Artisanal and Small-Scale Gold Mining (ASGM)

A curriculum for the health sector

Student Manual

Great Lakes Center for Occupational
& Environmental Safety and Health at
University of Illinois at Chicago

A WHO Collaborating Center

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

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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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Suggested ASGM Agenda Course- 2 Day
General Training

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	
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
9:15 – 10:00	Activity: Haddon matrix: Case studies in mercury toxicity/ASGM (done in pairs)
10:00 – 10:15	Break
10:15 – 11:45	Lecture/discussion: Identifying and Characterizing Hazards
11:45 – 1:00	Lunch
AFTERNOON	
1:00 – 2:00	Lecture: Reproductive hazards and ASGM
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

Suggested ASGM Agenda Course- 3 Day- Training of Trainers

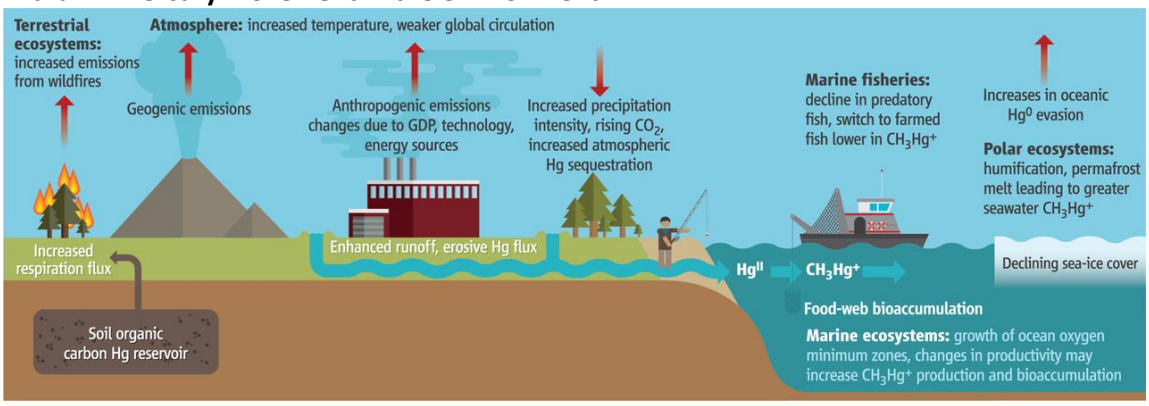
The below agenda is a suggested structure for the three-day course. It includes lectures and activities on ASGM and, unlike the two-day course, includes a day of train the trainer activities. The agenda can be retooled- you can rearrange the order of things, edit the PowerPoints to add in local photos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

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
12:15 – 1:00	**Lunch**
AFTERNOON	
1:00 – 2:00	Lecture: Clinical cases of mercury toxicity
2:00 – 3:00	Activity: Physical examination (vitals, pulmonary exam, neurological exam)
3:00 – 3:15	**Break**
3:15 – 4:00	Activity: Teach the physical examination (to each other)
4:00 – 4:30	Lecture: Occupational hygiene: hierarchy of controls applied to ASGM
4:30 – 5:00	Activity: place ASGM controls into hygiene hierarchy categories
5:00 – 5:10	Course evaluation: Day 1
Day 2	
MORNING	
8:30 – 9:15	Lecture/discussion: Introduction to injury and occupational health surveillance
9:15 – 10:00	Activity: Haddon matrix: Case studies in mercury toxicity/ASGM (done in pairs)
10:00 – 10:15	**Break**
10:15 – 11:45	Lecture/discussion: Identifying and Characterizing Hazards
11:45 – 1:00	**Lunch**
AFTERNOON	
1:00 – 2:00	Lecture: Reproductive hazards and ASGM
2:00 – 2:40	Lecture/Discussion: Clinical cases of mercury toxicity
2:40 – 3:00	**Break**
3:00 -- 3:30	Activity: Developing an algorithm for managing individual patients
3:30 – 4:15	Activity: Talking with miners and community members
4:15 – 4:45	Preparing for site visit (if applicable)
4:45 – 5:00	Post-test
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

Your Name_____

ARTISANAL AND SMALL-SCALE GOLD MINING (ASGM) PRE-TEST

Mural 1. Mercury movement in the environment



Mural 2. Artisanal gold and mercury pollution

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

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Not Applicable
1. I can describe ASGM work processes	☐	☐	☐	☐	☐	☐
2. I can describe the environmental effects of ASGM	☐	☐	☐	☐	☐	☐
3. I can describe the adverse health effects of ASGM	☐	☐	☐	☐	☐	☐
4. I am able to take a focused history related to ASGM	☐	☐	☐	☐	☐	☐
5. I am able to conduct a physical examination related to ASGM and to record my findings	☐	☐	☐	☐	☐	☐
6. I can list the most common neurological abnormalities associated with elemental mercury poisoning	☐	☐	☐	☐	☐	☐
7. I am able to treat or refer a patient for elemental mercury toxicity						

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Not Applicable
	☐	☐	☐	☐	☐	☐
8. I am able to advise ASGM workers and family members on protecting their health	☐	☐	☐	☐	☐	☐
9. I am able to advise workers about reducing their mercury exposure in ASGM	☐	☐	☐	☐	☐	☐

SLIDES

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- Contract numbers 201057080, 200909594, and 200846714

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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

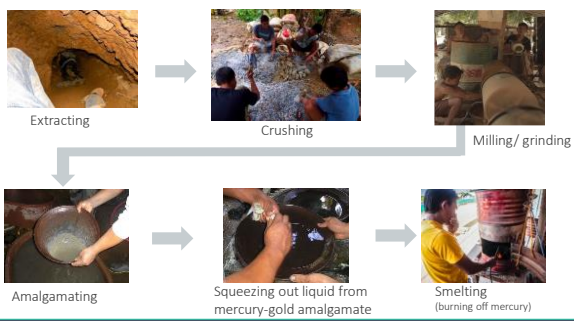
[UNEP, 2008; Telmer, 2009, WHO]

