EXPOSURE INVESTIGATION PROTOCOL

MERCURY EXPOSURE IN GOLD MINERS
NOME, ALASKA

Prepared by
Alaska Department of Health and Social Services

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Exposure Investigation Protocol

MERCURY EXPOSURE IN GOLD MINERS
NOME, ALASKA

Cost Recovery Number: AA97

Prepared by:

Section of Epidemiology
Division of Public Health
Department of Health and Social Services
State of Alaska

INTRODUCTION

Nome, Alaska has been an active gold mining area since the Alaskan gold rush of the 1890s. Recently, the price of gold has reached record levels, which has spurred increased gold mining operations in Nome. Miners recover gold by dredging the sea bottom along the coast of the Bering Sea, as well as by traditional panning and sluicing in streams. There are numerous anecdotal accounts of miners recovering mercury and gold-mercury amalgams during these operations. This mercury is apparently derived from historical gold mining and purification operations that released mercury to the environment. Gold miners of interest in this investigation are not workers, and they do not mine gold for an occupation; rather, they engage in small-scale and recreational mining.

Some miners typically sell their gold to an office of the General Refining Corporation (GRC) located in Nome. Because the GRC does not accept mercury-contaminated gold, the miners reportedly heat the gold to drive off the mercury. This activity may expose the miners to harmful levels of mercury fumes. Other miners reportedly have their own operations where they purify gold using methods that also potentially expose them to mercury fumes.

The Alaska Division of Public Health requested an Exposure Investigation (EI) to assess the potentially hazardous exposures. ADPH proposes to collaborate with the federal Agency for Toxic Substances and Disease Registry (ATSDR) and the National Center for Environmental Health (NCEH) laboratory. In this EI, ADPH aims to collect urine samples from gold miners and their family members who may have been exposed to mercury. ADPH will send the urine samples to the NCEH laboratory for mercury and creatinine analyses. ATSDR's Science Support Branch will provide technical assistance, including the review of this protocol and interpretation of the test results.

Gold mining operations in Nome are mostly limited to the summer months. Therefore, this EI must be conducted before the end of August 2012. After that time, mining activities taper off with the advent of winter in the Alaska Norton Sound area.

HEALTH EFFECTS [ATSDR Toxicological Profile for Mercury, March 1999]

The ATSDR Intermediate Minimal Risk Level for mercury is 0.2 $\mu g/m^3$. It is based on a study (Fawer et al. 1983) that showed increased frequency of tremors in workers. Hand tremors were measured in 26 male workers exposed to metallic mercury and 25 control males working in the same facilities, but not exposed to mercury. Workers had been exposed to mercury through the manufacture of fluorescent tubes, chloralkali, or acetaldehyde. Mercury-exposed workers had a duration of exposure of 15.3±2.6 years, blood mercury of 41.3±3.5 micromoles Hg/L, and urinary mercury of 11.3±1.2 micromoles Hg/mole of creatinine. The mean mercury level measured using personal air monitors was 0.026±0.004 mg/m^3 (3 subjects were exposed to greater than 0.05 mg/m^3). Hand tremors were measured in the subjects using an accelerometer attached to the dorsum of the hand both at rest and while holding 1,250 grams. The highest peak frequency of the acceleration was determined.

The highest peak frequency of the tremor was greater in exposed men than in controls. The highest peak frequency corresponded significantly to duration of exposure and age. Comparison of tremors using an index of the entire spectrum of the tremor showed no differences between exposed men and controls at rest, but the changes observed between rest and load were higher in the exposed men. These changes correlated with the duration of exposure and biological indices of exposure (blood and mercury levels), but not with age.

Inhaled metallic mercury is quickly absorbed through the lungs into the blood. Its biologic half-life in humans is approximately 60 days, with the half-life varying with the physiological compartment (*e.g.*, 21 days in the head, versus 64 days in the kidneys; Cherian et al. 1978). Since the duration of exposure does influence the level of mercury in the body, the exposure level reported in the Fawer et al. (1983) occupational study was extrapolated from an 8-hour/day, 40-hour/workweek exposure to a level equivalent to a continuous 24 hour/day, 7 days/week exposure as might be encountered near a hazardous waste site containing metallic mercury.

