LEADVILLE METALS EXPOSURE STUDY

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and

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DISCLAIMER

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INTRODUCTION

Leadville, a high altitude (10,200 feet) mountain community in Colorado, has been the site of extensive mining, milling and smelting of precious and base metals since 1860. Soil surveys done in connection with a remedial investigation of a Superfund site (California Gulch) found elevated levels of lead (Pb), arsenic (As), and cadmium (Cd) in surface soils in residential areas. A study of heavy metal exposure to individuals living in Leadville, Colorado is described in this report.

OBJECTIVES

The objectives of this study were to:

* Determine the levels of heavy metals and other indicators of metal toxicity in the blood and urine of individuals, principally young children, living in the Leadville community.

* Determine whether these levels are different from national averages or from those obtained in similar studies in areas such as East Helena, Montana.

* Characterize the levels of heavy metals in the residential environment and the relationships of human exposure to environmental concentrations.

* Determine the extent to which environmental, behavioral and socio-economic factors are predictive of heavy metal exposure to individuals in the area.

BACKGROUND

Because of concerns about possible heavy metal exposure within the community, a soil survey was conducted in Leadville for the Colorado Department of Law, in October of 1986 (1). The results of this survey showed that more than 60% of the residential surface soils sampled had lead levels higher than 1,000 parts per million (ppm) and more than 80% had levels higher than 500 ppm. The range was from 110 to 12,000 ppm. Cadmium levels ranged from 1 to 150 ppm and soil arsenic from 5 to 580 ppm. By way of comparison, a survey of U.S. cropland soils found median soil concentrations for lead and cadmium to be 11 ppm and 0.2 ppm, respectively, with 99% of the values for lead and cadmium below 120 ppm and 1.3 ppm, respectively (2). Other soil surveys have reported that the geometric means for concentrations of lead, arsenic and cadmium in Western U.S. soils are 14 ppm, 6.1 ppm, and <1 ppm, respectively with 95% of the values for these elements between 5-67 ppm, 1-20 ppm and <1-10 ppm, respectively (3).

The Centers for Disease Control (CDC) has stated that increases in blood lead concentrations, especially in young children, are associated with exposures to soils containing more than 500-1,000 ppm lead (4). The interest in soil lead concentrations arises from evidence that inadvertant soil ingestion by children can lead to significant lead exposure. Studies have linked lead in the blood of children to lead in dust on children's hands to lead in floor and sill dust in houses and to lead in the soil outside the children's houses (5). Studies also show an important interplay between environmental sources of lead, socio-economic factors and the blood lead of children (5).

Numerous studies have demonstrated that excess exposure to lead, cadmium, and arsenic constitute a significant health risk to humans. These risks include low birth weight (Pb), and other adverse reproductive effects (Pb), developmental deficits (Pb), anemia (Pb), effects on the central nervous system (Pb), and kidney (Pb, Cd), potential adverse effects on blood pressure (Pb, Cd), cancer (As, Cd, Pb) and a variety of other adverse effects depending upon the magnitude and duration of exposure (6-11).

Neurological effects of lead in children were recognized as early as 1904 (12), but for many years physicians assumed that these effects were reversible upon removal of the children from a leaded environment. In 1943, researchers (13) reported that lead had long term effects on the intellectual achievements and behavior of school children.

As the result of continuing investigations over the past several decades, the level of blood lead, as measured in terms of micrograms of lead per deciliter of blood or ug/dl (a measure of lead exposure) that is considered to cause health effects in young children, has dropped dramatically. During the 1950s, 60 ug/dl was considered a safe level of lead in the blood for children. This was revised downward to 40 ug/dl in 1973, to 30 ug/dl in 1978 and to 25 ug/dl in 1985 (4). In its 1985 statement, CDC explicitly stated that "The terms (defining lead toxicity) should not be interpreted as implying that a safe level of blood lead has been established."

In the past several years, careful studies of groups of children followed from before birth to ages of 5 and 6 years old have shown that neurotoxic effects are observed at blood lead levels well below 25 ug/dl (14-17). In fact, these studies have shown that prenatal (indicated by cord blood) as well as post-natal exposures to blood lead levels as low as 10 to 15 ug/dl are associated with numerous disabilities including cognitive deficit and reductions in birth weight and growth rates. Several of these studies predict an average deficit of approximately 5 intelligence quotient (IQ) points for every 10 ug/dl increase in blood lead. Needleman, et al., (18) argues that when children with elevated blood lead levels had an average drop of 4 points in IQ, there would be three times as many with IQs below 80 in the high lead group (compared to the low lead group) and none of the high lead group would be expected to have an IQ above 125.

Additionally, Schwartz, et al. found effects on hearing and neurobehavioral development (19). These studies imply that if there is a threshold for lead toxicity in children, it is below a value of between 10 and 15 ug/dl.

Research also shows that the fetus is at risk (20) as well as the pre-school child. There is some evidence (21), that pregnancy and lactation has the effect of mobilizing the lead ingested by the mother when she was a child and stored in the bone where lead is very stable, leading to transplacental exposure of the fetus.

While evidence points to the fetus and young child as the most vulnerable individuals for lead exposure, there is also some recent evidence that middle aged males with higher than average blood lead levels have a greater risk of hypertension (22) and that lead may aggravate osteoporosis in post menopausal women when their bone lead stores are released by the postmenopausal demineralization processes (21).

Free erythrocyte protoporphyrin (FEP) is a measure of lead toxicity, in that lead prohibits activity of ferric chelatase, an enzyme necessary for the production of hemoglobin.

Much of what we know about arsenic and cadmium is derived from occupational studies. Occupational studies of cadmium workers indicate an increased occurrence of lung cancer among those exposed to high level of cadmium through inhalation. This same population has shown evidence of kidney toxicity.

Beta-2-microglobulin is a substance measured in the urine of individuals occupationally exposed to cadmium. Its presence in the urine in the face of a history of prolonged high level exposures may indicate poisoning of the kidney's reabsorption mechanism.

Chronic arsenic exposure can affect the skin, liver, cardiovascular system, hematopoietic system and respiratory tract. In addition, populations exposed to arsenic through drinking water have an increased risk of skin cancer.

As a result of the elevated levels of arsenic, cadmium and lead in the surface soils of Leadville, the Colorado Department of Health requested and received funding and technical assistance from the Agency for Toxic Substances and Disease Registry (ATSDR) in performing a heavy metals exposure assessment of the community. The Environmental Protection Agency (EPA) provided analysis of environmental samples other than water.

Mining began in the Leadville district in 1860 following the discovery of placer gold, which is generated from alluvial and glacial deposits, in California Gulch. Although placer deposits were rapidly depleted, gold ore veins were discovered in 1868. The exhaustion of these ores in 1872 was followed by the discovery of oxidized ores consisting of lead and silver carbonate in 1875 causing another mining "boom". Between 1875 and 1880, 44 smelters were built in the area, some of which operated only a short time.

Later, sulfide ores were mined for silver and lead and around the turn of the century, zinc became a mineable commodity. As a result, from 1899 until the present, considerable quantities of lead and zinc have been mined and milled in the area. It is estimated that between 1860 and 1966 the total production of lead and zinc concentrates were approximately 1,000,000 and 700,000 tons, respectively.

The last smelter which extracted the metals from the ores ceased operation in 1961. At present, only one lead and zinc mine and mill is still in operation; the Black Cloud which is owned by American Smelting and Refining Company (ASARCO).

Waste material from these operations consisted of the large volume of rock or "overburden" removed from the mine, tailings resulting from the milling process, concentrate from the milling process that is lost from haulage, smelter emissions and slag from smelters.

The mining, milling and smelting operations were located on the edge of and within the present community of Leadville. As a result, the various waste materials have been dispersed by erosion, resuspension and deposition throughout the community. In addition to the contamination of soils by industrial processes, there were probably high background levels of heavy metals resulting from the rich mineralization of the area.

The Yak Tunnel (Figure 1) was constructed around the turn of the century to drain water from deeper mines in addition to providing ventilation and a route for ore haulage. California Gulch is the site of approximately 45 acres of tailings piles. Another area of the site, known as Stray Horse Gulch, is estimated to contain approximately 100 acres of waste piles, including mine dumps (overburden), tailings and prospect pits. Typical concentrations for arsenic, cadmium and lead in the tailings are approximately 300 ppm, 70 ppm and 10,000 ppm, respectively. The identification of water contamination from various wastes and abandoned mines as well as concern over windblown dust from the tailings piles resulted in the inclusion of the California Gulch site on the National Priority List in 1983.

Leadville proper sits on mixed glacial deposits. The mining district east of town can generally be regarded as being separated into areas of reduced mineralization, "Primary Zone" (e.g. upstream along California Gulch), and areas of oxidized mineralization (e.g. Carbonate Hill, Stray Horse Gulch). The oxidized forms, which account for about 50% of total mined ores, are thought to have been formed as a result of glacial and intrusive volcanic activity on the originally reduced minerals. Ores from the primary zones have higher percentages of galena (lead sulfide) and sphalerite (cadmium, zinc sulfide); while ores from the "oxidized" areas are dominated by cerusite (lead carbonate), anglesite (lead sulfate), and massicot (lead oxide).

In most lead mining districts, such as Flat River, Missouri, the predominant form of lead is galena or lead sulfide. The mineral deposits in Leadville are unusual because the mineral forms of lead are predominately cerusite, anglesite and massicot rather than galena.

In the environmental sampling conducted in October, 1986, the Colorado Department of Health collected surface and subsurface soil samples from residential and commercial areas of incorporated Leadville and the nearby community of Stringtown, located 2-3 miles southwest of Leadville (Figure 1). Most of the soil samples were from residential areas.

A total of 157 samples were collected from approximately 82 blocks of Leadville and 10 sampling locations in Stringtown. Sampling sites were separated by approximately one city block. The city blocks sampled were chosen on a random basis with more extensive sampling in quadrants near tailings piles. While there was some tendency for the higher levels to be in the areas near the tailings piles, the geographical distribution, particularly for lead, showed high levels
(>1000 ppm) throughout the town. The highest levels for arsenic occurred in Stringtown, the location of several past smelter operations.

The Leadville Metals Exposure Study described in this report consisted of two phases: Phase I was a census of individuals living in the survey area, necessitated because of extensive out-migration since the 1980 census, and Phase II was the collection of biological specimens, questionnaire data and household environmental samples from a subset of individuals identified in Phase I.

Before the survey began, a variety of individuals and organizations in Leadville were contacted and informed about the survey. Included were the county commissioners, mayor, town manager, local clergy, local press and community business leaders. Their support was solicited in an attempt to lessen antagonism between local townspeople and any governmental agency. Additionally, we hired Leadville residents for survey work and attempted to use local services as much as possible.

Phase I

Census

Training of the census takers included an orientation to the study, information on how to approach households and solicit participation in the census, instructions on how to complete the Census Form, role playing to discuss potentially difficult situations, and administrative details such as how to fill out time sheets. In addition to a training session, census workers were provided with written instructions which described how the Block Survey and Census Forms were to be completed (Attachment A). The census was conducted using a Block Survey Form on which each family household on a block was listed and the Census Form where demographic data from a family was recorded. The Census Form was also used to track the number of attempts to contact the residents of a house and to describe completion status; whether the family participated or refused to participate in the census, whether the dwelling was an invalid address (i.e. business) or whether contact was unsuccessful.

The census of the Leadville area using a town block map began on September 10, 1987. Workers were initially assigned one to three blocks in areas of town with which they were most familiar; as those were completed, additional blocks were assigned. The census was conducted from 9:00 am through 9:00 pm Monday through Saturday, September 10 through September 20. The hours worked on Sundays were flexible and depended on worker availability.

If an adult (18 years or older) was at home, the worker completed the Census Form; if no one or a minor was at home, a letter (Attachment B) was left which explained the study and also gave household members the option of calling the study headquarters with the census information.

A list of many of the houses which were vacant and/or for rent was obtained from local realtors. In addition, it was often possible to determine visually whether a house was vacant. Vacant houses were confirmed with neighbors when possible. Each household on every block in the survey area was contacted at least four times on different days at different times before it was assigned a "No Contact" status. Census Forms were reviewed each evening and areas which appeared to have excessive numbers of no contacts were visited again for a fifth contact.

Data from the Census Forms were entered into a computer using SURVEY, a data base manager developed by the Center for Environmental Health (CEH) at the CDC for use in the field. Census forms were filed by Household Identification numbers as eligible forms, invalid address, refusal or no contact after four attempts. Households with children 6 months to 71 months were contacted immediately by the coordinator to schedule an appointment for Phase II of the survey. All individuals 6 years and older were randomly sampled after completion of the census. Individuals older than 18 years of age selected in the random sample were asked to participate in Phase II of the survey. Parents of children younger than 18 years of age selected in the random sample were asked if their children could participate in Phase II of the survey.

<u>Phase II</u>

Survey Implementation and Questionnaire Administration

The first part of Phase II training involved a brief orientation to the study and instructions on administering the Consent Form for obtaining biologic samples and the Questionnaire (Attachment C). In the second part of Phase II training, workers were instructed on the objectives and techniques involved in collecting the environmental samples. This included training in the collection of dust, soil and water samples, prevention of cross-contamination of samples, and use of the x-ray fluorescence (XRF) instrument, in addition to completion of the forms associated with each aspect of sampling (Attachment D).

Phase II of the project involved the procedures listed below for all families with children under 6 years old, and randomly sampled individuals 6 years or older identifed during the census.

Appointments were scheduled at the family home by telephoning the family and soliciting participation in the survey. Repeated attempts were made until the last day of the survey to reach families where there was no answer to telephone calls; the family was then considered a "No Contact". Families without a telephone were visited, asked to participate and were scheduled for a survey team visit. Responses ranged from scheduling an appointment on the first phone call or contact to indicating they would like a call back after discussing the project with other family members. Scheduling an appointment took from one to six contacts. Some people indicated they would call the survey team back and if they did not, they were contacted again in an attempt to schedule an appointment. Appointments were scheduled from 9:00 am to 9:00 pm, at the participant's convenience.

The survey team included a phlebotomist, (a pediatric phlebotomist if there was a child under six years old scheduled), an assistant (if the subject was under six years old) to discuss the Consent Form and administer the Questionnaire and three environmental samplers; for indoor dust sampling, outdoor soil sampling and measuring lead in the paint using the XRF instrument. When a child less than six was not involved, the phlebotomist would also administer the Consent Form and the Questionnaire.

The Questionnaire collected demographic, socioeconomic, occupational and behaviorial characteristics for each individual participating in the survey. Attempts were made to schedule appointments so that at least two survey teams were operating simultaneously.

Biological Sampling, Preparation and Analysis

Trained phlebotomists drew a minimum of 1.75 milliliters (ml) of blood from each selected study subject into a 3 ml vacutainer to ensure the proper ratio of anticoagulant to blood. A second vacutainer was obtained for hematocrit and hemoglobin. Tubes were then inverted several times to ensure proper mixing and labeled with the date and a previously assigned laboratory identification number.

The blood samples were logged in on a chain of custody list as they were brought in from appointments and again when shipped for analysis or taken to the local hospital laboratory. Following completion of each day's appointments, the second vacutainers were taken to the local hospital laboratory where hemoglobin and hematocrit analyses were performed. Blood samples were refrigerated until shipment to CDC for lead and FEPs analyses.

First morning void urine samples were requested from a random sample of fifty children between three and five years and all participants six years or older. The collection cup was prepared and left at the study subject's home with instructions for collecting the sample. The cup was picked up by study personnel the following morning before 8:00, logged in on a chain of custody list and refrigerated.

A field urine blank was prepared every 20 samples. The study subject was asked to pour approximately 50 ml of deionized water into a 250 ml collection cup, using the same procedure as with the urine samples. The cup was labeled with a number, "field blank", and date, then stored and processed in the same way as the other urine samples.

Each day's collection of urine samples was processed that morning in the laboratory of the local hospital. Each sample was divided into four aliquots in the following order: 1) HNO_3 acidified for urine Cd and As analysis--tubes labeled with a turquoise dot, 2) azide addition for urine beta-2-microglobulin analysis--tubes labeled with a pink dot, 3) untreated for urine creatinine analysis, and 4) untreated for a reserve. Preparation of the acidified sample was prepared by pouring 12 ml urine into a 15 ml labeled conical bottom plastic tube, adding 100 ul concentrated "Suprapur" nitric acid, capping and then inverting the tube several times. For the azide sample, 5 ml of urine was poured into a 6 ml labeled plastic tube that contained an azide mixture (sodium azide, sodium carbonate and aprotinin in solution), capped and inverted. The two untreated 5 ml aliquots were poured into 6 ml labeled plastic tubes for creatinine analysis and a reserve. All samples were frozen immediately (2-5 minutes after preparation) in a dry ice/alcohol bath and remained frozen until analysis by CDC. Specific gravity was measured at this time on the remaining sample using a urine refractometer. In addition to the field blanks (one every 20 samples), a lab blank was run each day the urine samples were collected and processed. Deionized water at the lab was used to prepare the four aliquots in the same manner as described above.

Biologic analyses for lead, FEP, arsenic, cadmium and beta-2-microglobulin were performed by CDC (23-27).

Environmental Sampling, Preparation and Analysis

The following environmental samples were attained from each household: 1) one composite floor dust sample consisting of samples from the main entrance, the subject's bedroom and the subject's main room, the room where the subject spends most of their time (i.e. livingroom, kitchen, playroom) (28), 2) one composite windowsill dust sample consisting of samples from all windowsills in the subject's bedroom and the subject's main room (28), 3) two exterior surface scrapings from an exposed dirt surface from where the child played (as defined by the parents) and at the main entrance of the house, 4) an exterior soil core that was a composite of four core samples taken in the front yard, 5) an exterior soil core that was a composite of four core samples taken in the back yard, 6) one water grab sample from the house tap water, (it was recognized that first draw and fully flushed samples would be better techniques, but the team felt that the inconvenience posed by such sampling would adversely impact on the participation rate) and 7) XRF lead paint readings on the interior and exterior of the house.

The household dust sampling device consisted of a personal sampler pump, battery operated Bendix Corporation Environmental Sciences Division Model BDX 30/31. Tygon tubing, S-50-HL 6.4 mm o.d., was used to connect the pump to a polystyrene sampling cassette. The sampling cassette was a 37 mm diameter, three piece, Aerosol Analysis Monitors cassette, preassembled with a thin cellulose support pad, 0.8 um mixed cellulose ester plain white filter, with stoppers (Millipore Corp.). The cassette is connected with Tygon tubing to a stainless steel sampler nozzle, a 5 x 1 cm i.d. stainless steel 306 tube compressed at the sampling end to a 1.5 cm wide by 3 mm aperture (28).

Each floor area sample was measured using a plexiglass template, 22 cm x 22 cm square for a unit area of 484 cm^2. Three passes, each uni-directional were made over the unit area, the second pass at a 90° angle to the first (perpendicular), and the third pass at a 45° angle to the second (diagonal). On surfaces with long carpet, i.e., shag plush carpet, a fourth pass at a 90° angle to the third pass (other diagonal) was made. The pump flow rate was set at 2 liters/minute. The sampler cassettes were removed after the entire composite sample was taken, the stoppers replaced and the cassette labeled. The sampler nozzle and hose were cleaned between composite samplings by rinsing with household tap water, followed by a deionized water rinse and air dried.

The windowsills were sampled in an identical manner except that the 22 x 22 cm template was not used. The entire sill was sampled and the area of the sill measured after the sampling.

A single water sample was taken and stored in an acid washed 500 ml polyethylene bottle containing 1 ml triply distilled concentrated nitric acid. The bottle remained closed until just before sampling. Each sample was taken from the kitchen cold water supply. The water was allowed to run for 10 seconds; the bottle was then filled, capped and labeled.

The exterior surface samples were taken using a stainless steel curved spatula to scrape off the loose superficial soil/dust of the sampling location. This technique is described in Bornschein, et al. (29). If the area was large (i.e. an unpaved driveway or play area) several samples were taken and composited. The samples were placed and stored in labeled small Ziploc bags.

A second exterior surface sample was obtained from the entry way of the house. A minimum of 50 mg for each sample was collected and any obvious twigs, insects, trash, etc., were avoided.

A composite sample of four different core samples, was taken using a standard laboratory steel, 1/4 inch i.d. core borer and punch. A one inch deep sample was taken at the marked level on the core borer and the soil sample pushed out of the borer with the punch into a small labeled Ziploc bag. These were taken along the drip lines (roof edge) in the front and back yards, compositing four samples at roughly equal intervals. While the drip lines do not necessarily represent the play areas for children, they do allow for a consistent, and relatively repeatable measurement.

