Health Consultation

Exposure Investigation

Investigation into Potential Exposures to Mercury Vapor
In Small-Scale and Recreational Mining - 2012

NOME SMALL SCALE MINING AREAS
NOME, ALASKA

Prepared by
Alaska Department of Health and Social Services

SEPTEMBER 5, 2013

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

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Cost Recovery Number: AA97

Prepared By:

Alaska Department of Health and Social Services
Division of Public Health
Section of Epidemiology, Environmental Public Health Program
Under cooperative agreement with the
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SUMMARY

INTRODUCTION

The Alaska Section of Epidemiology (SOE) learned that gold miners in Nome were potentially exposed to mercury vapor from mining, purifying, and heating gold. In collaboration with federal and state partners, SOE conducted an exposure investigation (EI) at the Nome Small-Scale Mining site. The EI assessed urine mercury levels in 18 people who may have been exposed to mercury from gold mining and gold processing activities. Participants included 15 gold miners, one person who frequently heated gold, and two residential contacts of the latter. SOE informed participants of their results, which indicated if they had relatively recent mercury exposures.

CONCLUSIONS

Based on urinary mercury test results SOE reached three conclusions:

- One participant who frequently heated gold was exposed to mercury vapor by inhalation at levels that could be harmful. This participant reported frequently heating gold, not using appropriate engineering controls, and not wearing appropriate personal protective equipment (PPE). These exposures could also be harmful to anyone living in the same household not wearing PPE.
- Two participants who lived in adjacent housing to the person who frequently heated gold had higher urinary mercury levels than the general population. However, their exposures are not expected to harm their health.
- The rest of the EI participants' exposures to mercury vapor by inhalation for the past few weeks are not likely to harm their health, as their urinary mercury test results were well below this EI's health reference level, the level that is associated with breathing potentially harmful levels of mercury vapor.

BASIS FOR DECISION

- The person who repeatedly heated gold had urinary mercury levels above this EI's health reference level. This suggested potentially harmful exposures to mercury, likely from vapor inhalation.
- People living in adjacent housing to the participant who frequently heated gold could also be exposed to mercury by that operation. Two of those people participated in this EI and had urinary mercury levels above those typical of the general U.S. population. These participants' urinary mercury levels were also higher than those of this EI's gold miner participants.

	However, their urine mercury levels did not exceed this EI's reference level. • None of the 15 miners had urine mercury levels that exceeded the health reference level. Therefore, no harmful exposures are expected.
NEXT STEPS	• SOE is following up with the person with urinary mercury levels of concern to ensure that the planned engineering controls eliminate mercury exposures. • SOE is following up with the two residential contacts that had urine mercury levels distinctly higher than the rest of the EI participants to ensure that their mining-related mercury exposure is eliminated. • SOE plans to continue educating the mining community about mercury exposure and health effects associated with recreational gold mining in Alaska.
FOR MORE INFORMATION	If you have concerns about mercury exposure and health effects, you should contact SOE at 1-907-269-8000. You can also call ATSDR at 1-800-CDC-INFO and ask for information on mercury exposure and health effects.

Statement of Issues

In response to a request by the Alaska Department of Environmental Conservation (DEC), the Alaska Section of Epidemiology (SOE) planned this Nome Gold Miners Exposure Investigation to determine mercury exposures among gold miners and their contacts. DEC and SOE were concerned that miners may be exposed to harmful levels of mercury, which is a potent neurotoxin and may have adverse effects on the pulmonary, renal, and cardiovascular systems. Mercury analysis of urine samples would be most indicative of exposure during the few weeks prior to urine collection. SOE gathered information about miners' exposure risk factors in a questionnaire that was also a part of this investigation.

Background

Nome lies on the southern Seward Peninsula coast on the Norton Sound of the Bering Sea. It has a population of approximately 3,600 persons. Nome has a public water system supplied by artesian wells. No roads connect Nome to Anchorage or Fairbanks, Alaska's largest urban centers. Travel to and from Nome occurs mostly by sea or air. Nome has a subarctic climate with average temperatures ranging from -2 to 27 º F between November and April and from 31 to 59 º F between May and October.

Nome is rich in gold-containing minerals, which are mined on a recreational and small-scale basis mostly in the warmer summer months. Nome has been an active gold mining area since the Alaskan gold rush of the 1890s. Historically, miners used mercury to extract gold and silver from sand or slurries of ground ore. Concurrent larger scale hydromechanical mining processes resulted in considerable mercury contamination of soil and water. During gold purification, the mercury bound to gold may be heated off and recovered for reuse; if not properly recovered, some mercury escapes into the air and contaminates air, land, and water.

