Lead Poisoning among Battery Reclamation Workers in Alabama

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Lead exposures were evaluated at a battery reclamation facility in Alabama. A questionnaire obtained work and health information. Medical tests included blood lead, zinc protoporphyrin, hematocrit, creatinine, blood urea nitrogen, and uric acid. An investigation of workers' family members and neighborhood residents was conducted. Fourteen of 15 workers had blood lead levels greater than 50 μg/dL. Zinc protoporphyrin was >79 μg/dL in 14 workers. Four workers had hematocrit <40%; six had elevated serum creatinine (>1.3 mg/dL). Workers' blood lead levels increased significantly over 2 years (β = 1.004 μg/dL per month). Ten workers had elevated air lead levels. Twelve of 16 employee children had blood lead levels >10 μg/dL; 3 were greater than 40 μg/dL. Workers' children had significantly higher blood lead levels than did neighborhood comparison children. Reclamation of lead batteries unaccompanied by smelting poses a health hazard to workers and their children.

The adverse health effects of lead have been known for centuries; however, regulatory protection of lead-exposed workers in the United States has only recently been undertaken.[1-3] Despite the Occupational Safety and Health Administration's (OSHA) lead standard specifying permissible exposure limits to lead at work, reports of workers exposed to excessive quantities of lead continue to emerge.[4] Bridge workers, smelters, painters, and radiator repair shop workers exemplify some of the groups at risk for lead poisoning.[5-7]

In March 1991, the Alabama Department of Public Health received a report of a worker with a high blood lead level (BLL) employed in a battery reclamation facility. Subsequent work-site evaluations were made by the OSHA Region IV office, the National Institute for Occupational Safety and Health (NIOSH), and the Alabama Department of Public Health. The goals of the NIOSH study were to assess the workers' exposure status, workplace hygiene practices, and health effects.[8] We present our findings here, and present evidence for lead poisoning among battery reclamation workers and among the children of these workers.

Site Description

Automotive battery reclamation operations in this setting involve manual labor and mechanical activities through which the batteries are cut open and emptied (decased) of their contents. Both automobile and industrial batteries are recycled to reclaim the lead and plastic contents. Automobile batteries consist of a plastic case that holds lead plates and sulfuric acid. Spent batteries also contain lead

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oxide and lead sulfate. The battery breaking and reclamation plant investigated in this report has been in operation since 1979. The acid is drained away, and the lead and plastic are then placed on a conveyor, transported to a hammer mill, and ground by the mill into plastic chips and lead chunks. A series of augers and tanks separate these materials by flotation, and the plastic and lead chunks are deposited into open bins. All materials are then transported by front-end loader to trucks for shipment to other plants for further processing.

An industrial battery is much larger than an automotive battery and consists of a large steel container that holds several cells, each in turn composed of a plastic case that holds the lead plates. Industrial batteries were typically dismantled by first using an acetylene torch to cut through the steel case. The cells were then removed by using a front-end loader to dump out the lead plates and acid (which is drained away to a storage tank and then taken off-site). Individual plates that do not fall free are removed by chopping apart the plastic case with an axe and then manually dumping the contents. The cases and plates are placed by hand on a conveyor and transported to a second hammer mill for lead and plastic recovery.

Methods

Work-Site Investigation: Environmental Assessment

To address the goals of the study, the investigators developed a multidisciplinary investigative approach. We conducted a facility walk-through evaluation to observe the battery reclamation process and hygiene practices of the workforce. Aerosol measurements were made in the plant using a Real-Time Aerosol Monitor (RAM; manufactured by Monitoring Instruments For The Environment, Bedford, MA) to identify potential sources of lead exposure in the battery-breaking operation. This instrument samples the workroom air and instantaneously measures the concentration of airborne dusts and mists by measuring the amount of light scattered by these materials. Our RAM measurements were made in different locations in the plant. Samples were also taken outdoors, near the lunch room building, and used as "normal" or background aerosol for purposes of analysis.