Characteristics of small-scale/subsistence mining

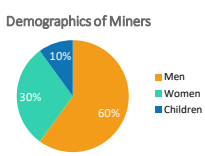
- Labor intensive, low level mechanization
- Remote, rural areas of country
- Low capital costs
- Low productivity/output
- Informal work sector
- No safety regulations
- Ineffective equipment

Hentschel 2002

[Jennings 1999, World Bank 2013; Hentschel 2003; Barry 1996]



Worker population



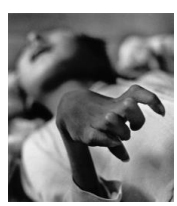
- Family Affair
- Often poorly educated
- Poorly skilled
- Driven to this work due to poverty
- Mining – main source of income for area
- Migrant and seasonal workers
- Night work common

Health hazards of ASGM

TYPE	HAZARD OR MEDIATING FACTOR
Chemical	Hg^0, CN, silica dust, gases (underground-confined space)
Biomechanical	Heavy loads, awkward postures, forceful use of hand tools, automated tools
Injury	Trench collapse, drowning, trip/fall, caught in machinery, struck by falling/flying objects; electrocution, heat/cold-related illnesses, trench foot
Physical	Noise, UV (outdoors), radon (underground)
Biological	Man-camps, mosquitoes, unclean water, insufficient food
Psychosocial	Child labor, slave labor, families separated, low wages

Minamata and Mercury

Minamata Disease

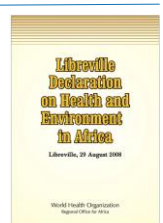


The Minamata Convention on Mercury

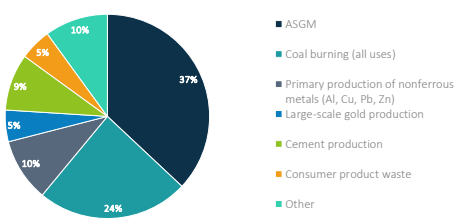
www.mercuryconvention.org

Libreville Declaration on Health & Environment in Africa (2008)

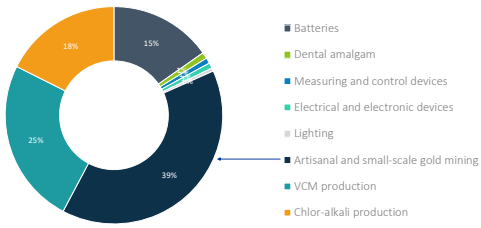
- Addresses environmental risk factors--access to safe water, air quality, vector borne diseases and chemicals in Africa
- Promotes creation of national and regional systems to address capacity building, surveillance, regulations, monitoring and evaluation



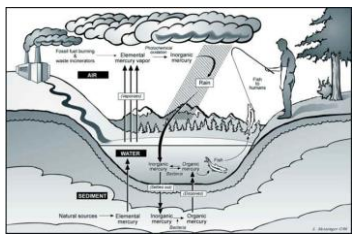
Air emissions sources



International uses of mercury



Mercury in the environment



Forms of mercury and health effects

Hg^0

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

$Hg^{+1,+2}$

- Irritability
- Shaking hands
- Kidney tox

Methyl-Hg

- Crosses GI tract, placenta, blood-brain barrier
- Paresthesias
- Incoordination
- Narrow visual fields, blindness
- Difficulty w speech
- Intellectual deficits
- Cardiovasc 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

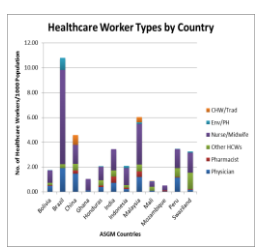
Overall Goals of this training

- 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



WHO 2013. WHO Global Health Workforce Statistics. http://www.who.int/hrh/statistics/hwfstats/en

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 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

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
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10:15 – 10:45	Activity: Taking an occupational history
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MORNING	
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1:00 – 2:00	Lecture: Reproductive hazards and ASGM
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

The end

URL to all powerpoints

Artisanal and Small-Scale Gold Mining (ASGM): Health Effects and Prevention of Mercury Toxicity

Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago
A WHO Collaborating Center

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Photo source: https://www.thegef.org/events/implementation-launch-gef-gold-programme

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

Hg^0

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

$Hg^{+1,+2}$

- Irritability
- Shaking hands
- Kidney tox

Methyl-Hg

- Crosses GI tract, placenta, blood-brain barrier
- Paresthesias
- Incoordination
- Narrow visual fields, blindness
- Difficulty w speech
- Intellectual deficits
- Cardiovasc disease
- Immune dysfunction

Routes of entry/exposure- Hg^0

Inhalation

Dermal absorption

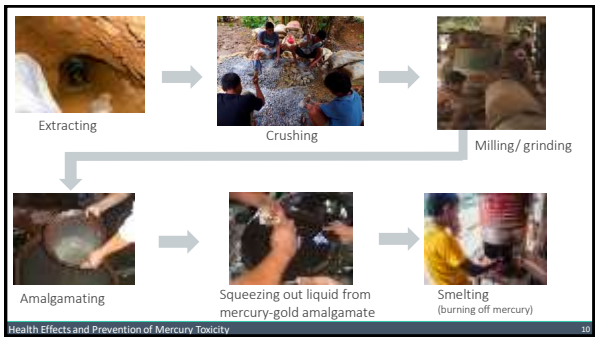
Ingestion

Routes of entry/exposure- Methyl-Hg

Ingestion

Inhalation

Dermal absorption



What is the route of exposure of mercury in the ASGM process?