Recently, the price of gold has reached record levels, spurring an increase in gold mining operations in Nome. Miners recover gold by suction dredging the sea bottom along the coast of the Bering Sea, as well as by traditional panning and sluicing in streams and locations inland. There are several anecdotal accounts of miners recovering mercury and gold-mercury amalgams during their recent operations. This mercury is mostly derived from historical gold mining and purification operations that released mercury into the environment.

Gold miners of interest in this investigation are those engaged in small-scale and recreational mining, not those working for an industrial-scale enterprise, or mining gold for an occupation.

SOE was not aware of any community concerns about mercury health effects from gold mining before this EI. Later, we learned that one person was concerned that a neighbor's gold processing activities may be harming their health.

Project Overview

Purpose

The purpose of this EI was to ascertain, by collecting personal exposure information via questionnaire and urine testing, whether exposure to harmful levels of mercury occurred among individuals who were engaged in small scale or recreational gold mining. . This investigation included gold miners, their household contacts, and affiliates who may have been exposed to mercury from handling or heating gold amalgams. SOE made recommendations for mercury exposure reductions when urine mercury concentrations were elevated.

Investigators and Collaborators

SOE led this investigation. The specific roles of the agencies that participated in this investigation were:

SOE:

1. Developed the EI protocol (see Appendix 1).
2. Identified and recruited participants for the EI.
3. Collected demographic and exposure information via an in-person questionnaire (see Appendix 1).
4. Collected urine samples and shipped them to the National Center for Environmental Health (NCEH) for analyses.
5. Notified participants of the test results.
6. Educated the community about potential mercury exposures and health effects in gold mining.
7. Provided and will continue to provide health education to the mining community about the findings of this EI.
8. Prepared this report summarizing the findings of the EI.

Agency for Toxic Substances and Disease Registry (ATSDR):

1. The Science Support Branch assisted SOE in developing the EI protocol and interpreting the urine test results. Data shared with ATSDR did not contain personal identifiers.
2. The regional representative for Alaska facilitated inter-agency communication about the feasibility of an EI and assisted in explaining its purpose to stakeholders and officials, and was part of the EI Team in Nome.

DEC:

1. Facilitated discussion surrounding this EI.
2. Communicated with stakeholders about environmental regulation and disposal of mercury and waste possibly contaminated with mercury.

NCEH Laboratory:

1. Provided supplies for collecting urine samples.
2. Analyzed urine samples for mercury and creatinine.

Methods

Criteria for participation

Gold miners and their household contacts who self-reported contact with mercury or gold amalgams were eligible to participate. Also eligible, were people who reported being near miners or others whose activities may have exposed them to mercury in the three weeks prior to testing.

Recruiting participants

Prior to the field investigation, SOE contacts in Nome posted fact sheets in local stores and the post office. This fact sheet included information on both EI recruitment and health effects from mercury exposure. In addition, SOE issued a press release and placed a recruitment ad in the Nome Nugget, Nome's weekly newspaper. They advertised the times, dates, and locations of the mercury survey and screening. Finally, local radio, television, print, and online media outlets interviewed SOE staff about participating in the EI.

The Nome EI team, composed of SOE and ATSDR staff, arrived in Nome on August 28, 2012. The team collected urine samples at the Nome Public Health Center for four days (August 29 to September 1). They also approached miners on the beach, in their camps, as well as in town at local restaurants. EI team members told potential participants that they were conducting a survey regarding mining practices and possible mercury exposure. EI team members asked individuals if they were interested in completing a voluntary questionnaire and submitting a urine sample. Participants were told that their information would remain confidential, their urine sample would only have a numeric identifier and they would receive their test results and an SOE interpretation of what the results mean in approximately 8 weeks. Individuals who agreed to participate in the survey received an $8 restaurant gift card as a token of appreciation. Participants understood that the EI was for public health purposes and that results would prompt educational campaigns, if warranted.

Each participant completed an EI team member-administered questionnaire (Appendix 1) and provided a urine sample for mercury testing. The EI team provided the mercury fact sheet to each participant and non-participant (those who declined participation). Table 1 indicates how EI participants were linked to gold mining and processing activities.

