Artisanal and Small-Scale Gold Mining (ASGM)

A curriculum for the health sector

Student Manual
Information about this curriculum

Artisanal and Small Scale Gold Mining is responsible for ~40% of the anthropogenic mercury emitted into the environment. ASGM is an economic endeavor that affects more than 80 million people in the world. Occurring in at least 75 countries, some 10-15 million men, women, and children are exposed to mercury, in addition to other chemical, biological, physical, ergonomic and psychosocial hazards, as they eke out a subsistence living trying to extract gold from underground, underwater, and surface mines. Child labor is also of great concern.

The Minamata Convention on Mercury, signed in Japan in 2013, has the goal of reducing mercury contamination in the environment. The Convention contains requirements to address the health aspects of exposure to mercury, to recognize the inter-relationship between health and environment, to promote appropriate healthcare services for prevention, to treat and care for mercury-intoxicated individuals, and to facilitate exchange of epidemiological information.

The curriculum was designed to be used globally in training healthcare workers to recognize, diagnose, treat, and prevent mercury toxicity among ASGM miners, their families, and their communities. This publication contains all elements of the curriculum, including recommended agendas, pre- and post-course evaluations, slide sets with narratives on each slide, lesson plans, and tools for classroom activities. You are invited to use all or any part of it, as is, or to alter it to make it more specific for the locality of interest. A companion document may be downloaded from the W.H.O.: [https://apps.who.int/iris/handle/10665/247195](https://apps.who.int/iris/handle/10665/247195)

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The slide sets are provided in Adobe pdf format here. If you would like the actual slide sets, please email us (lforst@uic.edu) and we will send you a cloud-link for download and ask you a few questions about how you plan to use them.

This work was developed by collaborators at the University of Illinois at Chicago and piloted in Kumasi, Ghana in 2015 as a 3-day Training of Trainers and then a 2 day Training. It was funded, in part, by the World Health Organization (Contract numbers 201057080, 200909594, and 200846714), but is **not an authorized publication of W.H.O.**

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The below agenda is a suggested structure for the two-day course. It includes lectures and activities on ASGM. The agenda can be retooled- you can rearrange the order of things, edit the PowerPoints to add in local photos and relevant examples, or add or delete activities based on your needs and preferences.

### Day 1

<table>
<thead>
<tr>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:30 − 9:00</td>
<td>Registration</td>
</tr>
<tr>
<td>9:00 − 9:15</td>
<td>Welcome and introductions</td>
</tr>
<tr>
<td>9:15 − 9:30</td>
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<td>Activity: Taking an occupational history</td>
</tr>
<tr>
<td>10:45 − 11:15</td>
<td>Activity: Categorizing occupational hazards</td>
</tr>
<tr>
<td>11:15 − 12:15</td>
<td>Lecture/discussion: ASGM—Health effects and opportunities for prevention</td>
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<tr>
<td>12:00 − 1:00</td>
<td>Lunch</td>
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</tbody>
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### Afternoon

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<th>Time</th>
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<tbody>
<tr>
<td>1:00 − 2:00</td>
<td>Lecture: Clinical cases of mercury toxicity</td>
</tr>
<tr>
<td>2:00−3:30</td>
<td>Activity: Physical examination (vitals, pulmonary exam, neurological exam)</td>
</tr>
<tr>
<td>3:30−3:45</td>
<td></td>
</tr>
<tr>
<td>3:45−4:15</td>
<td>Lecture: Occupational hygiene: hierarchy of controls applied to ASGM</td>
</tr>
<tr>
<td>4:15 − 4:45</td>
<td>Activity: place ASGM controls into hygiene hierarchy categories</td>
</tr>
<tr>
<td>4:30 − 5:00</td>
<td>Course evaluation: Day 1</td>
</tr>
</tbody>
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### Day 2

<table>
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<th>Time</th>
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<tr>
<td>8:30 − 9:15</td>
<td>Lecture/discussion: Introduction to injury and occupational health surveillance</td>
</tr>
<tr>
<td>9:15 − 10:00</td>
<td>Activity: Haddon matrix: Case studies in mercury toxicity/ASGM (done in pairs)</td>
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<td>Post-Test &amp; Course evaluation</td>
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Suggested ASGM Agenda Course- 3 Day- Training of Trainers
The below agenda is a suggested structure for the three-day course. It includes lectures and activities on ASGM and, unlike the two-day course, includes a day of train the trainer activities. The agenda can be retooled- you can rearrange the order of things, edit the PowerPoints to add in local photos and relevant examples, or add or delete activities based on your needs and preferences.

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</tbody>
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<td>Activity: Talking with miners and community members</td>
</tr>
<tr>
<td>4:15 – 4:45</td>
<td>Preparing for site visit (if applicable)</td>
</tr>
<tr>
<td>4:45 – 5:00</td>
<td>Post-test</td>
</tr>
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</table>

<table>
<thead>
<tr>
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<th>Day 3</th>
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<td>8:30 – 10:30</td>
<td>Teaching: Participants practice giving the 4 lectures (in small groups, then to whole class)</td>
</tr>
<tr>
<td>10:30 – 10:45</td>
<td>Break</td>
</tr>
<tr>
<td>10:45 – 12:00</td>
<td>Teaching: Participants practice facilitating activities from Days 1&amp;2 (small groups) Four stations: physical examination, occupational history, role play, algorithm</td>
</tr>
<tr>
<td>12:00 – 12:30</td>
<td>Lunch + Post-Test and course evaluation</td>
</tr>
<tr>
<td><strong>AFTERNOON</strong></td>
<td></td>
</tr>
<tr>
<td>12:30 – 4:00</td>
<td>Mine site visit</td>
</tr>
<tr>
<td>4:00 – 5:00</td>
<td>Debrief of site visit and course evaluation</td>
</tr>
</tbody>
</table>
Mural 1. Mercury movement in the environment

The following questions are based on study of the murals, above.

**MERCURY MURAL**
Please refer to the mercury mural 1 (mercury movement in the environment) to answer the following questions.

1. Based on the mural, identify 3 ways mercury is released into the environment.
   a. 
   b. 
   c. 

**ARTISANAL GOLD AND MERCURY POLLUTION**
Please refer to the artisanal gold and mercury pollution mural to answer the following questions.
2. Describe what is happening in the first panel.

3. Describe what is happening in the second panel.

4. Describe what is happening in the third panel.

5. Identify 3 potential health concerns from this mural (the panels).
   a. 
   b. 
   c. 
## PRE-TEST

<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Not Applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I can describe ASGM work processes</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>2. I can describe the environmental effects of ASGM</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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</tr>
<tr>
<td>3. I can describe the adverse health effects of ASGM</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>4. I am able to take a focused history related to ASGM</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>5. I am able to conduct a physical examination related to ASGM and to record my findings</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>6. I can list the most common neurological abnormalities associated with elemental mercury poisoning</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>7. I am able to treat or refer a patient for elemental mercury toxicity</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>8.</td>
<td>I am able to advise ASGM workers and family members on protecting their health</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
</tr>
<tr>
<td>9.</td>
<td>I am able to advise workers about reducing their mercury exposure in ASGM</td>
<td>☐</td>
<td>☐</td>
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SLIDES
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Global ASGM activity

• Over 77 countries
  • Asia, Sub-Saharan Africa, South America
• 10-15 million actively working miners
• 80-100 million indirectly dependent
• 20-30% of the world’s gold production
• Releases 640-1,350 tons of mercury/year to air
  • >35% of anthropogenic Hg0 to air
• Release to water is variable, and directly contaminates waterways
Characteristics of small-scale/subsistence mining

- Labor intensive, low level mechanization
- Remote, rural areas of country
- Low capital costs
- Low productivity/output
- Informal work sector
- No safety regulations
- Ineffective equipment

Worker population

Demographics of Miners

- Family Affair
- Often poorly educated
- Poorly skilled
- Driven to this work due to poverty
- Mining – main source of income for area
- Migrant and seasonal workers
- Night work common
Health hazards of ASGM

<table>
<thead>
<tr>
<th>TYPE</th>
<th>HAZARD OR MEDIATING FACTOR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Hg²⁺, CN, silica dust, gases (underground-confined space)</td>
</tr>
<tr>
<td>Biomechanical</td>
<td>Heavy loads, awkward postures, forceful use of hand tools, automated tools</td>
</tr>
<tr>
<td>Injury</td>
<td>Trench collapse, drowning, trip/fall, caught in machinery, struck by falling/flying objects, electrocution, heat/cold-related illnesses, trench foot</td>
</tr>
<tr>
<td>Physical</td>
<td>Noise, UV (outdoors), radon (underground)</td>
</tr>
<tr>
<td>Biological</td>
<td>Man-camps, mosquitoes, unclean water, insufficient food</td>
</tr>
<tr>
<td>Psychosocial</td>
<td>Child labor, slave labor, families separated, low wages</td>
</tr>
</tbody>
</table>

Minamata and Mercury

Minamata Disease
The Minamata Convention on Mercury

www.mercuryconvention.org

Libreville Declaration on Health & Environment in Africa (2008)

- Addresses environmental risk factors—access to safe water, air quality, vector-borne diseases and chemicals in Africa
- Promotes creation of national and regional systems to address capacity building, surveillance, regulations, monitoring and evaluation