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

Four-year-old girl plays in an amalgamation pond contaminated with mercury while adults process gold at a site in the Shinyanga Region of Tanzania. Zama Coursen-Neff/Human Rights Watch.

[Kristensen, A. et al, Int Arch Occup Environ Health, 2013]

Mercury toxicity

Three forms of mercury

Inorganic

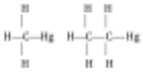
1. Elemental Hg^0

2. Chemical compound (mercury salts)

$Hg^{+1,+2}$

Organic

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



How is mercury toxic?

Mercury disrupts normal cellular physiology

Target organs

Clinical manifestations of acute elemental mercury (Hg^0) poisoning

Inhalation

Lung	GI	CNS
Fever/chills	Nausea/vomiting	Headaches
Cough	Difficulty swallowing	Visual disturbances
Shortness of breath	Diarrhea	Weakness
		Ataxia, incoordination

Clinical manifestations of chronic elemental mercury (Hg^0) 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

[UNIDO, 2006]

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

Acrodynia

Mee's lines

[UNIDO, 2006]

Neurological observations on exam

- Gait: Ataxia
- Tremors (intention, tongue, eyelids)
- Numbness toes/fingers
- Cognitive abnormalities

[UNIDO, 2006]

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
- Erethism
- 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

Acid-washed plastic container

50 mcg/L considered threshold for toxicity -USEPA

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

[EPA 1998]

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

[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

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Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago

A WHO Collaborating Center

Artisanal and Small Scale Gold Mining (ASGM): Reproductive and Children's Environmental Health

Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago
A WHO Collaborating Center

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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 $\mu g/m^3$ (public exposure)
- Airborne measurements at gold mines estimated at 6,315 $\mu g/m^3$
  - mean 8-hr average of 183$\mu g/m^3$

Mercury vapor

- Mercury vapor damages the central nervous system (CNS) and kidneys, and also affects the lungs
- Acute effects:
  - renal failure
  - respiratory distress
  - emotional instability
  - tremors

Mercury vapor

Effects on Children:

- Children - elevated blood and urine mercury levels
- **Acute affects**: 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, anesthesia, 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

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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

- International Labor Organization: Encyclopaedia of Occupational Health and Safety, Geneva: ILO; http://http://www.ilo.org/safework/info/publications/WCMS_113329/lang--en/index.htm/
- Burgess, WA: Recognition of Health Hazards in Industry, New York: John Wiley & Sons, 1995.
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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

Characterizing Agents

- 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

Characterizing Agents

- 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: ___

Location /Task	Number of workers	Physical Hazards[b]	Traumatic Hazards	Chemical Hazards	Biological Hazards	Psychosocial Hazards	Controls in use or needed

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

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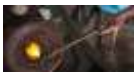
Objectives

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

Routes of exposure/entry

Inhalation



Ingestion

Skin Absorption

Types of hazards

- Chemical [mercury, metals, solvents, pestcides, 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*

Hazard Type	Exposure Source	Control
Chemical	Mercury	Use of cyanide
Chemical	Mercury	Gravimetric Methods

*This does not represent an endorsement of the change

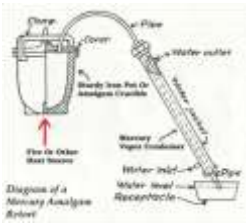
Cyanide use

- 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

Hazard Type	Exposure source	Control
Chemical	Mercury	Work in a well-ventilated area to reduce exposure
Chemical	Mercury	Retort (photo on next slide)
Chemical	Mercury	Hood or gravity control
Biomechanical	Musculoskeletal Disorders	
Biomechanical	Overexertion	

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

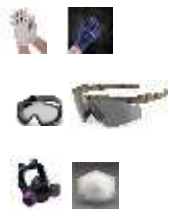
Hazard Type	Exposure Source	Control
Chemical	Lead, mercury, cyanide, borax, etc.	Remove ASGM work from the home
Physical	Vibrating tools (can cause Vibration White Finger)	Use power tools for only short periods
Physical	Dust (may be contaminated with chemical agents or metals)	Wash hands and face before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

http://hesperian.org/wp-content/uploads/pdf/en_cgeh_2012/en_cgeh_2012_21.pdf

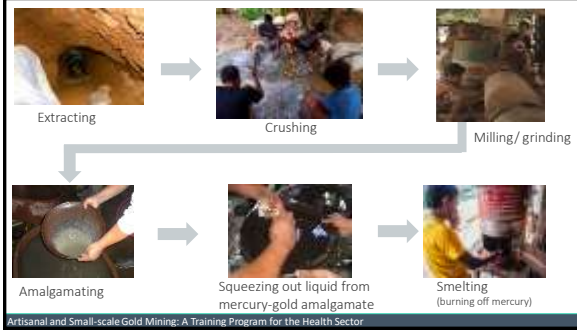
Examples: Personal Protective Equipment (PPE)

Hazard Type	Exposure Source	Control
Chemical	Mercury	Use respirators to minimize exposure
Physical	Dust	Use the proper mask; clean it regularly
Physical	Noise	Use ear plugs

What's the problem with PPE?



- Not available, costly
- Correct respirator must be used (eg, 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



Extraction controls

Crushing controls

Milling controls

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

Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago

A WHO Collaborating Center

Disclaimer

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- Contract numbers 201057080, 200909594, and 200846714

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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.)

$$K = mv^2 / 2$$

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

Mechanical Energy (M.E.)