Table 1. Nome Exposure Investigation Participants*

EI Participant	Questionnaire (number)	Urine Sample (number)
Gold Miners (Participants #1-14)	15**	14**
Participant possibly in contact with miners (Participant #15)	1	1
Participant A (Frequent gold heater; Participant #18)	1	1
Participant B (A's neighbor; Participant #17)	1	1
Participant C (A's neighbor; Participant #16)	1	1

* See Table 2 for urinary mercury results of Exposure Investigation participants
** One of the miners completed a questionnaire but declined to provide a urine sample

Urine sample collection

Each participant received a urine collection cup, gloves, and verbal instructions on how to collect a spot urine sample. Participants provided the spot sample when they received the collection cup. We subsequently transferred aliquots into two screw top cryovials. For mercury analysis, we pipetted 3 milliliters (ml) of urine into a tube containing 30 microliters (µl) of sulfamic acid preservative. For creatinine analysis, we pipetted 1.0 ml of urine into another tube. Creatinine measurements standardize urine mercury measurements to account for differences in hydration status among people.

We placed a unique code number on the vial identifying each participant's sample without any personal identifiers. To test for lab and field contamination, we prepared two blank samples with tap water. We placed the samples in a cooler at sub-ambient temperature for up to 6 hours before shipping. Ambient temperatures in Nome during the investigation were generally between 40 and 50 degrees Fahrenheit.

Sample handling and shipping

At the end of the Nome trip, SOE staff packaged the urine samples on non-dry-ice packs and enclosed a chain-of-custody form. The samples were kept frozen for a few days over the weekend in Anchorage and then shipped overnight to NCEH. For all but extreme cases, which we did not encounter during this EI, urinary creatinine is minimally affected by storage temperature and time (Spierto *et al*., 1997). We added sulfamic acid to the urine samples for mercury analysis, to prevent mercury loss.

Laboratory analysis

The NCEH laboratory analyzed the urine samples and two Nome tap water blank samples for total mercury and creatinine. The laboratory analyzed total mercury by inductively coupled plasma mass spectrometry (ICP-MS). The detection limit for mercury by this technique is 0.16 micrograms/liter (µg/L). The laboratory analyzed creatinine using an automated spectrophotometric technique.

Urine mercury Reference Level

Based on an extensive review, Clarkson and Magos (2006) found generally no adverse health effects reported in workers with exposures to mercury vapor with urinary mercury results below 20 µg/L; the authors add that µg mercury/L urine were more or less equivalent to µg mercury/g creatinine in the studies they reviewed (Clarkson and Magos, 2006). The U.S. Occupational Safety and Health Administration (OSHA) and Mayo Clinic Medical Laboratories both recommend a mercury concentration of 35 micrograms per gram of creatinine as the biological exposure index (BEI) at or beyond which follow-up and investigation are warranted (OSHA, 2012; Mayo Clinic, 2012). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a BEI of 20 micrograms per gram of creatinine as a permissible outcome (ACGIH, 2013). We adopted the level derived from the review by Clarkson and Magos (2006) and the ACGIH as it was more protective than the Mayo Clinic guideline and OSHA standard.

In-person questionnaire

SOE developed the questionnaire, and ATSDR personnel reviewed it. The questionnaire was primarily aimed at collecting information on gold miners and their household contacts' exposure to mercury both from the environment and from its use in gold extraction and processing in the three weeks prior to the exposure investigation. However, we did not fully validate or test this questionnaire prior to its administration.

Results

Questionnaire Results

The Nome EI team interviewed 19 individuals, 18 of whom submitted urine samples (Table 1). Eighteen (95%) were male, and the median age was 52 years (range: 23–68 years). Of the 19 participants, 15 (14 of whom submitted urine samples) reported participating in gold mining activities, one reported being in close proximity to mining activities, one (Participant A) reported processing substantial quantities of gold on a regular basis, and two (Participants B and C living in the same household) reported being concerned about odd smells when their neighbor (Participant A) heated gold in his house (see Table 1). The Nome EI team did not encounter children or pregnant women when recruiting participants and therefore these subpopulations were not included in the EI.

All but one of the miners practiced suction dredging of the sea floor, and the other practiced traditional panning and sluicing on the beach. Half of the participants denied seeing any mercury during the summer. Of those who encountered mercury, most reported this was a rare occurrence, though one miner indicated seeing mercury during every dive. Those practicing suction dredging wore full-body wet suits during the dives and wore masks with an ambient air supply through a hose from the rig's surface. Miners mainly used automated sluicers.