Air emissions sources

- ASGM
- Coal burning (all uses)
- Primary production of nonferrous metals (Al, Cu, Pb, Zn)
- Large-scale gold production
- Cement production
- Consumer product waste
- Other
International uses of mercury

- Batteries
- Dental amalgam
- Measuring and control devices
- Electrical and electronic devices
- Lighting
- Artisanal and small-scale gold mining
- VCM production
- Chlor-alkali production

Mercury in the environment

Forms of mercury and health effects

- $\text{Hg}^{2+}$
  - Vapor $\rightarrow$ lung $\rightarrow$ blood-brain barrier
  - Lung damage
  - Gingivostomatitis
  - Tremor, ataxia, shyness, irritability, memory loss, intellectual deficits
  - Kidney disease
  - Immune dysfunction
  - Acrodynia (pink disease)

- $\text{Hg}^{0}$
  - Irritability
  - Shaking hands
  - Kidney tox

- Methyl-$\text{Hg}$
  - Crosses GI tract, placenta, blood-brain barrier
  - Paresthesias
  - Incoordination
  - Narrow visual fields, blindness
  - Difficulty w speech
  - Intellectual deficits
  - Cardiovascular disease
  - Immune dysfunction
Key provisions: Minamata Convention

- Control mercury supply and trade
- Phase out or phase down use in products and processes
- Reduce or eliminate mercury use in artisanal and small scale gold mining
- Control emissions and releases to air and water
- Address wastes and contaminated sites
- Financial assistance and compliance mechanisms

Health in the Minamata Convention

- Article 1 – "Objective" – "to protect the human health and the environment from anthropogenic emissions and releases of mercury and mercury compounds"
- Article 16 – "Health Aspects" –
  - Strategies and programs to identify and protect populations at risk
  - Promote education and prevention related to occupational exposures
  - Promote health care services
  - Strengthen prevention, diagnosis, treatment and monitoring

Other health provisions in Minamata

| Art 4 | Phase out of some mercury-containing medical devices and products; phase down of dental amalgam |
| Art 7 | Public health strategies for ASGM communities |
| Art 12 | Guidance on health risk assessment of contaminated sites |
| Art 17 | Information exchange including health information |
| Art 18 | Public information, awareness and education |
| Art 19 | Research, development and monitoring – may include health assessments and monitoring levels of mercury in vulnerable populations |
| Art 22 | Effectiveness evaluation |
Role of WHO Member States and WHO Secretariat in “Minamata”

- Convention preamble recognizes the role of WHO, references to collaborate with WHO and IGOs in the Convention (Article 7, paragraph 4)
- Diplomatic Conference resolution on the Convention invites WHO to support implementation
- 67th World Health Assembly Resolution in May 2014 agreed with a resolution on the role of WHO and ministries of health in implementation (WHA67.11)

Healthcare sector needs

- Core competencies among health care providers at local level
- Access to appropriate interventions to reduce/prevent and if necessary treat mercury poisoning
- Adequate support systems (including laboratory capacity)
- Good practice standards/references

Public health strategies for ASGM

- Focus on “the exposure of ASGM miners and their communities to mercury”
- Strategy to include:
  - Gathering of health data
  - Training of health care providers
  - Awareness raising through health facilities
- Related requirement: prevent exposure of vulnerable populations:
  - Children
  - Women of child-bearing age, especially pregnant women
For Training of Trainers

Overall Goals of this training

- To reduce adverse health effects associated with artisanal and small scale gold mining (ASGM) among miners and their families
- To reduce emission of elemental mercury into the environment
- To assist signatory nations in meeting their obligations under the Minamata Convention

Audiences for Training

Variations in
- Educational level
- Educational experience
- Clinical skills
- Proximity to labs
- Availability of medication
- Ability to monitor

Learning Objectives of the Curriculum

By the end of the program, participating healthcare providers should be able to:

• Describe the work process, adverse environmental effects, and adverse health effects of ASGM
• Demonstrate the ability to conduct a focused history and physical examination for adults and children related to ASGM and record findings
• List the most common neurological abnormalities in elemental mercury poisoning
• Demonstrate ability to advise workers and their families on protecting their health
• Demonstrate ability to advise workers about reducing mercury exposure in ASGM

Course Content 1: Slideshows

1. Minamata Convention & Course Description
2. ASGM process and adverse health effects
3. Reproductive/pediatric health effects of ASGM
4. Identifying and characterizing exposures
5. Industrial hygiene controls and accident prevention
6. Injury control
7. Case studies in mercury toxicity

Course Content 2: Activities

• Describe mercury’s fate in the environment
• Describe ASGM process
• Take an occupational history
• Take a pediatric environmental history
• Categorize occupational hazards for adults and children
• Conduct a (virtual) hazard assessment
• Select preventive options for individual hazards
• Conduct a physical (neurological & pulmonary) examination
• Propose an algorithm for managing at-risk patients
• Discuss measures to prevent illness and injury in ASGM
• Communicate risk to patients/workers
Course Content 3: (added for Train-the-Trainer, 3-day curriculum

- Practice all aspects of training
- Organize field trip to ASGM site

Suggested agendas
2-day training

3rd day for Training of Trainers
(first 2 days are the same)

Day 1

Morning
8:30 - 9:00 Registration
9:00 - 9:15 Welcome and introductions
9:15 - 9:30 Pre-test
9:30 - 10:00 Lecture/Discussion: The Minamata Convention/Mercury in the environment
10:00 - 10:15 Break
10:15 - 10:45 Activity: Taking an occupational history
10:45 - 11:15 Activity: Categorizing occupational hazards
11:15 - 12:15 Lecture/discussion: ASGM – Health effects and opportunities for prevention
12:00 - 1:00 Lunch

Afternoon
1:00 - 2:00 Lecture: Clinical cases of mercury toxicity
2:00 - 3:30 Activity: Physical examination (vitals, pulmonary exam, neurological exam)
3:30 - 3:45 Break
3:45 - 4:15 Lecture: Occupational hygiene: hierarchy of controls applied to ASGM
4:15 - 4:45 Activity: place ASGM controls into hygiene hierarchy categories
4:30 - 5:00 Course evaluation: Day 1

Day 2

Morning
8:30 - 9:15 Lecture/discussion: Introduction to injury and occupational health surveillance
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Afternoon
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2:00 - 2:40 Lecture/Discussion: Clinical cases of mercury toxicity
2:40 - 3:00 Break
3:00 - 3:45 Activity: Developing an algorithm for managing individual patients
3:45 - 4:30 Activity: Talking with miners and community members
4:30 - 5:00 Post-test & Course evaluation

Day 3

8:30 - 10:30 Teaching: Participants practice giving the 4 lectures (in small groups, then to whole class)
10:30 - 10:45 Break
10:45 - 12:00 Teaching: Participants practice facilitating activities from Days 1 & 2 (small groups)
Four stations: physical examination, occupational history, role play, algorithm
12:00 - 12:30 Lunch + Post-test and course evaluation

Afternoon
12:30 - 4:00 Mine site visit
4:00 - 5:00 Debrief of site visit and course evaluation

The end
URL to all powerpoints
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Objectives

- Determine routes of entry/absorption of hazardous agents associated with ASGM
- Explain the meaning of “dose”
- Describe inorganic and organic mercury and their human health effects
- Diagnose and manage mercury toxicity

Toxicity of a chemical

Toxicity of a chemical agent depends on:

- Route of exposure
- Dose
- Age, sex, underlying disease, nutritional status
- Biological fate (how it’s handled by the body)

Routes of exposure (routes of entry)

- Inhalation
- Ingestion
- Skin absorption
- Mucous membrane absorption
Forms of mercury and health effects

- Hg⁰
  - Vapor → lung → blood-brain barrier
  - Lung damage
  - Gingivostomatitis
  - Tremor, ataxia, shyness, irritability, memory loss, intellectual deficits
  - Kidney disease
  - Immune dysfunction
  - Acrodynia (pink disease)

- Hg²⁺
  - Crosses GI tract, placenta, blood-brain barrier
  - Paroesthesia
  - Incoordination
  - Narrow visual fields, blindness
  - Difficulty w speech
  - Intellectual deficits
  - Cardiovsec disease
  - Intellectual deficits
  - Cardiovascular disease

- Methyl-Hg
  - Irritability
  - Shaking hands
  - Kidney tox

Health Effects and Prevention of Mercury Toxicity

Routes of entry/exposure - Hg⁰

- Inhalation
- Ingestion
- Dermal absorption

Health Effects and Prevention of Mercury Toxicity

Routes of entry/exposure - Methyl-Hg

- Ingestion
- Inhalation
- Dermal absorption

Health Effects and Prevention of Mercury Toxicity
What is the route of exposure of mercury in the ASGM process?

