# Artisanal and Small-Scale Gold Mining (ASGM)

## A curriculum for the health sector

## Instructor 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.

## 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)<br>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 |

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 |

# EVALUATION TOOLS

ASGM Evaluation of Training by New Trainers

Note: This is to be used by course developers or master instructors to evaluate new trainers and to consider 1) providing feedback to the instructors; 2) adjusting how material is presented; 3) adjusting content

| **Name of Trainer** | **Topic/session** | **Understanding of Content (Hi, Med, Lo)** | **How well presented (Hi, Med, Lo)** | **Teaching capability (Hi, Med, Lo)** | **Miscellaneous Comments** |
|---|---|---|---|---|---|
| | Lecture: Minamata | | | | |
| | Activity: Taking an occupational history | | | | |
| | Activity: Categorizing occupational hazards | | | | |
| | Lecture: ASGM Health effects and prevention | | | | |
| | Activity: physical examination | | | | |
| | Lecture: Occupational Hygiene – hierarchy of controls | | | | |
| DAY 2 | | | | | |
| | Lecture: Intro to Injury | | | | |
| | Activity: Haddon Matrix | | | | |
| | Lecture: Identifying Hazards | | | | |
| | Lecture: Reproductive Hazards | | | | |
| | Lecture/discussion: clinical cases | | | | |
| | Activity: Developing an algorithm for triaging/managing cases | | | | |

**Pre/post-test directions**

These directions apply for both the 2-day course and the 3-day course.

During the first day of training, instructors should show and discuss (1) the mercury mural and (2) the artisanal gold and mercury pollution mural with the descriptions. Participants should fill out the pre-test exam during this time which includes describing what's going on in the panels and they're current knowledge and understanding of ASGM.

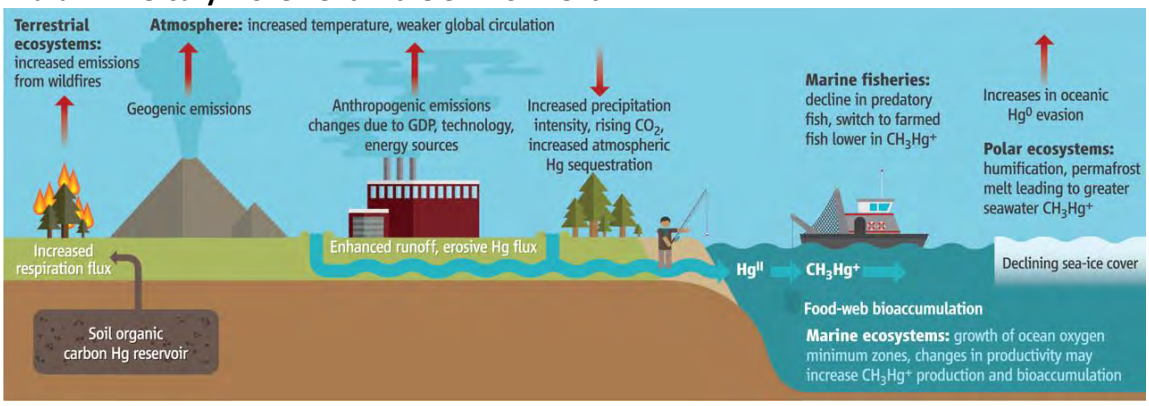
At the end of your training, show the murals without the descriptions. The mercury mural is saved as a PowerPoint slide so instructors can edit which descriptions are hidden by deleting and changing the shapes covering the text. Participants should fill out the post-test exam during this time.

The post-test is the same as the pre-test and will assist in helping evaluate the effectiveness of the course and if the goals were met. If the course met the goals, participants should be able to describe what is happening in the murals without the descriptions being provided and should agree/strongly agree with the statements regarding the knowledge and understanding of ASGM.

**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**

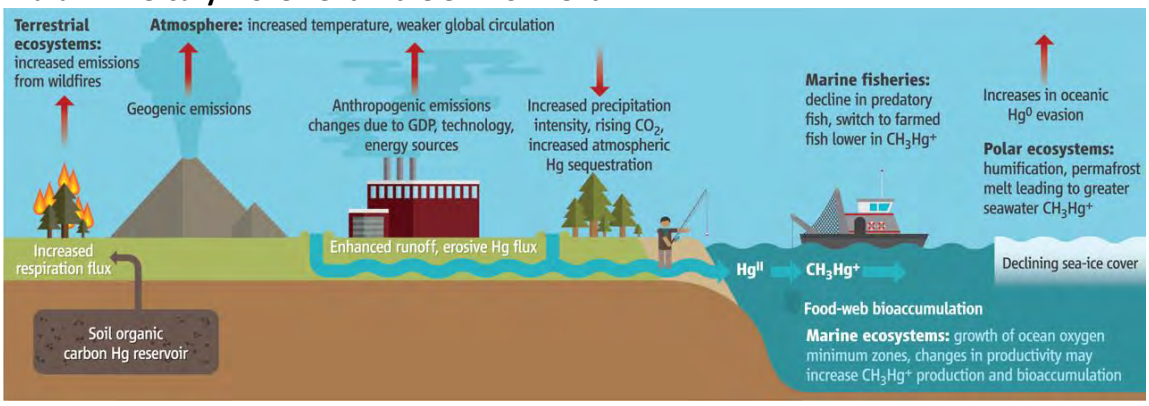
| | Strongly Disagree | Disagree | Neither agree nor disagree | Agree | Strongly Agree | Not Applicable |
|---|---|---|---|---|---|---|
| **1. I can describe ASGM work processes** | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **2. I can describe the environmental effects of ASGM** | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| **3. I can 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** | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**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** | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

# SLIDES


This is the opening lecture for a course on the health issues surrounding Artisanal and Small Scale Gold Mining. This course was developed to assist countries in preventing illnesses and injuries among gold miners and their families. By the end of this lecture, you should be able to describe at-risk populations in the subsistence gold mining sector and discuss the Minamata Convention and WHO's efforts to address the human health provisions. You also will get an introduction to elemental and organic mercury toxicity in this lecture. But we will spend more time on the health effects of mercury later in the course.

# Disclaimer

This work was funded, in part, by the World Health Organization:

- Contract numbers 201057080, 200909594, and 200846714

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Read the slide

# 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]



So what is the global status of ASGM? Artisanal and small scale gold mining takes place in over 77 countries, particularly in the Southern hemispheres of the globe. It is estimated that 10-15 million people work in this sector, and that upward of 80 million people are indirectly dependent on it for their livelihoods and sustenance of themselves and their families. ASGM provides 20-30% of the global gold production. There are various types of mining: gold ore can be extracted from underground tunnels, from surface mines, or from under water. There is a large range of estimates of how much mercury is released in gold mining, but it is believed to be responsible for over 35% of anthropogenic sources.

## 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

Fenintsoa.net 2002

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

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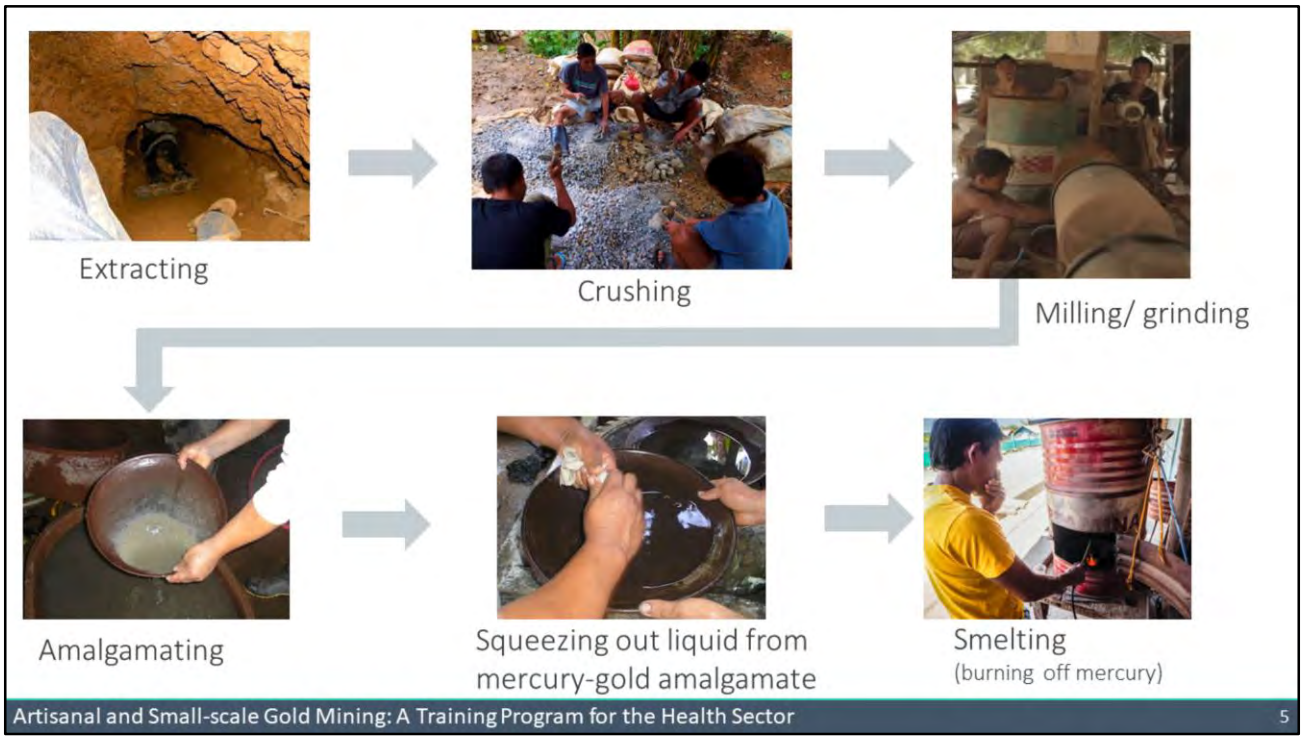
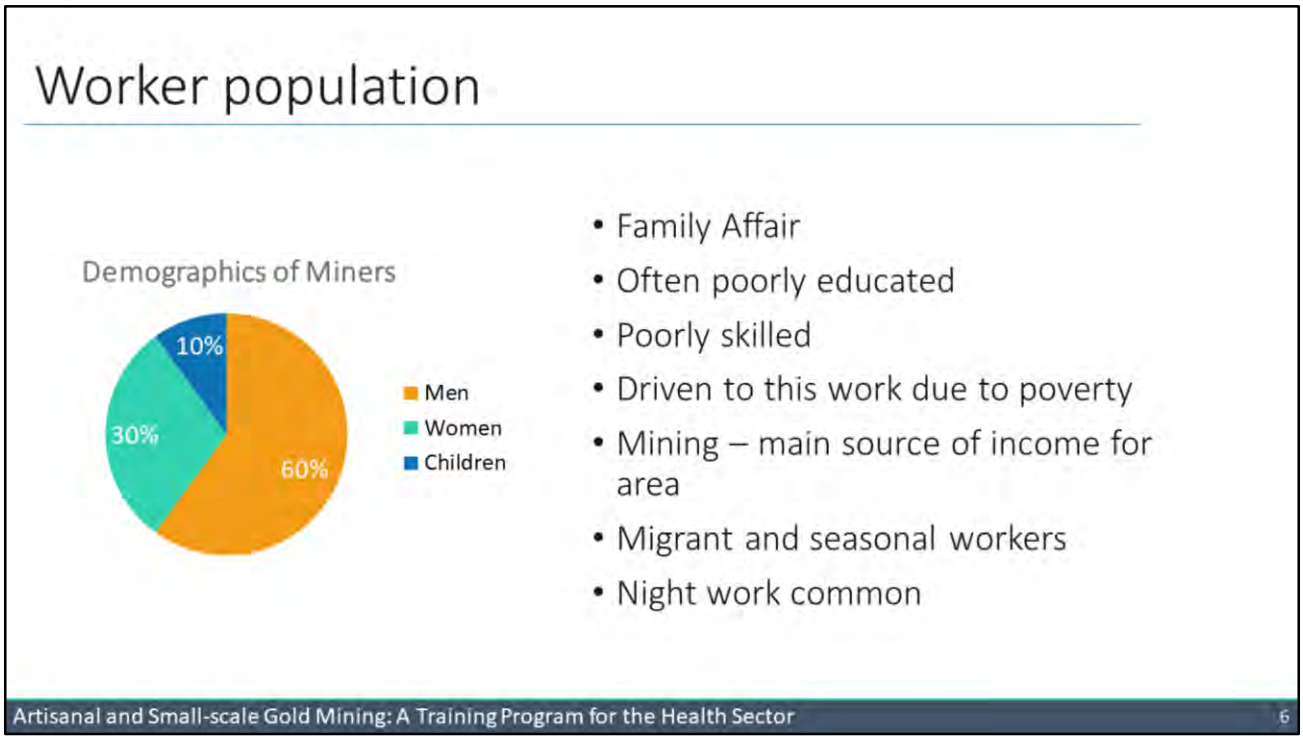
Artisanal and small scale gold mining is generally very labor intensive, particularly when it is done with low levels of mechanization. These small scale and subsistence enterprises tend to have low capital costs, and garner very small amounts of gold. Workers are often informally employed, either working for themselves and selling the gold they extract, or being paid in cash or goods from the contracting company. Because of the remote locations, the small number of workers, and the fact that this activity occurs within the cash economy, ASGM generally goes unregulated, putting workers at even greater risk of physical harm and exploitation.




These are the steps involved in gold mining. They are presented here for your to think about how these activities lead to mercury entry into the body. Don't forget that for ASGM miners and their families, it is elemental mercury we are talking about. Elemental mercury is not fat soluble. The Route of Entry in workplaces is mainly through inhalation that occurs during the burning or smelting process. Note the man in the bottom right corner of this slide—he is covering his mouth, probably because the mercury fumes are bothering him. There **is** volatility of mercury even when it is not being heated, though the amount that becomes fume is lower, exposing workers to a lower dose than the dose from burning it. Since the elemental mercury is handled directly during parts of the ASGM process, hand contamination can lead to ingestion and absorption through the GI tract.



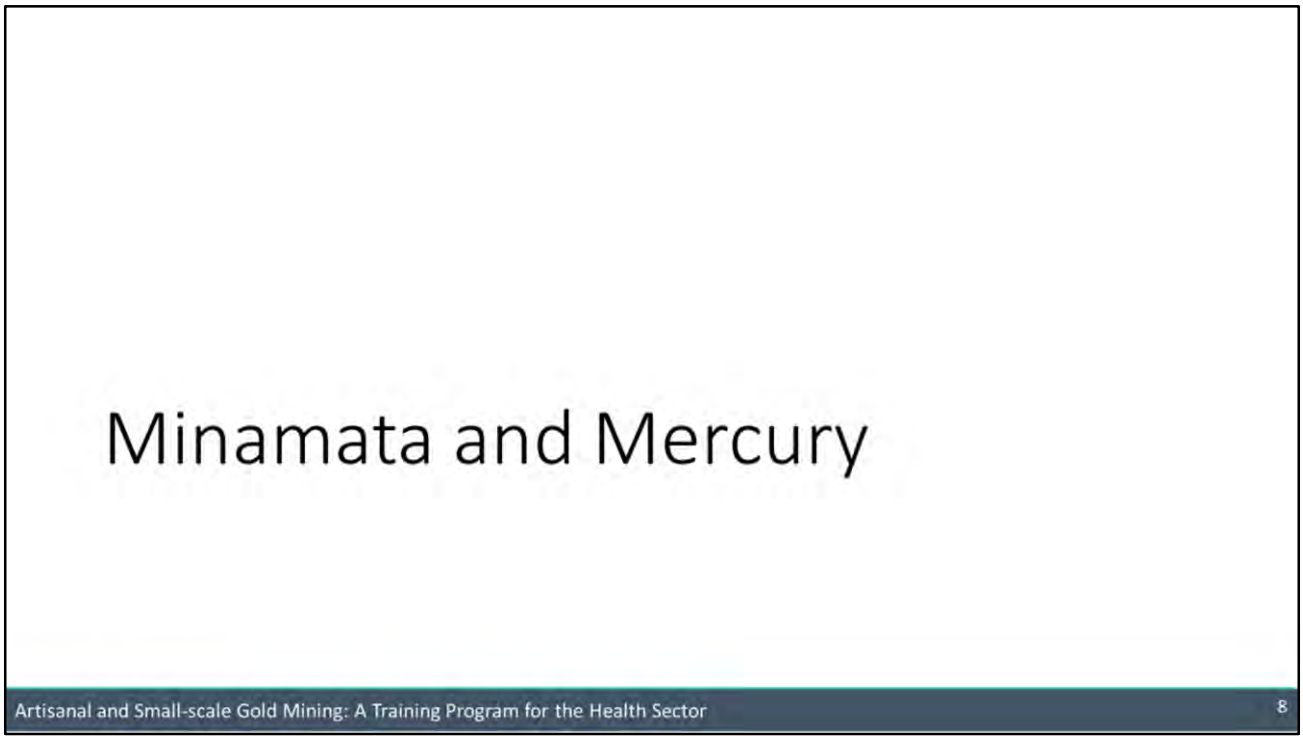

Who is engaging in the work? Although the vast majority are adult men, women comprise 1/3 of the workforce. Adolescents and younger children often assist in lieu of going to school. ASGM is often a family affair, where whole families live in or proximate to the work environment, blending mining and household work. Smelting of mercury and gold amalgam may be done on the family's cook stove. These gold miners are often poorly educated and poorly skilled, with no other sources of income. They are driven to do this work because of poverty and often migrate and work seasonally, commonly working over 8 hours per day and often at night.

# 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 |



You can classify workplace hazards into the categories in the left column of this slide. These are chemical, biomechanical, injury, physical, biological and psychosocial hazards. If you read across each category into the specific hazards, you can imagine the array of illnesses and injuries that can come about as a result of ASGM work. For example, mercury toxicity causes neurological effects. Noise causes hearing loss. There are significant traumatic injury hazards. And the employment conditions expose workers to infectious diseases. Child and slave labor are significant problems in ASGM, as are migrant and seasonal work where workers are separated from their families over long periods of time.




Let's talk about Minamata and Mercury

# Minamata Disease

Artisanal and Small-scale Gold Mining: A Training Program for the Health Sector 9

A terrible disease was recognized among Japanese populations living around Minamata Bay in the 1950s. So-called “Minimata Disease” is a neurological syndrome caused by severe mercury poisoning. Clinical abnormalities include ataxia, or instability and imbalance, numbness and tingling in the hands and feet, severe muscle weakness, narrowed visual fields, damage to hearing and speech, and, sometimes, profound dementia and paralysis leading to coma and death. Among the Minamata Bay populations, children were born with a congenital form of the disease, with profound mental retardation and neurological abnormalities. These conditions were first recognized in 1956 and were tied to the release of mercury into the environment by a chemical factory located on Minamata Bay, starting in 1932. The mercury bioaccumulated in fish in the Minamata Bay and nearby waterways. When fish and shellfish were eaten by the local populace, they suffered severe mercury poisoning. Thousands of people—adults and children--were affected. There have been other similar outbreaks around the world since that time. In recognition of the toxicity of mercury and the potential for preventing it, the Minamata Convention was established. The picture on the left is the Minamata Disease Memorial located on the Bay. The picture on the right shows the tragic consequences of mercury poisoning in someone living nearby.

# The Minamata Convention on Mercury

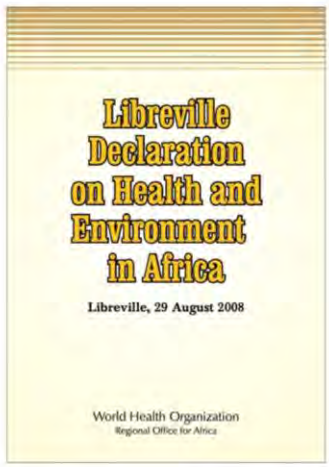
www.mercuryconvention.org



In 2003, in its Global Mercury Assessment, the United Nations Environment Programme (UNEP) first sounded the alarm about mercury as a global pollutant. Because mercury can travel through the atmosphere to locations thousands of miles away from where it is emitted, without regard for national boundaries, it is not possible that any one country can tackle this problem on its own - concerted and coordinated global efforts are required. There is now a global mercury agreement, the Minamata Convention on Mercury, which was signed in October 2013 in Japan. The Minamata Convention creates the foundation for international cooperation on mercury pollution. The Convention contains a concrete blueprint for action, with deadlines to achieve specific reductions in mercury emissions and uses, with an unprecedented level of specificity for a globally binding agreement. To see the status of the Convention—details of the convention, how many signatories there are, the status of implementation, and resources, you can go to the website listed on this slide.

# 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

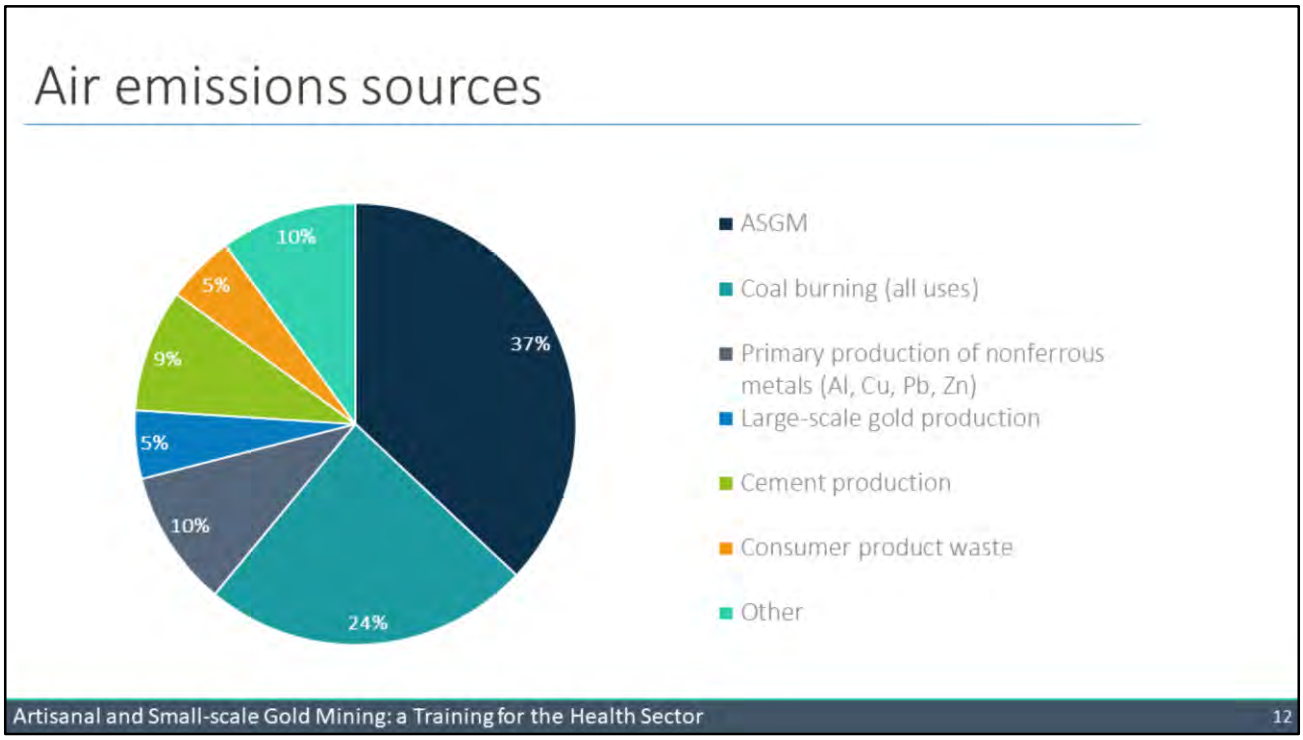





To contextualize the international efforts, the Libreville Declaration on Health and Environment came about with the recognition of the impact of the environment on human health. Exposure to physical, chemical and biological risk factors in the environment can harm human health in various ways. The challenges of access to safe drinking water, hygiene, and sanitation are further aggravated by the effects of climate change, accelerated urbanization and indoor and outdoor air pollution.
In 2008, on the continent of Africa, the government of Gabon worked in partnership with the World Health Organization (WHO) and the United Nations Environment Programme (UNEP) to organize a conversation among ministers of health and ministers of environment from 52 African nations. Born out of this effort was The Libreville Declaration on Health and Environment in Africa to address environmental risk factors. These include access to safe water, good air quality, and limitation of vector born diseases and chemical hazards. Libreville also promotes national and regional systems to build capacity, conduct hazard and illness surveillance, develop regulations, and evaluate these efforts.

**NOTE: THE FOLLOWING IS LISTED FOR THE PRESENTER, IN CASE THERE ARE QUESTIONS; NO NEED TO READ THIS:**
1. Establishing a health and environment strategic alliance, as the basis for plans of joint action;
2. Developing or updating our national, subregional and regional frameworks
3. Ensuring integration of agreed objectives in the areas of health and environment
4. Building national, subregional and regional capacities to better prevent environment-related health problems
5. Supporting knowledge acquisition and management on health and environment, particularly through applied research
6. Establishing or strengthening systems for health and environment surveillance
7. Implementing effectively national, subregional and regional mechanisms for enforcing compliance with international conventions and national regulations 8. Setting up national monitoring and evaluation mechanisms
9. Instituting the practice of systematic assessment of health and environment risks
10. Developing partnerships for targeted and specific advocacy on health and environment issues
11. Achieving a balance in the allocation of national budgetary resources for intersectoral health and environment programmes.

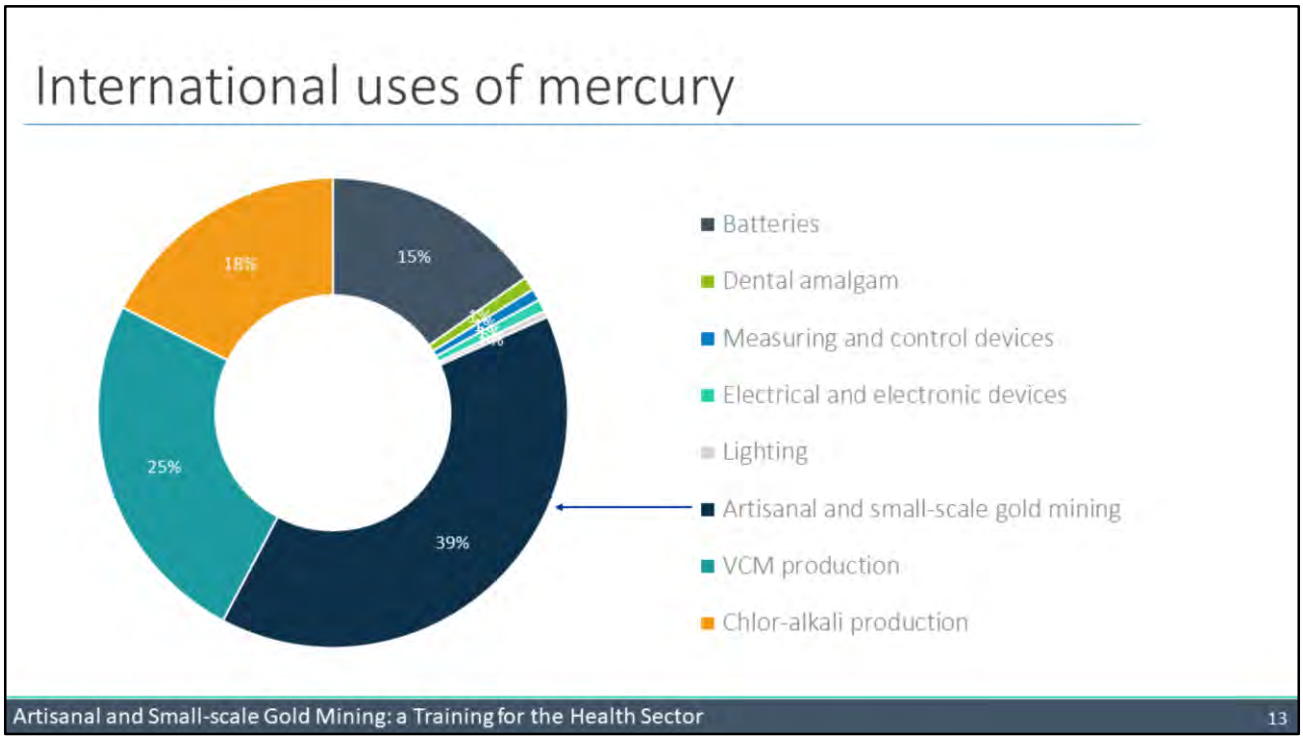
Reference:
http://www.aho.afro.who.int/profiles_information/index.php/AFRO:Progress_on_the_Libreville_Declaration




[Note: Many countries are performing "Minamata Initial Assessment" to look at most important mercury sources].

**PLEASE NOTE: PRESENTERS ARE ENCOURAGED TO ADAPT OR TAILOR THE SLIDE INFORMATION TO THE REPRESENTATIVE COUNTRY.**

Let's talk about mercury. Where does mercury pollution come from? A lot of mercury pollution originates from the burning of materials that contain trace amounts of mercury, such as burning of fossil fuels, smelting of mercury-containing ores, cement production, and waste incineration. Of note here, is that around 40% of mercury emitted into the environment comes from artisanal and small scale gold mining, making it the single largest source of anthropogenic emissions of mercury to the environment.

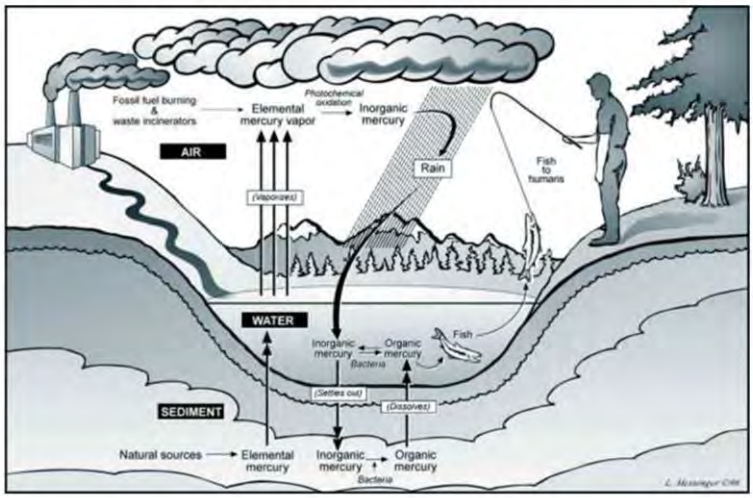



**PLEASE NOTE: PRESENTERS ARE ENCOURAGED TO ADAPT OR TAILOR THE SLIDE INFORMATION TO THE REPRESENTATIVE COUNTRY.**

**SAY:**
Mercury is intentionally added to certain products, such as button cell batteries, fever thermometers, blood pressure cuffs, and fluorescent lamps. Mercury is still used in certain industrial processes as well: in fact the largest use of mercury globally is ASGM, where miners use mercury to extract gold from ore. Mercury is also used in an outdated process to manufacture chlorine and caustic soda (that is, chlor-alkali production) and as a catalyst in a unique process for polyvinyl chloride (PVC) plastic manufacturing in China.

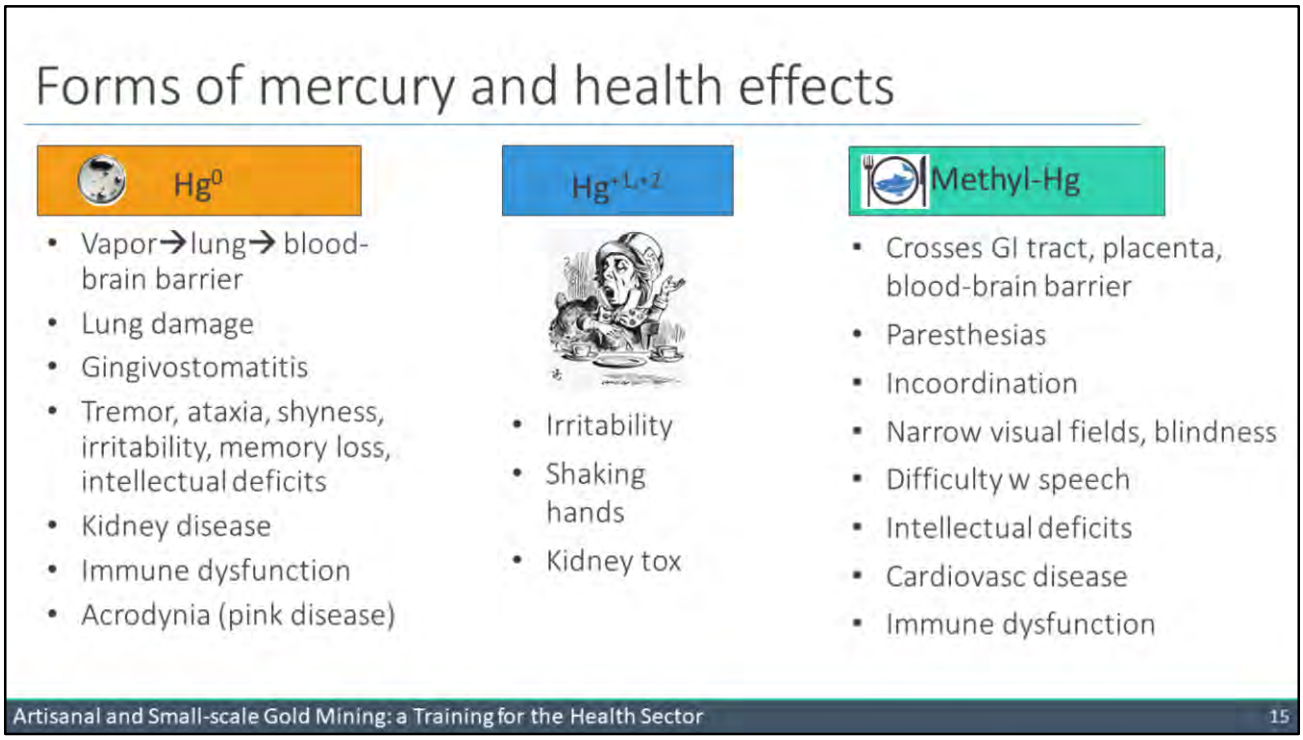
The United Nations Environment Programme (UNEP) estimated the total annual air emissions of mercury in 2018 at about 2,200 metric tons, with artisanal gold mining and fossil fuel burning as the two largest sources. (https://web.unep.org/globalmercurypartnership/technical-background-report-global-mercury-assessment-2018)

# Mercury in the environment






How does mercury move in the environment? Emissions of elemental mercury from factories, fossil fuel burning and waste inceineration go up into the air and fall onto the soil. Rain and water runoff carries the mercury that is deposited on land into the waterways. Mercury may also be deposited from the air directly into waterways. Elemental mercury evaporates into the air and is washed back into waterways with the rain. In the water, fish eat the mercury and transform the elemental mercury into an organic form. Big fish eat little fish and the organic mercury gets moved up the food chain. People who eat fish contaminated with organic mercury are at risk for mercury toxicity. Mercury toxicity causes adverse health effects. As learned from the Minamata Bay disaster in the 1950s, the nervous system is particularly affected, with abnormal intellectual development and abnormal motor and sensory function. Note that there may be elemental mercury that naturally occurs in soil or rock. But the natural environment contributes a very small amount of mercury compared to man-made sources.

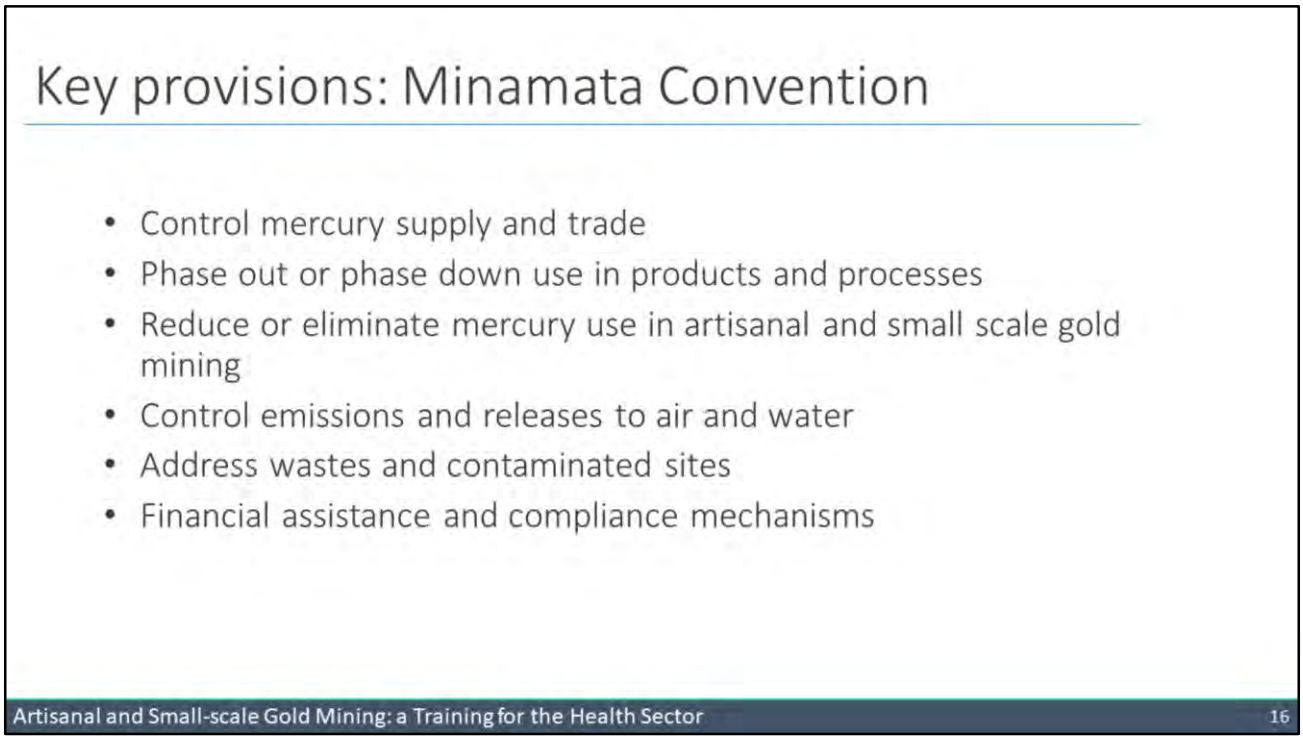



There are three major forms of mercury. One is elemental mercury – the silver stuff that is used in thermometers and pressure gauges like blood pressure machines (sphygmomanometers) and also meters that are used in industry and sometimes in homes. That form of mercury ($Hg^0$) is the type that is handled in ASGM. This form of mercury volatilizes easily, even at room temperature, and there are many case descriptions in the published literature of individuals, often children, playing with liquid mercury, spilling it at home, and multiple family members becoming ill due to inhaling the fumes. When they do this, they get direct lung damage, inflammation of their gums with ulceration, and kidney disease. But this elemental mercury can also get into the nervous system to cause neurologic disorders that are manifested in tremor, ataxia, irritability, memory loss, and individual deficits. It also causes a condition called "acrodynia" or "pink disease" with painful, pink, and desquamating hands and feet. We will spend time learning about these effects later in the course.

Methyl Mercury is the form that is of concern in Minamata Disease. As described, when elemental mercury is spilled into the environment, it gets processed in the environment and changed into an organic form. For example, it is eaten and organified by fish, where it gets stored in fat. As bigger fish eat littler fish, the methyl mercury becomes biomagnified—that is, higher concentrations can be found in larger fish. When humans eat those fish, they get larger doses of methyl mercury. This is what happened in the Minamata Bay of Japan, leading to Minamata Disease and, now, the Minamata Convention. Because it is lipophilic, or fat soluble, methyl mercury crosses the GI tract, the placenta, and the blood brain barrier. It causes paresthesias—tingling of the extremities—incoordination, intellectual deficits, difficulty with speech, immune dysfunction. It also narrows the visual fields, causing tunnel vision and eventually blindness.

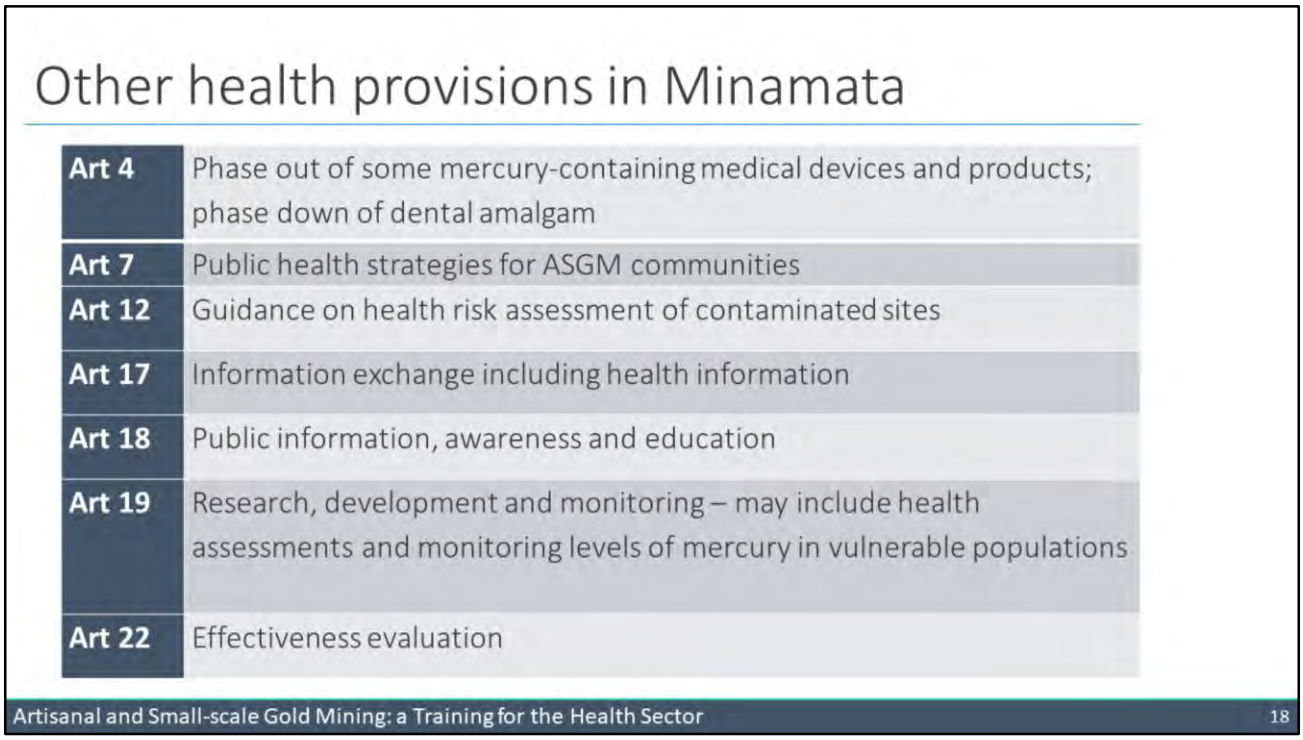
For the sake of completeness, the third form of mercury needs to be described. The picture in the center is a block print from the original Alice in Wonderland publication showing the Mad Hatter. Hat makers used mercury salts in their work process. This exposed them to mercury, as well, causing irritability, tremors, and kidney toxicity. It you read Alice in Wonderland, you can get a good description of the neurologic manifestations of mercury salt exposure. We've included this form of mercury for the sake of completeness.

So just to reiterate the point, elemental mercury ($Hg^0$) is the form used in ASGM processes that is handled by miners; it gets spilled into the environment where it becomes organified—or changed into methyl mercury--biomagnified, and ingested by humans, causing Minamata Disease.




The Minamata Convention comprehensively addresses all these major sources of mercury pollution. It requires the phase out mercury-based products and processes, such as measuring devices and chlorine manufacturing, and requires the phase down of others such as dental amalgam and plastics production; moreover, the Convention addresses measures to reduce mercury use in ASGM. It creates a framework to control supply and trade, which is intended to increase the price and reduce the availability of mercury, in order to create an incentive for users to switch to mercury-free alternatives. The control of mercury air emissions from coal-fired power plants, nonferrous metal smelters, cement plants and waste incinerators are also required by the Convention. (Countries must also take measures to control releases to water, but these provisions are more flexible.)


Despite the fact that the Minamata Convention is primarily an environmental convention, health protection plays a prominent role in the Convention language, and is, in fact, mentioned in the Convention objective, which is to "protect the human health and the environment" from mercury. Article 16, entitled "Health Aspects," is the most direct call for the involvement of the health sector in the implementation of the Convention. It encourages countries to develop and promote programs to identify and protect populations at risk; to promote programs on recognition of occupational exposures; to promote health care services for prevention, treatment and care of exposed populations; and to strengthen capacity for prevention, of diagnosis, treatment and monitoring of health risks from mercury.




While Article 16 is the most obvious place in the Convention where the health sector is called to action, there are a number of other provisions that are strongly related to health as well. Article 4 requires the phase-out of various medical devices, such as thermometers and blood pressure cuffs by 2020, while use of dental amalgam is to be phased down. The successful transition to mercury-free alternatives will require the close involvement and cooperation of medical professionals. In Article 7, public health strategies must be developed to address mercury exposure from artisanal and small scale gold mining – which is the subject of this training. More about this a bit later. Article 12 requires the development of guidance on assessment methods to help countries evaluate human health risks from mercury-contaminated sites. Article 17 encourages exchange of information, including information on health effects of mercury; Article 18 calls for provision of public information on health effects of mercury, among other topics, as well as education training and public awareness raising; and Article 19 calls on countries to cooperate on research, monitoring and assessment of impacts, which may include monitoring mercury in vulnerable populations. Finally Article 22 envisions the evaluation of the effectiveness of the convention, and part of this evaluation will consider trends in levels of mercury observed in vulnerable populations.

It is important to note that priority will be given by governments to the implementation of articles in the convention that are required. Among the list of articles presented above, only article 4 (the phase out of containing medical devices and procedures) and article 7 (addressing public health issues related to artisanal and small-scale gold mining, or ASGM) are legally binding, where applicable. In all of the other articles, parties are encouraged, or asked to promote or facilitate the related provisions.


**SAY:**
The 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), specifically:
Resolution WHA 67.11 encourages member states to:
-Promptly sign, ratify, and implement the Minamata Convention
-Address the health aspects of exposure to mercury
-Recognize the inter-relationship between health and environment and ensure close cooperation
-Promote appropriate healthcare services for prevention, treatment and care
-Facilitate exchange of epidemiological information
Resolution WHA 67.11 also requests WHO
(1) first, to provide advice and technical support to Member States in all health aspects related to mercury in order to promote and protect human health;
(2) second, to provide support to Member States in developing and implementing strategies and programmes to identify and protect populations at risk, particularly vulnerable populations. This may include adopting science-based health guidelines for minimizing health effects of mercury, setting targets for mercury exposure reduction, and public education in collaboration with the health sectors and other involved sectors;
(3) And third, to cooperate closely with the Minamata Convention Intergovernmental Negotiating Committee, the Conference of the Parties, the United Nations Environmental Programme and other international organizations to support the implementation of the health-related aspects of the Minamata Convention on Mercury
--The preamble of the Minamata Convention recognizes the role of WHO, making reference to collaboration between WHO and international government offices in the Convention—Article 7, paragraph 4 (ASGM)
--The Diplomatic Conference resolution on the Convention invites WHO to support implementation


As you can see there are many different places and ways for the health sector to support the implementation of the Convention. However, while it is good to see that the Convention recognizes so many different and vital roles for the health sector, these new responsibilities may be difficult to meet by health ministries that have limited capacity and resources. Countries' health authorities will need support to implement Minamata, including:

- Training and education to develop core competencies of health care providers, especially at the local level, i.e. where mercury exposure is taking place;
- Access to appropriate interventions to reduce/prevent and if necessary treat mercury poisoning;
- Adequate systems to support monitoring, diagnosis and reporting (including laboratory capacity); and
- Global good practice standards/references.

Hence, the development of this course to assist the healthcare sector in addressing the needs of healthcare providers that care for miners and their families, and also those who may be called upon to diagnose, treat, and prevent mercury toxicity.
The World Health Assembly resolution on the "Role of public health ministries in supporting the implementation of the Minamata Convention" provides evidence of formal recognition by Ministries of Health of their part to play in supporting these efforts, including in the area of artisanal and small scale gold mining (ASGM). The implementation of activities that reduce mercury exposure to people and the environment are critical to realizing the objectives of the Minamata Convention.

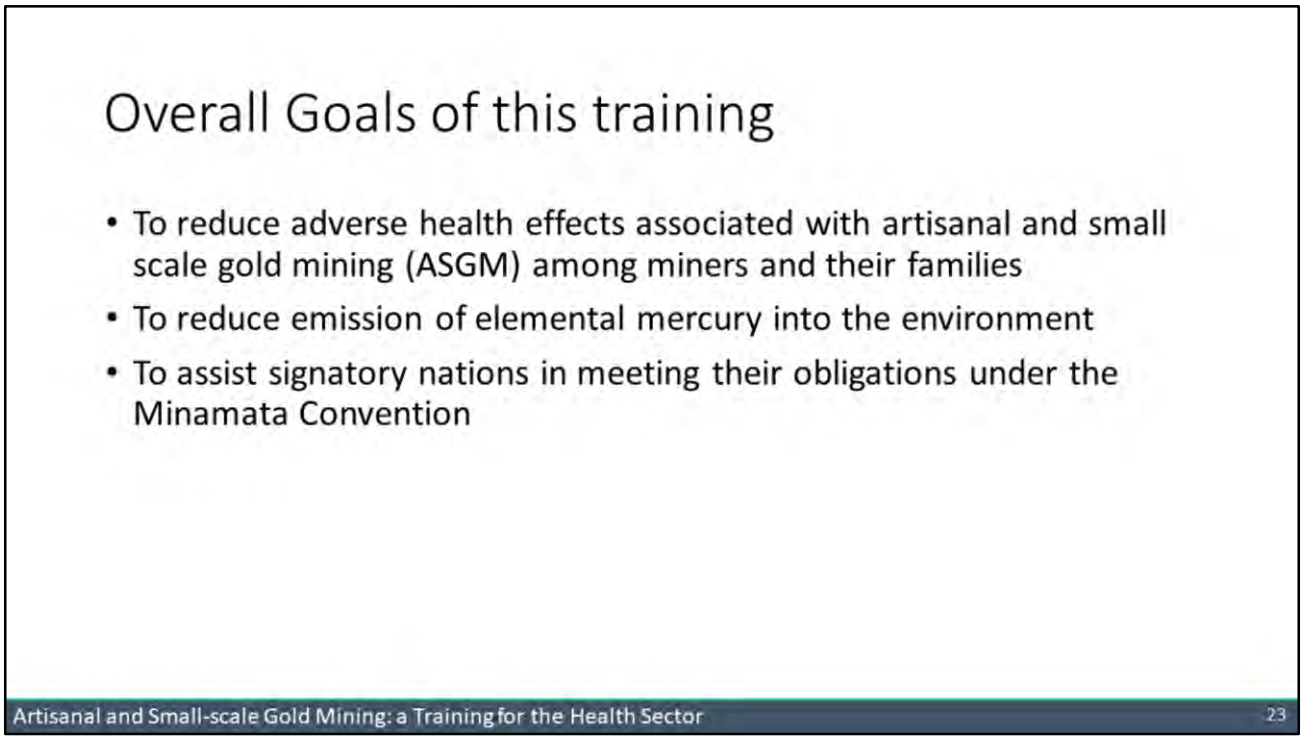
# Public health strategies for ASGM

- 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

Artisanal and Small-scale Gold Mining: a Training for the Health Sector 21

So what are the public health strategies for ASGM?
Under many of the Convention provisions where health is mentioned, countries are encouraged to address relevant health issues. Under Article 7, countries with significant ASGM must create a comprehensive National Action Plan that describes how they will reduce—and, where feasible, eliminate--mercury use and mercury releases from this sector. Annex C of the Convention describes the required elements of the National Action Plan. One mandatory element is the development of "a public health strategy on the exposure of artisanal and small scale gold miners and their communities to mercury," while a related element is the requirement to develop "strategies to prevent exposure of vulnerable populations , particularly children and women of child-bearing age, especially pregnant women, to mercury used" in ASGM. Because these are required elements of the Convention, this training focuses on describing typical public health risks from ASGM from mercury use, as well as other health hazards in the sector, and discusses particular strategies and interventions at the community level and at the policy level, to address these risks.

# For Training of Trainers

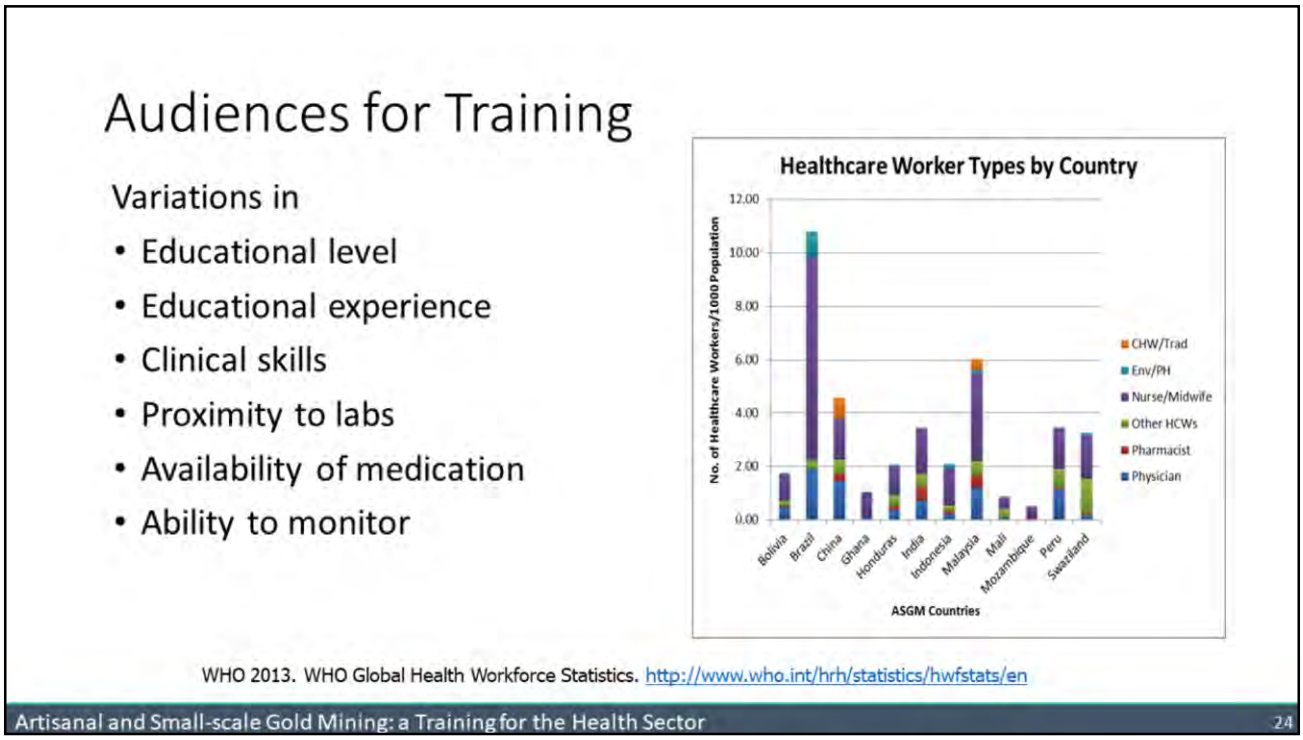



This course was initially developed for the World Health Organization (WHO) as part of a wider package of materials for use by Ministries of Health to support the implementation of health-related requirements under Article 7 of the Convention. The specific focus of this course is on building health care provider capacity to identify and address environmental and occupational health issues associated with ASGM, as part of wider efforts to reduce exposure to mercury in ASGM communities.

