NEWS & TERRORISM
COMMUNICATING IN A CRISIS

A fact sheet from the National Academies and the U.S. Department of Homeland Security

CHEMICAL ATTACK
WARFARE AGENTS, INDUSTRIAL CHEMICALS, AND TOXINS

WHAT IS IT?

A **chemical attack** is the spreading of toxic chemicals with the intent to do harm. A wide variety of chemicals could be made, stolen, or otherwise acquired for use in an attack. Industrial chemical plants or the vehicles used to transport chemicals could also be sabotaged. Harmful chemicals that could be used in an attack include:

- Chemical weapons (warfare agents) developed for military use.
- Toxic industrial and commercial chemicals that are produced, transported, and stored in the making of petroleum, textiles, plastics, fertilizers, paper, foods, pesticides, household cleaners, and other products.
- Chemical toxins of biological origin such as ricin.

The toxicity of chemicals varies greatly. Some are acutely toxic (cause immediate symptoms); others are not very toxic at all. Chemicals in liquid or vapor form generally lead to greater exposures than chemicals in solid form.

How Toxic Chemicals Could be Used

The severity of an attack is related to the toxicity of the chemical and its concentration when it reaches people. Many variables affect the concentration of a chemical including wind and the volatility of the chemical. The release of toxic chemicals in closed spaces (e.g., in subways, airports, and financial centers) could deliver doses high enough to injure or kill a large number of people. In an open area, a toxic chemical cloud (plume) would become less concentrated as it spreads and would have to be released in large quantities to produce a lot of casualties. Potential delivery methods of toxic chemicals include:

- Ventilation systems of a building.
- Misting, aerosolizing devices, or sprayers.
- Passive release (container of chemical left open).
- Bombs, mines, or other explosive devices that contain chemicals other than those used to create the explosion.
- Improvised chemical devices that combine readily available chemicals to produce a dangerous chemical.
- Sabotage of plants or vehicles containing chemicals.
- Introduction of toxins in the food and water supply.

Detection

Many chemicals at high concentrations can be readily detected with hand-held detection equipment carried by many emergency responders.

Symptoms of Exposure

Visual signs of exposure could include people grouped together who have similar symptoms such as choking or eye irritation. Symptoms in the animal population (birds, wildlife, pets) can be important first indicators, often at concentrations much lower than detected by hand-held devices.

Facts about Chemical Weapons

- First used in World War I, chemical weapons drew from existing industrial chemicals (chlorine, phosgene).
- The Chemical Weapons Convention was ratified by more than 160 nations in 1997 with the goal of eliminating state production, storage, and use. The United States is actively destroying its stockpile of chemical agents and has successfully eliminated over 25% to date.
- The 1995 sarin attack on the Tokyo subway by the cult Aum Shinrikyo proves that fabrication and use of chemical weapons by non-state groups is possible. Twelve people died and more than 5,000 were injured.

Facts about Industrial Chemicals

- Industrialized countries produce, transport, and store large quantities of chemicals, some of which are toxic.
- In 1984, a release from a tank of methyl isocyanate at the Union Carbide plant in Bhopal, India killed more than 3,800 people and injured 170,000.
- Environmental laws enacted in 1986 and 1990 were aimed at reducing risk of accidental releases.
- The overall safety record of the chemical and transportation industries are very good, and recent engineering and other advances have made them even safer.

Facts about Toxins of Biological Origin

Agents such as botulinum toxin and ricin are toxins produced by plants, animals, and bacteria. Other examples include toxins from dangerous algal blooms and snake venoms. These substances can be gathered in nature, or alternatively created in labs. Unlike biological agents, they do not reproduce or spread from person to person. Unlike other chemical agents, they are not volatile (do not vaporize) and tend to be more toxic on a weight basis.

Botulinum toxin is a nerve toxin produced by bacteria. It causes botulism, a rare but serious paralytic illness that can be fatal. The three naturally-occuring forms of the illness are foodborne, infant, and wound botulism. An antitoxin is available to treat botulism, but must be administered within hours of exposure.

Ricin is a toxin from castor beans that is part of the waste produced when castor oil is made. It is very toxic—a dose the size of the head of a pin could be lethal but only if injected. Ricin is not absorbed by the skin and is not effective when eaten or inhaled except in impractically large amounts. Ricin was reportedly found in Al Qaeda caves in Afghanistan in the 1980s. There is no antidote.

WHAT IS THE DANGER?