- Extracting
- Crushing
- Milling/grinding
- Amalgamating
- Squeezing out liquid from mercury-gold amalgamate
- Smelting (burning off mercury)

Dose

- Dose = Concentration x Time
- Dose response is the amount of a substance that is required to cause an adverse health effect
- Exposure can be acute—that is, a high quantity in a short time period
- Exposure can be chronic—continuous exposure over a prolonged period of time

Paracelsus (1493-1541)
Sola dosis facit venenum
“The dose makes the poison”
Fish-eating communities at risk for organic mercury exposure/toxicity

Mercury exposure at work and in the environment

- Handling of elemental mercury
- Worker and family exposed
- Surrounding community exposed by spills
- Burning of amalgam (vapors)
  - Inhaled by worker
  - Vapors spread through town
- Dumping waste → soil & water deposition
- Biotransformation to Methylmercury
- Contaminated food (fish, shellfish) and water supply
- Fish-eating workers and downstream communities affected

Mercury toxicity
Three forms of mercury

1. **Elemental Hg\(_0\)**

2. Chemical compound (mercury salts)

3. **Organic compound** (methyl, ethyl mercury)

---

How is mercury toxic?

Mercury disrupts normal cellular physiology

Clinical manifestations of **acute elemental mercury (Hg\(_0\)) poisoning**

- **Lung**
  - Fever/chills
  - Cough
  - Shortness of breath

- **GI**
  - Nausea/vomiting
  - Difficulty swallowing
  - Diarrhea

- **CNS**
  - Headaches
  - Visual disturbances
  - Weakness
  - Drowsiness, incoordination

**Target organs**

- Liver
- Spleen
- Kidney
Clinical manifestations of chronic elemental mercury (Hg⁰) poisoning

Inhalation

CNS
- Headache
- Dizziness
- Hearing loss
- Inability to do rapid, repetitive movements
- Difficulty writing
- Unsteady walking
- Blurred vision
- Slurred speech

Other
- Bleeding gums
- Metallic taste
- Impotence

General observation on exam

General
- Blood pressure high
- Weight loss signs
- Excessive salivation/stomatitis
- Respiratory distress, wheezing (pneumonitis)
- Skin discoloration: Acrodynia
- Mee’s lines in fingernails

Neurological observations on exam

- Gait: Ataxia
- Tremors (intention, tongue, eyelids)
- Numbness toes/fingers
- Cognitive abnormalities
Elemental mercury poisoning neurological manifestations & the neurological examination

- **Coordination:** heel-shin, finger-nose, alternating wrist movements show lack of smooth motion
- **Tremor:** of eyelids and of outstretched arms
- **Gait:** unsteady when walking across the room
- **Neurobehavioral/neuropsychological abnormalities:** unable to execute fine motor tasks easily

https://www.youtube.com/watch?v=95dm3g2Bl3U

Manifestations of chronic exposure to organic mercury

- **Central Intention Tremor**
- **Neuropsychiatric effects**
- **Tinnitus**
- **Fatigue and insomnia**
- **Headaches**
- **Cognitive impairment**
- **Motor dysfunction**
- **Proteinuria**
- **Acute Tubular Necrosis**
- **Renal failure**
- **Hypersalivation**
- **Nausea**
- **Metallic taste**
- **Loose teeth**
- **Gingivostomatitis**

Testing for mercury toxicity
Blood test

- Individual should stop eating fish for >5 days
- Blood collected in metal free tube
- Specimen sent to certified lab
- Abnormal level is >10 µg/L

Testing for mercury (U.S. based)

- 10-20 mcg/L considered background exposure
  - USEPA
- 50 mcg/L considered threshold for toxicity
  - USEPA
- 24hr
- Acid-washed plastic container

Treatment for mercury toxicity
Treatment: Acute elemental mercury poisoning

Inhalation
Supportive if only lungs affected

Systemic Symptomatic
Chelation therapy with succimer (DMSA)

Prevention

- Eliminate exposure if possible
- Educate patient on hazards of mercury
  - Inhalational exposure – most common/severe
  - Ingestion exposure – limit intake
- Use of proper safety and hygiene techniques
- Use of gloves when handling liquid mercury
- Use of hood or mask that protects from chemicals can be helpful, but may not be practical
- Use of well-ventilated spaces
- Stand down wind
- Use of tools to minimize exposure
- Keep contaminated work clothes/materials at worksite

Medical surveillance

- Regular medical examination
  - Complete neurological exam
    - Detailed cerebellar exam
- Based on history and physical exam
  - Biological exposure indicator testing
    - Urinary, hair, blood
  - Pulmonary Function testing for respiratory problems

Health Effects and Prevention of Mercury Toxicity [EPA 1998]
Long term goals

- Decrease/eliminate use of mercury in gold mining process
- Decrease exposure to mercury vapors
- Decrease waste of mercury into water/soil
- Improve education to miners on safety
- Safety interventions for artisanal small-scale gold mining
- Improved use of personal protective equipment
- Establish hierarchy of controls to minimize hazards
- Improve work-site and family living conditions
- Improve medical care for artisanal miners

Summary

- ASGM involves extraction, crushing, milling, amalgamating, smelting and refining
- Elemental mercury exposure occurs through inhalation into the respiratory tract and ingestion into the GI tract
- Exposure prevention and medical surveillance are key to protecting ASGM workers

References

References

- National Institute of Environmental Health Sciences (2014). “Mercury Exposure and Health Impacts among individuals in the Artisanal and Small-scale gold mining community: A comprehensive review.” Environmental Health Perspectives.

Health Effects and Prevention of Mercury Toxicity

References


Health Effects and Prevention of Mercury Toxicity

References

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Objectives

- Describe the impact of ASGM hazards on reproductive health of men and women; and
- Describe the impact of ASGM hazards on children
Commonly mined minerals

- Gold
- Coal
- Base metals (iron, lead, zinc, copper)
- Diamonds
- Gemstones

Artisanal miners

- Poverty driven activity
- 70+ countries
- 10-15 million miners
- Most prevalent in: China, India, Indonesia, Philippines, Bolivia, Brazil, Ecuador, Peru, Ghana, Malawi, Tanzania, Zambia, and Zimbabwe
- 80-100 million people impacted in surrounding communities

Women’s role

- 1/3 of artisanal mining workforce
- Roles of women vary by region
  - Digging, crushing, transporting, sorting, processing, and trading
  - Processing
- Processing ore at home increases risk to whole family
Reproductive environmental health

Environmental exposures during the entire life cycle that affect reproductive capacity & fertility
- fertility of both males and females
- sexual development

Environmental exposures during the preconception or prenatal period that affect
- maternal health during pregnancy
- fetal health and development
- child’s health and development

Reproductive hazards - Mother

Exposures can occur:
- Before pregnancy
- During pregnancy

Health Outcomes:
- Decreased fertility/infertility
- Decreased age at puberty
- Menstrual disorders
- Early menopause
- Decreased sex drive
- Mercury intoxication

Reproductive hazards - Father

Exposures can occur:
- Before partner’s pregnancy
- During spermatogenesis

Health Outcomes:
- Altered hormone production: decreased libido or fertility
- Decreased sperm count, motility, morphology
- Toxicants in the semen
In the offspring

Exposures can occur:
• During fetal life
• During breast feeding

Health Outcomes:
• Congenital Malformations – birth defects
• Developmental Disorders
• Impaired cognition
• Spontaneous Abortion and Fetal Loss
• Low Birth Weight (<2500 gm)
• Preterm Birth (<37 weeks)
• Childhood Malignancies
• Altered sex ratio (# of male/female births)

WHO: Global Plan of Action for Children’s Health and the Environment

To create safe, healthy and clean environments that allow children to grow and develop in good health and to contribute to the economic and social development of societies

Basic reproductive anatomy and physiology

Routes of exposure

Role of the placenta
Mercury vapor

- Mercury vapor is created when amalgam is heated
- Mercury vapors > WHO’s limit of 1.0 μg/m³ (public exposure)
- Airborne measurements at gold mines estimated at 6,315 μg/m³
  - mean 8-hr average of 183 μg/m³

Mercury vapor damages the central nervous system (CNS) and kidneys, and also affects the lungs

- Acute effects:
  - renal failure
  - respiratory distress
  - emotional instability
  - tremors

Effects on Children:
- Children - elevated blood and urine mercury levels
- Acute effects: pneumonitis, possibly leading to respiratory failure and death
- Long term effects: CNS effects - insomnia, forgetfulness, loss of appetite, tremor, ataxia
  - Progressive tremor, emotional lability, memory impairment
Mercury vapor

- Chronic effects: deficits in concentration and memory
- Developmental neurotoxicant for children
- Effects on reproductive health: risk to brain development in fetus

Methyl mercury

- Mercury vapor contaminates local water sources
- Methyl mercury is formed by bacteria which then bioaccumulates in fish
- Prenatal methyl mercury consumption can cause permanent effects on neurodevelopment
- Erethism

Arsenic

- Copper, gold, and metal mining
- Inhalation and ingestion
- Crosses the placenta
- Health consequences for prenatal exposures: spontaneous abortion, low birth weight
- Health consequences for early childhood exposures: impaired cognitive development, abnormal motor function, sensory neuropathy
Recognizing arsenic toxicity

**Acute, high dose exposure**
- Diarrhea, nausea, abdominal cramping, vomiting
- Shock

**Acute, low dose exposure**
- Gastrointestinal upset
- Peripheral neuropathy, ascending paresthesias, anesthesias, weakness
- Liver dysfunction

**Chronic exposure**
- Fatigue and weakness
- Bone marrow suppression with pancytopenia
- Skin rashes, hyperpigmentation
- Alopecia (hair loss)
- Mees lines on finger nails

Sulfur Dioxide and Nitrogen Dioxide (SO\(_2\), NO\(_2\))