Many different people were involved in the process of developing this course—at the University of Illinois in Chicago, across the US, and internationally. We based this work on workshops previously conducted by WHO—particularly one in Mongolia in 2013. And we also used print and web-based materials and case studies conducted by clinicians, public health professionals, and journalists around the globe. We piloted these materials in Ghana in 2015 and obtained student and connoisseur evaluations.

In keeping with the terms of the Minamata Convention, the overarching goals of this curriculum are:

- To reduce adverse health effects associated with 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




**PLEASE NOTE: PRESENTERS ARE ENCOURAGED TO ADAPT OR TAILOR THE SLIDE INFORMATION TO THE REPRESENTATIVE COUNTRY.**

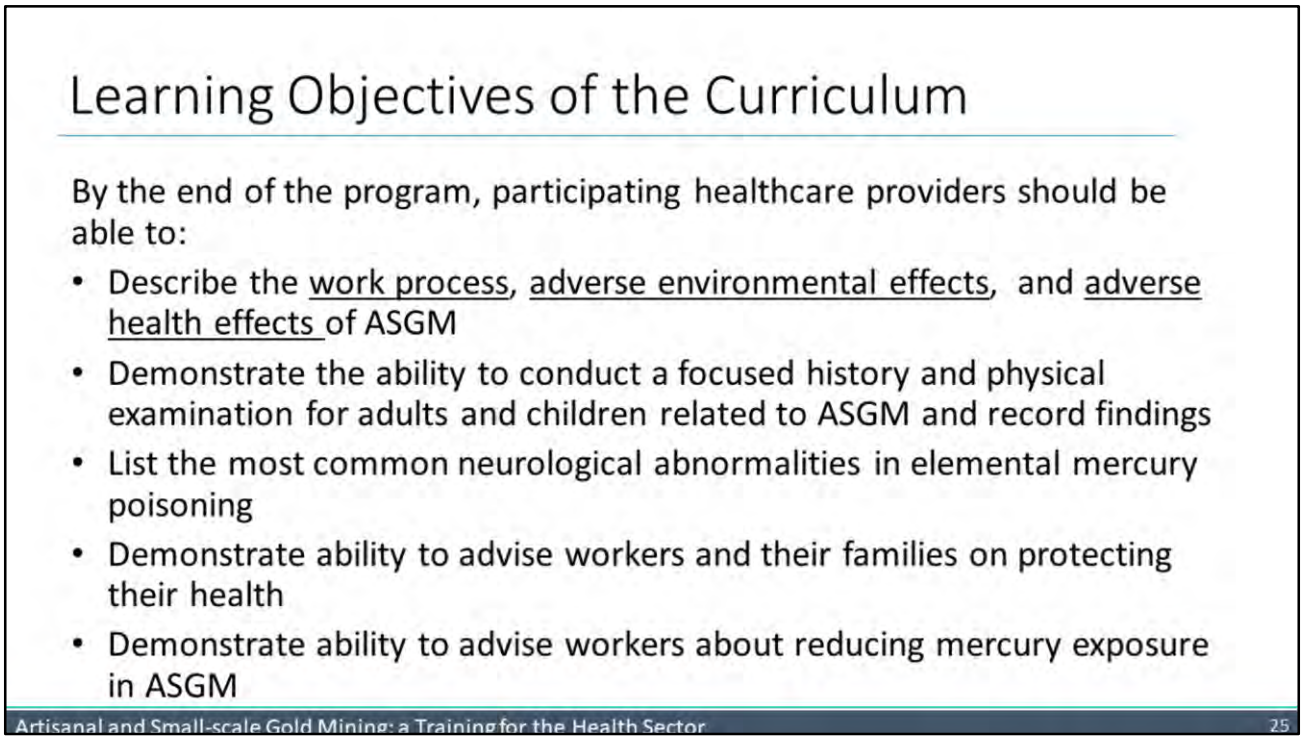
**THIS SLIDE IS ONLY FOR TRAINING OF TRAINERS; NOT IN ACTUAL TRAINING**

Primary health care workers are the target audience for this training. Who are the primary health care workers around the globe?

Based on the WHO database on human resources in primary health care in order to inform policy and resource allocation decisions on a national and international level [WHO 2013. WHO Global Health Workforce Statistics. http://www.who.int/hrh/statistics/hwfstats/en/]. The bar chart in this slide shows segments of the health care workforce among selected countries where ASGM occurs. In all of these countries, nurses and midwives are the largest part of the health care workforce, and there are efforts to increase the number of community health workers, worldwide. Notably, physicians, and particularly environmental and occupational health specialists, are a very small proportion of the health care workforce. Therefore, the content and pedagogical techniques need to be facilitated at a variety of levels. For example, physicians are most familiar with lectures and slideshows; they have considerable training in physical diagnosis and all organ systems. They are in position to diagnose subtle neurologic changes and treat mercury intoxicated patients with medication. Nurses, nurse midwives, community health workers, and pharmacists, have varied training and experience with clinical diagnosis. Furthermore, these groups have varied experiences with learning styles—classroom training, versus hands-on, workshop style training. A curriculum for the recognition and management of mercury poisoning and other health conditions associated with ASGM in adults and children needs to include an array of resources and activities designed for the varied workforces that need this training. Theories and principles of "adult learning," have been considered in curriculum development, as well.

In order to increase knowledge and skills of primary health care workers, as well as their attitudes and behavior, it is important to:

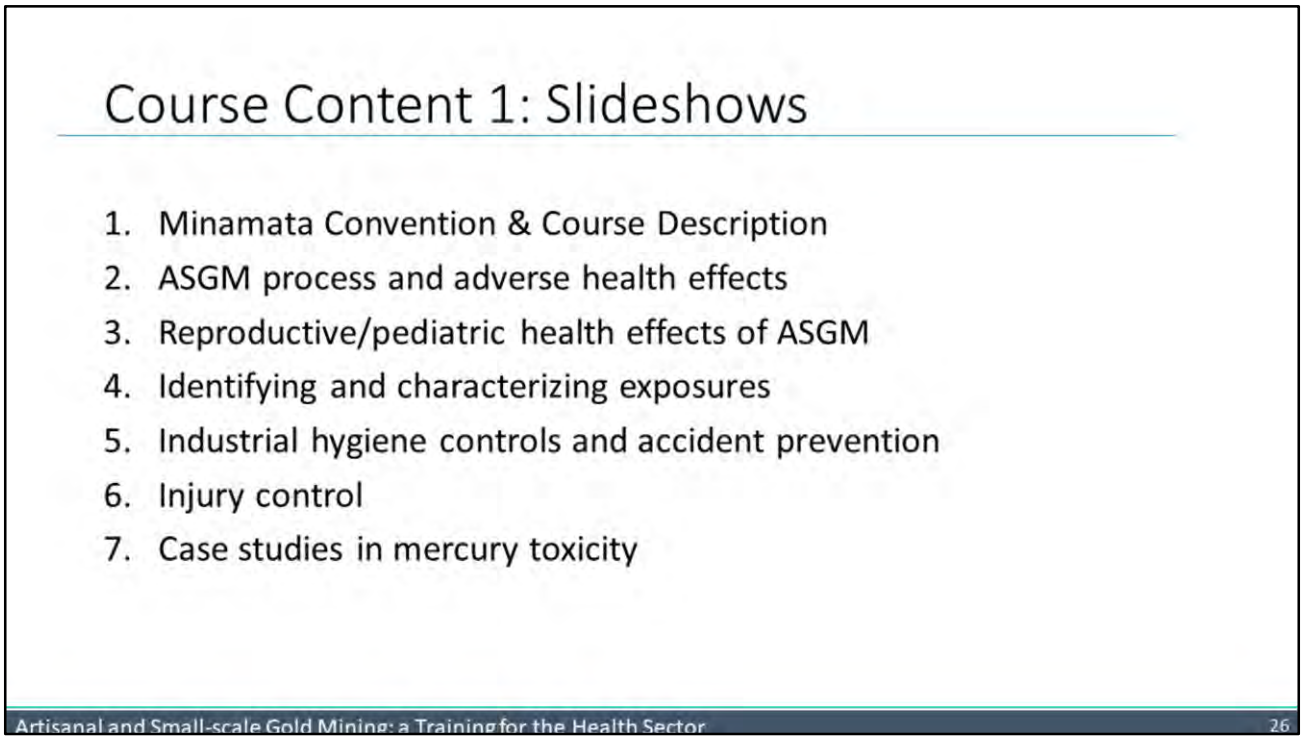
- Use familiar/comfortable modalities
- Promote interactivity and experiential learning
- Reinforce concepts with redundancy, different modalities to drill on single topics
- Use relevant/local examples to illustrate principles




**SAY:**

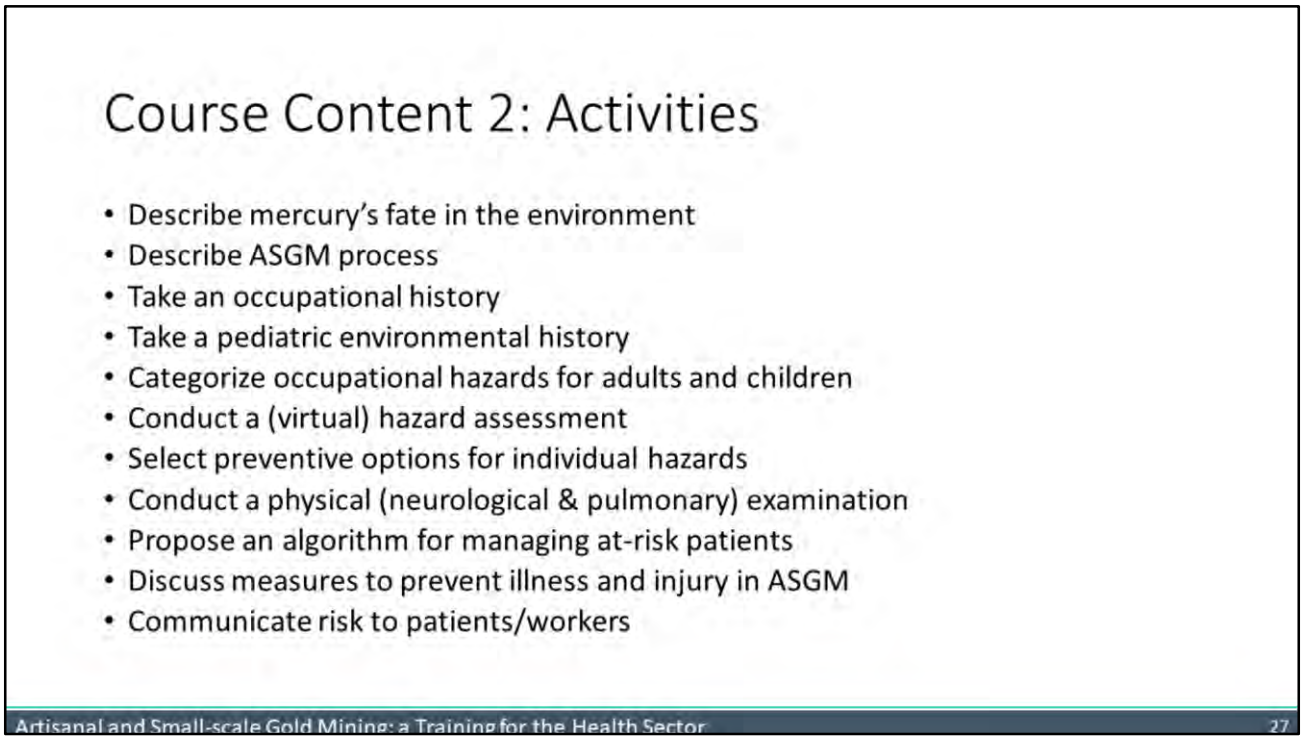
We have developed a 2-day course with the following learning objectives. By the end of this lecture participating healthcare providers should be able to:

- Describe the work process, adverse environmental effects, and adverse health effects of ASGM
- Demonstrate 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



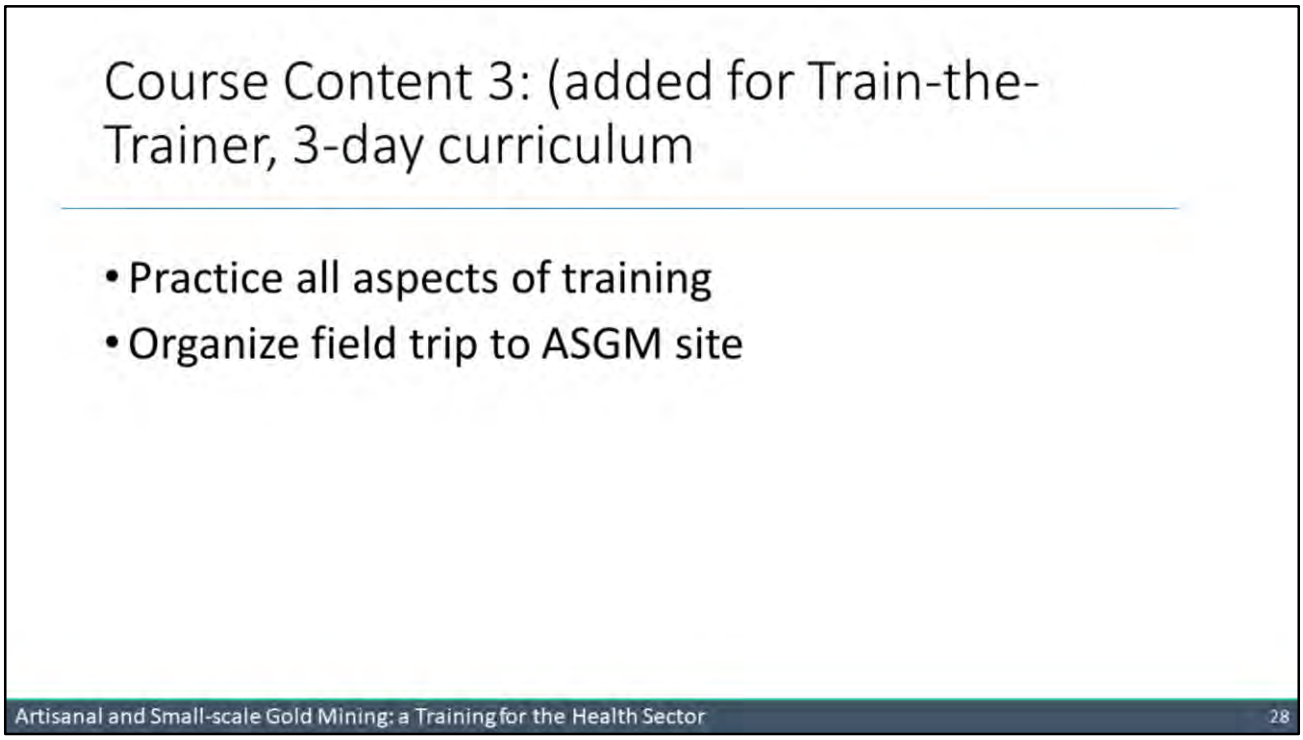

**SAY:**
This course has a series of slideshows and activities or exercises that you will engage in during the course. There are 7 slideshows, listed on this slide. This slideshow, that I am delivering right now, gives you an overview of the Convention and of the course. We will intersperse the other slideshows with activities and breaks so that you have time to digest what you are learning in an integrated fashion. There is redundancy built into the slideshows and activities in order to reinforce the points being made. You will also have the opportunity to practice the skills you are learning in this course.

For those of you who will go on to train others in this curriculum, we will provide opportunities during this training for you to practice teaching, using the slides and activity props we are using here.

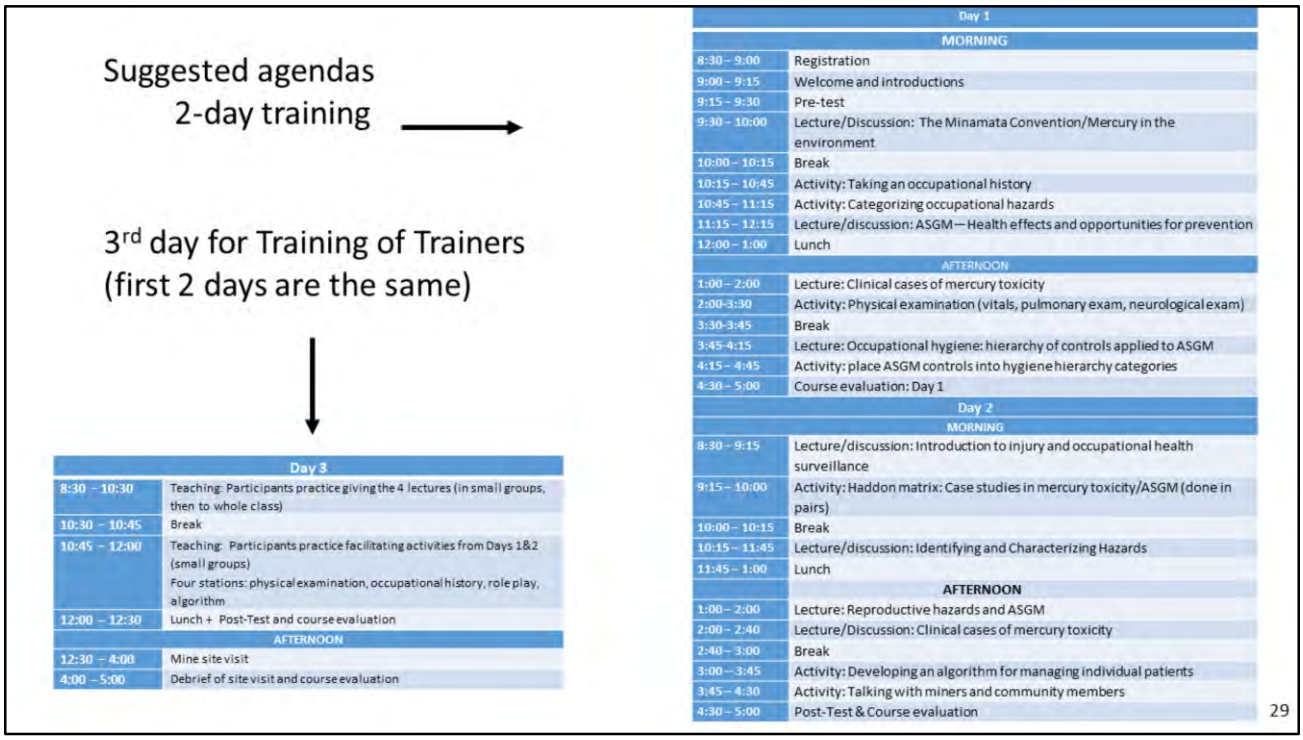



**SAY:**
In addition to slideshows, the activities described in this slide will be done, namely:

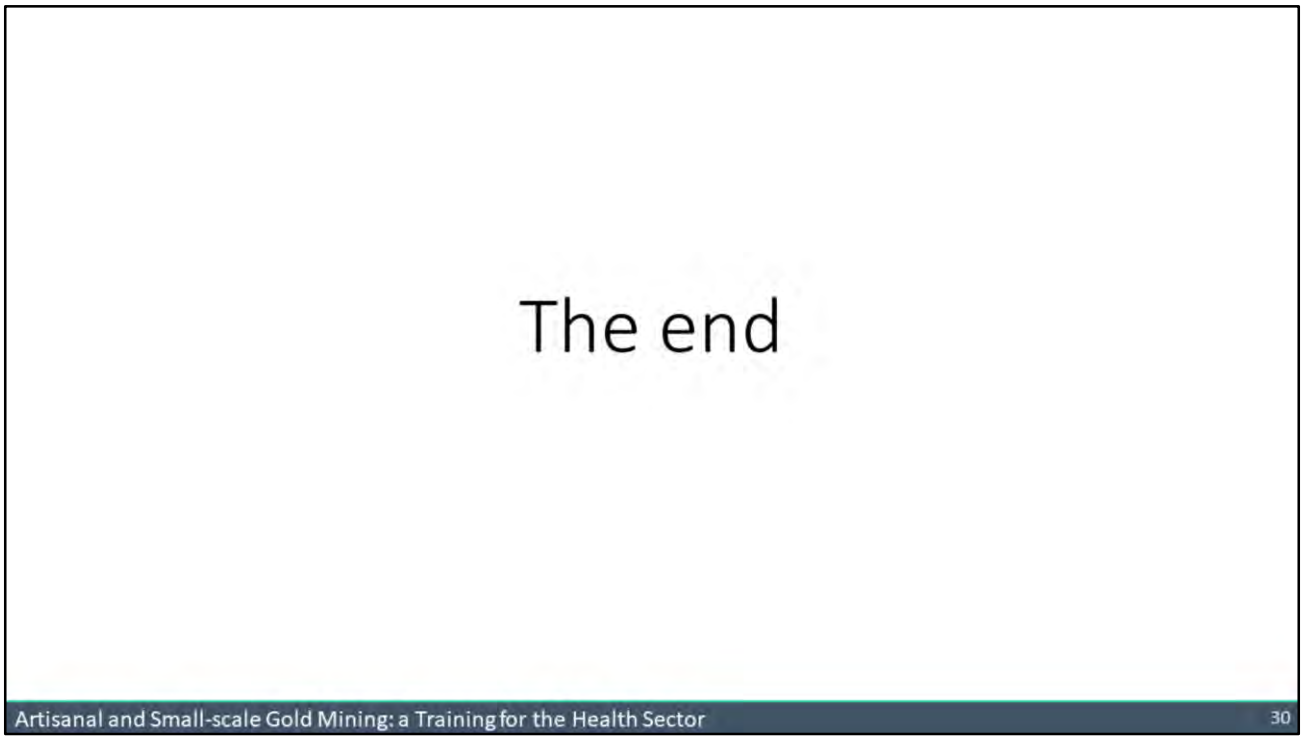
-Describe mercury fate in the environment
-Describe ASGM process
-Take an occupational history
-Take a pediatric environmental history
-Categorize occupational hazards for adults and children
-Conduct a (virtual) hazard assessment
-Select preventive options for individual hazards
-Conduct a physical (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




Throughout the training you will have several opportunities to apply what you are learning and obtain feedback from the trainers. If possible, we will also arrange a field trip to an ASGM site to help illustrate key aspects of the training.




Agendas are suggested for a 3 day training of trainers and a 2-day training of participants. It is expected that the trainers would get trained first in a 3-day program. They would then use the 2- day program to train participants. Slides, activities and evaluation tools can be printed and compiled into folders, one for each participant.



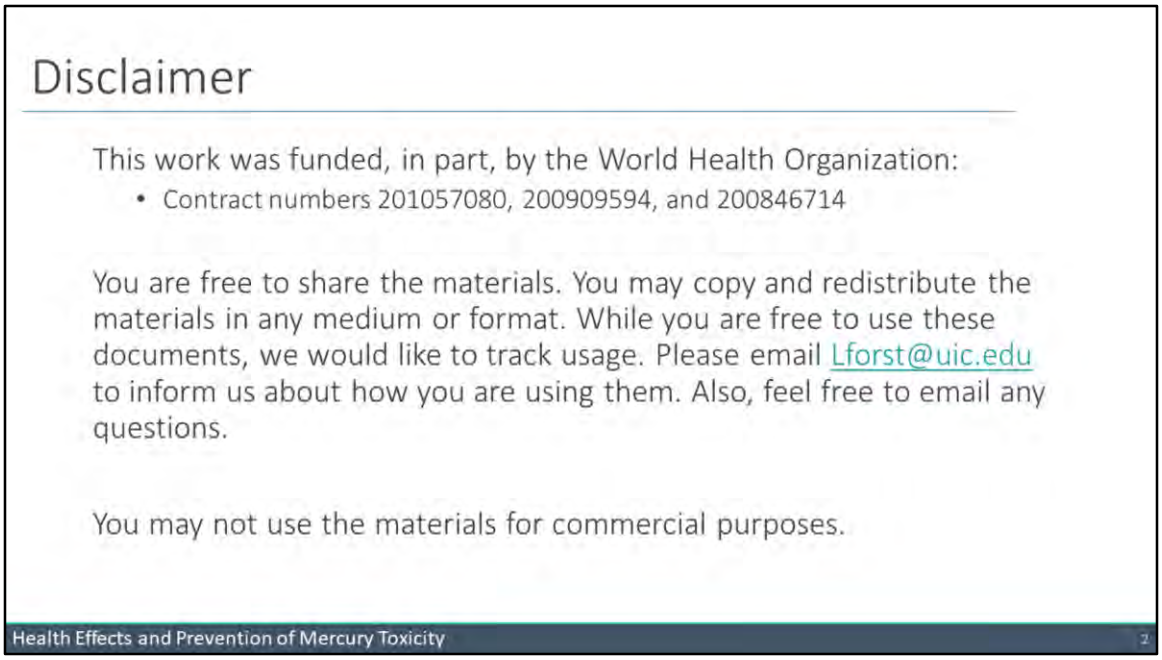

**SAY:**
We look forward to an engaging and interactive few days together. Thank you.

# URL to all powerpoints

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): Health Effects and Prevention of Mercury Toxicity
UIC
Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago
A WHO Collaborating Center

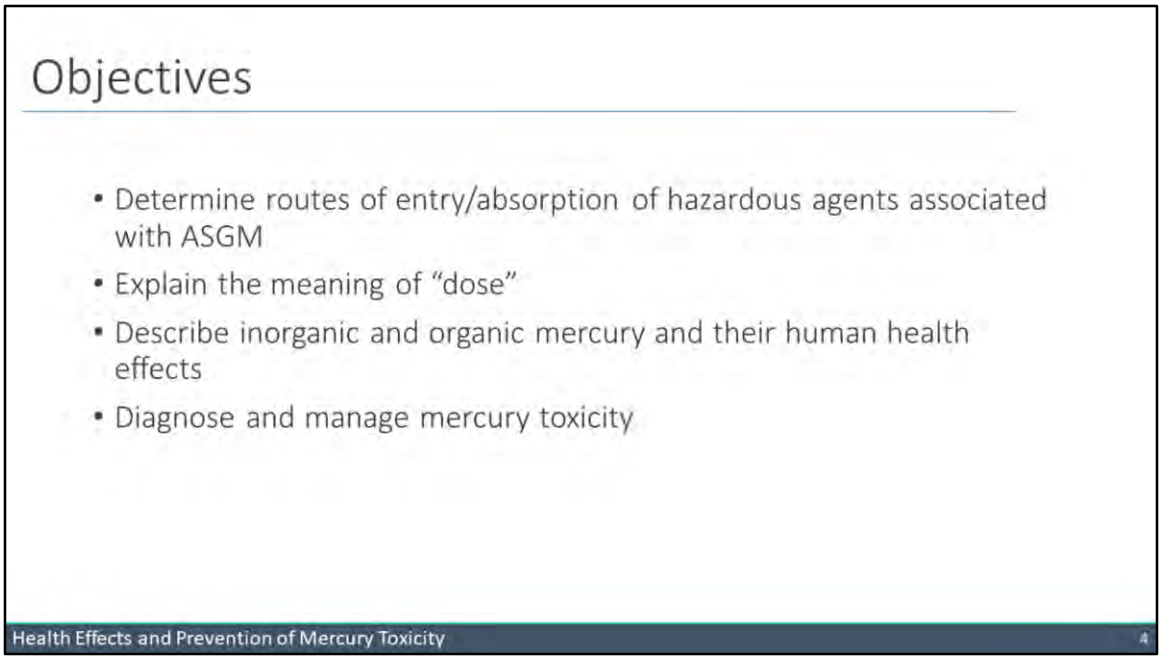



This is the opening lecture for the World Health Organization's course on the health issues surrounding Artisanal and Small Scale Gold Mining. This course was developed to assist countries in preventing illnesses and injuries among gold miners and their families. By the end of this lecture, you should be able to describe at-risk populations in the subsistence gold mining sector and discuss the Minamata Convention and WHO's efforts to address the human health provisions. You will get an introduction to elemental and organic mercury toxicity in this lecture. But we will spend more time on the health effects of mercury later in the course.

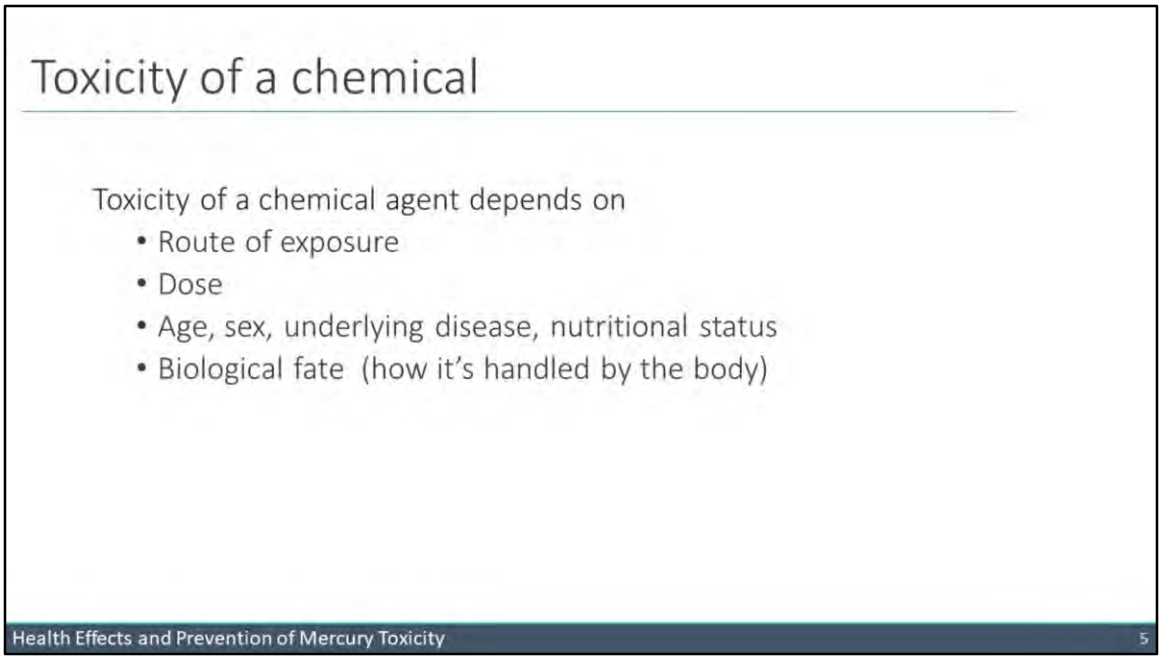
Photo source: https://www.thegef.org/events/implementation-launch-gef-gold-programme

Health Effects and Prevention of Mercury Toxicity 3

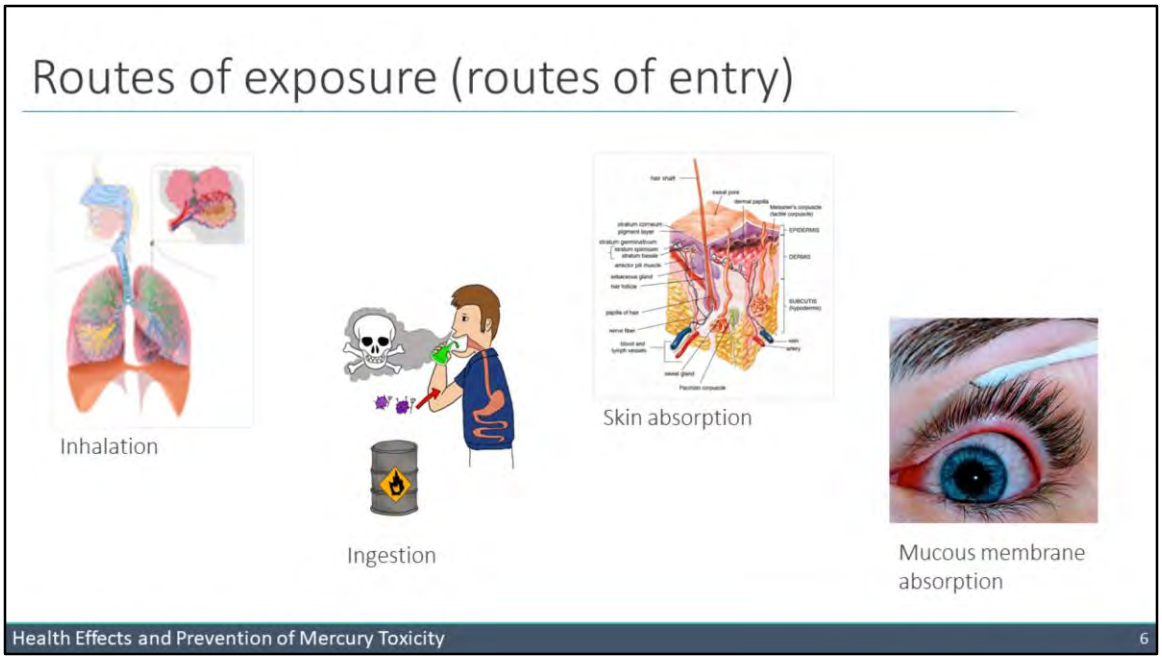
In this photo, taken for the GEF GOLD meeting in 2019, a miner holds a nugget of the combined mercury and gold almagam that comes from ore he mined after working a 28-hour shift at a gold mining process Peru. Thousands of artisanal gold miners work long shifts to earn enough income to support them and their families in regions where there is little economic activity. This slideshow was developed for the WHO curriculum on Artisanal and Small Scale Gold Mining with an intended audience of primary health care providers who are called upon to address the health and healthcare needs of ASGM miners and their families. This slide show is part of a 2- or 3-day comprehensive course and addresses only the human health hazards of ASGM.




This slideshow is designed to give you an overview of the ASGM process. We will also talk about how mercury and other chemical agents enter the body—the so-called "routes of exposure" or "routes of entry." We will talk about the differences between inorganic and organic mercury. And you will hear about the health effects of mercury poisoning and how you diagnose children and adults who are intoxicated with inorganic and organic mercury. Finally, this presentation will give you some information about laboratory procedures used to diagnose elevated mercury levels




The toxicity of any chemical agent depends on a number of things. These include the way the agent enters the body—the route of exposure or the route of entry. Second, it depends on the dose of the exposure: The age, sex and nutritional status of the exposed individual is also important. These all affect the biological fate of a chemical in the body.




**Routes of exposure or routes of entry** are the mechanisms by which chemicals get into the body. The four major routes are inhalation—breathing into the lungs. Ingestion—swallowing a chemical into the GI tract. Dermal or skin absorption. And absorption through mucous membranes—in this case, the eye. Chemical agents that are both water soluble and fat soluble can enter easily into the lungs or be ingested. Only fat soluble, or lipophilic agents get in through the skin unless there is a breach of the skin, like a laceration or cracking.

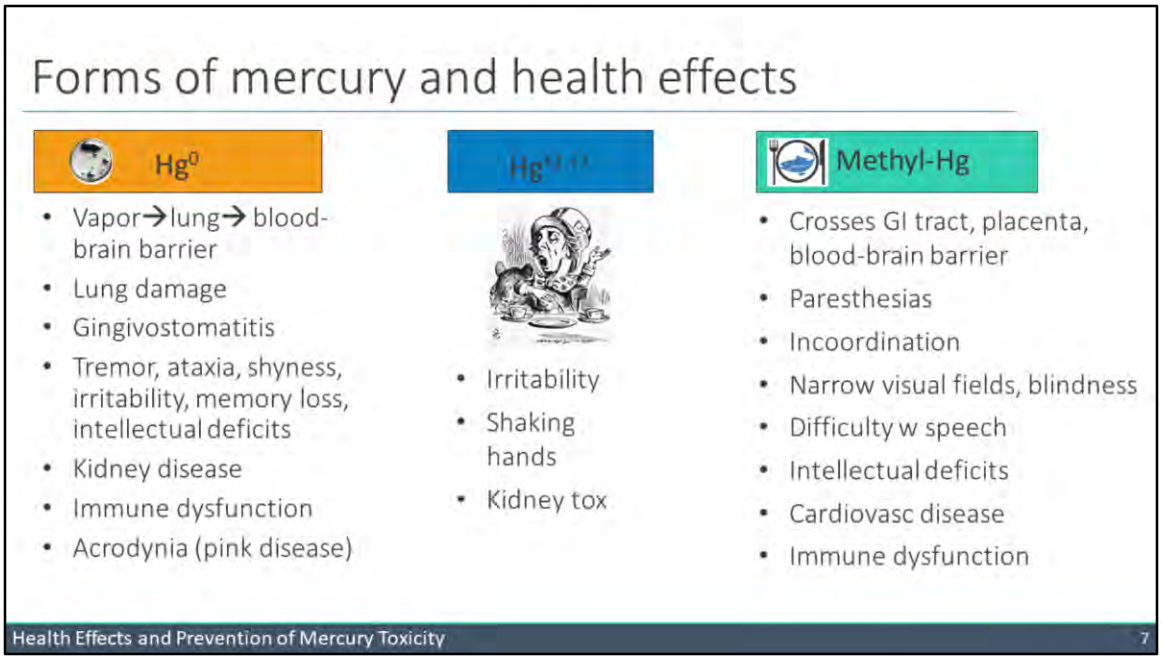
Inhalation: By Bibi Saint-Pol - en.wikipedia.org/wiki/File:Respiratory_system_complete_en.svg, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=28560769

Ingestion: By Erikaiijima - Own work, CC BY-SA 4.0, https://commons.wikimedia.org/w/index.php?curid=47587195

Skin: By US-Gov - http://training.seer.cancer.gov/ss_module14_melanoma/images/illu_skin01.jpg (as last archived 2008-06-12 09:37:35 at

http://web.archive.org/web/20080612093735/http://training.seer.cancer.gov/ss_module14_melanoma/images/illu_skin01.jpg) as displayed by Anatomy of the Skin (as last archived 2008-06-12 09:37:35 at Anatomy of the Skin), Public Domain, https://commons.wikimedia.org/w/index.php?curid=23214373

Eye (mucous membrane absorption): By Joyhill09 - CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=18954730




You saw this in the first slideshow of this set. Just to remind you: There are three major forms of mercury. One is elemental mercury – the silver stuff that is used in thermometers and pressure gauges like blood pressure machines (sphygmomanometers) and also meters that are used in industry and sometimes in homes. That form of mercury ($Hg^0$) is the type that is used to amalgamate gold in the ASGM prcess. Elemental mercury volatilizes easily, even at room temperature, and there are many case descriptions in the published literature of individuals, often children, playing with liquid mercury, spilling it at home, and multiple family members becoming ill due to inhaling the fumes. When they do this, they get direct lung damage, inflammation of their gums with ulceration, and kidney disease. But this elemental mercury can also get into the nervous system to cause neurologic disorders that are manifested in tremor, ataxia, irritability, memory loss, and individual deficits. It also causes a condition called “acrodynia” or “pink disease” with painful, pink, and desquamating hands and feet. We will spend time learning about these effects later in the course.

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eaten and organified by fish, where it gets stored in fat. As bigger fish eat littler fish, the methyl mercury becomes biomagnified—that is, higher concentrations can be found in larger fish. When humans eat those fish, they get larger doses of methyl mercury. This is what happened in the Minamata Bay of Japan, leading to Minamata Disease and, now, the Minamata Convention. Because it is lipophilic, or fat soluble, methyl mercury crosses the GI tract, the placenta, and the blood brain barrier. It causes paresthesias—tingling of the extremities—incoordination, intellectual deficits, difficulty with speech, immune dysfunction. It also narrows the visual fields, causing tunnel vision and eventually blindness.

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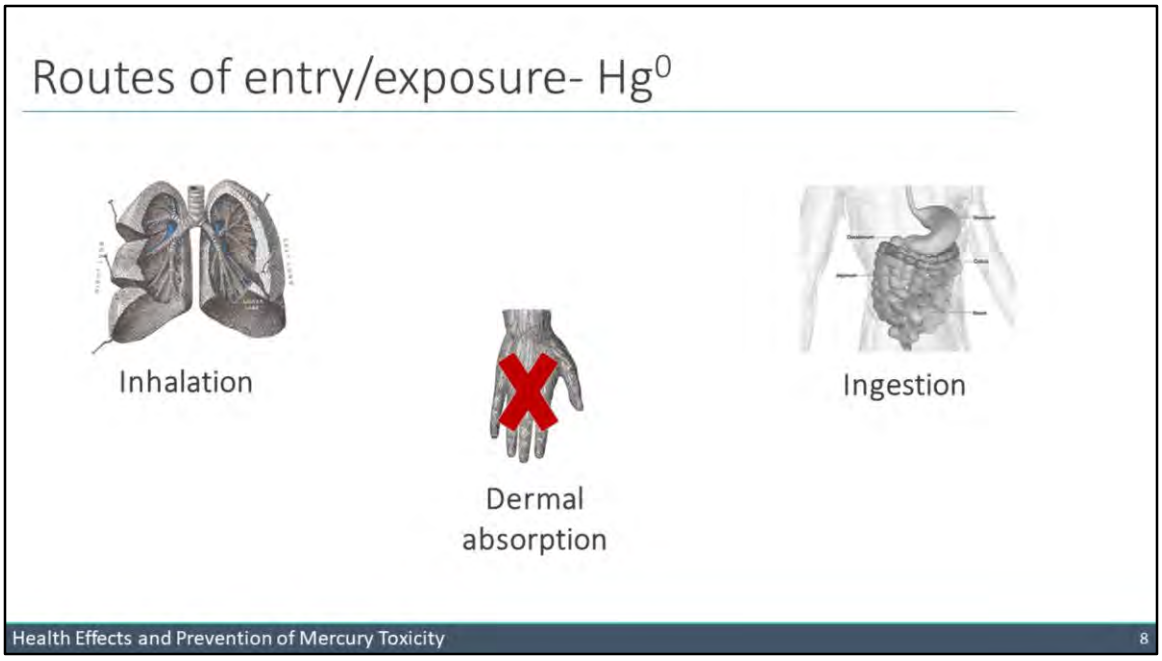
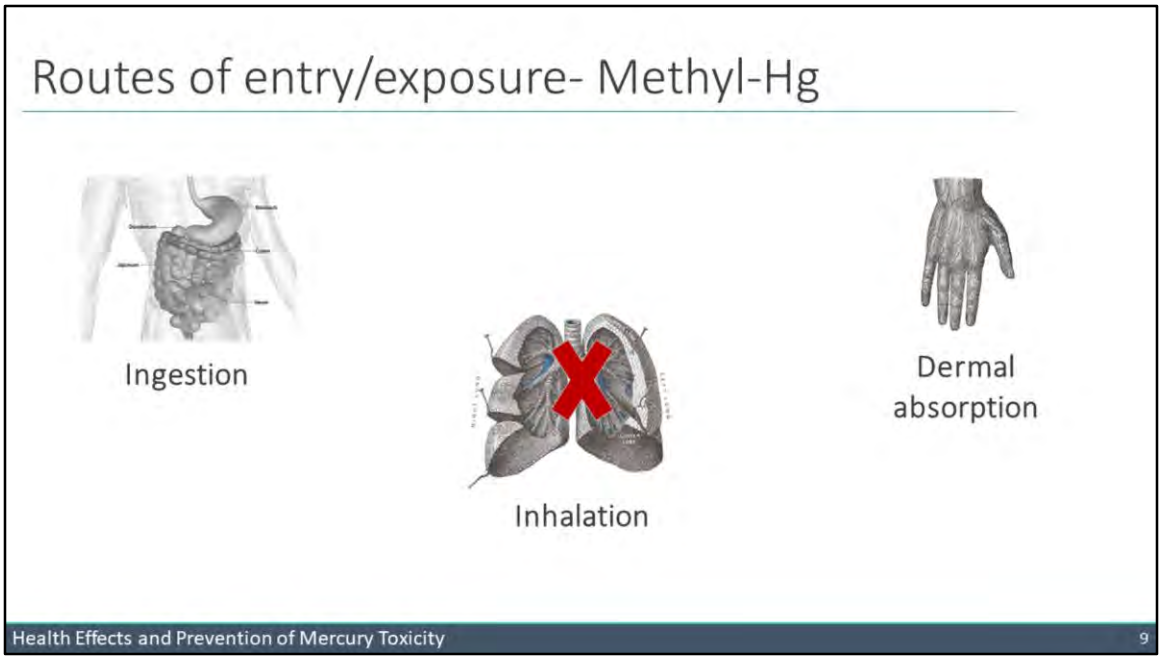


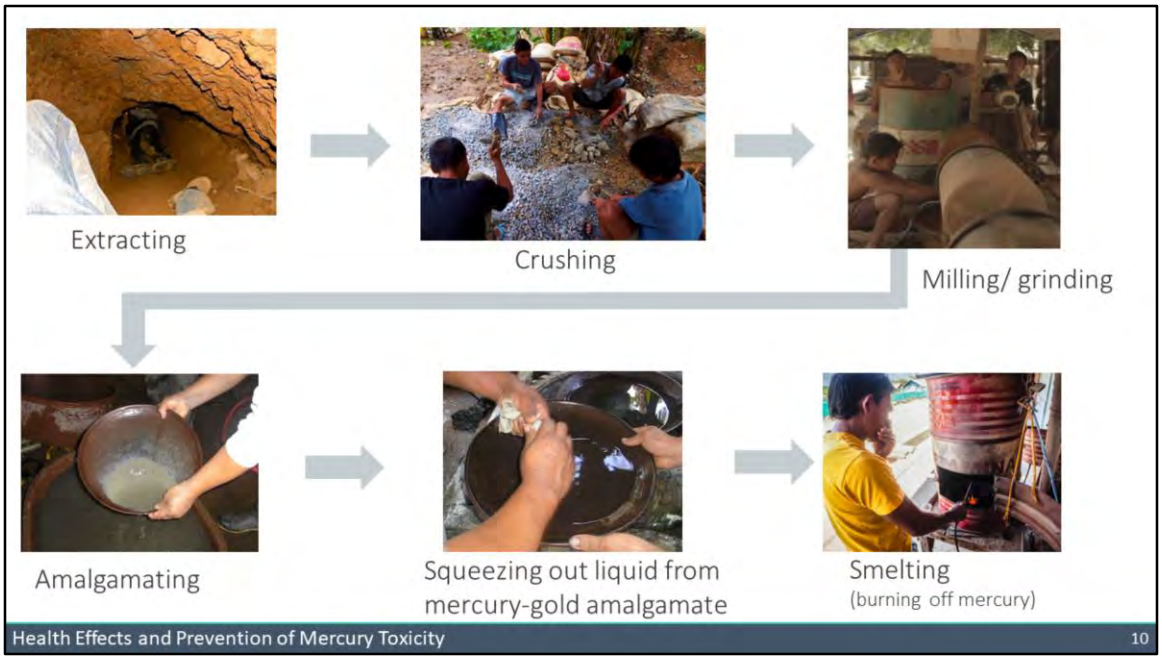

Elemental mercury is not fat soluble. It is typically absorbed via inhalation. It is minimally volatile, or airborne, at room temperature but when heated the volatility greatly increases, aerosolizing the mercury and creating a fume. Absorption by inhalation is about 80%. Elemental mercury can also enter the body secondarily through ingestion, when contaminated hands are put in the mouth, or food is eaten around sites with elemental mercury. Dermal absorption is slow and minimal.

**ASK**: How does the health impact come about?

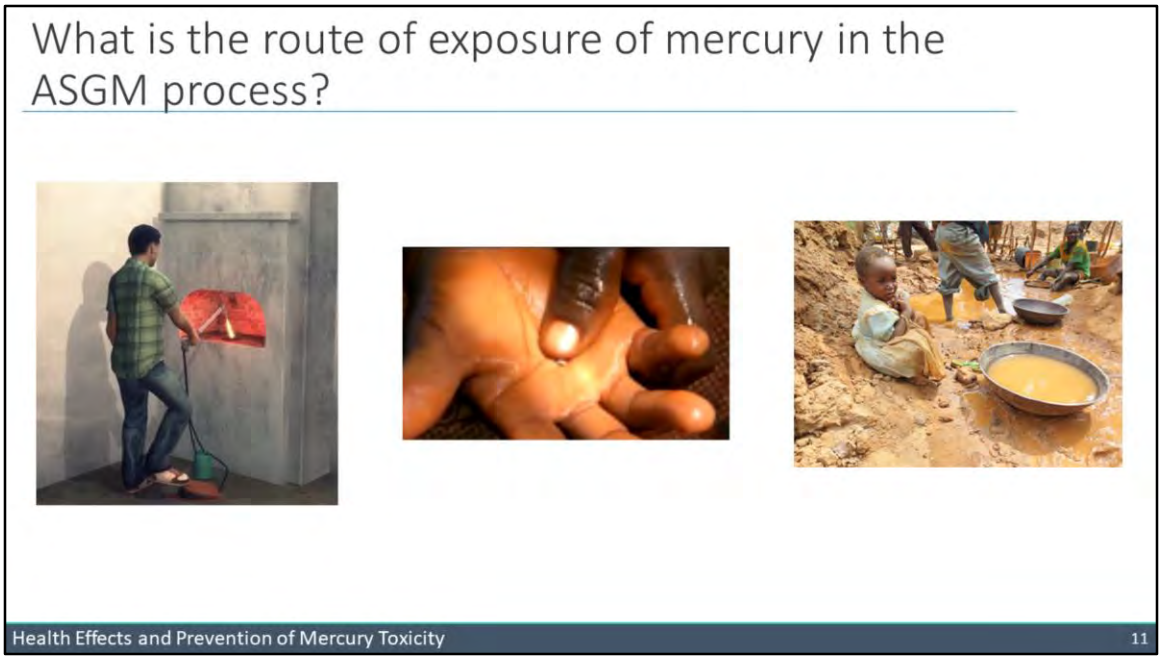
**SAY:** The mercury fume, and all toxins, can enter the body in three ways. Individuals can inhale it or ingest it. Chemical agents may also be absorbed by the skin or move across mucous membranes of the eyes or the nose. Occupational exposures most commonly occur from inhalation and absorption. Ingestion more likely occurs outside the workplace. In the field of Toxicology, inhalation, skin or mucous membrane absorption, and ingestion are the three routes of exposure.




The route of entry for methyl mercury is through the GI tract and through the skin. This is because methyl mercury is fat soluble. Just to remind you, Minamata Disease is due to ingestion of methyl mercury, or organic mercury, in contaminated fish. The aim of the Minamata Convention is to eliminate the use of elemental mercury altogether, which will prevent spillage into waterways or volatilization into air, both sources of which end up in fish in the organic form, as described previously.




You saw this slide in the opening slideshow. To remind you, these are the steps involved in gold mining. They are presented here for your to think about how these activities lead to mercury entry into the body. Don't forget that for ASGM miners and their families, it is elemental mercury we are talking about. Elemental mercury is not fat soluble. The Route of Entry in workplaces is mainly through inhalation that occurs during the burning or smelting process. Note the man in the bottom right corner of this slide—he is covering his mouth, probably because the mercury fumes are bothering him. There **is** volatility of mercury even when it is not being heated, though the amount that becomes fume is lower, exposing workers to a lower dose than the dose from burning it. Since the elemental mercury is handled directly during parts of the ASGM process, hand contamination can lead to ingestion and absorption through the GI tract.




**ASK:** What is the route of exposure of mercury in the ASGM process?

In the picture on the left, a torch is being applied to the amalgam to burn off the mercury. This transforms the solid into a fume. Inhalation is the route of exposure or the route of entry. The fume also could come into contact with the eyes of the worker, entering through the mucous membranes.

In the middle picture, the mercury-gold amalgam is held in the hand. Remember, skin or dermal absorption is limited because the mercury is uncharged and is not very fat soluble. Therefore, it does not readily enter the body through intact skin.

On the right is a baby playing near the (probable) amalgamation process. Babies and young children tend to put their hands in their mouths a lot. Ingestion is the major route of entry for this child. Ingestion can occur in workplaces when workers eat in work areas. Ingestion of contaminated water or mis-labeled containers is another way chemicals can be ingested.

## 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"*



When considering toxicity, dose—or the quantity of a substance absorbed into the body over time-- determines its harmful health effect. This effect is associated with the chemical's properties as it reaches a susceptible organ system within the body in a high enough concentration. Individuals can get exposed to high amounts of a chemical agent over a short period of time, or lower amounts over a prolonged period. The adverse health effects—whether they occur and how severe they are—depend on the the dose. Paracelsus, a Swiss physician and alchemist who lived in $15^{th}$-$16^{th}$ century, is credited as the father of toxicology.

## Fish-eating communities at risk for organic mercury exposure/toxicity

Health Effects and Prevention of Mercury Toxicity 13

For the sake of completeness, and because Minamata Disease relates to organic mercury in the environment, it is important to point out that diets rich in contaminated fish can lead to significant mercury toxicity among fish eating communities. Since organic mercury is lipid soluble, it is easily absorbed through the GI tract and it readily enters the nervous system and other organs where it can cause adverse health effects.

## 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

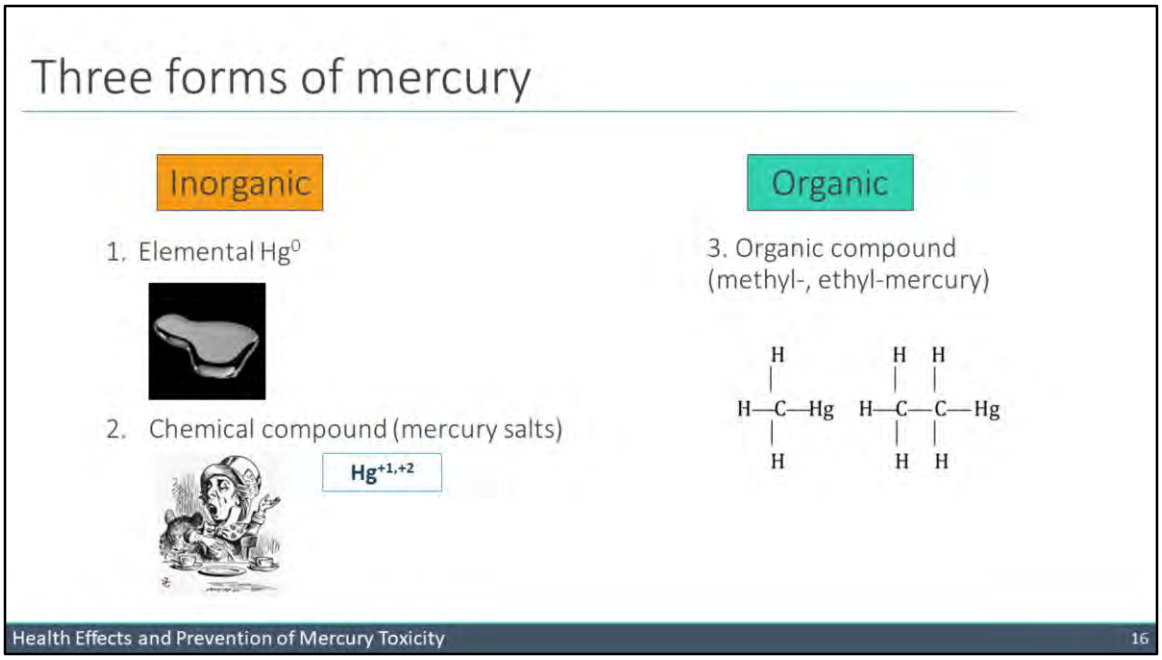
Four-year-old girl plays in an amalgamation pond contaminated with mercury while adults process gold at a site in the Shinyanga Region of Tanzania. Zama Coursen-Neff/Human Rights Watch.

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

Health Effects and Prevention of Mercury Toxicity 14

To summarize, what we have noted in the previous slides, ASGM miners may be exposed to mercury at work and also in the home environment. Aside from activities associated with the work, they may have diets heavy in fish. In this case they would be exposed to elemental mercury from mining and organified mercury from eating fish.