Immediate Impact to Human Health

Acutely toxic chemicals can cause injury or fatalities if they are inhaled or absorbed by the skin. The harm that chemicals can cause depends on; 1) their degree of toxicity 2) the concentration of the chemical, 3) the route of exposure, and 4) the duration of the exposure. The symptoms of exposure to most toxic chemicals would appear in minutes to hours. Different chemicals have different effects on the body. Table 1 shows the health effects for some chemical weapons. Some of the most toxic industrial chemicals can produce similar types of health effects at high concentrations. Table 2 shows lethal concentrations for some chemical weapons and industrial chemicals.

The Area Affected

In an open-air environment, the area affected would depend upon such factors as the type and amount of the chemical agent, the means of dispersal, the local topography, and the local weather conditions. For highly toxic chemicals, lethal or immediately life-threatening results could be seen close to where the agent is released where the concentration is highest, while severe to moderate symptoms could be seen at some distance from the event. A toxic cloud would spread roughly with the speed and direction of the wind, but the concentration of the chemical would be greatly diminished at distances far from the source. For a release in a closed space, a volatile chemical will disperse to fill the space. The smaller the space, the greater the concentration of the chemical.

Exposure Through Contaminated Food

Chemical agents can make foods highly toxic, sometimes without changing the appearance or taste of the foods. Butter, oils, fatty meats, and fish absorb nerve agents so readily that removal of the agents is virtually impossible. Foods in bottles, cans, or wrappings are not affected by agent vapor and can be salvaged following decontamination. The food supply is vulnerable to intentional contamination by toxins such as botulinum toxin.

Table 1. Effects and treatment of some chemical weapons developed for military use

	Nerve Agents		Blister Agents (injure skin, eyes, and airways)		Blood Agents (cause blood changes and heart problems)		Choking Agents	
Examples	Sarin	VX	Mustard	Lewisite	Hydrogen Cyanide	Cyanogen Chloride	Chlorine	Phosgene
Odor	Odorless		Garlic or Mustard	Geraniums	Burnt almonds		Bleach	Mown hay
Persistency*	Non-persistent (min. to hrs.)	Persistent (>12 hrs.)	Persistent		Non-persistent		Non-persistent; vapors may hang in low areas	
Rate of Action	Rapid for vapors; liquid effects may be delayed		Delayed	Rapid	Rapid		Rapid at high concentrations; delayed at lower concentrations	
Signs and Symptoms	Headache, runny nose, salivation, pinpointing of pupils, difficulty in breathing, tight chest, seizures, convulsions, nausea, and vomiting		Red, burning skin, blisters, sore throat, dry cough; pulmonary edema, eye damage, nausea, vomiting, diarrhea. Symptoms may be delayed 2 to 24 hrs		Cherry red skin/lips, rapid breathing, dizziness, nausea, vomiting, convulsions, dilated pupils, excessive salivation, gastrointestinal hemorrhage, pulmonary edema, respiratory arrest		Eye and airway irritation, dizziness, tightness in chest, pulmonary edema, painful cough, nausea, headache	
First Aid	Remove from area, treat symptomatically, Atropine and pralidoxime chloride (2-PAM chloride), diazepam for seizure control		Decontaminate with copious amount of water, remove clothing, support airway, treat symptomatically		Remove from area, assist ventilations, treat symptomatically, administer cyanide kit		Remove from area, remove contaminated clothing, assist ventilations, rest	
Decontamination	Remove from area, remove clothing, flush with soap and water, aerate							

*How long a chemical remains at toxic levels

Exposure Through Contaminated Water

Toxic chemicals could be used to contaminate the drinking water distribution system. Surface water sources in the area of a chemical release could become contaminated, but dying fish or aquatic life might warn of the release before human use. Deep ground water reservoirs and protected water storage tanks are regarded as safe sources of drinking water following a vapor release of chemical agents. There are methods of treating large volumes of potentially contaminated water for emergency drinking.

WHAT SHOULD PEOPLE DO TO PROTECT THEMSELVES?

Practical Steps

If the release is inside a building or a closed space, people should:

1. Do whatever it takes to find clean air quickly: exit the building if they do so without passing through the contaminated area or break a window to access clean air.
2. Remove outer clothing and place it in a sealed plastic bag.
3. Wash with soap (preferably liquid) and water. Flush skin with lots of water; flush eyes with water if they are irritated.
4. Put on clean clothes.
5. Seek medical attention if they have been exposed, even if they have no immediate symptoms.

