Medical Consequences of Chemical Weapons of Convenience

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Medical Consequences of Chemical Weapons of Convenience (WOC)

Objectives

- List Chemical WOC Prototypes & Their Major Medical Consequences
- Assess Community Vulnerability with EPA Risk Management Plan (RMP) Data
- Use ITF-40 Assess TIC/TIM Hazard

Poll

For a chemical to be an effective weapon of convenience it must be highly lethal.

- ○ True
- ○ False

Chem/Toxic-Terrorism Aims

- Frighten/Panic Community
- Gain Publicity, Harm Economy
- Paralyze a City
- Infrastructure Denial of Use
- Overwhelm Medical System
- Create Political Upheaval
- High Lethality not Required!

Weapons of Convenience / Opportunity: Scenarios

Large-scale toxic exposure or explosion at vulnerable target

- Indoor: arena, symphonies, etc.
- Outdoor: stadium, city center

Contaminated ingestant

- Food, drink, water, drug, etc.
- Acute or delayed toxicity

Deployments:

- ~~Bombs~~, ~~Missiles~~
- Storage Tanks
- Truck/Rail Tankers
- Spray Truck
- Crop Duster
- Food/Drinks/Drugs
- Drinking Water

Chem / Toxin Vulnerability

Weapons of Convenience

Explosives:
- Ammonium Nitrate

Toxic Gases:
- Acrolein
- Ammonia
- Carbon Monoxide
- Chlorine
- Cyanide
- Hydrogen Sulfide
- Methyl Bromide

Caustics:
- Toilet, Drain & Metal Cleaners
- Rust Removers
- Lye

Toxic Solids/Liquids:
- Paraquat
- (CH3)2Hg
- Organophosphate
- NaH3
- SMFA

Risks to Populated Areas

Large quantities of hazardous chemicals are often stored near highly populated or extremely sensitive sites.

Chemical tankers travel on rails or roads in or near highly populated or extremely sensitive sites.

BP Oil Refinery Explosion

In the news this week:

Texas Oil Refinery Blast Kills at Least 15

Image Source: CNN

… More Than 100 injured

Texas City, TX
March 23, 2005

1947 Texas City Blast

French freighter Grandcamp loaded with 2,300 tons of NH_4NO_3 caught fire producing a "pretty orange color coming from the black smoke." A large crowd of onlookers appeared to watch. As word of the fire traveled, the crowd of onlookers grew in number.

Before the Explosion

Sources:
http://www.rmstitanichistory.com/grandcamp/grandcamp.html
http://www.uh.edu/engines/epi1138.htm
http://www.local1259iaff.org/disaster.html

1947 Texas City Blast

Suddenly a huge explosion rocked the ship, created a violent shockwave, and quickly engulfed the Monsanto Chemical Plant, killing the entire Fire Department, the onlookers standing near the docks, nearby citizens and workers totally at least 663.

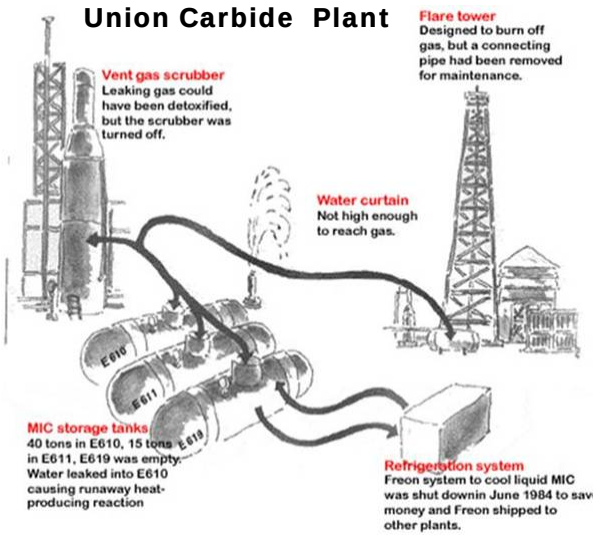
After the Explosion

Bhopal - Methyl Isocyanate

12/3/84 - Bhopal, India - Union Carbide Plant

- 200, 000 Inhabitants Injured
- 90,000 Patients/24 hr - Local Health Facilities
- 2,500 - 5,000 Dead, Most Downwind of Plant
- 24,545 kg MIC & 12,800 kg Reactant Products
- Resp Toxicity - Most Common & Lethal Effect
- Eye Toxicity - Common, Not Serious
- 43% Pregnancies - Spontaneously Aborted
- 71% Chromosomal Damage -1 yr (Control-21%)
- Psych - 45% Depressed, 35% Anxiety, 10% Adj Rx