Personal air-sampling information was collected by OSHA during a previous site visit the month before our joint investigation, March 20, 1991. Air samples were collected and analyzed on 11 of 15 workers at the facility according to OSHA Analytic Method CPL 2-2.43A. Personal air samples were collected from workers in each of the six job categories: battery breaker, hammer mill operator, front-end loader, battery cutter, industrial battery breaker, laborer/driver.

Wipe samples were taken from five of the employees' personal automobiles (while at the plant) during the joint OSHA/NIOSH site visit in May 1991. Wipe samples were collected and analyzed according to OSHA Analytic Method CPL2-2.20B. These samples were collected to determine whether workers carried residual lead home on their bodies and clothes after removing their coveralls. Wipe samples were collected from the following locations: steering wheel, seat, dash, and floor between driver and passenger seat.

Work-Site Investigation: Health Assessment

A physical examination conducted at the facility included assessment of blood pressure (BP), height, weight, gums, eyes, reflexes, tremors, and wrist and ankle strength. Blood specimens were analyzed for BLL, zinc protoporphyrin (ZPP), hemoglobin, hematocrit, blood urea nitrogen (BUN), creatinine, and uric acid. Laboratory protocols for collection and analysis of blood lead data were specified by Metpath Laboratories (Teterboro, NJ) using atomic absorption spectrophotometry. A questionnaire was administered to obtain demographic and work history information and a history of previous employment and symptoms associated with lead poisoning. Survey data were also collected on work practices and personal habits (eg, smoking, drinking, and hobbies), and training about the health effects of lead. All 15 employees volunteered to participate in the various phases of the site evaluation, which took place on May 21, 1991. A confidential notification letter with an explanation of blood test results was sent to each worker after the site visit. The letter included interpretations of results and recommendations for further follow-up when indicated.

Take-Home Investigation

A take-home investigation of the workers' family members and neighborhood comparisons was begun in June 1991. Plans to evaluate all family/household members of plant workers were announced to all employees and management personnel at the closing meeting of the joint NIOSH/OSHA site visit (May 1991). A follow-up letter was sent to the homes of the 15 workers. Eleven adults and 16 children were included in the worker family follow-up. A total of four adults and three children refused to participate in the follow-up. Family members were surveyed by Jefferson County Health Department (JCHD) officials for job history and potential nonoccupational exposures to lead. Each family member was contacted by telephone and offered either a clinic appointment or a home visit. Blood lead level specimens were collected in EDTA-buffered tubes and were analyzed by either the Alabama Department of Public Health's Bureau of Clinical Laboratories in Montgomery, using atomic absorption spectrophotometry or Roche Laboratories in Burlington, NC, using anodic stripping voltammetry. Test results were reported to each participant and to his or her family physician.

Neighborhood comparison data were obtained by the JCHD from a sample of local residents living within a one-block radius of the battery facility. The JCHD chose people living close to the facility because they believed that these people were at greatest potential risk and because some residents had already expressed concern about possible exposure to lead. The JCHD conducted a total of seven household interviews in which they obtained detailed information on current employment, job description, household plumbing, and hobbies. Selection criteria were as follows: (1) not employed at the facility, (2) no known exposures to lead at work, (3) no known exposure to lead at home, and (4) no current or previous treatment for lead poisoning.

Eleven adults and five children were selected. The adults ranged in age from 37 to 76 years; the five children ranged from 6 to 17 years old. These subjects received a letter explaining the purpose of the investigation. After providing informed consent, they received a follow-up call to set up a schedule for collection of blood specimens. Venous blood was drawn from these 16 subjects and was analyzed for lead level by the Alabama Department of Public Health Clinical Laboratory in Montgomery by atomic absorption spectrophotometry. Several subjects were excluded by the criteria listed above. One adult (45 years) with reasonably low BLL (13 μg/dL) was in the care of a physician and not examined further by JCHD. At a different address, a family of 6 had similarly sought medical attention before the JCHD study; the single parent (36 years) had low BLL (12 μg/dL). The five children ranged in age from 3 to 7 years and had levels ranging from 11 to 42 μg/dL (mean = 20 μg/dL; SD = 12.6). One home in the one-block radius of the facility was vacant, and the JCHD was unable to interview one other family of two persons.