Now we will take about mercury toxicity, specifically

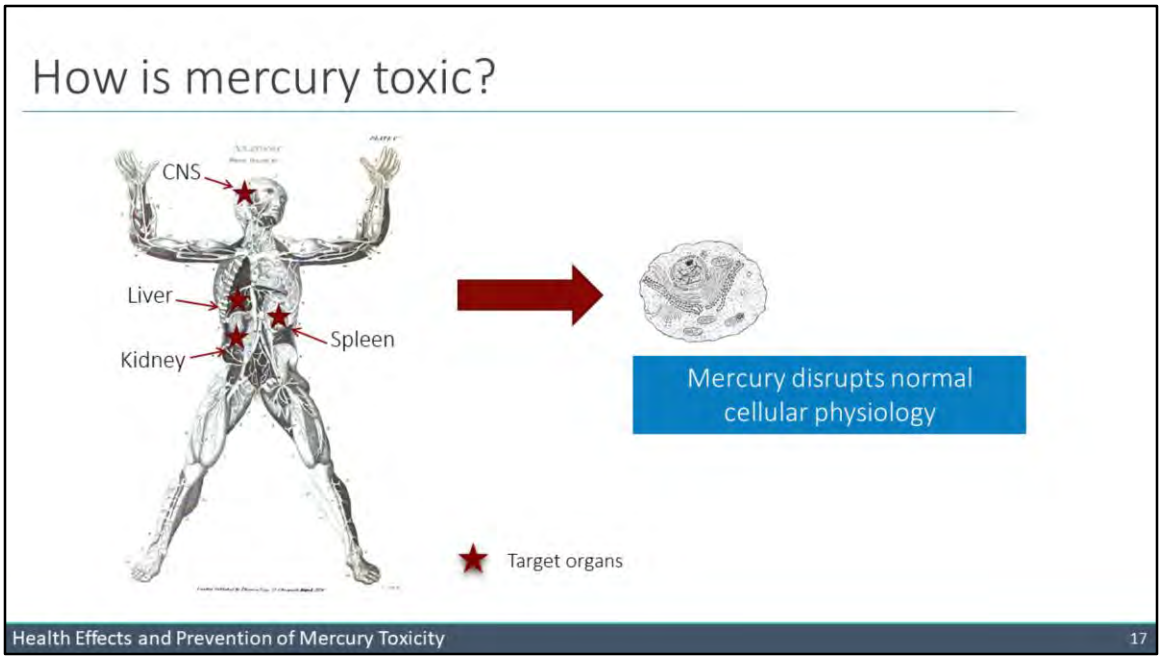



There are three forms of mercury: elemental mercury, mercury as a chemical compound or a mercury salt. And mercury as an organic compound.
An element is naturally occurring in the environment, as you recall, and by definition, it is not broken down further. However elements can form a chemical reaction and become part of a larger molecule. It is important to note this because when we talk about mercury toxicity and ASGM miners, we are talking about a different form of mercury than what fisheaters are exposed to. While any form of mercury is toxic to humans, there are differences in the toxic effects of organic mercury vs. inorganic or elemental mercury.

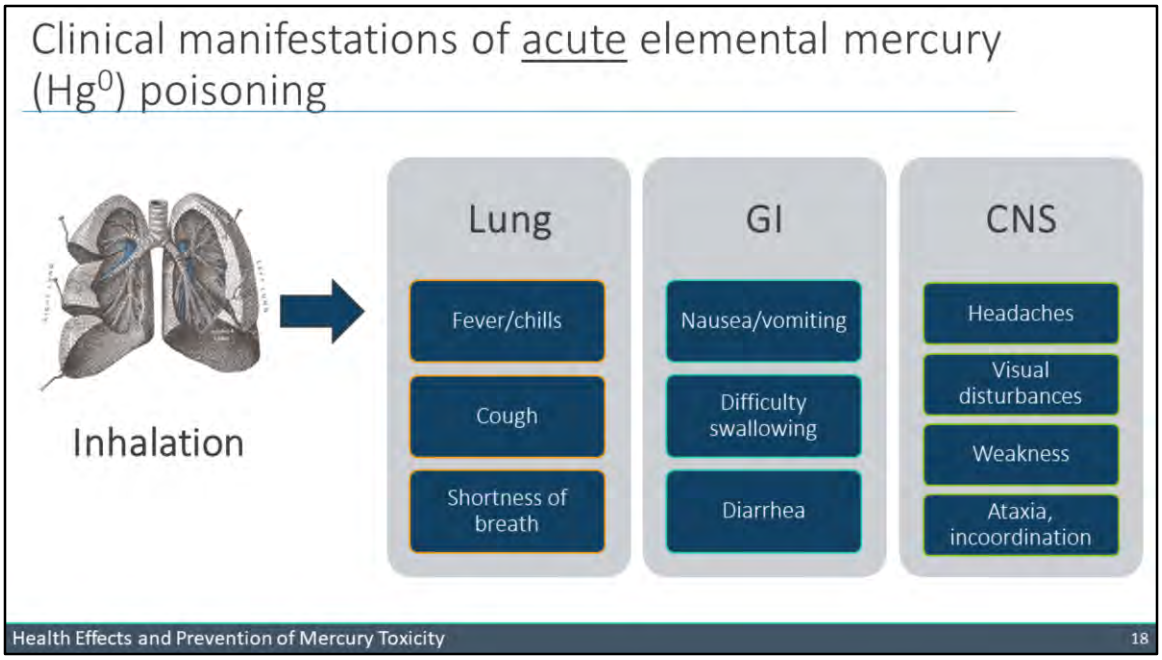
**ASK:** Which form of mercury are ASGM miners/populations exposed to in their work?

**ASK:** Which form of mercury are fish eating communities exposed to?

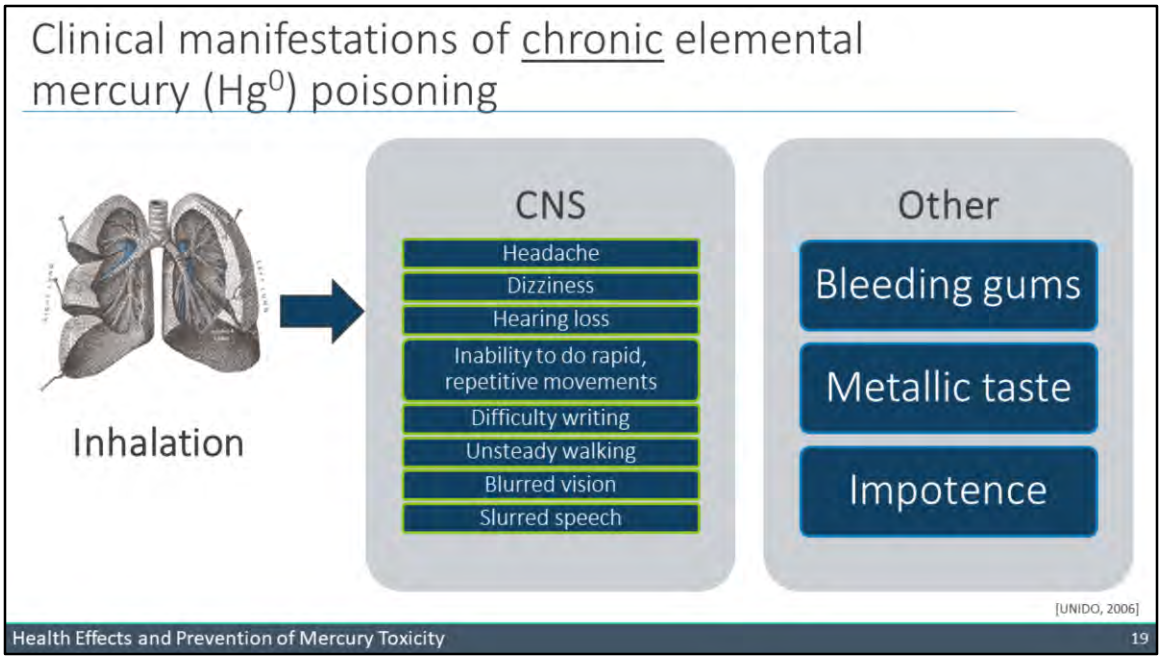
There are differences in absorption, too. Again, organic compounds are fat soluble and are more readily absorbed into the body.




Once absorbed, mercury is rapidly distributed to all tissues or organ systems in the body however its accumulation is primarily in the central nervous system, the liver, the spleen and the kidneys. When its absorbed into the blood and circulates, it affects the target organs. Once there, mercury interferes with normal cellular physiology. It causes dysfunction of enzymes, cellular transport, membrane function cellular structure.




Most acute effects occur through inhalational exposure when elemental mercury is heated and becomes volatilized. Patients will have symptoms affecting mostly the respiratory, gastrointestinal and central nervous systems. Mercury is directly toxic to the lungs at the site where it contacts the lungs. Therefore, respiratory effects predominate and in severe cases can progress to pulmonary edema, respiratory failure, and death. In those who survive, the respiratory symptoms may resolve; however, they may also persist due to the development of interstitial fibrosis or scarring of the lung tissue. Elemental mercury can get absorbed into the body through the lungs, as well as doing direct damage to the lung tissue. When it gets inhaled and absorbed, it primarily affects the GI tract, manifesting in nausea, vomiting, difficulty swallowing, and diarrhea. The Central Nervous System is also a primary target for mercury. CNS disturbances are manifested as headache, visual disturbances, weakness, and ataxia or incoordination.




When people have ongoing, intermittent or recurrent exposure to elemental mercury, they may not be as obviously sick as in acute, high dose poisoning (as you saw in the last slide). But over time they amass a significant body burden of mercury and they develop clinical abnormalities associated with chronic exposure. You can read the list of abnormalities here. Because of the gradual onset of these symptoms, they may tolerate them better and the problems may not be clinically obvious to you as their health care provider. It is essential to take a careful history (anamnesis) from them to increase your ability to detect more subtle findings. Also, a careful clinical examination, especially of the nervous system, is very important.

## 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

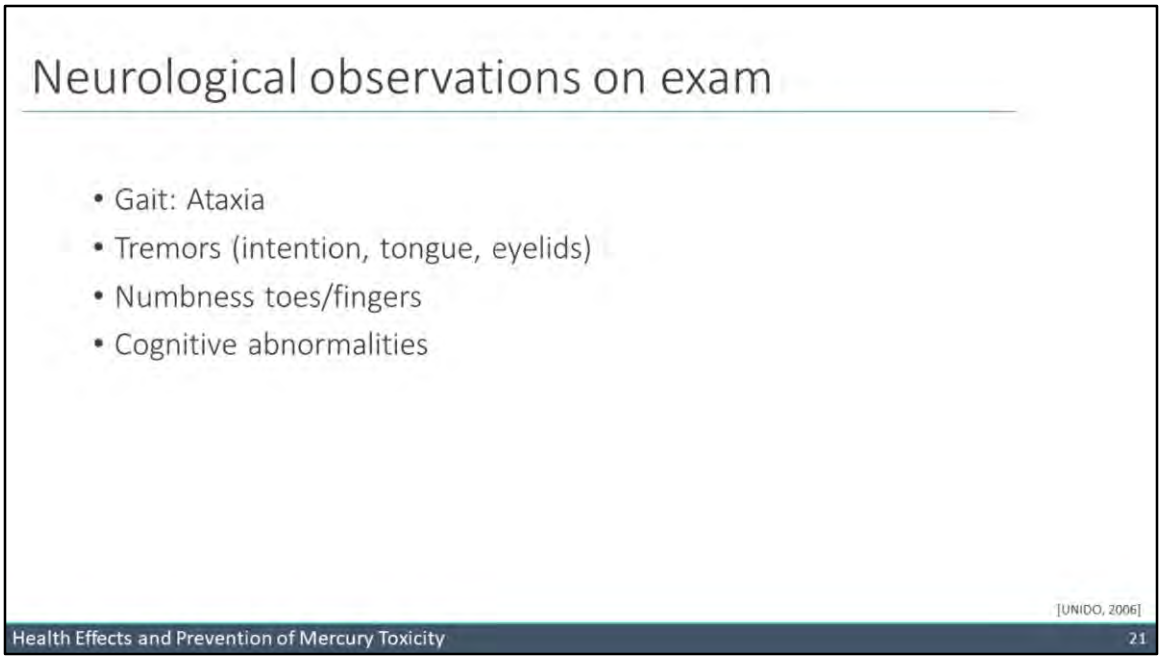
Acrodynia

Mee's lines

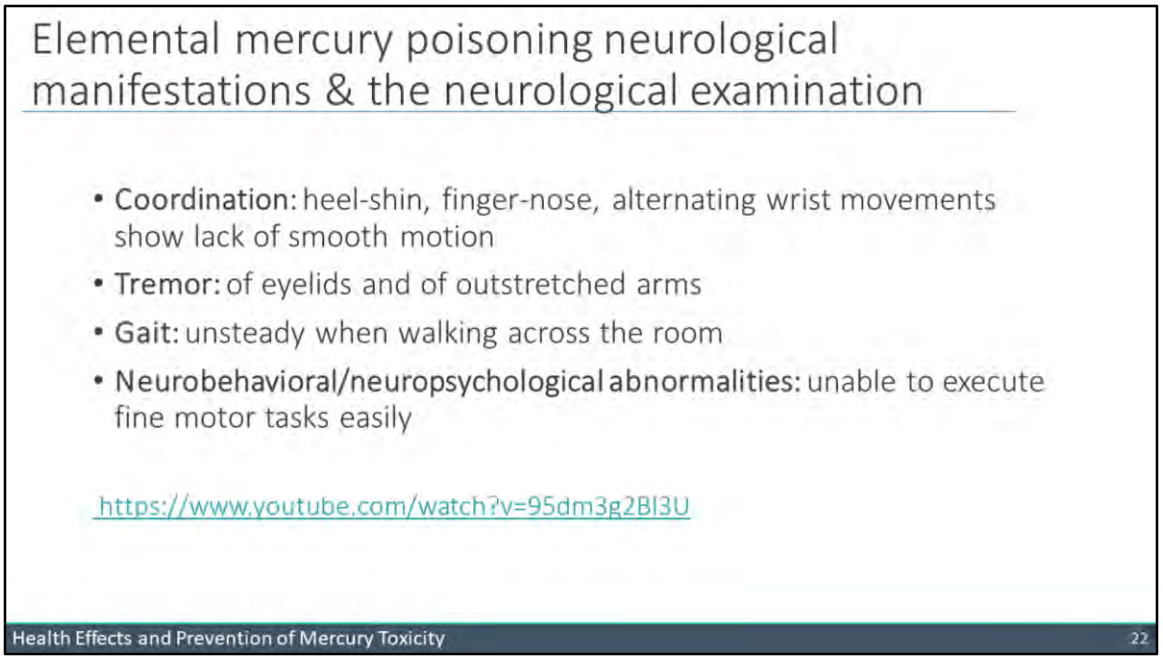
[UNIDO, 2006]

Health Effects and Prevention of Mercury Toxicity 20

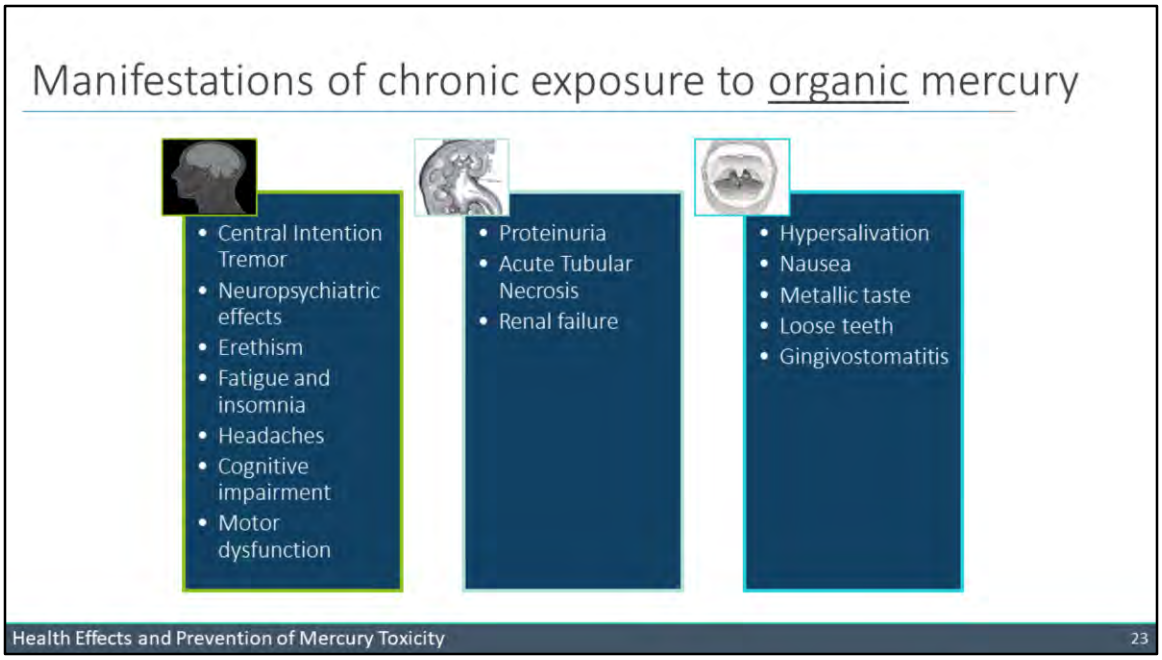
When a patient with mercury toxicity walks into your office, there are potentially obvious, general abnormalities that you might observe. These include high blood pressure, obvious weight loss, excessive salivation and lesions in the mouth, respiratory distress that can be heard as crackles or wheezing with your stethoscope; redness of the hands and feet with broken, irritated skin; and a white line with deformities of all the nails of both hands and feet. The neurological abnormalities that you might observe when the patient walks into the exam room is an unsteady gait, tremors and fasciculations of the eyelids, hands and tongue; the patient may complain of numbness or tingling of the toes and fingers if you ask; you may also observe cognitive abnormalities, like a slow intellectual response.



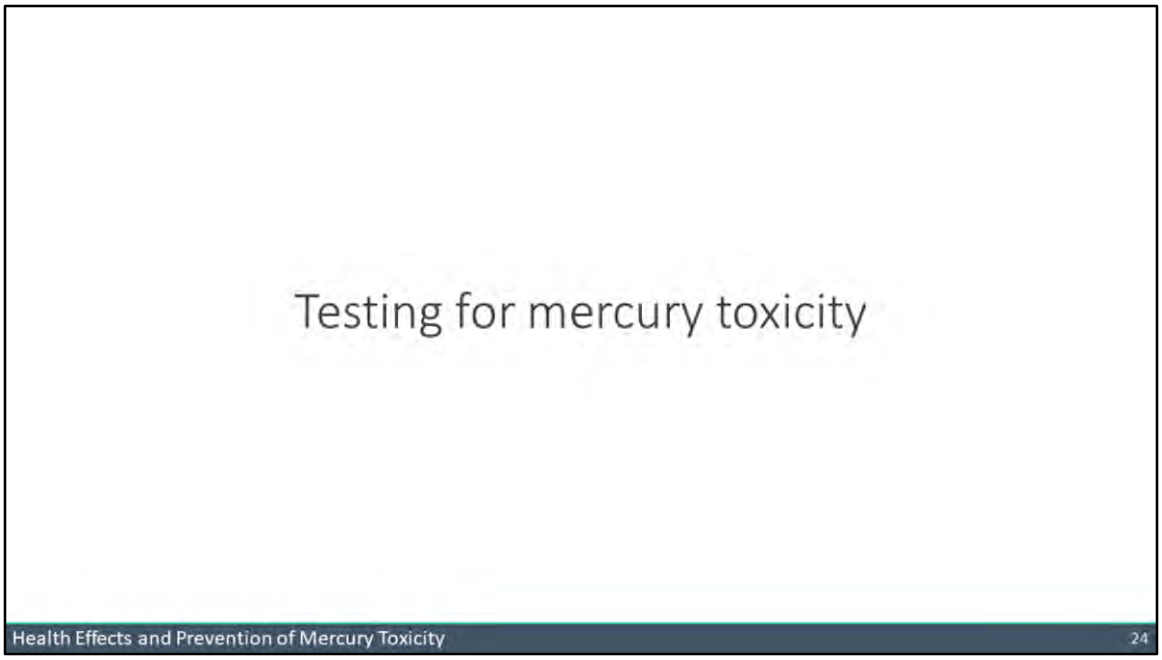

On physical examination, you might find an ataxic or unsteady gait, tremors of the tongue or eyelids. The patient may have numbness of the toes and fingers when the sensory exam is done. They may also demonstrate cognitive abnormalities, like confusion or memory loss.



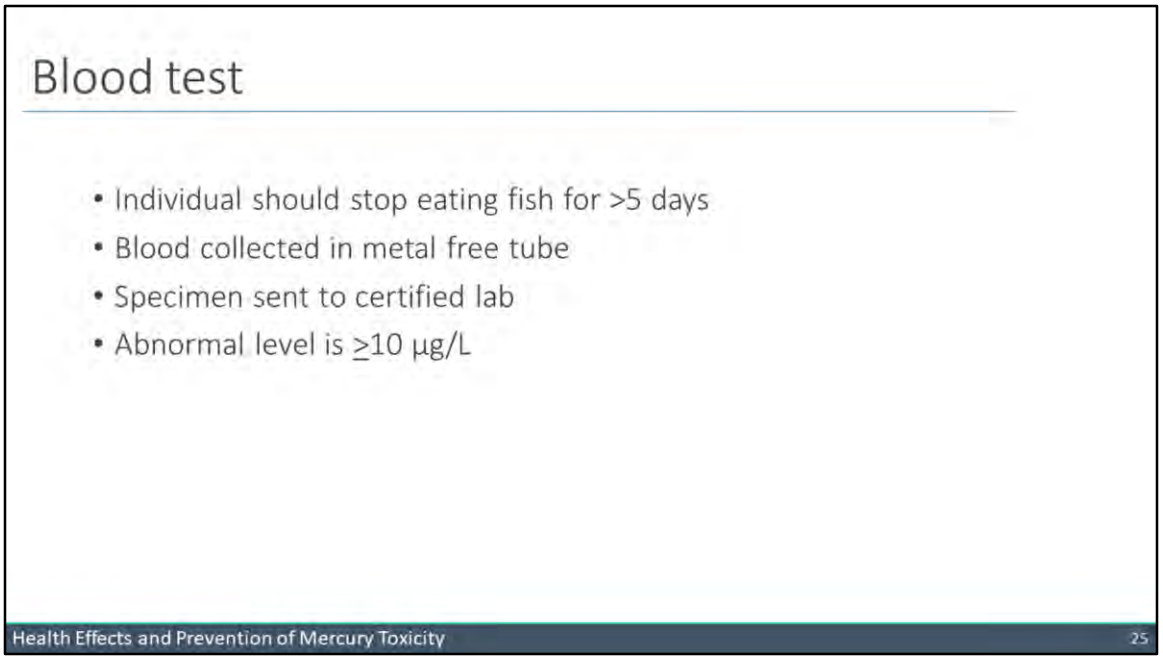

The physical examination and clinical manifestations of abnormalities of the nervous system can be seen in this video.



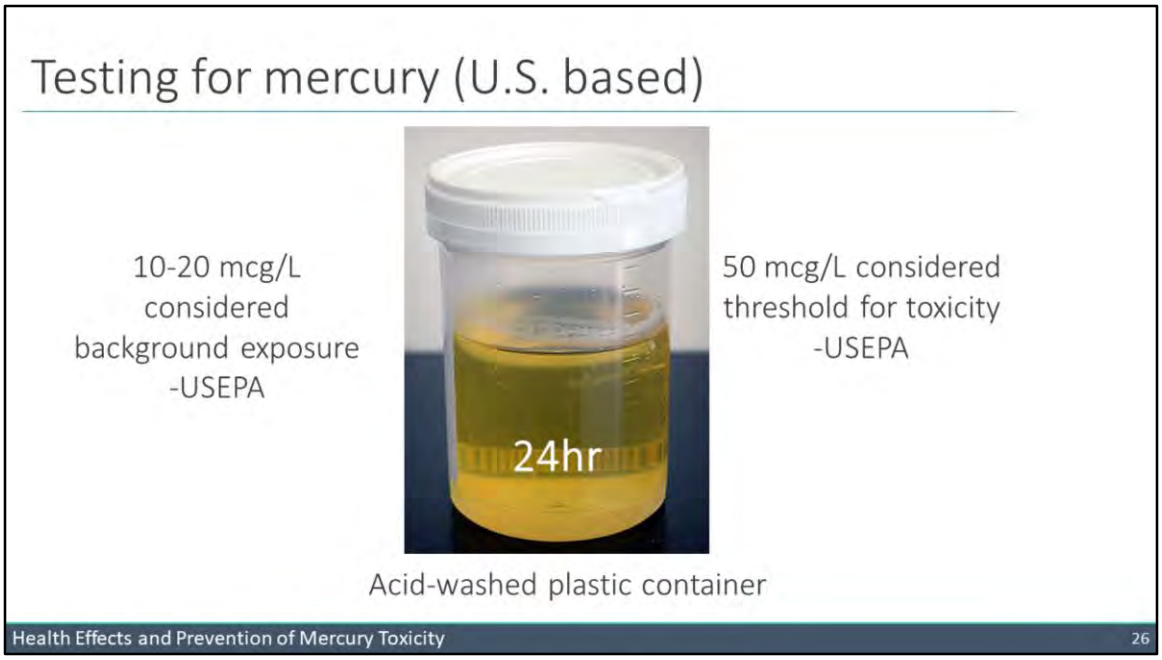

Chronic effects of organic mercury poisoning are primarily neuropsychiatric effects. The kidneys may have impaired function and you may observe oropharyngeal, or mouth and throat, irritation. The central nervous system effects are wide ranging and the most devastating. Erethism is abnormal irritation, sensitivity, or excitement sometimes described as extreme shyness. Because the mercury salts are not relevant to ASGM or Minamata, these will not be discussed any further.




Now I will describe laboratory testing for mercury. This is to give you a general idea of how this is done and how to interpret results.




Acute mercury poisoning can be detected by measuring mercury levels in the blood; this test is usually done in a specialized laboratory. A normal mercury level is less than 10 µg/L (micrograms/liter). Higher levels suggest toxic exposure. However, there are two problems with this test. First, the test on blood or urine should be performed five days or more after a person has stopped eating fish, because such a meal can raise the blood level of mercury higher than normal for a short (up to five days) time period. Second, it does not usually provide any valuable information about a previous short or chronic exposure. Further, urine tests are not reliable for measuring methylmercury or other compounds such as short-chained alkyl mercury compounds because they are mainly excreted in the feces and bile, respectively.
Tests to measure the ratio of mercury in blood plasma versus red blood cells is performed to help distinguish organic mercury poisoning from inorganic. Red cells concentrate organic mercury but not inorganic mercury compounds. The concentration of organic mercury in red cells is about 20 times that found in plasma; the concentration of inorganic mercury at maximum is only about twice that found in plasma.

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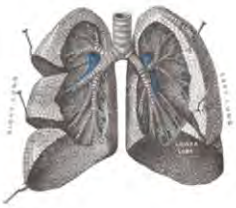
The most accurate method for determining mercury exposure is a 24hr urine collection. Urine needs to be collected in an acid-washed plastic container. Levels of 10-20mcg/L are typically considered background exposure. In patients with levels approaching 50 mcg/L you may begin to see signs of toxicity. Spot blood mercury levels can be done but need to be taken within 3 days of an acute exposure, so this is sometimes not feasible.

It should be noted that specialized laboratories are needed to do mercury testing. It is important to find out if there is a lab to send specimens.

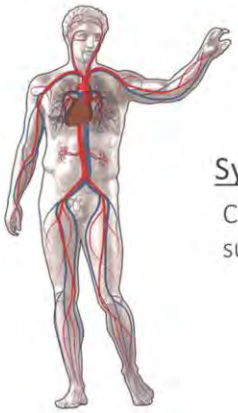

Treatment is being covered in this slideshow to give you an overview. There are no internationally accepted standards for treatment of mercury toxicity.

## Treatment: Acute elemental mercury poisoning



**Inhalation**

Supportive if only lungs affected

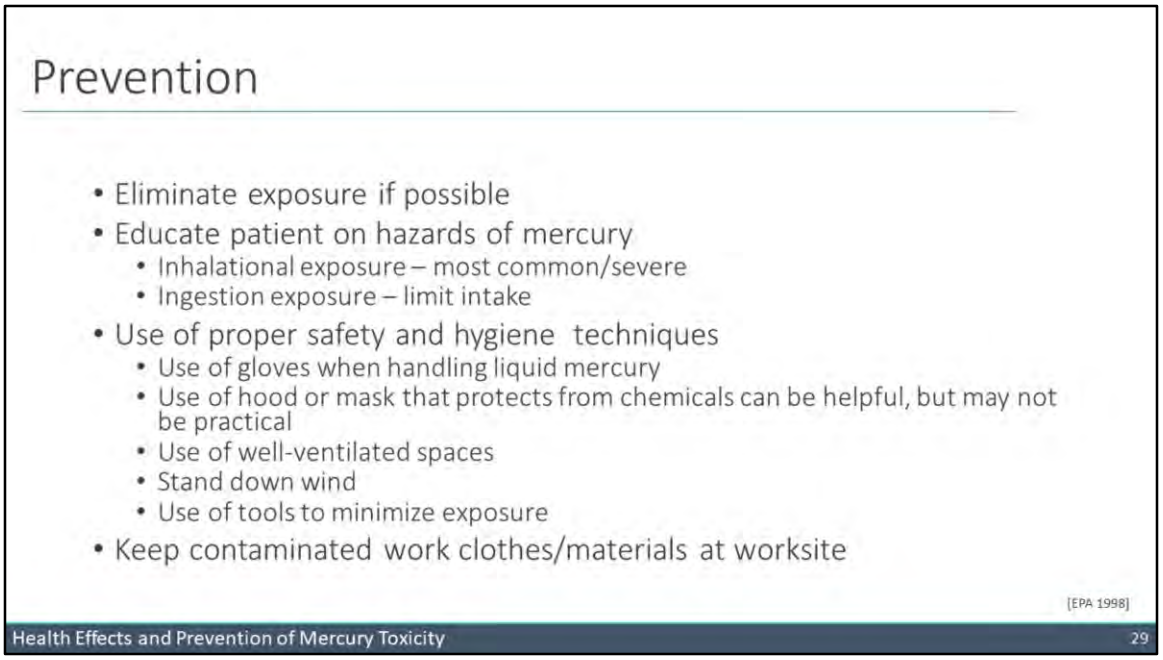


**Systemic Symptomatic**

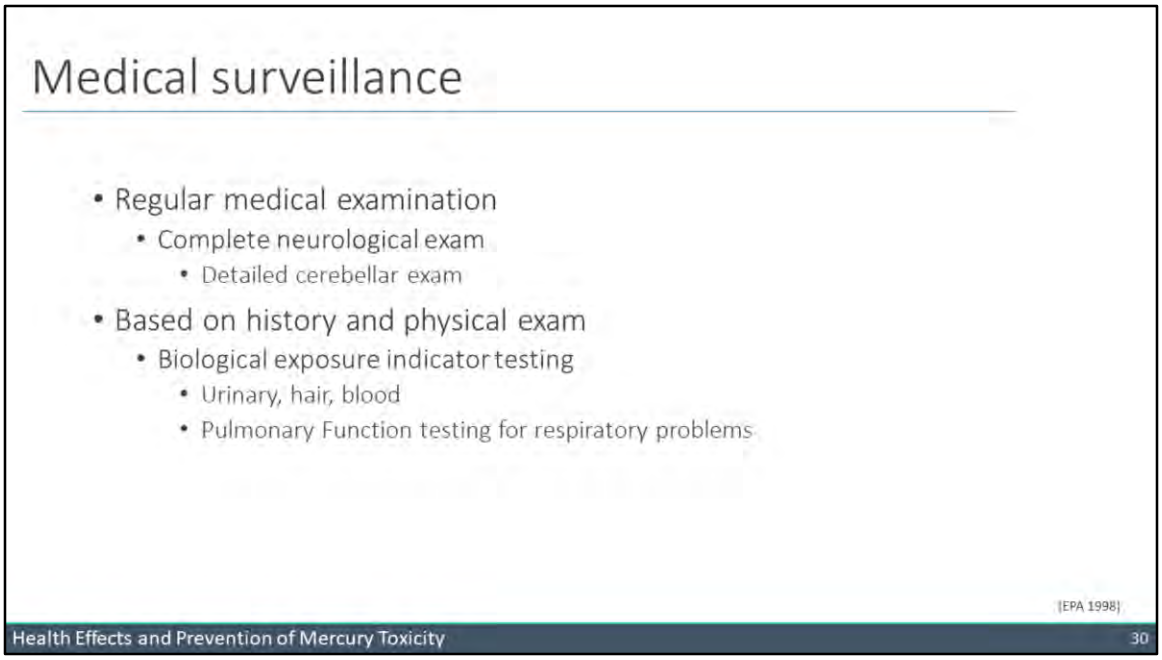
Chelation therapy with succimer (DMSA)

Health Effects and Prevention of Mercury Toxicity 28

Patients exposed acutely to elemental mercury via inhalation may require aggressive supportive care with possible intubation and ventilatory support, using a respirator, if needed. There is chelation therapy to initiate in symptomatic patients after a clear history of elemental mercury exposure or demonstration of high mercury levels in urine or blood from an acute exposure. Dimercaptosuccinic acid or DMSA is the preferred medication, It is not always easy to determine when to use DMSA and whether to hospitalize patients or give oral medication. Treatment should be undertaken with consultation with a Poison Control Center or an experienced clinician, as the chelating agent has significant side effects.




Prevention is critical when mercury exposure is possible. Complete elimination of the exposure is best. Children and pregnant women are particularly vulnerable and should be protected. Taking a careful exposure history (anamnesis) from patients or their parents will help detect mercury exposure. It will also help the doctor or nurse find the language that the patient uses to describe the exposure and their symptoms; the clinician can use this language to communicate about risk and prevention with the patient. Talking to the patient about routes of exposure—inhalation, skin absorption, and ingestion—can be helpful. Their understanding of the problem will help them make appropriate decisions to protect themselves and their family members. When complete avoidance is not possible, then use of proper hygiene and safety techniques is helpful. Also, keeping work processes, chemicals, and work clothes at the worksite, and away from the home environment, can prevent access by small children and other family and community members. Specific health and safety measures in the workplace will be given in a later presentation in this program.

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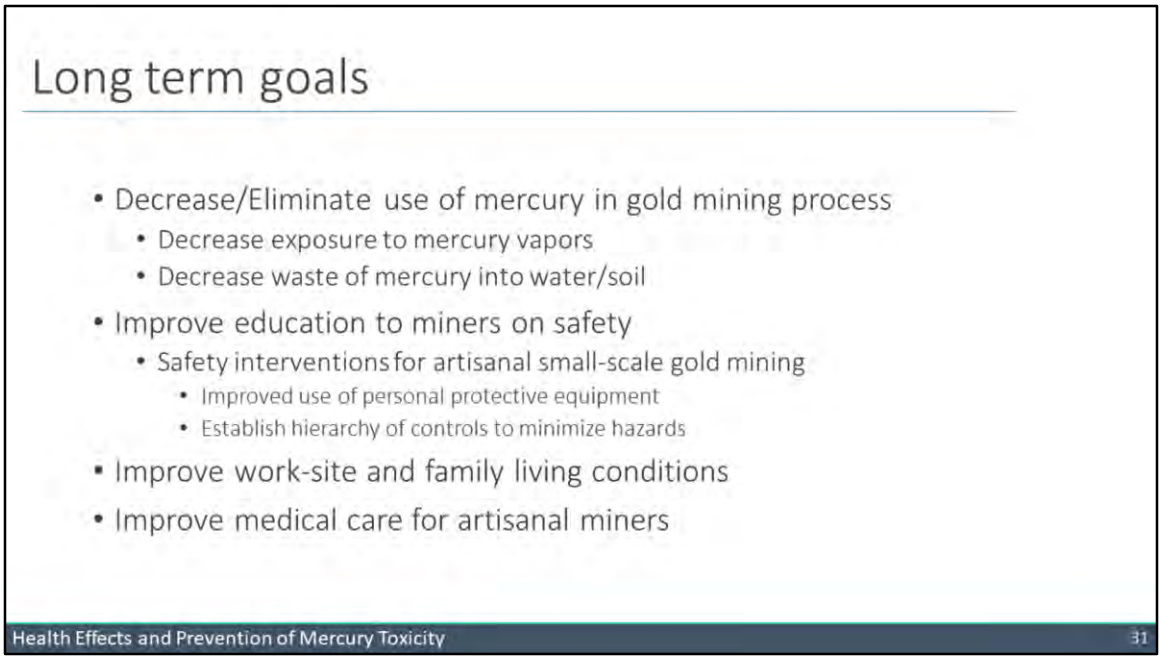
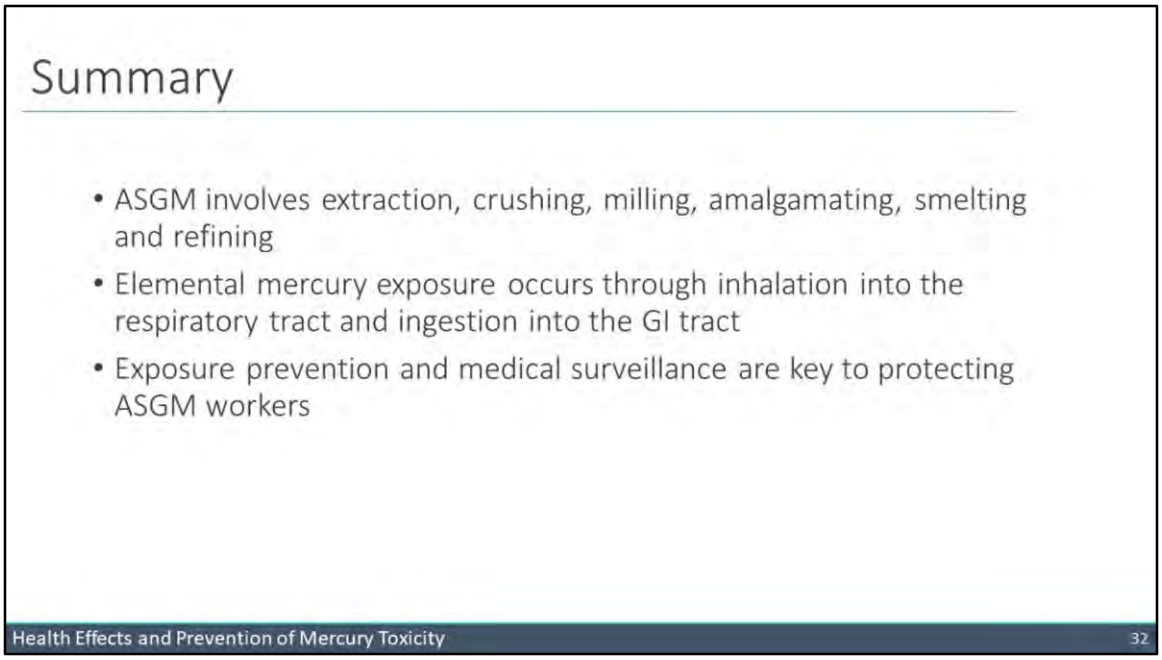
For someone with known, ongoing exposure to mercury, a regular clinical encounter and physical examination are in order. Blood pressure, listening to the lungs, and a good neurological examination are important. Based on the findings from this exam, decisions can be made to do further testing: checking blood, hair, or urine mercury; doing a pulmonary function test; or referring the patient for additional treatment.




The long term goals are to reduce or eliminate the use of mercury in the gold mining process. Improved education to miners regarding hazards to themselves and their families should be an ongoing effort on the part of primary healthcare workers. Implementation of safety interventions can be helpful, as described in this slideshow. Again, we will talk more about that later. Improved health care can provide secondary prevention, limiting the long term effects of mercury toxicity. Regulation at the country level, with improvement of economic and living conditions and opportunities for employment in less hazardous trades is the ultimate fix for this problem




In this slideshow, you heard about the ASGM process. You were also introduced to the toxicology concept of "routes of exposure" or "routes of entry" through inhalation, ingestion, or dermal absorption. Controlling or eliminating mercury exposure among miners, their families, and surrounding communities is the best way to prevent mercury toxicity. Medical monitoring or surveillance of at-risk patients can help with early identification and secondary prevention of disease related to mercury toxicity.

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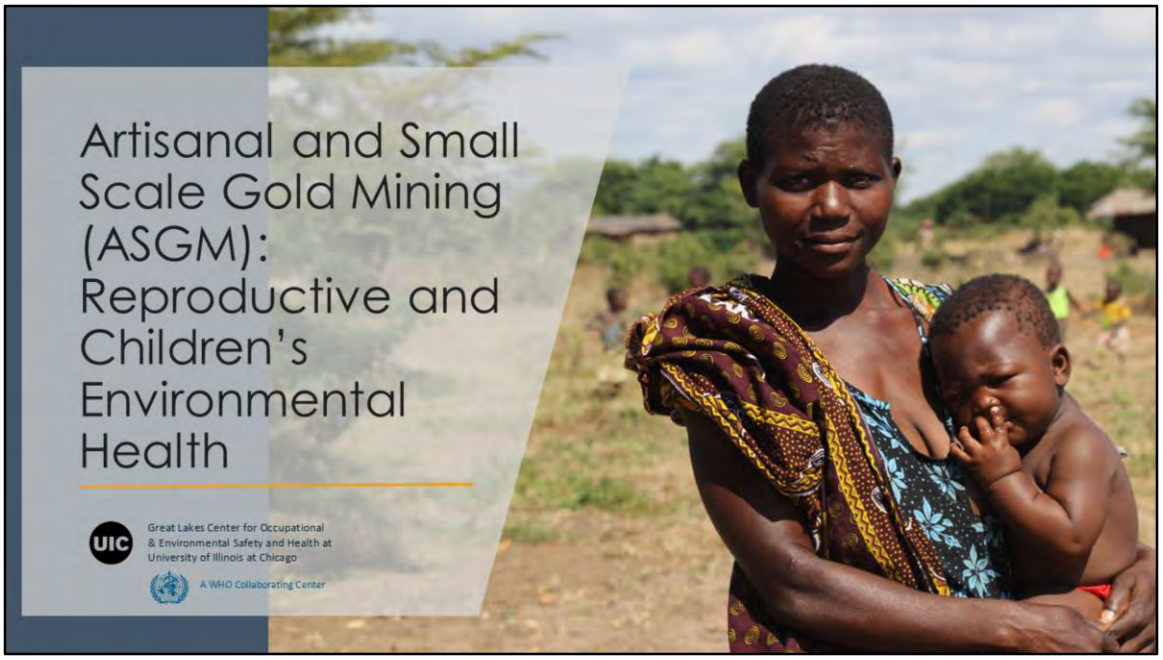
Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago

A WHO Collaborating Center




Welcome to this training module on Reproductive Health and Artisanal mining. This presentation was developed by the Great Lakes Center at the University of Illinois at Chicago, in collaboration with the World Health Organization. This presentation is for healthcare providers who care for patients participating in artisanal mining or living in small-scale mining communities.

We'll start with a brief overview of artisanal mining, followed by a short introduction to reproductive environmental health. Then we will move on to cover the reproductive health hazards in artisanal mining.

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*IMAGE*
CC-BY 2.0 "bubigold" by Kevin Walsh
Author's description: "Couple of seasonal small-scale gold miners, and their temporary accommodation, Bubi, Zimbabwe"
Link to flickr image:
https://www.flickr.com/photos/86624586@N00/11196880/in/photostream/
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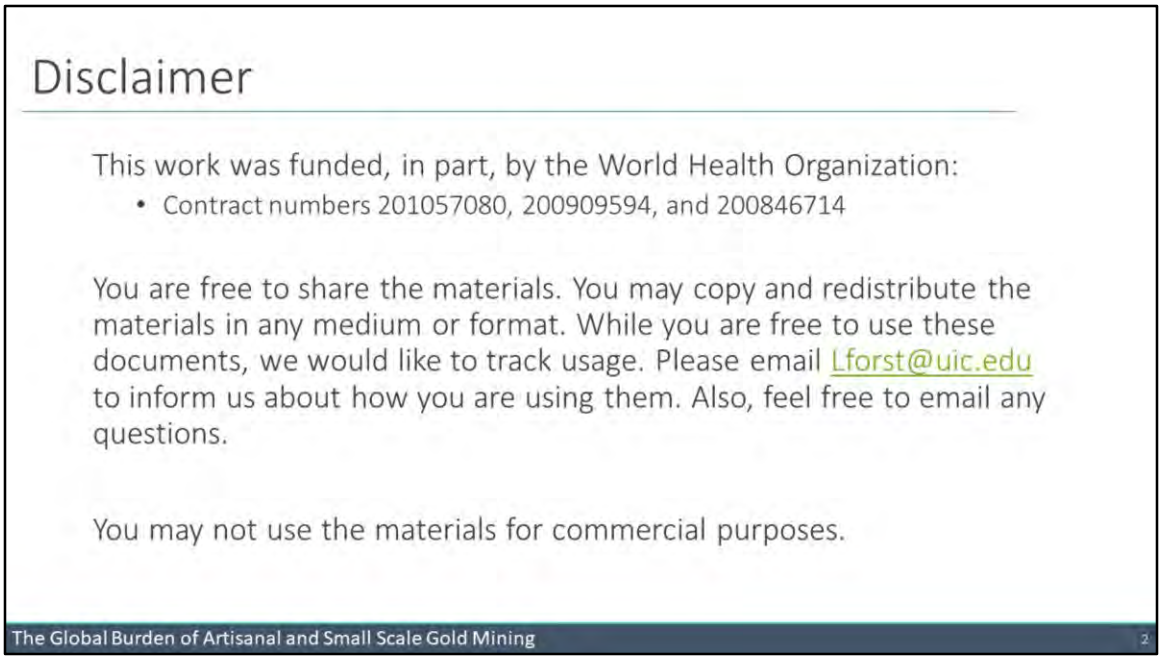
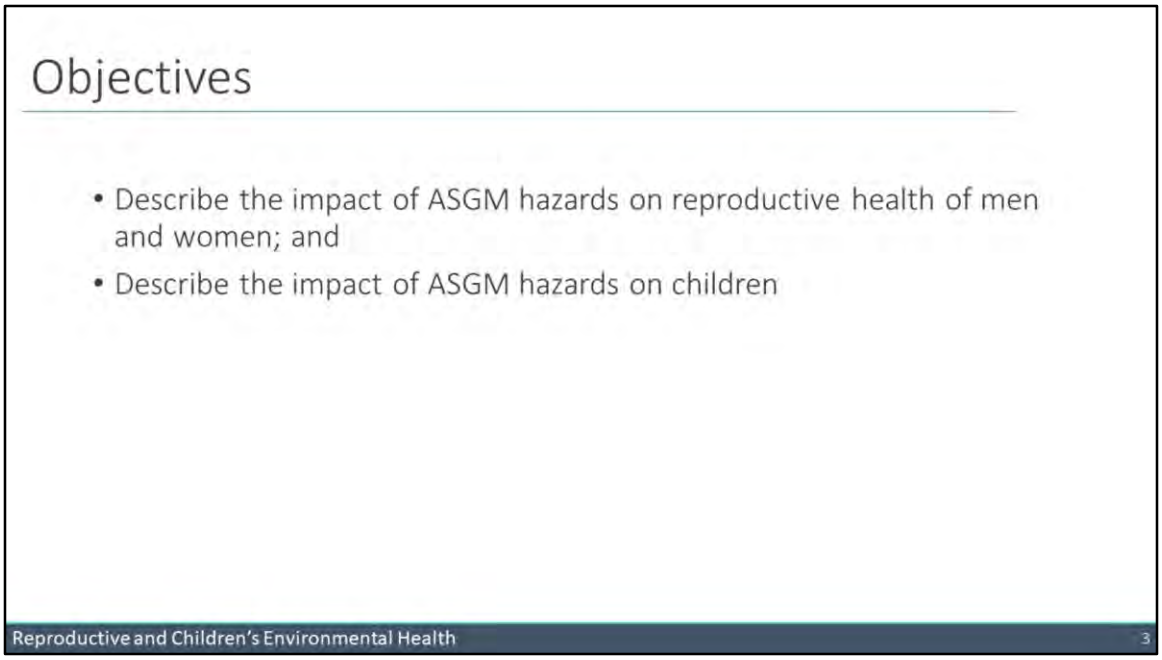
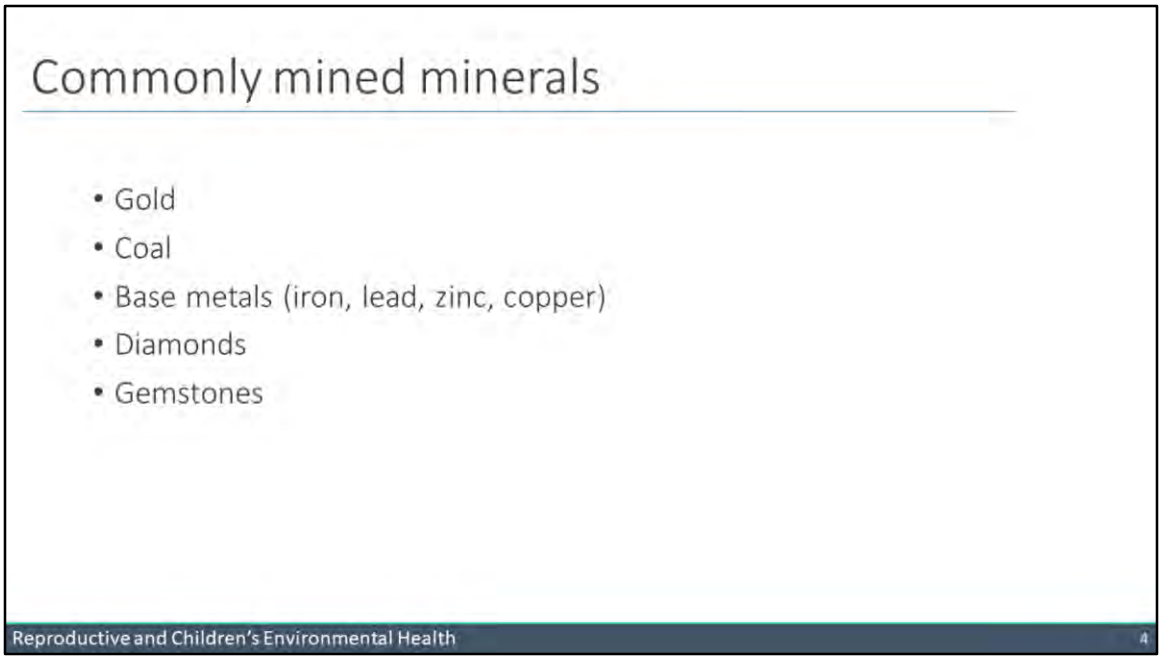



This is part of the series of lectures for the course on the health issues surrounding Artisanal and Small Scale Gold Mining. This course was developed to assist countries in preventing illnesses and injuries among gold miners and their families.

By the end of this lecture, you should be able to describe at-risk populations in the subsistence gold mining sector and discuss the Minamata Convention and WHO's efforts to address the human health provisions. You will get an introduction to elemental and organic mercury toxicity in this lecture. But we will spend more time on the health effects of mercury later in the course.




By the end of this slideshow, you should be able to explain:
The impact of ASGM hazards on reproductive health of men and women; and
The impact of ASGM hazards on children




It should be noted that the mining sector is very large and diverse, globally. It includes relatively organized worksites, a high level of mechanization, workers who are highly skilled, and mainly literate workers. There may be longstanding community traditions of mining; the work processes may be sophisticated and mechanized and employment circumstances formalized. Aside from gold, commonly mined minerals include coal, base metals like iron, lead, zinc, and copper, diamonds, and other gemstones.

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*IMAGE*

## 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

Reproductive and Children's Environmental Health 5

In contrast to the information on the previous slide, Artisanal and small-scale gold mining referred to in this course, and the target of the Minamata Convention, tends to be labor-intensive mining that is often performed by poor, itinerant-workers. (World Bank 2013). These artisanal miners typically have limited access to land for mining and limited access to markets to sell their product.

Typically, ASGM miners have low education levels and live in remote areas where there are few other options for work. (World Bank 2013). The work is labor intensive, with a low level of mechanization; it's done in remote, rural areas of poor, but mineral-rich countries with low capital costs; there is extremely low productivity or output; and it offers only unstable employment in the informal work sector. ASGM, as characterized here, has no safety regulations and workers generally use ineffective equipment that forces them into extreme manual labor putting them at risk for acute and chronic musculoskeletal injuries.

To remind you, Artisanal mining occurs in over 70 countries, totaling around 13 million miners. Aside from the miners, themselves, there are 80 to 100 million people who are indirectly impacted by this work—by mining or processing gold, themselves, by exposure to at or near home, and the entire gold-supply chain. ASGM mining is

most prevalent in Asia, Sub-Saharan Africa, and South America. ASGM provides 20-30% of the world's gold production. It is also responsible for considerable pollution, emitting 640 to 1300 tons of mercury into the air each year. There is an unknown amount of elemental mercury that is dumped directly into waterways. To remind you, ASGM is responsible for more than 1/3 of anthropogenic mercury release, globally.

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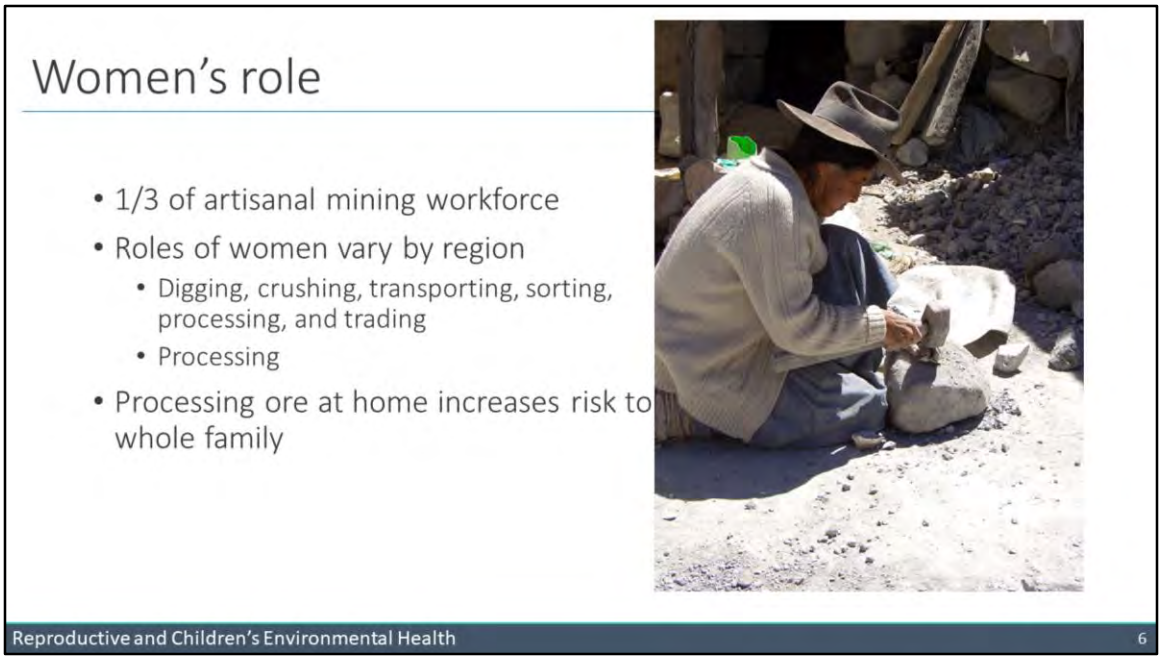
*IMAGE*


Author's description: "Small scale miners are well versed in the process of gold mining in Geita, Tanzania. They are here shown to dry the ores on the sun and separating smaller from bigger stones."
Link to flickr image:
https://www.flickr.com/photos/investingingold/8639945904/in/photostream/




It is important to note that artisanal mining is often a family-based activity, performed by men, women, and in some cases, their children. It is estimated that about 1/3 of artisanal miners are women. The role of women in these activities varies by region, but women participate in digging for ore, and crushing, sorting, and processing it. These activities are often performed at or near home home where family members can be exposed to associated hazards. This is a photo of a woman in South America.