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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

Tension

Shearing

Torsion

Bending

Compression

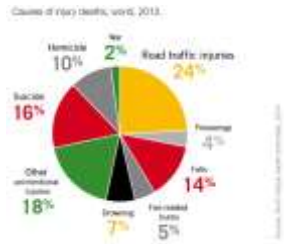
Kinetic Energy Forces

- BLUNT
- PENETRATING
- CRUSH

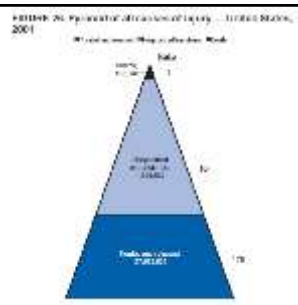
Severity

Mechanism	Severity LOW → HIGH
Fall	Bruises → Unconsciousness → Death
Noise	Mild hearing loss → Deafness
Scald	Mild burn → 3rd degree burn

Distribution of global injury mortality, 2012

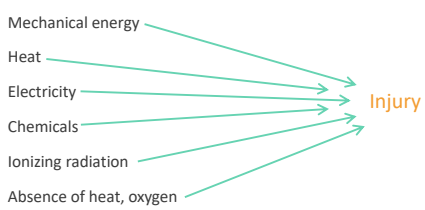


Mortality is a tiny fraction of adverse health outcomes from injury

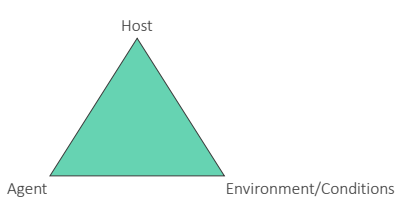


MMWR, Vol. 53 / No. SS—7, 2004

Causes of injury

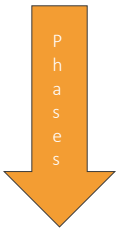


Prevention



Haddon's Matrix: Factors

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

Factor/ Phase	Host (Human)	Vector (Vehicle)	Physical Environment	Social/ Cultural Env
Pre-Event	Will an event with the potential to cause injury occur?			
Event	Will an injury occur?			
Post-Event	What will the outcome be (e.g. how severe)?			

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

Factors / Phases	Human Factors	Agent or Vehicle	Physical Environment	Sociocultural Environment
Pre-event				
Event				
Post-event				

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

Factor/ Phase	Host (Human)	Vector (Vehicle)	Physical Environment	Social/ Cultural Env
Pre-Event	Alcohol Experience Judgment	Brake status Tires	Night, Rain	Acceptance of drinking and driving
Event	No seat belt	No air bag Hardness of surfaces	Tree too close to road, no guard rail	Speed limits Enforcement of seat belt laws
Post-Event	Physical condition	Fuel system integrity Cell phone	Distance of emergency response	Support for trauma systems Training level of EMS personnel

Haddon Phase-Factor Matrix

Factor/ Phase	Host (Human)	Vector (Vehicle)	Physical Environment	Social/ Cultural Env
Pre-Event				
Event				
Post-Event				

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.

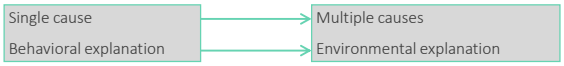
Haddon's 10 approaches to lessen energy transfer

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

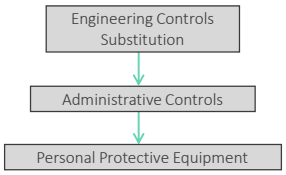
Haddon's 10 approaches to lessen energy transfer

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



Industrial hygiene hierarchy of controls



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

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Objectives

- Analyze cases of mercury toxicity from the published literature

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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

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

Case 1. Acrodynia in a child

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/m^3 (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

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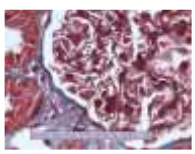
Case 2. Kidney disease in an adult



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 (3weeks 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?

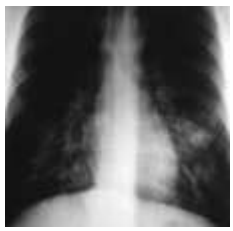
Case 4. Pneumonia

- 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 meth-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 w spontaneous crying, primitive reflexive movements

Consider algorithm for management of cases

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The End

ACTIVITIES

A1b

Occupational History

Name: _____

Birthdate/age: _____ Gender: M F

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

Job title: _____

Type of industry: _____

Name of employer: _____

Date job began: _____

Are you still working in this job? Yes No

If no, when did the job end? _____

Describe job, here:

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.

Dates of Employment	Job Title and Description of Work	Hazards*	Controls

*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?	__	Liquid metals?	__	Dusts/particles
__	Acids	__	Mercury	__	Asbestos
__	Alkalis	__	Lead	__	Coal dust
__	Ammonia	__	Arsenic	__	Saw dust
__	Solvents	__	Cyanide	__	Silica sand
__	Alcohols	__	Other metals (list)	__	Diesel
__	Benzene			__	Other dusts
__	Toluene	__	Pesticides (list)		
__	Other solvents?				