After a short-term exposure to mercury in air, mercury fumes are rapidly absorbed through the lungs into the blood (Sandborgh-Englund et al. 1998). Blood mercury concentrations increase rapidly after exposure and peak after about 7 hours; thereafter they fall rapidly over the next several days. Urine mercury concentrations increase above baseline values within a day and peak at about 8 days post exposure; thereafter they fall slowly over the next 2-3 weeks.

PROJECT OVERVIEW

Purpose

The purpose of this EI is to measure the concentration of mercury in urine samples from gold miners, their family members, and affiliates who may have been exposed to mercury from gold mining operations, including the handling and heating of gold amalgams.

The results from this testing will tell the miners if they have had relatively recent elevated exposures to mercury. If so, recommendations could be made to reduce their exposures to mercury.

Investigators and Collaborators

ADPH/Section of Epidemiology will:

(1) Write the EI protocol
(2) Identify and recruit participants for the EI
(3) Collect demographic and exposure information via an in-person questionnaire
(4) Make appointments for urine testing
(5) Collect the urine samples and ship them to NCEH for analyses
(6) Notify the participants of the test results

(7) Provide health education to the community on the findings of the EI
(8) Write a report that summarizes the collective findings of the investigation

ATSDR/Science Support Branch will:

(1) Provide technical assistance to ADPH in developing the EI protocol and interpreting the urine test results. Any data shared with ATSDR will not contain personal identifiers.

NCEH Laboratory will:

(1) Provide supplies for collecting urine samples
(2) Analyze the urine samples for mercury and creatinine

METHODS

Participant eligibility criteria

ADPH will include gold miners and their household contacts aged 7 years and older, including family members, who may have been exposed to or reported exposure to mercury in the three weeks preceding the EI.

The Nome EI team members will approach potential subjects and their household contacts to ask if they have:

(1) Seen mercury in the environment or in their gold concentrates,
(2) Personally heated mercury concentrate, or
(3) Been either in an enclosed space where this was done or an outdoor space where the subject was less than 10 feet away from the gold heating activity.

If the subject confirms any of the aforementioned situations, he or she will be eligible to participate in the EI. The subject will be asked to read and sign the consent form, answer the questionnaire; and donate a spot urine sample.

Recruitment of participants

ADPH staff will contact people in Nome who are knowledgeable about local miners and mining activities and request their assistance in identifying and recruiting participants for the EI. These contacts include: (1) Alaska Department of Natural Resources staff in Nome who permit gold dredging operations, (2) a representative of the General Refining Corporation that buys gold from the miners, (3) the state public health center in Nome, and (4) employees of the City of Nome. In addition, ADPH staff will place advertisements in the Nome Nugget, the widely-read local newspaper in Nome, to recruit participants. Further, ADPH staff will approach gold miners on the Nome beach, where many small-scale miners camp, for participation. Potential participants will be asked to

answer an ADPH staff-administered questionnaire (Appendix C) and to provide a urine sample for mercury testing.

Participation in this EI will be offered to gold miners and their household contacts (ages 7 years or older) in the Nome area who self-report that they have had contact with mercury or mercury amalgams or that they have been in the vicinity of other miners whose activities may have exposed the participants to mercury in the previous three weeks before testing. Priority will be given to miners who have engaged in heating gold-mercury amalgams to drive off mercury within the past three weeks. The ADPH aims to a spot urine sample from 50 participants.

Field activities

ADPH will conduct the field activities for this EI. ADPH staff will have several stations in the city of Nome where miners can go to answer the pre-screening questions and, if eligible, submit a urine sample and answer a few questions related to potential mercury exposure. Participants can also request an ADPH representative to visit their residence to collect a urine sample. Prior to sample collection, all participants are required to provide written informed consent form. This form is provided in Appendix A.