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*IMAGE*
CC-BY 2.0 “Potosi Mines" by Jenny Mealing
Author’s description: “The widow of a miner sits outside the mines and sifts through the waste trying to find minerals.”
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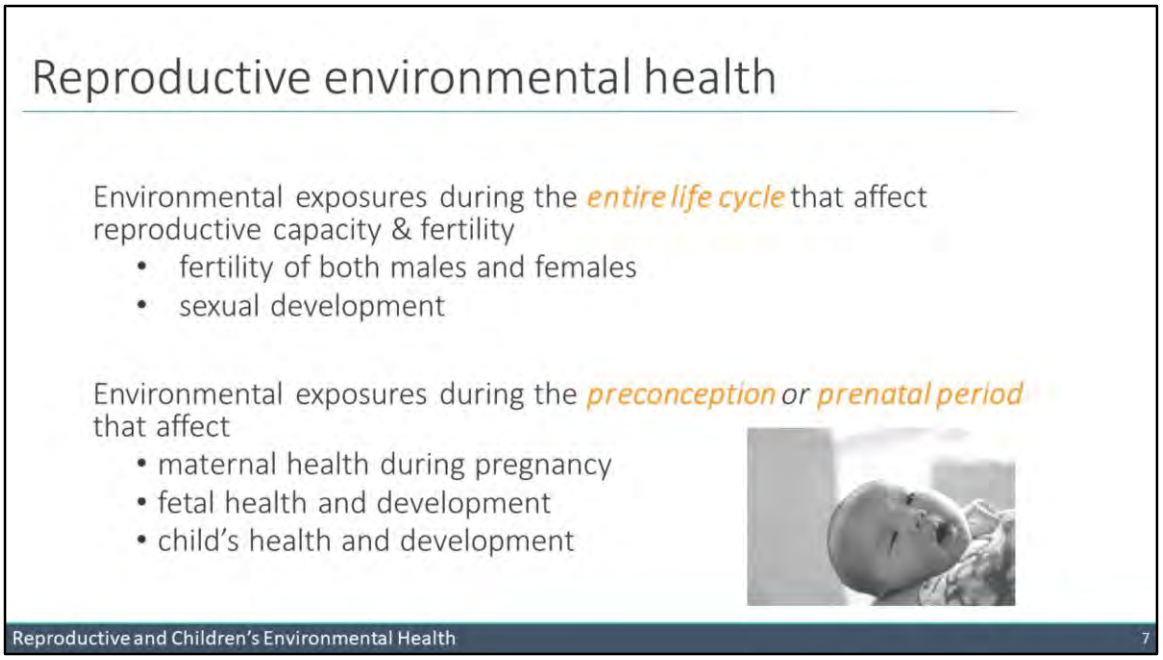


The hazards of artisanal mining can cause adverse outcomes on reproduction. We use the term reproductive environmental health to refer to environmental exposures during the *entire human life cycle* that affect reproductive capacity & fertility. It can impact the reproductive health of both women and men, with significant psychological effects that go along with infertility. Reproductive environmental health can also refer to environmental exposures during the *preconception or prenatal period specifically* that affect maternal health during pregnancy, the health and development of the fetus in utero, and the health and development of children from birth into

adolescence. In the next few slides, I am going to talk about general reproductive hazards for women, men, and children. While not specifically related to ASGM, this should give you a framework for considering the potential impact of ASGM and other hazardous condition on human reproduction and child development.

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*IMAGE*


A woman's exposure to environmental chemicals and other toxicants can affect her reproduction and the health of her baby even when the exposure doesn't occur during pregnancy. Exposure to hazardous substances before pregnancy can bioaccumulate in her body and cause infertility, menstrual disorders, and abnormal development during puberty. The health outcomes, as described in the slide, include low fertility, menstrual disorders, a decreased age at puberty, early menopause, decreased sex drive, and, of course, health problems related to mercury intoxication.

---

*IMAGE*



Image Name: "The ideal family size – Esnart Wisted, mother-of-four"

Link to Image: https://www.flickr.com/photos/dfid/7513648782

## 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

Reproductive and Children's Environmental Health 9

In men, environmental exposures can occur before they try to have children or during the formation of sperm; this process is called spermatogensis.
Exposure during these time periods can result in altered hormone production which results in decreased sex drive or decreased fertility. Exposure to hazardous substances can also result in a decreased sperm count, diminished sperm motility, and changes in sperm morphology. There are also cases of direct testicular toxicity. It's possible for a man to pass toxicants in his semen to his partner during intercourse.

---

*IMAGE*
CC-BY 2.0 Bart Speelman
Image name: Father_Child Sumberkima, Bali
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## 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)

Reproductive and Children's Environmental Health 10

Exposure to the fetus or young child can occur in utero and during breast feeding. Health outcomes include birth defects, developmental disorders, impaired cognition, spontaneous abortion, low birth weight, preterm birth, childhood cancers, and altered sex ratios. In some cases, these early life exposures predispose the children to health conditions later in life.

---

*IMAGE*
CC-BY 2.0 Nana B Agyei
Image name: Smile
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According to the WHO (https://www.who.int/ceh/global_plan/en/)

- Each year, at least 3 million children under the age of five die due to environment-related diseases.
- Acute respiratory infections annually kill an estimated 2 million children under the age of five. As much as 60 percent of acute respiratory infections worldwide are related to environmental conditions.
- Diarrheal diseases claim the lives of nearly 1.5 million children every year. 80 to 90% of these diarrhea cases are related to environmental conditions, in particular, contaminated water and inadequate sanitation.

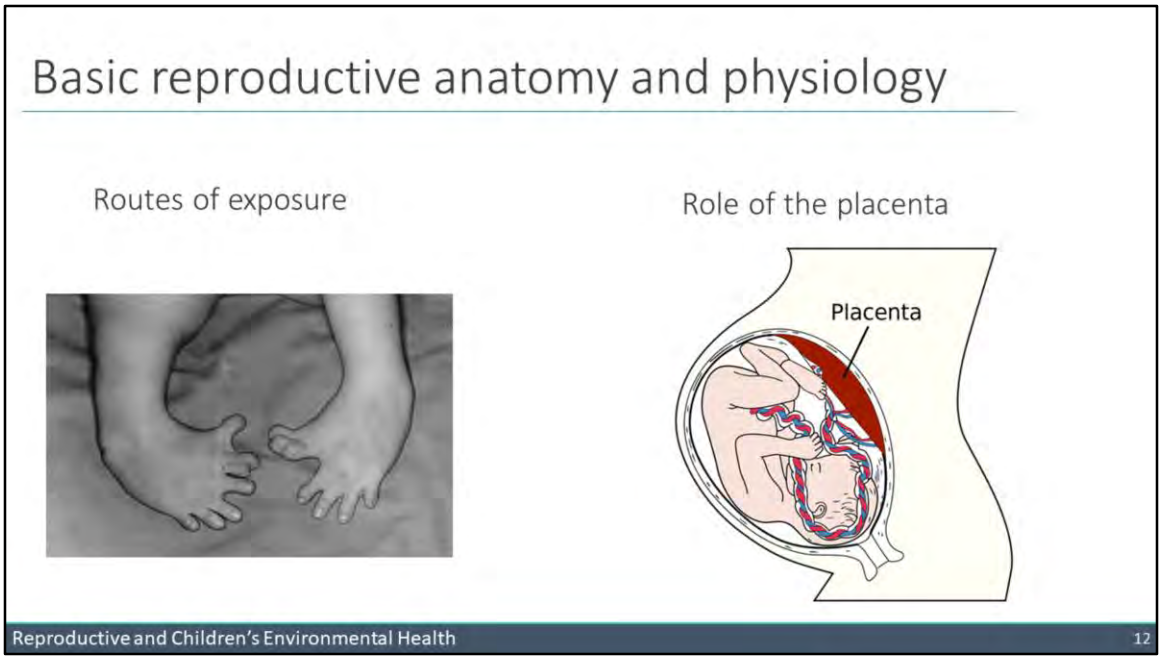
Children in many countries still face the major traditional environmental hazards, including unsafe water, lack of sanitation and contaminated food, injuries, indoor air pollution from use of solid fuel, outdoor air pollution and exposure to a myriad of toxic heavy metals, chemicals and hazardous wastes that may be brought home from the workplace.

**Notes for Instructor**

The Global Plan of Action is designed to provide a road map for WHO, governments, intergovernmental and non-governmental organizations--all concerned stakeholders--

to contribute to the attainment of the Millennium Development Goals and other internationally agreed upon development declarations, commitments and goals, in particular those related to reducing infant mortality and ensuring environmental sustainability.

Inclusion of training on Children's Health and the Environment in this training program on ASGM is in line with Strategy 4 of the Global Plan of Action: that is, clinical capacity building to increase service delivery and improve availability of environmental health clinical services




Let's review how environmental contaminants reach the fetus. Is the fetus protected by the placenta?

People used to believe that the placenta was an impenetrable barrier that keeps the baby protected from whatever the mother is exposed to. It took a few unfortunate cases to disprove that theory. One of these disasters was the introduction of Thalidomide in the late 1950's as a drug to help treat morning sickness in pregnant women. The result was that in 46 countries around the world, thousands of babies were born with birth defects, primarily defects of the limbs, but also of the heart, eyes, and urinary tracts, along with some blindness and deafness (Bren 2001). Minamata Disease in Japan is another prime example of a substance—methyl mercury—crossing the placenta to cause profound birth defects.

The placenta is the route of exposure for the fetus. Contaminants can reach the placenta via contaminants that have bioaccumulated in the mother's body, and through continuing exposures to the mother either orally, dermally, or through inhalation. Toxins in the mothers blood pass through the placenta into the developing fetus.

After birth the baby can be exposed through breast milk.

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*IMAGES*

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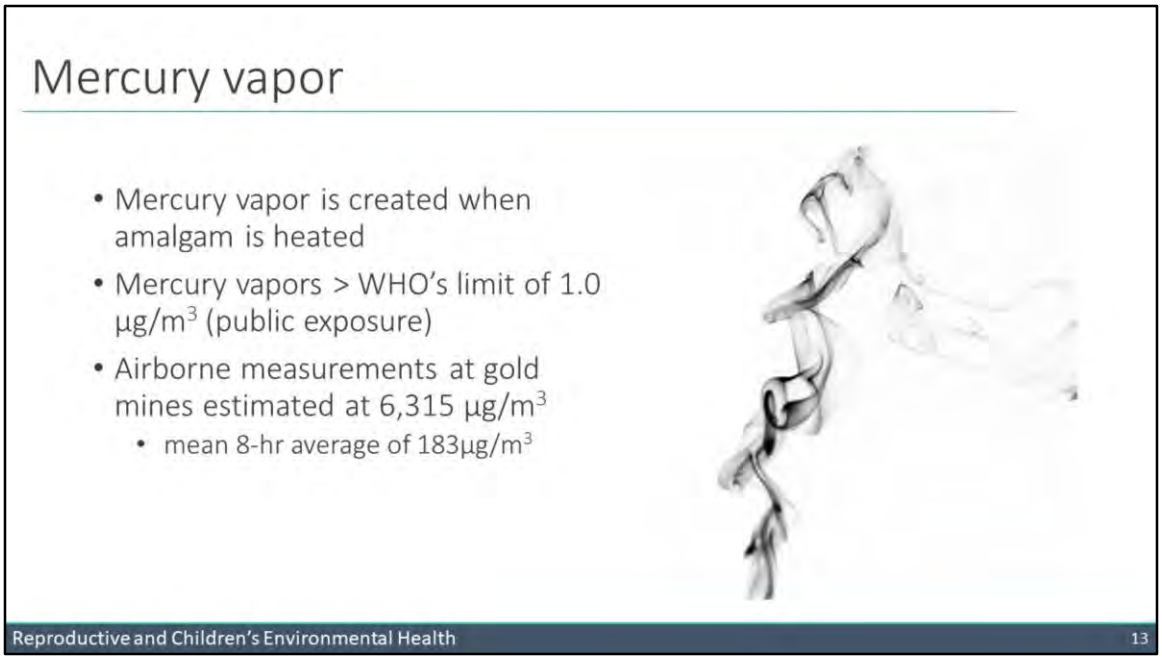


When the amalgam of gold and mercury is heated up to refine the gold, the mercury becomes a vapor that can be inhaled. Mercury vapors in the air around amalgam burning sites and in the communities surrounding burning sites almost always exceed the World Health Organization's safety limit of 1.0 microgram/$m^3$ of mercury vapor.(Gibb 2014; UNEP 2012) In Venezuela, airborne mercury levels in the air during processing were found to be over 6,000 micrograms/$m^3$ The mean 8 hour emission average was 183 micrograms per meter cubed. As you can see, this is two orders of magnitude higher than WHO's limit of 1. (Drake et al, 2001 in Gibb 2014).

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*IMAGE*
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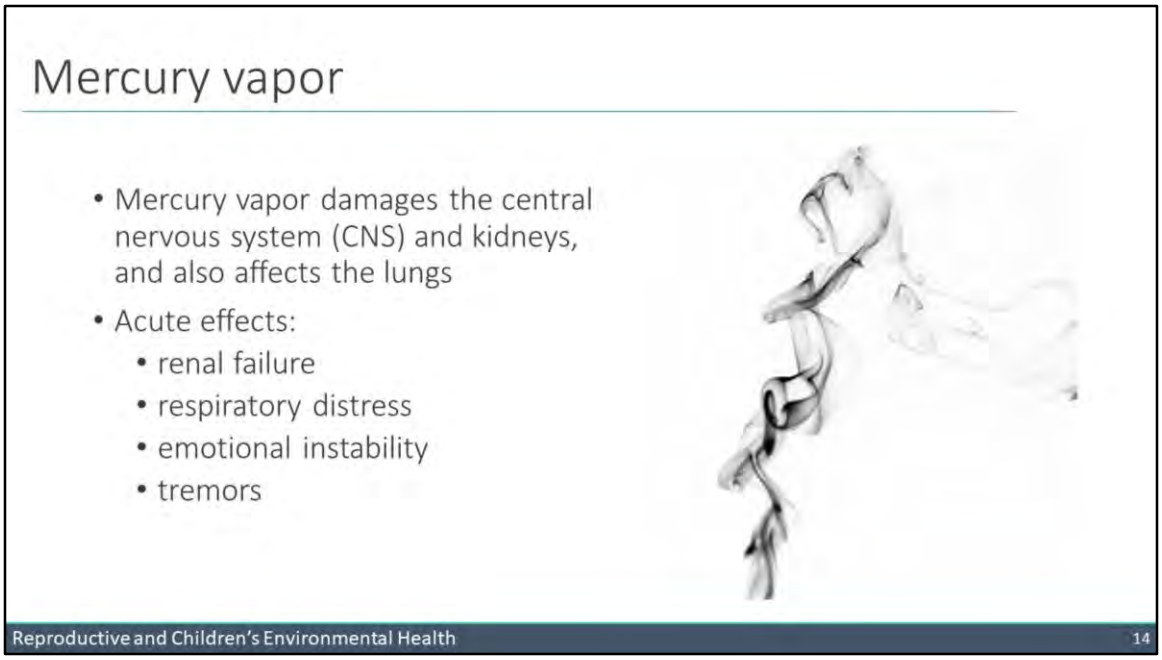


When inhaled, the uptake of mercury vapor in the lungs is nearly 100%. Mercury is metabolized and excreted over 30-40 days but at high levels the kidneys' ability to excrete mercury is overwhelmed and the mercury is stored in the brain and the kidneys, affecting the function those systems. Inhalation of high concentrations can be fatal.

Acute poisoning from mercury vapor can cause renal failure, respiratory distress and reduced respiratory function, airway irritation, chemical pneumonitis, and pulmonary edema. It causes emotional instability, shyness, irritability, and tremors. (ATSDR 2014) Tremor has been noted at air concentrations of 30 micrograms/$m^3$, below levels found during artisanal gold processing.

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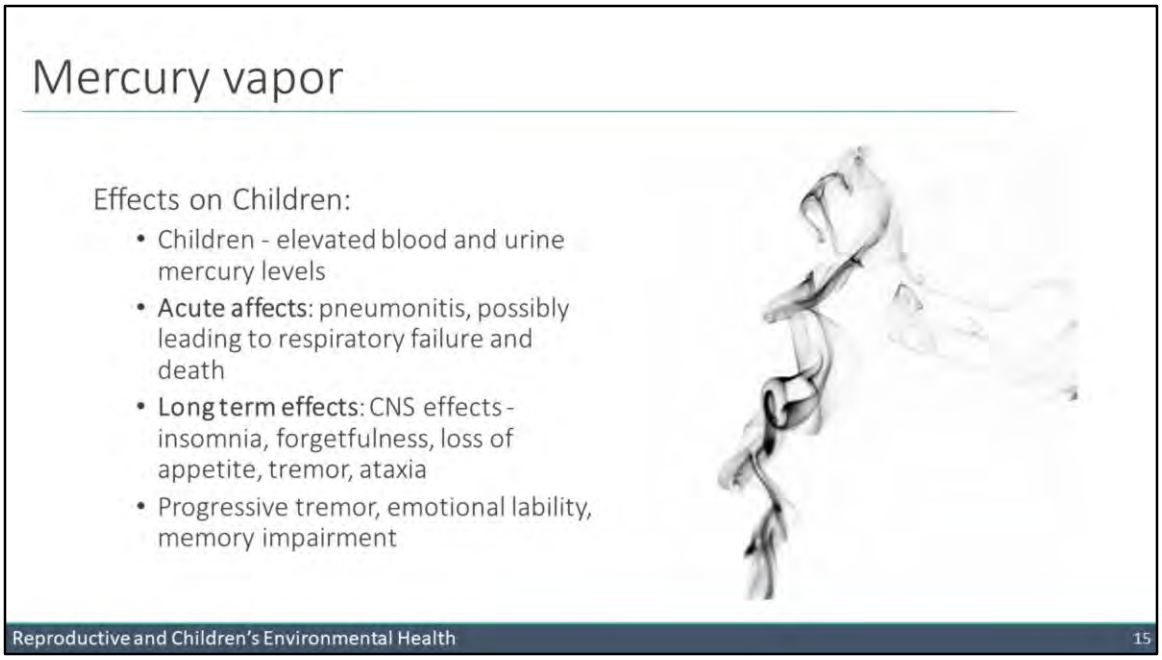


Children who work in or live near small scale gold mining are at risk for having elevated blood and urine mercury levels and exhibiting signs of mercury poisoning. A study of 80 children in Indonesia and Zimbabwe who worked directly with mercury found that 8% of them in Indonesia and 55% of them in Zimbabwe had elevated mercury levels, enough to consider them mercury poisoned. When the researchers looked at children living in the surrounding mining communities of Zimbabwe who were not directly working with mercury, they found 29% to be mercury intoxicated.

The long term effects of elemental mercury exposure on children are on the central nervous system, seen first as insomnia, forgetfulness, loss of appetite, tremor, and ataxia. Continued exposure leads to progressive tremor, emotional lability, memory impairment, excessive sweating and salivation. Erethism is a term used to describe the excessive shyness or social awkwardness associated with mercury intoxication. Chronically exposed children may develop red and painful hands and feet—called acrodynia, a metallic taste in the mouth, and bluish gums. Mercury exposure in childhood can cause permanent brain damage.

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*IMAGE*



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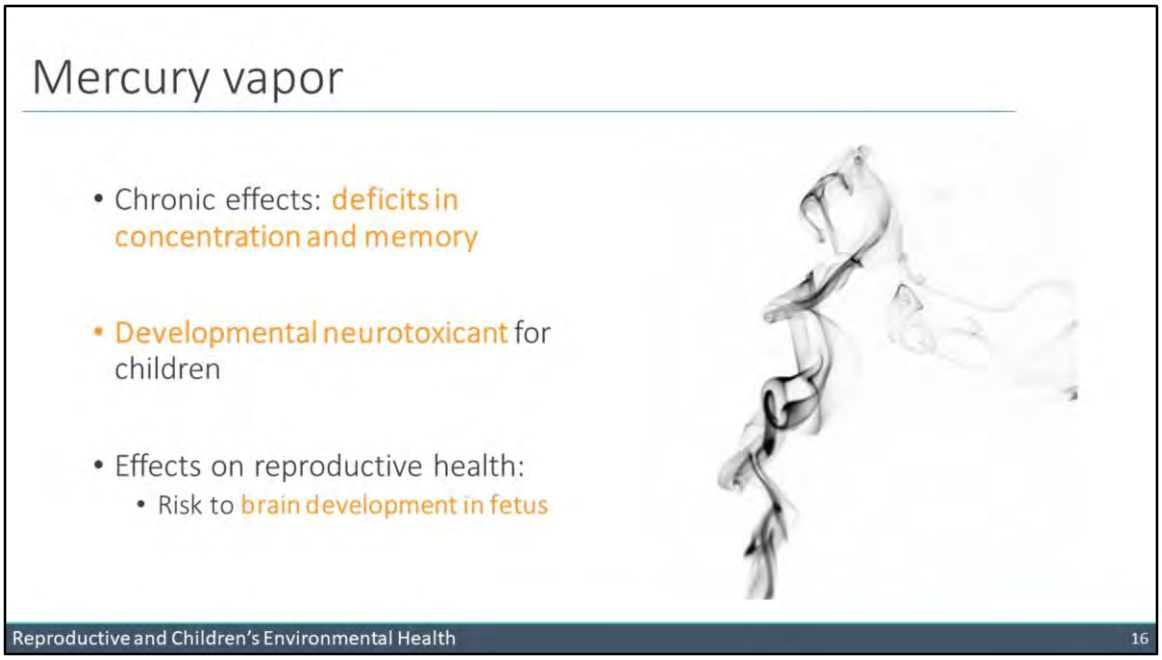
*IMAGE*




Chronic exposure to mercury vapor causes deficits in concentration and memory, and for children mercury vapor is considered a developmental neurotoxicant that can cause permanent brain damage.(Landrigan, Etzel 2014)

A number of studies have shown that urine mercury concentrations of small scale miners can be above 100 micrograms mercury/gram of Creatinine, a level at which the risk of developing adverse neurological effects is high. When mercury vapor is inhaled during pregnancy, it passes through the placenta and can harm the fetus. If exposure to mercury vapor occurs during early brain development, the effects are probably similar to methylmercury exposure.

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*IMAGE*
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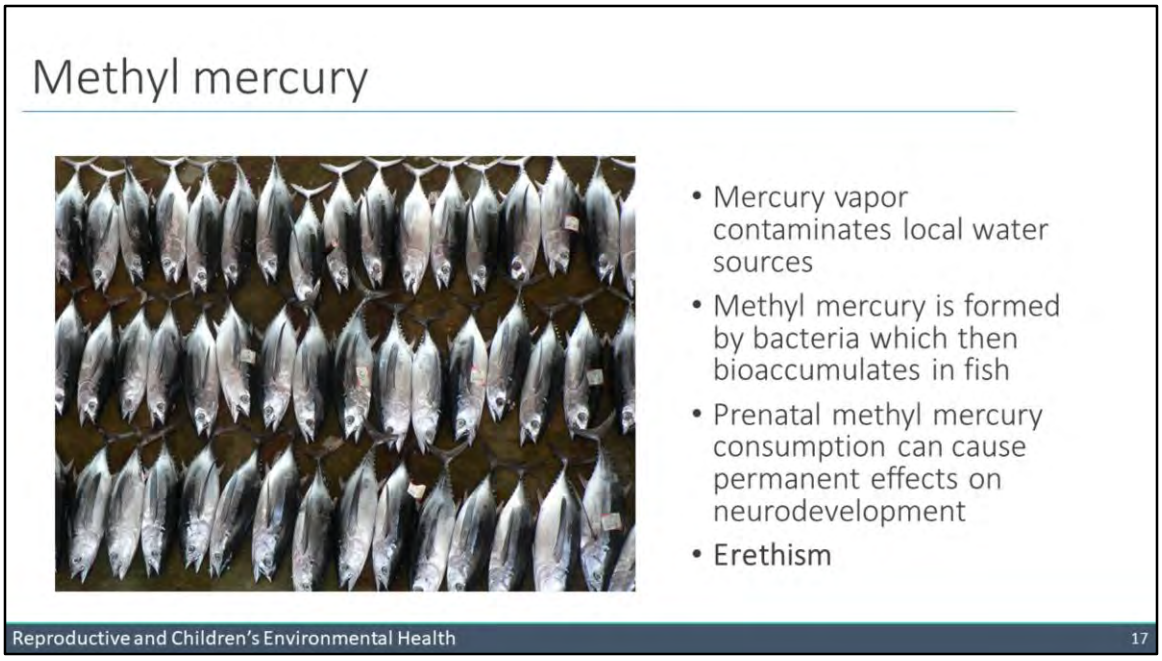


In addition to the risk of mercury vapor inhalation, mercury vapor contaminates local water sources. When mercury enters an aquatic ecosystem, methylating bacteria in the bottoms of ponds and rivers convert the elemental mercury to methyl mercury which bioaccumulates up the food chain. When residents of communities near mining areas eat locally-caught fish, they may be exposed to harmful levels of methyl mercury.

There is strong data to show that prenatal exposure to methyl mercury through fish consumption can result in serious and permanent effects on the neurodevelopment of the fetus. These include performance on tests of attention, language, visual-spatial ability and memory. At very high levels, severe neurological effects and psychomotor retardation can occur.

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*IMAGE*

## 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

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Arsenic is a constituent of ores in some geographic locations, and exposure to arsenic may occur during gold, copper, and other metal mining. Miners are at risk of inhaling or ingesting arsenic in all stages of the mining process. Arsenic dust can get onto clothing and be brought home. Also, arsenic residue on the hands can be ingested if hands aren't washed before eating. Since up to 50% of small scale miners are women, prenatal or early life exposure to arsenic is a concern.

Arsenic can cross the placenta from the mother to the baby, and umbilical cord blood levels have been found to be similar to maternal levels. There is little information about the consequences of prenatal arsenic exposure, but studies of smelter emissions suggest there is a higher risk of spontaneous abortion and low birth weight.

Exposure in early childhood may cause impaired cognitive development, decreased nerve conduction velocity affecting motor function, and sensory neuropathy, or decreased sensation in the hands and the feet.

Many small scale miners are unaware of the dangers of arsenic. A survey in Tanzania showed that 89% of those surveyed did not know about the possible health effects

caused by arsenic exposure.

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*IMAGE*

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Acute high dose exposure can cause diarrhea, nausea, vomiting, and vomiting of blood within 30 minutes of ingestion.

Acute reaction to lower dose exposure may include gastrointestinal upset and peripheral neuropathy. There may be ascending paresthesias (that is, tingling), anesthesia—which would be reported by a patient if asked--and weakness. There is also liver dysfunction.

Chronic exposure may present as fatigue, weakness, and bone marrow suppression. Skin rashes, hyperpigmentation, or alopecia may be present. White horizontal creases may appear across the fingernails. These are called Mees lines.(American Academy of Pediatrics 2003).

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*IMAGE*
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## 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

Reproductive and Children's Environmental Health 20

Sulfur oxides and nitrogen oxides are products of combustion and are emitted when engines are used during mining or when fuel is burned to create amalgam. These oxides react with air to produce Sulfur Dioxide and Nitrogen Dioxide which are air pollutants that may have a negative effect on the reproductive health of men and women miners. An epidemiological study in the Czech Republic found that exposure to $SO_2$ and $NO_2$ may cause decreased fertility.

Studies which look at exposure to multiple pollutants, including $SO_2$ and $NO_2$, during pregnancy, suggest there may be an increased risk of low birth weight babies with increases in exposure during pregnancy.

Infants who are chronically exposed to $NO_2$ or $SO_2$ suffer a higher incidence of lower respiratory symptoms such as chronic cough, wheeze, and shortness of breath, phlegm or bronchitis. This is more likely to occur if combustion activities occur at home, such as use of a fire for burning amalgam.(Landrigan 2014)

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*IMAGE*


Image name: “Making explosives”
Author’s description: “Here's our guide making explosives with the ingredients bought earlier that day (Potosi, Bolivia)” (Silver mining)
Image link: https://www.flickr.com/photos/philliecasablanca/2052675018

## 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)

Reproductive and Children's Environmental Health 21

Artisanal mining is labor-intensive and is conducted in hot and humid conditions. If heat exposure is high enough to elevate a male miner's core body temperature, he may have a temporary decrease in sperm count. Exposure in an environment that is hot year-round may result in fertility problems among males.

In females, animal studies have shown an association between developmental abnormalities and increased core body temperature, but this has not been confirmed in human studies. There is no known relationship between heat and a woman's fertility.

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*IMAGE*
CC-BY 2.0 Peter Taylor
Image name: “The Thin Blue Line”
Image link:  https://www.flickr.com/photos/nickstone333/8146230504
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## 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

Reproductive and Children's Environmental Health 22

Harsh conditions, subsistence living, and homelessness is thought to contribute to drug and alcohol abuse in artisanal mining communities. In males, drug and alcohol abuse may decrease fertility by lowering sperm counts, causing sperm malformations, and changing levels of gonadotropic hormones and testosterone. Abuse of drugs and alcohol by women before pregnancy can reduce their fertility, and cause menstrual disorders.

If alcohol is heavily used during pregnancy, spontaneous abortion may result. Also, lower birth weight, smaller head circumference, or shorter birth length are seen. (Landrigan 2014) Other effects on the child are termed Fetal Alcohol Effects, and include characteristic facial malformations, genitourinary malformations, limb malformations, learning problems, or mental retardation.

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Paul, M. 1993, *Occupational and environmental reproductive hazards: A guide for clinicians*, Lippincott Williams & Wilkins, Baltimore, Maryland.

*IMAGE*
CC-BY 2.0 by brankomaster
Image name: DSC00074
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## 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

Reproductive and Children's Environmental Health 23

Physically demanding work is significantly associated with preterm birth, small size of the baby, and hypertension or preeclampsia in the mother. Other occupational exposures significantly associated with preterm birth included prolonged standing, shift and night work, and high cumulative work fatigue.

---

**References**

Photo from instagram. No attribution found.

Information from publication:
Mozurkewich EL, Luke B, Avni M, Wolf FM. Working conditions and adverse pregnancy outcome: a meta-analysis. Obstet Gynecol. 2000 Apr;95(4):623-35.

Reference: Gynecol. 2000 Apr;95(4):623-35.

**Working conditions and adverse pregnancy outcome: a meta-analysis.**

Mozurkewich EL[1], Luke B, Avni M, Wolf FM.

**Author information**

**Abstract**

**OBJECTIVE:**

To evaluate the association between working conditions and adverse pregnancy outcomes by performing a meta-analysis of published studies.

**DATA SOURCES:**

We searched the English-language literature in MEDLINE through August 1999 using the terms standing, posture, work, workload, working conditions, shift, occupational exposure, occupational diseases, lifting, pregnancy complications, pregnancy, small for gestational age (SGA), fetal growth retardation (FGR), preterm, and labor.

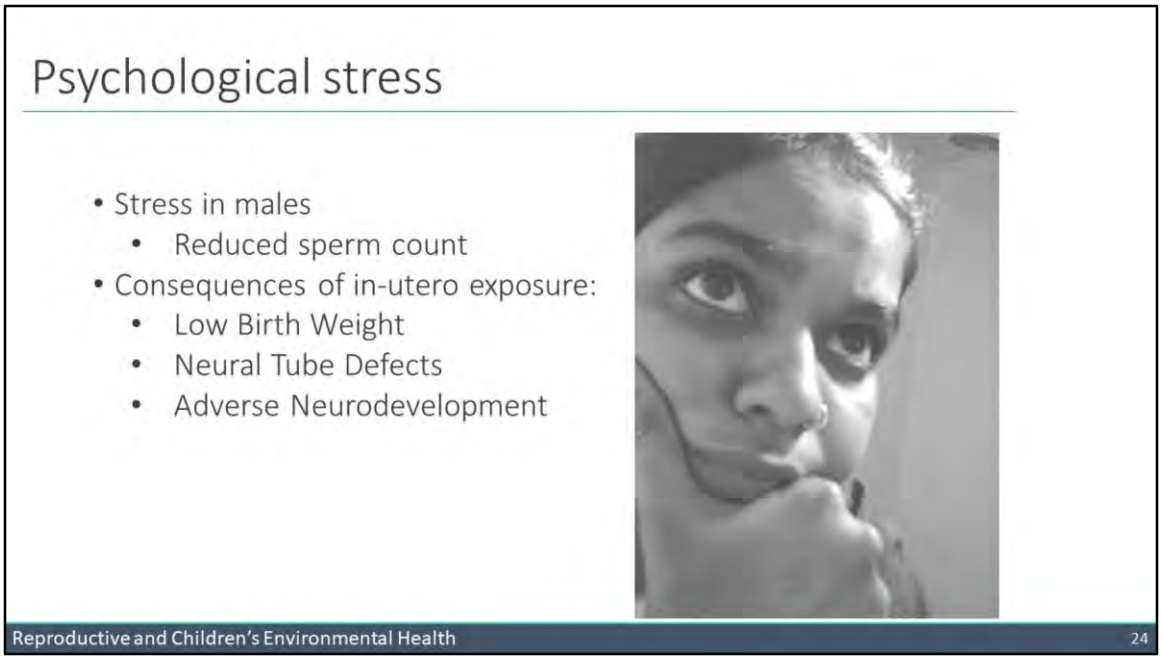
**METHODS OF STUDY SELECTION:**

We included observational studies evaluating the effect of one or more of the following work-related exposures on adverse pregnancy outcome: physically demanding work, prolonged standing, long work hours, shift work, and cumulative work fatigue score. Outcomes of interest were preterm birth, hypertension or preeclampsia, and SGA.We conducted a meta-analysis based on 160,988 women in 29 studies to evaluate the association of physically demanding work, prolonged standing, long working hours, shift work, and cumulative work fatigue score with preterm birth. Also analyzed were the associations of physically demanding work with hypertension or preeclampsia and SGA infants. The data were analyzed using the Peto-modified Mantel-Haenszel method to estimate the pooled odds ratios (ORs) and 95% confidence intervals (CIs).

**TABULATION, INTEGRATION, AND RESULTS:**

**CONCLUSION:**

Physically demanding work may significantly increase a woman's risk of adverse pregnancy outcome.




Artisanal and small scale gold miners may experience emotional stress due to the transient nature of their work, work that keeps them away from their families. They also experience poverty, long work hours, and cramped living conditions. This stress can have an effect on miners' reproductive health. For example, men may have lower sperm counts and lower semen quality during periods of stress which may decrease their fertility.

Pregnant women who are stressed have an increased risk of children with low birth weight, neural tube defects, cleft lip, and cleft palate. Abnormal neurodevelopment can occur among children who are prenatally exposed. Some of the suspected neurodevelopmental outcomes include autism, schizophrenia, emotional or behavioral problems, attention deficit hyperactivity disorder (or ADHD), and reduced cognitive ability.

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and male reproductive health. *Urologic Clinics of North America, 41*(1), 55-66. doi:http://dx.doi.org.proxy.cc.uic.edu/10.1016/j.ucl.2013.08.017
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Suarez L, Cardarelli K, Hendricks K. (2003) Maternal stress, social support, and risk of neural tube defects among Mexican Americans. Epidemiology 2003 Sep;14(5):612-616.

*IMAGE*

Image name: “the physical impossibility of anything for someone blasé”
Link to image: https://www.flickr.com/photos/rahima/157133651/

## 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

Reproductive and Children's Environmental Health 25

Environmental exposures throughout life can affect reproductive health including fertility, sexual development, and the health of future children. Exposures in-utero can permanently alter the health and development of the exposed fetus.

Mercury, Arsenic, and products of combustion are common exposures in artisanal mining that can cause severe damage to unborn children.

Other exposures such as heat, drug and alcohol abuse, and physical and emotional stress are common in mining communities and should not be overlooked as potential reproductive hazards.

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*IMAGE*
CC-BY 2.0 "Checkup" by J P Davidson
Image Author's Description: "The Gurukul Cluster is a large community of migrant workers who settled on the outskirts of Faridibad in Harayana, north India over ten years ago to mine a local quarry. In 1996 the Supreme Court closed the quarry due to the excessive number of Tuberculosis cases in the surrounding communities. Many

families are still recovering from the devestating effects mining in the local quary had on their community. “
Link to Image: https://www.flickr.com/photos/jpdavidsonimages/4656688391
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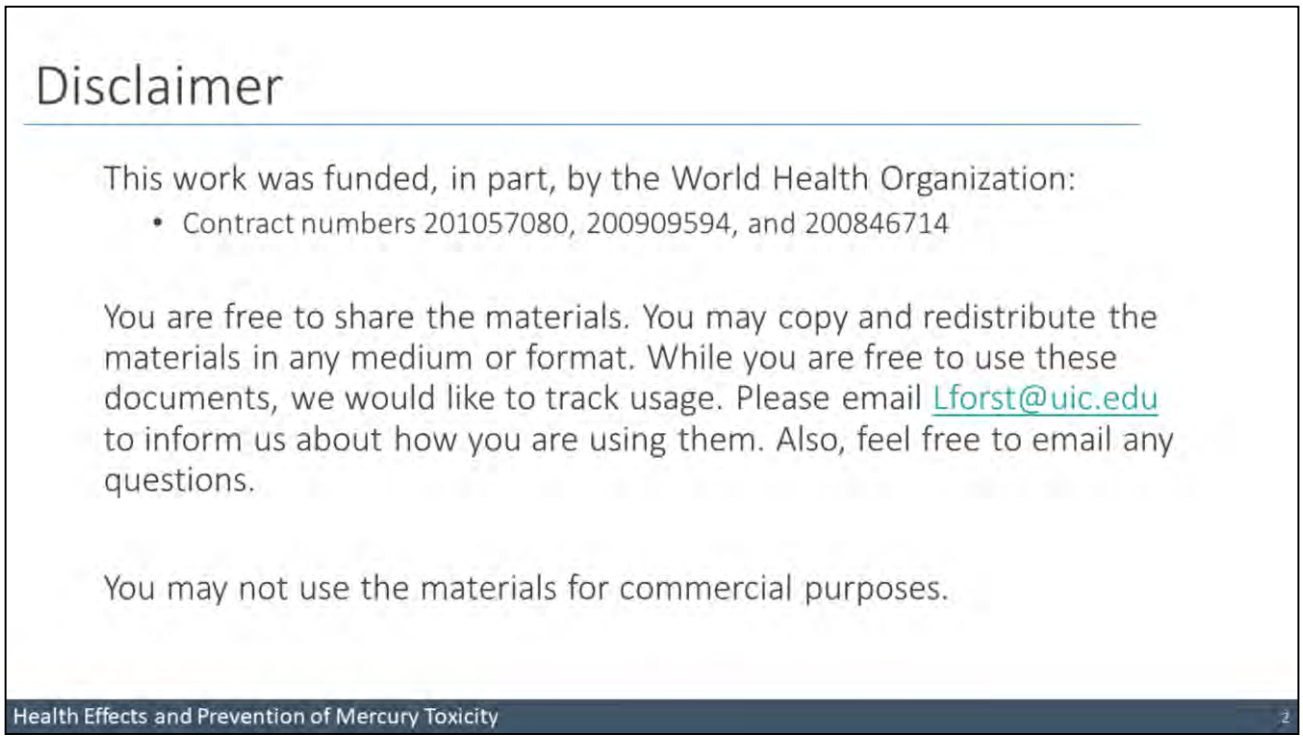
# URL to all powerpoints

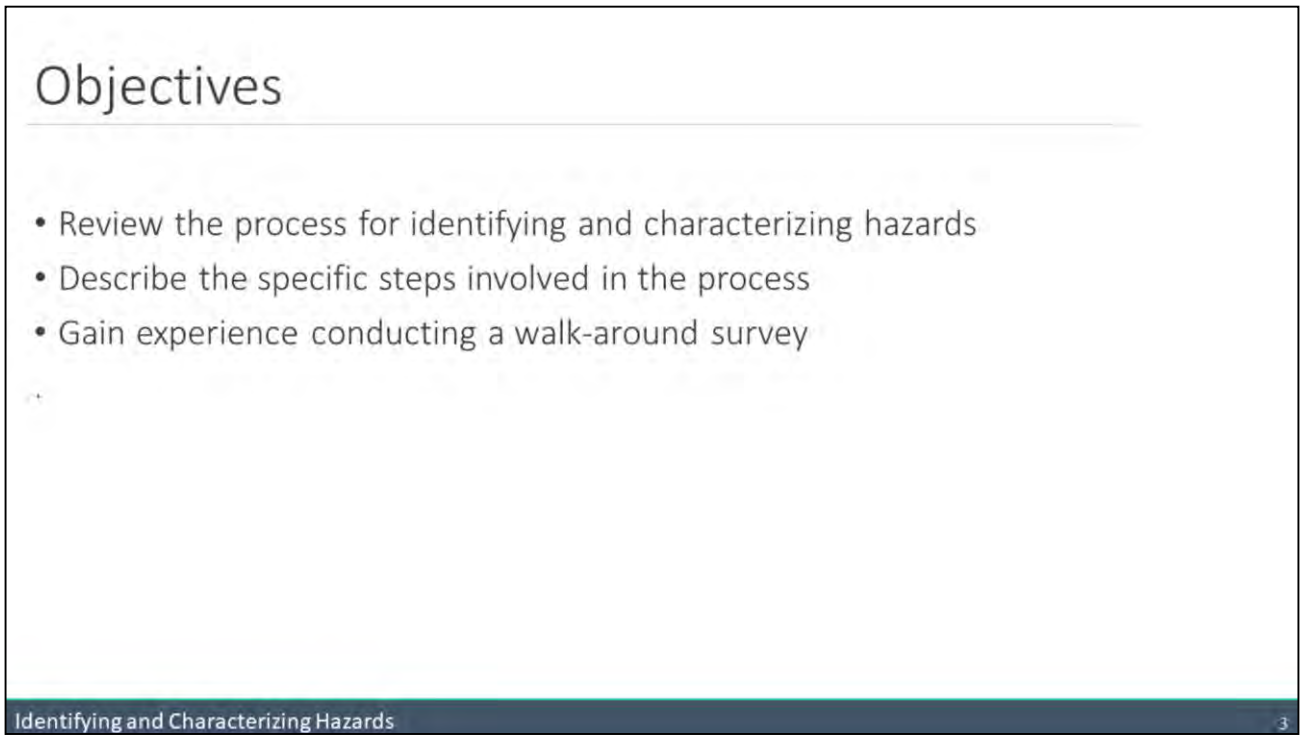
Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago

A WHO Collaborating Center

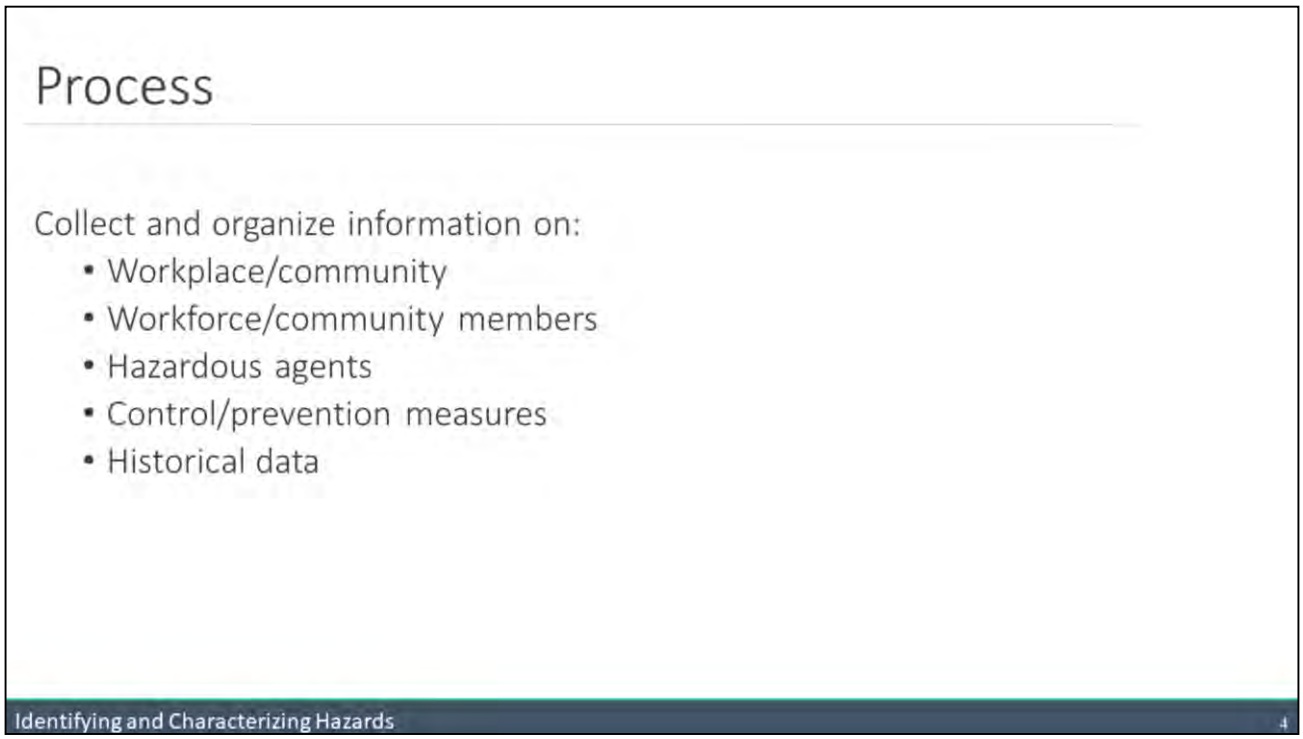

Artisanal and Small-Scale Gold Mining (ASGM): Identifying and characterizing hazards
UIC
Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago
A WHO Collaborating Center




This lecture is part of a course on the health issues surrounding Artisanal and Small Scale Gold Mining. This course was developed to assist countries in preventing illnesses and injuries among gold miners and their families.




By the end of this lecture, you should be able to describe an approach to identifying and characterizing hazards. You will gain virtual experience conducting a walk-around survey of a work site.

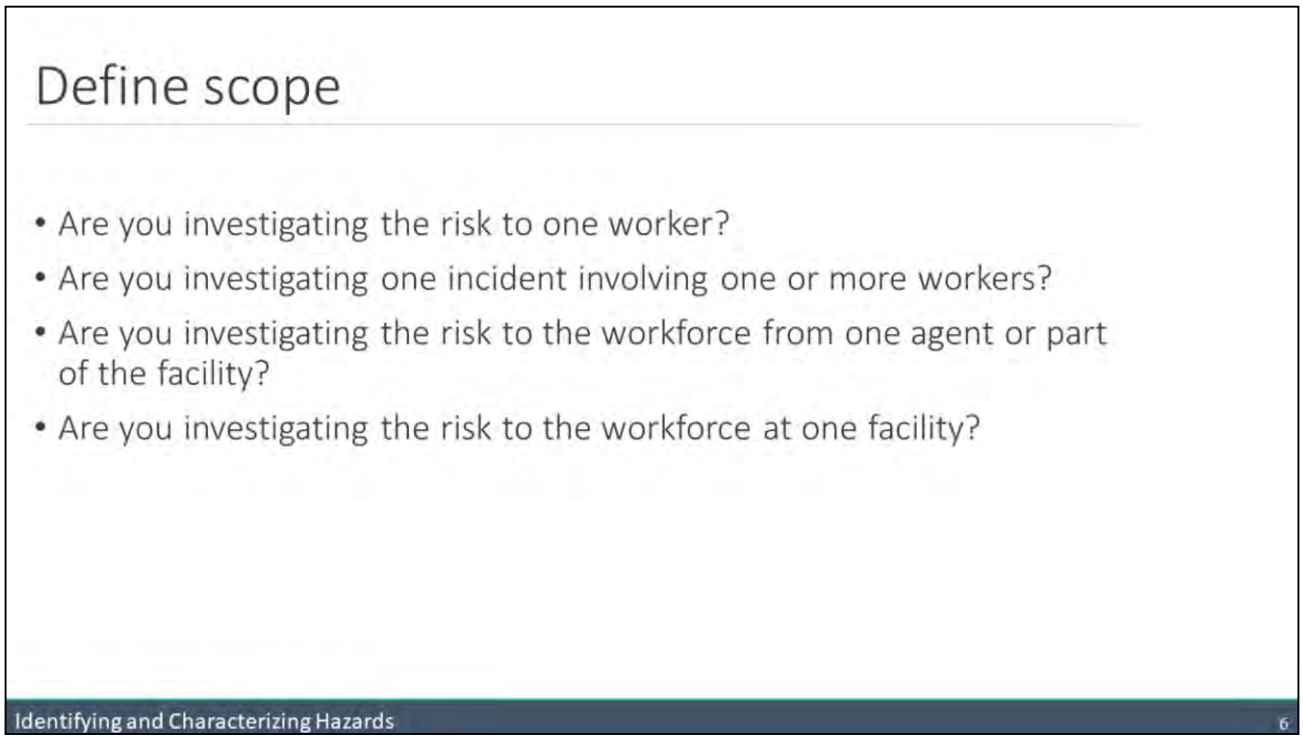



The process of identifying and addressing hazards involves collecting information about:

- The workplace or community
- The workforce or community members
- Hazardous agents
- Control or prevention measures
- Historical data


In order to identify ASGM workplace hazards and address them, you will need to:

- Characterize the ASGM workplace or the community where ASGM activities are going on
- Characterize the ASGM workforce or community members who are involved with these activities or working or playing in close proximity
- Characterize the biological, chemical, physical agents, as well as the ergonomic and psychosocial hazards associated with ASGM
- Characterize existing control measures to prevent illness or injury among gold miners
- Review past assessments or results of the workplace, if they are available for this mine or other mines overseen by the same company or in the same region
- Review historical exposure data in the workplace. Again, these may or may not be available.
- Review environmental emission data. While it would be helpful to have health and safety monitoring data, this is often not available.
- Review past biological monitoring data. This might include laboratory testing or other examinations of the workforce.

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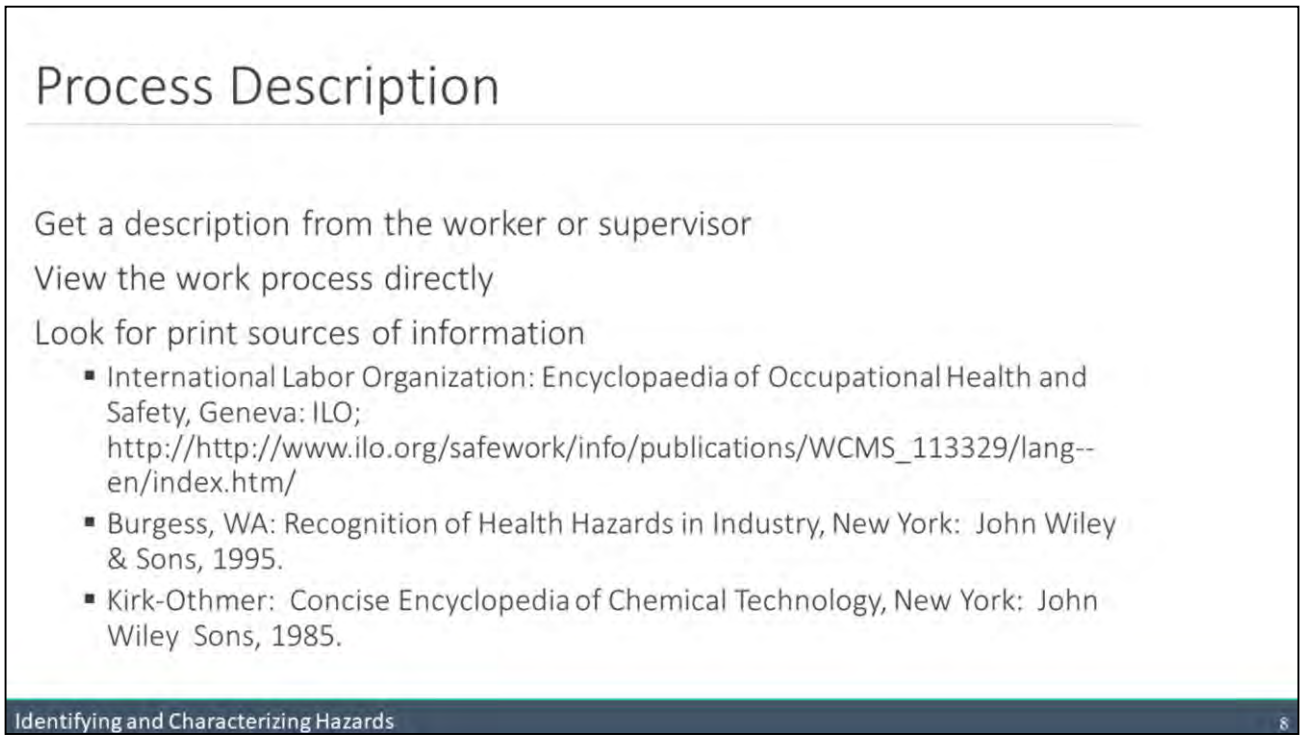
- Review past biological monitoring data. This might include laboratory testing or other examinations of the workforce.