- **Sulfur dioxide**
  - Possible decreased fertility, low birth weight
  - Infant exposure → lower respiratory symptoms

- **Nitrogen dioxide**
  - Possible decreased fertility, low birth weight
  - Infant exposure → lower respiratory symptoms

Heat

- Many miners work in hot and humid conditions
- In men, temporary decrease in sperm count → decreased fertility
- In females, increase in developmental abnormalities (animals)
Drug and alcohol abuse

- A psychosocial hazard in mining communities
- Drug and alcohol use by males:
  - Reduced fertility (low sperm, malformed sperm)
  - Abnormal hormone levels
- Use by women before pregnancy:
  - Reduced fertility
  - Menstrual disorders
- Use during pregnancy:
  - Spontaneous abortion
  - Low birth weight, smaller head circumference, shorter birth length
  - Congenital malformations (craniofacial, genitourinary, and limb)
  - Poor neurodevelopment/mental retardation, learning problems

Physical stress

- Physically taxing work conditions
  - Prolonged standing
  - Heavy lifting
  - Night work
  - Marked fatigue
- Adverse health outcomes
  - Babies premature
  - Small for gestational age
  - Mothers - pre eclampsia, high blood pressure

Psychological stress

- Stress in males
  - Reduced sperm count
- Consequences of in-utero exposure:
  - Low Birth Weight
  - Neural Tube Defects
  - Adverse Neurodevelopment
Summary

- Environmental exposures throughout life: fertility, sexual development, and health of future children
- Exposures in-utero: permanent alterations in health and development of the child
- Mercury, arsenic, and products of combustion are common exposures and can cause severe damage
- Heat, drug and alcohol abuse, and physical and psychological stress are common in mining communities

References

References


Artisanal and Small-Scale Gold Mining (ASGM): Identifying and characterizing hazards

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Objectives

• Review the process for identifying and characterizing hazards
• Describe the specific steps involved in the process
• Gain experience conducting a walk-around survey
Process

Collect and organize information on:

- Workplace/community
- Workforce/community members
- Hazardous agents
- Control/prevention measures
- Historical data

Steps

- Characterize ASGM workplace/community
- Characterize ASGM workforce/community member
- Characterize agents (hazards)
- Characterize existing control measures
- Review past assessments/results
- Review historical exposure data
- Review environmental emission data
- Review past biological monitoring data

Define scope

- Are you investigating the risk to one worker?
- Are you investigating one incident involving one or more workers?
- Are you investigating the risk to the workforce from one agent or part of the facility?
- Are you investigating the risk to the workforce at one facility?
Process Description

Get a description from the worker or supervisor
View the work process directly
Look for print sources of information

Characterize workforce

- Job title / job description
- Number of workers
- Task analysis
- Exposure duration
  - Shift length; continuous vs intermittent
- Other considerations
  - Children
  - Women
  - Community members
## Characterize agents

### Form of agent/source
- Chemical
- Physical
- Biological
- Biomechanical
- Psychosocial

### Health effects
- Toxicology
- Epidemiology

### Exposure Limits
- Occupational
- Environmental

## Characterize chemical agents

- Solid
- Liquid
- Gases
- Vapors
- Aerosols
  - dusts, mists, fumes, soot

## Characterize physical agents

- Temperature extremes (heat, cold)
- Noise and vibration
- Ionizing radiation
- Non-ionizing radiation (uv, visible, infrared, microwave/radio wave, power transmission)
**Characterize biological agents**

- Bacteria
- Virus
- Allergen

**Characterize biomechanical/trauma hazards**

- Machinery
- Heights and depth
- Power tools
- Hand tools
- Heavy weights
- Electrical

*cause injuries, not illnesses or diseases

**Characterization of Conditions: Psychosocial**

- Workplace "culture"
- Safety climate
- Shiftwork (night shift)
- Harassment/bullying/violence
- Unfair conditions (wages, hours)

*cause injuries, not illnesses or diseases
Characterizing Agents

Health Effects
• Sources of Information
  • Safety Data Sheets (SDS)
  • Toxicology Literature
  • Epidemiology Literature
  • Trade literature
  • Internet

Exposure Limits
• Regulatory—local or international equivalents
  • Occupational Safety and Health Administration
  • Environmental Protection Agency
  • Nuclear Regulatory Commission
  • National, State and Local Health Authorities
• Non-regulatory
Other Information

- Characterization of existing controls
  - permits, prior walkthrough
- Past assessments/results
  - literature, company records
- Historical exposure data
  - past permits, regulatory agency data, company data
- Environmental emission data
  - regulatory agency data, permits, company data, literature
- Past biological monitoring data
  - company data, health department data

Output

Complete summary of available essential information on
- workers
- community members
- tasks, agents
- potential exposures
- potential health effects

Conduct a walk-through

- Purpose: to look at the range of activities in a workplace and identify major health and safety problems.
- Components: either literally walk through the workplace or virtually walk through using photos or workplace mapping.
- Communication: Speak with workers and supervisors about the process: what could go wrong and how this can be controlled?
- Consider: Which work activities and tasks do you need to observe?
- Consider: Who do you need to talk with in order to fully understand the process and activities and to obtain other information such as chemical labels, SDS, chemical inventories, etc.?
### WALKAROUND SURVEY

**Facility:** ____________________________  
**Date:** __________  
**Page:** ___

<table>
<thead>
<tr>
<th>Location / Area</th>
<th>Number of workers</th>
<th>Physical Hazards</th>
<th>Traumatic Hazards</th>
<th>Chemical Hazards</th>
<th>Biological Hazards</th>
<th>Psychosocial Hazards</th>
<th>Controls in use or needed</th>
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</thead>
<tbody>
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</table>

### Skills practice

**Virtual Walk-around**
Summary

- It is important to collect as much information as possible on the workplace, workforce, agents and existing controls.
- Information gathering should include a mix of interviews/discussions with workers and supervisors, observations and reading.
- If done correctly, this process can yield a comprehensive summary of the workplace.
The End
**Objectives**

- Describe the occupational hygiene hierarchy of controls
- Explain how the hierarchy of controls relates to ASGM exposures

---

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**Routes of exposure/entry**

- Inhalation
- Ingestion
- Skin Absorption

**Types of hazards**

- Chemical [mercury, metals, solvents, pesticides, gases...]
- Biological [infectious agents, allergens]
- Physical [noise, radiation, heat]
- Biomechanical [ergonomic, "accident"]
- Psychosocial [stress, bullying, harassment]

**Hierarchy of controls**

1. Elimination
2. Substitution
3. Engineering Controls
4. Administrative Controls
5. Personal Protective Equipment
Examples: Substitution*

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Exposure Source</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Mercury</td>
<td>Use of cyanide</td>
</tr>
<tr>
<td>Chemical</td>
<td>Mercury</td>
<td>Gravimetric Methods</td>
</tr>
</tbody>
</table>

*This does not represent an endorsement of the change

Cyanide use

- Cyanide added to ore
- Gold bonds with cyanide
- Zinc added to remove cyanide
- Sulfuric acid added to remove zinc
- Paste of pure gold is left

Examples: Engineering controls

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Exposure Source</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Mercury</td>
<td>Work in a well-ventilated area to reduce exposure</td>
</tr>
<tr>
<td>Chemical</td>
<td>Mercury</td>
<td>Retort [photo on next slide]</td>
</tr>
<tr>
<td>Biomechanical</td>
<td>Musculoskeletal Disorders</td>
<td>Head or gravity control</td>
</tr>
<tr>
<td>Biomechanical</td>
<td>Overexertion</td>
<td></td>
</tr>
</tbody>
</table>

Occupational Hygiene and ASGM
How does a retort work?

Advantages/barriers to using a retort

**Advantages**
- Capture 80%-95% of mercury
- Improved environmental and occupational health
- Variety of options (price range)
- If used properly, can result in 100% gold recovery (compared to open pan burning)

**Barriers**
- Cost
- Requires education and training on proper use
- Adds time to the mining process
- Requires proper handling and storage
- Change in gold appearance

Examples: Administrative controls

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Exposure Source</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Lead, mercury, cyanide, borax, etc.</td>
<td>Remove ASGM work from the home</td>
</tr>
<tr>
<td>Physical</td>
<td>Vibrating tools (can cause Vibration White Finger)</td>
<td>Use power tools for only short periods</td>
</tr>
<tr>
<td>Physical</td>
<td>Dust (may be contaminated with chemical agents or metals)</td>
<td>Wash hands and face before eating or drinking</td>
</tr>
<tr>
<td>Physical</td>
<td>Dust (may be contaminated with chemical agents or metals)</td>
<td>Change out of work clothes before entering home</td>
</tr>
<tr>
<td>Physical</td>
<td>Dust and chemicals</td>
<td>Stand upwind from exposure</td>
</tr>
<tr>
<td>All categories</td>
<td>All types</td>
<td>Training program</td>
</tr>
</tbody>
</table>

Examples: Personal Protective Equipment (PPE)

<table>
<thead>
<tr>
<th>Hazard Type</th>
<th>Exposure Source</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td>Mercury</td>
<td>Use respirators to minimize exposure</td>
</tr>
<tr>
<td>Physical</td>
<td>Dust</td>
<td>Use the proper mask; clean it regularly</td>
</tr>
<tr>
<td>Physical</td>
<td>Noise</td>
<td>Use ear plugs</td>
</tr>
</tbody>
</table>

What’s the problem with PPE?

