

# Exposure to Lead in Children — How Low Is Low Enough?

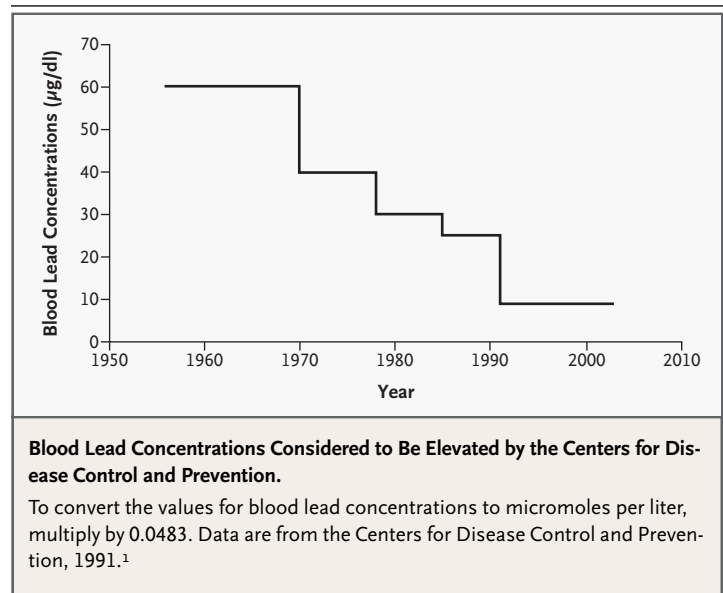
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Encephalopathy in childhood due to lead poisoning was described more than 100 years ago, and cognitive sequelae after recovery were reported in 1943. During the past three decades, epidemiologic studies have demonstrated inverse associations between blood lead concentrations and children's IQs at successively lower lead concentrations. In response, the Centers for Disease Control and Prevention (CDC) repeatedly lowered its definition of an elevated blood lead concentration, which now stands at 10  $\mu\text{g}$  per deciliter (0.483  $\mu\text{mol}$  per liter) (see Figure). Since the removal of lead from gasoline, the median blood lead concentration in U.S. children has fallen from 15  $\mu\text{g}$  per deciliter (0.724  $\mu\text{mol}$  per liter) in 1978 to 2  $\mu\text{g}$  per deciliter (0.097  $\mu\text{mol}$  per liter) in 1999, a triumph for public health. Yet exposure to lead from deteriorating lead paint in older homes continues; of U.S. homes where children under the age of six years live, 25 percent contain hazardous lead paint. The CDC has estimated that in 2000, there were still 454,000 children in the United States with blood lead concentrations greater than 10  $\mu\text{g}$  per deciliter.

In this issue of the *Journal*, Canfield et al. (pages 1517–1526) extend the unfortunately familiar relation between increased blood lead concentrations and decreased IQ to blood lead concentrations below 10  $\mu\text{g}$  per deciliter. Of 172 children in whom blood lead concentrations were measured serially between the ages of six months and five years, 101 did not have a recorded blood lead concentration above 10  $\mu\text{g}$  per deciliter. Strong and significant associations between blood lead concentration and IQ were observed in these children at both three and five years of age. A smoothed curve summarizing the data shows a decline in IQ of more than 7 points over the first 10  $\mu\text{g}$  per deciliter of lifetime average blood lead concentration and a further decline of

approximately 2 points associated with an increase from 10 to 20  $\mu\text{g}$  per deciliter (0.483 to 0.966  $\mu\text{mol}$  per liter).

Although most previous studies have provided little information about children with blood lead concentrations in this range, Canfield and colleagues' findings are a consistent and plausible extension of a very large epidemiologic, clinical, and experimental literature that has indicated adverse effects of lead on cognition. A previous meta-analysis suggested a 2.6-point decline in IQ for an increase in lead concentration from 10 to 20  $\mu\text{g}$  per deciliter.<sup>2</sup> Bellinger et al.,<sup>3</sup> in a study of children with blood lead concentrations closest to those in the current study, estimated a decline of 5.8 points with an increase in blood lead concentration from 10 to 20  $\mu\text{g}$  per deciliter. Although the remarkable steep-



ness in the range below 10  $\mu\text{g}$  per deciliter seen by Canfield et al. is influenced by results in 10 children whose blood lead concentrations were near or below 5  $\mu\text{g}$  per deciliter (0.242  $\mu\text{mol}$  per liter) and whose IQs were above 115, it is unlikely that the association is due only to these observations. To confirm the adverse effects of lead on IQ at these concentrations, more children whose blood lead value has never been more than 10  $\mu\text{g}$  per deciliter should be studied.

Lead exposure is more common among disadvantaged children, and so confounding by maternal IQ, socioeconomic factors, and characteristics of the home environment is always a concern. In the study by Canfield and colleagues, however, the association between the blood lead concentration and IQ persisted even after the investigators accounted for several potential confounders by the best available methods. Although critics question the importance of small decrements in the IQs of individual children, these measures are blunt instruments for detecting subtle changes in brain function; any detectable effect occurring from a widespread exposure is cause for concern. Relatively small changes in the mean IQ of a large number of children will dramatically increase the proportion of children below any fixed level of concern, such as an IQ of 80, and decrease the proportion above any “gifted” level, such as 120.

In a second article in this issue, Selevan and colleagues (pages 1527–1536) report that girls from the nationally representative third National Health and Nutrition Examination Survey who had very slightly elevated blood lead concentrations at 8 to 18 years of age had evidence of delayed puberty. Unlike cognitive development, sexual maturation is a relatively new area of investigation for effects of environmental exposures in general and exposure to lead in particular. In the current report, African-American girls with blood lead concentrations of 3  $\mu\text{g}$  per deciliter (0.145  $\mu\text{mol}$  per liter), as compared with girls with blood lead concentrations of 1  $\mu\text{g}$  per deciliter (0.048  $\mu\text{mol}$  per liter), had delays of two to six months in the age at which they attained given stages of breast and pubic-hair development, and four months in the age at which they began to menstruate. Delays were also observed in white and Mexican-American girls, although those associations were not uniformly statistically significant.

Because the study by Selevan et al. was cross-sectional, it remains possible that these findings, if

attributable to lead, may be the result of higher blood lead concentrations earlier in life; lead concentrations typically peak in early childhood. Nonetheless, although delays of a few months in the course of puberty are not likely to be a threat to health, these data raise the possibility of an effect on fundamental developmental processes occurring in girls from the general U.S. population at commonly encountered blood lead concentrations. Even though puberty, if delayed by lead, is not delayed by very much, these findings raise the possibility of effects on other hormonally mediated processes.

The effects of lead exposure appear to be long-lasting and irreversible. A previous report in the *Journal* indicated that chelation therapy given to lower moderately elevated blood lead levels in preschool children from environments similar to those studied by Canfield and colleagues had no beneficial effects on tests of cognition, behavior, or neuropsychological function.<sup>4</sup> Prevention is thus the only plausible strategy. Children should not live in housing that exposes them to hazardous amounts of lead, and children who are already exposed need to be identified and their source of exposure interrupted.

The fact that associations seen at these low lead concentrations are subtle is not reassuring; rather, it implies that there is no safety margin at existing exposures. Eliminating elevated blood lead concentrations by the end of this decade is already a federal objective.<sup>5</sup> The new reports underscore the importance of these goals and of the potential consequences of a delay in addressing this entirely preventable condition. They also imply that the job may not be finished even when all children have blood lead concentrations below 10  $\mu\text{g}$  per deciliter.

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