All exterior samples were dried in Ziploc bags using a microwave oven. Once thoroughly dry, they were sieved through a plastic screen with approximately 2 mm x 2 mm pores. The samples were placed into EPA approved glass containers for shipment to EPA contract labs.

The dusts and exterior scrapes and cores were all analyzed for lead, arsenic, and cadmium by EPA contract labs. The methodology of sample preparations and analytical procedures are described in "EPA User's Guide to the Contract Laboratory Program" December, 1986 and "Contract Laboratory Statement of Work" July, 1985.

The water samples were analyzed by the Colorado Department of Health for lead. The analytical procedure is described in Attachment E.

The painted surfaces in the rooms were measured for the presence of lead with a portable, hand-held, XRF lead-in-paint analyzer, Princeton Gamma Tech XK-3 model. The XRF was checked for accuracy at the beginning of each day and immediately before each residence was sampled by taking a reading of National Bureau of Standards (NBS) lead foil standards. At each sampling site, the XRF was held against the wall, and three consecutive readings taken (readings are in mg/cm^2 Pb), each reading taking 15 to 30 seconds. The three readings and the locations of the sampling sites were recorded (Attachment D). Also noted was the general condition of the paint, excessive peeling, chipping, etc.

The sites for XRF readings were any painted surfaces, with particular attention paid to any surfaces chipped or in poor condition. Although each house had similar sites sampled, the exact location and number of sites varied depending on the unique occurrences of painted surfaces. The paint on the walls and trim (doors and windows) of the subject's main room and bedroom were usually measured. Often the trim and doors in the kitchens, baths, and entries were measured. In addition, occasional pieces of painted furniture (cribs, high chairs, etc.) were sampled. A total of 6-8 sites were usually measured on the interior. On the exterior, painted siding and entry trims were usually measured. Other sites of interest included siding on outbuildings, trim on windows, shutters, porches and assorted furniture (picnic tables, flower boxes, wagons). Typically, a total of 4-6 exterior sites were sampled.

Quality Control

Attachments F and G detail the quality control procedures for the biologic and environmental sampling. All of the forms used and samples collected were tagged using labels generated prior to the study by ATSDR (Attachment H). The first two-digit number on the label indicated the year of the study which was followed by a four-digit ATSDR study identification number, followed by another four-digit identification number assigned to each study participant and a character code which identified the type of sample collected. Once an appointment was scheduled, a file was begun for each household. This file included a Consent Form, Questionnaire and sampling forms. All forms were labeled and the remaining labels were placed in the file to be used in the field to tag the biologic and environmental samples collected.

Data Management

After completion of the survey, each Questionnaire was reviewed and individual and household completion status assigned: complete, refused, unable to contact, environmental sampling complete/missing child blood lead, environmental sampling complete/missing child hematocrit, environmental sampling complete/missing child urine, environmental sampling complete/missing adult urine, environmental sampling complete/missing adult blood and urine, environmental sampling complete/refused on child under six but adult participated, environmental sampling complete/missing urine on one child and blood on another and environmental sampling complete/missing child blood.

Copies of the Questionnaires were sent to CDC for keypunching and editing. Data were keypunched twice for verification. A variety of logical checks were performed to test the accuracy of the data and corrections made. Personnel at CDC generated a SAS data set which was sent to the Colorado Department of Health for further data analyses.

Each household generated six environmental samples which were sent to EPA contract laboratories for trace chemical analyses. Along with raw summary data, standard data, and quality control data, a summary analysis sheet was returned for each sample. Each form was coded to indicate sample type including dust floor, dust sill, scrape entry, scrape play or core play, core front and core rear, each individual's lab label and household ID (Attachment I). These forms were copied and sent to CDC for keypunching. These data were also keypunched twice for verification.

Data from the XRF testing in each home were computerized by CDH personnel using the data base manager Dbase III+. Computerized data were checked against hard copy to identify data entry errors. These data were then converted to a SAS data set and merged with the larger SAS data set returned from CDC.

STATISTICAL ANALYSES

All the data were analyzed using Personal Computer Statistical Analysis Systems (PCSAS). Data analyses focused on children 6 to 71 months of age since behavioral characteristics place them at high risk for metal exposure in this setting. Some analyses further restricted the data to children less than three years as the population most likely to be at greatest risk of excessive exposure due to mouthing behaviors.

Univariate analyses of the questionnaire data were performed using t-tests and analysis of variance. Odds ratios were calculated for behaviorial characteristics and blood lead levels <10 or $\geq$ 10 ug/dl. The associations between environmental sampling results and biological values were examined using correlation coefficients. Stepwise forward regression was used to develop models explaining the variation in blood lead levels.

As is typical in such studies (33) the natural logarithm of the blood lead levels and environmental sampling results were more normally distributed than the blood lead values themselves. All statistical analyses were performed using log-transformed blood lead values and environmental sampling results. Biological and environmental values that were below the detection limit were used at 1/2 of the detection limit for all statistical analyses.

Some households had more than one child participating in the survey, which raised the issue of possible decreased variability in the data for siblings in the same household than for children of the same age in different households. This was addressed by comparing the mean blood lead level and standard deviation for households with more than one child participating in the study with the mean blood level and standard deviation for all children in the study.

Each individual participating in the survey received a letter listing and discussing the significance of the biological results. Letters for children under 18 years of age went to the child's parents. The letters interpreted each individual's results and provided a definition of the terms used. A sample letter is included in Attachment J.

Each household also received a letter discussing the results of the environmental sampling. The letters listed each household's results and the mean result for that sample from the study (Attachment K).

RESULTS

Survey Participation

The census screened 1513 households (Table 1). Approximately 9% of eligible households refused to participate in the census and 15% of all households were classified as "No Contact" after 4 or 5 attempts. The overall census response rate was 75%.

A total of 2,631 eligible individuals, aged 6 months through 65 years, were identified through the census; 239 were 6-71 months old (Table 2). One hundred-fifty children 6-71 months of age participated in the survey; a 62.8% response rate in this age group. Twenty-five individuals from each sex in the age groups 6-14, 15-44 and 45-65 years were randomly selected for the survey. Response rates by sex and for these age groups ranged from 44 to 65% (Table 3).

Biological Results

Blood Lead Levels

The arithmetic mean blood lead level for children 6-71 months was 10.1 ug/dl. Three children with lead levels >25.0 ug/dl did not meet the CDC definition of lead toxicity as their FEP levels were below 35 ug/dl. Mean blood lead levels for the age groups 6-14, 15-44 and 45-65 years were 5.8, 6.4 and 8.6 ug/dl, respectively (Table 4). One adult male with a blood lead level of 28.0 ug/dl is currently employed as a miner. An adult female with a blood lead of 27.6 ug/dl was found to have pica (the materials ingested did not have a local origin). The geometric mean of blood lead levels for children less than six years, children 6-14 years, adults 15-44 years and adults 45-65 years were 8.7, 5.1, 5.5 and 6.8 ug/dl, respectively (Table 4).

Males and females less than 6 years old had similar mean blood lead levels. With increasing age, males had consistently higher mean blood lead levels. The difference between males and females is statistically significant for the geometric means for the 15-44 year and 45-65 year age groups (Table 5).

Hispanics (self-reported on the Questionnaire) tended to have lower mean blood lead levels than non-hispanics with the exception of the 45-65 year age group. The geometric mean blood lead level of non-hispanics was significantly higher than hispanics in the 15-44 year age group. The opposite was found in the 45-65 year age group; hispanics had significantly higher geometric mean blood lead levels (Table 6).

Sibling Analysis

For households with more than one child less than six years old participating in the survey, the arithmetic mean blood lead level was 11.0 ug/dl with a standard deviation of 6.6 ug/dl (N = 41). This compares to a mean blood lead level of 10.1 ug/dl with a standard deviation of 5.6 ug/dl for all children less than six years old regardless of the number of children in a household participating in the survey (N = 150). It was expected that the population with more than one child in the household participating in the survey would have less variability in blood lead levels because of household clustering. This was not the case, and as a result, all children were included in subsequent analyses.

Free Erythrocyte Protoporphyrin Levels

The arithmetic mean FEP level for children 6-71 months was 19.0 ug/dl and 20.9 ug/dl for children 6-14 years. Persons 15-44 years and 45-65 years had mean FEP levels of 29.9 and 29.0 ug/dl respectively. Four children younger than 6 years with FEP levels >35 ug/dl did not have associated blood lead levels ≥25 ug/dl. The geometric mean FEP levels were 17.7 ug/dl for children 6-71 months, 20.3 ug/dl for children 6-14 years, 23.2 ug/dl for adults 15-44 years and 25.1 ug/dl for adults 45-65 years (Table 7). FEP levels were negatively correlated with hemoglobin levels ($R = 0.17$, $p = 0.04$) and hematocrit levels ($R = 0.15$, $p = 0.07$).

Hemoglobin and Hematocrit

The mean hemoglobin for children 6-71 months was 13.9 ug/dl and the mean hematocrit 40.1 ug/dl. Adults between 45-65 years had the highest mean hemoglobin and hematocrit levels; 16.3 ug/dl and 48.0 ug/dl, respectively (Tables 8-9).

Arsenic Levels

No urinary arsenic levels exceeded the expected range of 1-100 ng/ml. Mean levels of urinary arsenic were 9.0 ng/ml in children 6-71 months, 8.2 ng/ml in children 6-14 years, 7.4 ng/ml in adults 15-44 years and 13.0 ng/ml in adults 45-65 years. Geometric mean urinary arsenic levels were 7.4, 6.8, 6.03 and 8.5 ng/ml, respectively (Table 10).

Cadmium Levels

Urinary cadmium values corrected for creatinine did not exceed the expected values of up to 5 ug/g of creatinine. Mean urinary cadmium values ranged from 0.17 to 0.78 ug/g of creatinine and geometric mean values ranged from 0.10 to 0.30 ug/g of creatinine (Table 11).

Beta-2-microglobulin levels ranged from below the detection limit (detection limit = 98 ug/l) to 393.0 ug/l. Children less than six had the highest mean level of 176.6 ug/l and geometric mean level of 148.4 ug/l. Arithmetic and geometric mean levels of beta-2-microglobulin decreased in successively increasing age groups (Table 12).

Environmental Results

Soil and Dust Samples

Six different soil and dust samples were collected around the home from one hundred and seventy households. Varying circumstances in the households resulted in different numbers of samples being collected from one household to the next. For example, if the family lived in an apartment, rear core samples may not have been available.

Environmental samples were collected at each of the 170 households participating in the study. One hundred and thirty-eight samples (81.2%) were collected in the play areas (37 core and 111 surface scrapes), 166 (97.6%) core samples were collected in the rear of the households, 168 (98.8%) core samples were collected in the front of the houses, 169 (99.4%) scrape samples were collected at the entry of the houses, 170 (100.0%) composite dust samples from the windowsills were collected inside the houses and 169 (99.4%) composite dust samples from the floors were collected inside the houses.

Tables 13, 14, and 15 summarize the results of the Pb (Table 13), As (Table 14), and Cd (Table 15) analyses of the dust and soil samples. Because of the log-normal character of the distributions, both arithmetic and geometric means and standard deviations are listed. Also listed are the number of samples and the ranges of these elements in the sample types.

The samples having the highest individual values for Pb, As and Cd were all windowsill dust samples (Pb = 27,900 ppm, As = 744 ppm and Cd = 3,300 ppm). The samples with the highest geometric means of Pb, As and Cd were entry scrapes, (Pb = 1,879 ppm, As = 117 ppm) and sill dust (Cd = 26 ppm).

The geometric means for Pb in the front and rear soil cores were 1,108 ppm and 915 ppm, respectively, with ranges of 49-15,000 ppm for the front cores and 10-27,800 ppm for the rear cores. The geometric means for arsenic in the front and rear cores were 42 and 31 ppm, respectively, the geometric means for cadmium in the front and rear soil cores were both 11 ppm.

Water Samples

Water samples from the tap of each household participating in the survey were collected and analyzed for lead. All but two of the water samples had lead concentrations below the level of detection of 5 ug/L. The two samples above the detection limit had lead concentrations of 13 ug/L and 10 ug/L; well below the EPA's maximum contaminant level (MCL) of 50 ug/L although EPA has proposed a new MCL of 5 ug/L.

X-ray Fluorescence Measurements of Lead in Paint

XRF readings that deviated by more than 0.5 mg/cm^2 from the calibration standard were considered out of range and not included in these univariate analyses. Eighty-seven households out of the 170 households which participated in the survey had XRF data that were within the calibration standards (Table 16). High levels of lead in paint were defined by readings of >6.0 mg/cm^2. Thirteen and seven tenths percent of all interior walls and 16.7% of the exterior walls had high levels of lead in the paint. The main entry way of the households was the interior surface most frequently (18.9%) found to contain high levels of lead in the paint. The exterior house readings which were taken in the vicinity of the window had the largest percentage (21.7%) of high readings.

Correlation Between Environmental Samples

Lead in composite floor dust samples was significantly correlated with the lead in all other dust and soil samples (Table 17), and most strongly correlated with lead in composite windowsill dust samples ($r = .41$, $p < 0.001$). Composite windowsill dust samples were also significantly correlated with all other soil samples except core samples collected in the play area.

Core samples collected at the rear of the house were significantly correlated with all other dust and soil samples collected. Core samples at the rear of the house were moderately correlated with core samples collected in the play area ($r = .64$, $p < .001$) and core samples collected in the front of the house ($r = .52$, $p < .001$).

Play area scrape samples and play area core samples could not be correlated as these sample types are mutually exclusive. If a scrape sample was collected from the play area a core sample was not collected.

Biological Values by Environmental Contaminant

Lead

Analyses examining the relationship between the levels of contaminants in the environmental samples and biologic values in humans focused on children less than six years of age. With the exception of play area core samples, mean blood levels for children less than six years (Table 18) in households where soil lead levels were less than or equal to 500 ppm were less than mean blood lead levels for children living in households with soil lead levels greater than 500 ppm. This was not true for dust samples (Table 19).

Significant associations exist between blood lead levels greater than or equal to 10 ug/dl and soil lead levels greater than 500 ppm for core samples taken at the rear of the house (X^2 = 18.1, p <0.001) and scrape samples collected in the play area (X^2 = 6.9, p = 0.009) (Table 20). For children exposed to greater than 500 ppm lead in the core rear samples, odds of having a blood lead greater than or equal to 10 ug/dl was 8.40 (95% confidence limits 2.80 - 25.26). Additionally, for these children the odds of having a blood lead greater than or equal to 15 ug/dl was 8.21 (95% confidence limits 1.07 - 63.37) . The relationship between the blood lead levels and core samples from the front of the house (X^2 = 3.3, p = .071) and composite dust samples from the floor of the house (X^2 = 3.4, p = .066), approached statistical significance.

Blood lead levels were correlated with the lead in soil samples but not the indoor dust samples (Table 21). Blood lead levels for children less than six years were most strongly correlated with lead in core samples taken at the rear of the house ($r = .50$, $p < 0.001$).

Children less than three years but greater than or equal to one year, were examined as a separate group since their behaviorial characteristics may increase their ingestion of contaminated soil and dust. Blood lead levels for this group were also correlated with lead in core samples taken at the rear of the house ($r = .53$, $p < .001$).

For children less than three years, but greater than one year, blood lead levels greater than or equal to 10 ug/dl were significantly associated with lead concentrations in rear core samples of greater than 500 ppm. ($X^2 = 13.1$, $p < .001$) (Table 22).

Arsenic

Mean urine arsenic levels by soil and dust arsenic levels are shown in Tables 23 and 24. Urine samples were available from only 41 children, thus there are relatively few urine arsenic levels to stratify by soil and dust arsenic level. Urine arsenic levels were negatively correlated with arsenic concentrations in composite windowsill dust samples ($r = -.33$, $p = .03$). None of the other dust or soil arsenic concentrations were correlated with the urinary arsenic levels.

Cadmium

Tables 25 and 26 summarize mean cadmium levels versus soil and dust soil cadmium levels. No significant correlations exist between the urine cadmium levels and the cadmium concentrations in the soil and dust samples.

Lead in Paint

Mean blood lead levels by lead-based paint values are shown in Table 27. Mean blood lead levels vary among the lead-based paint categories. An analysis of variance found no association between blood lead levels and values of lead-based paint in the interior or exterior of the house.

Univariate Analyses

Variables that were found to be associated ($p < 0.05$) with blood lead levels are listed in Table 28. These initial analyses were performed to explore possible relationships between blood lead levels and various characteristics, and $p < 0.05$ was used to test for statistical significance. Significant odds ratios for behaviorial characteristics and blood levels <10 or ≥10 ug/dl are listed in Table 29.

Play habits associated with a child's blood lead level included whether the child took food or a bottle outside to play, whether the child washed his or her hands after playing, the type of ground played on and the hours spent outside playing.

Mouthing and eating habits of the child associated with blood lead levels included how often the child swallowed things other than food and how often household members ate leafy green vegetables grown in Leadville. Lead related household hobbies that were found to be associated with blood lead levels was having a household member work with soldering electronics or soldering pipes.

The parent's occupational habits were associated with the child's blood lead level if a miner in the household either wore his or her work clothes home or did not shower before coming home from the mine. Other variables associated with the blood lead levels included the child's age, whether dogs and cats go in and out of the house, whether anyone used materials from the mine around the house or yard, whether a household member smokes and whether the house had been refinished in the last month.

The list of variables which were examined and found not to be associated with blood lead levels is found in Tables 30 and 31.

Multivariate Analyses

The multivariate analyses focused on children 6-71 months of age. The log of the blood lead levels and the log of the environmental sampling results were used in all analyses.

Variables found to be significantly associated with the blood lead levels through the univariate analyses or from the calculated odds ratios (Tables 28 and 29) were used in a forward stepwise linear regression to determine which had independent effects on blood lead levels. Variables having a significant independent effect on blood lead levels included: eating leafy green vegetables grown in Leadville less than once a week; whether a child swallows things other than food; using materials from the mine around the house or yard; taking a bottle or food outside to play; the type of ground played on, and the child's age (Table 32).

These variables were used in a linear regression model. Because eating leafy green vegetables was used in the model as an ordered dummy variable, eating leafy green vegetables grown in Leadville more than once a week was forced into the regression to allow interpretation of the inclusion of eating leafy green vegetables grown in Leadville less than once a week in the model. Results of this model are presented in Table 32. Forty percent of the variation in childhood blood lead levels was explained using this model ($R^2 = .40$).

The negative regression coefficient of eating leafy green vegetables grown in Leadville less than once a week and the non-significance of eating leafy green vegetables grown in Leadville more than once a week indicates that children who ate leafy green vegetables grown in Leadville less than once a week had significantly lower blood lead levels than children who ate them more than once a week or never ate them.

The association with the dummy variable playing on dirt or soil indicates that children who played mainly on soil had higher blood levels than children who played on a grassy area or on concrete or asphalt.

Stepwise forward regression was also performed to identify the independent sources of variation in the blood lead levels among the environmental samples. After adjusting for the core rear sample no other environmental sampling variables were associated with the blood lead levels (Table 33).

The potential confounding effects of the behavioral characteristics on the association between the core rear sample and the blood lead levels were also examined. The behaviorial characteristics and the results of the core rear sample were combined into a single model (Table 34). After adjusting for the effects of the behaviorial characteristics the association with the core rear sample remains. This model explained 46% of the variation in the blood lead levels of children less than six (R^2 = .46).

This heavy metal exposure study in Leadville is unique from previous studies in several aspects. Other studies have looked at lead exposure in urban populations (14-15) or exposure to lead exclusively from smelters (30-32). Leadville is a rural community with a combination of lead contamination from past mining and smelting activities in addition to background mineralization.

Survey Participation

A 62.8% rate of participation of children less than 6 years was achieved in the study. The only data available for children identified through the census who did not participate in the study are age and sex. Children who did not participate in the study included a slightly higher percentage of males (57.8%) than children who did participate (50.7%). Childhood blood lead levels in this study were not different by sex, and the age distribution between participants and nonparticipants were similar; thus, it would appear that bias in the study results introduced by the nonparticipants is unlikely.

Response rates varied for the older age groups. The sample sizes were small ranging from 11 to 15 individuals for each sex and age group. The small number of participants and the lack of associated high risk behavior for heavy metal exposure (i.e., pica) resulted in data analyses being primarily restricted to children less than six years.

