hospital Medical Center, Boston, MA, is now with the University of Pittsburgh School of Medicine, Western Psychiatric Institute and Clinic, Pittsburgh, PA 15261.*

*Carl Hayes is the EPA Project Officer (see below).*

*The complete report, entitled "Studies in Children Exposed to Low Levels of Lead," (Order No. PB 82-108 432; Cost: \$8.00, subject to change) will be available only from:*

*National Technical Information Service  
5285 Port Royal Road  
Springfield, VA 22161  
Telephone: 703-487-4650*

*The EPA Project Officer can be contacted at:  
Health Effects Research Laboratory  
U.S. Environmental Protection Agency  
Research Triangle Park, NC 27711*

United States  
Environmental Protection  
Agency

Center for Environmental Research  
Information  
Cincinnati OH 45268

Postage and  
Fees Paid  
Environmental  
Protection  
Agency  
EPA 335



---

Official Business  
Penalty for Private Use \$300

PS 0000529  
U S ENVIR PROTECTION AGENCY  
REGION 5 LIBRARY  
230 S DEARBORN STREET  
CHICAGO IL 60604