

Research Report

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Inhalants Research Report

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Although many parents are appropriately concerned about illicit drugs such as marijuana, cocaine, and LSD, they often ignore the dangers posed to their children from common household products that contain volatile solvents or aerosols. Products such as glues, nail polish remover, lighter fluid, spray paints, deodorant and hair sprays, whipped cream canisters, and cleaning fluids are widely available yet far from innocuous. Many young people inhale the vapors from these sources in search of quick intoxication without being aware that using inhalants, even once, can have serious health consequences.

National surveys indicate that nearly 21.7 million Americans aged 12 and older have used inhalants at least once in their lives. NIDA's Monitoring the Future (MTF) survey reveals that 13.1 percent of 8th-graders have used inhalants. Parents and children need to know that even sporadic or single episodes of inhalant abuse can be extremely dangerous. Inhalants can disrupt heart rhythms and cause death from cardiac arrest, or lower oxygen levels enough to cause suffocation. Regular abuse of these substances can result in serious harm to vital organs, including the brain, heart, kidneys, and liver.

Through scientific research, we have learned much about the nature and extent of inhalant abuse, its pharmacology, and its consequences. This research has brought the picture of inhalant abuse in the Nation into focus and pointed to the dangers and the warning signs for parents, educators, and clinicians. We hope this compilation of the latest scientific information will help alert readers to inhalant abuse and its harmful effects and aid efforts to deal with this problem effectively.

Nora D. Volkow, M.D.

Director



What Are Inhalants?

Inhalants are volatile substances that produce chemical vapors that can be inhaled to induce a psychoactive, or mind-altering, effect.

What are inhalants?

Inhalants are volatile substances that produce chemical vapors that can be inhaled to induce a psychoactive, or mind-altering, effect. Although other abused substances can be inhaled, the term "inhalants" is used to describe a variety of substances whose main common characteristic is that they are rarely, if ever, taken by any route other than inhalation. This definition encompasses a broad range of chemicals that may have different pharmacological effects and are found in hundreds of different products. As a result, precise categorization of inhalants is difficult. One classification system lists four general categories of inhalants — volatile solvents, aerosols, gases, and nitrites — based on the forms in which they are often found in household, industrial, and medical products.

Volatile solvents are liquids that vaporize at room temperature. They are found in a multitude of inexpensive, easily available products used for common household and industrial purposes. These include paint thinners and removers, dry-cleaning fluids, degreasers, gasoline, glues, correction fluids, and felt-tip markers.

Aerosols are sprays that contain propellants and solvents. They include spray paints, deodorant and hair sprays, vegetable oil sprays for cooking, and fabric protector sprays.

Gases include medical anesthetics as well as gases used in household or commercial products. Medical anesthetics include ether, chloroform, halothane, and nitrous oxide (commonly called "laughing gas"). Nitrous oxide is the most abused of these gases and can be found in whipped cream dispensers and products that boost octane levels in racing cars. Other household or commercial products containing gases include butane lighters, propane tanks, and refrigerants.

Nitrites often are considered a special class of inhalants. Unlike most other inhalants, which act directly on the central nervous system (CNS), nitrites act primarily to dilate blood vessels and relax the muscles. While other inhalants are used to alter mood, nitrites are used primarily as sexual enhancers. Nitrites include cyclohexyl nitrite, isoamyl (amyl) nitrite, and isobutyl (butyl) nitrite. Amyl nitrite is used in certain diagnostic procedures and was prescribed in the past to treat some patients for heart pain. Nitrites now are prohibited by the Consumer Product Safety Commission but can still be found, sold in small bottles labeled as "video head cleaner," "room odorizer," "leather cleaner," or "liquid aroma."

Generally, inhalant abusers will abuse any available substance. However, effects produced by individual inhalants vary, and some users will go out of their way to obtain their favorite inhalant. For example, in certain parts of the country, "Texas shoeshine," a shoe-shining spray containing the chemical toluene, is a local favorite.

What is the scope of inhalant abuse?

According to the 2010 National Survey on Drug Use and Health (NSDUH), there were 793,000 persons aged 12 or older who had used inhalants for the first time within the past 12 months; 68.4 percent were under the age of 18. In fact, inhalants — particularly volatile solvents, gases, and aerosols — are often the easiest and first options for abuse among young children who use drugs. NIDA's annual MTF survey of 8th-, 10th-, and 12th-graders consistently reports the highest rates of



current, past-year, and lifetime inhalant use among 8th-graders.