- Not available, costly
- Correct respirator must be used (e.g., dust mask won’t prevent Hg fume exposure)
- Interferes with activity
- Uncomfortable to wear
- Depends on human behavior—choice to use it
- Needs to be cleaned and maintained
- PPE can present a hazard
Grinding controls

Amalgamation controls

Smelting controls
Approaches to controls

Controls should be specific, feasible, acceptable
• Need knowledge of local, environment, policies, work practices, culture
• Participatory is best: Actively involving workers in implementing knowledge, procedures and changes with the intention of improving working conditions, safety, productivity, quality, morale and/or comfort

Summary

• ASGM exposure routes include inhalation, ingestion and skin absorption
• “Human-proof” alternatives are always more effective
• Substitution, Engineering, Administrative and PPE controls should be prioritized appropriately
• If other measures are not possible, offer PPE and proper training

URL to all powerpoints
Objectives

- Define and describe injuries
- Describe occupational injuries that occur in ASGM
- Discuss the role of healthcare providers in treating and preventing workplace injuries
Definition of injury

“any unintentional or intentional damage to the body resulting from acute exposure to thermal, mechanical, electrical, or chemical energy or from the absence of such essentials as heat or oxygen”

US CDC. National Committee for Injury Prevention and Control

Mechanical Energy (M.E.)

\[ K = \frac{mv^2}{2} \]

\( K \) = kinetic energy in foot-pounds (joules)
\( m \) = mass (at earth’s surface = wt/32#)
\( v \) = velocity in ft/sec (m/sec); mph (kph)
Strain Mechanisms

Injury Types

Kinetic Energy Forces

BLUNT
PENETRATING
CRUSH
### Severity

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>LOW</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>Bruises</td>
<td>Unconsciousness</td>
</tr>
<tr>
<td>Noise</td>
<td>Mild hearing loss</td>
<td>Deafness</td>
</tr>
<tr>
<td>Scald</td>
<td>Mild burn</td>
<td>3rd degree burn</td>
</tr>
</tbody>
</table>

### Distribution of global injury mortality, 2012

![Pie chart showing distribution of global injury mortality, 2012]
Introduction to Injury

Causes of injury

Mechanical energy
Heat
Electricity
Chemicals
Ionizing radiation
Absence of heat, oxygen

Prevention

Host
Agent
Environment/Conditions
Haddon’s Matrix: Factors

Causal and Contributing Factors

Host/Human  Agent  Environment

Haddon’s Matrix: Phases of injury prevention

Pre-Event
Reduce # of events with the potential to cause injury

Event
Reduce # of injuries that occur

Post-Event
Reduce severity of injury and optimize outcome

Haddon Phase-Factor Matrix

<table>
<thead>
<tr>
<th>Factor/Phase</th>
<th>Host (Human)</th>
<th>Vector (Vehicle)</th>
<th>Physical Environment</th>
<th>Social/Cultural Env</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Event</td>
<td></td>
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<td>Event</td>
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<tr>
<td>Post-Event</td>
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</table>

Haddon’s Matrix Slides Adapted From: Community Action Training, Community Health Education Section, San Francisco Department of Public Health, 6/4/02
Introduction to Injury

Factors

Pre-event

Event

Post-event

Phases

Human Factors

Agent or Vehicle

Physical Environment

Sociocultural Environment

Case study 1

A teenager is driving on a country road in a storm after a party with 3 of his friends in the car. He drives around a bend in the road and crashes into a tree.

Haddon Phase-Factor Matrix

<table>
<thead>
<tr>
<th>Factor/Phase</th>
<th>Host (Human)</th>
<th>Vector (Vehicle)</th>
<th>Physical Environment</th>
<th>Social/Cultural Env</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Event</td>
<td>Alcohol</td>
<td>Experience</td>
<td>Judgment</td>
<td>Brake status</td>
</tr>
<tr>
<td>Event</td>
<td>No seat belt</td>
<td>No air bag</td>
<td>Hardness of surfaces</td>
<td>Tree too close to road, no guard rail</td>
</tr>
<tr>
<td>Post-Event</td>
<td>Physical condition</td>
<td>Fuel system integrity</td>
<td>Cell phone</td>
<td>Distance of emergency response</td>
</tr>
</tbody>
</table>
Haddon Phase-Factor Matrix

<table>
<thead>
<tr>
<th>Factor/Phase</th>
<th>Host (Human)</th>
<th>Vector (Vehicle)</th>
<th>Physical Environment</th>
<th>Social/Cultural Env</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Event</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Event</td>
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<td></td>
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<tr>
<td>Post-Event</td>
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</tr>
</tbody>
</table>

Case study 2

A miner is adding mercury to a ball mill at an ore processing facility. Someone switches on the machine without realizing that this worker is there. He falls underneath and gets crushed.

Case study 3

A 9 year old boy is crushing gravel by striking it with a rock. He smashes his thumb and fractures it.
Case study 4

A young man is standing on the edge of a pool washing the ore-containing gravel. He falls into the pool, gets disoriented, and drowns.

Haddon’s 10 approaches to lessen energy transfer

1. Prevent the initial creation of the hazard
2. Reduce amount of energy in hazard
3. Prevent the release of a hazard that already exists
4. Modify rate or spatial distribution of the hazard
5. Separate, in time or space, the hazard from that which is to be protected
6. Separate the hazard by a material barrier
7. Modify relevant basic qualities of the hazard
8. Make potential victim more resistant
9. Counter the damage already done by the hazard
10. Stabilize, repair, rehabilitate the injured person
Public health conceptual shift

- Single cause
- Behavioral explanation
- Multiple causes
- Environmental explanation

Industrial hygiene hierarchy of controls

- Engineering Controls
  - Substitution
- Administrative Controls
- Personal Protective Equipment

The role of the healthcare worker

- Prevention
- Treatment- rapid first aid treatment,
- Triage decisions: When to transport to a hospital
- When to refer to specialist
Summary

- A work-related injury results from hazardous events or exposures at work
- ASGM injuries are common and frequent—possibly the most common adverse health effect
- Health care providers need to recognize how to prevent, treat and refer cases as needed

URL to all powerpoints
Artisanal and Small-Scale Gold Mining (ASGM): Clinical case studies

Disclaimer

This work was funded, in part, by the World Health Organization:
• Contract numbers 201057080, 200909594, and 200846714

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You may not use the materials for commercial purposes.

Objectives

• Analyze cases of mercury toxicity from the published literature
Case 1. Acrodynia in a child

- 3 year old girl
- 3 day history of redness, pain and swelling of both hands, profuse sweats, irritability, chills, poor oral intake, severe periumbilical pain
- Within the 2 weeks before admission, she had been evaluated in the emergency department on two separate occasions for abdominal pain - diagnosed as constipation and viral gastroenteritis.

Case 1: Acrodynia in a child

- BP 158/100
- Differential diagnosis for elevated BP/rash
  - pheochromocytoma
  - neuroblastoma
  - coarctation of the aorta
  - vasculitis
  - Post viral acral desquamation
- What do you want to know?
Case 1. Acrodynia in a child

- Urine mercury: 178/24 hours (normal = 0-20 μg/l; 24 hour collection advised)
- HTN managed with oral medication.
- Chelation therapy with oral succimer (DMSA) initiated
- A compounded topical preparation was applied to feet for pain control

Triad of

- Skin: edematous, painful, pink/red, desquamating fingers/toes (“pink disease”)
- Neurologic sx: irritability, photophobia, weakness, paresthesias
- Hypertension

Case 1. Epilogue

- Ruled out: excess fish intake, exposure to broken thermometer, batteries, or fluorescent bulbs
- Environmental survey of the home found 40,000 ng/m³ (normal =<100)
- After 5 weeks of chelation therapy, signs and symptoms resolved
Case 2. Kidney disease in an adult

- 42 yo woman
- Fever, malaise, flushing, loss of appetite
- Hospitalized 3 days later for dyspnea, fever (41.5°C), erythematous, macular eruptions

Case 2. Exposure

- Her children brought home a peanut sized mercury piece from school chemistry
- Dropped the container on the floor, and mercury spill out
- Mom vacuumed several times; the room was not aired out

Case 2. Treatment

- Treated with IV DMPS for 7 days
- Went home, came back with signs of kidney disease (nephrotic syndrome); urine mercury was 55 μg/l (1-20, normal)
- Chelated intermittently and mercury levels were obtained, correspondingly
- Proteinuria (abnormal kidneys) resolved in 2 years
Case 2. Treatment

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- Proteinuria (abnormal kidneys) resolved in 2 years

Case 2. Kidney disease in an adult

Histological exam of the renal tissue showing the granular depositions on the glomerular capillary walls, a feature of membranous glomerulonephritis.

Histological examination of the renal tissue showing the spikes, a feature of membranous glomerulonephritis.