ADPH will give each participant a urine collection cup and instruct them to collect a spot urine sample of at least 40 millimeters (ml) (Appendix B). ADPH staff will transfer aliquots of urine into screw top cryovials. For mercury analysis, ADPH staff will pipette 3 ml of urine into a tube containing 30 microliters (µl) of sulphamic acid preservative. Into another tube, ADPH staff will pipette 1.0 ml of urine for creatinine analysis. Code numbers identifying the participants will be placed on the tubes; no personal identifiers will be used. To test for field contamination, blank samples will be prepared with distilled water. One blank sample will be prepared initially, then one for every 15 urine samples, and one at the end of the urine collection period. After collection, the samples will be placed on ice packs until they can be transferred to a freezer where they will be stored frozen until shipped.

ADPH will administer an in-person questionnaire to identify eligible participants and to collect demographic and exposure data from these participants (Appendix C).

Sample handling and shipping

ADPH staff will package the urine samples on dry ice (non-dry-ice packs if dry ice is not available), enclose a chain-of-custody form, and ship them by overnight delivery to the NCEH laboratory in Atlanta, Georgia, for analysis.

Laboratory analysis

The NCEH laboratory will analyze the urine samples for total mercury and creatinine. The lab will analyze total mercury by using inductively coupled plasma mass spectrometry. The detection limit for mercury by this technique is 0.16 micrograms/liter

(µg/L). The lab will analyze creatinine using an automated spectrophotometric technique.

The test results will be reported as µg mercury per liter urine and µg mercury per gram of creatinine.

DATA EVALUATION

The test results will be compared to the most recent data (2007-2008) from the National Health and Nutrition Examination Survey (NHANES) (NCEH 2012). NHANES data are derived from a representative sample of the civilian, non-institutionalized population in the United States (U.S.). NHANES contains data stratified according to age, gender, and race. Urine concentrations of creatinine-corrected mercury above the NHANES 95th percentile will be considered to be elevated.

Adverse health effects have not been reported in workers with occupational exposures to mercury that result in urine mercury concentrations of less 20 µg/L (Clarkson and Magos 2006). If any adults in this EI exceed 20 µg/L (or 20 µg/g creatinine), ADPH will immediately contact them to recommend that they seek medical evaluations to determine if their health has been impacted by mercury exposures.

Children may be more sensitive to the toxic effects of mercury than adults. Based on a review of the literature, the ATSDR, CDC/NCEH, and Mt. Sinai's PESHU considered 5 µg mercury/g creatinine as an appropriate reference level for mercury in children (ATSDR 2007). If any children exceed this level, ADPH will recommend further evaluations to determine the source(s) of exposure and whether follow-up medical records review and medical evaluations are necessary.

RISKS AND BENEFITS TO PARTICIPANTS

There are no anticipated risks to the participants of this EI.

By participating in this investigation, the participants will learn if they have experienced an unusual exposure to mercury. If test results indicate an unusual exposure to mercury, ADPH will follow-up with the test subject to identify all potential sources of mercury, and recommendations will be made to reduce exposures.

NOTIFYING PARTICIPANTS OF TEST REULTS

At the conclusion of the EI, ADPH will provide individual test results to the participants and an explanation of their significance.

WRITE-UP OF RESULTS

ADPH will prepare a written report that summarizes the findings of the investigation. No personal identifiers will be included in the report. The report will be available to the public and to other federal, state, and local environmental and public health agencies.

References

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Appendix A: Adult Consent Form and Child Assent Form

Participant ID No._____

Alaska Division of Public Health
Section of Epidemiology
Exposure Investigation

Nome, Alaska
August 2012

Adult Consent Form for Urine Mercury Testing

Who are we and why are we doing this Exposure Investigation?

We are from the Alaska, Division of Public Health, Section of Epidemiology. We are doing this exposure investigation (EI) with help from the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). They are a federal public health agency. We are doing this to see if people who come into contact with mercury when they mine gold have high exposures to mercury. Mercury is a chemical that can make you sick. We want to make sure you are safe.

The nervous system is sensitive to metallic mercury. Exposure to very high levels of metallic mercury vapor can cause brain, kidney, and lung damage and may seriously harm an unborn child. Exposure to mercury vapor concentrations high enough to produce such serious effects might also cause coughing, chest pains, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Exposure to lower levels of airborne mercury for prolonged periods of time would produce more subtle effects, such as irritability, problems sleeping, excessive shyness, tremors, coordination problems, changes in vision or hearing, and memory problems. Most of the effects of mercury resulting from prolonged lower level exposure disappear once exposure stops and the mercury has left your body.

