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June 17, 1977

TO: Mr. Bernie Roy
Mr. Gary Welch
Mr. Donald Beilstein
Mr. Jones
Mr. Gene Baker
Mr. Jerry Smith

FROM: Donald R. Lynam, Ph. D.

SUBJECT: EPA/CDC Smelter Study - Final Version

Enclosed is a final version of the paper entitled "A National Survey of Heavy Metal Absorption in Children Living near Primary Copper, Lead and Zinc Smelters". Evidently, this paper is being submitted to the American Journal of Epidemiology for publication. While there has been considerable improvement in the paper since the initial version, there are still some wild speculations and misleading statements, for example, the speculation in the last paragrph that chronic exposure to persons living near smelters may be causing undetected, latent disease that will become manifest in the future.

Sincerely,

Donald R. Lynam

Donald R. Lynam, Ph. D.
Manager, Environmental Health

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~~REP~~ 6/24
DHD 6/25/77
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A NATIONWIDE SURVEY OF HEAVY METAL ABSORPTION IN CHILDREN LIVING NEAR PRIMARY COPPER, LEAD, AND ZINC SMELTERS

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INTRODUCTION

Increased absorption of lead and arsenic by children living near certain nonferrous metal smelters in the United States (1-4) and abroad (5-10) has been documented. Inhalation and ingestion of metallic particulates emitted by the smelters appear to have accounted for the increased absorption. Disruption in heme biosynthesis (2,11) and fatal lead encephalopathy (12) have been the reported consequences; subclinical damage to the central and peripheral nervous systems has been noted in two studies (2,11) and not observed in one investigation (13) of children exposed to lead smelter emissions. In view of these findings, the Center for Disease Control (CDC) and the Environmental Protection Agency (EPA) undertook in 1975 to survey the extent and severity of heavy metal absorption in children living near primary nonferrous smelters throughout the United States. This report summarizes the results of the survey.

METHODS

Study design. The 19 smelters selected for study represent all the primary lead, zinc, and copper smelters in the United States where community exposure to metallic emissions had not previously been studied. Previously studied primary nonferrous smelters are located in El Paso, Texas; Kellogg, Idaho; Tacoma, Washington; and East Helena, Montana. Only those smelters were surveyed (Table 1) which were in operation May 1, 1975, or which if closed on that date, resumed production within the following six months, and which were located within five miles of a residential area. There were no homes within five miles of the copper smelter in Garfield, Utah. Studies in the vicinity of each smelter were restricted to children one to five years (12-71 months) of age, the age-group previously shown (1,2,14) to be at highest risk of heavy metal absorption from environmental exposure. Although arsenic is, strictly speaking, not a metal but a metalloid, we will, for the sake of simplicity, refer to all the elements discussed in this report as heavy metals. The survey area around each smelter (with exceptions as noted below) was a circle four miles in diameter with the main smelter stack at the center. We estimated that to obtain statistically adequate data on the prevalence of heavy metal absorption would require in each area a sample of 60-100 children. We chose the first house in each area at random and the rest of the sample using a sampling frequency that varied from every house to every tenth house, depending upon population density. All children one to five years old in a selected house were eligible to participate. There were no substitutions allowed for families that refused to participate or could not be reached. Two cities contained two smelter stacks; children living within two miles of either smelter constituted the population sampled. One smelter was located near the U.S.-Mexican border; a separate sample was drawn from children in Mexico living within two miles of the smelter, and results of testing in Mexico will be reported separately. In two sparsely populated locations (Bixby and Glover, Missouri) children living within five miles of the smelter made up the study population.

Three comparison towns without smelters were selected in New Mexico, Missouri, and Arizona, areas of the nation with the most smelters. Two of these comparison communities were rural and one was urban so as to approximate the rural-urban distribution of smelter communities. Children were selected from these owns in a manner similar to that described above for smelter towns.

ATA COLLECTION

le conducted door-to-door interviews at selected households. After obtaining signed parental permission, we took from children samples of venous blood, rine, and full-length hair, storing them in trace-metal-free containers. Data collected included the age and sex of tested children, length of residence at current and previous addresses, history of pica, and history of exposure to pottery used for culinary purposes.