Case 3. Adolescent with CNS, lung, GI problems

- Symptoms: malaise, cough, fever (41 degrees Celsius), disseminated erythematous rash
- Initially treated for infectious pneumonia without response
- History of Hg exposure obtained—brought home silver mercury from school
- Blood and urine laboratory tests showed elevated levels
Case 3. Adolescent with CNS, lung, GI problems

• Treated with IV chelation for 12 days → symptoms resolved, patient discharged from hospital
• A month later, he experienced muscle pains
  and jerks on his arms, legs and perioral zone. The 24-h
• Urine and blood mercury levels were 50 μg/L (0.1–20 μg/L) and 32 μg/L (0.6–59 μg/L), respectively
• Chelated again for 5 days, discharged

Case 3. Adolescent with CNS, lung, GI problems

• Month 3, readmitted to hospital: malaise, loss of weight (15 kg in 3 months), generalized muscle pain, peri-articular low extremity pain, constipation, periodic chest pain that caused dyspnea, dry mouth, polyuria, polydipsia, hyperhidrosis, photophobia, insomnia and hair loss.
• The physical examination revealed hypertension (155/100 mmHg); tachycardia (108/min); hyperemia on the dorsum of his hand; paleness of the hands and feet; reddish macular eruptions on his sternum, lateral parts of his feet and upper part of his back. He had bilateral posterior cervical lymphadenopathy and was fully conscious.
• Neurological exam: motor deficit in the proximal muscles of the lower extremities and twitching of proximal muscles of both extremities aggravated by tapping. No sensory deficit was present, cerebellar tests were normal.
• Kidneys: spilled protein in urine

Summary of inhalation → pneumonitis

• Phase 1 (1-3 days after exposure):
  • malaise, fever, pneumonitis, hypersalivation, swollen gingiva, dry cough, dyspnea, fever, abdominal pain, nausea, vomiting, diarrhea
• Phase 2 (3 weeks after exposure, even with treatment)
  • Signs of kidney disease, nephrotic syndrome
• Phase 3 (2 months after exposure)
  • malaise, sore throat, lumbar, and lower extremity pain, malaise, weight loss (15 kg in 3 months), generalized muscle pain, peri-articular low extremity pain, constipation, periodic chest pain that caused dyspnea, dry mouth, polyuria, polydipsia, hyperhidrosis, photophobia, insomnia and hair loss.
Case 4. Pneumonia

• 43 y.o. man
• 6 day history of malaise, chills, sore throat, cough, nausea, decreased appetite

• What do you want to know?

Case 4. Pneumonia

• He does all of gold mining tasks
• For the last 2 weeks he has been using a torch to evaporate mercury off of amalgamated gold.
• What are you concerned about? What organ systems will you focus on?

Case 4. Pneumonia

• BP= 140/90, Temp= 39.8, Pulse = 88, Resp rate=28 breaths per minute (bpm)
• Lungs: crackles (rales) heard throughout
• Abdomen: soft, non-tender, no hepatosplenomegaly
• Skin: extremities appear dry, but no skin lesions
• Remainder of exam is normal
Case 4. Chest x-ray

Case 4. How to manage him?

• Manage in clinic or hospital?
• What other studies do you want to get?

Case 4. Outcome

• Pt is sent for hospitalization
• Blood oxygen level is normal
• Sputum and blood cultures are sent – negative for bacteria
• Blood and 24 hour urine—high mercury level
• Pt is supported with IV fluids
• Symptoms resolve in 3 days
• The hospital sends him back to your clinic for followup
Case 4. Resolution of acute effects

- Follow up chest x ray
- What are your concerns?
- How will you counsel him?

Case 5. Organic mercury toxicity

Minamata Disease
- Low birthweight
- Poor muscle tone
- Profound developmental delay
- Seizure disorder
- Deafness
- Spasticity

Case 6. Methyl mercury in Iraq

- 95,000 tons of seed grain pre-treated with methyl merc was baked into bread
- 459 hospital deaths, 6350 hospitalizations
- Paresthesias of lips, nose, extremities
- Headaches, fatigue, tremor
- Ataxia, dysarthria, visual field constriction, blindness
- Hyperreflexia, hearing disturbances, movement disorders, salivation, dementia
- Most severely affected: lay mute in rigid posture with spontaneous crying, primitive reflexive movements
Consider algorithm for management of cases

References

- Oz SG et al. Mercury vapor inhalation and poisoning of a family in Turkey. *Inhal Toxicol* 2012;24(10):652–8

The End
ACTIVITIES
### Occupational History

Name: __________________________________________ Gender: M F

The following questions refer to your current or most recent job:

Describe job, here:

<table>
<thead>
<tr>
<th>Job title:</th>
<th>Type of industry:</th>
<th>Name of employer:</th>
<th>Date job began:</th>
</tr>
</thead>
</table>

Are you still working in this job? Yes No
If no, when did the job end? __________

Fill in the table below, listing all jobs you have worked including short-term, seasonal, part-time employment, and military service. Begin with your most recent job. Use additional paper, if necessary.

<table>
<thead>
<tr>
<th>Dates of Employment</th>
<th>Job Title and Description of Work</th>
<th>Hazards*</th>
<th>Controls</th>
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</table>

*List the chemicals, dusts, fibers, fumes, radiation, biologic agents, physical agents (extreme heat, vibration, noise, etc), trauma hazards (lifting, repetitive motion, work at heights, driving, operating machinery, etc.), and psychological hazards.
A1b

Have you ever worked at a job in which you came into contact with any of the following hazardous agents—by breathing or touching them? Think of all the jobs you’ve ever had.
[Put a check mark for any reported hazards]
[Note: add locally relevant hazards; remove irrelevant hazards]

- Any chemicals?
- Acids
- Alkalis
- Ammonia
- Solvents
- Alcohols
- Benzene
- Toluene
- Other solvents?

- Liquid metals?
- Mercury
- Lead
- Arsenic
- Cyanide
- Other metals (list)
- Other metals?

- Dusts/particles
- Asbestos
- Coal dust
- Saw dust
- Silica sand
- Diesel
- Other dusts

Use this space for specific pesticides, other chemicals, dusts

Have you ever worked at a job with exposure to:

- Noise
- Vibration
- Extreme Heat
- Extreme Cold
- Infrared radiation
- UV Radiation
- Microwaves
- Lasers
- Operating machinery
- Work at heights
- Electrical work
- Driving
- Repetitive/forceful tasks
- Lifting
- Infectious Diseases
- Work with animals
- Confined space
- Mandatory overtime
- Evening/night shift
- Trauma
- Harassment or bullying
- Robbery
- Other (specify below)

Have you ever been off work for more than one day because of an illness or injury related to work? Yes No

Have you ever been advised to changes jobs or work assignments because of any health problems or injuries? Yes No

Has your work routine changed recently? Yes No

Is there poor ventilation in your workplace? Yes No

If you answered Yes to any of the questions, please explain here.
## A2b. Categorizing Occupational Hazards

<table>
<thead>
<tr>
<th>Job/Occupation</th>
<th>Chemical (pesticides, solvents, metals, etc)</th>
<th>Biological (bacteria, mosquitoes, fungus, viruses, etc)</th>
<th>Physical (noise, UV light, vibration, radiation, etc)</th>
<th>Biomechanical (heavy lifting, awkward postures, repetitive work, work with hand tools and machines, etc)</th>
<th>Psychosocial (long hours, shift work, deadlines, piece work, angry boss, low wages, more than one job, etc)</th>
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<td>Psychosocial (long hours, shift work, deadlines, piece work, angry boss, low wages, more than one job, etc)</td>
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</table>
A3b. Lesson Plan. Physical Examination for Acute Elemental Mercury Toxicity

Learning objectives.

- By the end of this session, the participant will be able to conduct a focused physical examination to detect signs of mercury toxicity and interpret its results

Props: Stethoscope, blood pressure cuff, matchbox with 20 wooden matches, white pieces of paper, pen—ballpoint

Instructions: the instructor should ask for a volunteer and conduct a physical examination in the front of the class, describing the components and talking about abnormal findings. The class can then be broken into groups of 2; put a physician in each group. Take turns conducting the physical exam. Instructor should walk around and make sure this is being done properly.