Problems that contributed to the Bhopal disaster



Casualties of Bhopal

Source: Asheville Global Report, http://www.agrnews.org/issues/190/

Poll

Do you know if someone within your health department maintains and reviews a record of the required EPA risk management plans for facilities within your jurisdiction?

- ○ True
- ○ False

EPA Risk Management Plan

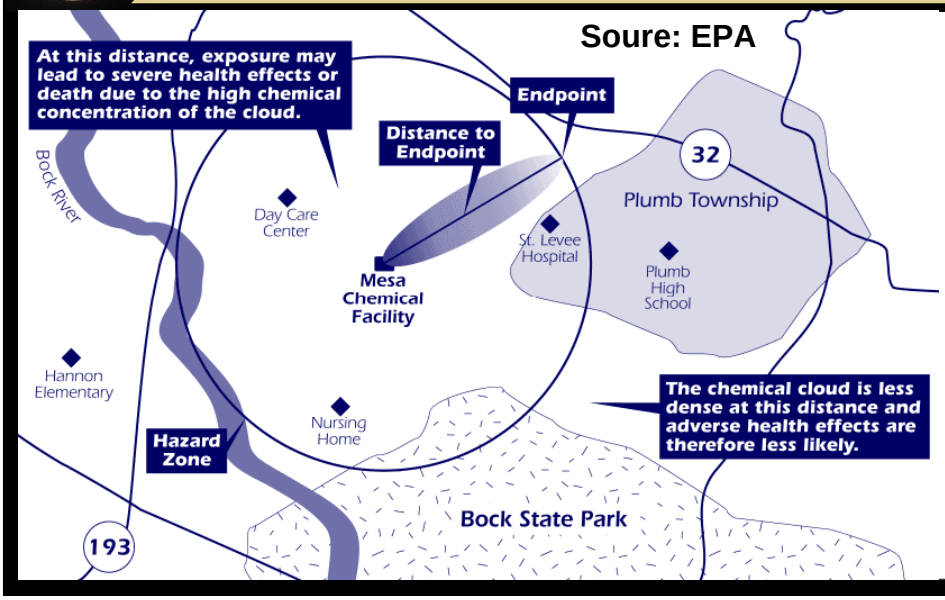
- Aim: Prevent/minimize consequences of accidental chemical releases from fixed facilities.
- Facilities that manufacture, process, use, store, or otherwise handle any of 140 listed substances at or above specified threshold quantities (range from 500–20,000 pounds) must submit a Risk Management Plan.

Worst-Case Scenario Likelihood

WCS are very unlikely because:

- They assume a very large release during worst-case atmospheric conditions.
- Facilities cannot include any active release mitigation such as water deluge systems and automatic shutoff valves. (They may include passive mitigation such as containment dikes and building enclosures.)

Typical Worst Case Map



Hazard Zones Near New Orleans

EPA RMP Limitations

Don't include:

- Reactants, food/water or dermal hazards
- Working (urban) populations
- Public receptor counts and identities (schools, hospitals, prisons, retirement homes, parks, etc.)

- Restricted access limits public scrutiny
- Passive not active risk reduction
- Toxic endpoints not severe enough!

"Chemical Plants Still Have Few Terror Controls"*

U.S. Dept. of Homeland Security:

- 4,391 Plants with Lethal Zone ≥ 1,000
- 2 Plants with Lethal Zone ≥ 1,000,000
- Modeled release of all the chemicals at a plant & used prevailing weather patterns to calculate a more deadly plume or wedge-shaped "kill zone" instead of circular "hazard zone."