Use this space for specific pesticides, other chemicals, dusts

Have you ever worked at a job with exposure to:

_____Noise	_____Operating machinery	_____Confined space
_____Vibration	_____Work at heights	_____Mandatory overtime
_____Extreme Heat	_____Electrical work	_____Evening/night shift
_____Extreme Cold	_____Driving	_____ Trauma
_____Infrared radiation	_____Repetitive/forceful tasks	_____ Harassment or bullying
_____UV Radiation	_____Lifting	_____ Robbery
_____Microwaves	_____Infectious Diseases	_____ Other (specify below)
_____Lasers	_____Work with animals	

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

Job/Occupation	**Chemical** (pesticides, solvents, metals, etc)	**Biological** (bacteria, mosquitoes, fungus, viruses, etc)	**Physical** (noise, UV light, vibration, radiation, etc)	**Biomechanical** (heavy lifting, awkward postures, repetitive work, work with hand tools and machines, etc)	**Psychosocial** (long hours, shift work, deadlines, piece work, angry boss, low wages, more than one job, etc)

Job/Occupation	**Chemical** (pesticides, solvents, metals, etc)	**Biological** (bacteria, mosquitoes, fungus, viruses, etc)	**Physical** (noise, UV light, vibration, radiation, etc)	**Biomechanical** (heavy lifting, awkward postures, repetitive work, work with hand tools and machines, etc)	**Psychosocial** (long hours, shift work, deadlines, piece work, angry boss, low wages, more than one job, etc)

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

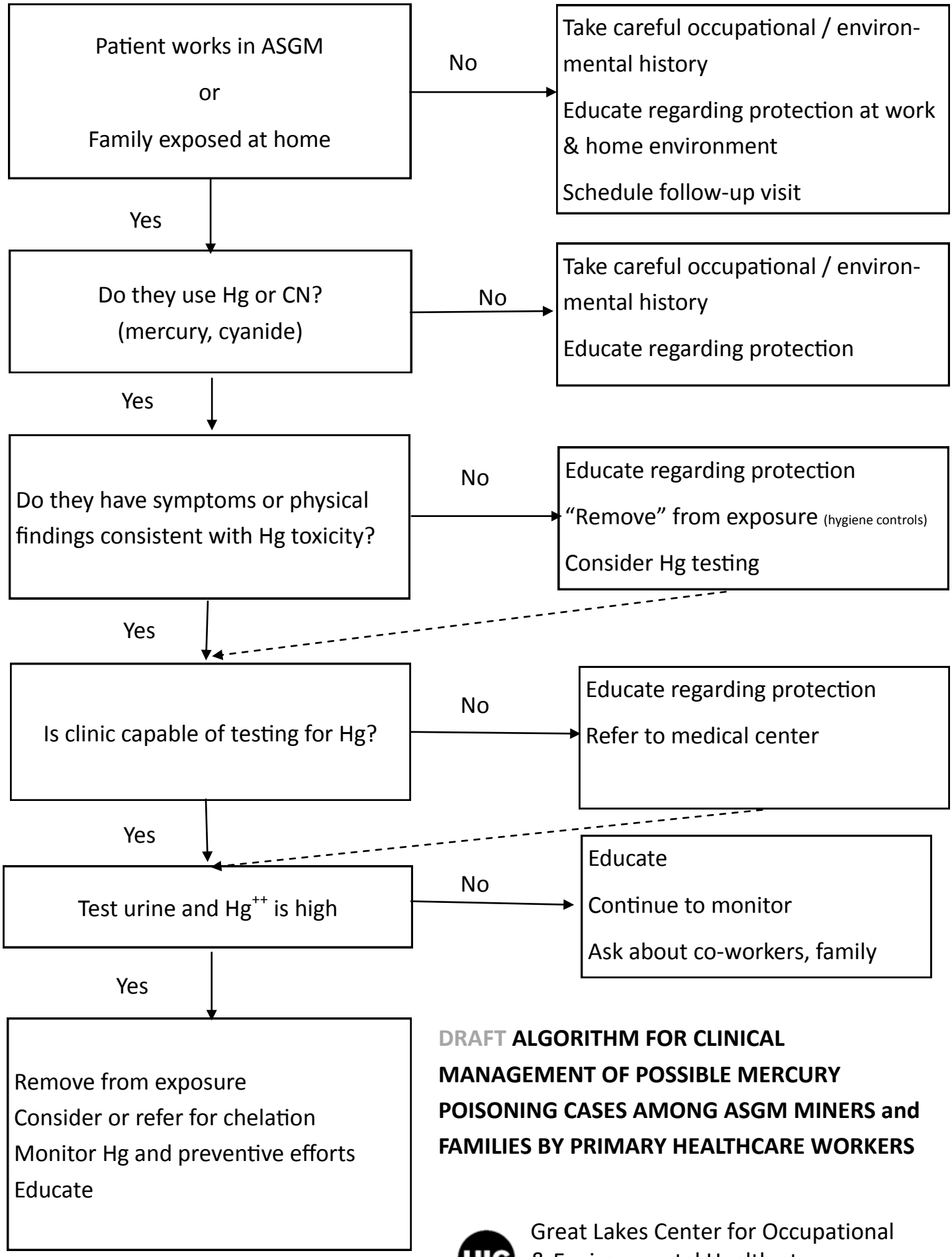
Instructions: the instructor should ask for a volunteer and conduct a physical examination in the front of the class, describing the components and talking about abnormal findings. The class can then be broken into groups of 2; put a physician in each group. Take turns conducting the physical exam. Instructor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