Inhalant use has decreased significantly among 8th-, 10th-, and 12th-graders compared to its peak years in the mid-1990s (see figure). According to the 2011 MTF survey, past-year use was reported as 7.0, 4.5, and 3.2 percent, for 8th-, 10th-, and 12th-graders, respectively. Data compiled by the National Capital Poison Center also show a decrease in the prevalence of inhalant cases reported to U.S. poison control centers — down 33 percent from 1993 to 2008. The prevalence was highest among children aged 12 to 17, peaking among 14-year-olds.

Demographic differences in inhalant use have been identified at different ages. The MTF survey indicates that in 2011, 8.6 percent of 8th-grade females reported using inhalants in the past year, compared with 5.5 percent of 8th-grade males.

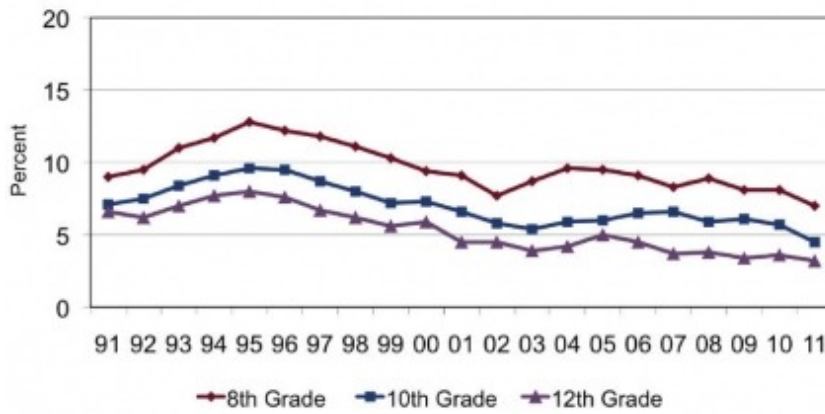
In terms of ethnicity, Hispanics have the highest rates of past-year use among 8th- and 10th-graders, compared to both Blacks and Whites.

People from both urban and rural settings abuse inhalants. Further, research on factors contributing to inhalant abuse suggests that adverse socioeconomic conditions, a history of childhood abuse, poor grades, and school dropout are associated with inhalant abuse.

How are inhalants used?

Inhalants can be breathed in through the nose or the mouth in a variety of ways, such as—

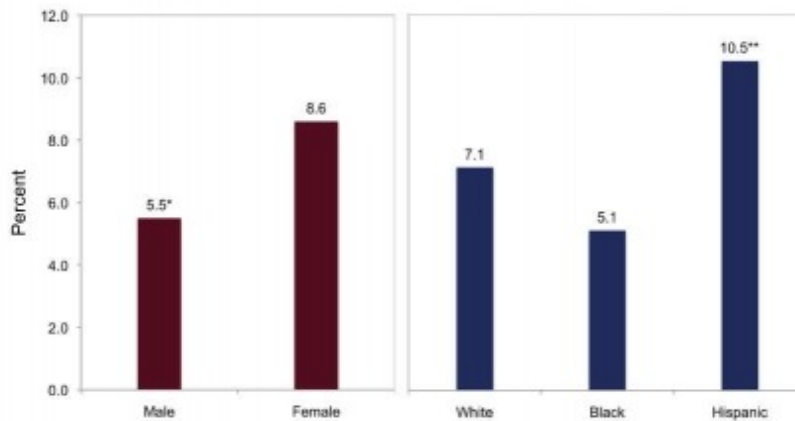
- "sniffing" or "snorting" fumes from containers;
- spraying aerosols directly into the nose or mouth;
- "bagging" — sniffing or inhaling fumes from substances sprayed or deposited inside a plastic or paper bag;
- "huffing" from an inhalant-soaked rag stuffed in the mouth; and
- inhaling from balloons filled with nitrous oxide.



Past-Year Inhalant Use Among 8th-, 10th-, and 12th-Graders, 1991–2011

Source: University of Michigan, 2011 Monitoring the Future Study

Inhaled chemicals are absorbed rapidly into the bloodstream through the lungs and are quickly distributed to the brain and other organs. Within seconds of inhalation, the user experiences intoxication along with other effects similar to those produced by alcohol. Alcohol-like effects may include slurred speech; the inability to coordinate movements; euphoria; and dizziness. In addition, users may experience lightheadedness, hallucinations, and delusions.