* **Source:** Robert Block, *Wall Street Journal*, 8/20/04

International Task Force–40

Industrial Chemical Hazards:
- Medical & Operational Concerns

Toxins, Flammables, Reactants
- Inhaled, Ingested, Dermal

Industrial Chemical Prioritization & Determination of Critical Hazards of Concern
- US Army Center for Health Promotion & Preventive Medicine

ITF-40 RISK ESTIMATES

	PROBABILITY				
HAZARD	***Frequent***	***Likely***	***Occasional***	***Seldom***	***Unlikely***
Catastrophic	**Extreme**	**Extreme**	**High**	**High**	**Moderate**
Critical	**Extreme**	**High**	**High**	**Moderate**	**Low**
Marginal	**High**	**Moderate**	**Moderate**	**Low**	**Low**
Negligible	**Moderate**	**Low**	**Low**	**Low**	**Low**

- Health Hazard: Highest Score of Health, Flammability, or Instability
- Probability of Occurrence: SUM of [physical state + production + history]

ITF-40 Chemical Risk Rankings

RISK	HPV	Non HPV	Totals
Extreme	34	5	**39**
High	267	56	**322**
Moderate	304	53	**354**
Low	307	18	**325**
Unranked*	660	52	**712**
Totals	**1572**	**184**	**1756**

- *Unranked due to incomplete data
- HPV - High Production Volume Chemicals

Fumigating Agents

Halocarbons
- Methyl bromide, chloropicrin, 1,3-dichloropropene,
- Dibromochloropropane, carbon tetrachloride, ethylene dibromide, ethylene dichloride, methylene chloride

Cyanides
- Hydrogen cyanide, acrylonitrile, cyanogen chloride

Oxides/aldehydes
- Acrolein, formaldehyde, ethylene oxide, propylene oxide

Phosphine
- Aluminum phosphide, magnesium phosphide

Sulfur compounds
- Sulfuryl fluoride, sulfur dioxide, carbon disulfide

Sulfuryl Fluoride

Used for 85% of structural fumigations
- Termites

Colorless, odorless gas
- Often mixed with CP
- Vapor density 3.5
- Supplied in pressurized cylinders

Exposure standards
- PEL: 5 ppm
- IDLH: 200 ppm


Specimen Label

RESTRICTED USE PESTICIDE DUE TO INHALATION TOXICITY

Dow AgroSciences

Vikane®

Specialty Gas Fumigant

Keep Out of Reach of Children

DANGER POISON

PELIGRO

First Aid

Directions for Use

Precautionary Statements
Hazards to Humans and Domestic Animals

Sulfuryl Fluoride: Application

- Cover building with tent
- Calculate amount fumigant, place fans
- Use CP as warning agent, post warnings
- Release warning agent, then fumigant
- Remove tent after set time, aerate area with fans until low air levels measured

Sulfuryl Fluoride Toxicity

- Mechanism: asphyxiation, Fl^{-}, SO_4^{-2}
- Respiratory: Irritation, edema
- Cardiac: Hypotension, dysrhythmias
- CNS: Depression, seizures
- GI: Vomiting, diarrhea
- Frostbite from compressed gas

Tampered Workplace Beverage

- 2 coworkers in separate offices collapsed while sipping/sniffing coffee
- Both recovered quickly, all routine & Tox laboratory tests were negative.

- 1 mo later, 3 coworkers collapsed while drinking coffee, all recovered, tests neg.

Tampered Coffee—Continued

Local police again notified of suspected coffee tampering. With WPC direction, police found a bottle of the suspected toxin and testing of coffee from both events revealed toxic concentrations.

Although the toxin was identified, the perpetrator was not and is still at large in Seattle. One suspect reported mild symptoms on two occasions after drinking coffee. The police suspected that this might have been a “smoke screen”.