MANEUVER	**ABMNORMALITY ASSOCIATED WITH MERCURY TOXICITY**
Vital Signs	
Temperature (37C/98.6F)	>38C/100F
Pulse (60-100) in adult	>100 beats per minute
Respiratory rate (12-20 breaths per minute	>20 breaths per minute
Blood pressure (140/90, adult)	>140/90
For children, consult local standards	
Pulmonary Examination	
Note breathing	Rapid, shallow, distressed
Auscultation with stethoscope	Crackles, or rales at bases of lung fields
Neurological Examination	
Orientation to time, place, self	Person does not know year/date, location, their name
Observation	
Ask person to close eyes gently	Tremors of eyelids
Ask person to hold arms straight out	Tremors of hands/arms
Sensory	
Bend paper clip; patient closes eyes; touch finger with point, say "this is sharp" Touch finger with round part, say this is dull; keep eyes closed and ask person whether they are feeling sharp or dull touch on all fingers; do this randomly so that this is not predictable; can do tops of toes and soft parts of fingers, if callused.	Cannot distinguish sharp from dull = "peripheral sensory neuropathy"
Motor	
Have person flex arms; pull out against resistance; push in against resistance	Note even strength; jerkiness suggests neuropathy
Have person sit with knees at 90 degrees; push legs out against resistance; pull in against resistance	Note even strength; jerkiness suggests neuropathy
Reflexes	
Patient sits on table with knees at 90 degrees or on floor with one leg crossed over other; tap patellar tendon with hammer	No reflexes suggest motor neuropathy; should be bilateral to call this abnormal for mercury; sometimes it is hard to elicit these reflexes, so diagnosis should not be made on this finding, along.

Coordination	
Touch examiners finger, then touch nose; examiner moves finger around; patient should alternate back and forth—ok to look with eyes	Patient unable to do this or trajectory of his hand is not steady; should be bilateral problem in mercury toxicity.
Heel to shin: patient told to run right heel down left leg, knee to ankle; then opposite	Patient unable to do this or this is not a steady or smooth motion; should be bilateral in mercury toxicity
Patient holds arms up, shoulders straight, elbows bent at 90 degrees. Swivel both hands simultaneously, back and forth	Erratic, jerky movements=dysdiadochokinesis
Ask patient to walk straight across room and back	Question of steadiness or instability= "ataxia"
Ask patient to do same walk with eyes closed	Unsteady, unstable
Ask patient to walk "heel to toe" along straight line	Unsteady
Romberg: Ask patient to stand with his eyes open, feet together; should be stable; ask patient to close eyes and maintain that posture	Patient sways/unsteady in mercury poisoning
Neuropsychiatric Testing	
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	Should take no more than 17 seconds
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	Should make $\geq$45 dots within 10 seconds

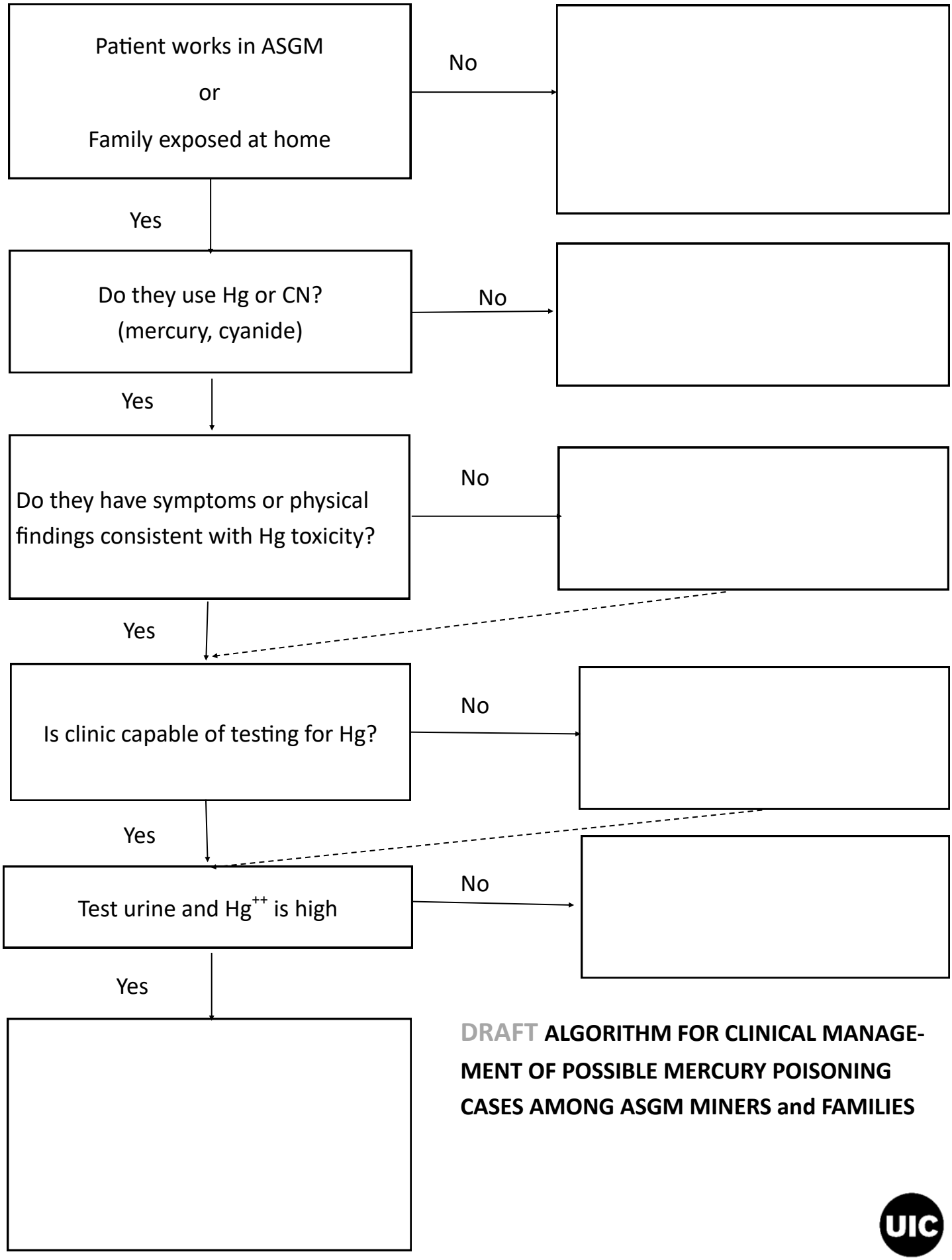
A4b. Haddon Matrix form for activity

Factors **Phases**	Human Factors	Agent or Vehicle	Physical Environment	Sociocultural Environment
Pre-event				
Event				
Post-event				



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



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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.