Laboratory analyses. At each of the three lead smelters, blood samples were analyzed for lead, cadmium, and erythrocyte protoporphyrin (EP) concentration, and hair samples for lead and cadmium. All analyses except certain "split" sample analyses were performed by Stewart Laboratories, Inc., Knoxville, Tennessee. At each of the 11 copper smelters, blood samples were analyzed for copper, lead, zinc, and EP concentration, urine samples for arsenic concentration, and hair samples were analyzed for zinc, lead, cadmium, and EP concentration; hair samples were analyzed for lead and cadmium concentration. At each of the comparison towns, blood samples were analyzed for lead, zinc, cadmium, copper and EP concentrations, urine samples for arsenic concentration, and hair samples for lead, cadmium, and arsenic concentration.

The minimum sample size required by the contract laboratory was 1 ml of blood, 0.2g of hair, and 25 ml of urine. Detection limits were these size samples were: 1 ppb for arsenic, 10 ppb for copper, 10 ppb for zinc, 10 ppb for lead using conventional atomic absorption (AA) or 0.5 ppb using flameless AA, and

1 ppb for cadmium using conventional AA or 0.02 ppb using flameless AA. Certain samples of less than the required size were processed by a separate laboratory using a separate methodology; these results were not used for statistical comparision but were reported to parents.

The contract laboratory conducted an internal quality control program and participated in a program of external controls. The internal program encompassed blind split-sample analyses for hair, blood, and urine; blind random analyses of standard reference samples, recovery and precision studies from two large, composite samples (blood and hair), and the analysis of standard sample splits with two reference laboratories. Results of this program have been published previously (15). Studies by the contract laboratory revealed 99%, 98%, and 97% recovery of copper, zinc, and lead, respectively, from whole blood samples. The principal external control on blood lead analysis consisted of CDC's submitting to the contract laboratory 39 bovine blood specimens, the lead content of which had been thoroughly documented through CDC's Proficiency Testing Programs. The degree of correlation between the CDC results and those of this contract laboratory was high (r = 0.96); the contract laboratory values were, on the average, 4% higher than the CDC values.

Analytical methodology

Blood: Erythrocyte protoporphyrin (EP) was assayed by the technique of Granick et al (16). Following EP determination, blood samples were acid-digested and analyzed for copper and zinc by conventional atomic absorption technique (17), and for lead by direct flameless AA spectrophotometry (with use of a graphite furnace with multilinear temperature programming and simultaneous background correction) (18). Cadmium analysis was performed on a 250μl sample of the original undigested blood specimen with flameless AA in a pyrolytic graphite tube (18).

Urine: Sample preparation of urine samples consisted of ashing with a mixture of nitric, perchloric, and sulfuric acids. The ash was treated with ammonium oxalate to remove HNO_3 (19). Samples were then analyzed by hydride evolution AA technique (19).

Hair: Samples were agitated for 30 minutes in a non-ionic detergent and thoroughly rinsed with distilled deionized water. After drying, the samples were acid-digested as described above for blood samples.

Lead and cadmium determinations were made with conventional AA spectrophotometry (17). Arsenic concentration was determined by the hydride evolution-AA technique.

Statistical methods. Mean values of the concentrations of metals in biologic samples were calculated for each town; sample determinations below the detection limit were estimated by substituting one-half the detection limit value for all "less than" values. Median and 95 percentile values were also determined. Arithmetic means were used for all calculations except those on urine arsenic, which were logarithmically transformed to make a positively skewed distribution more normal (no claim is made here for log normality). Data from the three comparison communities were pooled to form a single 258-member control group; the procedure is justified on the grounds that there were only minor differences among the three control towns in the mean concentration of heavy metals in hair, blood, and urine of residents. Although variances were often not homogenous, t-statistics were used to compare mean values for each smelter town with the pooled means from the control communities. The t-values are shown in the tables along with the sample sizes, means, variance, and ranges. No particular