Gender and Race/Ethnicity Differences in Past-Year Inhalant Use Among 8th-Graders, 2011

**Level of significance of difference between Male and Female = .05*

*** Level of significance of difference between Whites and Hispanics and Blacks and Hispanics = .001*

Source: University of Michigan, 2011 Monitoring the Future Study

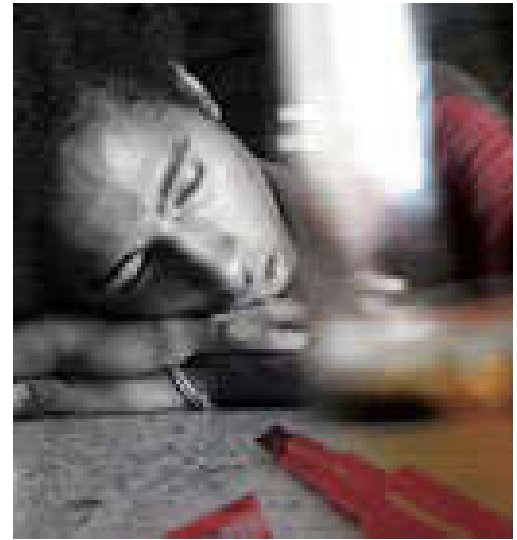
Because intoxication lasts only a few minutes, abusers frequently seek to prolong the high by inhaling repeatedly over the course of several hours, which is a very dangerous practice. With successive inhalations, abusers can suffer loss of consciousness and possibly even death. At the least, they will feel less inhibited and less in control. After heavy use of inhalants, abusers may feel drowsy for several hours and experience a lingering headache.

How do inhalants produce their effects?

Many brain systems may be involved in the anesthetic, intoxicating, and reinforcing effects of different inhalants. Nearly all abused inhalants (other than nitrites) produce a pleasurable effect by depressing the CNS. Nitrites, in contrast, dilate and relax blood vessels rather than act as anesthetic agents.

Evidence from animal studies suggests that a number of commonly abused volatile solvents and anesthetic gases have neurobehavioral effects and mechanisms of action similar to those produced by CNS depressants, which include alcohol and medications such as sedatives and anesthetics.

A 2007 animal study indicates that toluene, a solvent found in many commonly abused inhalants — including model airplane glue, paint sprays, and paint and nail polish removers — activates the brain's dopamine system. The dopamine system has been shown to play a role in the rewarding effects of nearly all drugs of abuse.



Most inhalants produce a rapid high that resembles alcohol intoxication, with initial excitation then drowsiness, disinhibition, lightheadedness, and agitation.

How can inhalant abuse be recognized?

Early identification and intervention are the best ways to stop inhalant abuse before it causes serious health consequences. Parents, educators, family physicians, and other health care practitioners should be alert to the following signs:

- Chemical odors on breath or clothing
- Paint or other stains on face, hands, or clothes
- Hidden empty spray paint or solvent containers, and chemical-soaked rags or clothing
- Drunk or disoriented appearance
- Slurred speech
- Nausea or loss of appetite
- Inattentiveness, lack of coordination, irritability, and depression



What are the short- and long-term effects of inhalant use?

Although the chemical substances found in inhalants may produce various pharmacological effects, most inhalants produce a rapid high that resembles alcohol intoxication, with initial excitation followed by drowsiness, disinhibition, lightheadedness, and agitation. If sufficient amounts are inhaled, nearly all solvents and gases produce anesthesia — a loss of sensation — and can lead to unconsciousness.

The chemicals found in solvents, aerosol sprays, and gases can produce a variety of additional effects during or shortly after use. These effects are related to inhalant intoxication and may include belligerence, apathy, impaired judgment, and impaired functioning in work or social situations; nausea and vomiting are other common side effects. Exposure to high doses can cause confusion and delirium. In addition, inhalant abusers may experience dizziness, drowsiness, slurred speech, lethargy, depressed reflexes, general muscle weakness, and stupor. For example, research shows that toluene can produce headache, euphoria, giddy feelings, and the inability to coordinate movements.

Inhaled nitrites dilate blood vessels, increase heart rate, and produce a sensation of heat and excitement that can last for several minutes. Other effects can include flush, dizziness, and headache.