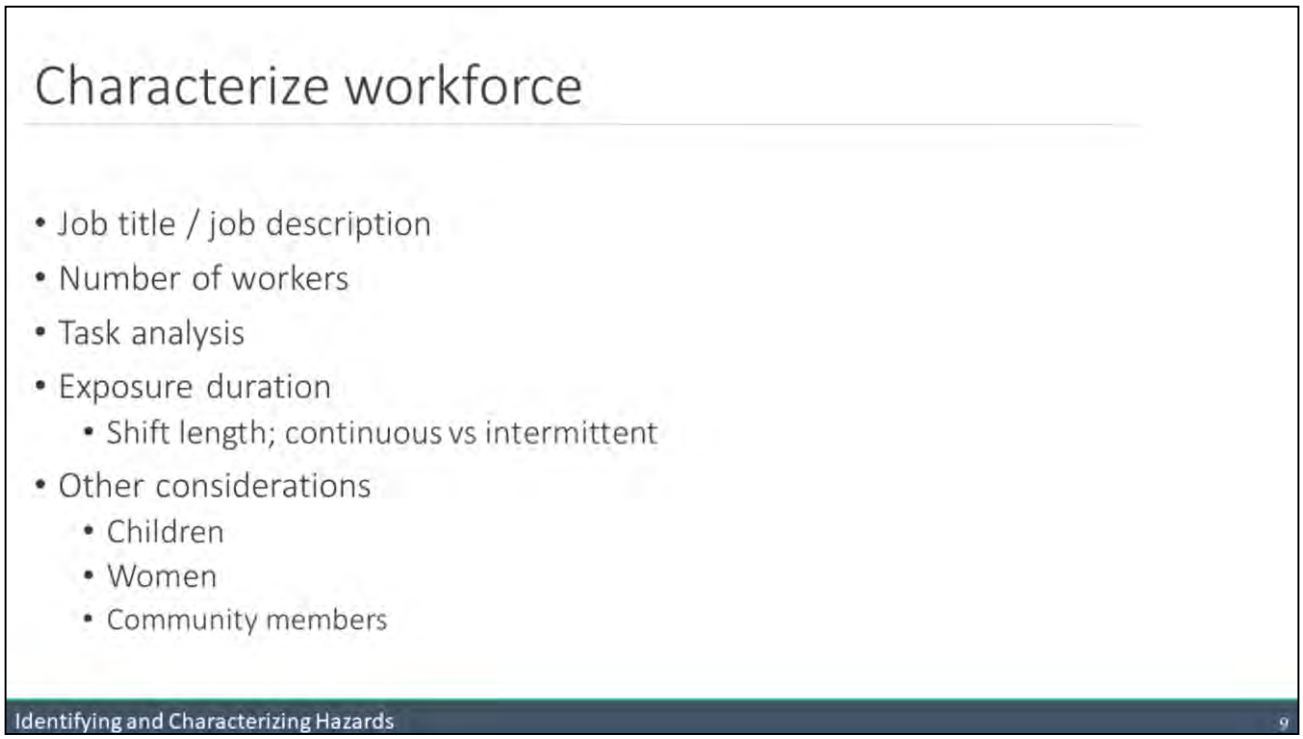

During a workplace characterization you want to identify and document:

- The work process
- Activities going on in the workplace
- Raw materials that are used in the work process
- Products that the work process is designed to produce
- By-products—these are unintended or un needed products that are left over from the process
- Waste products—we want to know what might get out into the environment or what kind of waste needs to be handled
- Processing aids—these could be machinery or tools, or could be adjunctive work process designed to facilitate production



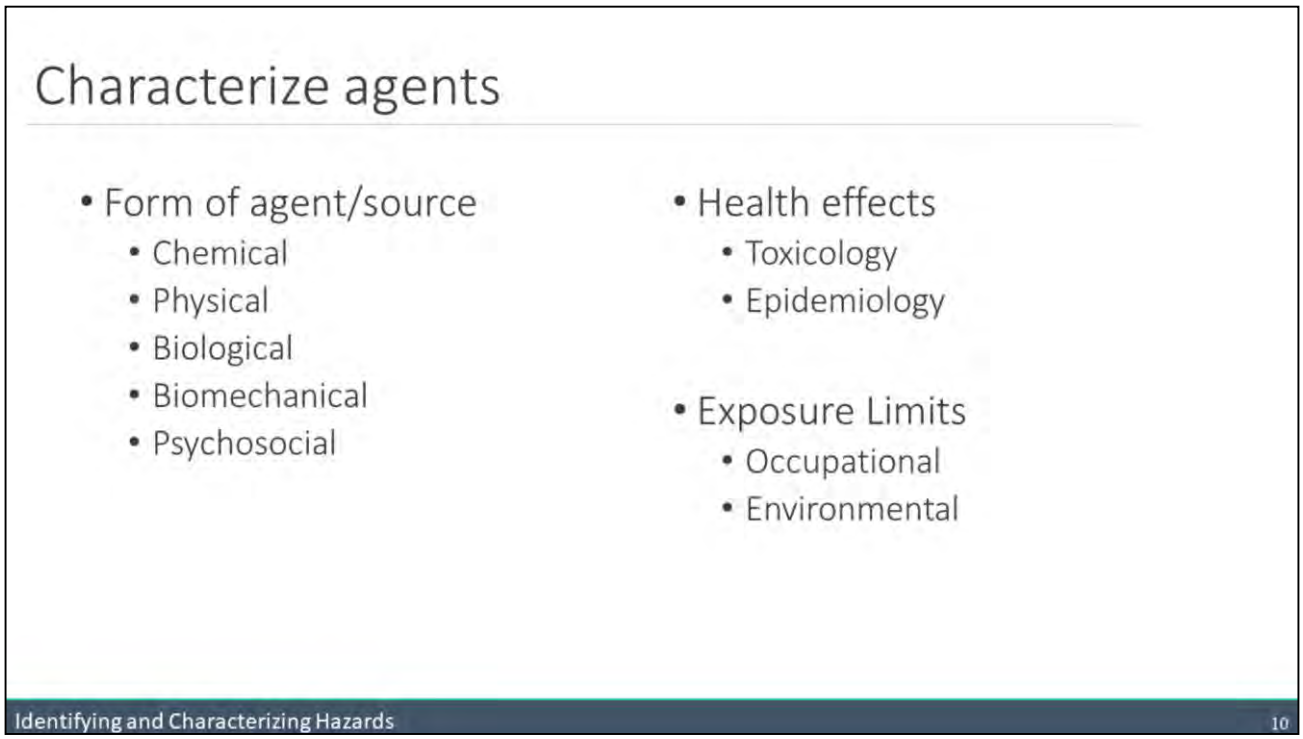

You can learn more about the work process by asking workers and supervisors about it, observing the work process directly or researching the work itself. A general description of work processes can be found at these sources, listed on the slide.

**PLEASE INSERT COUNTRY SPECIFIC INFORMATION AND RESOURCES HERE**

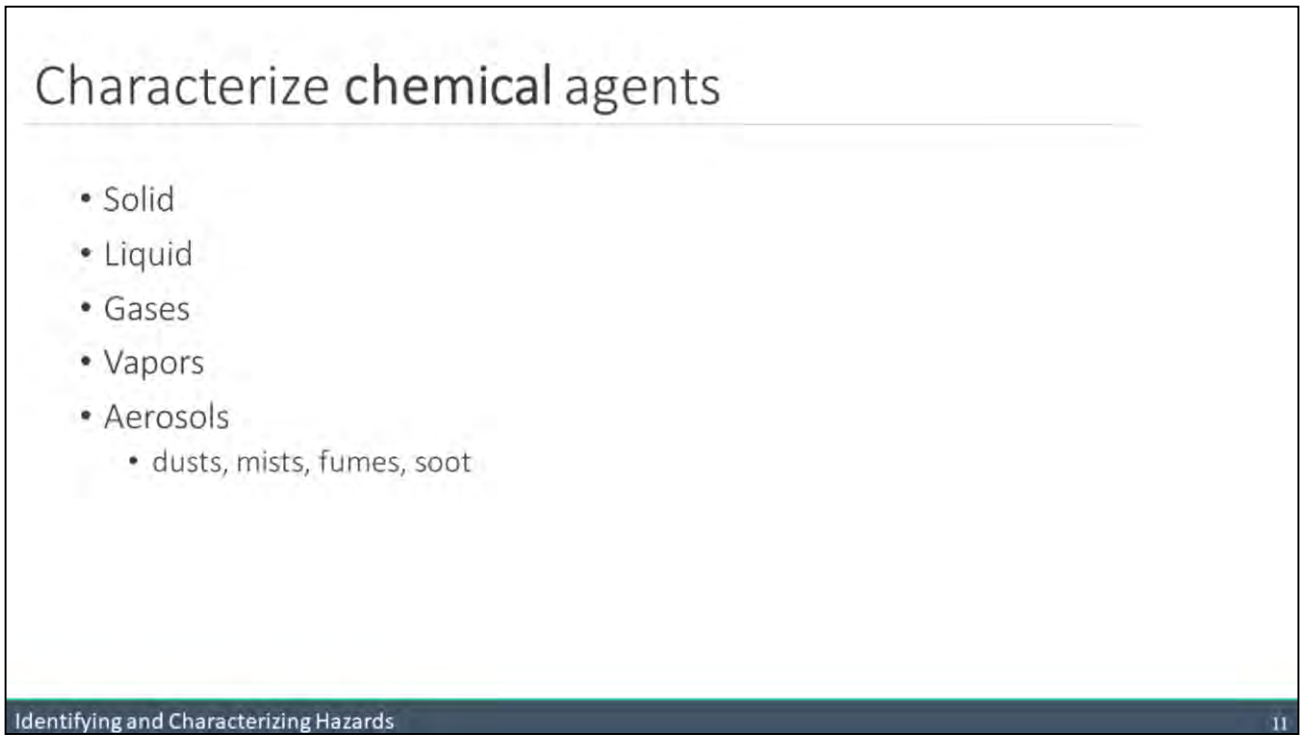



It's important that you know as much as you can about the workforce. This includes collecting information on:

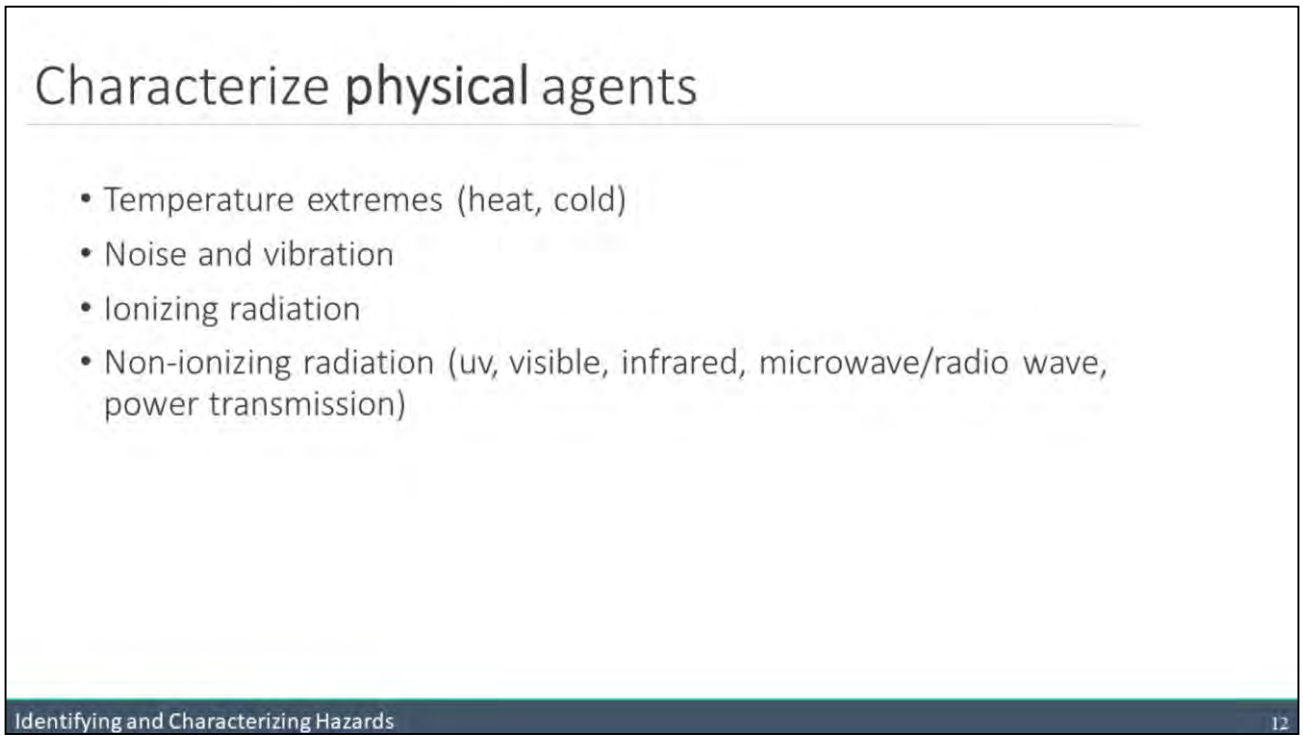
- Job titles and job descriptions-If possible, you will want to document names and contact information in case of an accident; you also want a job description that gives you a sense of work tasks and also orients you to the possible hazards that are associated.
- Number of workers in the workplace
- Task analysis: this comes from observation and from talking with managers and workers doing those tasks. It is possible to read about job tasks and their hazards.
- Exposure duration should include the amount of time the worker is in the job, overall, and also the amount of time he or she is exposed to hazards of interest – this could be hours per day or days per week, for example
- The involvement of women, children in job tasks is important, keeping in mind their particular vulnerability. You might also consider exposure to community members




As a review, agents or sources are categorized as: chemical, physical, biological, biomechanical and psychosocial. As part of this characterization, you will also want to examine the health effects and exposure limits. Workers generally have the highest exposures, since they are handling chemical agents or they are more proximate to emissions. Workers are permitted higher exposure levels at work than community members are. This is partly due to acceptance that work is hazardous and also that workers tend to be a healthy adult workforce. Environmental exposure limits are lower because there are vulnerable people (eg, women, children and individuals with chronic diseases) who are unable to tolerate the same levels that healthy adults can tolerate.




As a review, chemical forms include: solid, liquid gases, vapors and aerosols. Knowing this information can help consideration of how likely a worker is to be at risk for exposure.

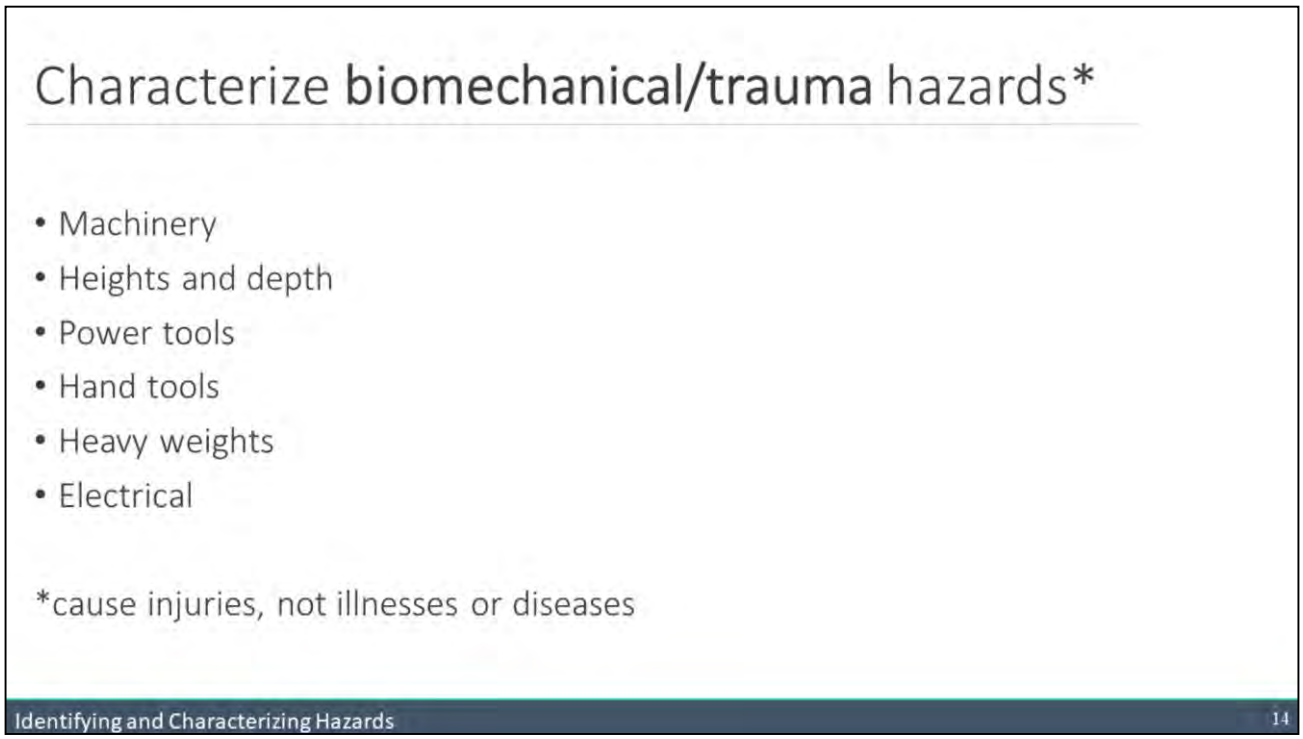



Examples of physical agents are:

- Temperature extremes
- Noise
- Vibration
- Ionizing radiation
- Non-ionizing radiation

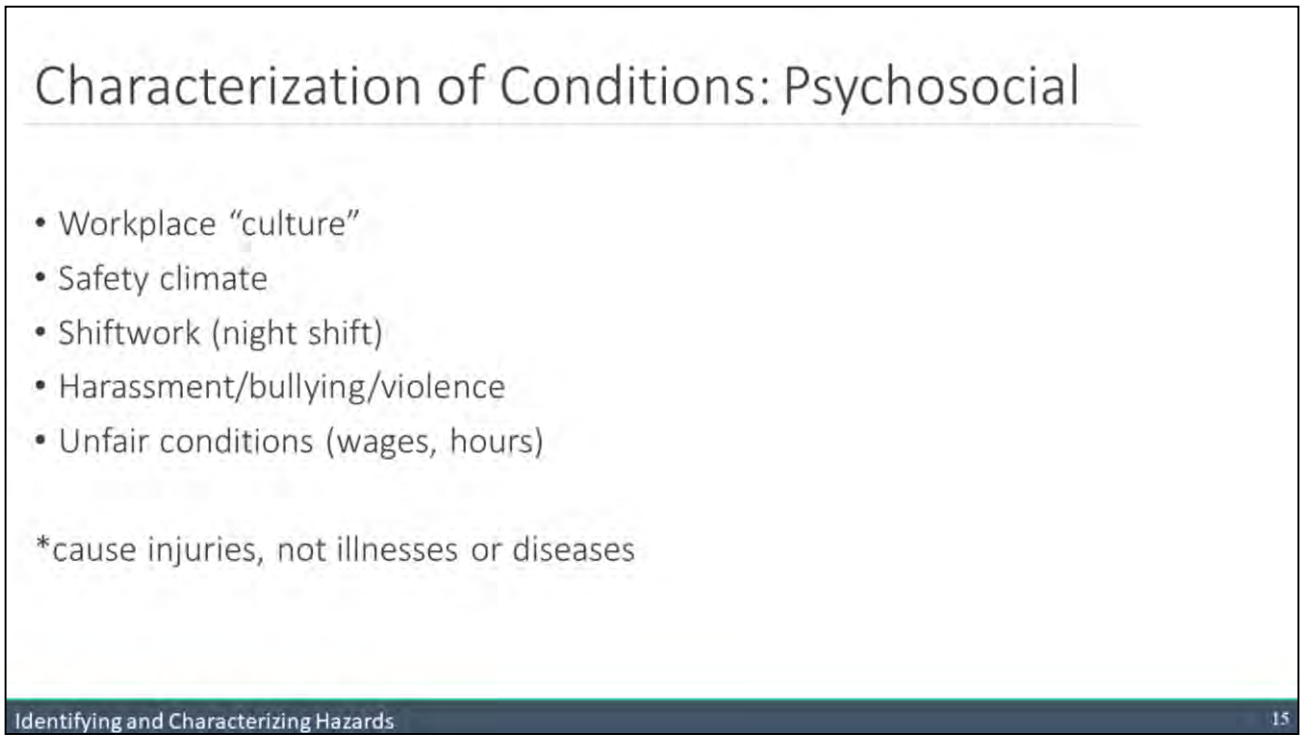
Sometimes people like to say that ergonomic or accident hazards are in the category of "physical" agents. We are using a different category for these – biomechanical hazards.


Some examples of biological agents are bacteria, viruses and fungi. These are infectious agents. Allergens are also in the category of biological agents, as there are workplace hazards from animal exposure—animals cause allergic reactions, like skin rashes, nasal congestion, cough, and wheezing. Actually, there are some chemical agents that can also cause allergic reactions, so allergens could be categorized in Chemical Hazards, as well.




Biomechanical hazards are caused by:

- Machinery, where workers can get their hands caught, or crush type injuries can occur
- Falls from heights, or diving underwater for work create hazardous conditions
- Power tools & Hand tools can cause injuries, generally the hands, arms and shoulders
- Heavy weights can strain muscles and the back
- Electrical sources can cause burns and electrocutions




Psychosocial hazards or stressors are caused by:

- Workplace "culture" describes the values, beliefs and attitudes of the workplace. Culture has been associated with safety behavior at work.
- Safety climate: how do workers thing the company approaches safety (Is it a priority? Do employees feel comfortable reporting incidents?)
- Shift work-for example, night shift work can cause health problems
- Harassment, bullying or violence is unfortunately not uncommon.
- Unfair conditions such as low wages and long work hours alter the attitudes of workers about work

# Characterizing Agents

## Health Effects

- Sources of Information
  - Safety Data Sheets (SDS)
  - Toxicology Literature
  - Epidemiology Literature
  - Trade literature
  - Internet


Identifying and Characterizing Hazards 16

After you've characterized the agents, you'll want to examine the health effects associated with them. You can find information on health effects through Safety Data Sheets (SDS), toxicology literature, epidemiology literature and the internet.


In addition to the health effects, you will also want to know whether or not there are exposure limits set by the government for these agents. Exposure limits are accepted concentrations that, if exceeded, can result in illnesses or injuries. Exposure limits can be either regulatory or non-regulatory. Examples of regulatory limits include the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs); the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission. An example of a non-regulatory exposure limit is the American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs). These are all agencies in the US that regulate health and safety in different workplaces. Different countries have corollaries of these agencies.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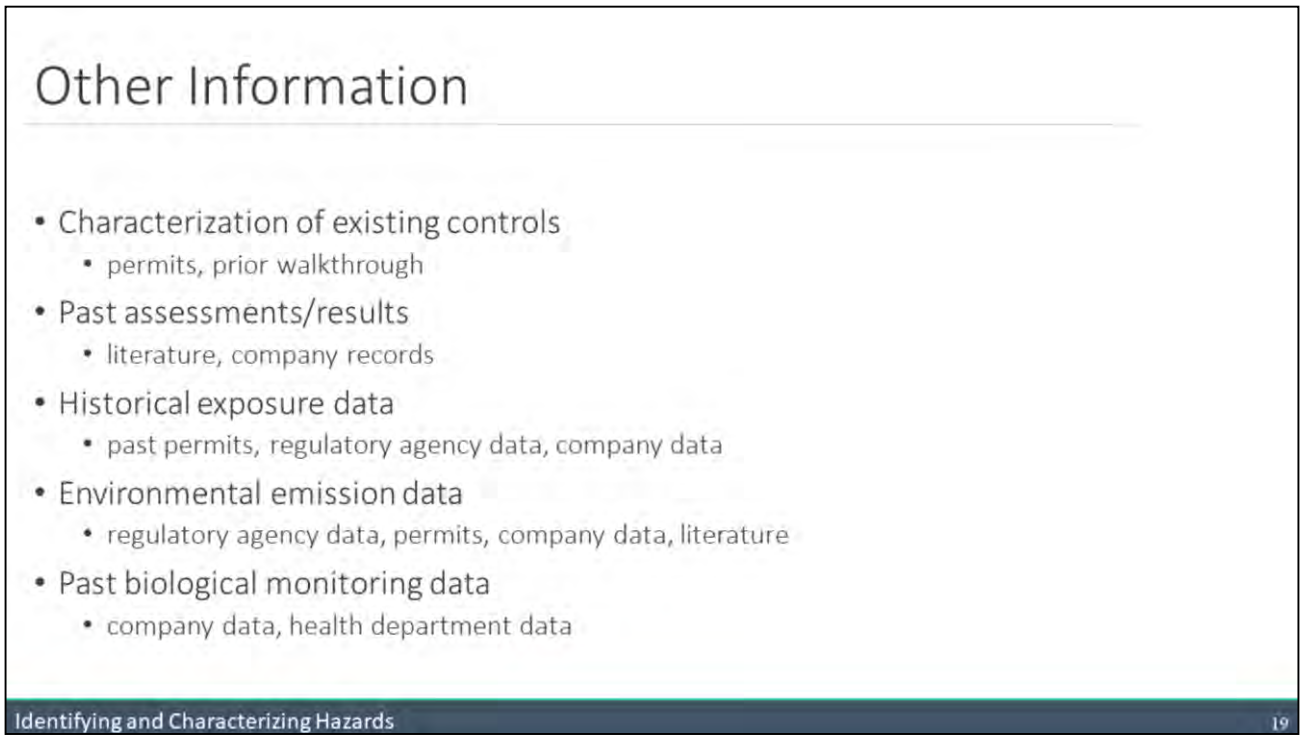
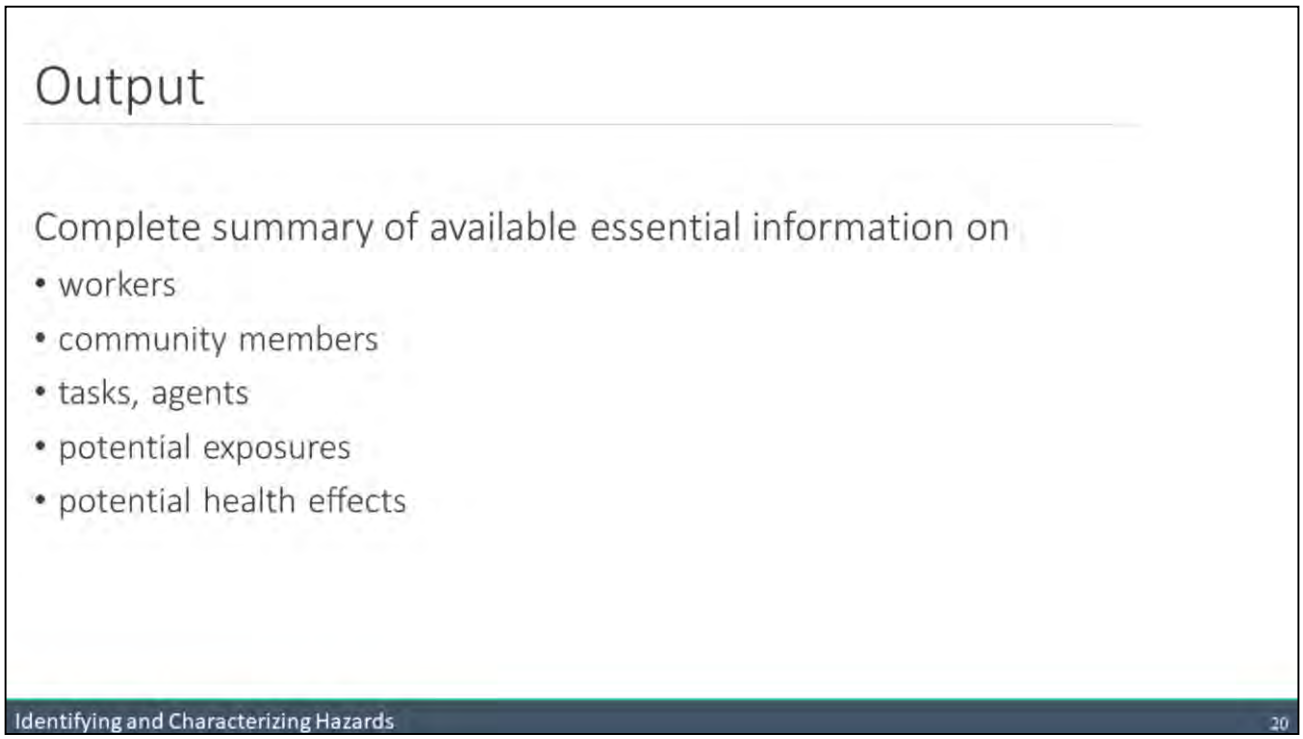
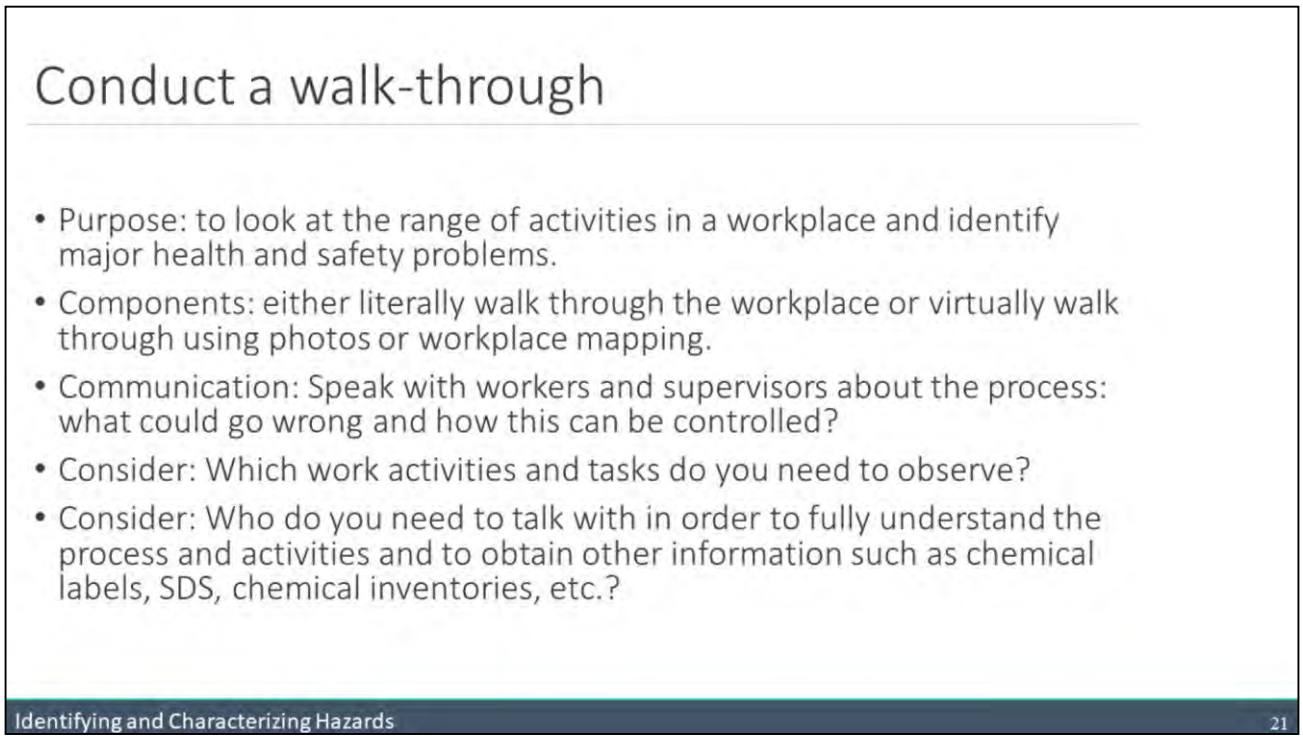



As part of this process, you may also want to review:

- Existing controls in the workplace
- Past assessments and results; you can get these from company records or from readings
- Historical exposure data in the workplaces can come from either the specific workplace you are looking at or from workplaces that are similar.
- Environmental emission data is generally required by law to be reported. These laws and practices vary by country.
- Past biological monitoring data can be helpful—if there was a problem in the past with an overexposure to a chemical, for example, this may focus you to look for sources of that hazard again or to look for substitution products.

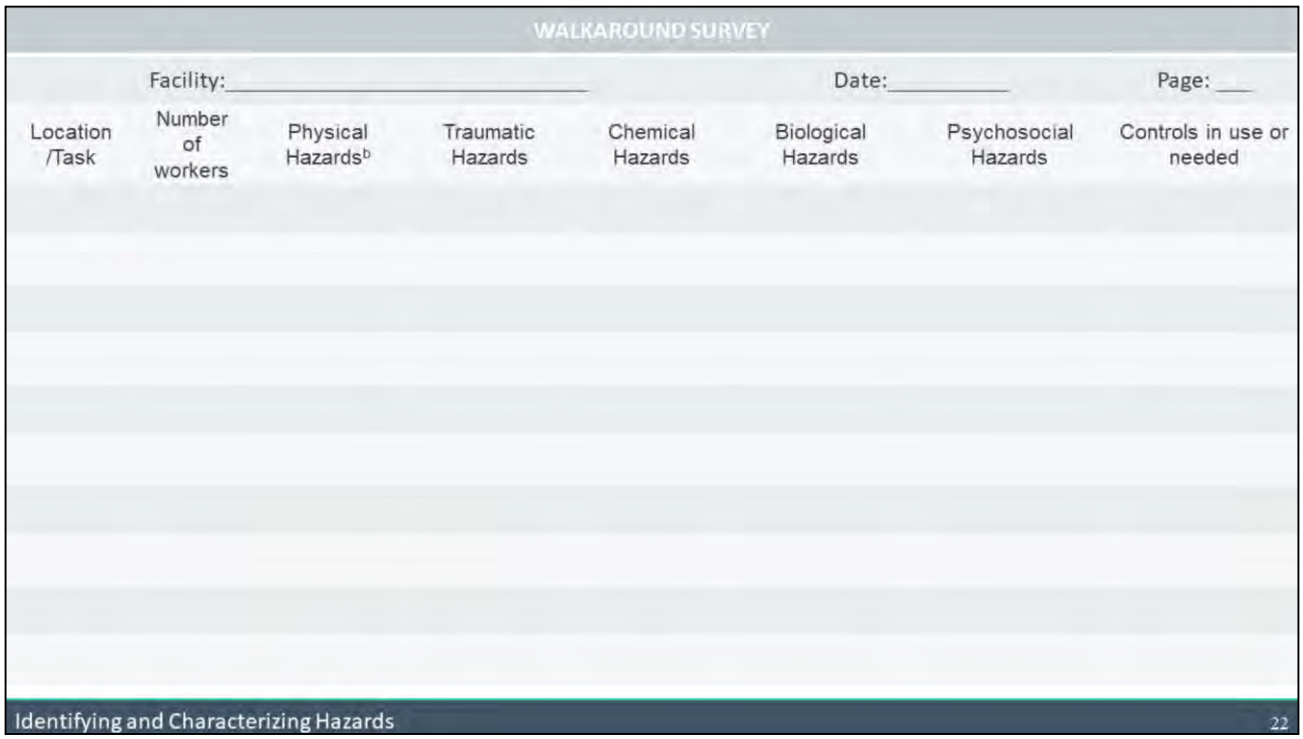



If done properly, this process will yield a detailed summary of all the information you will need to properly address the incident, hazard or exposure. Writing a report describing your findings is important to assist in finding conditions that can be ameliorated. Also, your report will establish a record of workplace hazards.

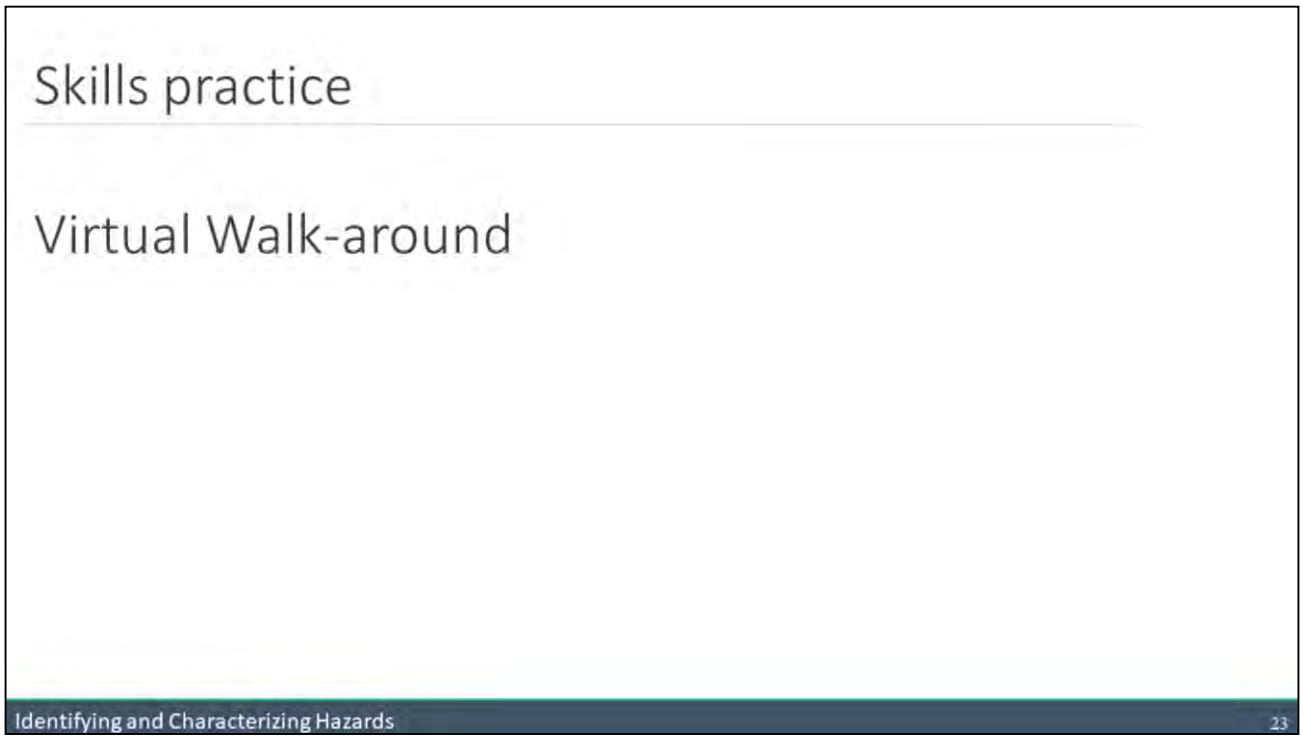



A walkthrough is an effective approach to collect some of the information we just discussed. The purpose of a walkthrough is to observe a range of activities or tasks in a workplace and identify major health and safety problems. It can be done in a real or virtual setting (review photos or workplace mapping if you are unable to enter the workplace). As part of the walkthrough, you'll want to speak with workers and supervisors to gain a better understanding of the processes as well as what could go wrong and how this may be controlled.

Before you conduct a walkthrough you'll want to identify which work activities and tasks require more attention and who you need to talk to in order to fully understand the process and access any other relevant information.




This is an example of a walkthrough survey. It includes space to describe the tasks, workforce, hazards and controls. We will be using this survey for the next exercise.

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Before you conduct a walkthrough you'll want to identify which work activities and tasks require more attention and who you need to talk to in order to fully understand the process and access any other relevant information.


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Man standing in field with 55 gallon drum  Looks like he is about to mix pesticides.

Hazards:

Chemical: pesticides

Physical: working alone in hazardous condition, sunlight

Ergonomic: uneven ground


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Worker is bending over lifting a bag

Hazards: same as previous

Ergonomic: bending and lifting heavy bag; on un-level ground.


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Pouring powder into 55 gallon drum.

Hazards :

Chemical: the powder can become airborne, no use of gloves. Inhalation and dermal routes of exposure are possible here


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

The worker is bending over a canal picking up water

Hazards:

Ergonomic:  bending over canal; standing on un-level ground.

Physical: danger of falling.

Chemical: No gloves, water may be contaminated with runoff of pesticides.


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Equipment left in field.  Unattended  Boxes, pesticides, chemical sprayers.

Hazards: chemicals left behind


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Workers are pouring pesticides into sprayer reservoirs. The reservoirs are on the backs of the workers.

<u>Hazards:</u>

Chemical-could spill onto the workers' backs—skin absorption

Ergonomic-sprayers are heavy→ back strain possible.


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Walking through fields right next to each other and spraying.

Hazards:

Chemical-walking right past their own spray;

Physical-carrying heavy gas powered sprayers; Noise possible;

Ergonomic-ground uneven.


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

**ANSWER:**

Worker talking with supervisor or boss.

<u>Hazards:</u>

Psychosocial-could be intimidating.

Chemical- note wet jacket of worker. This could be pesticides


**ASK:**

What is happening in this picture?

**ASK:**

What types of hazards are present?

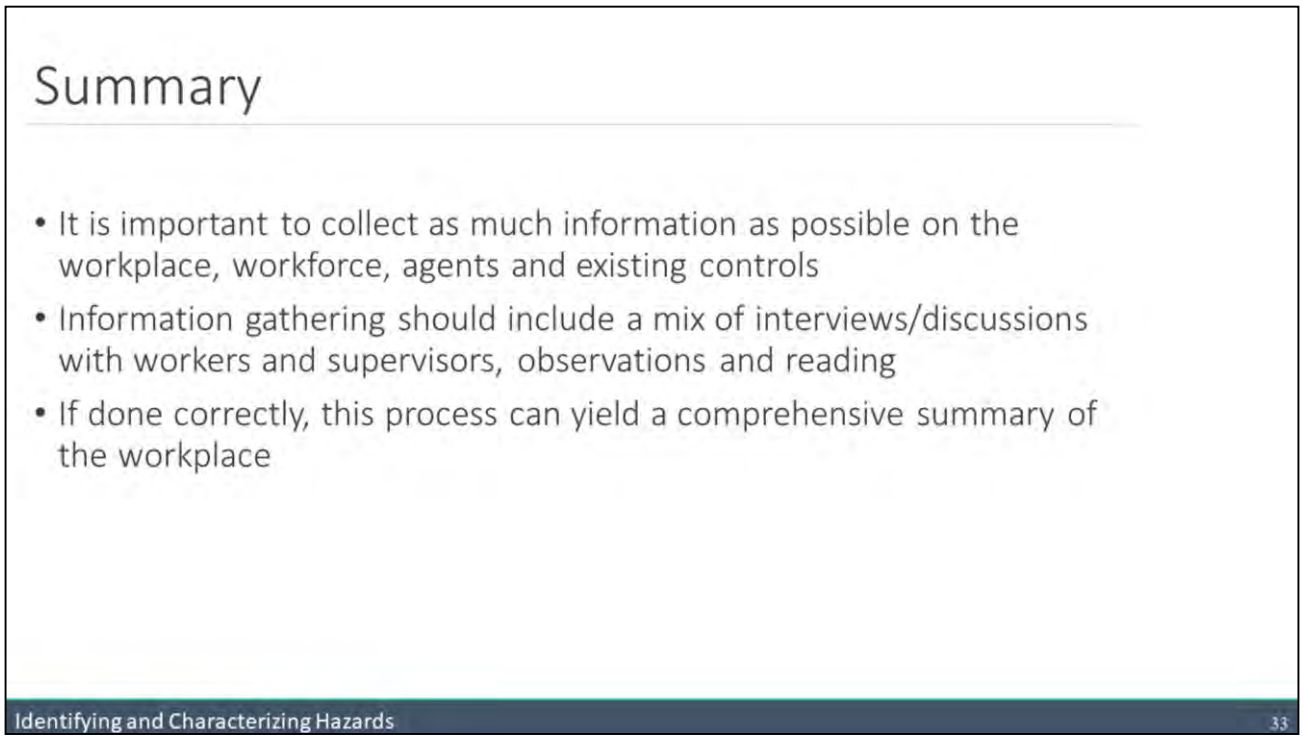
**ANSWER:**

Storage area for sprayers and chemicals.  Personal items right nearby.

Do they eat lunch here?

<u>Hazards:</u>

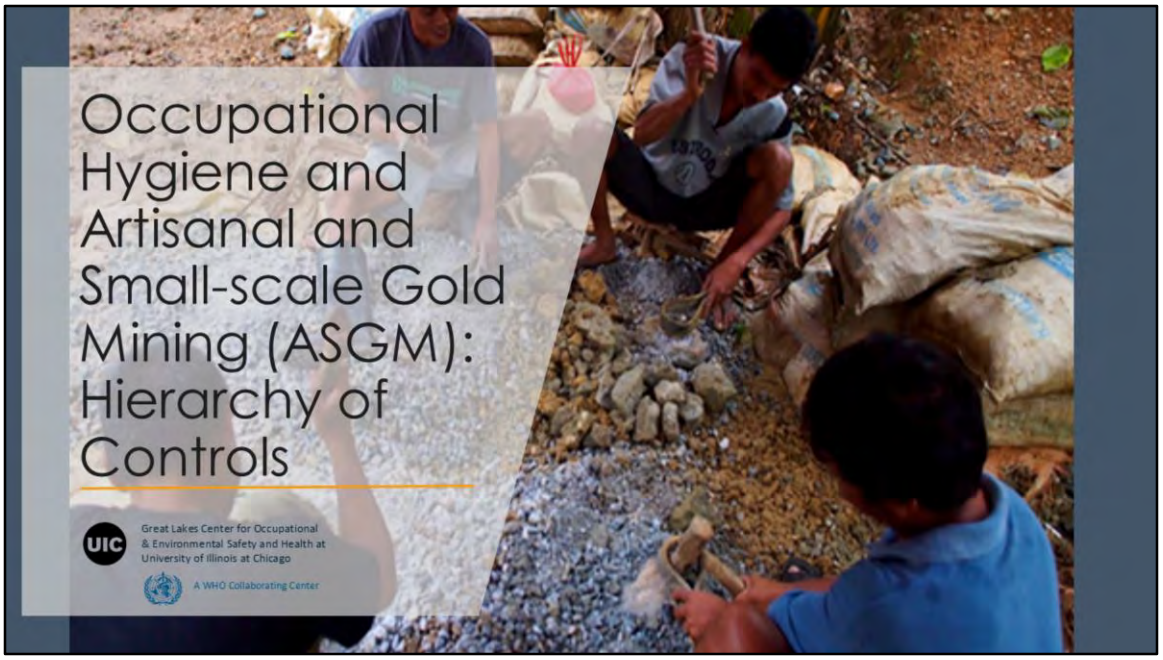
Physical: Housekeeping—trip and fall hazard.




To summarize:

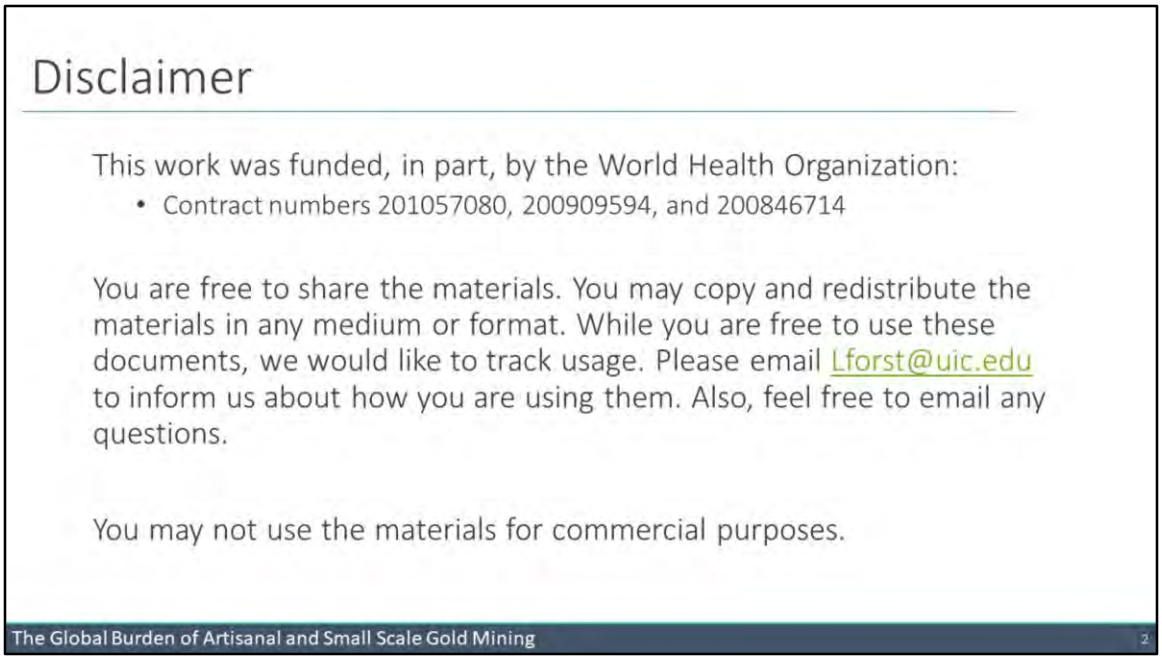
- It is important to collect as much information as possible
- Information gathering includes a mix of interviews, observations and research
- If done correctly, this process can yield a comprehensive summary o the workplace

# The End

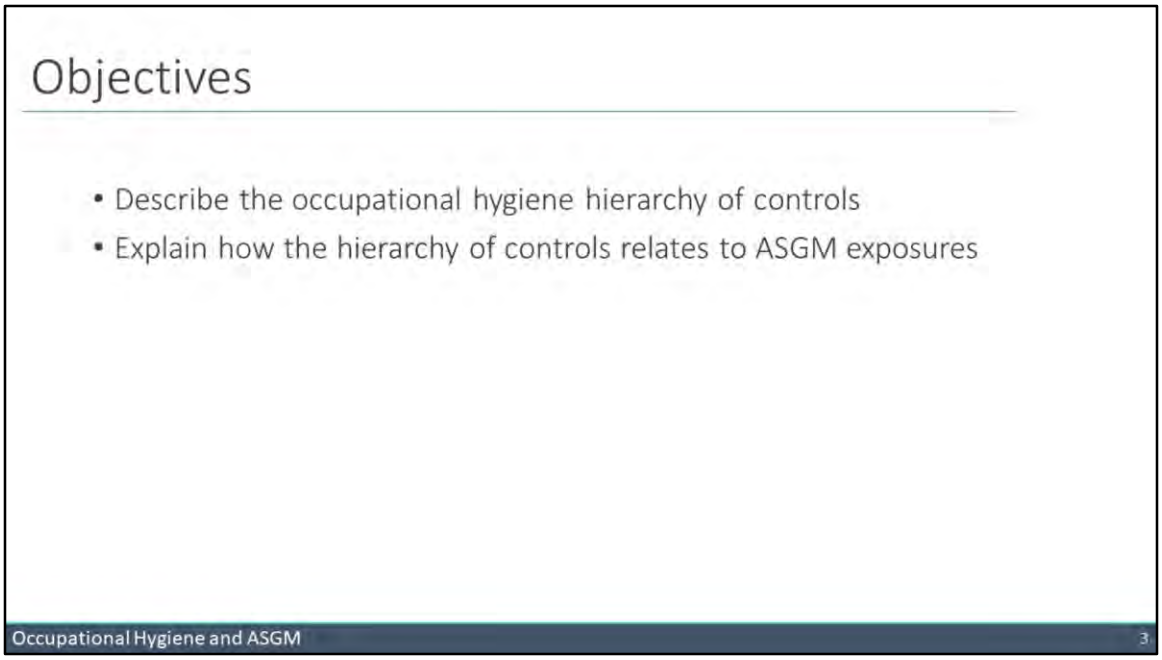



The focus of occupational hygiene is protecting the health and safety of workers and surrounding communities. Occupational hygiene involves identifying, evaluating and controlling hazards in the work place as best as possible.

We will be using the terms hazards and exposures throughout this presentation and it's important to clarify what these terms mean. A "hazard" is something that has the potential to cause harm. An exposure is the extend to which people are subjected to the hazard.




This course was developed to assist countries in preventing illnesses and injuries among gold miners and their families. By the end of this lecture, you should be able to describe at-risk populations in the subsistence gold mining sector and discuss the Minamata Convention and WHO's efforts to address the human health provisions. You will be introduced to the field of Occupational Hygiene or Industrial Hygiene, in the US. Occupational hygiene is the science of anticipating, recognizing, evaluating, and controlling workplace conditions that may cause workers' injury or illness.

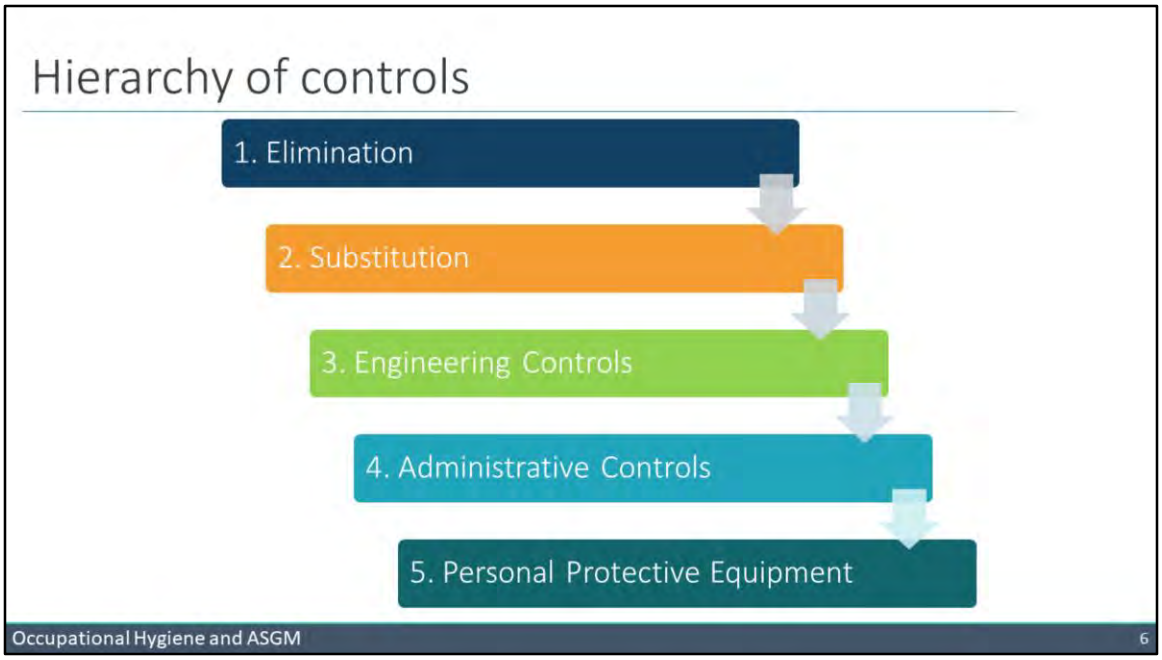



The aim of this slideshow is to introduce you to the concept of the occupational hygiene hierarchy of controls. We will talk about how the hierarchy can be applied in ASGM.


You have seen the routes of entry or the routes of exposure in a previous slideshow in this program. How do you think elemental mercury enters the body in these international scenes from ASGM?

Mercury is inhaled during the milling, amalgamation (when mercury is added to the gold powder to form a mercury-gold amalgam) and burning or smelting (when mercury is burned off) steps. During these steps, mercury is released, inhaled and absorbed by the lungs. Mercury can be ingested as a result of hand to mouth contact during the crushing, milling and amalgamation steps. Minimal skin absorption also occurs as a result of handling mercury.

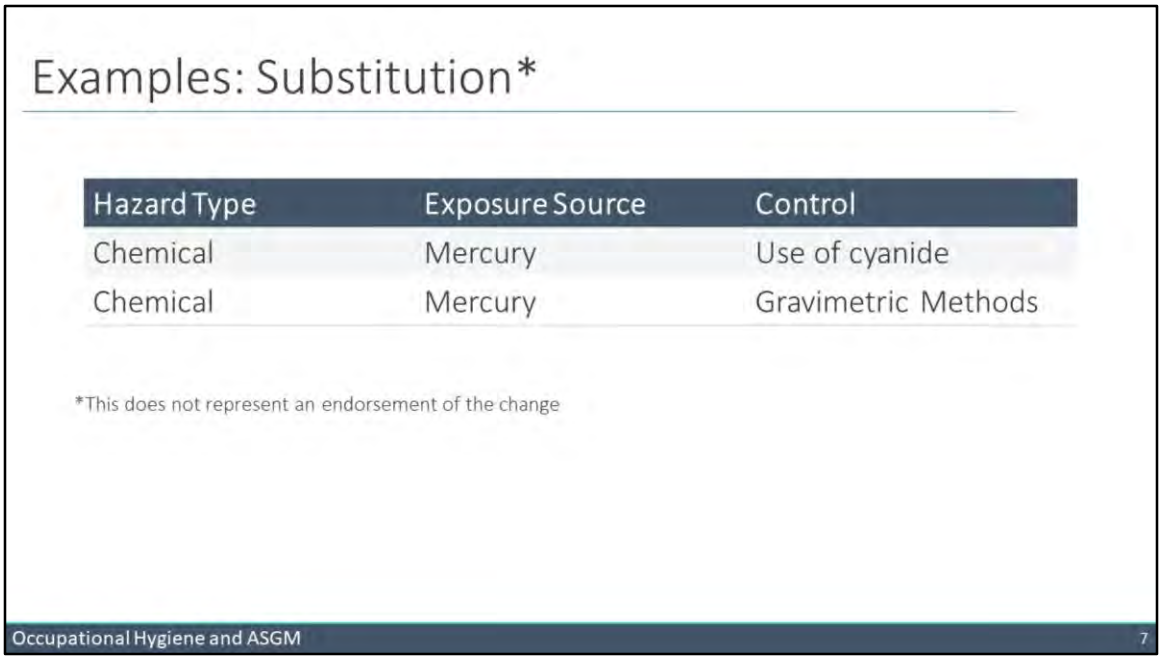

These are the categories of hazards that we looked at earlier. ASGM workers are exposed to hazards in all five categories. While mercury is the focus of this program, awareness of the other hazards they face is important.




The hierarchy of controls are the methods used to control exposures. The most effective methods are listed at the top.

Ask students to read these aloud; point out that these are in order of preferred intervention. Ask them why they think this is so. Discuss the problem with PPE—availability, cost, whether you get the right mask and gloves to actually protect yourself.