The most common practice that miners reported to dry their gold was through heating it in open pans. No one reported heating gold for more than 10 minutes per diving session, and most reported shorter durations of just a few minutes. Some miners heated the gold in an enclosed space such as their tent or yurt, while others heated it outside. All the miners denied heating gold with the purpose of burning off mercury, and they all denied using mercury to purify gold this summer. One miner reported adding mercury to sediment containing fine gold dust at the end of each summer, but had not yet done this in 2012. That miner reported heating the gold-mercury amalgam outdoors and stayed upwind of the vapor when he used this practice. No miner reported using personal protective equipment when heating gold.

Urine test results

Elemental mercury is the contaminant of concern in this EI. Urine test results are in Table 2. Three individuals had urinary mercury levels above the National Health and Nutrition Examination Survey (NHANES) 95th percentile based on μg/g creatinine. Of these individuals, one person (Participant A) had a urine mercury concentration that exceeded the 20 μg mercury/g of creatinine health reference level (Table 2). The person with the highest level was a person who heated gold frequently, and the next highest levels were from his non-mining neighbors, who reported no other specific mercury exposures.

When examining information collected for all of the participants (Figure 1), there is evidence that the sole individual who heated gold for the longest time had the highest urinary mercury concentration; Participant A. Participants having the next highest levels of urinary mercury concentration were the neighbors of Participant A; there were anecdotal complaints of frequent nuisance odors emitted from Participant A's home. Excluding these three individuals, there was no additional evidence to suggest an association between how long miners had been heating gold (exposure time) and their urine mercury levels (no correlation, $R^2 = 0.04$), as seen in Figure 2. The questionnaire did not collect information on the time period between when urine was collected and when they last heated gold; therefore, we could not assess the association between time of last void and urine mercury concentration. A calculated correlation coefficient between gold heating time and urinary mercury level for all 18 participants who submitted urine samples would be highly uncertain. This correlation would reflect a strong bias from the three individuals with the highest urine mercury levels, who were outliers with a different exposure pattern. Therefore, we do not present this coefficient, as it may be misleading in this specific situation. However, higher exposures to mercury vapor do result in higher mercury body loads and higher urinary mercury levels in people.

Table 2. Exposure Investigation Participants' Urine Mercury Results, Nome 2012[#]

Participant Number	µg/g creatinine	NHANES 95th percentile	Health Reference Level*
1	0.19	<2.5 µg/g creatinine**	≥20 µg/g of creatinine
2	0.49		
3	0.47		
4	0.52		
5	0.63		
6	1.81		
7	0.45		
8	0.66		
9	1.52		
10	1		
11	0.96		
12	0.89		
13	0.85		
14	2.38		
15	0.35		
16 (Participant C)	5.39		
17 (Participant B)	6.38		
18 (Participant A)	106.07		
Mean (geometric) mean)	7.28 (1.20)		
Mean (geometric mean) without Participants A–C included	0.88 (0.72)		

- µg/L = micrograms mercury per liter of urine
- µg/g creatinine – micrograms mercury per gram of creatinine in urine
- NHANES = National Health and Nutrition Examination Survey
- < = less than
- > = greater than
- [#] Participant A frequently heated gold; Participants B and C were Participant A's neighbors; Participants 1-14 were gold miners; Participant 15 is not a miner but may have come in contact with miners; All participants are male except for one who was not pregnant at the time of the EI.