Biologic Test Results

There were no cases of lead toxicity in children less than six years living in Leadville, as defined by the current CDC criteria for lead toxicity. Several ongoing prospective studies, however, have found significant effects on cognitive function at levels (10-15 ug/dl) well below the 1985 CDC guidelines of 25 ug/dl (14). Approximately fifteen percent of the children less than six years had blood lead levels greater than 15 ug/dl and 40.7% were greater than 10 ug/dl (Table 35).

Four children had elevated FEP levels and, as stated previously, there were no elevated blood lead levels associated with these. Thus, the abnormal FEP values were most likely an indication of iron deficiency and study participants were advised as such. In addition, FEP values are not a good indicator of potential lead toxicity at lower blood lead levels, the majority of blood lead levels identified in this study were less than 15 ug/dl.

We were unable to find information on expected normal ranges of hemoglobin and hematocrit at 10,000 feet above sea level.

No increased values of urinary arsenic (>100 ng/ml) or cadmium (>5 ug/g creatinine) were found indicating that excess exposure to these compounds is not taking place in Leadville.

There were three elevated beta-2-microglobulin levels in children. This is not a specific test of cadmium toxicity and it is likely that these were

were elevated due to other illnesses in these children. One child had a parent-reported streptococcal pharyngitis at the time the test was performed.

Comparison with Other Studies

Approximately 15% of the children less than six years had blood lead levels greater than 15.0 ug/dl (Table 35). Comparisons of the mean blood lead of children less than six years in Leadville with other studies is shown in Table 36. The mean blood lead level in Leadville is lower than other studies with the exception of Telluride, Colorado and Areas 2 and 3 in Helena, Montana. Areas 2 and 3 in Montana were designated as areas of decreasing exposure from a point source of lead at distances of 1-2.25 miles and > 5 miles respectively.

It is, in fact, very difficult to make comparisons with other studies because the other studies in similar environments (e.g. Helena, Montanta) were conducted from a few years to several years prior to this study. A dramatic decrease in blood leads has been taking place over the past decade (36). To predict this trend EPA has developed a model to account for the effect of reductions in lead used in gasoline and in food containers (20). This model predicts that the geometric mean for children two years of age in 1990 will be 3.0-4.7 ug/dl compared to the value of 14.9 ug/dl found by the National Health and Nutrition Examination Survey (NHANES II) study in 1978. This is a drop of nearly 1 ug/dl per year. Comparisons of the 1987 Leadville results with the original NHANES II data or, for that matter, any study that was done more than a year distant is meaningless unless it occurred before 1987 and is found to be significantly lower in lead exposure than our study (since the effect of the trend downward would only improve the significance).

It is currently not known what the baseline blood lead level is for 1987. EPA personnel ran their model for 1-6 year old children residing in the Western, rural United States in 1987, and predicted a geometric mean of 6-7 ug/dl. (Personal communication, 1987, Hugh Pitcher, EPA).

The Park City, Utah study was done a few months after the Leadville study (38). This study found a mean blood lead of 7.8 ug/dl in their target population (9-71 months) compared to 4.0 ug/dl in a control population.

Another study close in time to the Leadville study is the 1988 blood lead sampling at the Bunker Hill Superfund site in Idaho. A recent report (39) notes that 14% of the children had blood leads greater than 15 ug/dl and 41% had blood leads greater than 10 ug/dl. These figures are very close to those for Leadville (Table 37) where 41% were greater than 10 ug/dl and 15% were greater than 15 ug/dl. The Bunker Hill report does not give the geometric mean for the 1988 blood lead levels, but it does give the geometric standard deviation as 1.5 which allows an estimate of approximately 9.5 ug/dl for the geometric mean. In another survey done in Telluride, Colorado in 1986, a geometric mean of 6.2 ug/dl with a geometric standard deviation of 1.5 was obtained.

It is useful to compare the distributions of blood leads for Leadville, the "predicted" 1987 rural Western U. S. and Bunker Hill in 1988. Table 37 shows this comparison.

Table 37 indicates that the number of Leadville children with blood leads above 15 ug/dl was three times that predicted by EPA for Western rural U. S. and the same as that seen in Bunker Hill. But, even the comparison with 1988 Bunker Hill data is difficult because of the assumed downward trend with time.

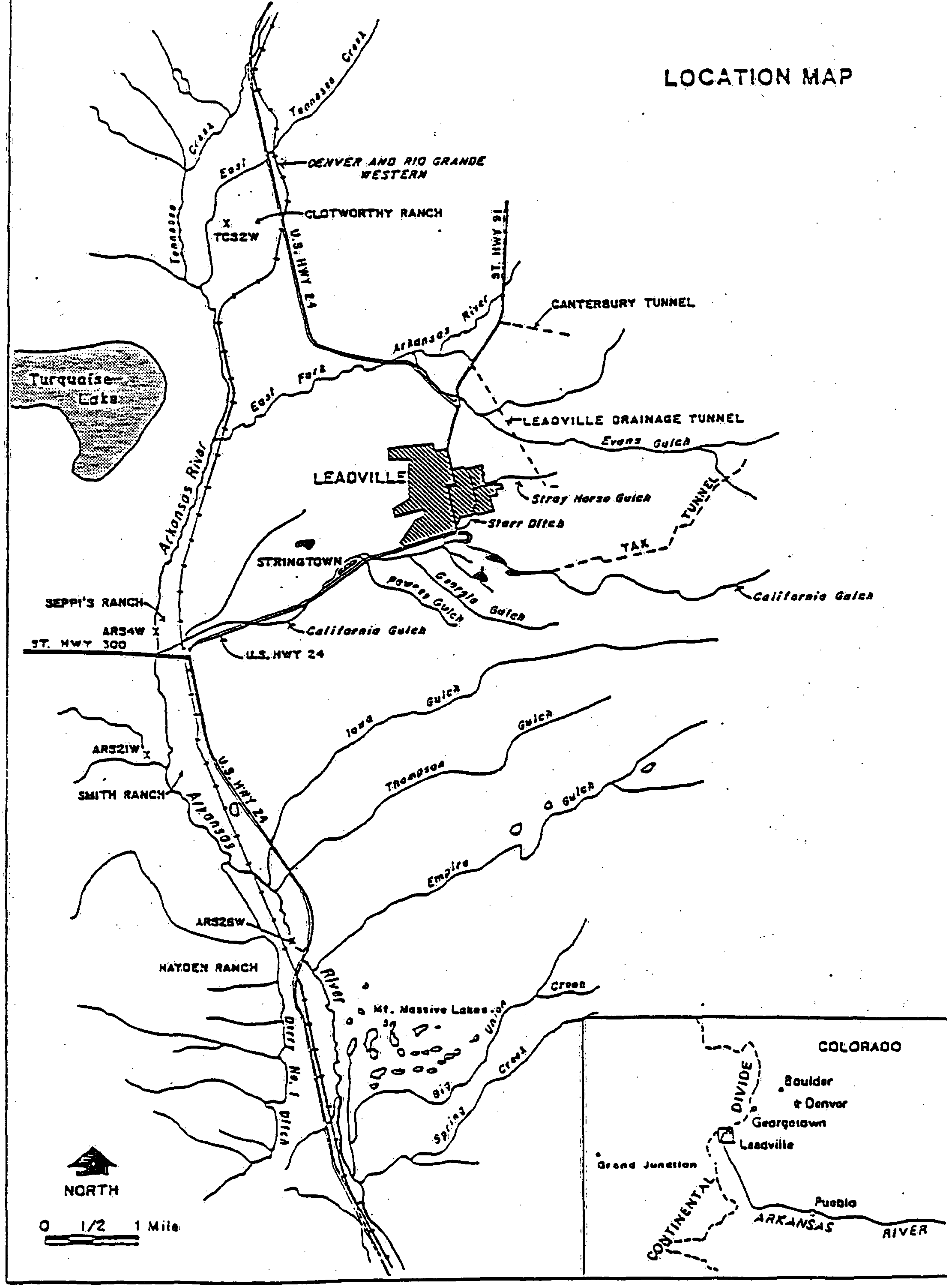
The comparison between the present study and the Bunker Hill results reveal another interesting result from this study. The geometric standard deviation (GSD) of 1.79 for the 6-71 months age group is significantly larger than the GSDs normally encountered which are typically in the range of 1.3 to 1.5. Several studies have obtained values close to 1.4. The NHANES II results have GSDs that vary with age, location and race between 1.31 and 1.40 (40). The Silver Valley Lead Study in Idaho found a GSD of 1.3 ug/dl in a study of 1149 children aged 1 to 9 years (41). A study of 377 children in New Haven, Connecticut (42) found GSDs for 1 to 6 year old children to vary from 1.29 to 1.35 depending on the type of housing. A study by Angle and McIntire in Omaha, Nebraska (43) found a value for the GSD of 1.395 for 831 subjects aged 1 to 18 years. A German study (44) for 114 children aged 6 to 7 years found a GSD of 1.4 ug/dl. On the basis of their studies, EPA uses 1.4 as a fixed constant in their predictive model (37).

An F-test reveals that the value of 1.79 from the Leadville study is significantly different ($p < .01$) from 1.4. Thus, the Leadville results for the children differ from those of several studies done over periods of 10 to 15 years and in various locations by having a very different geometric standard deviation for blood lead levels. The importance of this difference is shown in Table 38 which illustrates the difference in the distributions having the same geometric mean of 8.7 ug/dl as the Leadville children aged 6-71 months but with GSDs of 1.4 (the value usually found) and 1.79 (the value actually found).

This discrepancy is of concern since the effect of a larger GSD is to greatly increase the number of children at risk at any given level.

Why is the value for the blood lead GSD for Leadville so different from elsewhere? Since the blood lead analyses were performed by CDC under carefully monitored conditions, it is unlikely that differences in analytical variability could explain this result. One could argue that the Leadville population is very heterogeneous, but the same is true of many of the other groups studied. The NHANES II study involved many different groups, but the GSDs for all groups differed by less than 0.1 ug/dl. One difference between Leadville and the other studies is in altitude. Leadville, at 10,200 feet, is the highest incorporated city in North America. Both lead and altitude have dramatic effects on the oxygen carrying function and it is conceivable that altitude may provide a stress that affects the ability of the homeostatic mechanisms of individuals to respond to lead exposure. Since there is a

FIGURE 1


LOCATION MAP
Tennessee Creek
Creek
East
DENVER AND RIO GRANDE WESTERN
CLOTWORTHY RANCH
TC32W
Tennessee
U.S. HWY 24
ST. HWY 91
CANTERBURY TUNNEL
Arkansas River
East Fork
Turquoise Lake
LEADVILLE DRAINAGE TUNNEL
Evans Gulch
LEADVILLE
Stray Horse Gulch
Starr Ditch
Arkansas River
TUNNEL
YAK
STRINGTOWN
Pawnee Gulch
Georgia Gulch
California Gulch
SEPPI'S RANCH
ARS4W
ST. HWY 300
California Gulch
U.S. HWY 24
Iowa Gulch
Thompson Gulch
ARS21W
SMITH RANCH
U.S. HWY 24
Arkansas
Gulch
Empire
ARS28W
HAYDEN RANCH
River
Mt. Massive Lakes
Creek
Union
Ditch No. 1 Ditch
Big Creek
Spring
NORTH
0 1/2 1 Mile
COLORADO
DIVIDE
Boulder
Denver
Georgetown
Leadville
Grand Junction
CONTINENTAL
Pueblo
ARKANSAS RIVER

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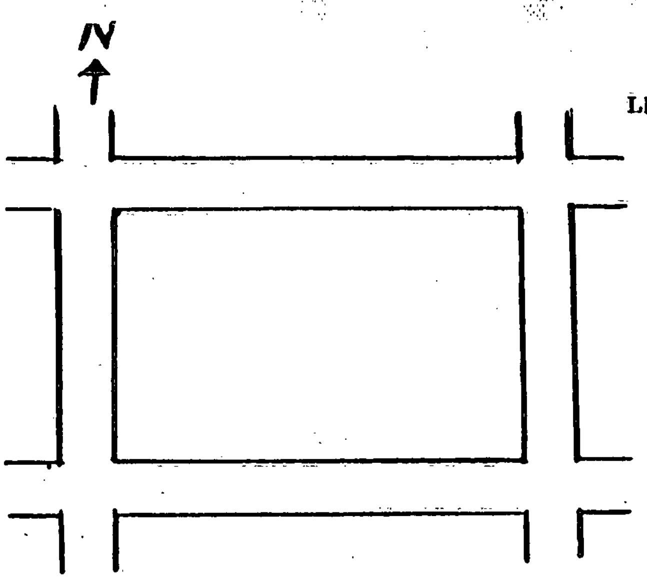
ATTACHMENT A



LEADVILLE HEAVY METALS EXPOSURE ASSESSMENT
SEPTEMBER 1987

page _ of _

BLOCK SURVEY FORM

Date _ _/_ _/87 Interviewer: ____________________

City: ____________________

Block # _ _ _ _

Building #	Premises Address	Residential/ Single Family	Residential/ Multiple Family	Vacation/ Weekend	Business	Vacant	Census Completed	Census Refused	Comments

LEADVILLE HEAVY METALS EXPOSURE ASSESSMENT
September, 1987
CENSUS FORM

_ _ _ BLOCK _ _ BLDG.

Interviewer Initials _ _ Date _ _/_ _/_ _ Time _ : _ am/pm Adult at home? 1=yes 2=no Is this a year round residence? 1=yes 2=no

Contact name ____________ (Last) ____________ (First) Best time to recontact _ _ : _ _ am/pm

Address ________ (Number) ____________ (Street)

Telephone Home _ _ _ - _ _ _ _
Work _ _ _ - _ _ _ _

Best day to recontact
__Sun
__Mon
__Tue
__Wed
__Thu
__Fri
__Sat

Total number of persons in home ____ Contact #1 ____
#2 ____
#3 ____
#4 ____

Completion Status
1=Refused
2=Participate
3=No contact
4=Invalid address
5=Other

NAME	Sex 1=M 2=F	Relationship 1=self 2=spouse 3=parent 4=child 5=other family 6=other	Birthdate mo-day-yr	Lived in house 3 months? 1=yes 2=no	Lived in Leadville 3 months? 1=yes 2=no	Current miner in household? 1=yes 2=no	Past miner in household? 1=yes 2=no
1. F__________ MI__ L__________	__	__	_ _/_ _/_ _	__	__	__	__
2. F__________ MI__ L__________	__	__	_ _/_ _/_ _	__	__	__	__
3. F__________ MI__ L__________	__	__	_ _/_ _/_ _	__	__	__	__
4. F__________ MI__ L__________	__	__	_ _/_ _/_ _	__	__	__	__
5. F__________ MI__ L__________	__	__	_ _/_ _/_ _	__	__	__	__

CENSUS FORM

NAME	Sex 1=M 2=F	Relationship 1=self 2=spouse 3=parent 4=child 5=other family 6=other	Birthdate mo-day-yr	Lived in house 3 months? 1=yes 2=no	Lived in Leadville 3 months? 1=yes 2=no	Current miner in household? 1=yes 2=no	Past miner in household? 1=yes 2=no
6. F____________ MI__ L____________	__	__	__ __/__ __/__ __	__	__	__	__
7. F____________ MI__ L____________	__	__	__ __/__ __/__ __	__	__	__	__
8. F____________ MI__ L____________	__	__	__ __/__ __/__ __	__	__	__	__
9. F____________ MI__ L____________	__	__	__ __/__ __/__ __	__	__	__	__
10. F____________ MI__ L____________	__	__	__ __/__ __/__ __	__	__	__	__

ATTACHMENT B

STATE OF COLORADO

COLORADO DEPARTMENT OF HEALTH
4210 East 11th Avenue
Denver, Colorado 80220
Phone (303) 320-8333

Roy Romer
Governor

Thomas M. Vernon, M.D.
Executive Director

A representative of the Leadville Heavy Metals Exposure Assessment team stopped by today as part of the census we are conducting throughout Leadville. The representative will stop by again to ask you if you would be willing to answer questions about the number of people living in your home.

If you have any questions or would like to call us with this information please contact us at 486-1162.

Thank you,

____
Representative

Date__ __/__ __/__ __ Time __ __:__ __ am
pm

Block # __ __ __ Building # __ __

ATTACHMENT C

STATE OF COLORADO

COLORADO DEPARTMENT OF HEALTH
4210 East 11th Avenue
Denver, Colorado 80220
Phone (303) 320-8333

Roy Romer
Governor

Thomas M. Vernon, M.D.
Executive Director

CONSENT FORM

LEADVILLE HEAVY METAL STUDY
BLOOD AND URINE SAMPLES

You are being asked to particpate in a study of your (or your child's/ward's) exposure to lead, cadmium and arsenic.

If you agree to participate in this study blood will be obtained by venipuncture which involves placing a needle in your (or your child's/ward's) arm and withdrawing 3 to 6 c.c.'s (about a teaspoonful) of blood. The needle will be left in for a few minutes. You can expect to experience some pain at the moment the needle goes into your arm. In about 10% of cases a small amount of bleeding under the skin will produce a bruise (hematoma). The risk of temporary clotting of the vein is about 1%, while the risk of infection of a hematoma or significant external blood loss is less that 1 in 1000.

In the case it is not possible to obtain blood from your child or ward by venipuncture, we will obtain blood samples by means of a finger stick. This is the standard method to obtain blood for routine hospital laboratory tests. Pain may be experienced when the lancet goes into the finger but otherwise the discomfort should be minimal. In about 10% of the cases a bruise will be produced and a small scar may persist for several weeks. The risk of infection is less than one in a thousand.

Urine samples may also be collected by urination into a container. The collections of blood and urine will be conducted by trained health specialists.

In addition, tap water samples and dust samples from inside and outside your home will be collected and analyzed for the content of arsenic, lead, cadmium and other metals. Furthermore, the paint on the inside and outside of your home will be measured for lead content. These procedures will take about one to one and a half hours. The investigators will also ask questions to help interpret the results such as smoking behavior, length of residence, etc.

Your participation is voluntary and refusal to participate will involve no penalty to you (or to your child/ward). You may withdraw from the study at any time without penalty or prejudice.

The investigators are not obligated to treat or further evaluate any problems that may be found. Results will be reviewed and interpreted by a panel of experts and a follow-up letter with interpretation will be sent to you. The results of the tests will be forwarded to your physician only with your permission. A list of private physicians will be supplied if you desire further care.

Blood samples will be analyzed for lead and a measure of the effects of lead. The blood sample will also be analyzed for the oxygen-carrying capacity of blood. The urine sample, if collected, will be analyzed for arsenic, cadmium and a measure of the effect of cadmium on the kidney.

The only benefit from this study will be the determination of the status of your (or your child's/ward's) exposure to lead, arsenic and cadmium.

Your name (or that of your child/ward) will NOT be used in any published report of this study.

AUTHORIZATION: I have read the above and understand the discomforts, inconveniences, and risks of this study. I agree to the participation of ______________________________. I also give my permission to be contacted in the future should further testing be indicated. I understand that I (he/she) can refuse to participate or withdraw at any time. (Initial the first page of Consent Form if there are two or more pages used.)

DATE______________

SIGNED: ____
Adult Volunteer or Parent/Guardian

WITNESS____
Investigator/Witness

To the Minor Child

We are going to take about a teaspoonful of blood by inserting a very small needle into your arm. There will be a small pain. It may leave a bruise or mark, but that will go away soon. We would also like you to take a small cup into the bathroom and urinate into it. This is to see if you have some chemicals in you.

For the participant who is a minor 7 years of age or older:
I agree with the consent given by my parent/guardian.

____
Check, Initial, or Signature of Minor

LEADVILLE HEAVY METAL EXPOSURE ASSESSMENT QUESTIONNAIRE

Household ID __ __ - __ __ Interviwer Initials __ __ __ (1-8)
Block / Bldg.

Date __ __ - __ __ - __ __ Number of Selected Participants __ __ (9-16)

A. Children 6 months - 71 months (List by age, oldest first)

NAME	ID	LAB LABEL	Individual Completion	
1. ____________________	__ __	______	__	(17-49)
2. ____________________	__ __	______	__	(50-82)
3. ____________________	__ __	______	__	(83-115)
4. ____________________	__ __	______	__	(116-148)

D. Person 6 - 14 years old

____________________	__ __	______	__	(149-181)

C. Person 15 - 65 years old

____________________	__ __	______	__	(182-214)

Contact Number	Household Completion Status	Indiv. Compl. Codes
1 ____	1=All complete	1=Complete
2 ____	2=Further visit needed	2=Refusal
3 ____		3=Unable to contact
4 ____		4=Other

Remarks:

The following person(s) has (have) been selected to be part of the second phase of the Leadville Heavy Metals Exposure Assessment. (List). We need to get some information on this (these) individual(s).