Soil samples were collected from three of the seven neighborhood homes and were analyzed for the presence of lead by the Alabama Department of Environmental Management (ADEM). The samples were collected at five separate locations around the perimeter of the homes. The samples were acquired by the ADEM, Land Division, on August 6, 1991. The samples were analyzed according to the Toxicity Characteristic Leaching Procedure, specified under the Resource Conservation and Recovery Act.[9] This procedure was used to determine the level of leachable lead and other toxic constituents in the soil of the homes of neighborhood comparisons.

Data Analysis

Analysis of the work-site questionnaire data was performed using DBase III version 1.1 (1985) and Statview version 512+ (1986). Descriptive statistics were calculated for the population to determine the distribution of potential risk factors collected from the questionnaire (eg, age, weight, height, blood pressure) physical examination, and industrial hygiene components of the study. Correlation matrices were used to identify pairwise associations between continuous variables (eg, BP, ZPP, height, weight, and BLL), and *t* tests were used to compare means between groups. General linear regression analysis, using the Statistical Analysis System (SAS) version 6.04 (1987), was used to describe the relationship among work history, medical, and physical examination variables.

During the 27 months preceding our May 1991 investigation, the employer arranged for monthly blood sample analyses by Lab Care of Birmingham, AL. When the NIOSH data were added to the preexisting worker BLL data, there were a total of 28 months of BLL data on the workers at the facility. The NIOSH measurements were in good agreement with the records provided by the employer.

Several models using BLLs as the dependent variable were constructed to estimate the contribution of the previously mentioned covariates (eg, work history and physical examination variables) and were adjusted for lack of independence between monthly BLLs using a repeated-measures analysis.

Detailed statistical analysis of the relationship between physical examination, medical history, and survey findings was not possible because of the limited number of study participants. The small number of study participants reduces the statistical power to detect differences in the multifactorial models assessing risk factors on BLLs. Because the workers participated in all the jobs at the facility, we were unable to construct job-related dose-response estimates of exposure on BLLs.

Results

Work-Site Investigation Demographics and Work History

The 15 employees at the facility ranged in age from 22 to 49 years (mean = 33 y; SD = 7). Ninety-three percent of the employees were men (n = 14) and one part-time employee was a woman. Sixty-seven percent were black (n = 10) and 33% were white. Sixty-seven percent (n = 10) of the workers had either high school education or some college. Among the 15 employees there were 31 children. Thirty-three percent of the employees (n = 5) shared households with persons other than family members.

The work force was stable and there was low turnover among the employees: 27% of the work force were employed more than 8 years, 27% were employed from 5 to 7 years, and the remainder from 1 to 4 years. Workers averaged 10.6 hours per work day and most worked 5 to 6 days per week.

Work-Site Questionnaire Responses and Physical Examinations

Painful joints was the most frequently reported symptom (27%), followed by trouble sleeping (13%), poor memory or confusion (13%), and muscle weakness (13%). Only four workers reported conditions diagnosed by a physician: one reported a kidney condition, another anemia, and two reported hearing loss. Two workers reported potential nonoccupational exposures to lead; one attended a firing range, and the other reported working with stained glass. None of the workers reported having a medical history of conditions such as diabetes or gout. Fundoscopic examination results were normal in all but one employee, who had arteriovenous nicking. No other physical indicators of lead exposure (tremor, decreased wrist or ankle strength) were seen in any of the employees.

The systolic and diastolic blood pressure averaged 122.8 mm Hg (SD = 9.2) and 74 mm Hg (SD = 10.17), respectively, for the group. Only one of the workers had a diastolic pressure greater than 90 mm Hg.

Work and Personal Hygiene Practices

Ninety-three percent of the workers reported wearing a half-face cartridge respirator, and one worker reported never wearing a respirator. Eight of 14 men, however, had some facial hair in the area of the respirator seal. The owner of the facility confirmed that there was no fit-testing program to ensure proper sizing of respirators. There was also no designated program of zones for respirator use. More than half of the employees (n = 8) reported changing respirator cartridges on a regular basis. Only one employee reported changing respirator cartridges daily.