Sodium Azide N_3^-

- Colorless, Odorless, Very potent
- Widely used in laboratories
  - Preservative, Interrupts metabolism
  - Suicidal & Homicidal agent of lab techs!
- Extremely Potent; rapid: onset, offset
- Weakness, Flushing, Sweats, Palpitations, syncope, shock, death

Methylmercury treated seed grain in home-baked bread Iraq

- Wheat crop failure in 1970
- 1971: 73,201 metric tons treated wheat and 22,262 tons treated barley seed distributed for planting but ground into flour

- ~40,000 persons exposed over several months

CH_3Hg Food Poisoning

- 1972 Data
  - 6530 hospital admissions
  - 459 hospital deaths
- All ages, primarily rural families
- Latency to onset of ≈ 2 to 6 weeks
- Initial lack of symptoms among animals fed grain instilled false sense of security that it was safe to eat

CH_3Hg Clinical Effects

- *In utero* exposure: cerebral palsy, altered motor tone and reflexes, delayed neurocognitive development
- Constricted visual fields, blurred vision
- Paresthesias
- Dysarthria
- Ataxia
- Hearing impairment

Epidemiologic Clues of Chem/Bio Terrorism

- Unusual increase in possible chemical or biological toxin related illness
- Unexplained deaths in healthy or young
- Unexplained odors on patients
- Clusters of illness in people with common air, food or water exposures

Acid Burns in Bangladesh

22 year old
Refused Love Affair

23 year old
Refused Love Affair

Source: *Annals of Burns and Fire Disasters - vol. XIV - n. 3 - September 2001*

"Toxic Caustics"

- Chromic Acid
- Formic Acid
- Hydrofluoric Acid
- Bromine & Cmpds
- Monochloroacetic Acid
- Osmium Tetroxide
- Nitrites
- Phosphorus
- Phenol
- Boron

Case Report
Yamaura K: J Tox Clin Toxicol 1997

64 yo M sustained 44% TBSA burns from 30% HF from tanker truck explosion. He was given cold shower at work then taken to hospital c/o severe pain but VS WNL.

At 2 hr, he was intubated for SOB & mouth swelling. At 2.5 hr, SBP 60 mm, QT prolonged & Ca_i 0.44 mmol/L (nl 2.2-2.6). Rx: 6 mmol Ca & dopamine infusion. At 5 Hr, VTach was followed by VFib. Rx: lidocaine, Ca & KCl, defib but VFib recurred 7x. QT was prolonged for 60 Hr. VTach/VFib stopped at 9 Hr.

He recovered fully & discharged at 78 days.

14 The Trentonian Wednesday, June 11, 1997

Chemist dies after toxin penetrates gloves

Associated Press

HANOVER, N.H. — A Dartmouth College scientist whose specialty was the dangers of heavy metals died of mercury poisoning this week, 10 months after as little as a drop of a rare toxic compound apparently seeped through her rubber gloves.

Karen Wetterhahn, 48, had been hospitalized since January, when tests showed 30 times the lethal dose of mercury in her blood, a college investigation showed.

After she was diagnosed on Jan. 28, Wetterhahn told investigators she remembered spilling one to several drops of dimethylmercury in August, Chemistry Department Chairman John S. Winn said yesterday.

After the diagnosis, Winn said Wetterhahn's attitude seemed to be, "I know what it is, I know what to do about it. I'm in a good place. I'm getting good care. Let's get on with it."

Three weeks after she was diagnosed, she went into a coma that lasted until her death Sunday at Dartmouth-Hitchcock Medical Center in Lebanon.

"Whether she knew the peril she was in at that time, I don't think we will ever know," Winn said.

Wetterhahn, a cancer researcher, was using the compound to examine the effects of toxic metals on human cells. At the time of the accident, she was studying how mercury prevents cells from repairing themselves, much like cancer does.

Wetterhahn had two episodes of nausea and vomiting about three months after the spill, but Winn said no one will ever know if the mercury caused them.

Mercury attacks the central nervous system well before the victim shows symptoms, and Wetterhahn began losing her balance and having trouble speaking and hearing in January.

CHEMIST KAREN E. WETTERHAHN was accidentally poisoned in her own lab.

Dimethylmercury

- Volatile liquid, rapidly absorbed thru skin and latex gloves
- Highly toxic – lethal at 400mg or 5 mg/kg
- In the described case several drops were spilled on a latex gloved hand during experiment under a ventilated hood
- She developed incoordination, trouble speaking, constriction of visual fields, deafness 154 days after exposure! She lapsed into a persistent vegetative state 22 days after that and died 9 months after exposure despite attempted chelation.