We are inviting you to have your urine tested for mercury.

What is involved in this testing?

We will give you a plastic cup to collect a urine sample. We will give you instructions on how to collect your sample. It should take 5 minutes or less for you to collect your urine sample.

We will send the urine sample to the CDC laboratory in Atlanta where it will be tested for mercury. The urine will only be tested for mercury, and any leftover urine will be discarded.

Participant ID No._____

What are the benefits from being part of this EI?

By being part of this EI, you will find out if you have been exposed to mercury and how your exposure compares to others in the U.S.

This test will not tell you if your health may be harmed by these exposures. We can tell you if the amount of mercury in your urine is similar to levels in others where health effects have been seen.

What are the risks of being part of this EI?

There is no risk from donating a urine sample.

There is no cost to you for this testing. You will not be paid for being in this EI.

What about my privacy?

We will protect your privacy as much as the law allows. We will give you an identification (ID) number. This number, not your name, will go on your urine sample. We will not use your name in any report we write. We will keep a record of your name, address, and ID number so that we can send you the test results. Your name and address will be kept in a password-protected computer. Copies of your consent form will be kept in a locked file cabinet.

How will I get my test results?

We will mail your test results to you one to two months after your sample is collected. We will also give you a phone number that you can call to discuss your test results. The Alaska Division of Public Health does not provide any follow-up medical care or evaluation.

What if I don't want to do this?

You are free to choose whether or not you want to be part of this testing. If you agree to be tested, you may change your mind any time and drop out without penalty. You must sign this consent form to be tested.

Who do I contact if I have questions?

If you have any questions about this testing, you can ask us now. If you have questions later, you can call the Alaska Section of Epidemiology (Ali Hamade at 907-269-8086 or Brian Yablon at 907-269-8891).

Participant ID No._____

VOLUNTARY CONSENT

I have read this form or it has been read to me. I have had a chance to ask questions about this testing and my questions have been answered. I agree to be part of this testing. I know I can change my mind at any time. I agree to let other agencies see my results, but not my name or address.

_____ _____

Participant's Signature Date

_____

Participant's Printed Name

Participant Address:

_____

_____

_____

Phone number: (_____)_____

Alternate phone number: (_____)_____

I have read the consent form to the person named above. He/she has asked questions about the investigation and had the questions answered.

_____ _____

Signature of person administering consent form Date

_____

Printed name of person administering consent form

Participant ID No._____

Alaska Division of Public Health
Section of Epidemiology
Exposure Investigation

Nome, Alaska
August 2012

Assent Form for Urine Mercury Testing for
Children Ages 7 to < 18 Years

Who are we and why are we doing this Exposure Investigation?

We are from the Alaska, Division of Public Health, Section of Epidemiology. We are doing this exposure investigation (EI) with help from the U.S. Agency for Toxic Substances and Disease Registry (ATSDR). They are a federal public health agency. We are doing this to see if people who come into contact with mercury when they mine gold have high exposures to mercury. Mercury is a chemical that can make you sick. We want to make sure you are safe.

The nervous system is sensitive to metallic mercury. Exposure to very high levels of metallic mercury vapor can cause brain, kidney, and lung damage and may seriously harm an unborn child. Exposure to mercury vapor concentrations high enough to produce such serious effects might also cause coughing, chest pains, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Exposure to lower levels of airborne mercury for prolonged periods of time would produce more subtle effects, such as irritability, problems sleeping, excessive shyness, tremors, coordination problems, changes in vision or hearing, and memory problems. Most of the effects of mercury resulting from prolonged lower level exposure disappear once exposure stops and the mercury has left your body.

We are inviting you to have your urine tested for mercury.

What will I have to do?

We will give you a plastic cup to collect a urine sample. We will give you instructions on how to collect your sample. We will ask you a few questions like how old you are and if you work with the gold. It will not take much of your time.
We will send the urine sample to a laboratory to be tested for mercury. The urine will only be tested for mercury. Any leftover urine will be thrown away.