A third of the employees reported they smoked at work. Twenty percent reported smoking at locations where there was a high risk of lead ingestion, such as their work station or in the lunch room. In addition, 93% reported eating their lunch at the work site.

Sixty percent (n = 9) of workers reported that they showered at work before leaving. However, the information reported on showering behavior was not consistent with investigator observations while at the facility. Only 20% of the employees showered at the end of the shift, and only a third of the workers changed clothes before leaving the work site.

Blood Analysis (Workers)

Worker blood specimen analyses are summarized in Table 1. Ninety-three percent (n = 14) of the employees had levels greater than 40 μg/dL (range, 52 to 86 μg/dL) at the time of the site visit. The mean BLL for the group was 65 μg/dL (SD = 18). Twelve of the 14 full-time employees (80%) had BLLs greater than 60 μg/dL, the level at which OSHA requires medical removal from lead exposure.

ZPP was elevated above the reference range for 93% of the workers with a mean level of 269 μg/dL (range, 27 to 616 μg/dL; reference range, 0 to 79 μg/dL). Only one employee had BLL and ZPP in the reference range. Hemoglobin was below average (13 g/dL; SD = 1) in 46% of the workers (range, 13 to 17 g/liter).

BUN was above the reference range in 1 worker (range, 9 to 29 g/dL); the average BUN for the group was 16 g/dL (SD = 4.5). Serum creatinine was elevated in 6 workers. The formula of Gault and Cockroft was used to estimate creatinine clearance for men based on serum creatinine levels, age, and weight.[10] Using a creatinine clearance of 90 mL/min as a generally accepted lower limit of normal, 7 of 14 (50%) had calculated creatinine clearance rates below normal.

Based on correlation coefficients, BUN and ZPP were positively associated (r = .73), whereas hemoglobin and ZPP were negatively associated (r = −.59). BLL and creatinine were positively associated (r = .67). Uric acid was positively associated with BLL and ZPP, with correlation coefficients of .68, and .64, respectively.

Take-Home Assessment of Family Members and Neighborhood Comparisons (Adults)

Figure 1 shows the average BLLs and 95% confidence intervals (95% CI) of workers (n = 15), family members (11 adults and 16 children), and neighborhood comparisons (11 adults and 5 children). Blood lead level results for adult family members of workers ranged from 4 to 21 μg/dL, with most below 10 μg/dL (55%). A total of 27 family members were tested in one follow-up and 16 neighborhood comparisons in the other. One worker family, with two children, moved out of state after the initial work-site investigation.

Worker BLLs averaged 66 μg/dL (95% CI = 55.5 to 76.1) compared with adult cohabitants who averaged 8.9 μg/dL (95% CI = 5.6 to 12.2) (adult = >20 y). Neighborhood comparison adults had an average BLL of 11.6 μg/dL (95% CI = 7.87 to 15.33).

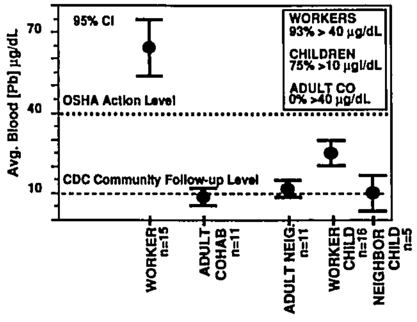

Fig. 1. Blood specimen analysis: workers, family members, and neighborhood comparisons.

TABLE 1
Results of Worker Blood Specimen Analysis*

	Mean (n = 14)	SD	Range	Reference Range	No. > Reference Range	% Outside Reference Range
Blood lead level (μg/dL)	65.8	18.6	9–86	0–40	14	93
Zinc protoporphyrin (μg/dL)	268.7	185.7	27–616	0–79	14	93
Blood urea nitrogen (mg/dL)	16.7	4.5	9–29	8–22	1	7
Hemoglobin (gm/dL)	13.6	1.3	11.1–16.1	13.5–17.7	4†	27
Hematocrit (%)	43.4	3.9	37.5–52.8	40.0–52.0	4†	27
Creatinine (mg/dL)	1.3	0.2	0.8–1.6	0.8–1.3	6	40
Uric acid (mg/dL)	6.6	1.3	3.2–8.4	2.6–8.1	1	7

* Results for one female part-time worker were excluded.
† Indicates hemoglobin/hematocrit outside reference range.