IF THERE ARE CHILDREN 6-71 MONTHS OR 6-14 YEARS:

For children under age 15 I will need to talk to the parent or legal guardian, preferably the person who can tell us about how the children spend their time.

IF THERE ARE SELECTED INDIVIDUALS 15+:

I will (also) need to talk to SELECTED INDIVIDUAL.

IF THIS IS PERSON NOT AVAILABLE:

When can I return to talk to SELECTED INDIVIDUAL?

__ __ __ DAY OF WEEK

__ __-__ __ MO-DAY

__ __:__ __ TIME AM PM

100. HOUSEHOLD CHARACTERISTICS

THE FOLLOWING QUESTIONS CAN BE ANSWERED BY ANY HOUSEHOLD MEMBER AGE 18 AND OVER

First I would like to ask you some questions about your home.

101. How long has this family been living in this home?

Years __ __ Months __ __ (215-218)

If less than three months, then obtain previous address within Leadville.

ADDRESS: ____

____

102. What year was this house built?

Year __ __ __ __ (If unknown then enter 8888) (219-222)

103. Does your house have lead pipes for the plumbing?

1=Yes 2=No 8=Don't know (223)

104. What is the source of water for this house?

1=City water lines (224)
2=Private well

3=Other

8=Don't know

105. Have you repainted, sanded, or otherwise refinished any part of your home in the last month?

1=Yes 2=No 8=Don't know (225)

106. Have you ever repainted, sanded or otherwise refinished any part of your home prior to the last month?

1=Yes 2=No 8=Don't know (226)

If yes, ask for approximate year and month.

Year__ __ Month __ __ (227-230)

107. Does your home have storm windows?

1=Yes 2=No 8=Don't know (231)

Now I'd like to ask you some questions about the work and hobbies of persons living in this house.

108. Have any of the adults in the household worked as a miner or in a mining related job in the last 3 months?

1=Yes 2=No 8=Don't know (232)

IF YES, THEN COMPLETE QUESTIONS 109 through 112; OTHERWISE GO ON TO QUESTION 113.

109. Have any household member engaged in the following types of mine work in the last month?

a. Underground	1=Yes	2=No	8=Don't know	(233)
b. Milling	1=Yes	2=No	8=Don't know	(234)
c. Mill	1=Yes	2=No	8=Don't know	(235)
d. Clerical/Admin.	1=Yes	2=No	8=Don't know	(236)
e. Other	1=Yes	2=No	8=Don't know	(237)

110. What type of mine have family members worked in in the last month?

a. Lead only	1=Yes	2=No	8=Don't know	(238)
b. Zinc only	1=Yes	2=No	8=Don't know	(239)
c. Lead/Zinc	1=Yes	2=No	8=Don't know	(240)
d. Silver	1=Yes	2=No	8=Don't know	(241)
e. Molybdenum	1=Yes	2=No	8=Don't know	(242)
f. Other	1=Yes	2=No	8=Don't know	(243)

111. Does any family member that works in a mine wear his/her work clothing home after working?

1=Yes 2=No 8=Don't know (244)

IF NO ASK Q.112; OTHERWISE GO ON TO Q.113.

112. Does any family member that works in a mine come home from work without showering?

1=Yes 2=No 8=Don't know (245)

113. Do you or any members of your household participate in any of the following hobbies or activities?

CODES: 1=Yes 2=No 8=Don't know

A. Paint pictures with artists paints?	1	2	8	(246)
B. Paint furniture in the home?	1	2	8	(247)
C. Work with stained glass?	1	2	8	(248)
D. Cast lead into fishing sinkers, bullets or anything else?	1	2	8	(249)
E. Work with soldering in electronics?	1	2	8	(250)
F. Work on soldering pipes?	1	2	8	(251)
G. Make pottery at home?	1	2	8	(252)
H. Ride a dirt bike or ATV in the local area?	1	2	8	(253)

Now I'd like to ask you some questions about your diet and food preparation:

114. Does your family have a garden?

1=Yes 2=No 8=Don't know (254)

IF YES ASK Q.115;OTHERWISE GO ON TO Q.117.

115. Has soil been hauled in and placed on your garden?

1=Yes 2=No 8=Don't know (255)

116. About how often do members of your household eat vegetables grown in your garden or elsewhere in Leadville?

1=Once a week or more (256)
2=Occasionally (less than once per week)
3=Never IF NEVER GO ON TO Q.119
8=Don't know

117. About how often do members of your household eat leafy green vegetables, (such as lettuce or spinach) grown in your garden or elsewhere in Leadville?

1=Once a week or more (257)
2=Occasionally (less than once per week)
3=Never
8=Don't know

118. About how often do members of your household eat root vegetables, (such as beets or turnips) grown in your garden or elsewhere in Leadville?

1=Once a week or more (258)
2=Occasionally (less than once per week)
3=Never
8=Don't know

119. When food is served, is it ever served in homemade or imported clay pottery or ceramic dishes?

1=Yes 2=No 8=Don't
know (259)

120. When food is stored or put away for awhile, is it sometimes stored in the original can after being opened?

1=Yes 2=No 8=Don't know (260)

121. Does anyone in this household smoke?

1=Yes 2=No 8=Don't know (261)

122. What is the highest grade or year of regular school that was completed by the head of this household

01=Elementary school (262-263)
02=Junior High School
03=Some High School
04=High school graduate
05=Some college
06=College graduate
07=Graduate degree
08=Vocational school
09=Other
88=Don't know

123. Which of the statements in the following list comes closest to the total household income for this family before taxes in 1986?

1=Under $5,000 (264)
2=$5,000 or more but less than $10,000
3=$10,000 or more but less than $15,000
4=$15,000 or more but less than $20,000
5=$20,000 or more but less than $25,000
6=$25,000 or more but less than $30,000
7=$30,000 or more
8=Don't know
0=Refused to respond to this question

124. Do you have any dogs or cats that go in and out of the house?

1=Yes 2=No 8=Don't know (265)

125. Has anyone ever used any materials from the mines around your house or yard?

1=Yes 2=No 8=Don't know (266)

IF THERE IS AT LEAST ONE PARTICIPANT IN THIS HOUSEHOLD AGE 6-71 MONTHS, THEN PROCEED WITH SECTION 200.

IF NOT, AND THERE IS A PARTICIPANT AGE 6-14 YEARS PROCEED TO SECTION 300.

IF THE ONLY STUDY PARTICIPANT IS AGE 15 AND ABOVE PROCEED TO SECTION 400.

200. QUESTIONS ABOUT CHILDREN 6-71 MONTHS OLD. THESE SHOULD BE ANSWERED BY THE PARENT OR GUARDIAN OF THE CHILD

I need to ask a number of questions about (your/each) child that was selected for the study.

IF MORE THAN ONE:

I would like to start with the oldest.

LIST ALL INFORMATION IN SECTION 200 FOR THE FIRST CHILD AND THEN RETURN TO QUESTION 201 FOR THE SECOND OLDEST, ETC. MAKE SURE ORDER OF CHILDREN IS CONSISTENT WITH PAGE 1 OF THE QUESTIONNAIRE. ENTER RESPONSES TO QUESTIONS 201-204 IN TABLE 1 BELOW:

201. First of all, what is (the/that) child's name?

202. What is the child's date of birth? (MO/DA/YR)

203. What is the child's sex?

1=Male
2=Female

204. Circle code for race of each child. (Ask if necessary).

1=White, non-Hispanic
2=Hispanic
3=Black, non-Hispanic
4=Asian or Pacific Islander
5=American Indian/Alaska native
6=Other
7=Refused
8=Don't know

Table 1
Child's Characteristics

Child No.	201 NAME	202 DATE OF BIRTH Mo-Da-Yr	203 SEX 1=Male 2=Female	204 RACE	
1	____________	__ __-__ __-__ __	__	__	(267-74)
2	____________	__ __-__ __-__ __	__	__	(275-82)
3	____________	__ __-__ __-__ __	__	__	(283-90)
4	____________	__ __-__ __-__ __	__	__	(291-98)

ENTER RESPONSE TO QUESTIONS 205-206 IN TABLE 2 BELOW:

205. Where does (child's name) spend most of his/her daytime hours?

1=At home
2=At babysitter
3=At a day care center
4=At a relative's home
5=At some other location.

206. About how many hours each day, on the average, does he/she spend away from home? (HOURS)

Table 2
Child's Daily Routine

Child No.	205 WHERE TIME SPENT DURING DAY	206 AVERAGE HOURS AWAY	
1	1 2 3 4 5	__ __	(299-301)
2	1 2 3 4 5	__ __	(302-304)
3	1 2 3 4 5	__ __	(305-307)
4	1 2 3 4 5	__ __	(308-310)

ENTER RESPONSES TO QUESTIONS 207-211 IN TABLE 3 BELOW:

207. Does he/she play outdoors around the house or in the neighborhood?

1=Yes   2=No   8=Don't know

208. If yes, then how many hours a day on the average does he/she play outdoors? (HOURS)   88=Don't know

209. Where does he/she usually play when outdoors around the house?

1=Back yard   7=Other
2=Front yard   8=Don't know
3=Side yard

210. Is the ground where he/she usually plays mainly grassy, concrete/asphalt, plain dirt or soil, just a sandbox, or some other composition?

1=Grassy   4=Sandbox
2=Concrete/asphalt   7=Other (specify)
3=Dirt/soil   8=Don't know

211. Does he/she often take some food or a bottle with him/her outside to play?

1=Yes   2=No   8=Don't know

Table 3
Outdoor Play Habits

CHILD NO.	207 PLAYS	208 HOURS	209 WHERE PLAY	210 GROUND TYPE	211 TAKES BOTTLE	
1	_	_ _	_	_	_	(311-16)
2	_	_ _	_	_	_	(317-22)
3	_	_ _	_	_	_	(323-28)
4	_	_ _	_	_	_	(329-34)

ENTER RESPONSES TO QUESTIONS 212-214 IN TABLE 4 BELOW:

212. Are his/her hands or face usually washed before eating?

1=Yes 2=No 8=Don't know

213. Are his/her hands or face usually washed before going to sleep?

1=Yes 2=No 8=Don't know

214. Are his/her hands or face usually washed after making mud pies, or playing with dirt or sand?

1=Yes 2=No 7=Not applicable 8=Don't know

Table 4
Hand Washing

Child No.	212 BEFORE EATS	213 BEFORE SLEEP	214 AFTER PLAY	
1	1 2 8	1 2 8	1 2 7 8	(335-37)
2	1 2 8	1 2 8	1 2 7 8	(338-40)
3	1 2 8	1 2 8	1 2 7 8	(341-43)
4	1 2 8	1 2 8	1 2 7 8	(344-46)

ENTER ANSWERS TO QUESTIONS 215-220 IN TABLE 5 BELOW:

215. Has (CHILD'S NAME) used a pacifier in the last 6 months?

1=Yes 2=No 8=Don't know

216. Does he/she suck his/her thumb or fingers?

1=Yes 2=No 8=Don't know

217. Does he/she chew on his/her fingernails?

1=Yes 2=No 8=Don't know

218. Does he/she have a favorite blanket or stuffed toy?

1=Yes 2=No 8=Don't know

IF YES, ASK 219 AND 220. OTHERWISE SKIP TO QUESTION 221.

219. Does he/she carry this around during the day?

1=Yes 2=No 8=Don't know

220. Does he/she often put this in his/her mouth?

1=Yes 2=No 8=Don't know

Table 5

Mouthing Behavior

	215	216	217	218	219	220	
CHILD NO.	PACIFIER	SUCK THUMB	CHEW NAILS	FAVORITE BLANKET/TOY	CARRY AROUND	TOY/ BLANKET MOUTH	
1	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	(347-52)
2	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	(353-58)
3	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	(359-64)
4	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	1 2 8	(365-70)

ENTER THE RESPONSES TO QUESTIONS 221-226 IN TABLE 6 BELOW:

221. How many hours during the day do you think he/she usually spends playing on the floor when indoors in this home? (HOURS)
88=Don't know

222. Many children put some things other than food into their mouths. Would you say that (CHILD'S NAME):

1=Does this alot 3=Almost never
2=Just once in a while 8=Don't know

223. Does he/she put his/her mouth on furniture or on the window sill:

1=Does this alot 3=Almost never
2=Just once in a while 8=Don't know

224. Sometimes children swallow things other than food. Would you say that (CHILD'S NAME) swallows things other than food:

1=Does this alot 3=Almost never
2=Just once in a while 8=Don't know

(IF YES, SPECIFY ITEMS SWALLOWED BELOW)

225. Does (CHILD'S NAME) ever put paint chips in his/her mouth?

1=Does this alot 3=Almost never
2=Just once in a while 8=Don't know

226. Does (CHILD'S NAME) eat snow?

1=Does this alot 3=Almost never
2=Just once in a while 8=Don't know

Table 6
Things in mouth

CHILD NO.	221 HOURS	222 THINGS IN MOUTH	223 FURNITURE/ WINDOW SILL	224 SWALLOWS	225 PAINT CHIPS	226 EATS SNOW	
1	__ __	__	__	__	__	__	(371-77)
2	__ __	__	__	__	__	__	(378-84)
3	__ __	__	__	__	__	__	(385-91)
4	__ __	__	__	__	__	__	(392-98)

SPECIFY THINGS SWALLOWED:

Child No Item(s) swallowed:

__ ____

ENTER THE RESPONSES TO QUESTIONS 227 AND 228 IN TABLE 7 BELOW:

227. How often does (CHILD'S NAME) eat fish including tuna, shrimp, crabs, clams, or other seafood?

1=At least once a week 2=At least once a month
3=Less than once a month 8=Don't know

IF YES, PLEASE ASK QUESTION 228; OTHERWISE SKIP TO NEXT PAGE.

228. In the past week, how many meals did he/she have seafood? (MEALS)

Table 7
Seafood

CHILD NO.	227 EATS SEAFOOD	228 SEAFOOD MEALS LAST WEEK	
1	1 2 3 8	___ ___	(399-401)
2	1 2 3 8	___ ___	(402-404)
3	1 2 3 8	___ ___	(405-407)
4	1 2 3 8	___ ___	(408-410)

IF THERE IS NO CHILD AGE 6-14 OR ADULT PARTICIPANT IN THIS HOUSEHOLD, THEN THE QUESTIONNAIRE IS COMPLETED.

IF THERE IS A CHILD PARTICIPANT 6-14 THEN PROCEED WITH SECTION 300.

IF THERE IS NO CHILD PARTICIPANT, BUT THERE IS AN ADULT PARTICIPANT GO ON TO SECTION 400.

300. QUESTIONS ABOUT SELECTED CHILDREN 6-14 YEARS OLD. THESE SHOULD BE ANSWERED BY THE PARENT OR GUARDIAN OF THE CHILD WITH THE CHILD PRESENT

I need to ask a number of questions about your child (CHILD'S NAME) that was selected for the study.

301. First of all, the child's name is (CHILD'S NAME), is this correct?

IF CORRECT, ENTER HERE; OTHERWISE DETERMINE IF THE PROPER INDIVIDUAL HAS BEEN CONTACTED AND MAKE APPROPRIATE ADJUSTMENTS

NAME ____

302. What is the child's date of birth?

__ __-__ __-__ __ (MO-DA-YR) (411-416)

303. What is the child's sex?

1=Male (417)
2=Female

304. Circle code for race of each child. (Ask if necessary).

1=White, non-Hispanic	5=American Indian/Alaska native	
2=Hispanic	6=Other	(418)
3=Black, non-Hispanic	7=Refused	
4=Asian or Pacific Islander	8=Don't know	

305. Where does (child's name) spend most of his/her daytime hours?

1=At home (419)
2=At babysitter
3=At a day care center
4=At a relative's home
5=At some other location.

306. About how many hours each day, on the average, does he/she spend away from home?

__ __ (HOURS) (420-421)

307. How often does (CHILD'S NAME) eat fish including tuna, shrimp, crabs, clams, or other seafood?

1=At least once a week (422)
2=At least once a month
3=Less than once a month
4=Never
8=Don't know

IF YES, PLEASE ASK QUESTION 308; OTHERWISE GO ON TO QUESTION 309.

308. In the past week, how many meals did he/she have seafood?

__ __ (MEALS) (423-424)

309. Does he/she play outdoors around the house or in the neighborhood?

1=Yes 2=No 8=Don't know (425)

310. If yes, then how many hours a day on the average does he/she play outdoors?

__ __ (HOURS) (426-427)

311. Where does he/she usually play when outdoors around the house?

1=Back yard 7=Other (428)
2=Front yard 8=Don't know
3=Side yard

312. Is the ground where he/she usually plays mainly grassy, concrete/asphalt, plain dirt or soil, just a sandbox, or some other composition?

1=Grassy 4=Sandbox (429)
2=Concrete/asphalt 7=Other (specify)
3=Dirt/soil 8=Don't know

313. Does he/she often take some food or a bottle with him/her outside to play?

1=Yes 2=No 8=Don't know (430)

314. Where does he/she usually play outdoors in the last 3 months when he/she is not playing in your own home yard?

1=Neighbor's yard (431)
2=School playground
3=Near or around creek
4=On or near tailings or slag piles
5=On sidewalks or streets
6=Other (specify)
8=Don't know

315. Are his/her hands or face usually washed before eating?

1=Yes 2=No 8=Don't know (432)

316. Are his/her hands or face usually washed before going to sleep?

1=Yes 2=No 8=Don't know (433)

317. Are his/her hands or face usually washed after making mud pies, or playing with dirt or sand?

1=Yes 2=No 7=Not applicable 8=Don't know (434)

318. Does he/she suck his/her thumb or fingers?

1=Yes 2=No 8=Don't know (435)

319. Does he/she chew on his/her fingernails?

1=Yes 2=No 8=Don't know (436)

320. Sometimes children swallow things other than food. Would you say that (CHILD'S NAME) swallows things other than food:

1=Does this alot (437)
2=Just once in a while
3=Almost never
8=Don't know

IF YES, SPECIFY THINGS SWALLOWED: ____________________

____

321. Does (CHILD'S NAME) eat snow?

1=Does this alot (438)
2=Just once in a while
3=Almost never
8=Don't know

322. Does (CHILD'S NAME) participate in any of the following hobbies or activities?

1=Yes 2=No 8=Don't know

A.	Paint pictures with artists paints?	1	2	8	(439)
B.	Paint furniture in the home?	1	2	8	(440)
C.	Work with stained glass?	1	2	8	(441)
D.	Cast lead into fishing sinkers, bullets or anything else?	1	2	8	(442)
E.	Work with soldering in electronics?	1	2	8	(443)
F.	Work on soldering pipes?	1	2	8	(444)
G.	Make pottery at home?	1	2	8	(445)
H.	Ride a dirt bike or ATV in the local area?	1	2	8	(446)

IF THERE IS NO ADULT STUDY PARTICIPANT, THEN THE QUESTIONNAIRE IS COMPLETE.

IF THERE IS AN ADULT PARTICIPANT, PROCEED WITH SECTION 400.

400. QUESTIONS FOR SELECTED PERSON AGE 15-65; THESE QUESTIONS NEED TO BE ANSWERED BY THE SELECTED INDIVIDUAL

401. First of all, let me verify that your name is (NAME)); is this correct?

IF CORRECT, ENTER HERE; OTHERWISE DETERMINE IF THE PROPER INDIVIDUAL HAS BEEN SELECTED AND MAKE APPROPRIATE ADJUSTMENTS

NAME ______________________________

402. What is your date of birth?

__ __-__ __-__ __ (MO-DA-YR) (447-452)

403. Your sex is (SEX):

1=Male (453)

2=Female

404. What is your race?

1=White, non-Hispanic	5=American Indian/Alaska native
2=Hispanic	6=Other (454)
3=Black, non-Hispanic	7=Refused
4=Asian or Pacific Islander	8=Don't know

405. Do you work as a miner or in a mining related job?

1=Yes 2=No (455)

IF YES, CONTINUE WITH QUESTION 407;OTHERWISE ASK QUESTION 406.

406. Have you worked as a miner or in a mining related job in the past 6 months?

1=Yes 2=No (456)

IF YES, CONTINUE WITH QUESTION 407;OTHERWISE GO ON TO QUESTION 413.