If they are near an outdoor chemical release, people should:

1. Avoid any obvious plume or vapor cloud.
2. Walk away from the site and into a building in order to shelter-in-place.
3. Bring family and pets inside.
4. Lock doors, close windows, air vents, and fireplace dampers.
5. Turn off fans, air conditioning, and forced air heating systems.
6. Go into a room with as few windows as possible. Seal the room to create a temporary barrier between people and the contaminated air outside.
7. Seal all windows, doors, and air vents with plastic sheeting and duct tape.
8. Improvise with what is on hand to seal gaps to create a barrier from any contamination.
9. Watch TV, listen to the radio, or check the Internet often for official news and instructions as they become available.

Decisions Regarding Evacuation

Evacuation as a toxic cloud is passing could result in greater exposures than staying inside. The best course of action will be provided by emergency officials who may use computations from models to calculate the path and potential health effects of the toxic cloud.

Medical Treatment

Immediate medical treatment is required for those exhibiting signs and symptoms of exposure to toxic chemicals. (See Table 1)

Antidotes

There are reliable antidotes for nerve agent exposure, which may be available from medical professionals. Some antidotes, such as atropine, pralidoxime chloride (2-PAM chloride), and diazepam, are contained in the medical kits of first responders, but larger quantities of these antidotes may be found at hospitals and treatment facilities. A specific antidote kit is available for cyanide, but it may have to be administered in a hospital. Supportive medical care and hospital therapy is required for large exposures to phosgene and chlorine vapor.

Table 2. Varying toxicity of chemicals.

The more toxic a chemical, the smaller the amount of chemical required to cause harm. The table compares the lethal concentrations in parts per million (ppm) for acute (all-at-once) exposures to some chemical weapons and some common industrial chemicals.

Chemical agent	Approx. lethal concentration* (in ppm)
Some Chemical Weapons	
Sarin (GB)	36
Hydrogen Cyanide**	120
Some Industrial Chemicals	
Chlorine**	293
Hydrogen chloride	3,000
Carbon monoxide	4,000
Ammonia	16,000
Chloroform	20,000
Vinyl chloride	100,000

Increasing Toxicity

*Based on LC_{50} values in laboratory rats: exposure concentration for 60 minutes at which 50% of rats would die. Rats are used for toxicology tests in part because of similarity to humans, but they are likely to be more susceptible because they have higher metabolisms.

**Used both as chemical weapons and as industrial chemicals

Source: NRC, EPA, and ATSDR

WHAT ARE THE LONG-TERM CONSEQUENCES?

Late Health Effects of Chemical Agent Exposure

Most health effects from a chemical attack would occur quickly. Some injuries from acute exposure to toxic chemicals, such as eye damage and chemical burns, can persist for a lifetime. Detailed information on the possibility of developing other types of health effects later in life would be made available once a specific exposure is known. Of the military chemical weapons, only mustard gas is a known carcinogen. Although some industrial chemicals are carcinogenic, the risk of developing cancer later in life is not likely to increase significantly following a one-time exposure.

Monitoring and Clean-up of Affected Areas

In the days and weeks following the use of a chemical agent, officials might be expected to:

- Evacuate the limited area near the release site.
- Ensure proper ventilation of the area.
- Establish a plan for careful monitoring and assessment of affected areas.
- Decontaminate areas where liquid agent was present.
- Assure the public that the threat has passed after thorough testing of the affected area.

Economic Impact

Such impacts might involve disruption to lives and livelihoods as the contaminated area is being cleaned up. An attack on a food or agricultural crop could result in long-lasting economic impact for suppliers and their communities as well as consumers.

ADDITIONAL INFORMATION

Department of Homeland Security—**http://www.dhs.gov/dhspublic** • **http://www.ready.gov**

Centers for Disease Control and Prevention—**http://www.bt.cdc.gov/agent/agentlistchem.asp** • **http://www.atsdr.cdc.gov** • **http://www.bt.cdc.gov/agent** • **http://www.bt.cdc.gov/planning**

Department of Defense—**http://www.njha.com/ep/pdf/bio-USAMRICDResources.pdf** • **http://chemdef.apgea.army.mil/TBMED296.aspx**

Other Resources—**http://www.biomedtraining.org** • **http://www.chem-bio.com/resource**

This report brief was prepared by the National Academy of Engineering and the National Research Council of the National Academies in cooperation with the Department of Homeland Security. For more information, contact Randy Atkins at 202-334-1508, atkins@nae.edu, or visit www.nas.edu/factsheets. *Making the Nation Safer, Tracking the Atmospheric Dispersion of Hazardous Materials Releases,* and other National Academies reports related to this topic are available from the National Academies Press, 500 Fifth Street, NW, Washington, DC 20001; 800-624-6242; www.nap.edu.

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