Ninety-three percent of the workers had BLLs above 40 μg/dL, but none of the adult cohabitants or neighborhood comparison adults had BLLs greater than 40 μg/dL. BLLs were not statistically different between the adult cohabitants of workers and neighborhood comparison adults (t = 1.23, df = 20, P = .23).

Analysis of Family Members and Neighborhood Comparisons (Children)

Six of the workers' children (38%) had BLLs ranging from 26 to 42 μg/dL, five (31%) had levels between 15 and 25 μg/dL, one child had a level between 10 and 14 μg/dL and four were below 10 μg/dL. The Centers for Disease Control currently recommend community follow-up when levels reach 10 μg/dL.[11] Twelve of 16 employee children (75%) had BLLs ≥10 μg/dL, compared with only two of five neighborhood children. The workers' children had an average BLL of 22.4 μg/dL (95% CI = 15.6 to 29.2), contrasting with neighborhood comparison children, who averaged only 9.8 μg/dL (95% CI = 2.3 to 17.3). BLLs were significantly different between worker children and neighborhood comparison children (t = 2.10, df = 19, P = .049).

It is interesting to see that a number of children living in close proximity to this facility had BLLs that were lower than those of children residing with a worker parent. This suggests that take-home lead may have contributed to elevated BLLs among the workers' children more so than environmental exposure. However, it should be mentioned that in a family residing across the street from the battery facility, but not participating in the JCHD study, all 5 children were known to have elevated BLL (see Methods). We do not know what the source of the lead poisoning was in this one family, but the soil in their yard had an extremely high lead content (ADEM found 2170 μg/kg).

Regression Analyses

Linear regression analysis was used to evaluate trends in the blood lead data over time and variables associated with worker BLLs. Several simple linear and multivariable models were used to evaluate the effect of different constructs of BLL measurement as the dependent variable (eg, peak BLL, first and last BLLs, percent change in BLL) and independent variables such as month of the measurement and time on the job (duration). None of these models showed statistically significant trends or associations. However, we did observe that within individual workers, there was consistently a positive relationship between month in the workplace and concentration of lead in the worker's blood: over the 28 month study period, the data for 14 of 15 workers had a positive sloping best-fit line (see Fig. 2, inset). The mean slope was 1.004 μg/dL per month (SE = 0.322), and this was highly significant when tested against the null hypothesis of slope equal to zero, or no relationship (P = .0076, t = 3.115, df = 14). These data indicate that blood lead was increasing within workers over time.

The same trend existed in the data collected before the initiation of our investigation (see Methods): none of the slopes changed direction with the exclusion of the 28th month; on average, slopes were only changed by 3% with this exclusion.

Workplace Environmental Measurement

Employee exposures to airborne dust and mist from the battery-breaking operations were monitored during the site visit at work station locations throughout the facility. Workplace dust and mist measurements ranged from 40 to 400 μg/m^3. Workplace dust and mist were greatest at the trailer door (400 μg/m^3), in the industrial battery-breaking area (170 μg/m^3), and at the hammer mill (90 to 120 μg/m^3). Personal air sampling measurements for lead shown in Fig. 3 (collected by OSHA in March 1991) indicated 10 of 14 workers had exposures above the permissible exposure limit of 50 μg/m^3 (no air sampling was performed on the part-time female employee). In addition, wipe samples from the workers' automobiles revealed the presence of lead in all of the five cars sampled. The highest concentrations of lead dust were found on the drivers seat (3.00 mg/100 cm^2), floor (1.70 mg/100 cm^2), and dash (1.90 mg/100 cm^2) locations.