Participant ID No._____

What will I get for doing this?

You will find out if you have been exposed to mercury. We can tell you if your exposure is above normal.

What are the benefits?

This test will not tell you if your health may be harmed by these exposures. We can tell you if the amount of mercury in your urine is similar to levels in others where health effects have been seen.

What are the risks?

There is no risk from giving us a urine sample to test. You may feel uncomfortable or embarrassed.

We cannot pay you for doing this.

What about privacy?

We will not share your name or where you live with anyone. Even the laboratory will not know this. We will keep a record of your name and address so that we can send you the test results. Your name and address will be kept under lock and key. Your name and address will be kept in a password-protected computer. Copies of this assent form will be kept in a locked file cabinet.

How will I get my results?

We will mail your test results to you and your parents in one to two months. We will also give you a phone number that you can call if you have questions.

What if I don't to do this?

You don't have to do this if you don't want to. If you say "yes" and then don't want to, that is ok. You can change your mind. Before you give us a urine sample, you must sign this form that says you went to be tested to have your child tested.

What if I have questions?

If you have any questions about this testing, you can ask us now. If you have questions later, you can call the Alaska Section of Epidemiology (Ali Hamade at 907-269-8086 or Brian Yablon at 907-269-8891).

Participant ID No._____

VOLUNTARY ASSENT

I have read this form or it has been read to me. My questions about this testing have been answered. I agree to be part of this testing. I know I can change my mind at any time and not get in trouble.

_____ _____
Signature of Minor Date

_____
Printed Name of Minor

_____
Signature of Parent

Age of Participant: _____ Gender of Participant: _____

Participant Address:
_____
_____
_____

Phone number: (_____)_____

Alternate phone number: (_____)_____

May we share your test results (without your name or address) with other Federal and State health and environmental agencies? YES _____ NO _____

I have read the consent form to the person named above. He/she has asked questions about the investigation and had the questions answered.

_____ _____
Signature of person administering consent form Date

_____
Printed name of person administering consent form

Appendix B: Specimen Collection Procedure for Urine Mercury

Urine Collection Instructions

Urine collection cups will be provided for each participant. Label each cup with a bar-coded specimen ID label. Instruct each participant to do the following for a clean-catch urine collection.

- Wash hands and dry them with a clean towel
- Do not remove the cap from the specimen cup until ready to void
- Place the cap turned inside-upwards on a clean and stable surface while collecting urine
- Collect at least 10 ml of urine in the cup; do not touch the inside of the cup or cap at any time
- Recap the specimen cup
- Return the cup to the Exposure Investigation (EI) staff

Appendix C: Exposure Investigation Questionnaire for Potential Mercury Exposure from Small-scale Gold Mining

Nome, AK

Summer 2012

Participant ID No._____

Mercury Exposure Questionnaire for Gold Miners — Nome, Summer 2012

Date of interview: _____
Name or Code of the interviewer: _____

INTRODUCTION

We are with the Alaska Division of Public Health. We are looking into some of the small-scale gold mining practices in Nome and we are particularly interested in the health of miners who may be exposed to mercury when extracting and/or purifying gold. We would like to ask you a few questions about how you look for gold and how you purify gold. If you have been in contact with mercury during the past three weeks we would also like to collect a urine sample from you to measure your exposure.

Completion of this questionnaire is voluntary. Any information you give us will be kept confidential and will only be used for the purpose stated above. All information will be summarized as a group, and none of the information will be directly linked to you. You may skip any question or stop at any time without consequence.