1. Elimination: remove the hazard
2. Substitution: replacing materials for a safe alternative
3. Engineering: designs or modifications to equipment, systems and processes to reduce exposure
4. Administrative: address work practices to limit exposure
5. Personal Protective Equipment (PPE): use masks, gloves, work clothes, protective shoes




An example of a substitution control is the use of cyanide during gold amalgamation. Cyanide is viewed as a somewhat safer alternative to mercury, however, it also has significant adverse health effects that need to be considered—hazardous chemical agents should be replaced by ones that are less so. Mercury or cyanide react with gold in the ore creating an amalgam or a complex which is then treated to extract gold. Borax is a flux that is used during the refinement stage, where it lowers the melting point of mineral impurities in the sponge gold, which allows the separation of the gold from the other material (mostly silica). It does not react with the gold, and does not replace mercury in the process, but, rather, is used in the refinement stage.

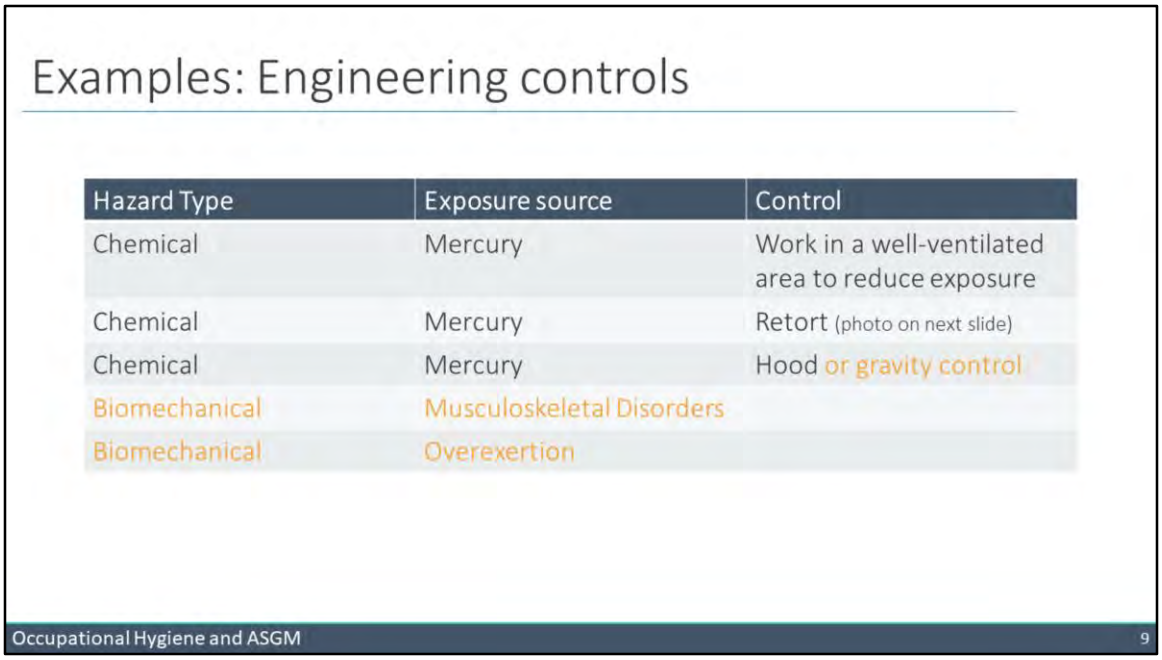
## Cyanide use

- 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


Occupational Hygiene and ASGM 8

Cyanide can be used in place of, or along with mercury. If used in place of mercury, the cyanide is added to the ore to dissolve gold (and other metals). The gold is removed from the cyanide solution using different methods, including carbon adsorption or precipitation with zinc. If zinc is used, additional processing with acid (sulfuric or nitric) is used to remove zinc, leaving the gold behind. Cyanide has high gold recovery rates and even works well on low gold grade ore.

Although cyanide is easier on the environment, good cyanide management practices are essential, since cyanide can be deadly if mishandled. Additives should be used to degrade cyanide after use so that it is not an environmental hazard.

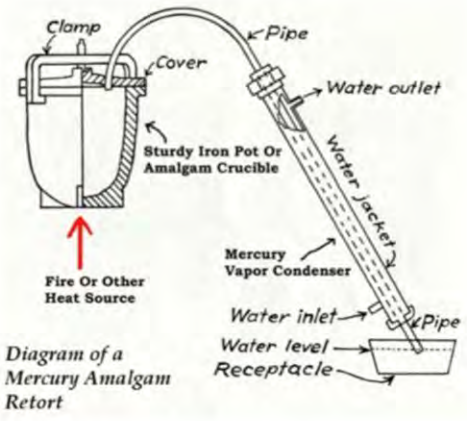



The engineering controls to limit mercury exposure in ASGM include:
Working in a well-ventilated area: this includes using fans or working outside.

Working under a ventilated hood can also reduce exposure

Using a retort: When used correctly, a retort is 80-95% effective at captured Hg and prevent its release into the environment.

## How does a retort work?

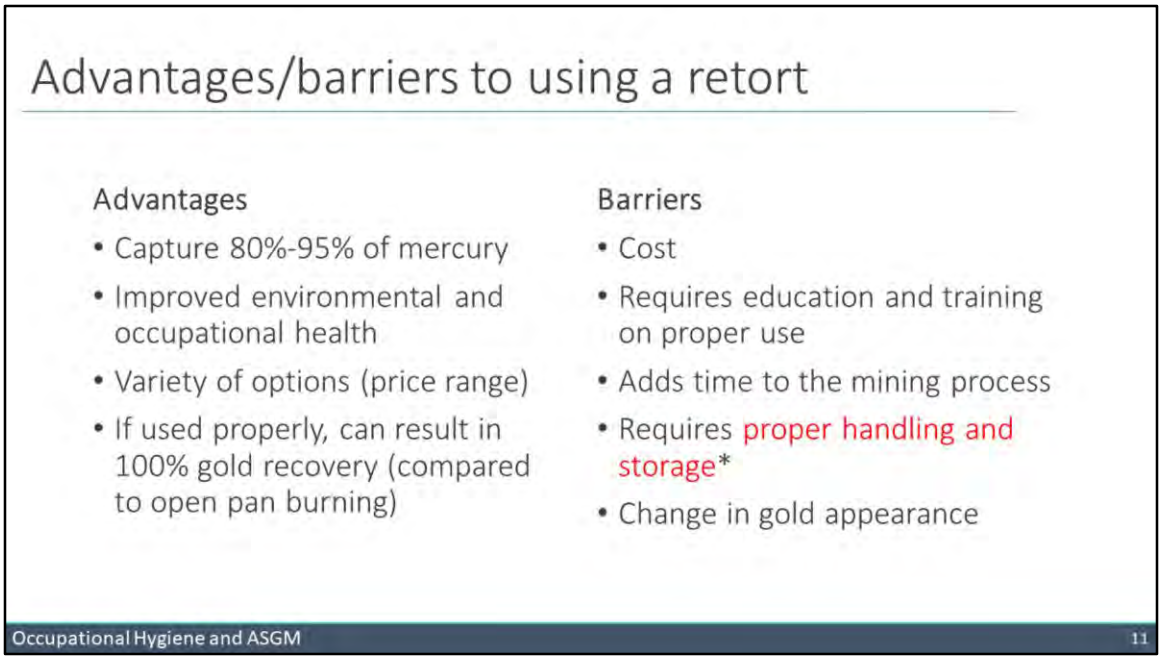



Occupational Hygiene and ASGM 10

A retort (shown here) is used to collect mercury vapor during the smelting step. There are several different types of retorts, but in general, the body of the retort is placed over a heat source and the bent pipe is placed in a glass or bowl of cold water. Mercury escapes through the pipe into the water. The water prevents mercury fumes from being released into the air and cools down the mercury so it becomes a liquid and can be reused (Practical Action, The Schumacher Centre of Technology and Development 2014). While the retort can result in improved environmental and occupational health and result in 100% gold recovery (when used properly), there are some barriers to its use. These include cost, the need for training and education to ensure proper use, the added time to the mining process and the need for proper storage of the mercury.

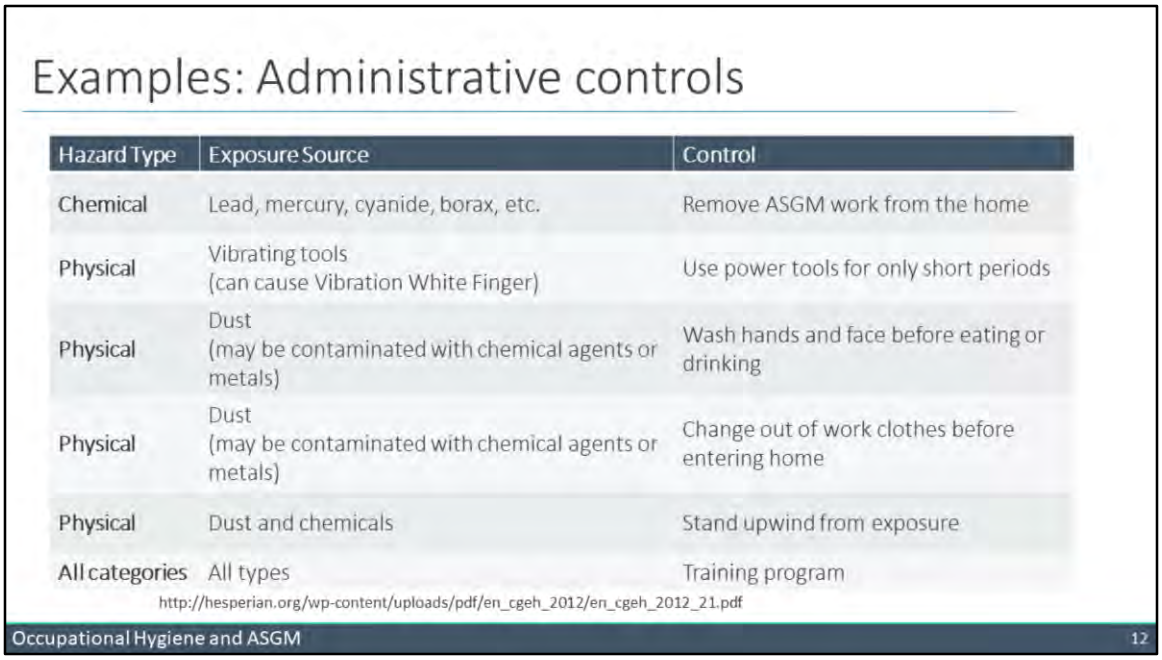
One problem with this retort is mercury may stick to the inside the first several times it is used.

Practical Action: Technology Challenging Poverty (2014). “A Simple Retort.” Accessed Nov 2014.
http://practicalaction.org/docs/technical_information_service/mercury_retort.pdf




As described, a retort can capture 80-95% of the mercury that is used, allowing for recycling. Clearly, the workers are less exposed and there is less loss to the environment. It is also a more effective way to recover gold, compared to an open process. When considering the barriers, cost and logistics are important. Also, training is needed. Use of a retort adds time to the mining process and requires proper storage. The appearance of gold may be a little different when a retort is used.

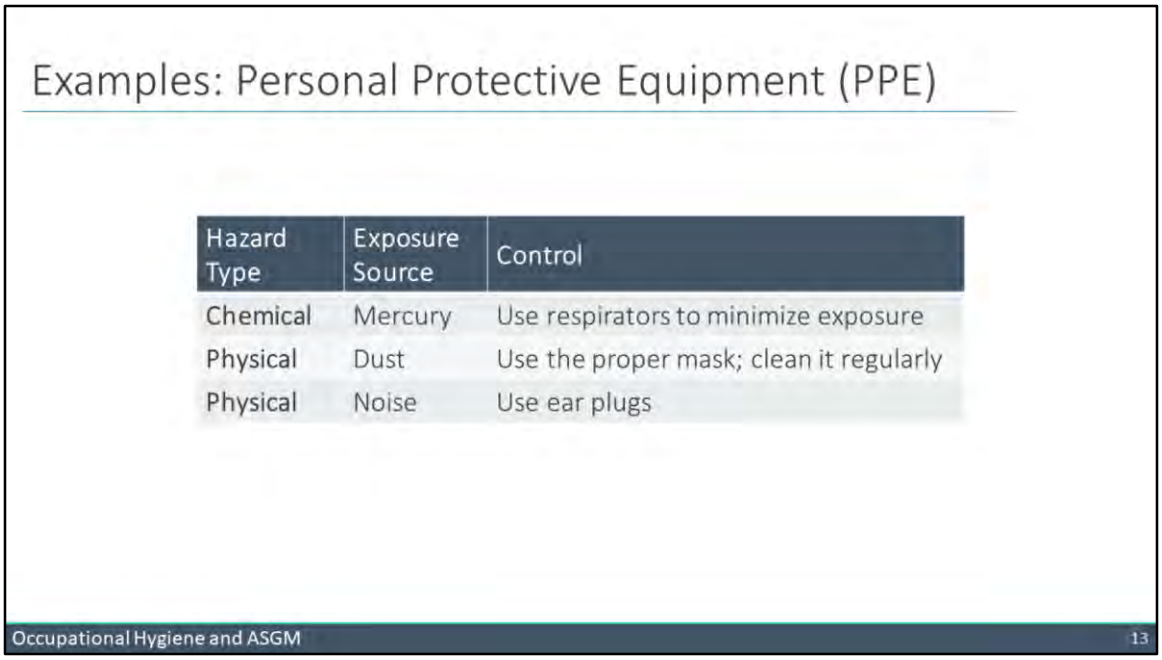
*The devices themselves become contaminated over time, and they need to be handled appropriate to prevent exposure (eg people bring them home, or leave them in a car and this allows for exposure to families.




As you can see, there are several administrative controls that can be applied to ASGM work. Exposure to chemicals like lead, mercury and cyanide can be contained by not carrying out any mining activities at home. Similarly, workers can control dust exposure by washing their hands and faces before eating or drinking, changing out of their work clothes before entering the house and standing upwind (away) from the exposure.

A formalized training program for workers is also an administrative control.

http://hesperian.org/wp-content/uploads/pdf/en_cgeh_2012/en_cgeh_2012_21.pdf
Chapter 21: Mining Health




The last resort to control hazardous exposures in the workplace is personal protective equipment or PPE. The most common examples of PPE in ASGM are respirators to control mercury exposure and masks for dust exposure.

Many miners do not use PPE? Why do you think this is?

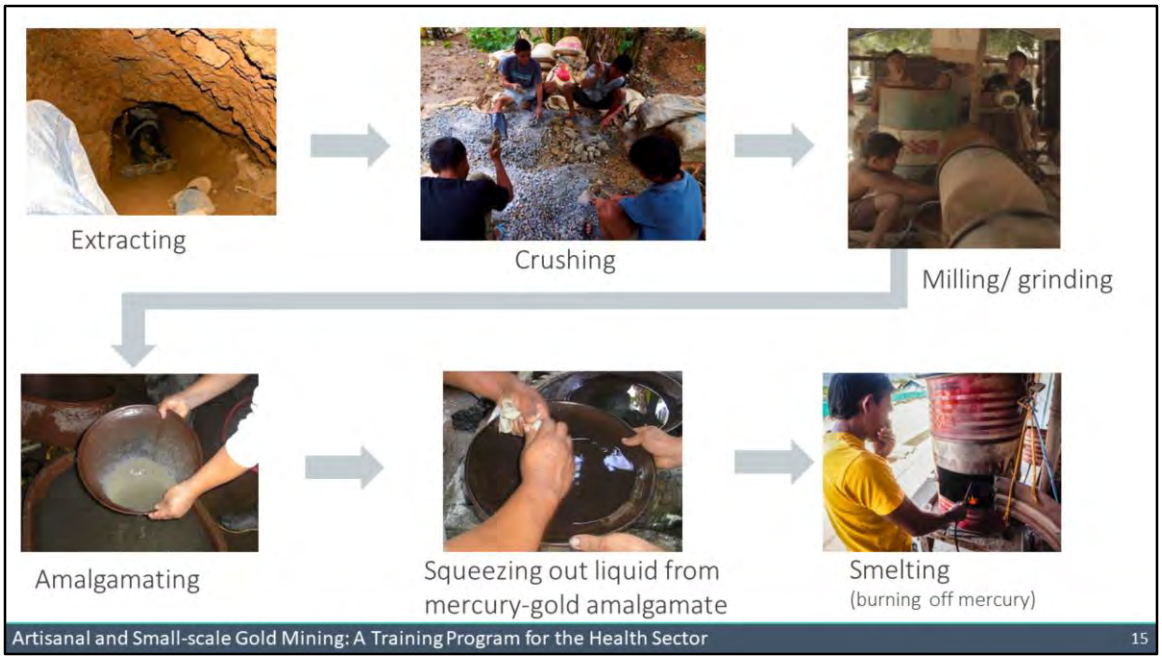
## What's the problem with PPE?

- 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

Occupational Hygiene and ASGM 14

Ask in the previous slide and review answers here.

[Reinforce that PPE is uncomfortable to wear—mask in a hot climate can be intolerable; PPE could be dangerous—a)gloves around machinery can get caught and pull in the hand; b) ear plugs to prevent noise exposure prevents the worker from hearing warnings, or communicating with co-workers—ear plugs have been implicated in leading to accidents at work; the appropriate, protective PPE must be selected—for example, the wrong type of mask will not protect the worker; finally, use of PPE depends on the worker to use it. Human error is very common in workplace accidents; engineering and administrative controls take this out of the hands of workers]




You saw the steps involved in gold mining in a prior slideshow. They are presented here for your to think about hygiene controls. Note the man in the bottom right corner of this slide—he is covering his mouth, probably because the mercury fumes are bothering him. There **is** volatility of mercury even when it is not being heated, though the amount that becomes fume is lower, exposing workers to a lower dose than the dose from burning it. Since the elemental mercury is handled directly during parts of the ASGM process, hand contamination can lead to ingestion and absorption through the GI tract.


We've talked about the different types of hazards (chemical, biological, physical, ergonomic and psychosocial) and the different types of controls (elimination, substitution, engineering, administrative and PPE). I'm going to go through some ASGM processes and I want you to tell me what kinds of hazards exist and what controls we could use (if any).
The first step is the extraction step which occurs in underground, surface and alluvial mining, at the bottom of river beds, and on the ground service. What is happening in this picture?

Ask students to identify hazards and potential controls.

**Biomechanical:** handling dynamite
**Controls:** protection of worker; control of the environment where this is happening.

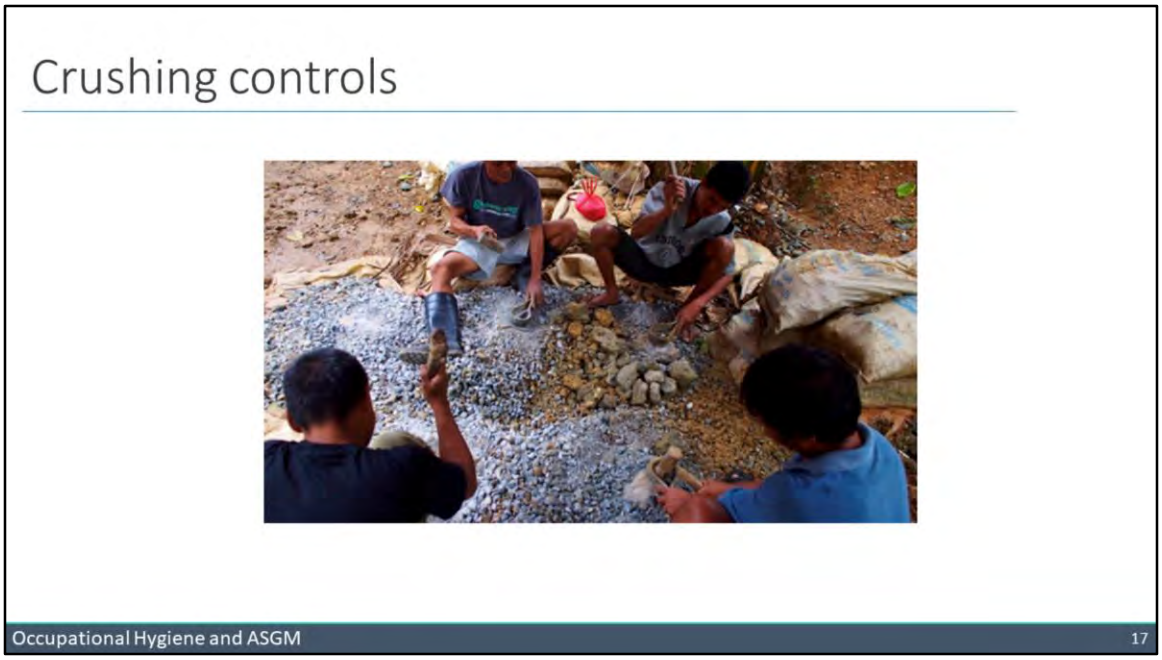
**Physical hazards**: confined space, dust, heat, noise, falling objects
**Controls:** confined space-having another worker nearby to provide assistance if needed (administrative control); dust-eye protection or a mask (PPE control), heat and dust: use of a fan or blower (administrative); heat-drinking water (administrative); **noise; falling objects**

**Biological:** oxygen deficiency
**Controls: ?**

**Ergonomic:** small opening, entering head first
**Controls: ?**

**Psychosocial:** stress
**Controls: ?**
**----------**
"Artisanal mine interior near Lows Creek Mpumalanga 01" by Manyeva - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Artisana_mine_interior_near_Lows_Creek_Mpumalanga_01.jpg#mediaviewer/File:Artisana_mine_interior_near_Lows_Creek_Mpumalanga_01.jpg

Dynamite photo: By Alfred T. Palmer - Library of Congress, Public Domain, https://commons.wikimedia.org/w/index.php?curid=4808071




Ore is crushed by hand or with a machine. Ask students to identify potential hazards and controls.

**Chemical hazards**: dust
**Controls:** Use an enclosed hood (engineering), applying water to contain dust exposure (administrative), dust mask (PPE)
**Ergonomic hazard:** sudden forceful use of the upper extremities can cause acute trauma to the muscles, tendons, ligaments, and bones. Chronic use of a hammer to crush stone can also lead to joint damage with development of arthritis.
**Controls:** mechanize this process (engineering); limit the amount of time an individual does this work—rotate the task (administrative)

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"Artisanal mine interior near Lows Creek Mpumalanga 01" by Manyeva - Own work. Licensed under CC BY-SA 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:Artisana_mine_interior_near_Lows_Creek_Mpumalanga_01.jpg#mediaviewer/File:Artisana_mine_interior_near_Lows_Creek_Mpumalanga_01.jpg


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

During the milling process, machines are used to grind the rock into a powder. Ask students to identify potential hazards and controls.

**Chemical hazards**: dust
**Controls:** Use an enclosed hood (engineering), applying water to contain dust exposure (administrative), dust mask (PPE)
**Physical hazards:** Noise
**Controls:** keep machinery lubricated (engineering); force workers to keep a distance from the machines when they are operating (administrative); use ear plugs (PPE)
**Biomechanical hazards:** moving machinery
Controls: put guards on the machine so that workers can't get caught in them (engineering); create a lockout-tagout system—when maintenance is being done on the machine, but a lock and a sign on on the operating switch (administrative)

## Grinding controls

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During the grinding process, coarse ore is dumped into the hopper and ground to a fine powder. A large amount of dust is generated in this process. Also, machinery is exposed.

Controls for dust:
Engineering control: enclose the process
Administrative controls (process controls): stand downwind, wet down the process,
PPE: wear dust mask

Controls for operating machinery:
Enclose moving parts
Put a guard on the machine to prevent hands from touching the machine
Lock out the electricity when maintenance is being done or machine is being touched


During the amalgamation step, elemental mercury is added to form an amalgam with gold. This can be done on a cloth, and excess mercury is removed by wrapping the cloth around the amalgam and squeezing out the excess mercury-containing liquid.

Ask students to identify hazards and potential controls.

**Chemical**: release of mercury vapor
**Controls**: substituting mercury for a different process; working in a well-ventilated area (engineering); standing upwind (administrative); using a hood or retort (engineering); using a mask (PPE), using gloves to handle mercury (PPE)
**Chemical:** liquid mercury
**Controls:** wear appropriate gloves


As part of the smelting step, the mercury is burned, sometimes with a torch and sometimes over a fire, to evaporate off much of the mercury.

Ask students to identify hazards and potential controls.

**Chemical**: release of mercury vapor
**Controls**: use of a retort (engineering); working in a well-ventilated area (engineering); using a hood (engineering); standing downwind (administrative); using a mask (PPE), using gloves to handle mercury (PPE)

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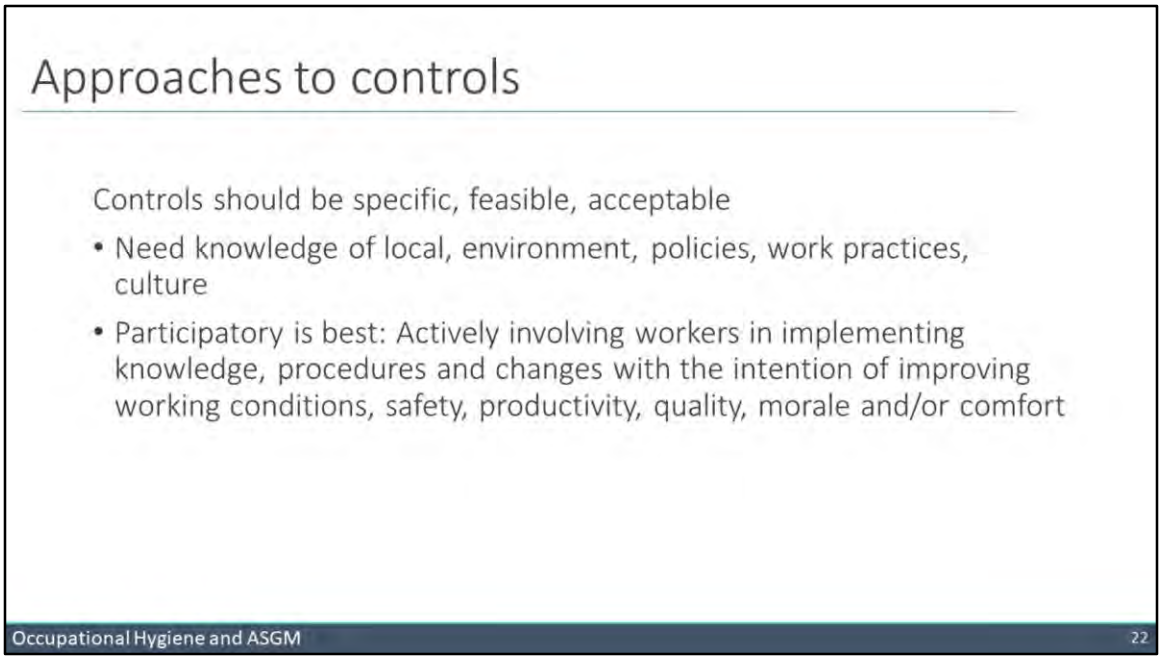
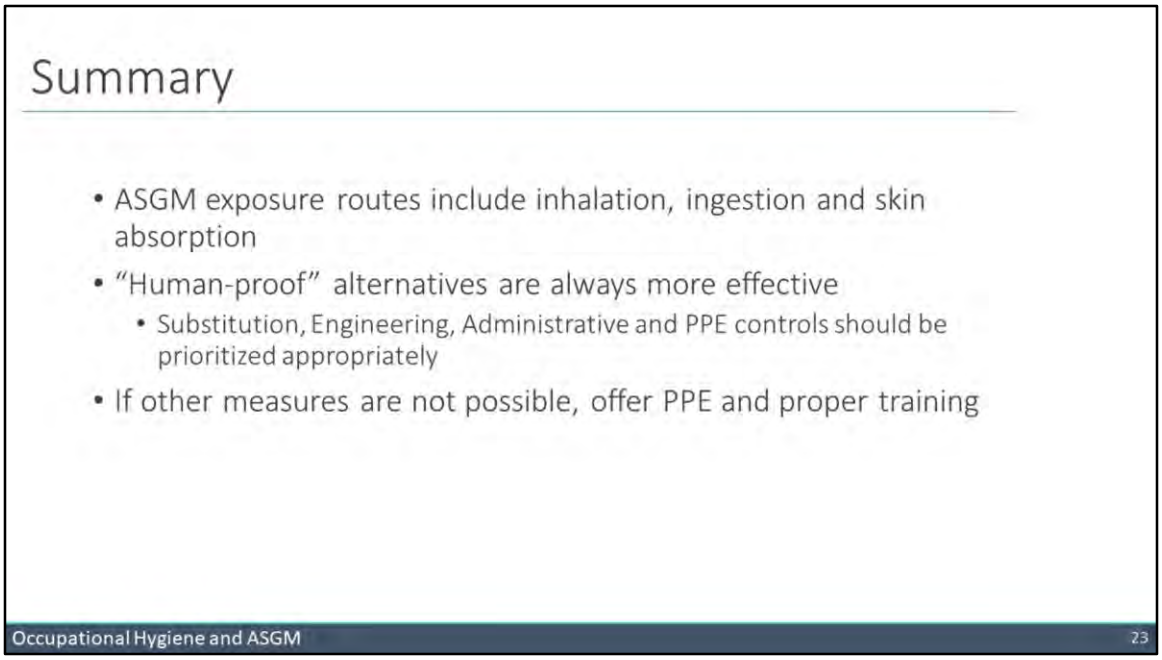
Image by Larry C. Price. Philippines, 2013. Note: I have emailed, called and left messages for this photographer and have not received a response. He has many series of photos available on the web, but no info about copyright.




Overall, approaches to occupational hygiene and safety controls need to be specific, feasible, and acceptable. Knowledge of local norms, environmental factors, applicable policies, usual work practices and the local culture are critical factors in figuring out the best controls to apply in specific workplaces. Also, the active engagement of workers and supervisors in deciding on and implementing preventive measures is critical.




As you have seen, ASGM work exposes workers to a number of different agents and conditions by all routes of entry or routes of exposure. According to the occupational hygiene hierarchy of control, substitution and engineering controls are always most effective. Administrative controls are the next most effective, as they can prevent exposures if they are targeted appropriately. A training program, rotating exposed individuals in and out of specific job tasks are two examples of administrative controls. These require avid involvement of management to assure implementation. Personal Protective Equipment is always the least effective. It depends on availability of the masks, gloves, and glasses, as well as willingness to use them, conditions for storing and repairing them, and the environmental conditions that make it possible.

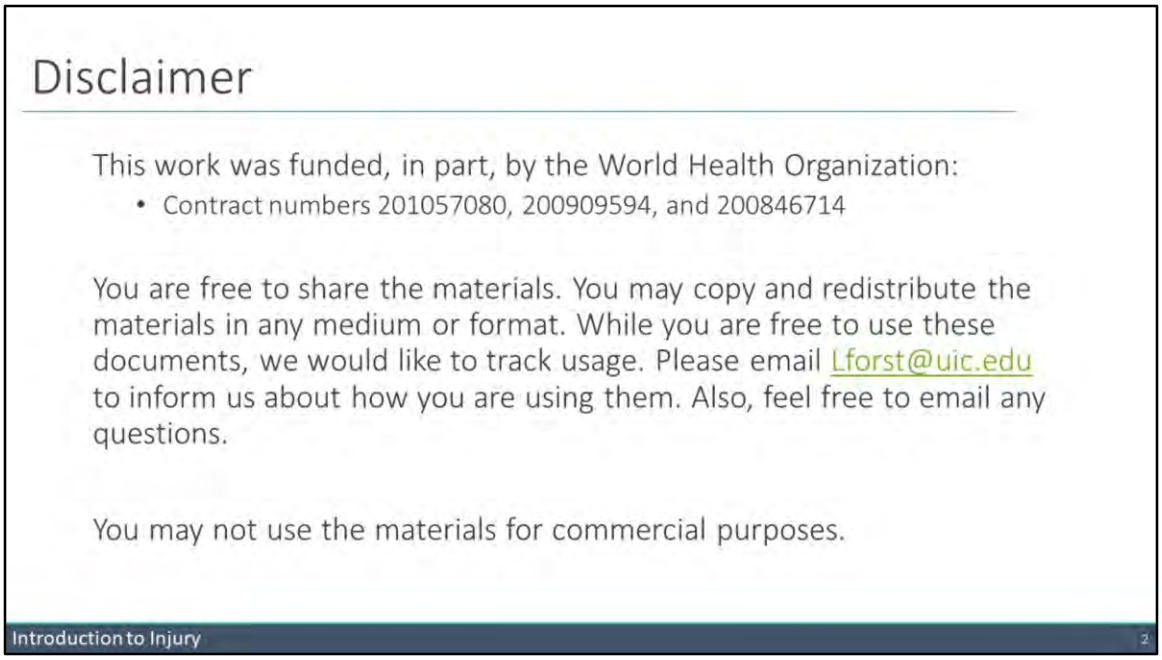
# URL to all powerpoints

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

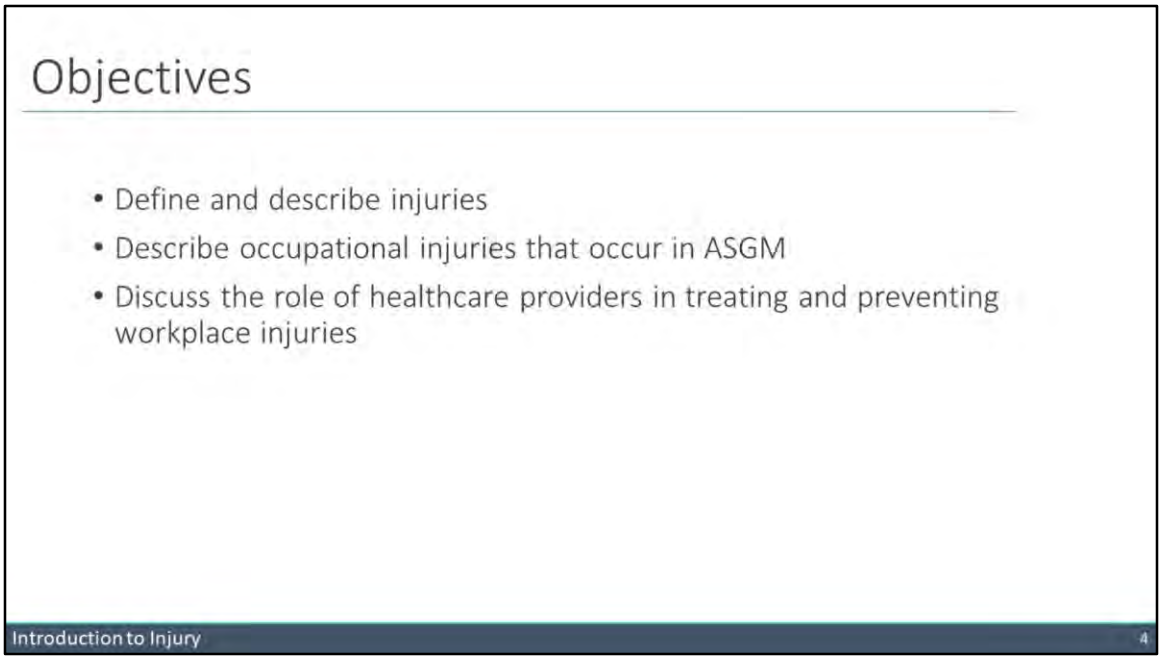
A WHO Collaborating Center


**NOTE TO INSTRUCTOR**: See Slide #3 before giving this lecture.

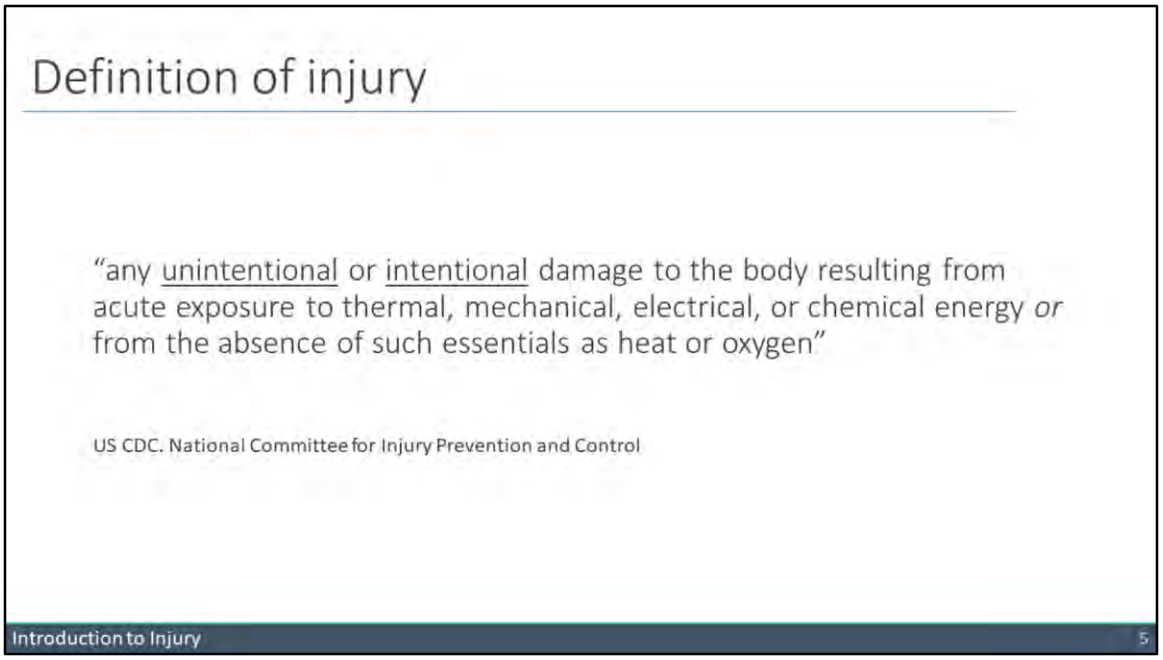
**SAY:**
As you can imagine from looking at the working conditions and the tasks done in Artisanal and Small Scale Gold Mining, the risk of major and minor injury is extremely high. Acute, traumatic injury is common in many work settings. And many workers, employers, doctors, and nurses accept it as a "given;" that is, they assume that getting injured is simply a part of the job. In fact, the field of Safety Science is pretty developed at this point in time. There is a good understanding of how and why injuries occur in the workplace. There are methods for investigating the causes and there are many tested interventions for preventing them. This talk will introduce you to injury epidemiology and prevention. We will talk about the field, in general, and we will specifically apply it to the working conditions of small-scale gold miners.




This is part of the course on the health issues surrounding Artisanal and Small Scale Gold Mining, developed to assist countries in preventing illnesses and injuries among gold miners and their families. This slideshow is particularly related to injury associated with work in ASGM.




By the end of this talk you should be able to define and describe injuries, in general and specifically those that occur in ASGM. You will also be able to discuss the role of doctors, nurses, and other healthcare workers in the treatment and prevention of occupational injuries

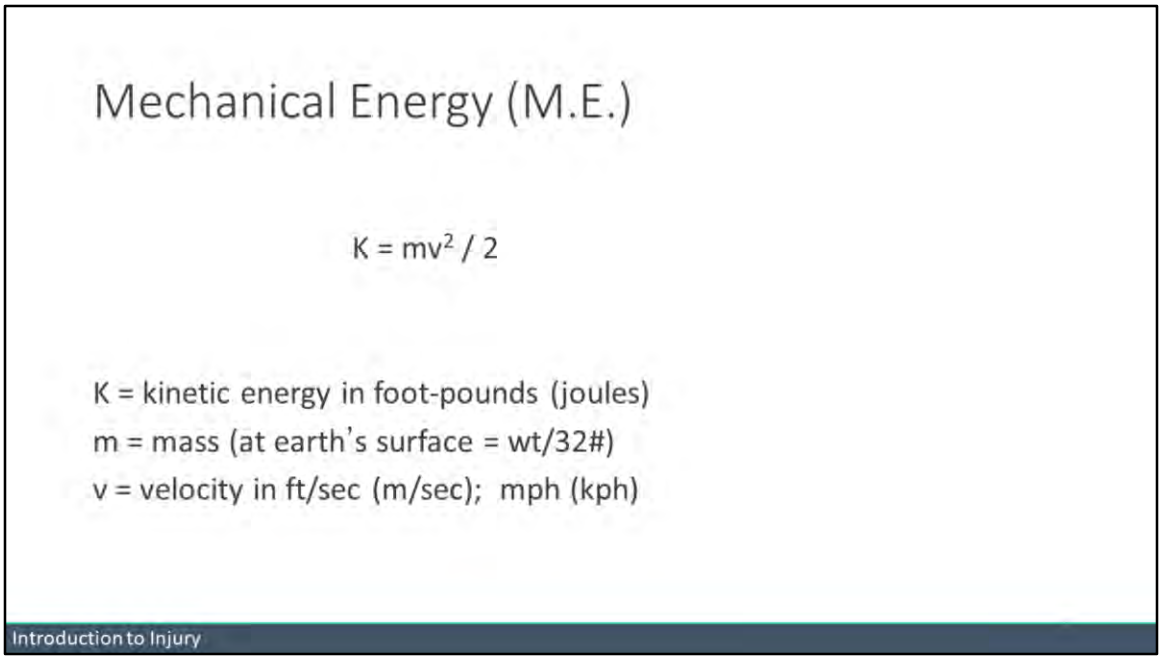



**ASK:** for a volunteer to read this.
**SAY:**
There are a few things I want to point out here. First, injury is to be distinguished from "disease." An injury comes about as a traumatic event occurs. This definition talks about energy being applied to the body, the energy that comes from either heat, electricity, chemicals, or mechanical events. Noting the type of energy causing an injury helps us think about how to prevent the injury. How can we stop the energy from contacting the human body? Or to put it in terms we have used already, how do we reduce exposure so that we can reduce risk?

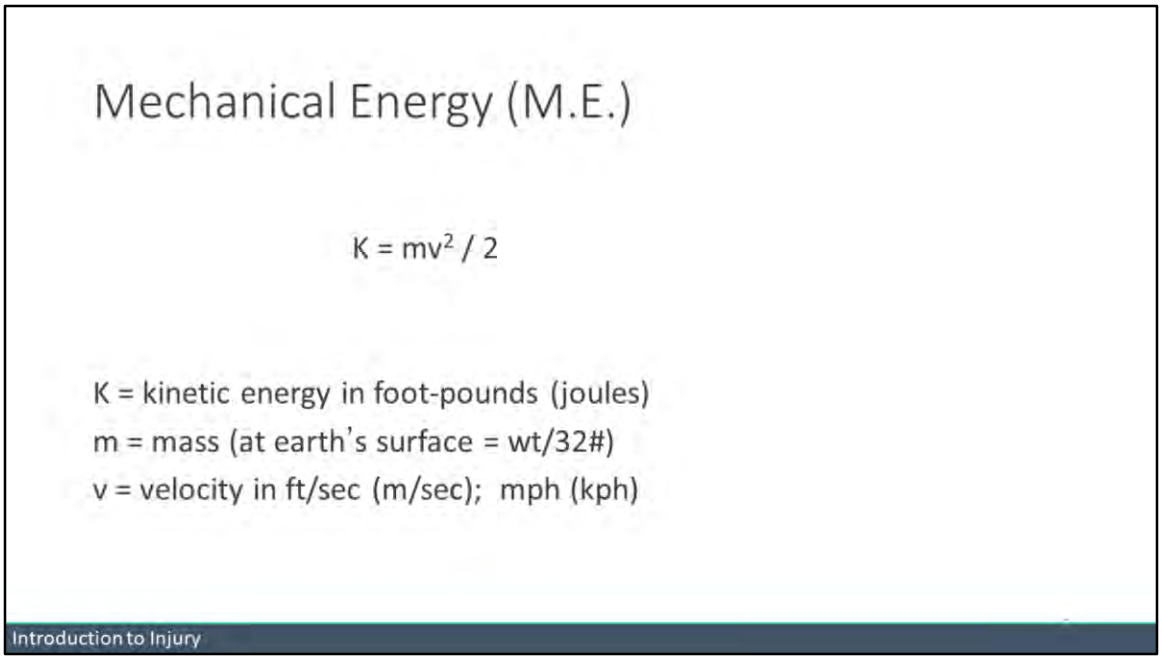
In the field of injury, people also categorize injuries as "intentional" or "unintentional. "intentional" injuries are due to violence—violence of people against each other or people against themselves. Homicide and suicide are 2 intentional injuries. Most work-related injuries are "unintentional." This is why we tend to call them accidents.

May want this somewhere else; too much for this slide
need to distinguish between acute and chronic effects. Acute trauma can occurs with a sudden burst of energy while exposure to lower levels of energy over a long period of time can also cause injury. What are examples of this? A burn might come

about as a sudden exposure to heat, like spilling hot water or chemicals on the skin. A loud explosion can cause sudden hearing loss. A motor vehicle crash will cause sudden trauma to the body. These are examples of acute injuries. There are also conditions where a worker is exposed to energy that damages the health, but at a lower level and over time. Some examples of this are noise: loud noise in the workplace may not cause sudden hearing loss, but over time the sound energy can produce changes in the structure of the ear that lead to hearing loss that worsens over time. Another example is repetitive use of the arm. In the short term, forceful repetition may not be a problem, but if a worker continues to do repetitive motion activities, like using a hammer every day, this can lead to microtrauma of the muscles and nerves and this minor trauma can lead to an injury to the muscles or nerves over time. Today I am only going to talk about sudden events that lead to acute injuries.

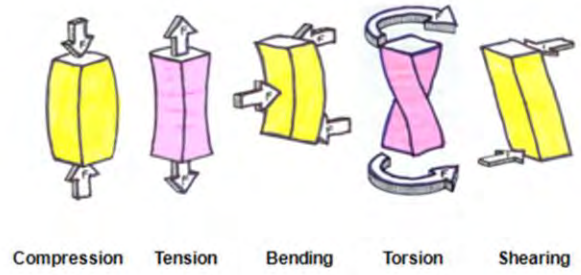



Note that injury occurs as a result of force applied to the (soft, fragile) human body. The energy/force applied to our human tissues is related to the mass and the velocity of the force.



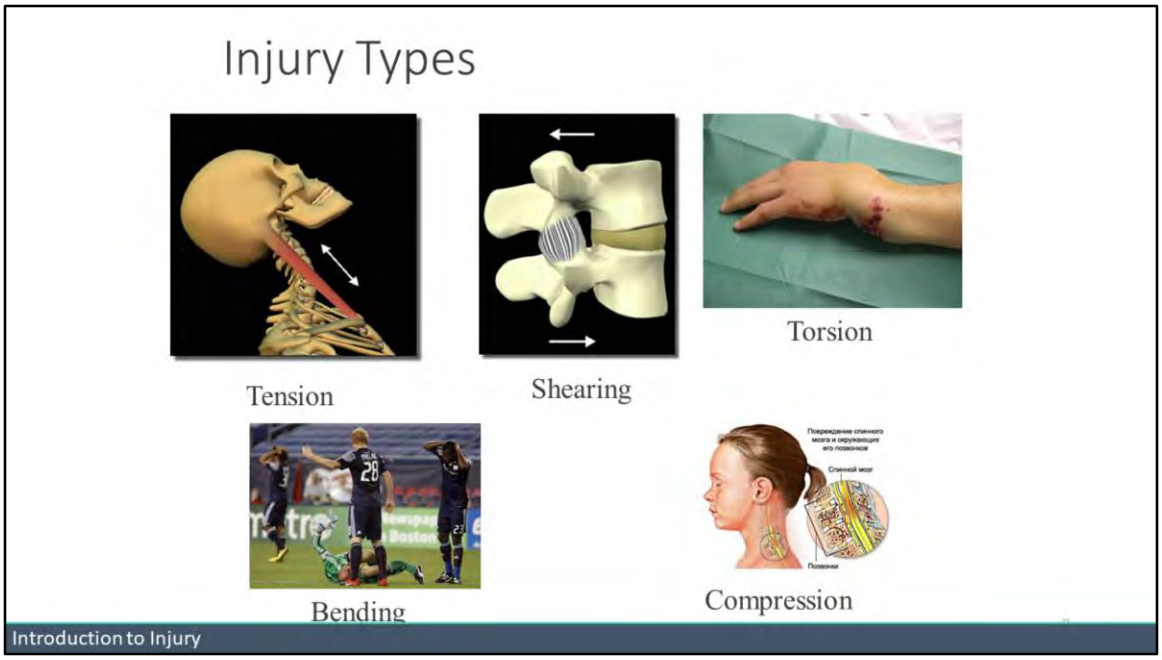

Note that injury occurs as a result of force applied to the (soft, fragile) human body. The energy/force applied to our human tissues is related to the mass and the velocity of the force.

## Strain Mechanisms






If you think of injury in a mechanical way, these are the strain mechanisms that lead to bodily injury.

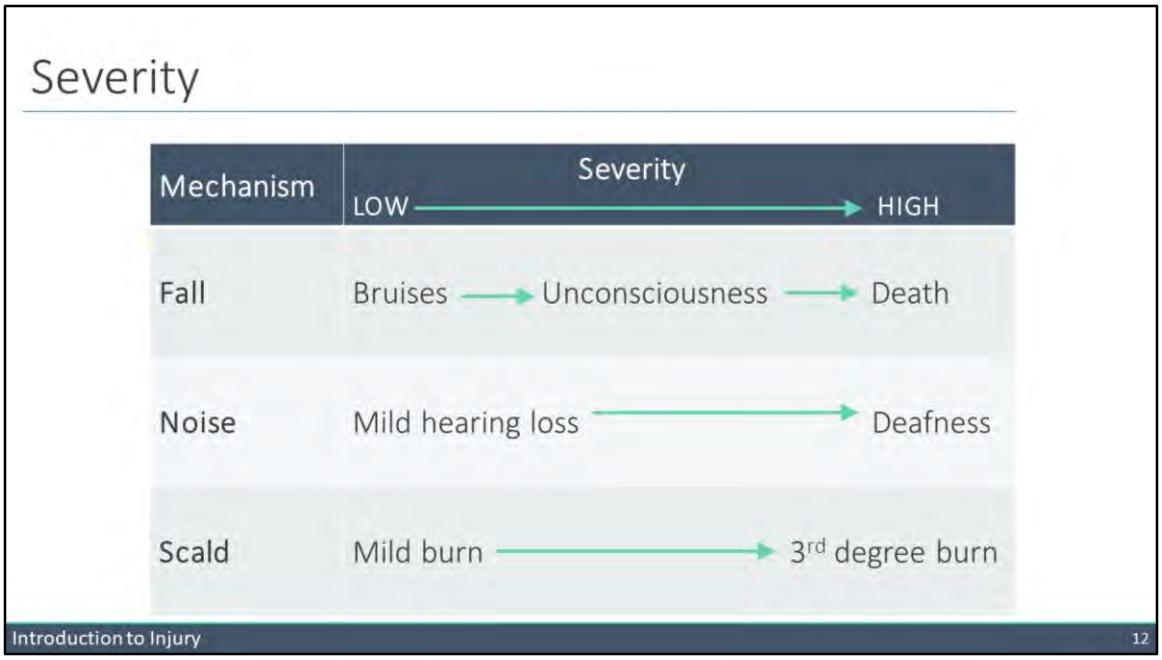



Here are the common injuries that occur via the strain mechanisms described in the previous slide.
Tension: whiplash injury that strains the neck
Shearing is a back injury that entails opposite forces applied to adjacent vertebrae, leading to a ligament strain
Torsion injury of the forearm occurs from twisting parts of the arm in opposite directions – as in a fight, or child abuse
Bending. This poor football/soccer player has a dislocated or fracture knee joint
The Compression fracture of the spinal column is typically caused by diving incidents


Kinetic forces are other ways of thinking about injuries. In the workplace, crush injuries (from machinery) and blunt injuries (from falls or motorized vehicles) are by far the most common. Gun violence does occur in workplaces, as well. Energy concentrated in one body area

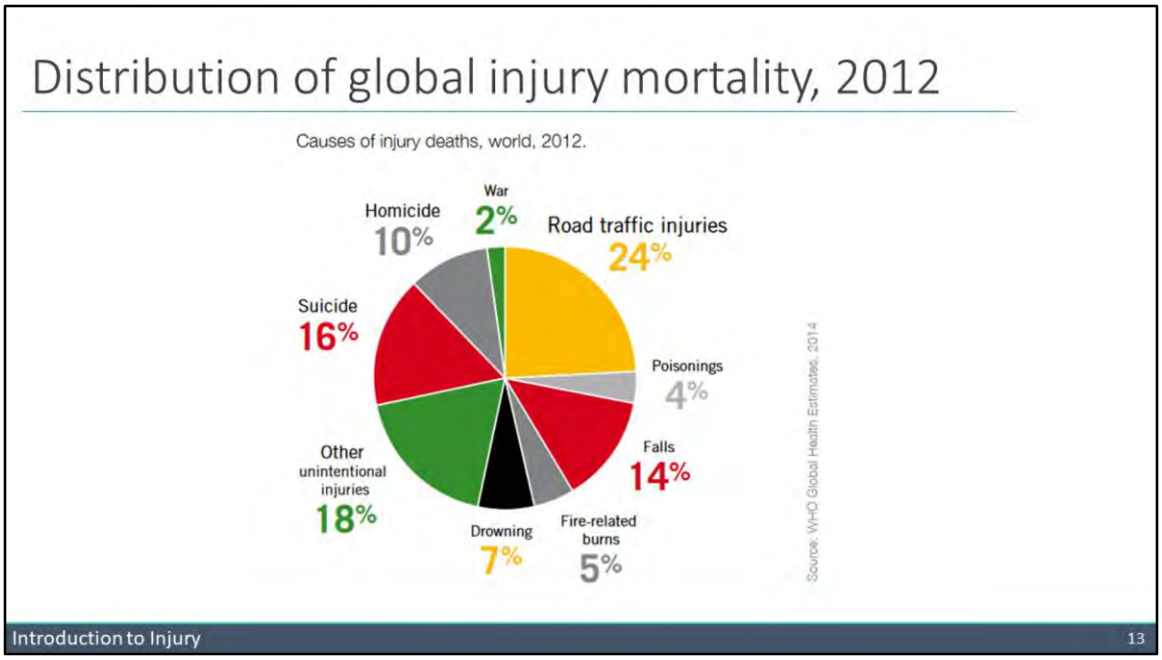
Usually involves nerves, muscle, bone, and tendons


We need to understand that, especially in occupational settings, it is possible to anticipate injuries and intervene. A lot of times people think that injuries are just a part of the job. If you think the same thing, I hope that after this talk, you will see that there really is no such thing as an accident. We know a lot about the forms of energy that lead to injury. It is possible to put measures in place to prevent injuries. In short, a workplace injury is NOT an accident.



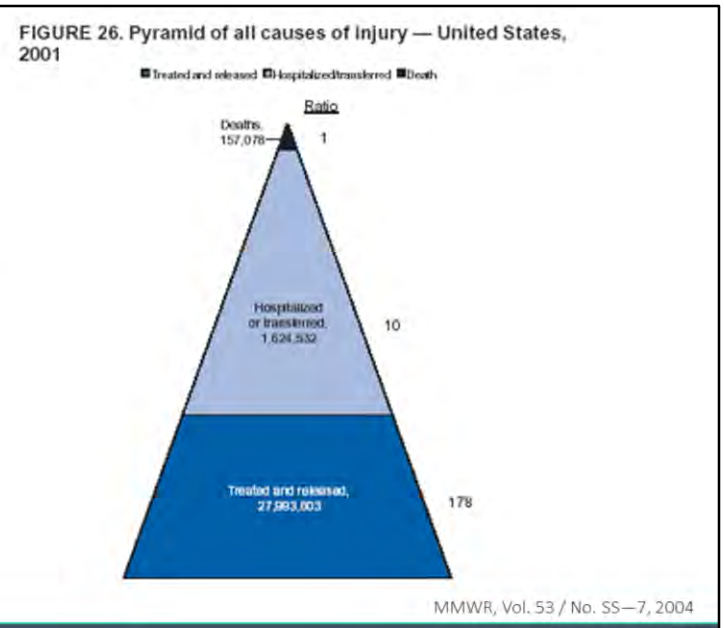

In the field of injury, we talk a lot about "severity." Death is the most severe outcome of an injury, but there are less severe consequences, as well. If someone falls from a ladder, they can get simple bruises or broken bones. They can bang their head and become unconscious. They can also be injured so severely that they die. When we think about noise, ongoing exposure to high decibel or high energy sound can damage the hearing a little. Exposure to certain energy levels can worsen hearing loss over time. The sound energy produced in a sudden explosion can lead to immediate deafness. A final example is a scald. If someone spills hot water on their hand, they can get a minor burn. If the water is super-heated or it stays on the skin for a long time, it can lead to a much more severe burn.