Great Lakes Center for Occupational
& Environmental Safety and Health at
University of Illinois at Chicago

A WHO Collaborating Center

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

Accident Hazards	• Risk of deadly explosions from methane and coal explosions.	1 2 3
	• Electrical shocks, thermal and electrical burns caused by equipment and tools.	4
	• Chemical burns from the skin or eyes coming in contact with rock dust, lime or sulfuric acid (a byproduct of mining).	4
	• Accidents related to falling rocks from unstable pillars supports and improper storage of waste rock.	4 5
Physical Hazards	• Numbness in the hands and arms caused by vibrating tools.	4 6 7
	• Hearing loss caused by repeated exposure to loud noises in the form of tools, blasting, drilling, crushing and ore processing.	4 7
	• Heat stress resulting in dizziness, faintness, shortness or difficulty breathing, palpitations and excessive thirst.	4 7
	• Low oxygen environment causing increased breathing rate, dizziness, nausea, headache, coma, asphyxiation and sometimes death.	1 4
Chemical Hazards	• Mercury inhalation and poisoning resulting in neurological, kidney and autoimmune impairment.	4 8
	• Silicosis from dust inhalation during drilling, extracting minerals, ore crushing and blasting processes.	3 4
	• Arsenic inhalation, ingestion and poisoning during the smelting process can cause health problems ranging from headaches and convulsions to bladder, skin and lung cancers.	4
	• 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.	3 4
Biological Hazards	• Water-borne diseases (cholera, malaria, dengue fever) from working or living near areas susceptible to water contamination.	9
	• Sexually transmitted infections, HIV and AIDS as a result of the migratory nature of the work and engaging in unsafe health behaviors.	10
	• Skin infections due to chemical exposures.	4
	• Respiratory infections as a result of living in close quarters.	3
	• Drug and alcohol abuse as a result of the isolation and transient nature of the work.	12
Ergonomic, psychosocial and organizational factors	• 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.	12
	• Fatigue caused by long work shifts, heavy workloads and repetitive actions.	7
	• Chronic injury and fatigue from carrying heavy materials over long distances, and bending over in awkward positions.	11
	• Overexertion from uncomfortable postures and carrying out repetitive tasks using non-mechanized tools.	11

Preventive measures

1	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.
2	Rock dusting limestone or dolomite to prevent explosions. Alternatively, use the wetting method by spraying an area with water to reduce dust levels.
3	Improve air ventilation through the use of fans or exhaust systems.
4	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).
5	Use scaling down procedures to help stabilize pillars and supports.
6	Replace worn down tools that expose worker to greater noise or vibration levels.
7	Take work breaks to minimize the exposure.
8	Use retorts during the mercury amalgamation step to reduce mercury inhalation. Use gravity only, direct smelting and chemical leaching techniques.
9	Education around waste management (mining, animal and human) and accessing clean water.
10	Education around HIV transmission and prevention, condom use, healthy behaviors.
11	Learn and use safe lifting techniques.
12	Obtain counseling or treatment.

Specialized information

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

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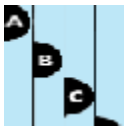
Definitions and/or description