<table>
<thead>
<tr>
<th>MANEUVER</th>
<th>ABNORMALITY ASSOCIATED WITH MERCURY TOXICITY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vital Signs</strong></td>
<td></td>
</tr>
<tr>
<td>Temperature (37°C/98.6°F)</td>
<td>&gt;38°C/100°F</td>
</tr>
<tr>
<td>Pulse (60-100) in adult</td>
<td>&gt;100 beats per minute</td>
</tr>
<tr>
<td>Respiratory rate (12-20 breaths per minute)</td>
<td>&gt;20 breaths per minute</td>
</tr>
<tr>
<td>Blood pressure (140/90, adult)</td>
<td>&gt;140/90</td>
</tr>
<tr>
<td>For children, consult local standards</td>
<td></td>
</tr>
<tr>
<td><strong>Pulmonary Examination</strong></td>
<td></td>
</tr>
<tr>
<td>Note breathing</td>
<td>Rapid, shallow, distressed</td>
</tr>
<tr>
<td>Auscultation with stethoscope</td>
<td>Crackles, or rales at bases of lung fields</td>
</tr>
<tr>
<td><strong>Neurological Examination</strong></td>
<td></td>
</tr>
<tr>
<td>Orientation to time, place, self</td>
<td>Person does not know year/date, location, their name</td>
</tr>
<tr>
<td><strong>Observation</strong></td>
<td></td>
</tr>
<tr>
<td>Ask person to close eyes gently</td>
<td>Tremors of eyelids</td>
</tr>
<tr>
<td>Ask person to hold arms straight out</td>
<td>Tremors of hands/arms</td>
</tr>
<tr>
<td><strong>Sensory</strong></td>
<td></td>
</tr>
<tr>
<td>Bend paper clip; patient closes eyes</td>
<td>Cannot distinguish sharp from dull =</td>
</tr>
<tr>
<td>point, say “this is sharp”</td>
<td>“peripheral sensory neuropathy”</td>
</tr>
<tr>
<td>Touch finger with round part, say</td>
<td></td>
</tr>
<tr>
<td>this is dull; keep eyes closed and</td>
<td></td>
</tr>
<tr>
<td>ask person whether they are</td>
<td></td>
</tr>
<tr>
<td>feeling sharp or dull touch on all</td>
<td></td>
</tr>
<tr>
<td>fingers; do this randomly so that</td>
<td></td>
</tr>
<tr>
<td>this is not predictable; can do</td>
<td></td>
</tr>
<tr>
<td>tops of toes and soft parts of</td>
<td></td>
</tr>
<tr>
<td>fingers, if callused.</td>
<td></td>
</tr>
<tr>
<td><strong>Motor</strong></td>
<td></td>
</tr>
<tr>
<td>Have person flex arms; pull out</td>
<td>Note even strength; jerkiness suggests neuropathy</td>
</tr>
<tr>
<td>against resistance; push in</td>
<td></td>
</tr>
<tr>
<td>against resistance</td>
<td></td>
</tr>
<tr>
<td>Have person sit with knees at 90</td>
<td>Note even strength; jerkiness suggests neuropathy</td>
</tr>
<tr>
<td>degrees; push legs out against</td>
<td></td>
</tr>
<tr>
<td>resistance; pull in against</td>
<td></td>
</tr>
<tr>
<td>resistance</td>
<td></td>
</tr>
<tr>
<td><strong>Reflexes</strong></td>
<td></td>
</tr>
<tr>
<td>Patient sits on table with knees at</td>
<td>No reflexes suggest motor neuropathy; should be bilateral to call</td>
</tr>
<tr>
<td>90 degrees or on floor with one leg</td>
<td>this abnormal for mercury; sometimes it is hard to elicit</td>
</tr>
<tr>
<td>crossed over other; tap patellar</td>
<td>these reflexes, so diagnosis should not be made on this finding,</td>
</tr>
<tr>
<td>tendon with hammer</td>
<td>along.</td>
</tr>
<tr>
<td><strong>Coordination</strong></td>
<td></td>
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<td>---</td>
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</tr>
<tr>
<td>Touch examiners finger, then touch nose; examiner moves finger around; patient should alternate back and forth—ok to look with eyes</td>
<td>Patient unable to do this or trajectory of his hand is not steady; should be bilateral problem in mercury toxicity.</td>
</tr>
<tr>
<td>Heel to shin: patient told to run right heel down left leg, knee to ankle; then opposite</td>
<td>Patient unable to do this or this is not a steady or smooth motion; should be bilateral in mercury toxicity.</td>
</tr>
<tr>
<td>Patient holds arms up, shoulders straight, elbows bent at 90 degrees. Swivel both hands simultaneously, back and forth</td>
<td>Erratic, jerky movements=dysdiadochokinesis</td>
</tr>
<tr>
<td>Ask patient to walk straight across room and back</td>
<td>Question of steadiness or instability= “ataxia”</td>
</tr>
<tr>
<td>Ask patient to do same walk with eyes closed</td>
<td>Unsteady, unstable</td>
</tr>
<tr>
<td>Ask patient to walk “heel to toe” along straight line</td>
<td>Unsteady</td>
</tr>
<tr>
<td>Romberg: Ask patient to stand with his eyes open, feet together; should be stable; ask patient to close eyes and maintain that posture</td>
<td>Patient sways/unsteady in mercury poisoning</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Neuropsychiatric Testing</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Take small matchbox; put 10 matches on each side of box at ~15cm from box; ask patient to add match on R and L side, alternately</td>
<td>Should take no more than 17 seconds</td>
</tr>
<tr>
<td>Take a piece of paper and a pen; ask patient to tap points onto the paper as fast as he can; time this; stop at 10 seconds</td>
<td>Should make &gt;45 dots within 10 seconds</td>
</tr>
</tbody>
</table>
### A4b. Haddon Matrix form for activity

<table>
<thead>
<tr>
<th>Factors Phases</th>
<th>Human Factors</th>
<th>Agent or Vehicle</th>
<th>Physical Environment</th>
<th>Sociocultural Environment</th>
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<tbody>
<tr>
<td><strong>Pre-event</strong></td>
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<tr>
<td><strong>Event</strong></td>
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<tr>
<td><strong>Post-event</strong></td>
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DRAFT ALGORITHM FOR CLINICAL MANAGEMENT OF POSSIBLE MERCURY POISONING CASES AMONG ASGM MINERS and FAMILIES BY PRIMARY HEALTHCARE WORKERS

Great Lakes Center for Occupational & Environmental Health at University of Illinois at Chicago
Patient works in ASGM
or
Family exposed at home

Yes

Do they use Hg or CN? (mercury, cyanide)

Yes

Do they have symptoms or physical findings consistent with Hg toxicity?

Yes

Is clinic capable of testing for Hg?

Yes

Test urine and Hg$^{++}$ is high

Yes

DRAFT ALGORITHM FOR CLINICAL MANAGEMENT OF POSSIBLE MERCURY POISONING CASES AMONG ASGM MINERS and FAMILIES
A6b. Script for Role Play: Taking an Occupational History

Scenario: A worker goes to the doctor because he is not feeling well.

Worker/Patient: I haven’t been feeling well for just about a week.

Clinician: What seems to be the problem?

Worker/Patient: Every day this week I’ve started the day feeling just fine. But sometime in the afternoon I start to feel weak and shaky. I’m sweating a lot, and I feel nauseated. This lasts until I go to bed, but it disappears while I am sleeping. I think I must have some kind of virus.

Clinician: Have you had a headache, fever, vomiting, dizziness, changes in your vision?

(Worker/patient shakes his head “no” to all of these).

Clinician: How about diarrhea, change in bowel habits? Are you urinating more frequently than usual?

(still shaking his head “no”)

Clinician: Any change in your appetite? Is anyone else at home sick?

Worker/Patient: Well my appetite is down a little bit, but I just can’t figure out what it is.

Clinician: Do you have any medical illnesses? Do you take any medication?

Worker/Patient: Nope.

Clinician: What kind of work do you do?

Worker/Patient: I’m a gold miner

Clinician: Can you describe your work to me?

Worker/Patient: I do all different things at the mine—whatever’s needed. I mostly carry sacks of rocks and bags of chemicals back and forth. This week, though I’ve been working with the chemicals.
Clinician: Do you know the name of those chemicals?
Worker/Patient: I’m not sure of the names. Maybe mercury? Cyanide?
Clinician: Can you describe the operation to me…How do you handle the chemicals? What are you wearing? How many people are around you?
Worker/Patient: Well, I do it like I’m shown. I wear a t-shirt, long pants, and my work boots. When someone hands me a pan of rocks, I dip the whole pan into the chemical and see if any gold settles out.
Clinician: Do you wear any gloves? Does the chemical bother your skin?
Worker/Patient: We don’t have gloves. And it’s too hot to wear them anyway. My skin is really dry and I have some cracks on it.
Clinician: Do you take off your clothes and wash up before you go home?
Worker/Patient: Oh, I only have one set of clothes. My wife and kids are with me all day, anyway.
Clinician: Have you told your boss about this?
Worker/Patient: Yes, and he told me to stop complaining or go home.

Note: Clinician and patient can take this in a different direction if they want.
Hazard Data Sheet on Occupation

Artisan Miner

What is a Hazard Datasheet on Occupation?

This datasheet is modeled after the ILO’s international Datasheets on Occupations. It is intended for participants in this course—those professionally concerned with health and safety at work: occupational physicians and nurses, safety engineers, hygienists, education and information specialists, inspectors, employers’ representatives, workers’ representatives, safety officers and other competent persons.

This datasheet lists, in a standard format, different hazards to which [list your job title] may be exposed in the course of their normal work. This datasheet is a source of information rather than advice. With the knowledge of what causes injuries and diseases, is easier to design and implement suitable measures towards prevention.

This dataset consists of four pages:

- Page 1: Information on the most relevant hazards related to the occupation.
- Page 2: A more detailed and systematized presentation on the different hazards related to the job with indicators for preventive measures (marked as numbered shields and explained on the third page).
- Page 3: Suggestions for preventive measures for selected hazards.
- Page 4: Specialized information relevant primarily to occupational safety and health professionals and including information such as a brief job description, a list of tasks, notes and references.

Who is an artisan miner?
A worker who mines precious metals and ore using non-mechanized, rudimentary tools and simple recovery and processing techniques.

What is dangerous about this job?