A strong need to continue using inhalants has been reported by many individuals, particularly those who have abused inhalants for prolonged periods over many days. Compulsive use and a mild withdrawal syndrome can occur with long-term inhalant abuse. A recent survey of 43,000 American adults suggests that inhalant users, on average, initiate use of cigarettes, alcohol, and almost all other drugs at younger ages and display a higher lifetime prevalence of substance use disorders, including abuse of prescription drugs, when compared with substance abusers without a history of inhalant use.

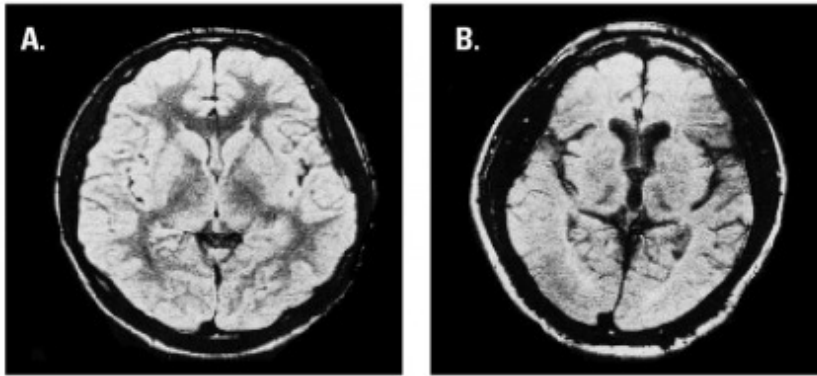
What are the other medical consequences of inhalant abuse?

Inhalant abusers risk an array of other devastating medical consequences. The highly concentrated chemicals in solvents or aerosol sprays can induce irregular and rapid heart rhythms and lead to fatal heart failure within minutes of a session of prolonged sniffing. This syndrome, known as "sudden sniffing death," can result from a single session of inhalant use by an otherwise healthy young person. Sudden sniffing death is associated particularly with the abuse of butane, propane, and chemicals in aerosols. Inhalant abuse also can cause death by—

- **asphyxiation** — from repeated inhalations that lead to high concentrations of inhaled fumes, which displace available oxygen in the lungs;
- **suffocation** — from blocking air from entering the lungs when inhaling fumes from a plastic bag placed over the head;

- **convulsions or seizures** — from abnormal electrical discharges in the brain;
- **coma** — from the brain shutting down all but the most vital functions;
- **choking** — from inhalation of vomit after inhalant use; or
- **fatal injury** — from accidents, including motor vehicle fatalities, suffered while intoxicated.

Based on independent studies performed over a 10-year period in three different states, the number of inhalant-related fatalities in the United States is approximately 100–200 per year.



Compared with the brain of an individual with no history of inhalant abuse (A), that of a chronic toluene abuser (B) is smaller and fills less of the space inside the skull (the white outer circle in each image). Courtesy of Neil Rosenberg, M.D., NIDA Research Report (NIH 05-3818).

Animal and human research shows that most inhalants are extremely toxic. Perhaps the most significant toxic effect of chronic exposure to inhalants is widespread and long-lasting damage to the brain and other parts of the nervous system. For example, chronic abuse of volatile solvents, such as toluene or naphthalene (the volatile ingredient in mothballs), damages the protective sheath around certain nerve fibers in the brain and peripheral nervous system. This extensive destruction of nerve fibers is clinically similar to that seen with neurological diseases such as multiple sclerosis.

The neurotoxic effects of prolonged inhalant abuse include neurological syndromes that reflect damage to parts of the brain involved in controlling cognition, movement, vision, and hearing. Cognitive abnormalities can range from mild impairment to severe dementia.

Inhalants also are highly toxic to other organs. Chronic exposure can produce significant damage to the heart, lungs, liver, and kidneys. Although some inhalant-induced damage to the nervous and other organ systems may be at least partially reversible when inhalant abuse is stopped, many syndromes caused by repeated or prolonged abuse are irreversible.

Abuse of inhalants during pregnancy also may place infants and children at increased risk of developmental harm. Animal studies designed to simulate human patterns of inhalant abuse suggest that prenatal exposure to toluene can result in reduced birth weights, occasional skeletal abnormalities, delayed neurobehavioral development, and altered regulation of metabolism and body composition in males, as well as food intake and weight gain in both sexes. A number of case reports note abnormalities in newborns of mothers who chronically abuse solvents, and there is evidence of subsequent developmental impairment in some of these children. However, no well-controlled prospective study of the effects of prenatal exposure to inhalants in humans has been conducted, and it is not possible to link prenatal exposure to a particular chemical to a specific birth defect or developmental problem.