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

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Other Health Issues in ASGM

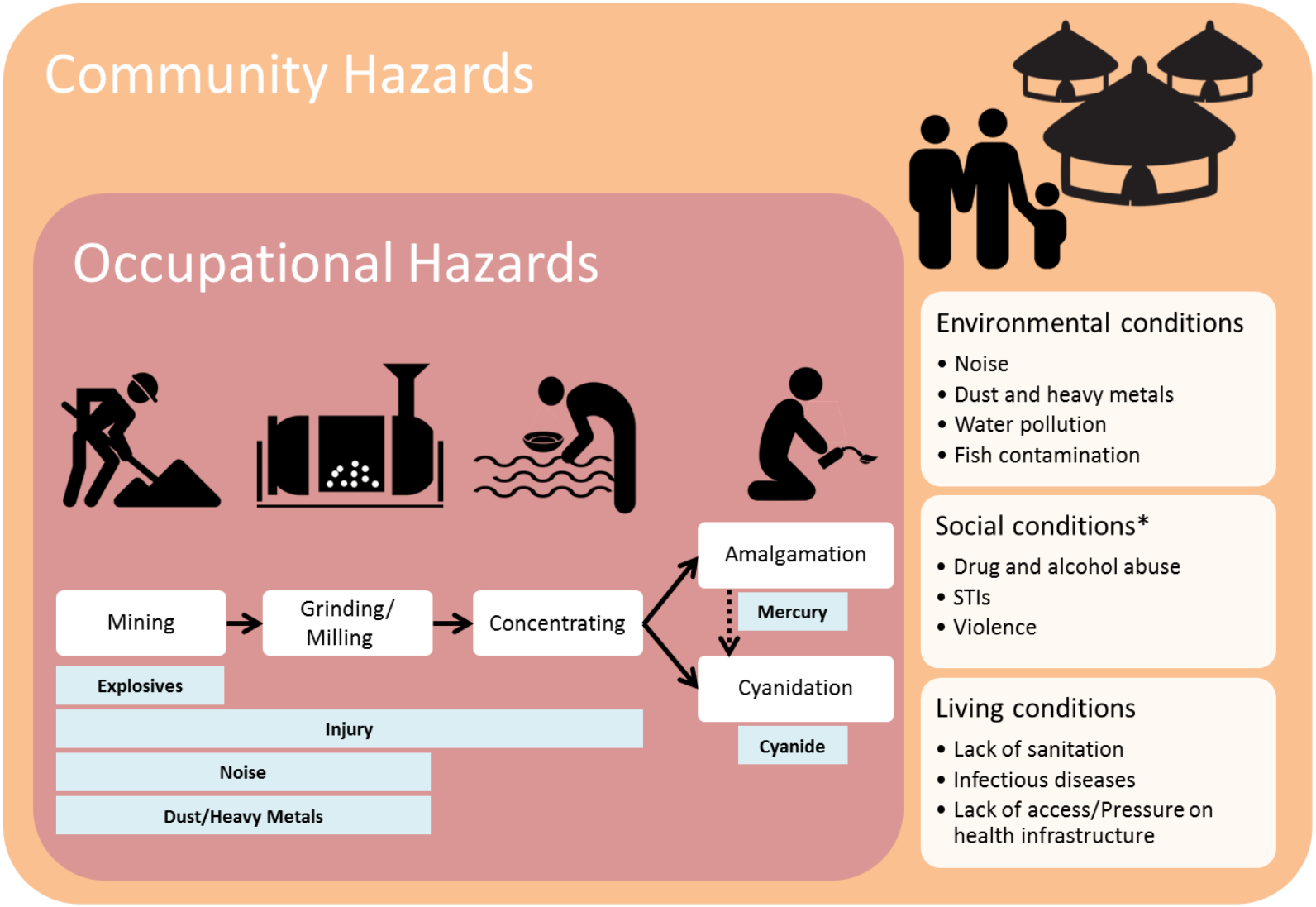


Image from: Natural Resource Defense Council

A miner climbs a 20-foot ladder with an 80-pound sack of ore balanced on his shoulders. Image by Larry C. Price. Philippines, 2013.

A toxic stream in the central mining area at Diwalwal. Image by Larry C. Price. Philippines, 2013.

A miner prepares to add gold ore and mercury to a ball mill near Diwalwal. Image by Larry C. Price. Philippines, 2013.

A miner adds mercury to a ball mill at an ore processing facility outside Diwalwal. Image by Larry C. Price. Philippines, 2013.

Mercury is added to ore and water during ball mill processing of ore. Image by Larry C. Price. Philippines, 2013.

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 mills are flushed. Image by Larry C. Price. Philippines, 2013.

A miner uses a piece of nylon cloth to form a pea-sized amalgam of mercury and gold after panning the slurry produced by a ball mill. 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

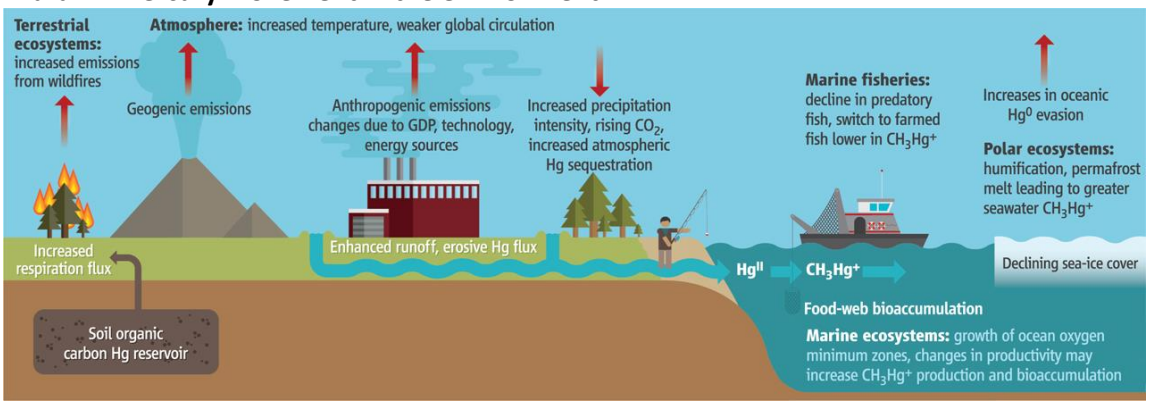
Panning with mercury

WALK AROUND SURVEY							
		HAZARDS					
Location/Task	**Number of Workers**	**Chemical**	**Physical**	**Biological**	**Traumatic/ Biomechanical**	**Psychosocial**	**Controls in use/needed**

Your Name_____

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

Mural 1. Mercury movement in the environment



Mural 2. Artisanal gold and mercury pollution

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

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Not Applicable
1. I can describe ASGM work processes	☐	☐	☐	☐	☐	☐
2. I can describe the environmental effects of ASGM	☐	☐	☐	☐	☐	☐
3. I can describe the adverse health effects of ASGM	☐	☐	☐	☐	☐	☐
4. I am able to take a focused history related to ASGM	☐	☐	☐	☐	☐	☐
5. I am able to conduct a physical examination related to ASGM and to record my findings	☐	☐	☐	☐	☐	☐
6. I can list the most common neurological abnormalities associated with elemental mercury poisoning	☐	☐	☐	☐	☐	☐
7. I am able to treat or refer a patient for elemental mercury toxicity						

	Strongly Disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree	Not Applicable
	☐	☐	☐	☐	☐	☐
8. I am able to advise ASGM workers and family members on protecting their health	☐	☐	☐	☐	☐	☐
9. I am able to advise workers about reducing their mercury exposure in ASGM	☐	☐	☐	☐	☐	☐