407. What type of mine work have you (or were you) engaged in primarily in the last month?

1=Underground (457)
2=Milling
3=Mill
4=Clerical/Admin.
5=Other

408. What type of mine do you work (have you worked) at?

1=lead only (458)
2=zinc only
3=lead/zinc
4=silver
5=molybdenum
7=other

409. What is the name of the place where you work (have worked)?

---

410. How long have you worked (did you work there) there, in years?

__ __ YEARS 00=Less than one year (459-460)

411. Do (did) you change out of your work clothes and leave them at work?

1=Yes 2=No (461)

412. Do (did) you shower at work before coming home?

1=Yes 2=No (462)

413. Do you participate in any of the following hobbies or activities?

1=Yes 2=No

A.	Paint pictures with artists paints?	1	2	(463)
B.	Paint furniture in the home?	1	2	(464)
C.	Work with stained glass?	1	2	(465)
D.	Cast lead into fishing sinkers, bullets or anything else?	1	2	(466)
E.	Work with soldering in electronics?	1	2	(467)
F.	Work on soldering pipes?	1	2	(468)
G.	Make pottery at home?	1	2	(469)
H.	Ride a dirt bike or ATV in the local area?	1	2	(470)

414. How often do you eat fish including tuna, shrimp, crabs, clams, or other seafood?

1=At least once a week (471)
2=At least once a month
3=Less than once a month
4=Never

IF EVER, PLEASE ASK QUESTION 415; OTHERWISE GO ON TO QUESTION 416.

415. In the past week, how many seafood meals did you have?

__ __ (MEALS) (472-473)

416. Do you have a garden?

1=Yes 2=No (474)

417. If yes, then do you frequently till, plant and weed the garden yourself?

1=Yes 2=No (475)

418. Have you done any of the following activities in the last month?

1=Painted a house inside or out	1=Yes	2=No	(476)
2=Painted furniture	1=Yes	2=No	(477)
3=Applied insecticides	1=Yes	2=No	(478)

END OF QUESTIONNAIRE

ATTACHMENT D

XFR Readings Sheet

Leadville
Pb Study

Household #:

Date:

Operator:

Instrument #:

XRF Standard:

Start: ___ ___ ___ : ___

Finish : ___ ___ ___ : ___

AREA	WALL Paint Chipping/ Peeling?	WALL XRF Readings 1	2	3	ave.	TRIM Paint Chipping/ Peeling?	TRIM XRF Readings 1	2	3	ave.
Interior:										
Bedroom										
Main room										
Kitchen										
Bathroom										
Main Entry										
Other:										
Exterior										
Entry										
Siding										
Trim										
Window										
Other:										

ENVIRONMENTAL DATA SHEET

Leadville
Pb Study

EXTERIOR SAMPLING

Household #:

Sketch house location and property lines.
Mark sampling locations.

Date:
Operator:

O Location of soil cores (4 sites)

X Location of surface scrapings

G : Gutter downspout area
P : Play area
C : Curb area
E : Entry area

COMMENTS:

ENVIRONMENTAL DATA SHEET

Leadville
Pb Study

INTERIOR SAMPLING

Household #:

Date: Operator:

DUST COMPOSITES:

1 Floors
(check where sampled)
Bedroom
Main room
Main Entrance
Other:

2 Window Sills
Dimensions (cm) :
Bedroom: x
x
Main Room: x
x
x
Other: x
x

3 WATER SAMPLE (check type)

Pipe type: Copper
Lead
PVC
Stainless S.
Other

ATTACHMENT E

Document Control #________

Title: Lead

Reference: EPA Methods for Chemical Analysis of Water and Waste: Method 239.2

Purpose: Analysis of Lead by carbon furnace in water and waste water.

Sample Requirements: 5ml of acidified sample.

Reagents:

1. Lead standard, certified 1000 ppm
2. Nitric acid, conc: suitable for metal analysis

[illegible]

Equipment: IL video 22 AA

IL 655 furnace atomizer

IL Fastac II autosampler

Instrument Parameters (suggested)

__V22__

Pb-HC	
signal	4 ma
background (S-H)	3 ma
wavelength	283.3 nm
bandpass	0.5 nm
integration	peak height
integration time	4 sec.

__Fastac II__

delay	6
deposit	5
repeat	2

__655__

Setting	Time (X 5 sec)	Temp. °C
1	0	0
2	1	165
3	3	350
4	3	600
5	0 (start integration)	1900
6	2	1900

Use: normal heat

uncoated rod (DAC)

N_2 as purge and nebulizer gas

Procedure: Samples and standards are analyzed by carbon furnace AA. The standards are 0, 5, 10, 20, 30, 40, and 50 ug/l Pb in .15% HNO_3.

Calculations: Calculate calibration curve and correlation coefficient. The concentration of lead in ug/l is calculated from the calibration curve.

spike amount = -0.1 mls of 1000 ug/l Pb = 100 ng Pb

$$\text{spike recovery} = \frac{(\text{ug/l spike})(5.1\text{ mls})}{(\text{ug/l sample})(5.0\text{ mls}) + \text{ng spiked}} \times 100$$

Clean up: All glassware should be acid washed with 1% HNO_3 and rinsed with D.I.

Note: Lead may be run simultaneously with cadmium.

Written by ________ Date 11-10-87 QA ________ Date 5-2-...

Approved by ________ Date 5-22-87

RfPak 6/17/87

Revision date ________

ATTACHMENT F

Colorado Metal Study

CASE 87-0026

SPECIMEN COLLECTION AND SHIPPING PROTOCOL

Division of Environmental Health Laboratory Sciences
Center for Environmental Health
Centers for Disease Control
Atlanta, Georgia 30333

Prepared:
Revised:

2360s

I. INTRODUCTION

The proper collection processing, storage and shipment of physiologic specimens from participants in the Colorado Metal study is critical to the success of the study. The following sections describe the procedures which must be followed for all specimen collections. These procedures must be strictly adhered to in order to avoid contamination, loss, or degradation of the specimens. Please familiarize yourself with the study protocol and insure that you understand the concept of the study, the role of all of the personnel involved, and your own role.

Note that subjects are to report to the clinic in a fasting state and this will require that blood collection be accomplished early in the visit to avoid discomfort to the subject and an adverse impact on compliance. Blood and urine collection must be completed and processed under carefully controlled conditions of good laboratory practice. Blood separation and processing must be accomplished promptly to avoid degradation of the specimen.

It is extremely important that all records associated with each subject be maintained in an organized and complete manner to ensure that all information is properly collected and accurate. Specimens should be labeled promptly and processed as a unit or "run" and precautions must be taken to avoid patient - specimen - label - record mixups. This type of error is usually the most common error in the laboratory setting, but careful planning and a well organized work area will keep such errors at a minimum. Some of the information required for the specimen label and shipping list will be collected at the time of specimen collection. Problems in blood and/or urine collection should be noted in the sample log and in the comments section of the shipping list.

II. URINE COLLECTION AND PROCESSING (See protocol flowchart on page 20 and 21)

A. COLLECTION PROCEDURE

1. Materials needed per participant.

- Urine collection cup (250 mL, plastic, sterile)
- Small Zip-lock bag
- Preprinted label

2. Preparation of urine collection cup for participant.

- Remove the cup and cap from its plastic wrapping being careful not to dislodge the cap or touch the inside of the container or cap.

- Seal the cap on the container and affix the participant's preprinted label marked "URINE CONTAINER" and write their name on the label using a ballpoint pen.

3. Instructions for urine collection.

- The following instructions should be explained to the participant prior to urine collection.

  . Hands should be washed with soap and water.

  . The collection cup should not be opened until just before voiding.

  . The person should leave the cap turned up while voiding, then recap the filled container immediately.

  . IT IS MOST IMPORTANT that the inside of the container and the cap not be touched or come into contact with any parts of the body or clothing or external surfaces. Exposure to air should be minimized.

  . The participant should deliver the capped specimen immediately to the clinic personnel.

B. PROCESSING PROCEDURE

1. Materials and equipment needed per participant.

- 15 mL Conical-bottom plastic tube (containing 120 uL nitric acid) (1)

- 6 mL Plastic tube (3)
- Powder-free lab gloves
- Safety glasses
- Lab apron
- Laboratory hood
- Deionized water
- Ultrapure concentrated nitric acid (G. Frederick Smith Chemical Co., Columbus, Ohio 43223, Catalogue No. 63, ultrex grade, or equivalent)
- Pipettor (Gilson Pipetman or other precision adjustable pipettor capable of dispensing 200 uL)
- Biorad BR-33 clear (metal-free) disposable pipet tips capable of containing 120 uL, or equivalent)
- Racks
- Preprinted labels
- Freezer (-20°C)

2. Special safety precautions.

   - Nitric Acid - Special care should be taken when handling and dispensing the concentrated acid, since it is a caustic chemical capable of severe eye or skin damage. Wear a lab apron, powder-free gloves, and safety glasses. If the nitric acid comes in contact with any part of the body, quickly wash with copious quantities of water for at least 15 minutes.

   - Sodium Azide - Special care should be taken when handling the 6 mL plastic tube with the pink dot, since it contains a small quantity of sodium azide (a poison). Wear a lab apron, powder-free gloves, and safety glasses. If the sodium azide comes in contact with any part of the body, quickly wash with copious quantities of water for at least 10 minutes.

3. Additon of sodium azide, sodium carbonate, and aprotinin to beta-2-microglobulin.

   While working under a hood and wearing protective, unpowdered gloves, apron, and safety glasses, use pipettor to rinse a pipet tip with the mixture. Using the same pipet tip, aliquot 128 ul into each of 6 ml plastic tubes to be used for beta-2-microglobulin analyses. Process one tube at a time, removing the cap, adding the mixture, and replacing and tightly screwing the cap. Change the tip each time it becomes contaminated. Affix a pink dot to the side of the tube.

4. - Preparation of laboratory blanks.

. Wearing protective clothing and working under a hood, prepare one cadmium laboratory blank for each day on which urine specimens are collected.

. Select one of the 15 mL plastic tubes labeled with a turquoise dot and slowly add 12 mL $\pm$ 1 mL of deionized water. Then carefully aliquot 120 µl of nitric acid with the pipettor.

. Cap, label with the preprinted label "LAB BLANK-CD/AS", seal, and invert the tube five times.

. On each label and using a ballpoint pen, write the date collected and the initials of the laboratory technician preparing the lab blanks. Freeze the blanks in an upright position at -20°C and store them frozen until shipment to CDC with the urine specimens.

5. Processing (specimen).

- Wear powder-free lab gloves, safety glasses, and work over a laboratory sink.

- Using the preprinted labels provided for each participant, label each of the plastic tubes as follows:

Size/Type Bottle	Bottle Label
15 mL plastic (nitric acid)	87-0026-0001-T1 "UR CD/ARSENIC"
6 mL plastic (sodium azide)	87-0026-0001-T2 "URINE BETA-2-M"
6 ml plastic (no preservative)	87-0026-0001-U1 "URINE CREATINE"
6 mL plastic (no preservative)	87-0026-0001-U2 "URINE RESERVE"

- Use a ballpoint pen to add the date collected and your initials to the labels on all tubes.

- Gently swirl the specimen in the capped collection container to resuspend any solids.

- Immediately after mixing, pour the proper quantity of urine into each plastic tube and use the correct aliquoting priority as shown in the protocol flowchart on page 20.

- Cap and tightly seal each tube.

- Dissolve the preservatives in the "URINE BETA-2-M" tube by inverting 4–6 times. Immediately freeze (within 2–5 minutes) in an upright position in a dry ice/ethanol bath or a -70°C or colder freezer.

6. Addition of acid preservatives.

- Addition of nitric acid to cadmium/arsenic tubes.

NOTE: RINSE OUTSIDE OF PIPET TIP WITH DISTILLED WATER BEFORE USE.

. While working under a hood and wearing protective unpowdered gloves, apron and safety glasses, use a pipettor to rinse a pipet tip with nitric acid. Using the same tip aliquot 120 mL into each of the 15-mL conical-bottom tubes containing the participant's urine which will be used for cadmium analyses. Process one tube at a time, removing the cap, adding the acid, and replacing and tightly screwing the cap. Do not touch the interior of the cap or tube or place the cap or pipet tip on external surfaces which may be contaminated for trace elements. Change the tip each time it becomes contaminated. Affix a turqoise dot to the side of the tube. Invert the tubes gently 5 times and freeze immediately at -20°C.

7. Processing (Field Blank).

- After every 19 study participants one conical-bottom tube will be prepared as a "Field Blank" using deionized water in place of urine. Prepare these blanks under the same conditions as for processing specimens.

  . Immediately after processing the preceding urine specimen, obtain one of the conical-bottom tubes labeled with a turquoise dot.

  . Affix a preprinted Field Blank label "FIELD BLANK-CD/AS".

  . Using the deionized water provided, pour 12 mL ± 1 mL of water into the tube to the graduation mark. Then carefully add 120 mL nitric acid, recap and mix as for urine specimens.

  . Using a ballpoint pen, add the date collected and your initials to the label.

  . Freeze the Field Blanks in an upright position at -20°C and store them frozen with the urine specimens until they are shipped to CDC.

8. Tests done at the field site.
A specific gravity will be done on all urines. The results should be written in the comments section of the inventory sheet.

III. WHOLE BLOOD COLLECTION

1. Materials needed per participant.

   - Gauze sponges, sterile, individually wrapped 2x2" (2).
   - Alcohol wipe
   - Bandaid
   - 5 mL lavender-top vacutainer for adults 12 years and older.(2)
   - 3 ml lavender-top vacutainer for children 11 years old and younger.(2)
   - 20 gauge 1 1/2" needle, sterile
   - 23 G butterfly assembly with adapter for children.
   - Preprinted labels
   - Tourniquet
   - Vacutainer holder
   - refrigerator

2. Venipuncture procedure.

   - Locate the puncture site. Hold with 2 fingers on one side of the "alcohol wipe" so that only the other side touches the puncture site. Wipe the area in a circular motion beginning with a narrow radius and moving outward so as not to cross over the area already cleaned. Repeat with a second alcohol wipe.

   - Locate a suitable table and chair for blood drawing and lay out blood collection supplies.

   - Locate vein and cleanse in manner previously described, then apply the tourniquet. If it is necessary to feel the vein again, do so; but after you feel it, cleanse with alcohol prep again, and dry with a sterile gauze square.

   - Fix the vein by pressing down on the vein about 1 inch below the proposed point of entry into the skin and pull the skin taut.

   - Approach the vein in the same direction the vein is running, holding the needle so that it makes a 15° angle with the examinee's arm.

   - Push the needle, with bevel facing up, firmly and deliberately into the vein. If the needle is in the vein, blood will flow freely into the tube. If no blood enters the tube, probe for the vein until entry is indicated by blood flowing into the tube.

   - For collection, loosen the tourniquet immediately after blood flow is established and release entirely as the last tube fills.

- When the needle is out of the arm, press gauze firmly on the puncture. Heavy pressure as the needle is being withdrawn should be avoided because it may cause the sharp point of the needle to cut the vein.

- Have the examinee raise his arm (not bend it) and continue to hold the gauze in place for several minutes. This will help prevent hematomas.

- Invert the lavender-top tube several times to ensure proper mixing.

- Report to the physician any reaction experienced by the participant during the venipuncture procedure.

- Label all tubes with the preprinted labels provided, and use a ballpoint pen to add the date collected and your initials to the label. The lavender-top tube should be affixed with the label showing the participant's ID number (e.g. 87-0026-0001-B1) and identified "BLOOD-PB".

- Place a bandaid on the subject's arm.

- Place the lavender-top tubes upright in a rack in the refrigerator within 30 minutes after being drawn. Log in the specimens and keep refrigerated (not frozen) until picked up for shipment.

IV. SHIPMENT OF SPECIMENS TO CDC, ATLANTA, GA.

A. BEGINNING OF STUDY AND GENERAL INSTRUCTIONS

- Determine the times 'FEDERAL EXPRESS' packages are picked up in order to connect with the best flights to Atlanta, Georgia. Shipments to Atlanta will be scheduled weekly and scheduled only Monday through Wednesday mornings. IMPORTANT: Since the materials packed in accordance with the instructions below will remain frozen (over dry ice) or cool (over cold packs) only about 2 1/2 days, shipments should not arrive in Atlanta on weekends or on Federal holidays.

- Inquire about regulations in your area concerning shipment of human blood, serum, and urine specimens with dry ice and the quantity of dry ice allowed per shipper. Also, make sure the specimens will be received at CDC within 24 hours.

- Maintain a supply of dry ice from a local supplier for shipping specimens each week. A block should be sawed at the plant into "1 slabs. Then each of these should be sawed lengthwise. A 7"x10" slab would fit easily into the shipper without having to break the slab. (Large pieces are preferable to small chunks, since they do not volatilize as rapidly.)

- Shipments of whole blood require a coolant to keep the materials cool during the shipment (NOT FROZEN). The laboratory techs should keep 10-12 coolant packs in the freezer at all times; replace the ones used weekly to maintain the inventory for other unexpected demands for these items.

- For all shipments, do not pack shippers with frozen specimens and dry ice or with whole blood and frozen coolant until just before shipment.

- Telephone the laboratory at CDC the day the shipment is mailed (404) 454-4300. Speak with Brenda Lewis.

B. SPECIMEN SHIPPING LIST

- For each shipment, fill out a blank Specimen Shipping List provided by CDC. If the number of specimens in a shipment is too large to fit on one page, please use the continuation sheets provided. Please give the following information on the blank shipping lists (See attached example of a completed Specimen Shipping Lists):

  . Page number - e.g. 1 of 4
  . Shipment Number - number shipments sequentially starting with 1
  . No. frozen shippers - total number of shippers (containing frozen urine specimens) which are being mailed in this shipment.
  . No. refrigerated shippers - total number of shippers (containing refrigerated whole blood) which are being mailed in this shipment
  . Type of Specimens - whole blood and/or urine
  . No. of Specimens - number of each type of specimen shipped
  . Name, Title, Signature, and Phone Number of person sending shipment or initials as indicated on the continuation sheets.
  . Date Shipped
  . Specimen ID for each participant - e.g. 87-0026-0001
  . For each participant, check (X) each individual specimen type/aliquot included in this shipment
  . Date Collected - e.g. 081187
  . Comments - Specify any deviations from collection, storage, and shipment protocols, and date of occurrence.

- Photocopy 2 extra copies of the completed shipping list. As will be described again later, the original will be shipped with the specimens, a copy mailed to CDC in a separate envelope, and a

C. FROZEN SPECIMENS

1. Materials needed per shipper

- 1 styrofoam shipper (each shipper will hold frozen specimens from approximately 10-12 participants)
- 10-12 lbs. dry ice
- 30-36 bubble-pack bags 4" x 7 1/2"
- Safety glasses or eye shield
- Strapping tape
- Gloves for handling dry ice and frozen specimens
- Sheets of bubble-pack packing material
- 'FEDERAL EXPRESS' label, preaddressed by Centers for Disease Control personnel
- DRY ICE label
- HUMAN BLOOD - THIS SIDE UP label
- CDC 'Specimen Shipping List' filled out
- Zip-lock bag
- Frozen urine specimens (6 urine tubes per participant)

2. Packing procedure.

- When packing the shippers, use gloves to handle the dry ice to avoid burning the hands. Glasses or an eye shield should also be worn if the dry ice cakes are to be broken into small pieces.

- Place the six frozen urine specimens from each participant in one 4" x 7 1/2" bubble bag and seal using the peel-off adhesive strip.

- Pack 10-12 sets of filled bubble bags upright in the bottom of the shipper. If necessary, use sheets of bubble-pack packing material to ensure the specimens vertical position.

- Put one layer of sheet bubble-pack material on top of the specimens.

- Fill the shipper with dry ice (probably will hold 10-12 lbs).

- Place more bubble material to even the top and place the polyfoam lid on top of the shipper.

- Insert the completed 'Specimen Shipping List' in a 12" x 12" Zip-lock bag and secure to the top of the polyfoam lid with filament tape. (Remember to photocopy two copies of the 'Specimen Shipping List'. Keep one copy for your records and mail the other copy in a separate envelope to the same CDC address listed below.)

- Secure the outer carton lid on the shipper with filament tape.

3. Shipping procedure.

- Cover or remove previous address labels on all shippers.

- Label each shipper with the following:

  . Preaddressed, 'FEDERAL EXPRESS' label with the following address:

    Brenda Lewis
    Chamblee, Building 32, Room 1502
    Centers for Disease Control
    4770 Buford Highway
    Chamblee, GA. 30341

D. REFRIGERATED SPECIMENS

1. Materials needed per shipper

- 1 styrofoam shipper
- 2 foam racks each capable of holding fifteen 5 or 3 mL vacutainers
- 4 twenty-four oz. cold packs (frozen before shipment)
- 6 layers of bubble-pack
- Filament tape
- Gloves for handling frozen cold packs
- 'FEDERAL EXPRESS' label
- HUMAN BLOOD - THIS SIDE UP label
- KEEP REFRIGERATED - DO NOT FREEZE label
- Zip-lock bag
- Refrigerated blood specimens in 5 or 3 mL lavender top vacutainers

Note: Inventory of blood specimens should be included in specimen shipping list enclosed with frozen specimens.