DEMOGRAPHIC INFORMATION

1. Name: _____
2. Date of Birth: _____ Age: _____(years)
3. Sex: ____ Female ____ Male
4. Occupation (Current or last job): _____
5. Permanent mailing address:_____
6. Place of residence while in Alaska: _____
7. Phone: _____ Alternate phone: _____
8. Email address:_____
9. What is the best way to reach you in the next two months?:_____

NOME MINING INFORMATION

10. Have you come across mercury (a shiny silver metal) in the environment while you've been mining this summer? ____ Yes, ____ No
    a. If yes, where? _____
    b. If yes, how often? _____
        i. ____ Daily
        ii. ____ Weekly
        iii. ____ Other _____

Participant ID No._____

c. If yes, on average, how much mercury?
    i. ____As big as a pinhead
    ii. ____As big as a bead
    iii. ____As much as a thimble full of sand
    iv. ____Other amount _____
    v. What is the largest amount of mercury that you have found in one day? _____

11. Have you heated any gold concentrate in the past three weeks?

____ Yes, ____ No (If no, skip to #12). If yes,

a. Have you heated gold concentrate that you found in Nome this summer to remove mercury? ____ Yes, ____ No
b. Do you heat the gold concentrate in open pans?____ Yes, ____ No

If yes,

    i. How often have you done this? _____;
    ii. This summer, have you ever worn personal protective equipment such as a respirator or face mask when heating gold concentrate? ____ Yes, ____ No
        1. If yes, what kind of personal protective equipment? _____
        2. How often do you use the personal protective equipment?
            a. ____Always
            b. ____Most of the time (~75% of the time)
            c. ____Some of the time (~50% of the time)
            d. ____Almost never (~25% of the time)
            e. ____Never

c. On average, how much time per day do you spend purifying? _____
d. Where do you heat the gold you find? (list all locations – e.g., in a tent, in the open, on the coast, at home, in a room - window open or closed?, in a specialized facility) _____
_____

Participant ID No._____

e. Have you used a retort when heating your gold concentrate in Nome this summer? ____ Yes, ____ No

f. Do you have household contacts, including family members, helping you purify gold?

____ Yes, ____ No

If yes,

i. Would you be willing to share their names and contact info?

_____

ii. How are they related to you?

_____

iii. How old are they? _____

iv. How do they help? _____

g. Do you use other methods (such as chemical) to remove mercury from gold? ____ Yes, ____ No

i. If yes, please list these methods _____

12. Have you seen other miners burn off mercury or use mercury to purify the gold this summer in Nome? ____ Yes, ____ No

a. If yes, how many times have you seen this per week? _____

b. How many times did you see it indoors per week? _____

c. How many times did you see it outdoors per week? _____

d. Were you within ten feet of this activity outdoors? _____

e. Were you in an enclosed space (like a tent or hut or apartment) when this was done? ____ No, ____ Yes, Please specify location_____

13. Have you used mercury to extract gold in the past three weeks?

____ Yes, ____ No

14. Do you feel that exposure to mercury during your gold mining could be bad for your health?

_____a. No

_____b. A little

_____c. A lot

_____d. Yes

_____e. Not sure

Participant ID No._____

15. Would you like us to contact you at a later date to inform you about the health risks of breathing in mercury fumes or handling mercury? ____ Yes, ____ No

DIETARY HABITS

16. Have you consumed any fish that you caught yourself, ate at a restaurant, ate at home, ate from a can (canned fish/tuna), were smoked, or dried in the past three weeks? ____ Yes, ____ No
    a. If yes,
        i. How much fish did you typically eat at a time? Let's use a deck of cards, which is about a 3 ounce portion of fish. How many portions have you consumed in:
            a. The past 24 hours? ____
                i. What kind of fish? _____
            b. The past week? ____
                i. What kind of fish? _____
            c. The past two weeks? ____
                i. What kind of fish? _____
            d. The past three weeks? ____
                i. What kind of fish? _____

URINE SAMPLE COLLECTION

17. Thank you for answering these questions. Part of our project is to see if people who come in contact with mercury during gold mining activities have high exposures to mercury. Testing urine is one way to do this. Would you be interested in having your urine tested for mercury at no cost to you?
    Yes _____ (Great). [go to appropriate consent form]
    No _____ (May I ask why you're not interested in being tested for mercury exposure?) _____

REPORT PREPARATION

This Exposure Investigation Protocol for the Nome Small-Scale Mining Areas site was prepared by the Alaska Department of Health and Human Services under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with the approved agency methods, policies, procedures existing at the date of publication. Editorial review was completed by the cooperative agreement partner. ATSDR has reviewed this document and concurs with its findings based on the information presented.

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