Finally, a 2008 survey of over 13,000 high school students has identified an association between disordered eating (defined as a positive response to one or more of three questions about engaging in inappropriate behaviors for weight control during the past 30 days) and inhalant use among both male and female students.

Hazards of Chemicals Found in Commonly Abused Inhalants

amyl nitrite, butyl nitrite

("poppers," "video head cleaner")

sudden sniffing death syndrome, suppressed immunologic function, injury to red blood cells (interfering with oxygen supply to vital tissues)

benzene

(found in gasoline)

bone marrow injury, impaired immunologic function, increased risk of leukemia, reproductive system toxicity

butane, propane

(found in lighter fluid, hair and paint sprays)

sudden sniffing death syndrome via cardiac effects, serious burn injuries (because of flammability)

freon

(used as a refrigerant and aerosol propellant)

sudden sniffing death syndrome, respiratory obstruction and death (from sudden cooling/cold injury to airways), liver damage

methylene chloride

(found in paint thinners and removers, degreasers)

reduction of oxygen-carrying capacity of blood, changes to the heart muscle and heartbeat

nitrous oxide ("laughing gas"), hexane

death from lack of oxygen to the brain, altered perception and motor coordination, loss of sensation, limb spasms, blackouts caused by blood pressure changes, depression of heart muscle functioning

toluene

(found in gasoline, paint thinners and removers, correction fluid)

brain damage (loss of brain tissue mass, impaired cognition, gait disturbance, loss of coordination, loss of equilibrium, limb spasms, hearing and vision loss), liver and kidney damage

trichloroethylene

(found in spot removers, degreasers)

sudden sniffing death syndrome, cirrhosis of the liver, reproductive complications, hearing and

What are the unique risks associated with nitrite abuse?

Nitrites are abused mainly by older adolescents and adults. Typically, individuals who abuse nitrites are seeking to enhance sexual function and pleasure. Research shows that abuse of these drugs in this context is associated with unsafe sexual practices that greatly increase the risk of contracting and spreading infectious diseases such as HIV/AIDS and hepatitis.

Animal research raises the possibility that there may also be a link between abuse of nitrites and the development and progression of infectious diseases and tumors. The research indicates that inhaling nitrites depletes many cells in the immune system and impairs mechanisms that fight infectious diseases. A study found that even a relatively small number of exposures to butyl nitrite can produce dramatic increases in tumor incidence and growth rate in animals.

Where can I get further information about inhalants?

To learn more about inhalants and other drugs of abuse, visit the NIDA Web site at www.drugabuse.gov or contact the *DrugPubs* Research Dissemination Center at 877-NIDA-NIH (877-643-2644; TTY/TDD: 240-645-0228) or online at drugpubs.drugabuse.gov.

What's New on the NIDA Web Site

- Information on drugs of abuse and related health consequences
- NIDA publications, news, and events
- Resources for health care professionals
- Funding information (including program announcements and deadlines)

- International activities
- Links to related Web sites (access to Web sites of many other organizations in the field)

NIDA Web Sites

- www.drugabuse.gov
- www.teens.drugabuse.gov

Other Web Sites

Information on inhalant abuse is also available through these other Web sites:

- [Centers for Disease Control and Prevention](http://www.cdc.gov) (CDC)
- [National Inhalant Prevention Coalition](http://www.inhalantprevention.org)
- [Substance Abuse and Mental Health Services Administration](http://www.samhsa.gov) (SAMHSA)

Glossary

Anesthetic: An agent that causes insensitivity to pain and is used for surgeries and other medical procedures.

Central nervous system: The brain and spinal cord.

Dementia: A condition of deteriorated mental function.

Dopamine: A brain chemical, classified as a neurotransmitter, found in regions of the brain that regulate movement, emotion, motivation, and pleasure.

Naphthalene: Volatile, active ingredient in mothballs.

Toxic: Causing temporary or permanent effects that are detrimental to the functioning of a body organ or group of organs.

Withdrawal: Symptoms that occur after chronic use of a drug is reduced abruptly or stopped.

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