- Work carried out in confined spaces at risk for low oxygen and extreme temperatures
- Risk of methane and coal explosions
- At risk for falling objects
- Silicosis from dust inhalation
- Potential for mercury and arsenic inhalation and poisoning
- Musculoskeletal injuries from repeated motions and awkward postures
### Hazards related to this job

<table>
<thead>
<tr>
<th>Accident Hazards</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>● Risk of deadly explosions from methane and coal explosions.</td>
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<tr>
<td>● Electrical shocks, thermal and electrical burns caused by equipment and tools.</td>
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<tr>
<td>● Chemical burns from the skin or eyes coming in contact with rock dust, lime or</td>
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<td>sulfuric acid (a byproduct of mining).</td>
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<tr>
<td>● Accidents related to falling rocks from unstable pillars supports and improper</td>
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<td>storage of waste rock.</td>
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<tr>
<td>Physical Hazards</td>
<td>4</td>
<td>6</td>
<td>7</td>
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<tr>
<td>● Numbness in the hands and arms caused by vibrating tools.</td>
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<tr>
<td>● Hearing loss caused by repeated exposure to loud noises in the form of tools,</td>
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<tr>
<td>blasting, drilling, crushing and ore processing.</td>
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<tr>
<td>● Heat stress resulting in dizziness, faintness, shortness or difficulty breathing, palpitations and excessive thirst.</td>
<td>4</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>● Low oxygen environment causing increased breathing rate, dizziness, nausea, headache, coma, asphyxiation and sometimes death.</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Chemical Hazards</td>
<td>4</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>● Mercury inhalation and poisoning resulting in neurological, kidney and autoimmune impairment.</td>
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<tr>
<td>● Silicosis from dust inhalation during drilling, extracting minerals, ore crushing and blasting processes.</td>
<td>4</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>● Arsenic inhalation, ingestion and poisoning during the smelting process can cause health problems ranging from headaches and convulsions to bladder, skin and lung cancers.</td>
<td>4</td>
<td></td>
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</tr>
<tr>
<td>● Sulfur dioxide and nitrous oxide inhalation during the initial blasting phase and the later tailings collection phase resulting in airway inflammation, bronchoconstriction and asthma symptoms.</td>
<td>3</td>
<td>4</td>
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</tr>
<tr>
<td>Biological Hazards</td>
<td>9</td>
<td>10</td>
<td></td>
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<tr>
<td>● Water-borne diseases (cholera, malaria, dengue fever) from working or living near areas susceptible to water contamination.</td>
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<tr>
<td>● Sexually transmitted infections, HIV and AIDS as a result of the migratory nature of the work and engaging in unsafe health behaviors.</td>
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<tr>
<td>● Skin infections due to chemical exposures.</td>
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<tr>
<td>● Respiratory infections as a result of living in close quarters.</td>
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<tr>
<td>● Drug and alcohol abuse as a result of the isolation and transient nature of the work.</td>
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<tr>
<td>Ergonomic, psychosocial and organizational factors</td>
<td>7</td>
<td>11</td>
<td></td>
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<tr>
<td>● Stress related to poverty, being away from one’s family, long work hours, social isolation, cramped living conditions, loss of work due to injury, fear of injury or death.</td>
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<tr>
<td>● Fatigue caused by long work shifts, heavy workloads and repetitive actions.</td>
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<tr>
<td>● Chronic injury and fatigue from carrying heavy materials over long distances, and bending over in awkward positions.</td>
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<tr>
<td>● Overexertion from uncomfortable postures and carrying out repetitive tasks using non-mechanized tools.</td>
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</tbody>
</table>
### Preventive measures

<table>
<thead>
<tr>
<th>No.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monitor gases through the use of inexpensive gas detector tubes (methane, carbon dioxide, hydrogen sulfide, sulfur dioxide). Use of flame safety lamps to check for methane and oxygen deficiency.</td>
</tr>
<tr>
<td>2</td>
<td>Rock dusting limestone or dolomite to prevent explosions. Alternatively, use the wetting method by spraying an area with water to reduce dust levels.</td>
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<tr>
<td>3</td>
<td>Improve air ventilation through the use of fans or exhaust systems.</td>
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<tr>
<td>4</td>
<td>Use appropriate protective equipment (long sleeve shirts, protective gloves, eye protection with side shield, safety helmet, ear plugs and earmuffs, respirator, self-contained breathing apparatus, dust mask).</td>
</tr>
<tr>
<td>5</td>
<td>Use scaling down procedures to help stabilize pillars and supports.</td>
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<tr>
<td>6</td>
<td>Replace worn down tools that expose worker to greater noise or vibration levels.</td>
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<tr>
<td>7</td>
<td>Take work breaks to minimize the exposure.</td>
</tr>
<tr>
<td>8</td>
<td>Use retorts during the mercury amalgamation step to reduce mercury inhalation. Use gravity only, direct smelting and chemical leaching techniques.</td>
</tr>
<tr>
<td>9</td>
<td>Education around waste management (mining, animal and human) and accessing clean water.</td>
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<tr>
<td>10</td>
<td>Education around HIV transmission and prevention, condom use, healthy behaviors.</td>
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<td>11</td>
<td>Learn and use safe lifting techniques.</td>
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<tr>
<td>12</td>
<td>Obtain counseling or treatment.</td>
</tr>
</tbody>
</table>
## Specialized information

### Synonyms

Small-scale mining, informal mining, artisan mining, prospecting, excavating

### Definitions and/or description

Artisan mining is labor-intensive work carried out with low-level mechanized tools. Characteristics of artisan mining include: an informal work sector, limited use of mechanized tools, labor intensive work, low-capital and productivity and limited access to land and markets. Artisanal mining is carried out in 55 countries by 13 million people.

### Related and specific occupations

Mining, prospecting, excavating

### Tasks

Exploring (mine); crushing (ore); concentrating (ore); adding (mercury to extract ore); adding (heat to remove mercury); commercializing (ore); repairing (site); closing (site).

### Primary equipment used

Sledgehammers; hammers; drills; pickaxes; rock crushers; chisels; shovels; wheelbarrows; picks; pans; sieves; sluices; pestle and mortar.

### Workplaces where the occupation is common

Mines

### References


Production of this datasheet was sponsored by the University of Illinois at Chicago School of Public HealthThis datasheet was authored by Gabriela Gracia, in partial fulfillment of requirements for EOHS 400, Fundamentals of Environmental Health.
Other Health Issues in ASGM

Community Hazards

Occupational Hazards

Environmental conditions
- Noise
- Dust and heavy metals
- Water pollution
- Fish contamination

Social conditions*
- Drug and alcohol abuse
- STIs
- Violence

Living conditions
- Lack of sanitation
- Infectious diseases
- Lack of access/Pressure on health infrastructure

Image from: Natural Resource Defense Council


A teenage boy works in a ball mill beneath a house in Diwalwal. Mercury is added directly to the ore in the iron cylinders to make the gold extraction process more efficient. Mercury particulate is released as the ball mill is flushed. Image by Larry C. Price. Philippines, 2013.

Stores like this one on a main street in Diwalwal buy and smelt gold and sell illegal mercury to the mining community. Image by Larry C. Price. Philippines, 2013.
Extraction of Ore

Panning with mercury
<table>
<thead>
<tr>
<th>Location/Task</th>
<th>Number of Workers</th>
<th>Chemical</th>
<th>Physical</th>
<th>Biological</th>
<th>Traumatic/Biomechanical</th>
<th>Psychosocial</th>
<th>Controls in use/needed</th>
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</table>
Your Name________________________

ARTISANAL AND SMALL-SCALE GOLD MINING (ASGM) Post Test Part 1.

Mural 1. Mercury movement in the environment

The following questions are based on study of the murals, above.

MERCURY MURAL
Please refer to the mercury mural 1 (mercury movement in the environment) to answer the following questions.

1. Based on the mural, identify 3 ways mercury is released into the environment.
   a. _____________________________
   b. _____________________________
   c. _____________________________

ARTISANAL GOLD AND MERCURY POLLUTION
Please refer to the artisanal gold and mercury pollution mural to answer the following questions.
2. Describe what is happening in the first panel.

3. Describe what is happening in the second panel.

4. Describe what is happening in the third panel.

5. Identify 3 potential health concerns from this mural (the panels).
   a. 
   b. 
   c. 
<table>
<thead>
<tr>
<th></th>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neither agree nor disagree</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Not Applicable</th>
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</thead>
<tbody>
<tr>
<td>1. I can describe ASGM work processes</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<td>2. I can describe the environmental effects of ASGM</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>3. I can describe the adverse health effects of ASGM</td>
<td>☐</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>4. I am able to take a focused history related to ASGM</td>
<td>☐</td>
<td>☐</td>
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<tr>
<td>5. I am able to conduct a physical examination related to ASGM and to record my findings</td>
<td>☐</td>
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<td>6. I can list the most common neurological abnormalities associated with elemental mercury poisoning</td>
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<td>☐</td>
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<tr>
<td>7. I am able to treat or refer a patient for elemental mercury toxicity</td>
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<td>☐</td>
<td>☐</td>
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<tr>
<td></td>
<td>Strongly Disagree</td>
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<td>Neither agree nor disagree</td>
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<tr>
<td>8.</td>
<td>I am able to advise ASGM workers and family members on protecting their health</td>
<td>☐</td>
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<tr>
<td>9.</td>
<td>I am able to advise workers about reducing their mercury exposure in ASGM</td>
<td>☐</td>
<td>☐</td>
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</tbody>
</table>