2. Packing procedure.

   - Place cold paks in a $-20^{o}C$ freezer the day before the shipment. Four 24 ounce packs will be needed for each shipper used. More cold packs may be needed if freezer does not attain $-20^{o}C$. Up to 50 specimens can be shipped per shipper.

   - Working quickly, so that the blood will not be exposed to ambient temperature for more than 5 to 10 minutes, wrap up to 50 tubes with bubble-pack material; secure with tape.

   - Place two ice paks in the bottom of the shipper. Cover with bubble paper before adding wrapped specimens; add specimens and cover with additional bubble paper before adding two additional ice paks. Fill the shipper with additional bubble material and place the polyfoam lid on top of the shipper.

   - Secure the outer carton lid on the shipper with filament tape.

3. Shipping procedure.

   - Cover or remove previous address labels on all shippers.

   - Label each shipper with the following:

     . Preaddressed, 'FEDERAL EXPRESS' mailing label with the following address:

       Brenda Lewis
       Chamblee, Building 32, Room 1502
       Centers for Disease Control
       4770 Buford Highway
       Chamblee, GA 30341

     . HUMAN BLOOD-THIS SIDE UP label.

     . KEEP REFRIGERATED-DO NOT FREEZE label.

     .ORM-A written on the box.

- Call the 'FEDERAL EXPRESS' office at 1-800-238-5355 to arrange for pick-up.

   - Telephone the laboratory at CDC the day the shipment is mailed (404) 454-4300. Speak with Brenda Lewis.

Colorado Metal Exposure
Leadville, Colorado
Case 87-0026
Urine Collection and Processing Protocol

Urine Sample (30ml)

Collection Container Labeled
"Urine Container"

Aliquot into
Designated Bottles

T1	T2	U1	U2
15 ml plastic "Ur. Cd/As"	6 ml plastic "Ur. Beta-2-M"	6 ml plastic "Ur. Creatinine	6 ml plastic "Ur. Reserve"
Add 12 ml Urine	Add 128 ul Azide Mixture		
Add 120 ul HNO3	Add 5 ml Urine	Add 5 ml Urine	Add 5 ml Urine
Mix by Inverting 5 times	Mix by Inverting 4-6 times		
Freeze at -20^{o}C	Freeze at -70^{o}C within 2-5 minutes	Freeze at -20^{o}C	Freeze at -20^{o}C

Mail to CDC on dry ice using
of "Federal Express"

Page ___ of ____

SPECIMEN INFORMATION SYSTEM
FORM 1 - COLORADO EXPOSURE
SPECIMEN SHIPPING LIST - Continued

Case Number : 87-0026

Shipment Number : ______

Initials of Shipper ______________

Initials of Receiver ______________

Specimen ID 87-0026 - Person	Type*/Aliquot No. (Mark Shipped Specimen) T1 T2 U1 U2 B1 B2	Date Collected MM-DD-YY	Comments (Specify any deviation fr collection, storage, and shipment protocols, and date of occurrence)
87-0026-XXXX	X X X X X X X X X	XX-XX-XX	
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
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87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______
87-0026 ______	__ __ __ __ __ __ __ __ __	______	______

*Type of specimens: T = Urine (preserved), U = Urine (unpreserved), B = Whole Blood

ATTACHMENT G

The duplicate sill dust samples are slightly more involved. The primary sample should be taken from only half the window sill (right side or left side). The duplicate will then be obtained from the unsampled areas. While it is not unreasonable to expect differences between right and left side samples, closer agreement should exist between sill dust duplicates than between floor dust duplicates. Thus, the sill dust duplicates offer insight to relative determination accuracy.

SPLITS. Split samples will be prepared by the lab coordinator at the rate of one split for each twenty samples recored in the master log. Split samples will be obtained for water, soil cores and surface scrapings only since it is undesirable to open the dust cartridges. Splits are accomplished by removing approximately one half of the original sample to a second container and assigning a new and independent sample number to the split fraction.

The absence of analytical systematic error can be claimed if the difference between split samples is less than the reported analytical precision.

YOUDENS. Youden pairs are based on QC procedures developed by Youden(1) for determining interlaboratory errors and modified by Meglen(2) for assessing temporal intralaboratory errors. The interpretive process will follow that described by Meglen and results will be used to identify systematic interlaboratory errors and random errors outside of acceptable limits.

The environmental laboratory coordinator will include two Youden pairs (four samples total) in each shipment of 200 total solid samples. One pair will be from the dust composite; the second pair will be from the soil composite. Each pair will be assigned sample numbers such that their treatment by receiving laboratories will be identical to other samples' treatment.

The soil composite will be prepared by the lab coordinator. A small fraction of each soil core and surface scraping will be retained in a soil composite container. When a sufficient quantity of material is accumulated, the entire composite will be homogenized and used as a source for Youden determinations. The dust composite will consist of a sieved and homogenized floor dust sample previously acquired.

Water samples will include Youden pairs at a rate of one pair per twenty samples. The water Youden composite will be obtained using a procedure analogous to that described above for soils.

BLANKS. Blank samples will be sent with each sample shipment at the rate of one blank per youden pair. A blank sample has "less than detection limit" concentrations for the desired analytes. These blanks allow data interpretation to readily identify erroneously positive results.

Distilled deionized water will be used for water blanks. A National Bureau of Standards standard reference soil with below detection limit values (total digest, graphite furnace analysis) will be used for the soil and scrapings blank. Crushed and sieved Brazilian quartz will be used for dust blanks.

By following the above procedures and viewing the data with a degree of skepticism, any conclusions drawn wholly or in part from the environmental samples should be both conservative and accurate.

Quality Control Protocol For Environmental Samples

This protocol is intended to identify both systematic and stochastic errors in either the environmental sampling or analytical results. Numerous sources of error can be anticipated in an environmental sampling survey of this nature. This protocol is designed to discover systematic errors in analytical results caused by: 1-incorrect zero determinations (false positives), 2-interlaboratory bias (more than one analytical laboratory will determine trace metal concentrations in the dust samples, soil cores and entry way surface scrapings), 3-sampling bias among environmental teams. Additionally, the stochastic variance will be used to identify values which occur, apparently at random, outside an acceptable range.

While no QA/QC protocol can prevent systematic and random errors, a training session emphasizing consistent sampling procedures among the environmental teams will allow this protocol to detect suspect data. These data should be treated on an individual basis, and interpretations should be tempered by a motivation toward "general conclusions", not isolated incidents. An effective protocol allows data interpretations based on general trends with minimum influence from unique or biased data. In essence this leads to the most robust, yet conservative, conclusions.

This protocol requires four types of QC samples: blanks, splits, duplicates and Youden pairs. These samples are described below for the environmental sampling phase of the Leadville Survey. In addition to QC samples, the teams must take careful field notes which are to be recorded in the lab coordinator's master log. Also, some samples (scrapings and soil cores) will be retained in the advent of future concerns regarding sample acquisitions or analyses.

This protocol is capable of assessing data precision and to a limited extent data accuracy. The absence of a certified standard reference material for heavy metals in soil and dust (using the specific digestion protocol employed at the EPA analytical sites) limits accuracy assessment in an absolute sense. However, the use of blanks and Youden pairs allows relative accuracy to be determined and false positives (values erroneously reported above detection limit) to be identified.

DUPLICATES. Each environmental sampling team will collect duplicate water, soil cores, entry way scrapings and dust samples at the 20th, 40th, 60th, etc. sampled houses. The duplicate samples will be assigned unique sample numbers and will be treated as completely independent samples. The team will note which houses have been doubly sampled and this information will be recorded in the master log, but not provided to the analytical laboratories.

The water sample duplicate will consist of a second tap aliquot being drawn after the primary sample is drawn. The same faucet should be used and water flow should not be interrupted between samples. Duplicate water samples are intended to gauge analytical precision at actual field concentrations.

The duplicate soil cores, surface scrapings and floor dust samples will be acquired in the general vicinity of the primary sample sites. It is not necessary to obtain these duplicate samples adjacent to the primary samples, but if possible the duplicate should be from the general vicinity. Specifically, soil cores should be within two feet of each other, surface scrapings should be from the same entry way, floor dust should be from the same room/hallway. These duplicates are not anticipated to yield the same analytical values, but are intended to allow data interpretors to address the representativeness of the primary samples.

1. Youden, W.J.: Statistical Techniques For Collaborative Testing: Association of Official Analytical Chemists, Washington, D.C., 1969 (rev 1973).

2. Meglen, R.R.: A Quality Control Protocol For The Analytical Laboratory: Center for Environmental Sciences, University of Colorado, Denver, 1977.

ATTACHMENT H

87-0026-0548-D4 BEDROOM WINDOW DUST DATE____INIT___	87-0026-0548-D5 MAIN ROOM WINDOW DUST DATE____INIT___	87-0026-0548-S1 PLAY AREA EXTERIOR SCRAPE DATE____INIT___	87-0026-0548-S2 GUTTER/CURB EXTERIOR SCRAPE DATE____INIT___	87-0026-05- HAND WIPE DATE____INI
87-0026-0548-H2 HAND WIPE BLANK DATE____INIT___	87-0026-0548-W1 WATER TAP SAMPL DATE____INIT___	87-0026-0548-C1 PLAY AREA EXTERIOR CORE DATE____INIT___	87-0026-0548-C2 FRONT YARD EXTERIOR CORE DATE____INIT___	87-0026-054 BACK YARD EXTERIOR C DATE____INI
87-0026-0549-B1 COLORADO METALS HEMOGLOBIN DATE____INIT___	87-0026-0549-B2 COLORADO METALS BLOOD LEAD, FEP DATE____INIT___	87-0026-0549 COLORADO METALS URINE CONTAINER DATE____INIT___	87-0026-0549-T1 COLORADO METALS URINARY AS, CD DATE____INIT___	87-0026-054 COLORADO ME URIN. BETA- DATE____INI
87-0026-0549-U1 COLORADO METALS UR. CREATININE DATE____INIT___	87-0026-0549-U2 COLORADO METALS UR. RESERVE DATE____INIT___	87-0026-0549 COLORADO METALS DATE____INIT___	87-0026-0549 COLORADO METALS DATE____INIT___	87-0026-054 COLORADO ME DATE____INI
87-0026-0549-Q1 QUESTIONNAIRE DATE____INIT___	87-0026-0549-XR XRF READINGS DATE____INIT___	87-0026-0549-D1 MAIN ENTRANCE FLOOR DUST DATE____INIT___	87-0026-0549-D2 BEDROOM FLOOR DUST DATE____INIT___	87-0026-05- MAIN ROOM FLOOR DUST DATE____INI
87-0026-0549-D4 BEDROOM WINDOW DUST DATE____INIT___	87-0026-0549-D5 MAIN ROOM WINDOW DUST DATE____INIT___	87-0026-0549-S1 PLAY AREA EXTERIOR SCRAPE DATE____INIT___	87-0026-0549-S2 GUTTER/CURB EXTERIOR SCRAPE DATE____INIT___	87-0026-05- HAND WIPE DATE____INI
87-0026-0549-H2 HAND WIPE BLANK DATE____INIT___	87-0026-0549-W1 WATER TAP SAMPL DATE____INIT___	87-0026-0549-C1 PLAY AREA EXTERIOR CORE DATE____INIT___	87-0026-0549-C2 FRONT YARD EXTERIOR CORE DATE____INIT___	87-0026-05- BACK YARD EXTERIOR CC DATE____INI
87-0026-0550-B1 COLORADO METALS HEMOGLOBIN DATE____INIT___	87-0026-0550-B2 COLORADO METALS BLOOD LEAD, FEP DATE____INIT___	87-0026-0550 COLORADO METALS URINE CONTAINER DATE____INIT___	87-0026-0550-T1 COLORADO METALS URINARY AS, CD DATE____INIT___	87-0026-055 COLORADO ME URIN. BETA- DATE____INI
87-0026-0550-U1 COLORADO METALS UR. CREATININE DATE____INIT___	87-0026-0550-U2 COLORADO METALS UR. RESERVE DATE____INIT___	87-0026-0550 COLORADO METALS DATE____INIT___	87-0026-0550 COLORADO METALS DATE____INIT___	87-0026-055 COLORADO ME DATE____INI
87-0026-0550-Q1 QUESTIONNAIRE DATE____INIT___	87-0026-0550-XR XRF READINGS DATE____INIT___	87-0026-0550-D1 MAIN ENTRANCE FLOOR DUST DATE____INIT___	87-0026-0550-D2 BEDROOM FLOOR DUST DATE____INIT___	87-0026-055 MAIN ROOM FLOOR DUST DATE____INI
87-0026-0550-D4 BEDROOM WINDOW DUST DATE____INIT___	87-0026-0550-D5 MAIN ROOM WINDOW DUST DATE____INIT___	87-0026-0550-S1 PLAY AREA EXTERIOR SCRAPE DATE____INIT___	87-0026-0550-S2 GUTTER/CURB EXTERIOR SCRAPE DATE____INIT___	87-0026-055 HAND WIPE DATE____INI

ATTACHMENT I

Form I

U.S. EPA Contract Laboratory Program
Sample Management Office
209 Madison St. - Alexandria, VA 22314
703/557-2490 FTS: 8-557-2490

EPA Sample No.
MHK343

Date 11-20-87

INORGANIC ANALYSIS DATA SHEET

LAB NAME ROCKY MOUNTAIN ANALYTICAL
SOW NO. 784
LAB SAMPLE ID. NO. -

CASE NO. 8271
QC REPORT NO. 87364

Elements Identified and Measured

Concentration: Low X Medium ____
Matrix: Water ____ Soil X Sludge ____ Other ____

mg/kg ~~dry~~ WET weight

1.	ALUMINUM	5640	P	13.	MAGNESIUM	2780	P
2.	ANTIMONY	12U	P R	14.	MANGANESE	810	P
3.	ARSENIC	19	F	[redacted]			
4.	BARIUM	156	P X	16.	NICKEL	[9.8]	P
5.	BERYLLIUM	[1]	P	17.	POTASSIUM	[1390]	P
6.	CADMIUM	8	P	18.	SELENIUM	2.5U	F R
7.	CALCIUM	15500	P	19.	SILVER	2U	P
8.	CHROMIUM	9.8	P	20.	SODIUM	545U	P
9.	COBALT	[7.2]	P	21.	THALLIUM	5U	F
10.	COPPER	45	P XR	[redacted]			
11.	IRON	13700	P	23.	VANADIUM	[12]	P
12.	LEAD	344	P X	24.	ZINC	2010	P

[redacted]

Percent Solids (%) ~~100~~ NR

Footnotes: For reporting results to EPA, standard result qualifiers are used as defined on Cover Page. Additional flags or footnotes explaining results are encouraged. Definition of such flags must be explicit and contained on Cover Page, however.

Comments: ____

Lab Manager ____

ATTACHMENT J

STATE OF COLORADO

COLORADO DEPARTMENT OF HEALTH
4210 East 11th Avenue
Denver, Colorado 80220
Phone (303) 320-8333

Roy Romer
Governor

Thomas M. Vernon,
Executive Director

March 18, 1988

To the Parent of

Leadville, CO 80461

Dear Parent:

Thank you for participating in the Leadville Heavy Metals Survey conducted by the Division of Disease Control and Environmental Epidemiology, Colorado Department of Health, and the University of Colorado at Denver, this past September and October. Test results are attached along with expected ranges of values.

The Centers for Disease Control (CDC), U. S. Public Health Service guidelines define lead poisoning in children as having a blood lead level greater than or equal to 25 ug/dl and a free erythrocyte protoporphyrin (FEP) level greater than or equal to 35 ug/dl. The CDC definition states that both blood tests must be elevated to indicate lead toxicity in children.

Although these results are considered normal, we suggest that you provide these to your physician for his/her information.

If you have further questions, we request that you contact your private physician or Lane Cook or myself at the Division of Disease Control and Environmental Epidemiology at 331-8330. Thank you again for your cooperation.

Sincerely,

Ellen J Mangione, MD MPH

Ellen J. Mangione, MD, MPH
Director, Division of Disease Control
and Environmental Epidemiology

EJM/sjm
Attachment

BLOOD TEST RESULTS

.ood Test	Your Result	Expected Result
ood Lead (ug/dl)	8.7	less than 25
ree Erythrocyte Protoporphyrin (ug/dl)	23	less than 35
-moglobin (ug/dl)	14	**
matocrit (%)	39	**

URINE TEST RESULTS

.rine Test	Your Result	Expected Result
rinary Cadmium (ug/g creatinine) .	Not Done	0 to 5
-inary Arsenic (ng/ml)	Not Done	0 to 100
inary Beta-2-Microglobulin (ug/l)	Not Done	less than 450

these values vary with age and altitude

LOSSARY

ood Lead - the amount of lead in the blood.

ree Erythrocyte Protoporphyrin - the amount of a substance in the ood which may be found at increased levels when either the fects of excess lead or iron deficiency are present.

-moglobin - the amount of a substance in the blood which carries ygen. One measure of whether or not a person is anemic.

ematocrit - The percentage of red blood cells in tne blood. other measure of whether or not a person is anemic.

rinary Cadmium - the amount of cadmium in urine.

inary Arsenic - the amount of arsenic in urine.

-inary Beta-2-Microglobulin - the amount of a particular protein in ine. A measure of possible kidney damage due to cadmium.

ATTACHMENT K

STATE OF COLORADO

COLORADO DEPARTMENT OF HEALTH
4210 East 11th Avenue
Denver, Colorado 80220
Phone (303) 320-8333

Roy Romer
Governor

Thomas M. Vernon, M.D.
Executive Director

November, 1988

To the Example Family
Address
Leadville, CO zip
Household ID #

Please find enclosed the results of environmental sampling done inside and outside your home during the Leadville Metals Survey conducted in September and October of 1987. Listed next to your results are the average levels of lead, arsenic and cadmium found in Leadville during this project.

We would like to thank you for your participation in this survey which was conducted by the Division of Disease Control and Environmental Epidemiology, Colorado Department of Health and the Center for Environmental Sciences at the University of Colorado at Denver. We anticipate that we will have a final report of this project completed by spring, 1989 and at that time we will discuss the results at a public meeting held in Leadville.

If you have any questions, please call Dr. Bill Chappell at (303) 556-3460 or Lane Cook or myself at (303) 331-8330. Thank you again for your cooperation.

Sincerely,

Ellen J. Mangione, MD, MPH, Director
Division of Disease Control and
Environmental Epidemiology

Bill Chappell, PhD, Professor
Center for Environmental Sciences

Enclosures

EJM/BC/sjm

ENVIRONMENTAL TEST RESULTS
LEAD RESULTS

Area Sample Taken	Your Result (ug/g)	**Leadville Average (ug/g)
Lead in floor dust	1220	841
Lead in scrape entry	2260	1879
Lead in sill dust	2870	969
Lead in play area	5300	782
Lead in front yard	not done	1108
Lead in back yard	not done	915

CADMIUM RESULTS

Area Sample Taken	Your Result (ug/g)	**Leadville Average (ug/g)
Cadmium in floor dust	9.8	14
Cadmium in scrape entry	6.8	12
Cadmium in sill dust	44	26
Cadmium in play area	27	10
Cadmium in front yard	not done	11
Cadmium in back yard	not done	11

ARSENIC RESULTS

Area Sample Taken	Your Result (ug/g)	**Leadville Average (ug/g)
Arsenic in floor dust	36	36
Arsenic in scrape entry	234	120
Arsenic in sill dust	92	29
Arsenic in play area	738	32
Arsenic in front yard	not done	42
Arsenic in back yard	not done	31

** Geometric means

The enclosed tables list the results of analyses of environmental samples collected inside and outside your home. You can compare the average levels found in Leadville in this study to the levels found in and around your home. Other studies have found 95% of samples collected in the Western United States had lead levels ranging from 4.8 - 67.0 ug/kg and in Colorado ranging from 10.7 to 73.0. Cadmium has been found at levels less than 1 to 10 ug/g in other studies in Colorado or the Western United States. In 95% of the samples collected for studies in the Western United States arsenic levels ranged from 2.0 to 20.0 ug/g and in Colorado ranged from 1.0 to 20.0 ug/g.