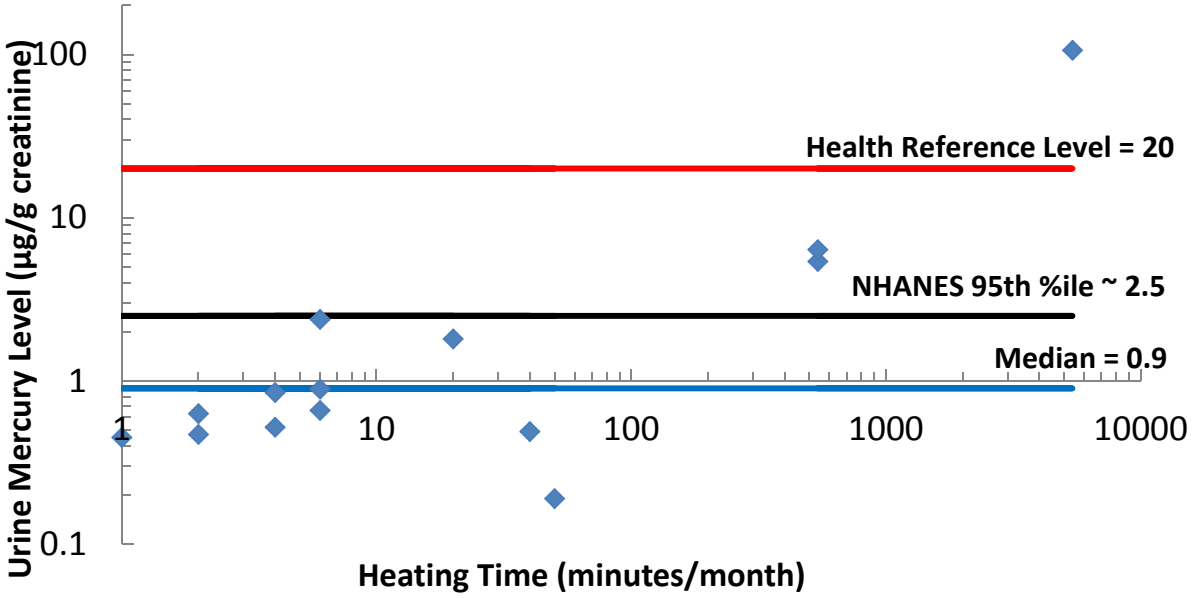
**Adverse health effects have generally not been reported in workers with exposures to mercury vapor that result in urine mercury concentrations <20 µg/L (Clarkson and Magos, 2006). Clarkson and Magos state that µg mercury/L urine were more or less equivalent to µg mercury/g creatinine in the studies they reviewed. U.S. Occupational Safety and Health Administration (OSHA) and Mayo Clinic Medical Laboratories both recommend a mercury concentration of 35 micrograms per gram of creatinine as the biological exposure index at or beyond which follow-up and investigation are warranted (OSHA, 2012; Mayo Clinic, 2012). The American Conference of Governmental Industrial Hygienists (ACGIH) recommends a BEI of 20 micrograms per gram of creatinine as a permissible outcome (ACGIH, 2013).*

***Approximate*

Notifying the Participants of Test Results

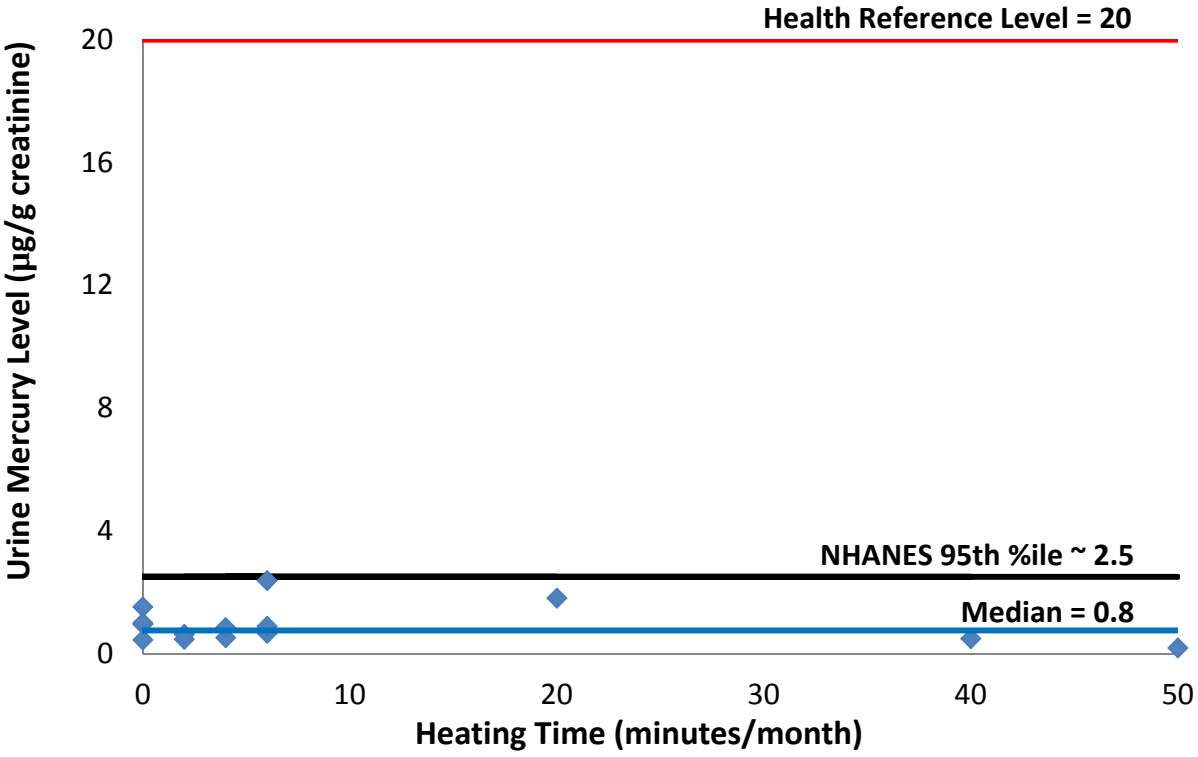
SOE sent a letter to each EI participant with his or her test results and an interpretation. The letter contained information for contacting SOE if they wanted to discuss their test results. SOE also called the three participants having notably higher urine mercury content than the NHANES 95th percentile (creatinine-adjusted) value.