So putting into place a mechanism for prevention can be designed to completely prevent the injury. It can also be designed to limit severity. We'll see examples of this later on.



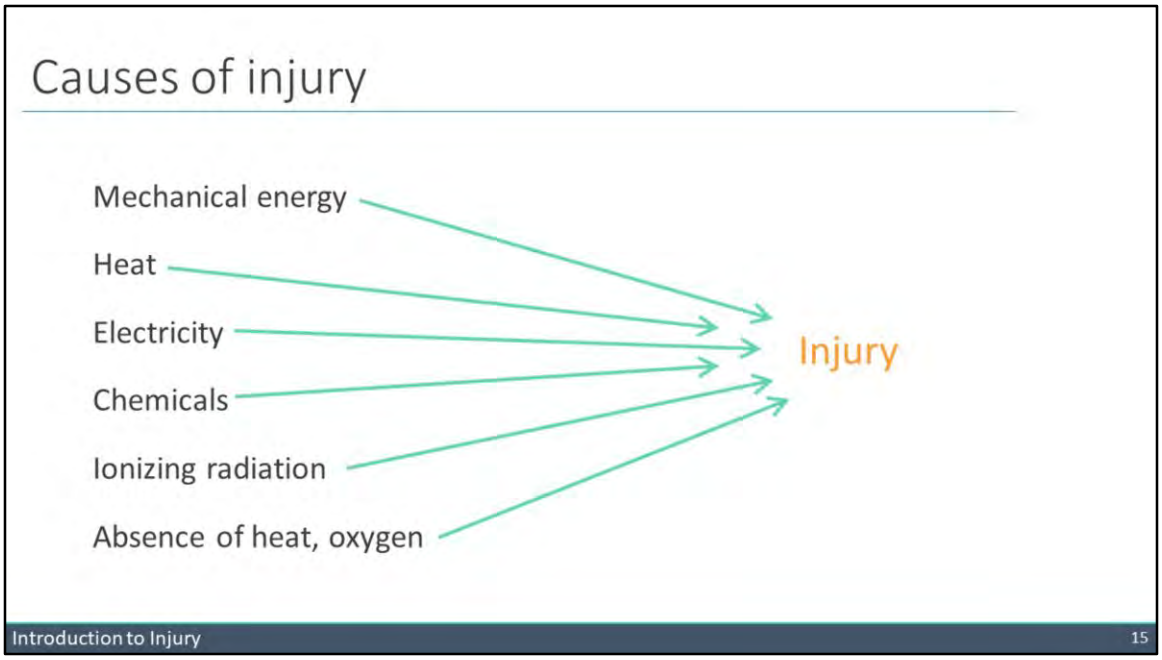

There is an international project to look at causes of injury mortality around the world. The data presented here is from 2012 and comes from the WHO website. As you can see, Road Traffic injuries are by far the most common injuries. Suicide and homicide—the two intentional injuries—come next, when combined. After that, falls are the highest cause of injury mortality, and you can see all the others. The "Other" group accounts for less than 2% each and are grouped together.

Mortality is a tiny fraction of adverse health outcomes from injury

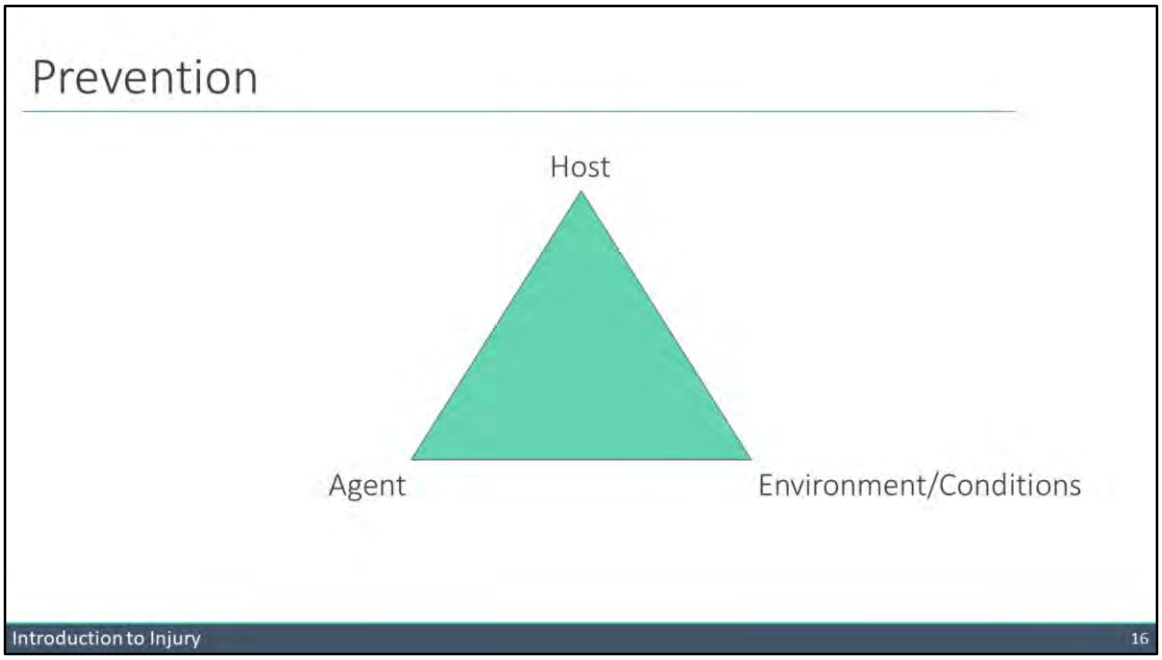




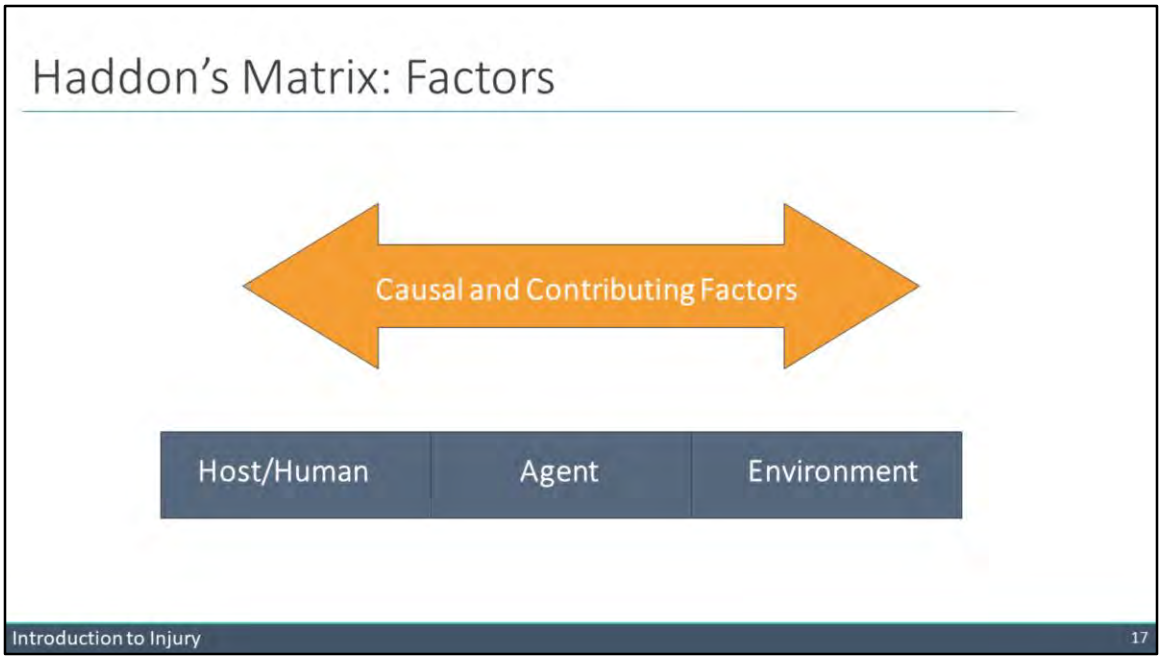

This is a pyramid that is taken from US data of a long time ago. I am showing it to you to present the idea that most traumatic injuries are not severe. If you look at the results of a study done in 2004 in the US, deaths are at the tip of the iceberg, hospitalizations come next in number, and then traumatic injuries treated and released from emergency departments or clinics are the most common. The ration in this study was 1 death for 10 hospitalizations for 178 outpatient visits. What is not on this chart and would be a much bigger proportion, below, are the injuries that never seek medical attention—those are generally more minor and much more prevalent than injuries that cause death or require medical attention.



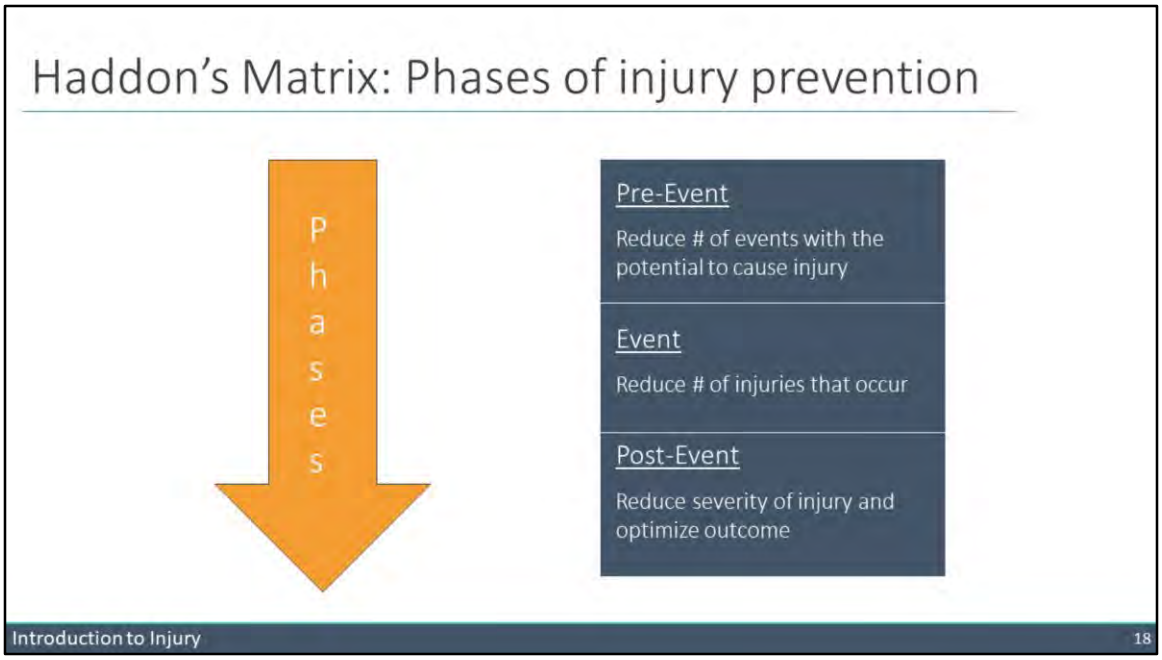

So again, I want to point out the major causes of injury. By far, mechanical energy is the most common. You saw in the WHO Global Burden slide that motor vehicle crashes are the most common cause of injury death. When an automobile crashes, there is sudden mechanical energy put on the human body, which is the cause or that leads to injury. Note at the bottom of this list, that the absence of heat, or extreme cold can lead to injury. The same for absence of oxygen. You can imagine from the prior lectures on ASGM that all of these causes may be present in the work environment of miners.




This is an adaptation of the triangle that usually describes considerations for population based infectious disease. There are 3 things to consider when you are talking about injury prevention. One is the host, or the worker. The worker has a certain age, a certain health status, and has certain behaviors that may put him or her at greater risk for injury. There are also agents—hot water, noise, chemicals—that the worker may contact that put him at increased risk. There are also environmental conditions—cold, wet or slippery floors, a fast assembly line, or work under water—that are important factors to consider when you are thinking about prevention. The host, the agent, and the environment interact or come together in a way that put workers at risk for injury. It is possibly to intervene on one or two or all three of these factors to reduce injury.



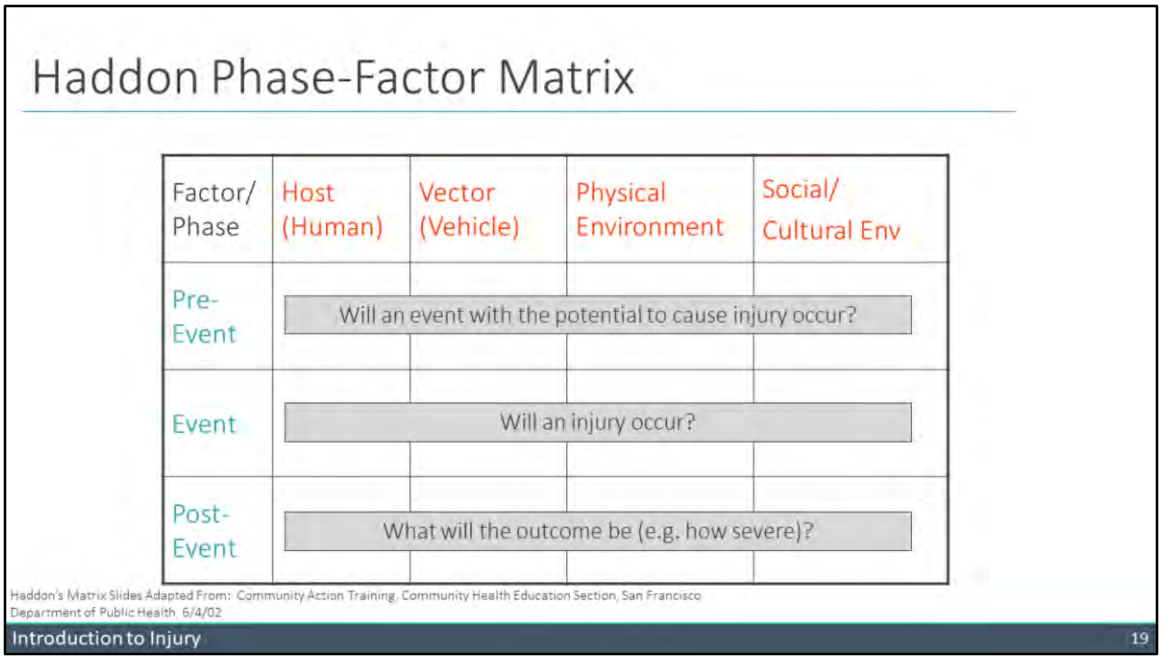

**SAY:**
Haddon's Matrix is another important conceptual model for developing injury prevention strategies. This model was developed by Dr. William Haddon who was investigating automobile crashes and figuring out ways to limit them. Dr. Haddon took the Public Health Model that you saw in the last slide--the triangle of Host, Agent and Environment--one step farther by looking at injuries in terms of causal and contributing factors; these factors interact in a way that results in an injury.




**SAY:**
Haddon also believed that injuries occur with a certain time sequence consisting of three phases: pre-event, event and post-event phases. The build-up of uncontrolled energy is released in the pre-event phase, energy is transferred in the event phase, and factors about the state of the person, agent or environment affect what the energy does in the post-event phase. To repeat, uncontrolled energy is released in the pre-event phase, energy is transferred in the event phase, and factors about the state of the person, agent or environment affect what the energy does in the post-event phase. The value of the Haddon Matrix is that it separates out components, allowing you to consider points at which interventions can be applied.

In general, interventions in the Pre-Event phase are designed to reduce the number of events with the potential to cause injury. Interventions in the event phase don't stop the event, but reduce the number of injuries that occur as a result of the event. And finally, interventions in the post-event phase don't stop the event or the injury from occurring, but reduce the severity of injury and optimize the outcome to the injured party. Keep in mind, though, that all of the Haddon analysis is intended to focus on prevention of injuries and their consequences. Strategies which affect the post-event phase would need to be planned in anticipation of the potential for an

injury occurring; that is, it would be worked out prior to an injury event occurring.




The goal in using Haddon's matrix is to identify major modifiable factors that lead to unhealthy outcomes. This table is the Haddon Matrix. It is divided into a series of cells. Each of these cells represents a focus for prevention possibilities. The Matrix encourages us to think about all the phases and their relationships to the factors in a comprehensive manner. It urges us not to devote all of our attention to one or two cells on the matrix.

For Factors, we have the host, vector, and the environment. Over time, the Environment got split into the Physical and Social or Cultural environment because each of these factors may be manipulated for prevention. The factors form the columns, the phases form the rows.

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

Introduction to Injury 20

**NOTE TO INSTRUCTOR:** Print out this Haddon Matrix for students. There are 4 cases, slides 17-20, to use to complete this form. If you want each student tow work alone, then each student needs 4 copies of this table. Students could work as groups of 2 or three and look at each case together, completing one Haddon Matrix table as a group. Then they could come back to the whole group and present their work. Consider creating 4 groups. Then let each group take leadership, presenting one Case/Haddon Matrix and asking for input from the other groups. If students have laptops, they could be sent a Haddon Matrix to save 4 times. They could name the file and project it in the classroom when they are ready to present. If each student does one himself, you could have someone sit at the laptop in front of the class and let students report back their answers, with the scribe typing it in as they talk. This could be done with writing on a flip chart, as well.

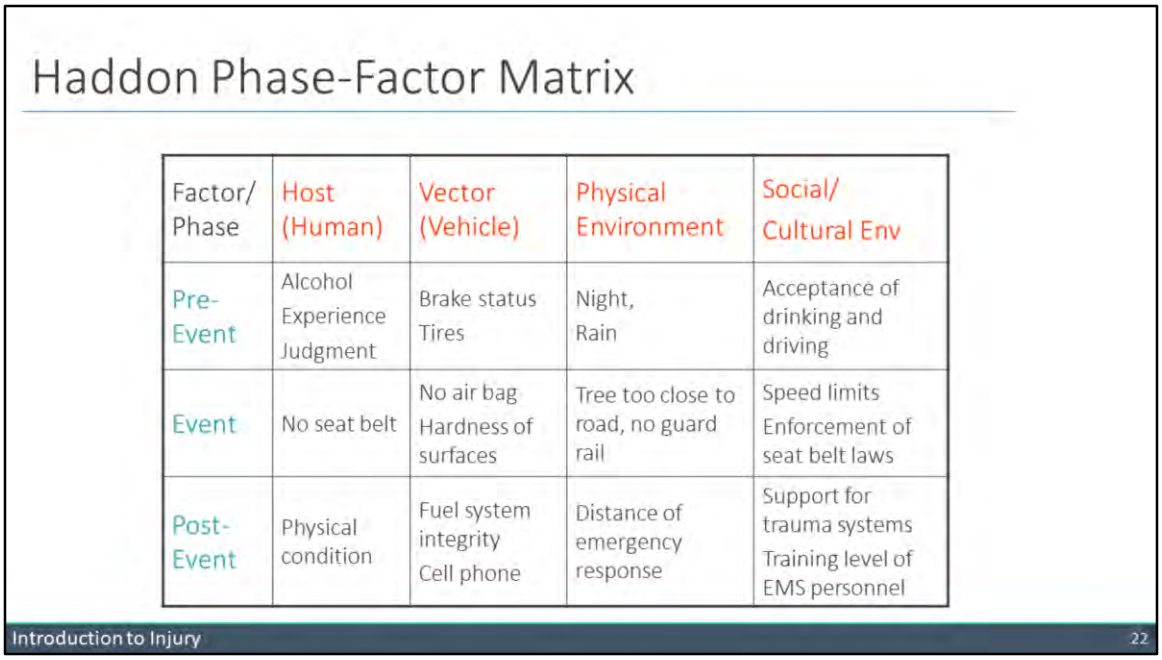
## Case study 1

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.



We will now go through some cases and put them into a Haddon Matrix to see how this works.

**NOTE:** Ask for a student volunteer to read the case aloud.




Let's take a look at this motor vehicle crash using Haddon's matrix.

Let's look at the Host. In the pre-event phase, after a party these young people may have been drinking, the driver is pretty new and inexperienced, there are a bunch of friends in the car taking the driver's attention. It is possible that the driver wears glasses, but did not have them or use them. In the event phase, the driver and passengers may have decided not to use seatbelts. In the post event phase, the physical condition of the driver and passengers may be important. If they are completely drunk or if someone takes medication that makes him bleed easily, like aspirin, these could put them at greater risk.

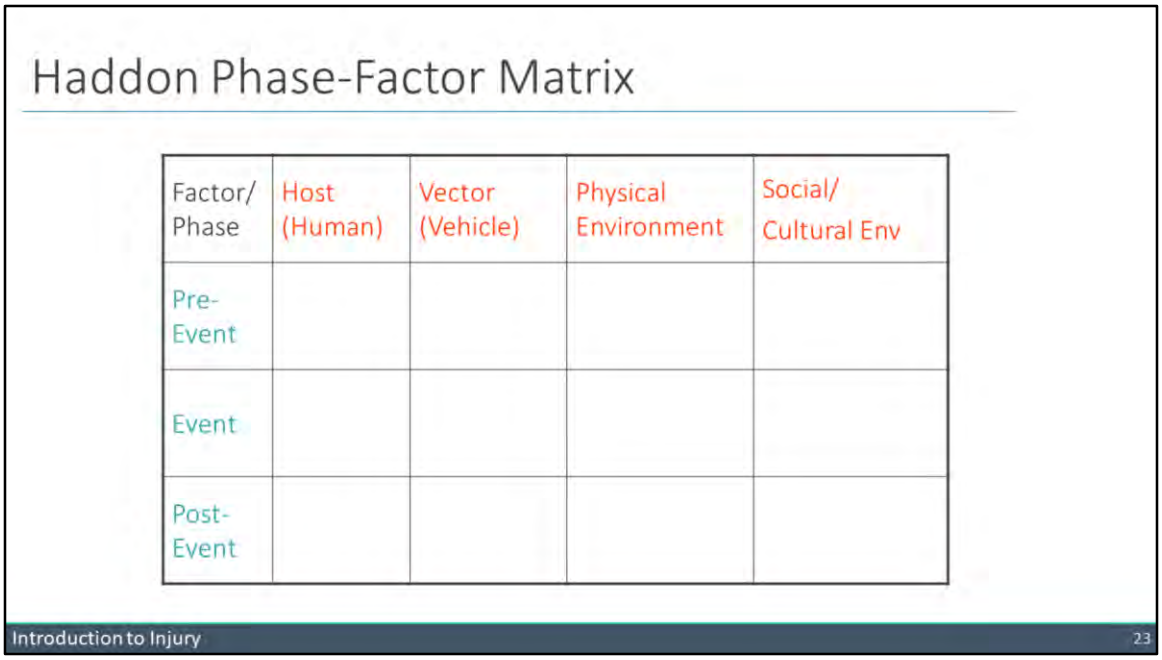
**SAY:**

For the host, what are some of the strategies to address these issues? [ask students for ideas; some are—raise the drinking age, don't allow passengers in the vehicles of new drivers, have seatbelts engage automatically, create an educational program about the hazards of drinking and driving]

The vector in this scenario is the car. In the pre-event phase, the condition of the brakes or tires are important. In the event phase, air bags need to be in place and working; also the hardness of surfaces is important. A tree in the bend of a road

could be cut down or rigid sides could be made to fly away if hit. In the post event phase, there could be a cell phone in the car or an alert system that automatically activates in the event of a crash.

The physical environment that contributes to this event is that the driving is at night in the rain. Not allowing new drivers to drive at night, or the presence of windshield wipers are preventive. In terms of the event, the tree is at a bend in the road and is apparently too close to the road. Cutting it down, or putting in a guard rail or an earlier sign to slow down could be helpful. In the post-event phase, have an emergency response system in place that is close to the site of the injury. In terms of the social or cultural environment, there needs to support for a trauma system that includes ambulances, training of EMS personnel, a hospital that is capable of caring for trauma, and a system for certifying all of these can reduce the impact of the injuries.




**NOTE TO INSTRUCTOR:** Print out this Haddon Matrix for students. There are 4 cases, slides 17-20, to use to complete this form. If you want each student tow work alone, then each student needs 4 copies of this table. Students could work as groups of 2 or three and look at each case together, completing one Haddon Matrix table as a group. Then they could come back to the whole group and present their work. Consider creating 4 groups. Then let each group take leadership, presenting one Case/Haddon Matrix and asking for input from the other groups. If students have laptops, they could be sent a Haddon Matrix to save 4 times. They could name the file and project it in the classroom when they are ready to present. If each student does one himself, you could have someone sit at the laptop in front of the class and let students report back their answers, with the scribe typing it in as they talk. This could be done with writing on a flip chart, as well.

## 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.

Introduction to Injury 24

INSTRUCTOR NOTE: These cases can be done as a whole class, or in groups of 2 or three. Instructor may put up each case in a slide or may be printed for students to have at the table.

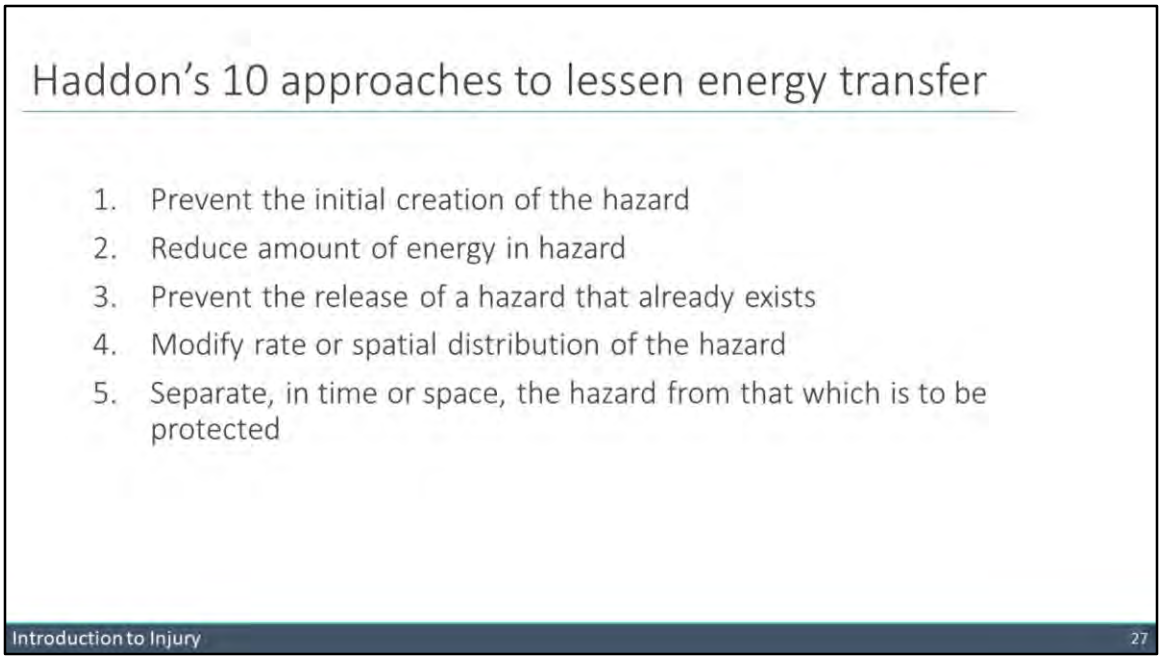
SAY: Now we will go through these cases. [Describe what you want them to do—work alone? Work as a group? Type this into a laptop? Write it in on a piece of paper?]

# 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

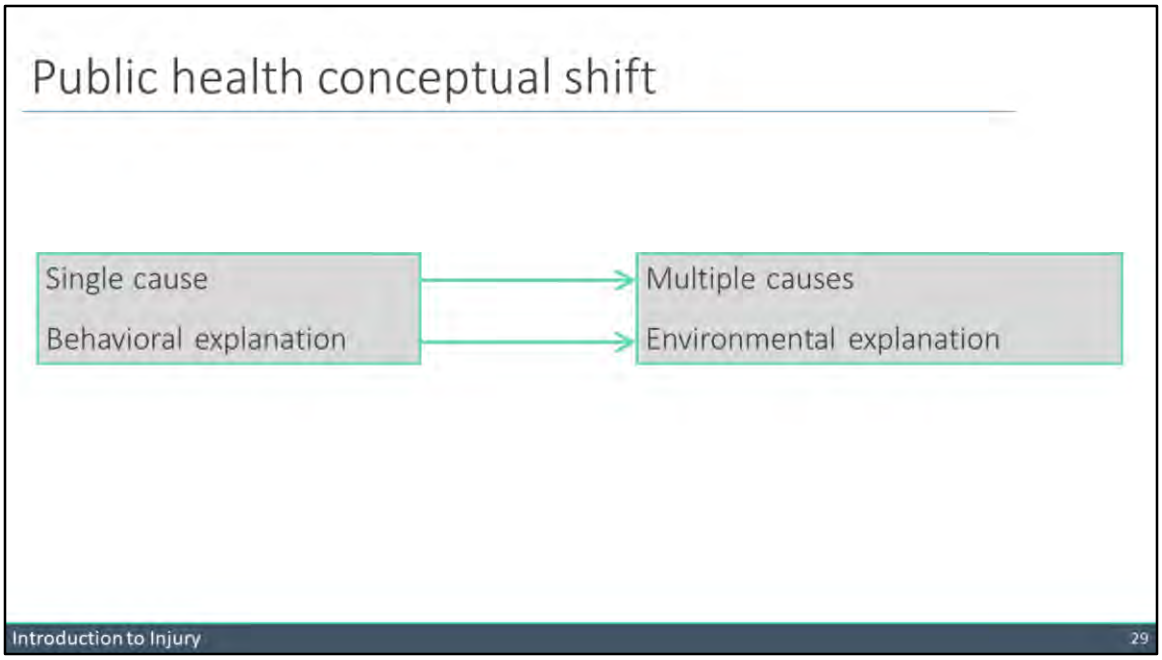
A young man is standing on the edge of a pool washing the ore-containing gravel. He falls into the pool, gets disoriented, and drowns.



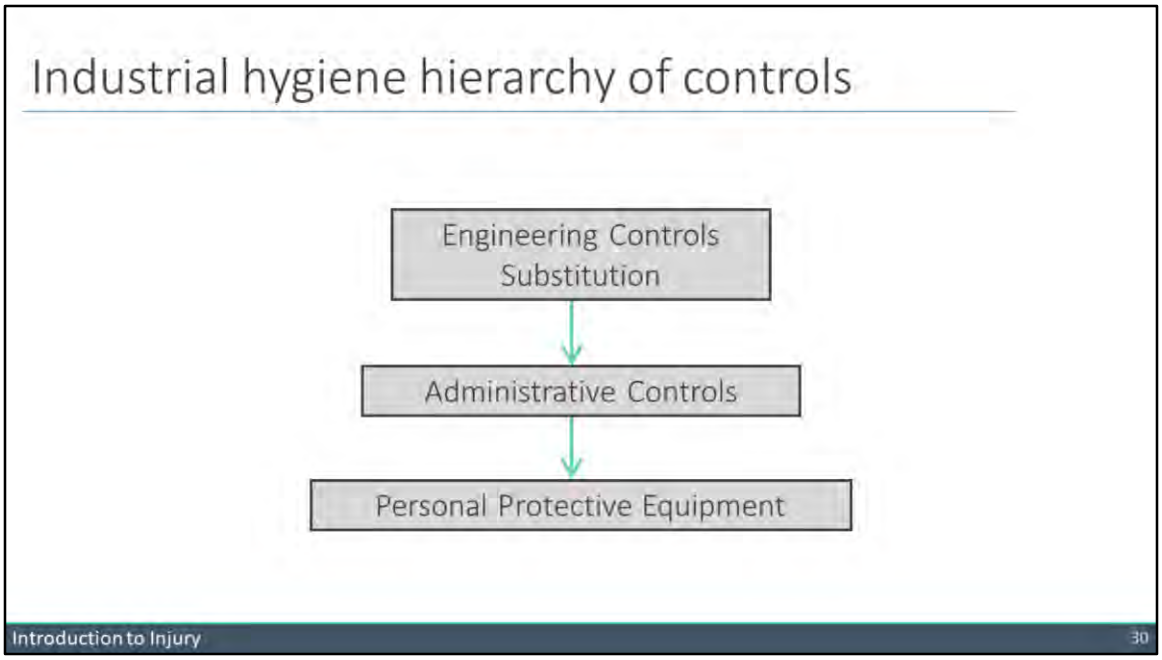

**SAY:**
Dr. Haddon described 10 approaches to lessen energy transfer that can lead to injury. Let's go around the room and have each student read one approach. After each one, let's make sure we understand what it means and how it might apply in ASGM, specifically. We'll try to explain or define each one, and we will give an example in an ASGM work process.

## Haddon's 10 approaches to lessen energy transfer

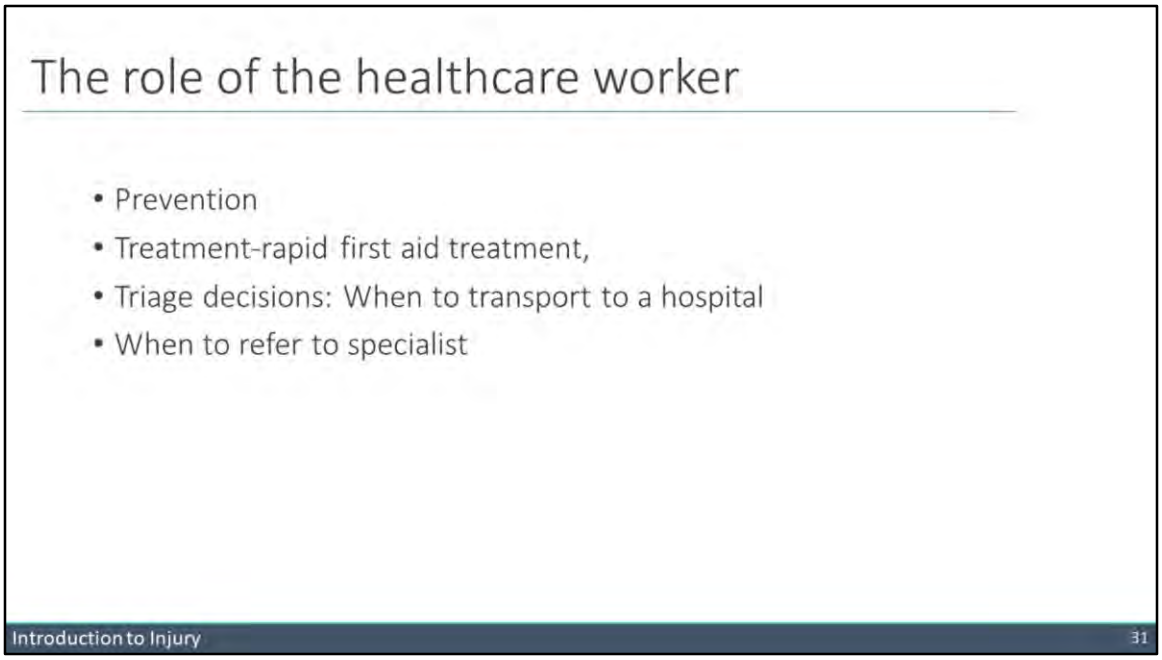
6. Separate the hazard by a material barrier
7. Modify relevant basic qualities of the hazard
8. Make potential victim more resistant
9. Counter the damage already done by the hazard
10. Stabilize, repair, rehabilitate the injured person




**SAY:**
There has been a conceptual shift in thinking of workplace injury within a public health framework. We used to think about injuries as coming about as a result of single causes. Often the blame was put on the worker—someone with an amputation of the finger might have been said to have stuck his hand in the machine. This implies that the behavior of the individual is the single cause and that the host is the only factor responsible for the amputation injury. We now understand that there are multiple causes that converge to create an injury risk and that there are factors outside the Host that can explain the reason for the injury.




We can also frame injury controls in terms of the Industrial Hygiene Hierarchy of Controls. Engineering controls and substitution in the IH Hierarchy is similar to the Haddon Matrix controls that might impact both the agent and the conditions—physical and sociocultural--under which exposure might occur. You can engineer out the problem or substitute a less hazardous situation. Change a work process, separate the individual from the hazardous part of the machine or the process—machine guarding to prevent an amputation is one example. Administrative controls can include establishing a "lock out-tag out" protocol, whereby machinery is shut off and tagged during maintenance so that no one can turn it on while a worker has his hands in there. Administrative controls also include health and safety training, certifying the workers' ability to follow a protocol or work safety; or rotating workers' time spent doing a hazardous task. Use of personal protective equipment is always the lowest form of controls. Again, it is often unavailable or uncomfortable to wear PPE. If you want to prevent an injury to the hearing, for example, ear plugs may not be available, workers may not want to use them, and they also may reduce hearing so that workers can't hear warnings in the workplace—this could make them more susceptible to another injury.




**SAY:**
So what is the role of the healthcare provider? It is most common for healthcare workers to provide treatment and to decide on when to refer a patient to a specialist or when to transport an acutely injured patient to the hospital. After seeing this slideshow and working on the Haddon Matrix, you should have a better handle on the importance of prevention and recommendations that you can make for miner patients and for companies that do mining.

# Summary

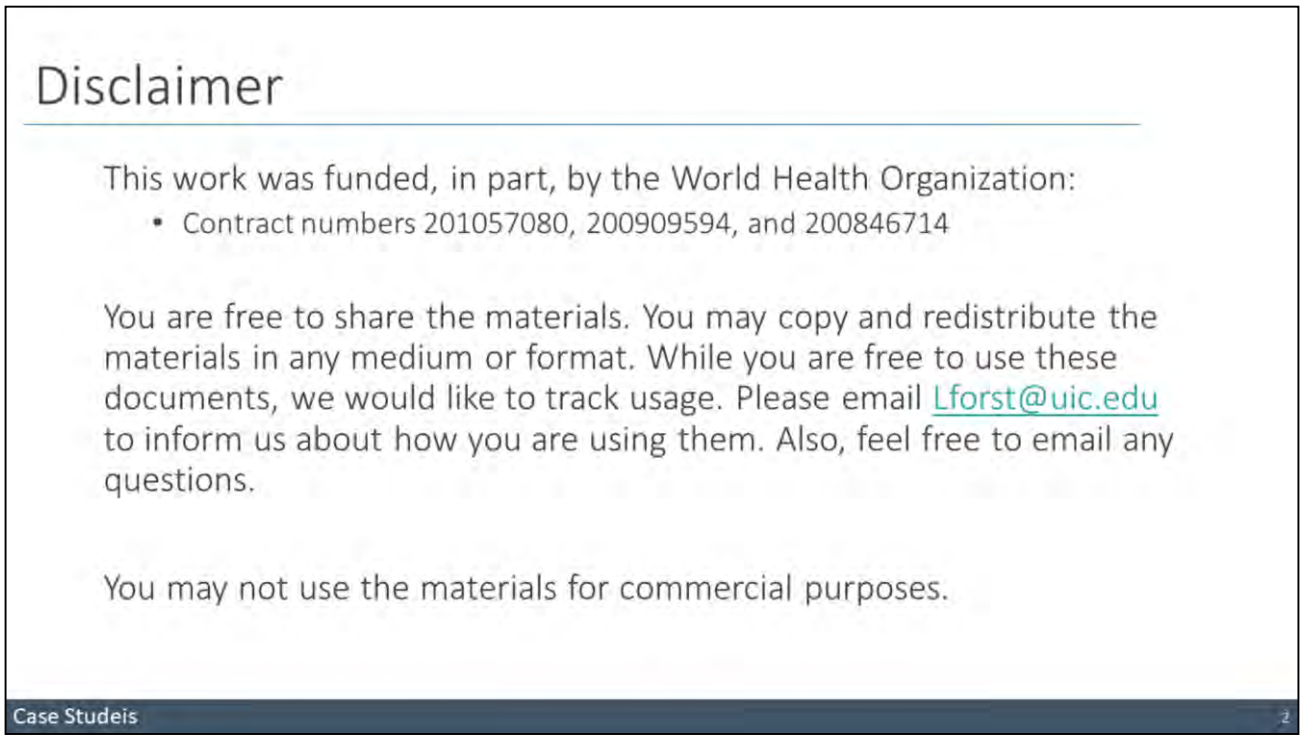
- A work-related injury results from hazardous events or exposures at work
- ASGM injuries are common and frequent-- possibly the most common adverse health effect
- Health care providers need to recognize how to prevent, treat and refer cases as needed

# URL to all powerpoints

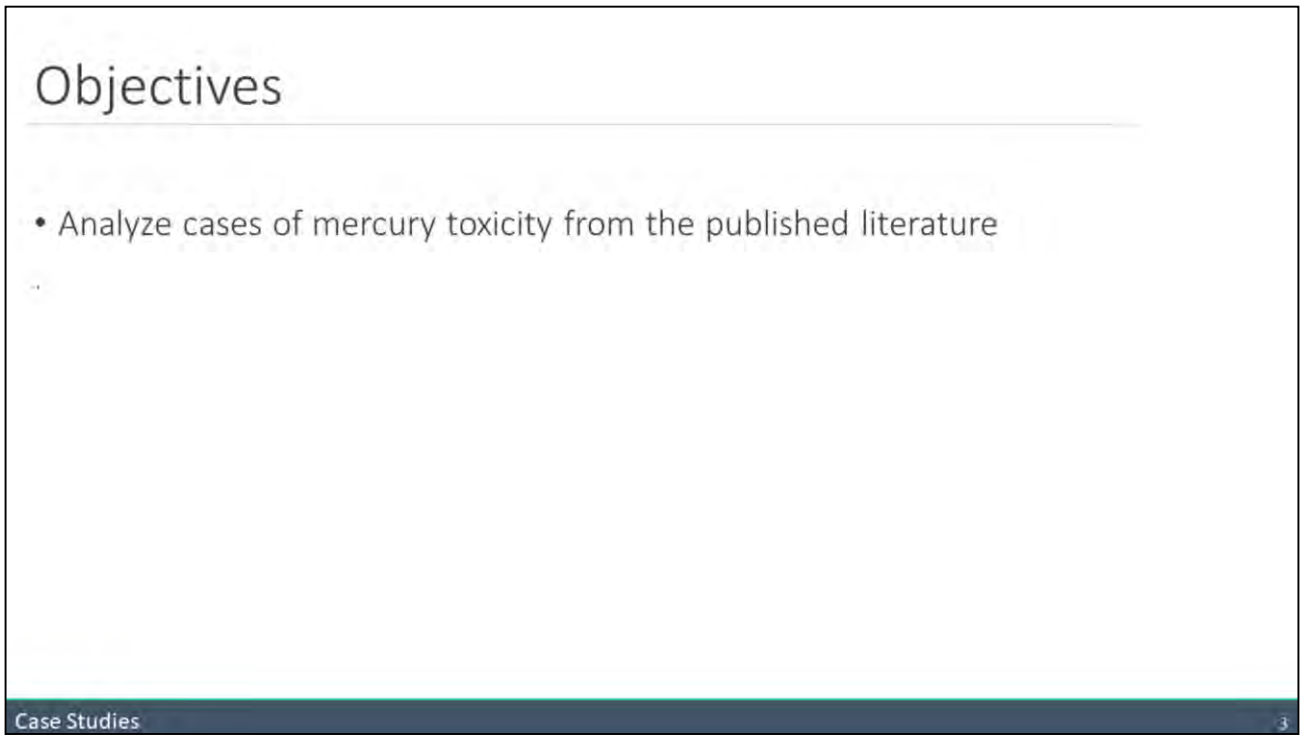
Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago

A WHO Collaborating Center

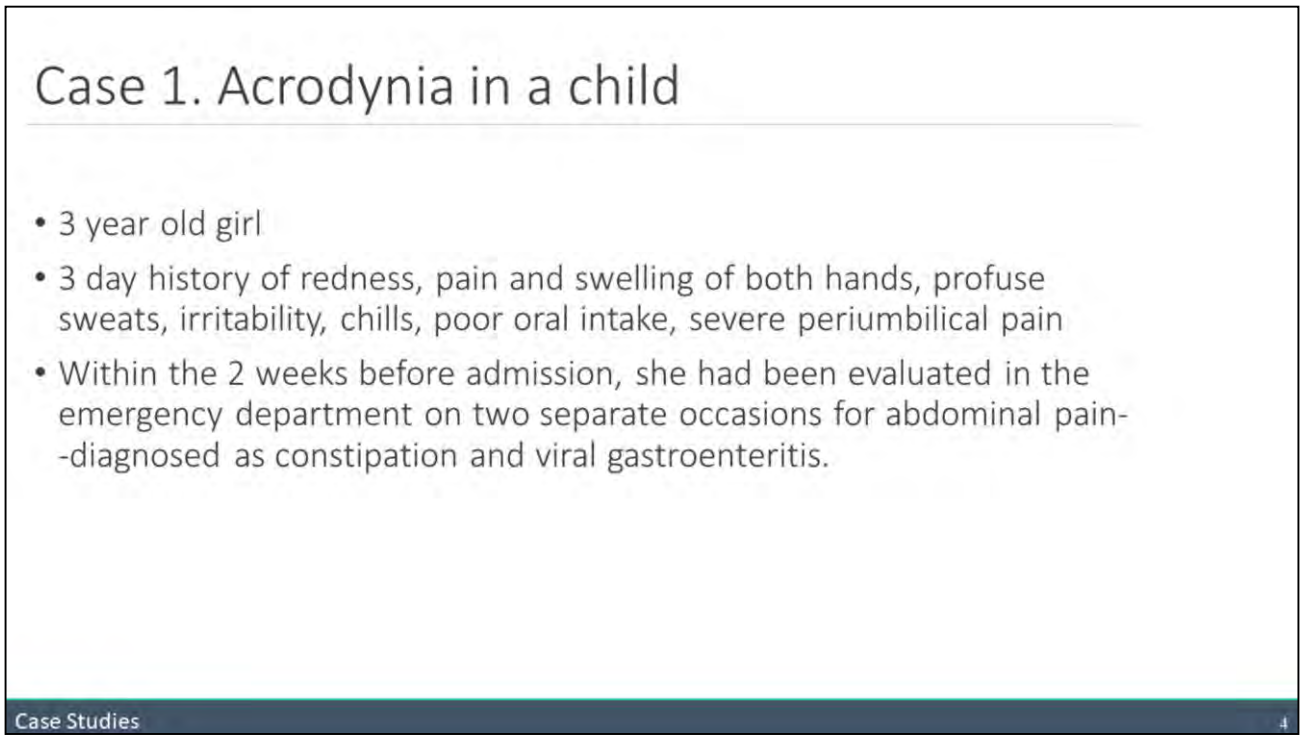

Artisanal and Small-Scale Gold Mining (ASGM): Clinical case studies
UIC
Great Lakes Center for Occupational & Environmental Safety and Health at University of Illinois at Chicago
A WHO Collaborating Center




This lecture is part of a course on the health issues related to Artisanal and Small Scale Gold Mining. This course was developed to assist countries in preventing illnesses and injuries among gold miners and their families.




By the end of this lecture, you should be able to discuss cases of mercury toxicity based on published literature. Each of the following slides has a bullet-pointed description of case findings and photos illustrating the characteristic health effects of mercury toxicity. The publications are listed for downloading from the internet.




This is a case that adpated from a publication in the peer reviewed scientific literature

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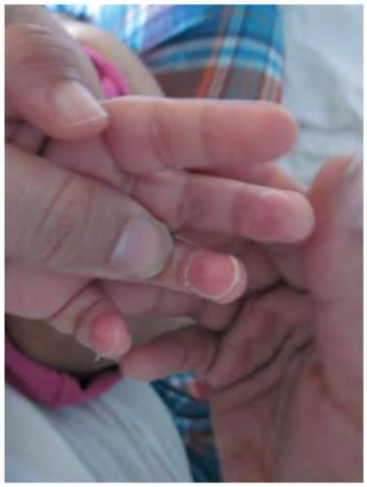
Reference:
Mercer JJ[1], Bercovitch L, Muglia JJ. Acrodynia and hypertension in a young girl secondary to elemental mercury toxicity acquired in the home. Pediatr Dermatol. 2012 Mar-Apr;29(2):199-201. doi: 10.1111/j.1525-1470.2012.01737.x.

## Case 1: Acrodynia in a child



Case Studies 5

Here are photos of her extremities

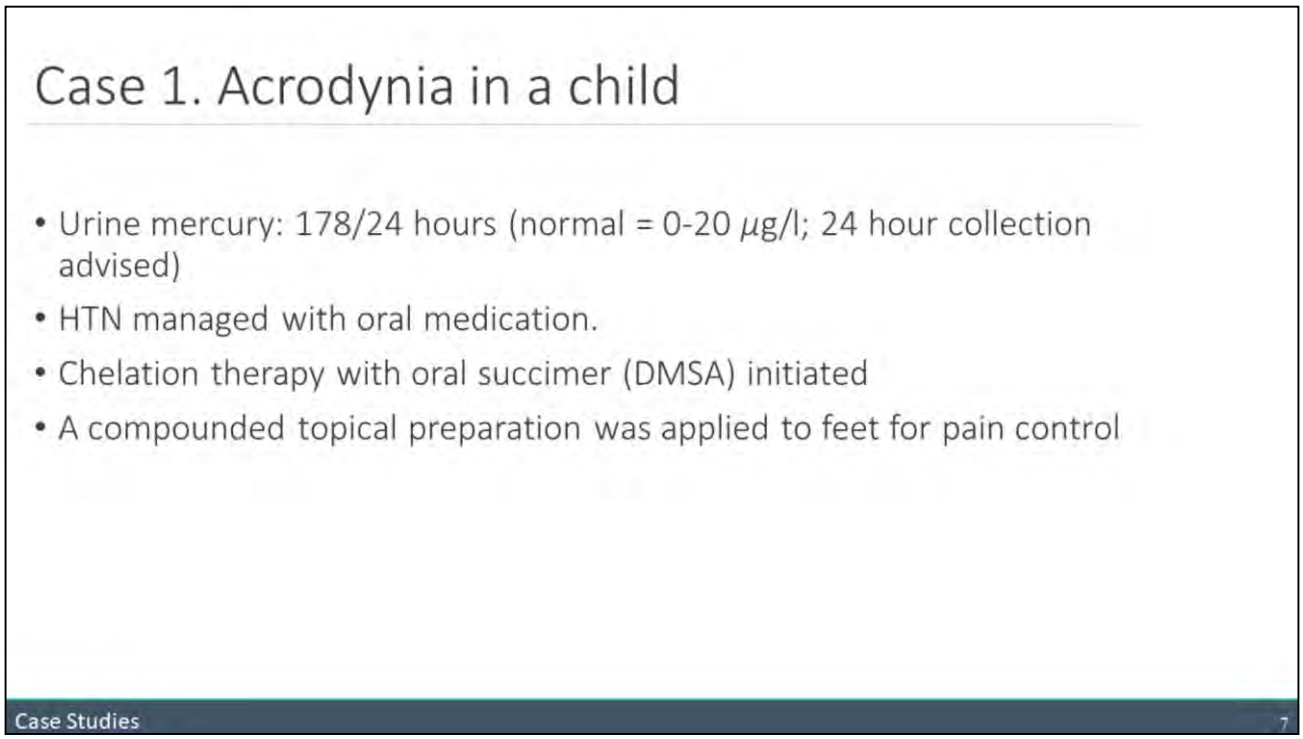
# Case 1: Acrodynia in a child

- 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?

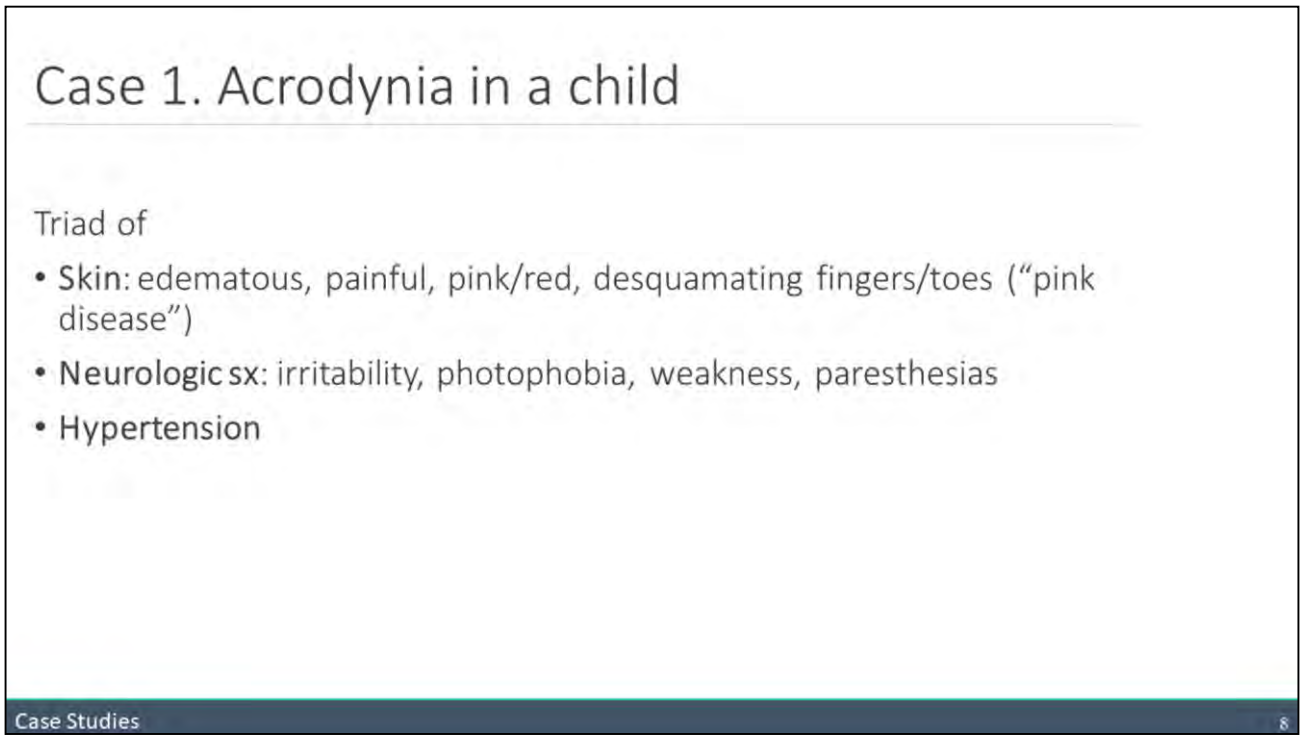
Case Studies 6

Total metanephrine level was high at 475 pg/mL (normal ≤205 pg/mL), but was nondiagnostic of a catecholamine-secreting tumor, which typically is greater than four times the reference range. Magnetic resonance imaging, angiography, and echocardiogram excluded internal masses, aortic coarctation, and other cardiovascular abnormalities.