Neighborhood Environmental Measurements

Analysis of three soil samples collected at different sites within a one-block radius of the battery facility revealed high lead content ranging from 802 to 2170 mg/kg. Background levels measured by the Environmental Protection Agency for Alabama range from 2 to 26 mg/kg.[12]

Discussion

In 1978, OSHA passed the Lead Standard (29 CFR 1910.1025) mandating the protection of workers from excessive exposure to lead.[13] The permissible exposure limit for lead in air was set at 50 μg/m^3 as an 8-hour time-weighted average.[14] Workers exposed to lead in excess of the action level are required to receive medical monitoring and notification of their BLL results. Under the standard, workers with BLLs ≥50 μg/dL (averaged over a 6-month period), or a single level ≥60 μg/dL, must be medically monitored and removed from exposure until their levels drop below 40 μg/dL.[15]

Over the past decade the business of battery reclamation has undergone many changes. The Standard Industrial Classification system assigns battery-breaking facilities to code 5093, which includes small "scrap and waste material establishments . . . primarily engaged in assembling, breaking up, sorting and wholesale distribution of scrap and waste materials."[16] The most recent data available from the US Bureau of the Census indicate there are 8248 establishments in the 5093 code, employing 93,158 workers nationwide.[17] However, the total number of sites where workers are actually engaged in battery-breaking jobs and potentially exposed to excessive amounts of lead is not known, nor is the actual number of exposed workers.

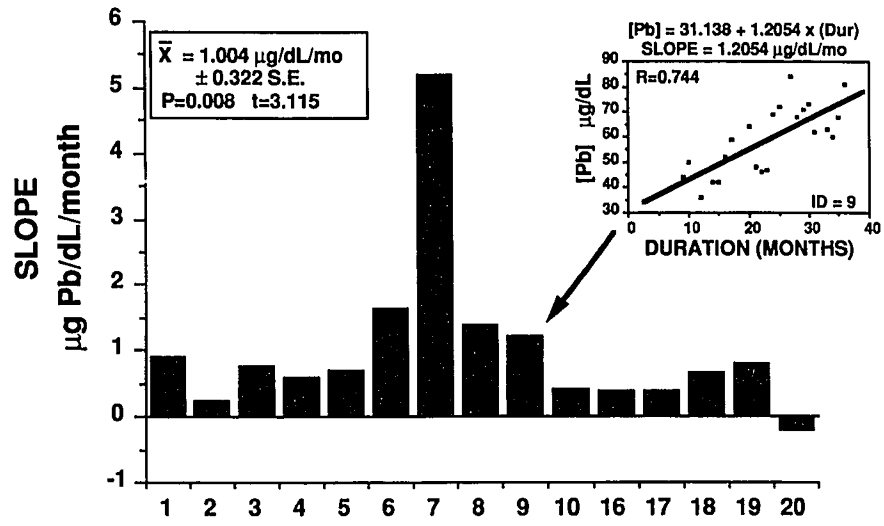

Fig. 2. Rates of increase for BLL concentration.

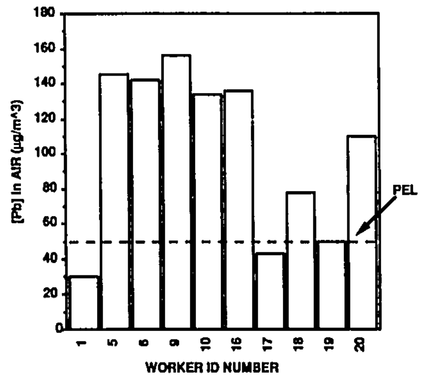

Fig. 3. OSHA air sampling results.

Efforts to reclaim metals such as lead from batteries are on the rise, and have resulted in the passage of legislation regulating battery recycling in 30 states at the time of this report (*Battery Council International News Bulletin*. Chicago, IL; May 1991.). Such efforts may assist in more precise estimates of the exposed population.

The NIOSH evaluation determined that workers at this battery reclamation facility were inadequately protected from lead exposure. Personal air-sampling measurements documented that the level of lead in the air at the facility was above the permissible exposure limit, and RAM measurements highlighted specific operations that were particularly dusty. Discussion with workers and management during the walk-through revealed there was, in fact, no fit-testing program in place, calling into question the adequacy of respirator protection.