Poll

Which of the following is NOT a method of primary prevention of chemical weapons of convenience?

- ○ Eliminate/reduce toxins in processes
- ○ Enhance emergency response
- ○ Produce onsite as needed
- ○ Locate in low population density areas

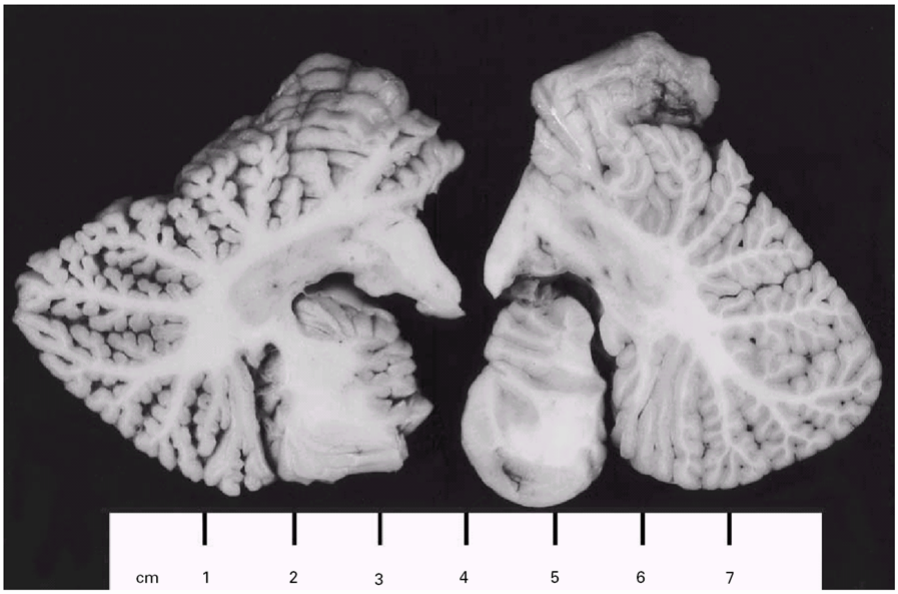
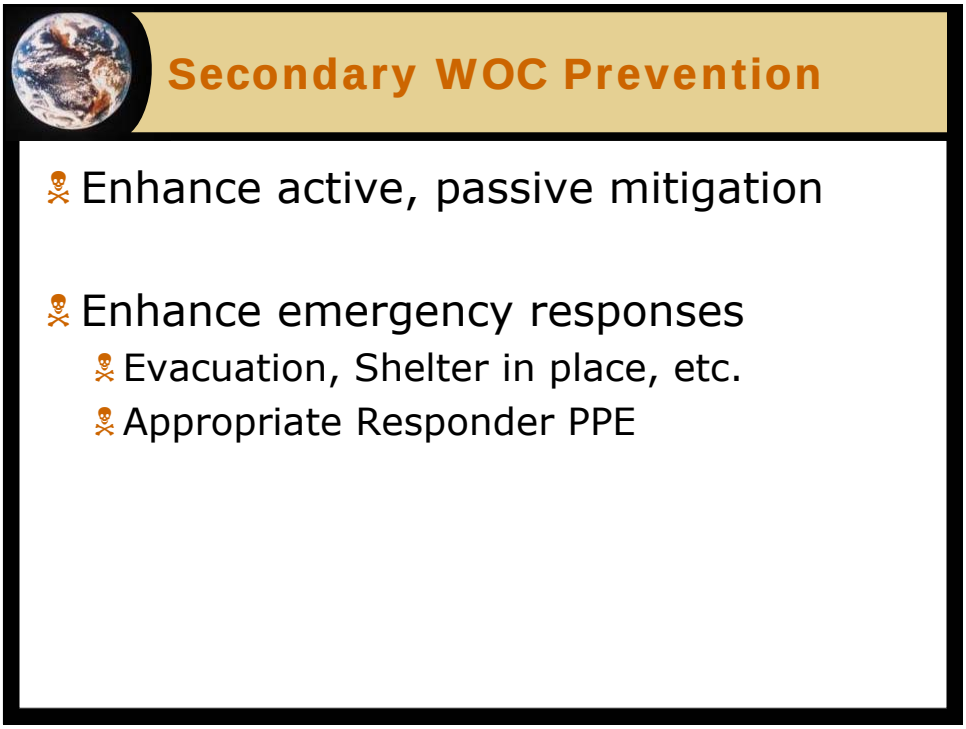
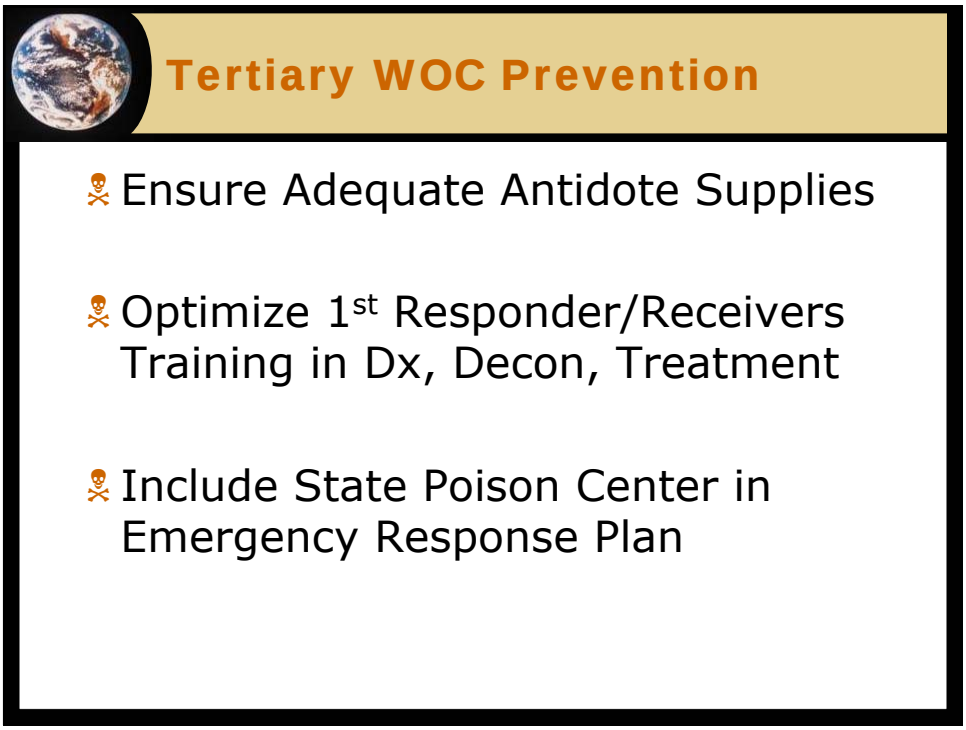


Figure 3. Cerebellar Hemispheric Sections from the Patient (Left) and from a Woman of Approximately the Same Age without Neurologic Disease (Right).
Widespread shrinkage of the folia and diminution of the cerebellar cortical thickness are evident in the section from the patient.

Primary WOC Prevention

- Eliminate/Reduce Toxins in Processes
- Reduce Amount Stored/Transported
- Produce Onsite as Needed
- Locate in Low Population Density Areas
- Enhance Security


Secondary WOC Prevention
Enhance active, passive mitigation
Enhance emergency responses
Evacuation, Shelter in place, etc.
Appropriate Responder PPE


Tertiary WOC Prevention
Ensure Adequate Antidote Supplies
Optimize 1st Responder/Receivers Training in Dx, Decon, Treatment
Include State Poison Center in Emergency Response Plan

Chemical WOC/O Summary

- Major Cities – Most Attractive Targets
- Open Air Stadiums Most Vulnerable
- Many Different Choices of Weapons
- Chemicals Stored/Transported at Risk
- Terrorism Doesn't Require High Lethality
- Bioterrorism (Anthrax) & Explosives – More Likely Terrorism Choices