Figure 1. Mercury Level versus Gold Heating Time in All Participants



Graph shows results from all 18 EI participants who donated a urine sample. Heating time for Participant A was 5,400 minutes/month. We calculated his neighbors' exposure time by dividing his time by 10; this approximation was a post-hoc assumption. While this may not be an accurate representation of the neighbors' exposure, it is more likely to be the case rather than 0 minutes/month or 5,400 minutes/month. The neighbors' exposure is dependent on several factors, such as living space ventilation and time spent in the home. Please note that the axes of this graph are logarithmic. A logarithmic scale is a scale of measurement that displays the value of a physical quantity using intervals corresponding to orders of magnitude (multiples of 10), rather than a standard linear scale.

Figure 2. Mercury Level versus Gold Heating Time in Miners Only



Graph shows results from 15 miners but not Participants A, B, and C (all non-miners), who had the highest urine mercury concentrations. Linear correlation is poor, with $R^2 = 0.0412$ indicating no evidence of trend (There is no association between gold heating time and miner mercury exposure in our study). The closer the R^2 is to 1.0, the better the correlation. The closer it is to zero, the poorer the correlation. g = gram, µg = microgram.

Exposure Pathway

For a chemical to harm health there must be a way for people to be exposed to the chemical. An "exposure pathway" describes how a chemical moves from its source and how people contact it. An exposure pathway has five parts:

1. Contaminant source or release;
2. Way for the chemical to move through the environment to a place where people could come in contact with it;
3. Place where people could contact the chemical;
4. Route of exposure to the chemical, such as breathing, swallowing, or absorption through skin; and
5. People are exposed to the chemical.

An exposure pathway is "completed" if all five parts are present and occurring. Even when a completed exposure pathway exists, the potential harm from a chemical contaminant highly depends on several factors. These are the amount and concentration of the chemical present, how often a person comes in contact with the chemical, how long a person is in contact with the chemical, how harmful or toxic the chemical is, and the route of exposure (how the chemical contacts the body).

Inhaled metallic mercury is rapidly absorbed through the lungs into the blood (Sandborough-Englund *et al*., 1998). Its biologic half-life in humans is approximately 60 days, with the half-life varying by body organ (Cherian *et al*., 1978). 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 of exposure and peak at about 8 days post exposure; thereafter, they fall slowly over the next few weeks (Sandborough-Englund *et al*., 1998).

Some miners heat the gold, both to dry it and possibly to drive off mercury. This activity may expose miners to harmful mercury vapor. Other miners reportedly use mercury to extract gold from ore, which may expose them to mercury vapor. Ingestion is not an important route of exposure in this exposure investigation (EI) as elemental mercury is poorly absorbed through the gastrointestinal tract. Ingestion of inorganic mercury salts is possible. However, ingestion is expected to be minimal when considering that 1) only a small amount may be ingested as dust or particles and 2) less than ten percent of ingested inorganic mercury salts may be absorbed through the gastrointestinal tract.

All five parts of the exposure pathway, as described earlier, are present and occurring (see Table 3 below). Inhalation is the exposure pathway of concern as heating gold-mercury amalgam or metallic mercury can release inhalable mercury-containing vapor. Anyone who heats gold, their household contacts, and those living in adjacent housing can be exposed to mercury vapor.