When comparing your levels to other areas in the country remember that Leadville is unique in its mining past and background levels of a variety of metals. If you are concerned about the levels found in your home there are steps you can take to reduce potential exposure. These include, particularly for young children, more frequent handwashing, not taking food or a bottle outside to play and not allowing children to swallow or mouth foreign objects. Also, not using materials from the mines around your home and if you are employed as a miner, showering and changing clothes before coming home will reduce potential exposures.

While considerable care was taken in making these measurements, occasional problems can occur. Before taking any steps based on this information, other than those recommended above, it would be wise to repeat the measurements.

RESULTS OF LEAD MEASURED IN THE PAINT

Room Measured	Your Result
Bedroom	Low or None
Main Room	Low or None
Kitchen	Low or None
Bathroom	Low or None
Entryway	Low or None
Other	Low or None
Other	Low or None
Outside Entry	Low or None
Outside Siding	Low or None
Outside Trim	Low or None
Outside Window	Low or None
Other Outside	Low or None
Other Outside	Low or None

Lead in paint is common in houses built prior to 1950. It is not a hazard unless it is available as chips or dust which may be ingested or inhaled by young children or inhaled by adults. This can occur if the paint is chipping or peeling or if a room is being remodeled and the paint is disturbed. If you have leaded paint that is chipping or peeling, it could be covered with new paint or wallpaper or access blocked by a piece of furniture so children are not able to chew on the chips. If you are planning to remodel a room that has lead in the paint, precautions should be taken so that neither you or your child is exposed to lead contaminated dust. Types of precautions would include wearing a respirator while remodeling and wet cleaning of the dust. Children should not be exposed to dust which contains lead and may need to be housed elsewhere during the remodeling.

variation in that ability from one individual to another, the larger GSD may be a reflection of individual differences in response to the coupled stresses. This is obviously a hypothesis, and its validity can only be checked by additional research. Another possible explanation is that the multiple sources of lead contamination in Leadville have given rise to an unusually diverse mix of epicenters of lead as well as differing lead compounds and particulate sizes, both of which could affect bioavailability. Still another explanation is that the drawing of blood in the homes provided variability in the setting however, the blood samples were drawn by venipuncture.

In addition to comparing blood lead distributions from different sites, another comparison that is frequently made involves the relationship of blood lead to soil lead. Several studies (40), have used linear regression analysis to obtain a slope of the blood lead, soil lead curve. The values obtained have ranged from 0.6 ug/dl/1000 ppm soil lead to 7.6 ug/dl/1000 ppm soil lead. The present study gives a regression line involving the logs of blood lead and soil lead leading to the following equation for blood lead (PbB)

$$PbB = 1.52 \text{ (soil lead in ppm)}^{0.25}$$

Using values of soil lead of 100 ppm and 1100 ppm leads to a difference in blood lead over that range of 3.9 ug/dl or a slope in that range of 3.9 ug/dl per 1000 ppm. It is important to note the nonlinearity, which is typical, leads to a slower increase of blood leads with higher soil concentrations.

Environmental Samples

Geometric mean levels of lead in the soils and dust of Leadville were found to range from 572 ppm to 1879 ppm. For comparison purposes, one study of Colorado soils found a geometric mean of 28 ppm lead with a geometric standard deviation (GSD) of 1.62, while another study of soils in the Western United States obtained a geometric mean of 18 with a GSD of 1.96 (3). It is to be anticipated that background soil lead concentrations would be higher than normal in Leadville because of extensive mineralization, but no information exists on soil lead levels prior to the initiation of mining activities.

No water samples had levels of lead greater than the EPA's MCL of 50 ug/L. However, it must be recognized that the sampling method was not optimal for detecting exposure to lead by this route because it did not obtain first draw or fully flushed samples.

XRF Data

Because there are many pre-1950 houses in Leadville, it was anticipated that many houses would have had lead-based paint used at some time in the past (34). A similar study in Telluride, CO found nearly 70% of the houses to have lead-based paint present (35).

It must be noted that problems with the XRF units (for lead in paint measurements) caused reservations in the interpretation of the XRF data. The portable XRF units have both inherent and operational problems. Inherently, the primary excitation source involves a random process and is subject to statistical fluctuation. The source has a half life (270 days) that affects the reliability of the readings as it ages. The physical shape of the instrument and window requires a flat, sufficiently sized area to obtain an accurate reading. Many curved and narrow trims and surfaces did not allow correct placement of the instrument. Operationally, the units had occasional problems with the battery packs not fully charging. The units needed considerable "warm-up" time for the first readings of the day. Certain types of surface compositions gave unreliable readings, aluminum siding in particular. One unit had a defective LED readout that made correct reading of the display very difficult under certain conditions. While there were two National Bureau of Standards (NBS) standards to judge the accuracy of the units, one standard was at the instrument's detection limit (0.6 mg/cm^2) where the readings were particularly unstable. This means there was one mid-range standard to use for two instruments.

While these operational problems are not insurmountable to a highly experienced operator, some operators were not highly experienced and often there was not enough time in the field to obtain an accurate and precise reading. Although the instrument may be intended for quantitative measurements, it is believed that these particular instruments and field circumstances permitted only qualitative measurements. The lead in a surface can only be quantified to 3 levels: low, medium, and high. In general, readings <1 correspond to little to no detectable lead paint. Readings between 1 and 6 mg/cm^2 indicate one coat of lead-based paint (a full coverage reading 5-6 mg/cm^2, with chipped or partial coverage between 1-4 mg/cm^2). Readings between 6-10 mg/cm^2 indicate more than one coat of lead-based paint (6-9 mg/cm^2 on chipped or partial coverage with 9-10 mg/cm^2 at full coverage). The results presented in Table 14 are valid in terms of the distribution into none, low, medium, and high levels. The reservations discussed here are in ascribing validity to the precise value in mg/cm^2. These results only indicate that there is or is not lead on a surface. While the instrument provides that information reliably, quickly and non-destructively, and the XRF unit was a valuable qualitative tool in this study, it must be noted that the readings cannot be viewed as accurate or precise quantitative measures of lead concentrations.

Environmental Samples and Blood Lead Levels

The strongest association was found between childhood blood lead levels and environmental lead levels in the core samples taken at the rear of the house. The odds ratios would indicate that children exposed to lead levels greater than 500 ppm in Leadville are at risk of increased blood lead levels (>10 or >15 ug/dl).

While other studies have described an association between indoor dust lead levels and blood lead levels, such an association was not found in this study (24-28). Environmental samplers often had difficulty in collecting dust in quantities sufficient for analysis. House cleaning prior to a scheduled appointment may have contributed to this and, as a result, indoor dust samples may not be indicative of the actual household dust lead levels. In addition, the weight of dust collected at each home was small due to time restrictions at the home (the 2 dust composites alone often took 45 minutes to 1 hour to collect). The EPA laboratory analysis protocol was not designed for small volumes of dust, introducing additional errors in the handling, weighing, additional dilution factors and reduction of the total number of elements analyzed. Also, the digestion used in the analysis of the dust, scrapes, and soils is designed as only a partial digestion. While this would not affect intra-study associations, it makes it difficult to have inter-study comparisons of the elemental levels of the dusts/scrapes/soils.

Multivariate Analysis and Blood Lead Levels

As has been found in other studies, children's age was negatively correlated with blood lead levels. Younger children exhibit more of the risk factors associated with elevated blood lead levels.

An association appears to exist between children's blood lead levels and eating leafy green vegetables grown in Leadville. Children who ate these less than once a week had lower blood lead levels than children who ate them more than once a week. However, this study also found children who never ate leafy green vegetables grown in Leadville had higher blood lead levels than children who ate them less than once a week. Because of the erratic dose response gradient, this may be a spurious association.

Selected mouthing characteristics of the child were also associated with elevated blood lead levels. Children who swallowed objects other than food or who took a food or bottle outside to play had higher blood lead levels than children who did not. Swallowing non-food items may indicate exposure to lead through ingestion of dirt or contaminated objects.

Blood lead levels were also higher for children whose parents had used material from the mines around the home. Bringing contamined dirt home for whatever purpose could increase the potential for excess lead exposure.

Playing on a grassy area was protective for the the child's blood lead level versus playing on concrete/asphalt or dirt. Children playing on grassy areas had lower blood lead levels than children playing on ground with no cover, i.e. dirt, concrete or asphalt. Ground that is covered with grass would help prevent exposure to children from contaminated dust and soil. Concrete/asphalt while potentially covering a previously contaminated area, may have made subsequent metals deposition more readily accessible to children.

The only environmental sample which was associated with blood lead levels following forward stepwise linear regression using all the environmental samples was the core sample taken at the rear of the house. This variable remained an independent contributor to blood lead even after accounting for the confounding of other effects.

The final regression model for these data explained 46% of the variation in the blood lead levels of children less than six years living in Leadville (R2 = .46). This compares to research in Helena, Montana and Kellog, Idaho which examined blood lead levels of children living near smelters. Regression models including behaviorial and environmental characteristics found a R^2 of .28 in Montana and .33 in Idaho.

It appears that blood lead levels in children 6-71 months old living in Leadville are higher than would be expected. Recent data from a childhood lead screening project in Denver found a mean blood level of 5.6 in 617 children screened from a clinic population judged to be at elevated risk of lead exposure versus 10.1 in Leadville. The perecentage of children in Leadville above 15 ug/dl was higher than would be predicted based on EPA modelling. In addition, soils in Leadville were found to have much higher levels of lead than soils in other parts of the United States. Although comparisons are difficult because of the lack of current data, it would appear that some excess exposure to lead is taking place in Leadville. Potential health effects in this population at these blood lead levels are not known and need to be identified through a health effects study.

Associations with selected behavioral characteristics and blood lead levels in children were identified through this study. Exposure to lead can be reduced through implementing the following recommendations:

1) Lower the exposure to lead in soils and dusts.
2) Cover exposed play areas with grass.
3) Minimize the number of times the child takes food or a bottle outside.
4) Monitor and attempt to minimize the child swallowing things other than food.
5) Do not use materials brought from the mines around the home.
6) If a miner, change clothes and shower at the mine before coming home.
7) Improve hand washing habits.

TABLE 1
Completion Status for Household Census
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Completion Status	Number of Households
Total Households Screened	1513
Vacant/Invalid	165
Total Eligible Households	1348
Complete	1014
No Contact	210
Refused	124

TABLE 2
Leadville Census, Distribution by Age Group
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age Group	N	%
< 6 months	23	0.9
≥ 6 months and < 6 years	239	9.1
6 - 14 years	373	14.2
15 - 44 years	1186	45.1
45 - 65 years	556	21.1
> 65 years	254	9.6
TOTAL	2631	100.0

TABLE 3
Response Rates by Sex and Age Group
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

	SEX					
			Male			Female
Age Group	N	Participants	%	N	Participants	%
6-71 mos.	125	76	60.8	114	74	64.9
6-14 yrs.	25	14	56.0	25	15	60.0
15-44 yrs.	25	13	52.0	25	15	60.0
45-65 yrs.	25	15	60.0	25	11	44.0

TABLE 4
Mean and Range of Blood Lead Levels (ug/dl) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
6-71 mos.	150	10.1	5.58	8.7	1.79	0.5-30.1
6-14 yrs.	29	5.8	2.95	5.1	1.66	1.8-13.2
15-44 yrs.	28	6.4	4.15	5.5	1.75	2.5-18.5
45-65 yrs.	26	8.6	6.70	6.8	1.93	2.4-28.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 5
Mean and Range of Blood Lead Levels (ug/dl) by Age and Sex
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD*	Range
6-71 mos.	M 76	10.3	6.11	8.8	1.74	2.5-30.1
	F 74	10.0	5.01	8.6	1.84	0.5-24.0
6-14 yrs.	M 14	6.6	2.98	6.6	1.55	2.9-13.2
	F 15	5.0	2.80	4.4	1.71	1.8-13.2
15-44 yrs.	M 13	8.6	4.79	7.6	1.66	3.5-18.5
	F 15	4.5	2.27	1.1	1.54	2.5-18.5
45-65 yrs.	M 15	10.1	6.13	8.7	1.76	2.6-28.0
	F 11	6.5	7.16	4.9	1.95	2.4-28.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 6
Mean and Range of Blood Lead Levels (ug/dl) by Age and Ethnic Group
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD*	Range
6-71 mos.	Hisp 58	9.7	5.87	8.0	1.98	0.5-25.4
	Non-Hisp 89	10.4	5.28	9.2	1.65	2.5-30.1
6-14 yrs.	Hisp 7	5.7	3.72	4.9	1.79	2.4-13.2
	Non-Hisp 22	5.8	2.76	5.2	1.64	1.8-11.2
15-44 yrs.	Hisp 5	3.6	1.09	3.5	1.35	2.6- 5.0
	Non-Hisp 23	7.0	4.33	6.0	1.74	2.5-18.5
45-65 yrs.	Hisp 3	15.2	11.34	12.2	2.30	5.2-27.6
	Non-Hisp 23	7.7	5.69	6.3	1.86	2.4-28.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 7
Mean and Range of FEP Levels (ug/dl) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	Arithmetic SD*	Geometric Mean	GSD**	Range
6-71 mos.	150	19.0	10.2	17.7	1.40	8-110
6-14 yrs.	29	20.9	5.3	20.3	1.29	12-34
15-44 yrs.	28	29.9	23.2	23.2	1.66	14-248
45-65 yrs.	26	29.0	25.1	25.1	1.39	15-141

*Standard Deviation
**Geometric Standard Deviation

TABLE 8
Mean and Range of Hemoglobin Levels (ug/dl) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
6-71 mos.	145	13.9	0.98	13.9	1.07	10.1-16.3
6-14 yrs.	29	14.7	0.68	14.7	1.05	13.6-15.8
15-44 yrs.	27	15.7	1.55	15.7	1.10	12.9-18.6
45-65 yrs.	29	16.3	1.91	16.2	1.12	12.3-20.8

*Standard Deviation
**Geometric Standard Deviation

TABLE 9
Mean and Range of Hematocrit Levels (ug/dl) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	Arithmetic SD*	Geometric Mean	Geometric GSD**	Range
6-71 mos.	145	40.1	3.69	40.0	1.11	28.0-47.0
6-14 yrs.	29	42.8	3.75	42.8	1.09	38.0-48.0
15-44 yrs.	27	46.1	3.83	45.9	1.05	37.0-51.0
45-65 yrs.	25	48.0	3.86	47.7	1.12	37.0-60.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 10
Mean and Range of Urinary Arsenic Levels (ng/ml) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
36-71 mos	39	9.01	5.92	7.41	1.87	BDL-29.8
6-14 yrs	29	8.22	5.11	6.81	1.85	BDL-18.3
15-44 yrs	26	7.35	5.34	6.03	1.83	BDL-20.9
45-65 yrs	25	12.99	12.39	8.49	2.52	BDL-39.0

BDL = Below Detection Limits (8 ng/ml)
*Standard Deviation
**Geometric Standard Deviation

TABLE 11
Mean and Range of Urinary Cadmium Levels (ng/g creatinine) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
36-17 mos.	41	0.17	0.23	0.10	2.73	0.01-1.28
6-14 yrs.	29	0.20	0.17	0.14	2.34	0.02-0.70
15-44 yrs.	26	0.60	0.92	0.30	3.32	0.03-4.59
45-65 yrs.	25	0.78	0.97	0.30	5.17	0.01-3.97

*Standard Deviation
**Geometric Standard Deviation

TABLE 12
Beta-2 Microglobulin
Mean and Range of Levels (ug/l) by Age
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Age	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD*	Range
36-71 mos.	37	176.6	90.5	248.4	1.9	BDL-393.0
6-14 yrs.	26	131.1	61.7	114.5	1.8	BDL-246.0
15-44 yrs.	26	84.1	40.5	75.1	1.6	BDL-156.0
45-65 yrs.	25	81.8	51.3	70.6	1.7	BDL-240.0

BDL = Below Detection Limit (98 ug/l)
*Standard Deviation
**Geometric Standard Deviation

TABLE 13
Lead Concentration in Samples Collected from
Resident's Home and Yard (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Type of Sample and Sampling Location	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
Core Front	168	1762.5	1867.2	1108.3	2.8	49.0-15,100.0
Core Rear	166	1625.4	2609.6	914.7	3.1	10.0-27,800.0
Core Play	37	1055.3	1183.7	572.3	3.3	43.0- 4,870.0
Scrape Play	111	1643.4	1824.3	868.1	3.7	2.7- 8,620.0
Scrape Entry	169	2463.2	2022.4	1878.9	2.2	134.0-14,700.0
Composite dust Windowsill	170	1948.5	3588.2	969.2	3.3	30.0-27,900.0
Composite dust Floor	169	1095.6	1049.1	841.0	2.2	8.0-11,100.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 14
Arsenic Concentration in Samples Collected from
Resident's Home and Yard (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Type of Sample and Sampling Location	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
Core Front	168	56.9	48.2	41.9	2.2	5.7 - 281.0
Core Rear	166	42.6	39.2	30.5	2.3	1.9 - 282.0
Core Play	37	38.0	31.3	24.5	3.0	0.7 - 122.0
Scrape Play	111	80.9	132.2	34.3	4.0	0.7 - 738.0
Scrape Entry	169	160.5	119.5	117.3	2.5	2.5 - 556.0
Composite Dust Windowsill	170	52.7	74.8	28.5	3.3	0.7 - 744.0
Composite Dust Floor	169	43.8	27.9	35.5	2.0	3.5 - 149.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 15
Cadmium Concentration in Samples Collected from
Resident's Home and Yard (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Type of Sample and Sampling Location	Number Tested	Arithmetic Mean	SD*	Geometric Mean	GSD**	Range
Core Front	168	17.7	34.3	10.7	2.6	0.5 - 424.0
Core Rear	166	15.2	13.6	11.3	2.1	1.4 - 92.0
Core Play	37	15.1	15.4	9.6	2.7	1.0 - 60.0
Scrape Play	111	15.6	16.8	10.0	2.7	0.4 - 103.0
Scrape Entry	169	15.6	16.8	11.6	2.2	1.0 - 190.0
Composite dust Windowsill	170	79.4	283.9	25.7	3.5	0.3 - 3300.0
Composite dust Floor	169	17.2	13.5	14.2	1.8	1.8 - 115.0

*Standard Deviation
**Geometric Standard Deviation

TABLE 16
Lead-Based Paint Values (mg/sq.cm) for Interior and Exterior Walls of Resident's Homes
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Sampling Location	None	Below Detection(<0.07)	Low (0.7-2.9)	Moderate (2.0-5.9)	High (>6.0)	TOTAL MEASUREMENTS
INTERIOR						
Bedroom	24 (32.0)	33 (44.0)	7 (9.3)	3 (4.0)	8 (10.7)	75
Main room	34 (45.3)	21 (28.0)	8 (10.7)	2 (2.7)	10 (13.3)	75
Kitchen	27 (38.0)	19 (26.8)	12 (16.9)	1 (1.4)	12 (16.9)	71
Bathroom	18 (33.3)	26 (48.1)	4 (7.4)	1 (1.9)	5 (9.3)	54
Main Entry	14 (26.4)	12 (27.6)	12 (22.6)	5 (9.4)	10 (18.9)	53
TOTAL	117 (35.1)	111 (33.8)	43 (13.1)	12 (3.7)	45 (13.7)	328
EXTERIOR						
Entry	20 (28.2)	10 (14.1)	21 (29.6)	6 (8.5)	14 (19.7)	71
Siding	19 (28.8)	22 (33.3)	11 (16.7)	5 (7.6)	9 (13.6)	66
Trim	16 (3.4)	6 (13.0)	12 (27.3)	5 (11.4)	5 (11.4)	44
Window	11 (23.9)	9 (19.6)	14 (30.4)	2 (4.3)	10 (21.7)	46
TOTAL	66 (29.1)	47 (20.1)	58 (25.6)	18 (7.9)	38 (16.7)	227

TABLE 17
Correlations Among Lead Levels in Soil and Dust Samples
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

	Dust Floor	Dust Sill	Core Rear	Core Front	Core Play	Scrape Play	Scrape Entry
Dust Floor	-* --** ---***	0.41 <0.001 (169)	0.24 0.002 (165)	0 .31 <0.001 (167)	0.35 0.034 (37)	0.22 0.022 (110)	0.22 0.004 (168)
Dust Sill			0.26 <0.001 (166)	0.28 <0.001 (168)	0.03 0.87 (37)	0.23 0.013 (111)	0.26 <0.001 (169)
Core Rear				.52 <0.001 (165)	.64 <0.001 (36)	.37 <0.001 (108)	.35 0.001 (165)
Core Front					.62 <0.001 (37)	.41 <.001 (109)	.32 <0.001 (167)
Core Play							.004 0.97 (37)
Scrape Play							.44 <0.001 (110)

*Pearson Correlation Coefficient
**Significance probability of correlation
***Number of samples in parentheses

TABLE 18
Mean Blood Lead Levels (ug/dl) for Children <6 Years
by Soil Lead Level (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

SAMPLING SITE	<500	501-1000	1001-2500	2501-5000	>5000
Core Samples					
Front	7.7 (36)*	10.5 (26)	10.5 (55)	10.5 (27)	18.6 (6)
Rear	6.4 (37)	9.2 (30)	11.8 (53)	11.7 (22)	16.3 (8)
Play Area	9.2 (12)	6.7 (8)	10.7 (12)	17.3 (4)	
Scrape Samples					
Entry	7.5 (13)	10.7 (20)	9.3 (62)	11.0 (43)	13.7 (12)
Play Area	7.8 (36)	11.0 (19)	10.2 (31)	13.2 (18)	11.7 (6)

*Numbers of participants appear in parentheses.