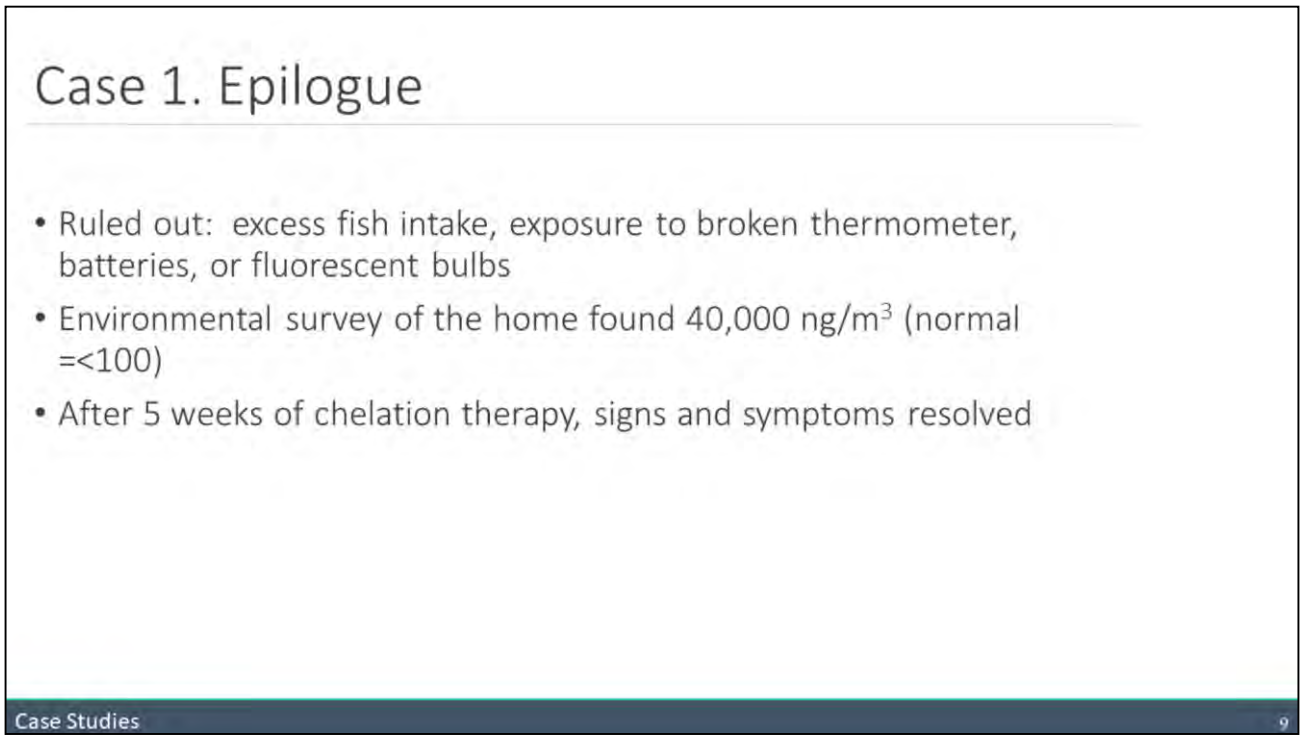
Thereafter, mercury toxicity was suspected. Want to know: pediatric environmental history



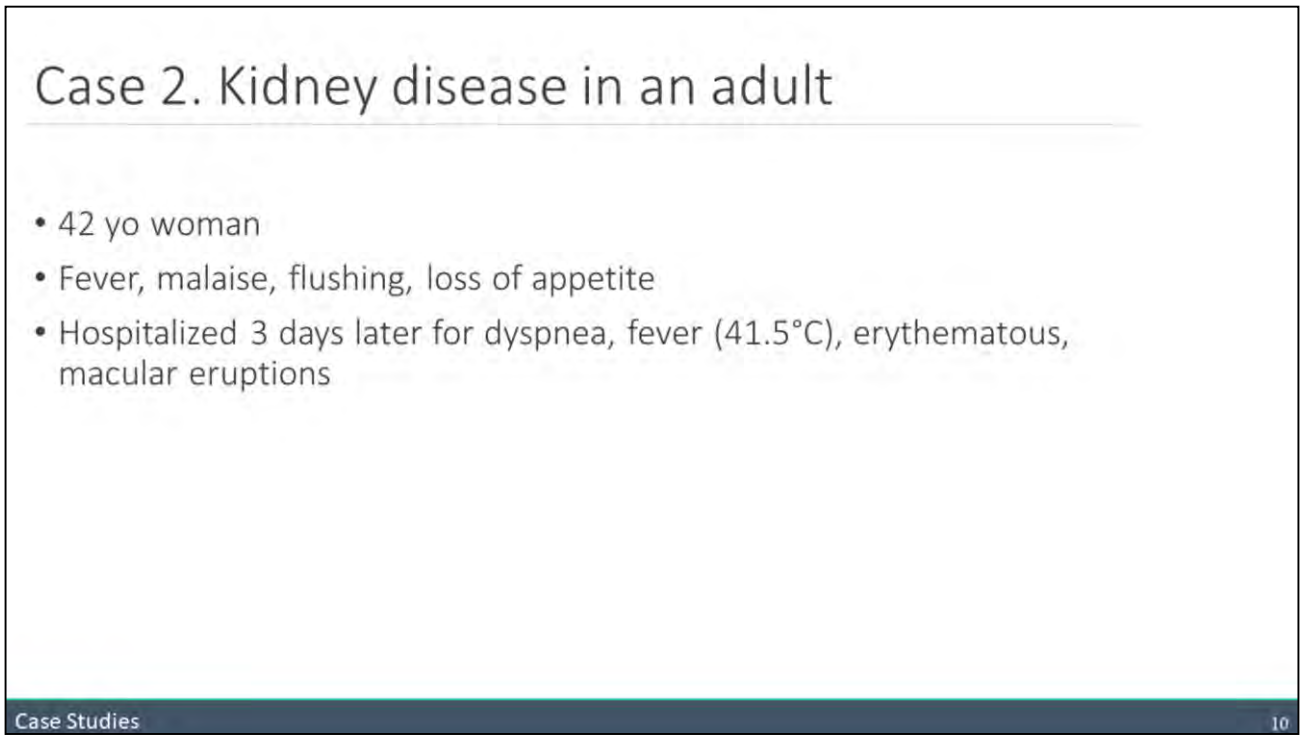

Later confirmed by a 24-hour urine mercury level of 178 lg⁄24 hours (normal 0–20 lg⁄24 hours). Hypertension was managed with amlodipine and labetalol. Chelation therapy with succimer was initiated. A compounded topical preparation containing mexiletine 2%, a lidocaine analog, and ketamine 2% applied to her hands and feet provided transient pain control. There was no history of excess fish intake or exposure to mercury, broken thermometers, batteries, or fluorescent bulbs.



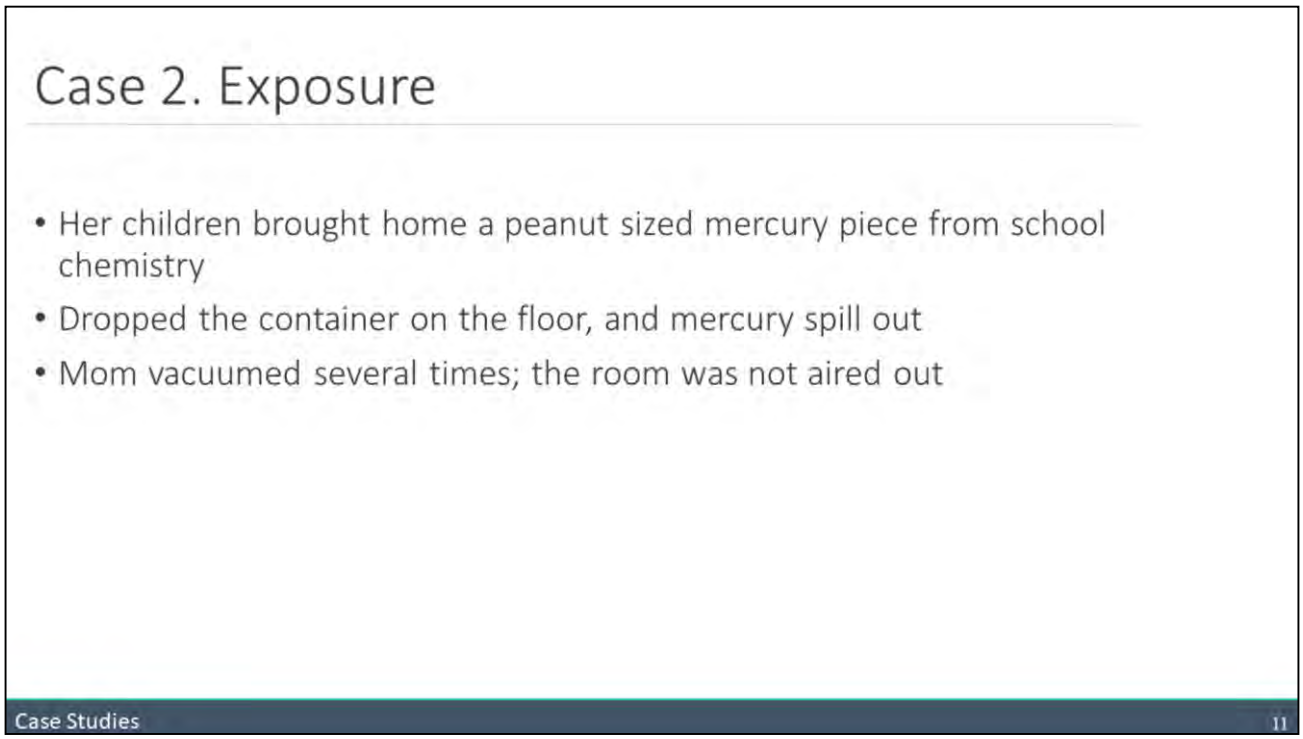

Acrodynia is also called Pink Disease



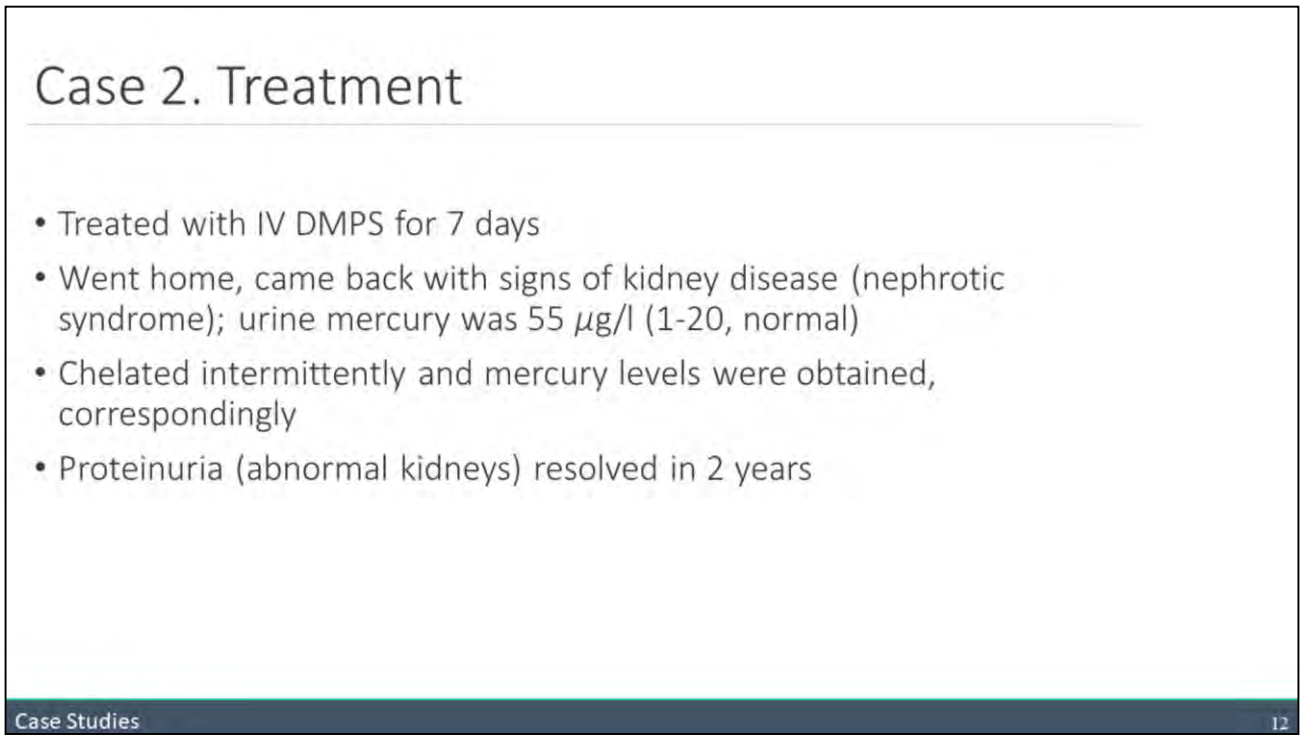

There was no history of excess fish intake or exposure to mercury, broken thermometers, batteries, or fluorescent bulbs. Environmental survey of the home, where the family had lived for 2 months, revealed mercury levels in the carpet of 40,000 ng⁄m$^3$ (normal<100 lg⁄m$^3$). After 5 weeks of chelation therapy, all signs and symptoms resolved.



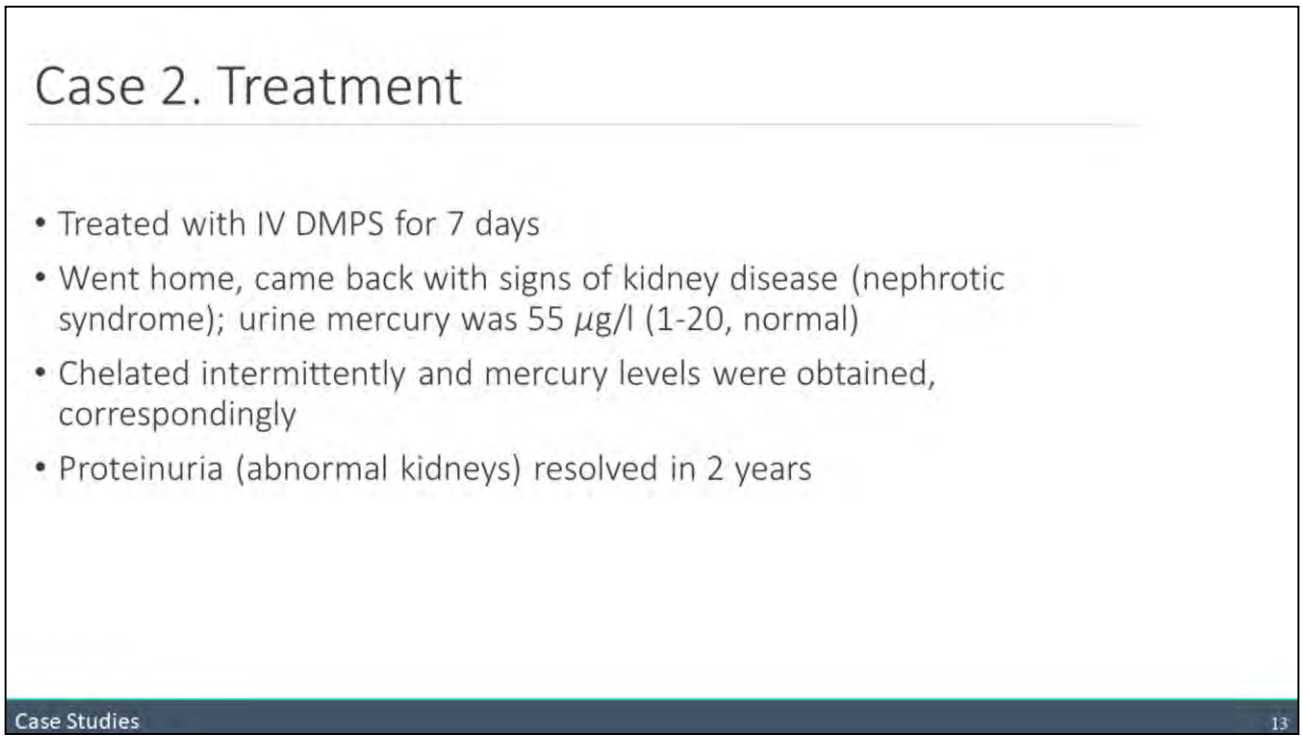

A 42-year-old female without any previous medical problem presented with fever, malaise, flushing over her face and hands and loss of appetite. On the third day of exposure, cough and malaise began and three days later she was admitted to a local hospital for the aggravation of these symptoms along with dyspnea, fever (41.5° C) and erythematous macular eruptions.




Before the development of these symptoms, one of her children had brought home a piece of peanut sized mercury in a glass from the school chemistry laboratory. While the children were playing with it, the glass fell down and the mercury spilled over the floor of the living room. She tried to gather the spilled mercury and vacuumed it two consequent days but didn't air the room.




A detailed questioning revealed her mercury exposure for 6 days. She received intravenous (iv) **Chelation** therapy with 2,3-dimercaptopropane-1-sulfonate. (**DMPS**) has been used to treat acute and chronic heavy metal poisoning. It is thought to work by forming an insoluble complex with the metal that is firmly bound to intracellular sites. **DMPS** penetrates into the kidney cells, and removes the **mercury** accumulated in renal tissues and excrete **mercury** into the urine. Based on clinical and experimental evidences, it has been shown that **DMPS** removes mercuric **mercury** deposits in human tissues except brain [76,77].

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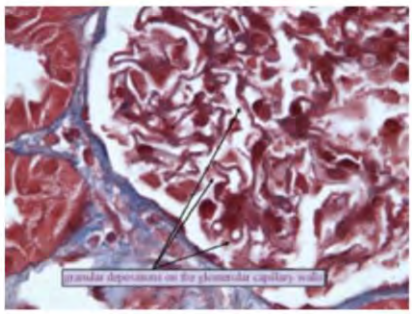
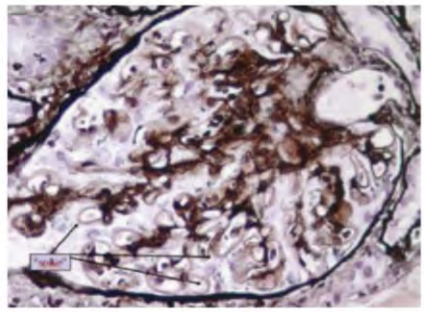
# Case 2. Kidney disease in an adult



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

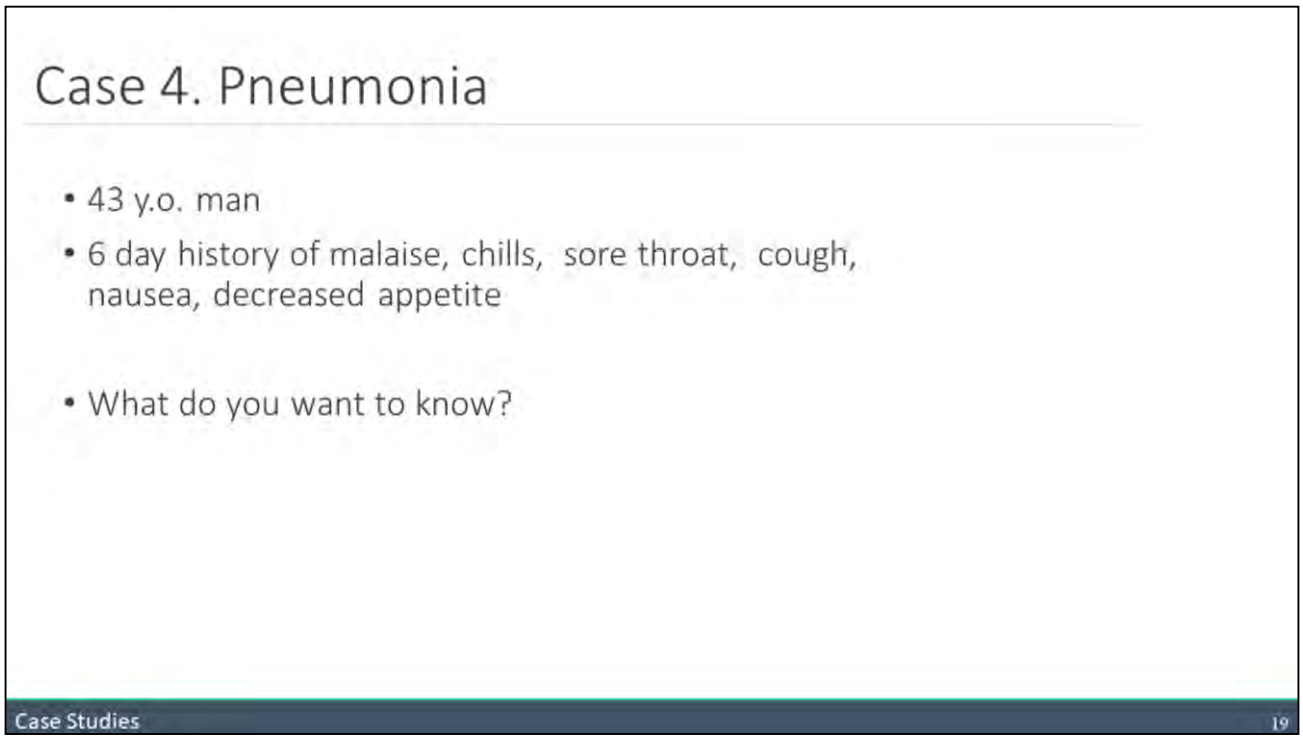
- Treated with IV chelation for 12 days→ symptoms resolved, patient discharged from hospital
- A month later, he experienced muscle pains
- and jerks on his arms, legs and perioral zone. The 24-h
- Urine and blood mercury levels were 50 μg/L (0.1–20 μg/L) and 32 μg/L (0.6–59 μg/L), respectively
- Chelated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




A 43-year-old, 70 kg male gold miner was admitted to hospital with a six-day history of cough, pharyngitis and nausea, as well as back and epigastric pain. He does not have a fever; he does appear to have a little respiratory distress.

What does he do in his job?—ask for details in job task

Does he wear any respiratory protection?

How many hours does he work?

What is he exposed to – chemicals? Metals? Mercury?

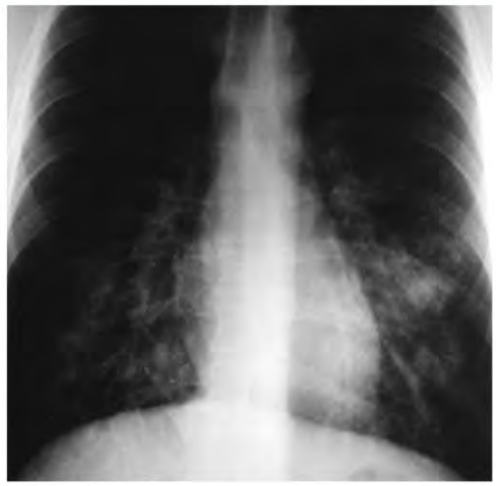
# Case 4. Pneumonia

- 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 Studies 22

You get a chest x-ray. He has blood work to rule out an infectious disease. He stays in the hospital, but the doctors can't figure out what the problem is. They repeat the x ray on day 3, the panel on the right.

What do you see in the film?

# 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

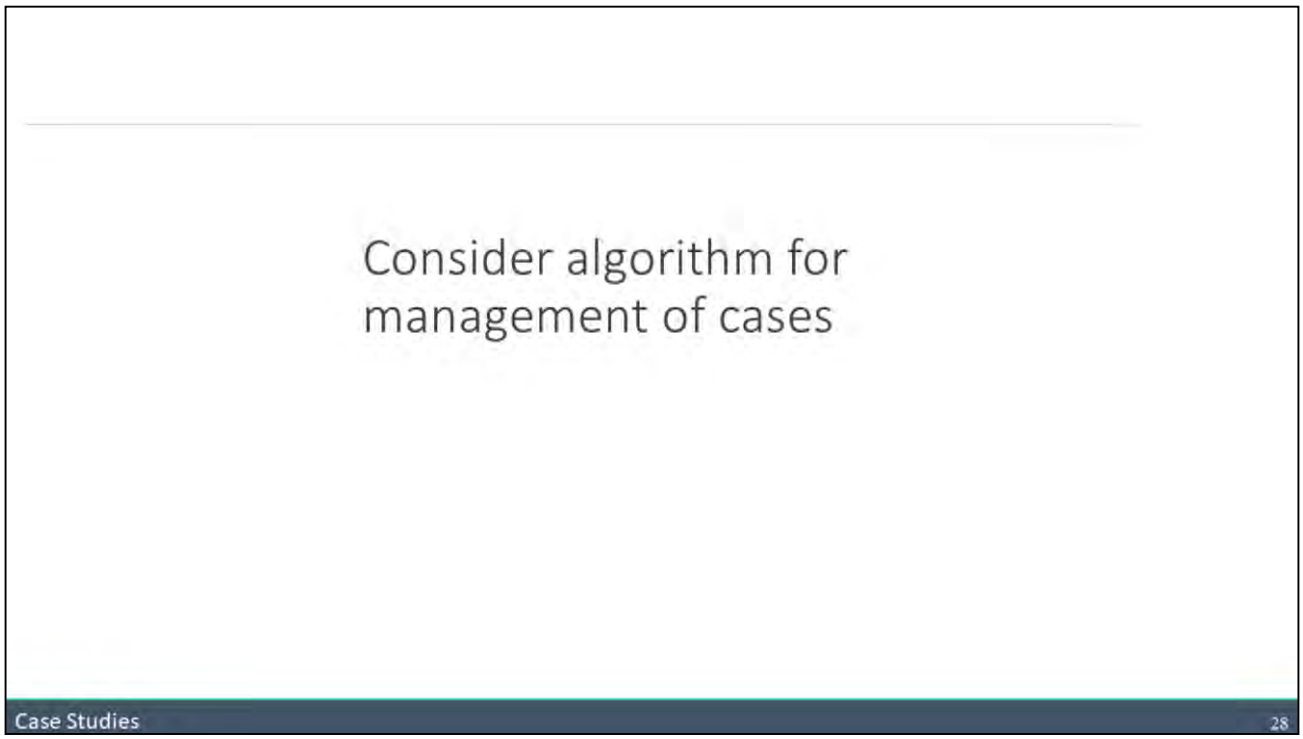
- Low birthweight
- Poor muscle tone
- Profound developmental delay
- Seizure disorder
- Deafness
- Spasticity

Case Studies 26

Shinobu Sakamoto, born in 1956, is a victim of in utero mercury toxicity. She came to the Minamata Convention on Mercury held in Geneva, Switzerland to tell her story.

# 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




Note: This is for an activity that comes after this slideshow.

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# The End

# ACTIVITIES

## A1a

LESSON PLAN: Taking an Occupational History

Objectives

By the end of this activity, student will:

- Meet and interact with a classmate
- Be able to describe the elements of an occupational history
- Be able to take an occupational history from a worker-patient

Props: Occupational History form. One copy for each student—distribute these (or include in the student manual).

Activity: Take an occupational history, starting with current job and going back for the 3 last jobs. If the person is not working, focus on the most hazardous job they have ever had—could talk about work in the hospital or clinic as a student. Fill out the form. The student should be focusing on these things.

1. What is your job title?
2. What does the industry or company produce or do?
   Then:
3. Ask them everything you need to in order to find out what they did (physically), and what hazards they were exposed to. List the hazards associated with each job.
4. Did they ever get sick or injured from their work? Describe this in as much detail as you can: what was the event? What was the injury/illness? Did they need medical care? Did they miss work? Were they compensated for their lost work time or medical care?

Instructions. Say to students: You will take an occupational history from one of your classmates using the form we have provided. Start with the current job or the most hazardous job and ask about it, according to the list. Ask them to describe the jobs and all the associated hazards. ON the back of the form is a list of chemical agents and other hazardous agents and conditions at work. Find out if your partner has had any of these exposures. Write them down on the form. After you are done, we will convene the whole class and you will report these back for us.

[Alternatively, the instructor may do a demonstration of this for the students.]

## 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.

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)

__ Pesticides (list)

__ 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.

## A2a. Categorizing Hazards

Lesson plan: Hazard categories after occupational history_05202016

*Note: This activity is a follow on after taking the occupational history*

Objectives

- To gain skills in incorporating an occupational history into a clinical encounter
- To gain familiarity with categories of occupational hazards
- To appreciate the fact that every occupation exposes workers to one or more hazard categories

Tools

- Occupational history form
- Pen/pencil
- Erasable markers (or chalk if using a chalkboard)
- Chalkboard or whiteboard or computer-projector (will need a typist if using the computer)
- Chalk or erasable markers

Teaching instructions

1. After students take the occupational history from their classmate, students will report back to the class, introducing their classmate and reporting on his/her occupational history.

2. Instructor writes the following **column headings** on blackboard or whiteboard:

| **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) |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

3. Instructor calls the group to order; asks students to volunteer to provide an introduction of their partner and also the most hazardous job recorded. The student says the job and describes associated hazards. As the student is talking, the instructor (or a student?) records the reported hazards under the appropriate column.

4. The instructor continues calling on students, asking for different job types in order to get a varied list of jobs and hazards. If there is time and a small class, every student should present.

5. After 4+ jobs/occupations are presented, if no one has presented on health care workers, ask if someone got a HCW occupational history and have the student present that. Depending on time limitations, ask if there is an occupation to report that is quite different from those already recorded.

6. The instructor summarizes this activity:

**[SCRIPT]**

As you can see, every job is associated with a variety of hazards--even jobs that we think are not too hazardous. As health care workers, we are at risk for being exposed to hazards in all of these categories—we use chemical agents for cleaning and in our laboratories, we are exposed to infectious diseases, and potentially exposed to UV light and radiation from x-rays. We are often moving around equipment or patients, so we work in awkward postures and lift heavy objects. Every job is associated with psychosocial stressors—as HCWs, ours are often long working hours and difficult patients. All of these hazards can lead to illnesses and injuries. It is important to ask people what kind of work they do and to get a good idea of what they are exposed to. Although you have this form as a tool for asking an occupational history, you can do it without a guide. You could ask:

What work do you do?

Explain all the tasks you do at work.

What tools or machinery do you use?

Do you work with chemicals? Is your work noisy?

What do you think is most dangerous about your job?

How do you protect yourself from these hazards?

**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) |
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|---|---|---|---|---|---|
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**A3a. Lesson Plans and Activity:**
**Teaching Neurological Examination for Mercury and Arsenic Toxicity**

Objectives: By the end, participants will be able to:

- Conduct a neurological examination
- Describe findings associated with arsenic and mercury toxicity

Tools:

- Stethescope, blood pressure cuff
- Reflex hammer
- Chart showing physical exam maneuvers with table describing abnormalities
- Video (Bose-OReilly) https://www.youtube.com/watch?v=lRWtXEbFRA4

**Content of Physical Examination**

Vital signs: pulse, respirations, blood pressure
6 components of Neurological exam; red ones are targeted to adverse effects of Hg

- Mental status (pp.2-3)
    - Alert, voice, pain, unresponsive
    - Recall—short and longer term memory questions
    - Mini-mental status exam
- Cranial nerves (pp.4-5)
    - Pupil examination
    - CN 2-12
- Motor response (p.5)
    - Equality of muscle strength, ton, symmetry in upper and lower extremities
    - Test pronator drift
- Sensory response (p. 5)
    - Gross sensory
    - Dermatomes
- Coordination (pp.5-6)
    - Look for symmetry
    - Finger to nose
    - Heel to shin
    - Observe gait
    - Tandem walking
    - Rhomberg
- Reflexes (p. 6)
    - Deep tendon reflexes (elbows, knees, ankles)

## Mental Status

**Level of Consciousness**

1. Is the person alert?
2. If not alert, does the person respond to your voice
3. If the person does not respond to your voice, is he/she responsive to pain?
4. Is the person unresponsive?

Normal ____ Abnormal____

**Recall: Short and Long-term Memory**

1. Show the person 3 items (eg, clock, pencil, paper clip) and ask him/her to remember them.
2. Move them out of sight. Ask him/her to name the three items.
3. Hide three items from view again. Do other activities for 20+ minutes. Ask person to name the 3 items after 20 minutes.

**Mini Mental Status Examination**

Reference. Folstein, M., Folstein, S.E., McHugh, P.R. (1975). "Mini-Mental State" a Practical Method for Grading the Cognitive State of Patients for the Clinician. *Journal of Psychiatric Research*, 12(3); 189-198.

The MMSE is used to determine cognitive impairment. It can be repeated many times in order to follow an individual over time.

Patient_____ Examiner _____
Date_____

Maximum Score =30; abnormal score <23

**Orientation**

5 ( ) What is the (year) (season) (date) (day) (month)?
5 ( ) Where are we (state) (country) (town) (hospital) (floor)?

**Registration**

3 ( ) Name 3 objects: 1 second to say each. Then ask the patient all 3 after you have said them.
Give 1 point for each correct answer.
Then repeat them until he/she learns all 3. Count trials and record.
Trials _____

**Attention and Calculation**

5 ( ) Serial 7's. 1 point for each correct answer. Stop after 5 answers.
Alternatively spell "world" backward.

**Recall**

3 ( ) Ask for the 3 objects repeated above. Give 1 point for each correct answer.

**Language**

2 ( ) Name a pencil and watch.

**Repetition**

1 ( ) Repeat the following “No ifs, ands, or buts”

**Complex Commands**

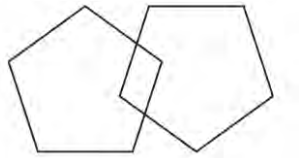
3 ( ) Follow a 3-stage command:

“Take a paper in your hand, fold it in half, and put it on the floor.”

1 ( ) Read and obey the following: CLOSE YOUR EYES

1 ( ) Write a sentence.

1 ( ) Copy the design shown.



_____ Total Score (add the points/marks from above)

ASSESS level of consciousness along a continuum(list consciousness level here): _____

Alert Drowsy Stupor Coma

References:

**Cranial Nerves**

Nerve number:

1. **Olfactory** (smell): not usually tested
2. **Optic nerve**:
    a. Test visual acuity with eye chart
    b. Screen visual fields by confrontation
        i. Stand 2 feet in front of patient and have him look into your eyes
        ii. Hold your hands ~1/3 meter away from the patient's ears and wiggle a finger on one hand
        iii. Ask the patient to indicate which side they see the finger move
        iv. Repeat 2 or 3 times to test both temporal fields
        v. If there is an abnormality, test the four quadrants of each eye while asking the patient to cover the opposite eye with a card
    c. Test pupillary reaction to light
        i. Dim the room lights
        ii. Ask the pt to look into the distance
        iii. Shine a bright light obliquely into each pupil in turn
        iv. Look for both the direct (same eye) and consensual (other eye) reactions
        v. Record pupil size in mm and asymmetry or irregularity
        vi. If abnormal, do the test for accommodation (next)
    d. Test pupillary reaction to accommodation
        i. Hold your finger 10 cm from the patient's nose
        ii. Ask patient to alternate looking into the distance and at your finger
        iii. Observe the pupillary response in each eye
3. **Oculomotor**
    a. Observe for ptosis (drooping eyelid)
    b. Test extraocular movements
        i. Stand or sit 1-2 meters in front of patient
        ii. Ask patient to follow your finger with their eyes without moving their head
        iii. Move your finger in H formation and check bilateral eye movement in each direction
        iv. Pause during upward and lateral gaze to check for nystagmus (eyeball oscillation)
        v. Check convergency by moving your finger toward the bridge of the patient's nose
4. **Trochlear nerve**
    (same as 3.b.iii. above): normal if eyes can move inward and downward (looking at nose; "cross-eyed")
5. **Trigeminal (facial sensation)**
    a. Touch the patient on both sides of forehead, upper cheek, lower cheek, one spot at a time. Ask if he/she can feel it. Should have feeling
6. **Abducens**
    (same as 3.b.iii, above): normal if eyeballs can move laterally to the right and to the left
7. **Facial nerve** (muscles of facial expression)
    a. Raise eyebrows, close both eyes tight, smile, frown, show teeth, puff out cheeks
8. **Acoustic**

a. Face the patient and put your fingers near each ear. Rub fingers together on one side and ask patient to tell you which side she/he hears a sound

9. **Glossopharyngeal** (see 10. Vagus)
10. **Vagus**
    a. Listen to voice. If hoarse, this is abnormal (may be vocal cord paralysis)
    b. Ask patient to swallow.
    c. Ask patient to say "ahh"—should see soft palate move up
11. **Accessory**
    a. Ask patient to shrug up shoulders against resistance—should have good strength
12. **Hypoglossal**
    a. Ask patient to stick out tongue, move it side-to-side—should be symmetrical

**MOTOR**

1. Observe patient for involuntary movements
   a. Ask patient to close eyes. Look for tremor of eyelids
   b. Ask patient to hold out hands. Look for tremor of hands
2. Muscle Tone
   a. Ask patient to relax. Flex and extend hands, fingers, wrists, elbows, knees, ankles. There should be small, continuous resistance to passive movement. Observe for decreased tone (flaccid) or increased tone (rigid/spastic)
3. Muscle strength
   a. Test strength by having the patient move against your resistance. Grade all extremities/joints at 0-5/5. Should be strong and equal bilaterally.
4. Pronator Drift
   a. Ask patient to stand for 20-30 seconds with both arms straight forward, palms up and eyes closed. Look for drift into pronation (sign of upper motor neuron disease)

**SENSORY**

1. Vibration
   a. Test vibration with a tuning fork (128 Hz) over joints of index fingers and great toes; if they do not feel vibration, proceed proximally, joint by joint.
2. Light Touch
   a. Use your fingers to touch the skin lightly on both sides simultaneously. Check several areas on both sides of the upper and lower extremities. As patient to tell you if they feel it normally and if it is the same on both sides. (normally will be the same)

**COORDINATION**

Rapid Alternating Movements

1. Ask patient to hold both hands in the air and swivel them simultaneously
2. Ask the patient to tap the distal thumb with the index finger as fast as possible
3. Ask the patient to strike one hand on the thigh, raise the hand, turn it over, then strike it back down as fast as possible. Do this quickly and repetitively.
4. Ask the patient to tap your hand with the ball of each foot as fast as possible
   (Abnormal if patient cannot do these activities quickly or if they look uncoordinated- "dysdiadochokinesis")

Point-to-Point Movements

1. Ask the patient to touch your index finer and their nose alternately, several times. Move your finger about as the patient performs this task (finger-nose-finger-nose)
2. Ask the patient to place one heel on the opposite knee and runit down the shin to the big toe. Repeat with eyes closed.
3. Hold your finger ½ meter from the patient. Ask him/her to touch your finger with their finger. Keep your finger in the same position. Ask them to relax their arm and close their eyes. Then to touch your finger again.

Rhomberg

1. Ask patient to stand with their feet together and their eyes open. Check for steadiness. Then ask them to close their eyes. Be prepared to catch them if they are unstable. (abnormal if they are unsteady in their stance)

Gait

1. Ask patient to walk across the room, turn, and come back
2. Ask them to do the same walk with their eyes closed—across the room and back
3. Ask the patient to walk heel-toe in a straight line
   (Abnormal if gait is unsteady)

**REFLEXES**

1. Biceps: With arm flexed, place your thumb firmly on biceps tendon; strike your thumb
2. Knee: with patient seated, strike the patellar tendon
3. Ankle: strike the Achilles tendon
   (Should be present and equal bilaterally).

Grade reflexes
0/4=absent
1+/4=hypoactive
2+/4=normal
3+/4=hyperactive
4+/4 =hyperactive with clonus

**NEUROPSYCHOLOGICAL EXAMINATION**

these are selected by Stephan Bose-O'Reilly

1. Matchbox test
   a. Put a matchbox in the center of the table
   b. Put 10 matches on each side of the matchbox, ~15 cm away
   c. Set timer for 17 seconds
   d. Have patient put matches into box, one at a time, first right hand then left then right alternating until they are all in.
   e. Normal is completion at 17 seconds
2. Pencil tapping
   a. Have the patient take a pen or pencil and a piece of paper
   b. Set timer for 10 seconds
   c. Have patient make dots quickly on the paper for 10 seconds
   d. Count the number of pen marks at the end of 10 seconds. >45 is normal

**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 |

**A4a. LESSON PLAN: Haddon Matrix**

Objectives

By the end of this activity, student will be able to:

- Complete a Haddon Matrix for 5 injury case scenarios
- Discuss injury prevention measures in the context of the Haddon Matrix

Props:

- Haddon Matrix Form—print 5 for each student or 5 for each group of 2-3 students.
- Slideshow (S-5) on Injury—may project slides (at the end of this lecture) or may print them for use in this activity if you want students to have a copy at the table where they are sitting. Print 1 copy of each case for each group

Instructions.

Say to students: you will complete a Haddon Matrix for each of the 5 case scenarios presented to you. Work as a small group. When you are done, we will then come back to the large group and discuss each group's ideas about each case.

Instructor asks for reporter from each group to report back the discussion. This could either be typed by a scribe on a laptop and projected, or simply discussed.

Summarize at the end: The Haddon Matrix is designed to help us think about ways to prevent these injuries. By breaking down categories, we are able to dissect the details in a way that lets us think about multiple interventions for a single injury. It also reminds us that all injuries are preventable—an injury is not an accident!

**A4b. Haddon Matrix form for activity**

| **Factors**<br>**Phases** | Human Factors | Agent or Vehicle | Physical Environment | Sociocultural Environment |
|---|---|---|---|---|
| Pre-event | | | | |
| Event | | | | |
| Post-event | | | | |

**A5a**

**Lesson Plan. Developing and algorithm for clinically managing a suspected case of mercury poisoning**

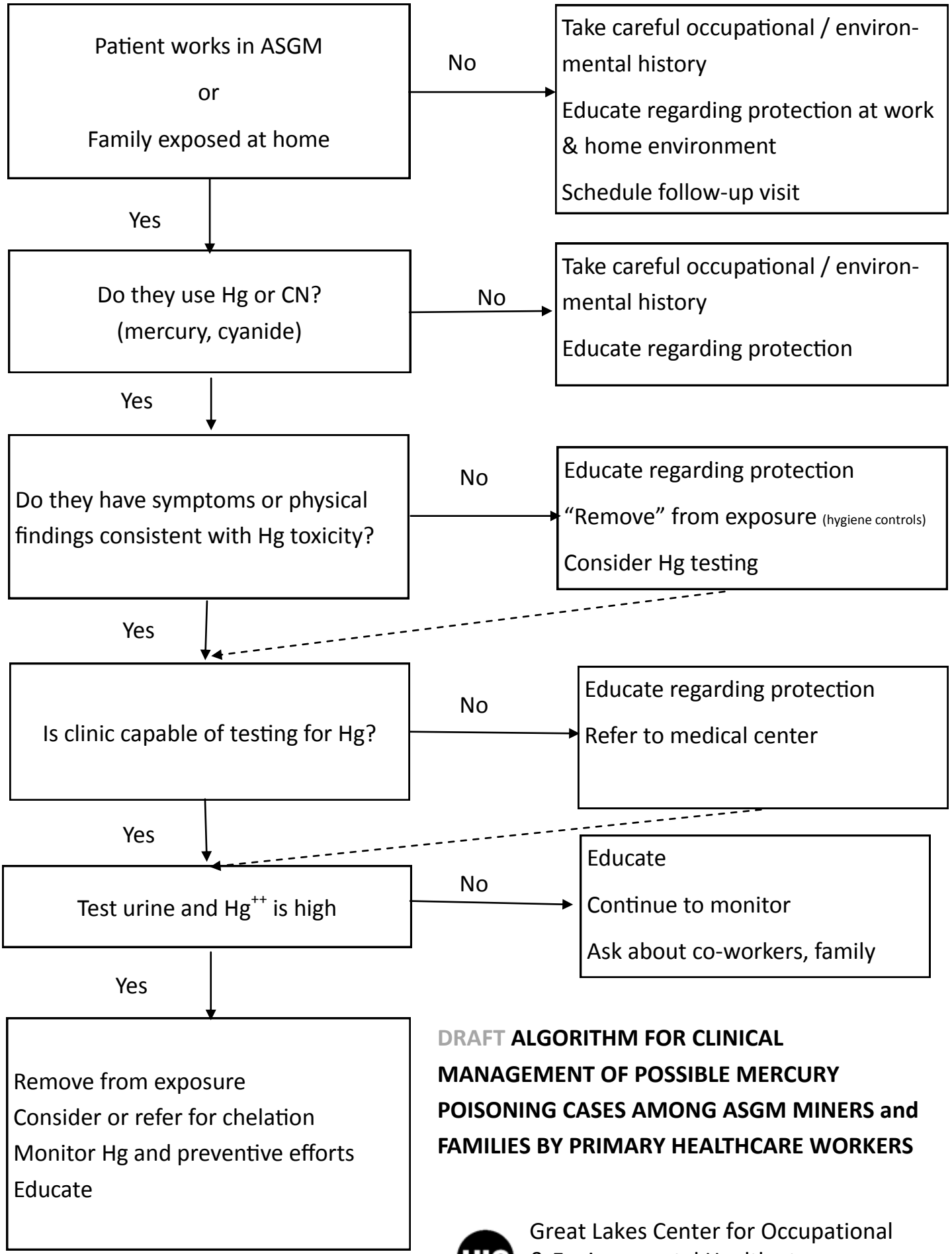
Objectives:

By the end of this activity participants will have developed an algorithm for managing a suspected case of mercury poisoning that is locally relevant.

Props. Blank algorithm form

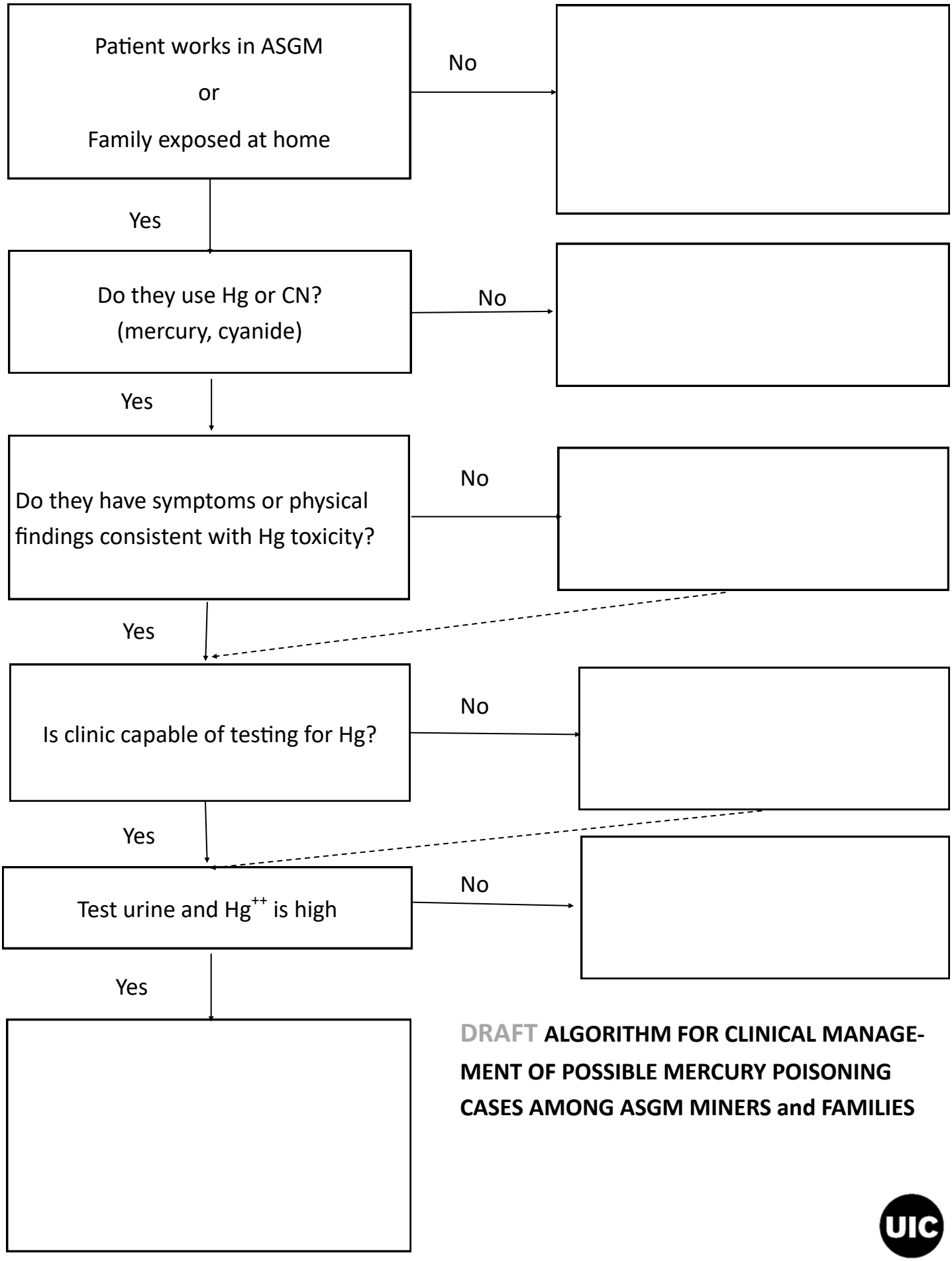
Instructions. Project the adobe pdf form onto the board. Ask students to look at their form and the example on the projected form. Students will, as a group, be talked through each box and will complete this form in a way that is locally relevant. For example, the local hospital, the academic hospital, a lab, or the poison center could be part of a local referral system. These will get filled in as the students discuss how to manage a case at each phase that is shown on the form.

At the end, the instructor could either type this into the form or make a copy to distribute to the class.




**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




**DRAFT ALGORITHM FOR CLINICAL MANAGEMENT OF POSSIBLE MERCURY POISONING CASES AMONG ASGM MINERS and FAMILIES**

**A6a.**

Lesson Plan. Role play—Clinical Encounter

Learning objectives.

By the end, students will be able to:

- Take a history from an ASGM patient;
- Discuss what he/she would do in terms of case management

Props/resources.
Hazard Datasheet on ASGM Miner

Instructions.

Have students study the Hazard Datasheet on ASGM Mining. Select 2 volunteers from the class; one will be the patient and one will be the doctor or nurse. Give them this script or give them time to make up their own script. At the end, refer back to the algorithm and talk about how you might manage this patient.

## 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.

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### 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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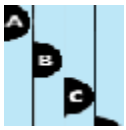
**Definitions and/or description**

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.

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**Related and specific occupations**

Mining, prospecting, excavating

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**Tasks**

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

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**Primary equipment used**

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

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**Workplaces where the occupation is common**

Mines

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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.

**A7a. Lesson Plan. Create a mural to display a public health message**

Props/Resources

- Easel paper
- Markers

Instructions. Give the students this list of public health messages. The audience for this message is ASGM miners and people living in ASGM communities. The list was generated by public health practitioners, researchers, and other stakeholders. Students may use this list and create their graphic to illustrate a message from the list, or they may create their own. Each student should have a large piece of paper and markers. After they are done, each student should tape up their poster and should describe it to the class. There is a graphic already done that you could show them as a final product after they are done with this.

Possible messages:

1. Children should not work in ASGM.
    - children should not work in tunnels/shafts/pits or other dangerous places
    - children should not handle or be near mercury, cyanide or other chemicals
    - children should be at school, not work!
    - The workplace is not a playground. Keep your kids away from work!
2. Mark containers holding mercury and other toxic chemicals clearly (toxic symbol)
3. Store toxic chemicals securely—in locked cabinets, outside the home
4. Mercury is not healthy for children and other living things
5. Don't take toxic chemicals home. Wash with soap and clean water at the end of your work shift.
6. Change clothes and wash up before you go home.
7. Wash hands with soap and water before eating
8. Make a separate eating area away from work activities
9.. Mercury damages your health
10. Mercury is bad for your children
11. Mercury is bad for the environment
12. Reduce, re-use, re-cycle mercury
13. Find a mercury substitute for gold extraction
14. Use mercury free technologies in ASGM
15. Mercury is expensive. Reducing its use and losses saves money
16. A work place is not a playground! Don't let your kids play around mining activities; mercury
17. Miners should wear masks/gloves/hearing protection
18. Mention the risk of alcohol and other (illegal) drugs and their risk at workplace
19. Don't breathe in dust!
20. Prevent accidents
21. Don't use contaminated water to wash dishes or clothes

# Other Health Issues in ASGM

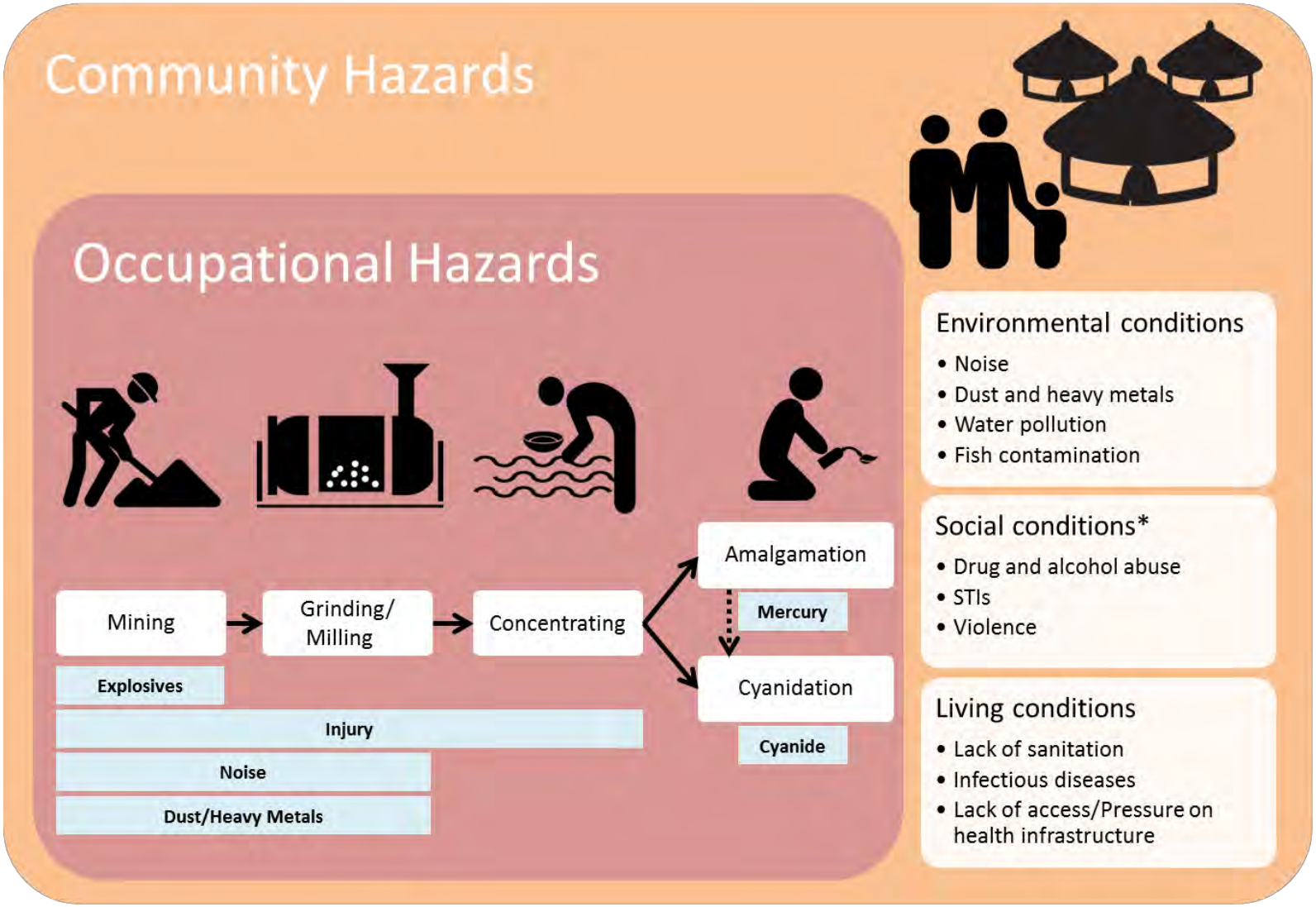




Image from: Natural Resource Defense Council

A8a.

Activity. Preparation for Site Visit to ASGM Mine

Objectives. By the end, students will have experience completing a survey form after investigating a worksite for hazards.

Props. Slides to project, survey should be handed out. Instructor should ask student what the task is in each photo. Write down the task, then write down the number of workers in the photo and categorize the hazards. IN the last column, fill in or discuss what sort of controls might help prevent illness or injury.

# WALK-AROUND 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 |
| | | | | | | | |
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| | | | | | | | |
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| | | | | | | | |

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** |
| | | | | | | | |
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