Table 3. Nome Gold Miners: Completed Exposure Pathway

Source	Media/Transport	Point of Exposure	Route of Exposure	Exposed Population
Mercury-gold amalgam from gold mining	Mercury vapor is released when amalgam is heated to extract the gold	At location where gold is heated (mostly in enclosed spaces)	Inhalation of vapor from heating the amalgam	Gold heater, household contacts, and those close enough to be exposed (*e.g.*, neighbors)

Discussion and Limitations

In this EI, only one participant's (Participant A) urine mercury level was above the health reference level (20 µg/L or 20 µg/g creatinine) which warrants further investigation and recommendations. Participant A had been regularly heating and processing gold samples in recent months. Two other EI participants, Participant A's neighbors (Participants B and C), had urine mercury levels considerably higher than those for most U.S. residents, as indicated by the NHANES 95th percentile. However, those levels were below the health reference level. The

urine mercury levels of all the miners tested were at or below the NHANES 95th percentile based on µg/g creatinine, though two were slightly above the 95th percentile based on µg/L urine.

Having a urine mercury concentration higher than the NHANES 95th percentile does not mean that adverse health effects will occur; however, it does indicate higher mercury exposure than most of the U.S. population. Although Participant A reported he was asymptomatic, SOE recommended that he seek consultation from a health care provider, which he agreed to do. SOE will continue to work with Participant A to minimize future mercury exposures to himself and his neighbors.

It is noteworthy that Participant A did not see mercury in the samples he processed, except on one occasion where he decided to heat a suspect sample outside. This underscores the fact that mercury can be present in crude gold even when it is not readily visible. Heating this crude gold may release mercury vapor that generate potentially toxic air concentrations in the short term from a one-time exposure or in the long term from repeated heating and exposure. In addition, without the proper engineering controls, a person who heats gold, particularly in enclosed spaces, may not only expose themselves, but those nearby as well. This was conceivably the case for Participants B and C, who were exposed to vapor from Participant A's place.

There are many reasons that the miners themselves may not have had evidence of significant mercury exposure. First, they may have only encountered very small amounts of mercury. Second, their heating practices of short duration and low temperature heating to dry gold may not have vaporized most of the mercury in their gold. Third, they may have self-regulated potential exposure by maintaining a sufficient distance from the gold they were heating or using adequate ventilation; however, some miners did report heating gold in an enclosed indoor space. Fourth, it is also possible that some miners' practices exposed them to mercury but that there was sufficient time between that exposure and the urine collection to clear most of the mercury out of their bodies.

A fifth reason for the observed result in miners is that they heated gold only very infrequently during the three weeks preceding the EI. This was one of the worst summers in recent history for suction dredge mining because of stormy weather. Successful mining requires calm waters both for safely navigating the rig and for adequate visibility at the sea floor. The miners reported at most three days during the preceding three weeks when mining was possible, and thus they had little gold to heat. This was a major limitation of the EI. This limitation along with recall bias could account for the weak association between gold heating time and urinary mercury results. However, there is clear evidence of exposure of Participant A, who spent much greater time heating gold (2–3 hours daily).

Another limitation is the use of a small convenience sample of miners who were willing to participate in the EI. Between 20 and 25 miners declined to participate for a variety of reasons, mainly based on mistrust of motives of government-employed investigative team. The EI team did not encounter miners if they practiced in relatively secluded areas, on the far west end of the beach or inland along creeks, and thus those miners were not part of this investigation. The results of this EI are not generalizable to the Nome area population, and may not be representative of typical or worst case mercury exposures of those tested.

Public Health Implications

Mercury has many potential acute and chronic adverse health effects. Exposure to high concentrations of mercury vapor can cause brain, kidney, and lung damage and may seriously harm an unborn child. Vapor concentrations high enough to produce such serious effects might also cause coughing, chest pain, nausea, vomiting, diarrhea, increases in blood pressure or heart rate, skin rashes, and eye irritation. Lower level exposures for prolonged periods could produce more subtle effects, such as irritability, problems sleeping, excessive shyness, tremors, coordination problems, changes in vision or hearing, and memory problems. Most effects of chronic lower level exposure disappear once exposure stops and the mercury has left the body (ATSDR, 1999).

Child Health Considerations

The main concern for children's health in gold mining communities is their lower body weight and higher breathing rates compared to adults, which can result in higher doses per unit of body weight. We did not test children potentially exposed to mercury vapor in this EI; our youngest study participant was 23 years old. The Nome EI team did not encounter children or pregnant women when recruiting participants and therefore these subpopulations were not included in the EI. No children or pregnant women lived with Participants A, B, or C. Any children or pregnant women who may have visited Participants A, B, or C would have visited for only short periods.