TABLE 19
Mean Blood Lead Levels (ug/dl) for Children <6 Years
by House Dust Lead Level (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

SAMPLING SITE	<500	501-1000	1001-2500	2501-5000	>5000
Floor	9.4 (39)*	9.1 (66)	12.7 (42)	7.3 (2)	5.8 (1)
Windowsill	9.9 (45)	9.2 (34)	11.1 (50)	10.7 (11)	9.2 (10)

*Numbers of participants appear in parentheses.

TABLE 20
Chi-Square Analyses of Blood Lead Levels and Lead in
Dust and Soil for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Sample Type	Contaminant Level (ppm)	Blood Lead Level (ug/dl) < 10	≥ 10	X^2	p value
Core Rear	≤500	33	4	18.1	<0.001
	>500	56	57		
Core Front	≤500	26	10		
	>500	63	51	3.3	0.071
Dust Floor	≤500	28	11	3.4	0.066
	>500	61	50		
Dust Sill	≤500	28	17	0.22	0.637
	>500	61	44		
Scrape Entry	≤500	8	5	0.03	0.866
	>500	81	56		
Core Play	≤500	72	54	1.6	0.211
	>500	17	7		
Scrape Play	≤500	53	23	6.9	0.009
	>500	36	38		

TABLE 21
Correlations Among Log-Transformed Lead Levels in Blood
and Environmental Samples
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

	≥ 1 year and < 3 years	< 6 years
Dust Floor	0.13* 0.35** (52)***	0.10 0.19 (49)
Dust Sill	0.10 0.49 (52)	0.07 0.37 (150)
Core Front	0.27 <0.05 (52)	0.35 <0.001 (149)
Core Rear	0.53 <0.001 (52)	0.50 <0.001 (148)
Core Play	0.23 0.45 (13)	0.35 0.037 (36)
Scrape Play	0.27 0.10 (38)	0.33 <0.001 (110)
Scrape Entry	0.31 0.02 (51)	0.30 <0.001 (148)

*Pearson Correlation Coefficient
**Significance probability of correlation
***Sample size in parentheses

TABLE 22
Chi-Square Analyses of Blood Lead Levels and Lead in
Dust and Soil for Children ≥1 Year and <3 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Sample Type	Contaminant Level (ppm)	Blood Lead Level (ug/dl) <10	≥10	X^2	p value
Core Rear	≤500	12	2	10.9	0.001
	>500	13	25		
Core Front	≤500	6	5	0.2	0.629
	>500	19	22		
Dust Floor	≤500	11	6	2.8	0.100
	>500	21	23		
Dust Sill	≤500	7	7	0.03	0.866
	>500	18	20		
Scrape Entry	≤500	3	3	0.01	0.920
	>500	22	24		
Core Play	≤500	3	3	0.07	0.797
	>500	4	3		
Scrape Play	≤500	8	5	1.6	0.207
	>500	10	15		

TABLE 23
Mean Urine Arsenic Levels (ng/ml) for Children <6 Years
by Soil Arsenic Level (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

SAMPLING SITE	Arsenic <10	11-100	101-250	251-500
Core Samples				
Front	6.6 (3)*	9.1 (35)	9.9 (2)	10.7 (1)
Rear	10.7 (7)	8.7 (30)	9.7 (3)	4.0 (1)
Play Area	13.3 (2)	10.8 (7)	8.3 (1)	0
Scrape Samples				
Entry	0	9.2 (16)	8.3 (21)	12.1 (4)
Play Area	4.8 (5)	9.2 (19)	8.5 (4)	8.8 (3)

*Numbers of participants appear in parentheses.

TABLE 24
Mean Urine Arsenic Levels (ng/ml) for Children <6 Years
by House Dust Arsenic Levels (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

SAMPLING SITE	Arsenic <10	11-100	101-250
Floor	11.7 (12)*	8.3 (25)	5.7 (4)
Windowsill	1.34 (11)	8.1 (26)	5.7 (4)

*Numbers of participants appear in parentheses.

TABLE 25
Mean Urine Cadmium Levels (ng/ml)*
for Children <6 Years by Soil Cadmium Level (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

SAMPLING SITE	Cadmium <0.5	0.6-10	11-100
Core Samples			
Front	0.1 (2)**	0.2 (17)	0.1 (20)
Rear	0.1 (2)	0.2 (17)	0.1 (22)
Play Area	0	0.1 (5)	0.1 (5)
Scrape Samples			
Play Area	0	0.3 (17)	0.1 (12)
Entry	0	0.2 (17)	0.1 (22)

*Values are corrected for creatinine
**Numbers of participants appear in parentheses.

TABLE 26
Mean Urine Cadmium Levels (ng/ml)* for
Children <6 Years by House Cadmium Level (ppm)
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

SAMPLING SITE	Cadmium <0.5	0.6-10	11-100	>100
Floor	0	0.2 (13)**	0.1 (25)	0.1 (1)
Windowsill	0.3 (5)	0.1 (3)	0.1 (25)	0.2 (6)

*Values are corrected for creatinine.
**Numbers of participants appear in parentheses.

TABLE 27
Blood Lead Levels (ug/dl) for Children <6 Years by
Lead-Based Paint Values (mg/sq.cm)
Level in Paint Values
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Sampling Location	None	Below Detection(<0.07)	Low (0.7-2.9)	Moderate (2.0-5.9)	High (>6.0)	TOTAL MEASUREMENTS
INTERIOR						
Bedroom	11.4 (32)	9.3 (21)	8.1 (8)	14.2 (3)	10.0 (4)	10.4 (68)
Main Room	10.9 (50)	7.2 (10)	10.4 (5)	0	8.4 (4)	10.2 (69)
Kitchen	11.2 (35)	7.5 (17)	11.3 (7)	0	10.8 (9)	10.3 (68)
Bathroom	10.7 (30)	9.8 (19)	11.9 (3)	13.1 (1)	6.3 (1)	10.4 (54)
Main Entry	9.4 (18)	14.6 (12)	9.8 (17)	9.3 (6)	11.4 (6)	10.7 (59)
EXTERIOR						
Entry	9.3 (16)	15.4 (11)	8.1 (16)	7.4 (6)	11.6 (8)	10.2 (57)
Siding	11.2 (26)	6.9 (13)	10.9 (12)	12.3 (4)	8.9 (9)	10.4 (64)
Trim	10.9 (27)	5.8 (1)	9.0 (13)	10.6 (5)	13.3 (6)	10.6 (52)
Window	10.4 (27)	11.6 (11)	11.2 (6)	0	9.5 (5)	10.7 (49)

TABLE 28
Variables Significantly Associated with
Log Blood Lead Levels ($p < .05$) for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
September, 1987

Variable Description	F Value	DF	P Value	Mean Log Blood Lead Level by Response
LEAD RELATED				
Do any household members work with soldering in electronics?	4.37	1,142	0.038	yes 2.40 no 2.15
PLAY SURFACE TYPE AND PLAY HABITS				
Does child often take food or bottle outside to play?	16.56	1,59	<0.001	yes 2.46 no 2.13
Type of ground played on	2.75	4,130	0.031	dirt 2.27 conc* 2.14 grassy 2.10
Does child wash his/her hands after playing?	3.88	1,132	0.051	yes 2.20 no 1.74
Hours play outside	R=.18**		0.039	
PARENTS OCCUPATION				
If there is a miner in the household does he/she wear work clothes home?	14.67	1,25	<0.001	yes 2.67 no 2.10
Does miner not shower before coming home	4.75	1,20	0.041	yes 2.36 no 1.95
MOUTHING BEHAVIOR				
How often does child swallow things other than food?	8.94	1,144	0.003	some 2.55 no 2.12
EATING HABITS				
How often do household members eat leafy green vegetables grown in your garden or elsewhere in Leadville?	5.66	3,146	0.001	1/wk or > 2.14 < 1/wk 1.88 never 2.30

TABLE 28 (continued)
Variables Significantly Associated with
Log Blood Lead Levels (p <.05) for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
September, 1987

Variable Description	F Value	DF	P Value	Mean Log Blood Lead Level by Response	
CHILD DEMOGRAPHICS					
Age	4.19	5,144	0.001	<1	1.60
				1	2.42
				2	2.26
				3	2.21
				4	2.17
				5	2.12
OTHER					
Do dogs and cats go in and out of house?	4.24	1,147	0.041	yes	2.27
				no	2.09
Has anyone ever used materials from the mines around the house or yard?	4.97	1,119	0.028	yes	2.36
				no	2.10

*Concrete or Asphalt
**Correlation coefficient

TABLE 29
Significant Odds Ratios for Blood Lead Levels <10 ug/dl and ≥ 10 ug/dl
and Behavioral Characteristics for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Description	Odds Ratio	Confidence Limits
LEAD RELATED		
Household member solders in electronics	1.65	(1.12, 2.42)
Household member solder pipes	1.94	(1.36, 2.76)
PLAY SURFACE TYPE AND PLAY HABITS		
Does child often take food or bottle outside to play?	2.12	(1.41, 3.20)
PARENTS OCCUPATION		
If there is a miner in the household does he/she wear work clothes home?	2.91	(1.37, 6.16)
MOUTHING BEHAVIOR		
How often does child swallow things other than food?		
Alot vs. never	2.67	(2.13, 3.33)
Some vs. never	1.72	(1.14, 2.62)
Alot vs. some	1.54	(1.09, 2.19)
EATING HABITS		
How often do household members eat leafy green vegetables grown in your garden or elsewhere in Leadville?		
Once a week or more vs. never	0.71	(0.41, 1.21)
Less than once a week vs. never	0.49	(0.26, 0.91)
OTHER		
Has anyone ever used materials from the mines around the house or yard?	1.86	(1.24, 2.78)
Household members smoke	1.63	(1.09, 2.43)
Refinished house in last month	1.50	(1.03, 2.19)

TABLE 30
Variables Not Associated with
Log Blood Lead Levels (>0.05) for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Description	F Value	DF	P Value
LEAD RELATED HOBBIES			
Household member ride dirtbike or ATV	1.04	1, 148	0.31
Household member cast lead into sinkers	0.05	1, 146	0.83
Household member paint furniture	0.15	1, 148	0.46
Household member paint picture	0.01	1, 147	0.94
Household member solder pipes	2.44	1, 146	0.12
PLAY SURFACE AND PLAY HABITS			
Does child have favorite blanket or toy	0.16	1, 148	0.69
Does child carry blanket or toy during day	0.34	1, 35	0.56
Does child play outdoors	1.61	1, 17	0.22
Where child spends time during day	0.99	4, 145	0.41
Where child usually plays outdoors	1.90	3, 130	0.13
Hours away from home	R=.10*		.90
PARENT'S OCCUPATION			
Adults worked as miner or related job	2.72	1, 148	0.10
MOUTHING BEHAVIOR			
Does child chew fingernails	0.18	1, 147	0.66
Child put mouth on furniture or windowsill	0.53	2, 146	0.59
Used pacifier last six months	2.37	1, 5	0.18
Does child suck thumb or fingers	0.01	1, 148	0.93
Child put blanket or toy in mouth	0.31	1, 16	0.50
Child often puts things other than food in mouth	1.18	2, 146	0.31
Does child ever put paint chips in mouth	0.05	2, 146	0.95
EATING HABITS			
Food served in clay pottery	0.05	1, 147	0.83
How often child eats seafood	1.88	2, 145	0.27
Does child eat snow	0.29	3, 145	0.83
How often household member eats vegetables from own garden	0.17	2, 30	0.84
Soil hauled to garden	0.74	1, 18	0.40
Family have garden	2.96	1, 29	0.09
How often household members eat root vegetables	1.41	4, 144	0.23
Food stored in cans	1.74	1, 148	0.19
CHILD DEMOGRAPHICS			
Household income	1.3	1, 142	0.24
Race	1.30	2, 147	0.27
Sex	0.60	1, 148	0.80

*Correlation coefficient

TABLE 30 (continued)
Variables Not Associated with
Log Blood Lead Levels (>0.05) for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Description	F Value*	DF	P Value
HOUSE LIVED IN			
Year house built	R= -.17*		0.10
Refinished house in last month	2.53	1, 148	0.11
Refinished house prior to last month	1.80	1, 117	0.18
Anyone in household smoke	2.62	1, 148	0.11
House have storm windows	0.62	1, 82	0.43
OTHER			
Child wash face and hands before eating	0.13	1, 145	0.72
Child wash face and hands before sleep	0.36	1, 146	0.54
Household members smoke	1.62	1, 148	0.11
Household education	0.62	1, 142	0.59

*Correlation coefficient

TABLE 31
Non-significant Odds Ratios for Blood Lead Levels <10 ug/dl and ≥ 10 ug/dl and Behavioral Characteristics for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Description	Odds Ratio	Confidence Limits
LEAD RELATED HOBBIES		
Household member ride dirtbike or ATV	1.19	(0.76, 1.85)
Household member cast lead into sinkers	0.94	(0.38, 2.35)
Household member paint furniture	1.11	(0.63, 1.93)
Household member paint picture	1.18	(0.71, 1.99)
Household member makes pottery	0.61	(0.05, 6.80)
Household member makes stained glass	0.61	(0.05, 6.80)
PLAY SURFACE AND PLAY HABITS		
Does child have favorite blanket or toy	1.09	(0.52, 2.29)
Does child carry blanket or toy during day	1.53	(0.78) 2.98)
Does child play outdoors	1.43	(0.67, 3.07)
Does child wash his/her hands after playing	5.12	(0.36, 73.33)
PARENT'S OCCUPATION		
Adults worked as miner or related job	1.49	(0.99, 2.23)
Does miner shower before coming home	3.75	(0.60, 23.35)
MOUTHING BEHAVIOR		
Does child chew fingernails	0.67	(0.35, 1.30)
Child put mouth on furniture or windowsill		
Alot vs. never	1.47	(0.87, 2.49)
Some vs. never	1.23	(0.79, 1.90)
Used pacifier last six months	0.40	(0.70, 2.42)
Does child suck thumb or fingers	1.00	(0.61, 1.66)
Child put blanket or toy in mouth	0.91	(0.60, 1.37)
Child often puts things other than food in mouth		
Alot vs. never	1.24	(0.79, 1.95)
Some vs. never	0.78	(0.49, 1.26)
Does child ever put paint chips in mouth		
Some vs. never		
EATING HABITS		
Food served in clay pottery	0.83	(0.46, 1.5)
How often child eats seafood		
1/week vs <1/month	1.47	(0.89, 2.44)
1/month vs <1/month	1.04	(0.59, 1.85)

TABLE 31 (continued)
Non-significant Odds Ratios for Blood Lead Levels <10 ug/dl and ≥ 10 ug/dl
and Behavioral Characteristics for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Description	Odds Ratio	Confidence Limits
Does child eat snow		
Alot vs. never	1.03	(0.59, 1.80)
Some vs. never	0.92	(0.59, 1.43)
How often household member eats vegetables from own garden		
1/week or more vs. never	1.12	(0.51, 2.49)
<1/week vs. never	0.90	(0.42, 1.93)
Soil hauled to garden	1.14	(0.46, 2.87)
Family have garden	1.23	(0.76, 2.11)
How often household members eat root vegetables		
1/week or more vs. never	1.66	(.94, 2.94)
<1/week vs. never	1.07	(0.66, 1.75)
Food stored in cans	1.53	(0.88, 2.64)
CHILD DEMOGRAPHICS		
Household income		
<\$5,000 vs. ≥\$30,000	0.47	(0.07, 3.19)
<\$5,000 vs. \$25-29,999	0.38	(0.06, 2.47)
<\$5,000 vs. \$20-24,999	0.29	(0.04, 1.81)
<\$5,000 vs. \$15-19,999	0.32	(0.04, 2.18)
<\$5,000 vs. \$10-14,999	0.29	(0.04, 1.85)
<\$5,000 vs. \$ 5- 9,999	0.64	(0.07, 5.73)
SEX		
	0.88	(0.60, 1.30)
RACE		
White vs. Hispanic	1.11	(0.73, 1.68)
White vs. Other	0.92	(0.46, 1.85)
Hispanic vs. Other	0.83	(0.40, 1.72)
HOUSE LIVED IN		
House have storm windows	0.88	(0.59, 1.31)
Refinished house prior to last month	1.19	(0.80, 1.77)
OTHER		
Child wash face and hands before eating	1.51	(0.56, 4.05)
Child wash face and hands before sleep	1.26	(0.60, 2.65)
Do dogs and cats go in and out of house	1.44	(0.98, 2.12)

TABLE 32
Final Model Based on Forward Stepwise Linear Regression of
Behaviorial Characteristics for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Name	Regression Coefficient	Partial R^2	Model R^2	Partial F-value	P-value
Intercept	4.40			120.27.	<0.001
Eating leafy green vegetables grown in Leadville less than once a week	-0.42	.10	.10	13.32	0.001
Swallows things other than food	-0.33	.10	.21	6.20	<0.015
Uses materials from the mines around the home	-0.25	.06	.26	9.13	0.003
Takes a bottle or food outside to play	-0.35	.06	.32	10.89	0.001
Playing on dirt or soil	0.20	.014	.36	5.96	0.016
Age	-0.005	.03	.39	4.10	0.046
Eating leafy green vegetables grown in Leadville more than once a week	0.11		.40	1.33	NS

$R^2 = .40$

TABLE 33
Forward Stepwise Linear Regression of
Environmental Samples for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Name	Partial R^2	Model R^2	Partial F-value	P-value
core rear	.19	.19	22.77	0<.001

TABLE 34
Final Linear Regression Model for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Variable Name	Regression Coefficient	Partial F-value	P-value
Intercept	3.35	43.11	<0.001
Eating leafy green vegetables grown in Leadville less than once a week	-0.35	9.91	0.002
Eating leafy green vegetables grown in Leadville more than once a week	0.10	1.22	0.273
Swallows things other than food	-0.32	6.38	0.013
Uses materials from the mines around the house	-0.20	6.25	0.014
Takes a bottle or food outside to play	-0.31	9.51	0.002
Playing on dirt or soil	0.17	4.76	0.032
Age	-0.005	5.10	0.026
Core rear	0.13	12.50	0.001

$R^2 = .46$

TABLE 35
Distribution of Blood Lead Levels for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Lead Group (ug/dl)	N	%
< 10	89	59.3
10.0 - 14.9	39	26.0
15.0 - 19.9	8	5.3
20.0 - 24.9	11	7.3
≥ 25.0	3	2.0

TABLE 36
Comparison of Arithmetic Mean Blood Lead Levels in Leadville with Other Studies for Children <6 Years
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

Study Area	Arithmetic Mean Blood Lead Level (ug/dl)
Leadville, CO	10.1
NHANES	14.9
Helena, MT	
Area 1	13.0
Area 2	9.4
Area 3	6.6
Kellog, ID	
Area 1	21.0
Area 2	17.0
Area 3	12.0
Telluride, CO	7.4

TABLE 37
Comparison of Blood Lead Distributions for Children
Ages 6 Months to 71 Months
Percent in Range
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

	Blood Lead Group (ug/dl)			
Study	0-4.9	5-9.9	>10	>15
Leadville	14	45	41	15
Western U.S.*	43	41	14	4
Bunker Hill	**	**	41	14

* Estimated
**Not Available

TABLE 38
Percent of Blood Leads Greater Than a Given Level for
GSD = 1.4 AND GSD = 1.8
With a Geometric Mean of 8.7 ug/dl
LEADVILLE METALS EXPOSURE STUDY
LEADVILLE, CO
September, 1987

GSD	>10	>15	>25
1.8	40	17	3.5
1.4	34	5	0.1