Work practices such as storage of food in close proximity to work activities, underutilized shower facilities, and failure to change clothing before eating or leaving at the end of the shift indicated inappropriate hygiene practices for working with lead and the possibility of take-home exposure.

Medical histories and physical examination data revealed little in terms of characteristic findings of lead poisoning. Such findings are consistent with other reports in the literature that suggest that overt symptoms of lead poisoning in adults generally begin at BLLs between 60 and 120 µg/dL.[18]

Blood specimen analysis provided the most instructive information as to the health of the worker population, and specifically, how worker blood lead levels compared with the OSHA lead standard. The average BLL was high, 65 µg/dL with 13 out of 15 workers' levels above the OSHA criterion requiring medical removal from further exposure to lead. ZPP, a measure of the effect of lead on heme synthesis, was also elevated among all but one worker. Measurement of serum creatinine was used as an initial screening device to determine possible renal impairment among the work force. More than one-third of the work force had levels outside the normal range. When creatinine clearance was estimated based on serum creatinine, age, and weight, three workers had ranges outside of the reference range, suggesting the need for verification by actual measurement.

There are a number of ways in which the battery facility, and its adult work force, may expose children to lead. One possible explanation for the elevated lead levels in workers' children is through exposure to the workers' contaminated work clothes; another is from exposure in the workers' automobiles. In addition, soil lead levels found in the neighborhood near the battery facility were substantially elevated above background (Robert E. Meintzer, personal communication, 1992), and this clearly poses a potential hazard to the neighborhood children. Neighborhood residents did report that soil was removed from the facility grounds and transported across the street to a vacant lot several years before the investigation.

Outcome of Work-Site Investigation

In May 1991, OSHA requested technical assistance from NIOSH to evaluate the health status of the workers at the facility. Previous site visits made by OSHA (1985 and 1988) had uncovered numerous health and safety violations. Upon reinspection in March 1991, there was still no evidence of remediation of health and safety problems. Workers with BLLs higher than the medical removal criteria remained on the job. On the basis of environmental and medical data collected in May 1991, the NIOSH investigators determined that a health hazard existed from overexposures to lead during the breakdown processing of automobile and industrial batteries.

These data were used by OSHA to protect worker health and safety. The facility was declared an Imminent Danger (OSHA Instruction 2.45B) and all workers were medically removed from their jobs until their BLLs declined to 40 µg/dL.[19] During the course of their medical removal the workers were denied compensation required by law under the OSHA Lead Standard. This violation of the lead standard was remedied by court action; however, the magnitude of health and safety fines overall ($1.2 million) ultimately resulted in the owner's permanently closing this facility.

Conclusion

This report describes an investigation of lead poisoning among battery reclamation workers and shows that reclamation of batteries unaccompanied by smelting poses a health hazard to workers and their children. "Take-home" lead from contaminated workers' clothing could be an important potential source of lead exposure in the home environment.

The problem of lead poisoning in the battery reclamation business alerts us not only to the danger to workers, but also the potential risk to their family members. This investigation highlights the importance of adult blood lead epidemiology and surveillance, which identified an elevated BLL in a worker and triggered an in-depth investigation of the workplace. The magnitude of BLLs found in both the workers and their children emphasizes the need for continued concern by the public health community over occupational lead exposure as a source of childhood lead exposure via the take-home route.

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The Name "Nylon"

Ever wonder how nylon got its name? In 1938 Du Pont launched a campaign to give its new product a snappy moniker. Its official chemical name of *polyhexamethyleneadipamide* wasn't very marketable. A naming committee rejected 400 suggestions before coming up with the winner. Here's how:

They started with *norun*, because nylon stockings were run-resistant. That word was turned backward, into *nuron.* More brainstorming changed the *r* to an *l*, resulting in *nulon.* But that was too close to an existing registered trademark, so the *u* was switched to an *i*, producing *nilon.* But the committee feared people would mispronounce that word, so the *i* became a *y*. And thus was *nylon* coined.

From "Metropolis," by D. Shaw in *The Philadelphia Inquirer Magazine*, November 14, 1993, p 8