Children may be at greater risk than adults from exposure to hazardous substances. Children engage in activities such as playing outdoors and hand-to-mouth behaviors that could increase their intake of hazardous substances. They are shorter than most adults, and therefore breathe dust, soil, and vapor found closer to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of an unborn child can sustain permanent damage if toxic exposures are high enough during critical growth stages. Injury during key periods of growth and development could lead to malformation of organs (teratogenesis), disruption of function, and premature death. Exposure of the mother could lead to exposure of the fetus, via the placenta, or affect the fetus because of injury or illness in the mother. The implication for environmental health is that children can experience substantially greater exposures to toxicants in soil, water, or air than adults can.

Conclusions

- One participant (Participant A) had a urinary mercury concentration above the health reference level (20 µg/L urine or 20 µg/g creatinine). This is most likely attributable to his frequent heating of gold in recent months. SOE concludes that Participant A's inhalation exposure to mercury vapor for the past few months could be harmful to his health.

- Participant A's neighbors had urine mercury levels considerably higher than most U.S. residents, based on the NHANES 95th percentile. However, the measured levels were below the health reference level. SOE concludes that Participants' B and C's exposure to mercury vapor by inhalation for the past few months are not likely to harm their health.

- The rest of the EI participants had urinary mercury levels that did not indicate harmful mercury exposures in the prior few weeks. SOE concludes that these EI participants' exposures to mercury vapor by inhalation for the past few weeks are not likely to harm their health.

Recommendations

The following are general recommendations for miners, their household contacts, and others in the mining business:

1. Avoid direct contact with mercury. If contact cannot be avoided, gloves should be worn at all times.
2. Avoid using mercury to separate gold from ore.
3. Avoid exposure to mercury vapor.
4. Miners who choose to burn gold-mercury amalgam should:
    a. Never heat mercury indoors or in an enclosed space such as a tent
    b. Never heat mercury around pregnant women or children
    c. Properly use a retort to substantially decrease exposure to mercury vapor
5. Wash thoroughly and change mercury-contaminated clothes before coming in contact with other people, especially pregnant women and children.
6. Avoid washing mercury-contaminated clothing in the washing machine because they can contaminate other clothes, release mercury into the air, and contaminate the septic system.
7. Place all mercury and mercury waste, such as clothes, paper towels, newspapers, and gloves in a sealed container like a jar inside of a plastic bag.

Public Health Action Plan

Actions Undertaken

- SOE contacted Participant A, the one person whose urinary mercury concentration exceeded the health reference level of 20 µg/L (and 20 µg/g creatinine). SOE encouraged this individual to seek a medical evaluation. This person reported appropriately following up for medical consultation and retesting of urine mercury. This person does not currently report any adverse health effects. In December, 2012, Participant A's urine mercury concentration had dropped to approximately half the concentration during the EI (personal communication with Participant A; exact test result not obtained). Participant A had not processed gold for approximately two months at the time of this testing.
- SOE provided a fact sheet about mercury and health effects to both the mining community in Nome and the Alaska Miners Association.

Actions Underway

- Participant A is in the process of acquiring the appropriate engineering controls, which will help eliminate his and his neighbors' mercury exposure.
- SOE is coordinating subsequent blood and urine collection for mercury analysis from Participant A's neighbors to determine if their mercury exposure has subsided.

Actions Planned

- SOE will follow-up with Participant A to ensure that the planned engineering controls eliminate mercury exposures.
- SOE will continue to follow up with the three participants with urine mercury test results distinctly higher than the rest of participants in this EI to ensure that their mercury exposure is eliminated.
- SOE will continue to provide health education materials about mercury exposure and health effects to the Alaska gold mining community.

Acknowledgements

The SOE thanks all those who were critical to the success of this EI, including Joe Sarcone (ATSDR regional representative), Jerry Troshynski and each and every one at the Nome Public Health Center, the City of Nome and its Supervisor, Josie Bahnke, the EI participants, Kerwin Krause and Byron Redburn of the Alaska Department of Natural Resources, Jenny Kosin, Marty Brewer, and the Alaska Department of Environmental Conservation team, Kenneth Orloff, Susan Metcalf, Audra Henry, and others at ATSDR, Kathleen Caldwell, Charles Dodson, and others at the NCEH. SOE also thanks Ashish Jachak, Amber Rinderknecht, and Sarah Yoder for reviewing this health consultation.

Report Preparation

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APPENDIX 1.

Exposure Investigation Protocol

Mercury Exposure in Gold Miners
Nome, Alaska

Cost Recovery Number: AA97

August 2012

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 sulfamic 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.

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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.

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.

Participant ID No._____

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).

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: _____
_____
_____

Participant ID No._____

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.

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.

Participant ID No._____

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 _____

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

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

Participant ID 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?)
    _____