NATIONAL INSTITUTE ON DRUG ABUSE

Research Report SERIES

INHALANT *Abuse*

from the director

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, canned whipped cream, and cleaning fluids are widely available. Many young people inhale the vapors from these sources in search of quick intoxication without being aware of the serious health consequences that can result.

National surveys indicate that more than 22.9 million Americans have abused inhalants at least once in their lives. NIDA's Monitoring the Future study reveals that approximately 16 percent of eighth-graders have abused inhalants. Parents and children need to know that experimentation with these substances should not be taken lightly. Even a single session of repeated inhalant abuse 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 our 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
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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 found in hundreds of different products that may have different pharmacological effects. 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 form in which they are often found in household, industrial, and medical products.

Volatile solvents are liquids that vaporize at room temperatures. 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 marker fluids.

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 anesthetic gases 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. Household or commercial products containing gases include butane lighters, propane tanks, whipped cream dispensers, 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. And 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. Cyclohexyl nitrite is found in room odorizers. Amyl nitrite is used in certain diagnostic procedures and is prescribed to some patients for heart pain. Illegally diverted ampules of amyl nitrite are called "poppers" or "snappers" on the street. Butyl nitrite is an illegal substance that is often packaged and sold in small bottles also referred to as "poppers."

What are the patterns of inhalant abuse?

Inhalants—particularly volatile solvents, gases, and aerosols—are often among the first drugs that young children use. One national survey indicates that about 3.0 percent of U.S. children have tried inhalants by the time they reach fourth grade. Inhalants also are one of the few substances abused more by younger children than by older ones. Nevertheless, inhalant abuse can become chronic and extend into adulthood.

Generally, inhalant abusers will abuse any available substance. However, effects produced by individual inhalants vary, and some individuals will go out of their way to obtain their favorite inhalant. For example, in certain parts of the country, "Texas shoe-shine," a shoe-shining spray containing the chemical toluene, is a local favorite. Silver and gold spray paints, which contain more toluene than other spray colors, also are popular inhalants.

Data from national and State surveys suggest inhalant abuse reaches its peak at some point during the seventh through ninth grades. In the Monitoring the Future (MTF) study, an annual NIDA-supported survey of the Nation's secondary school students, 8th-graders also regularly report the highest rate of current, past year, and lifetime inhalant abuse; 10th- and 12th-graders report less abuse.

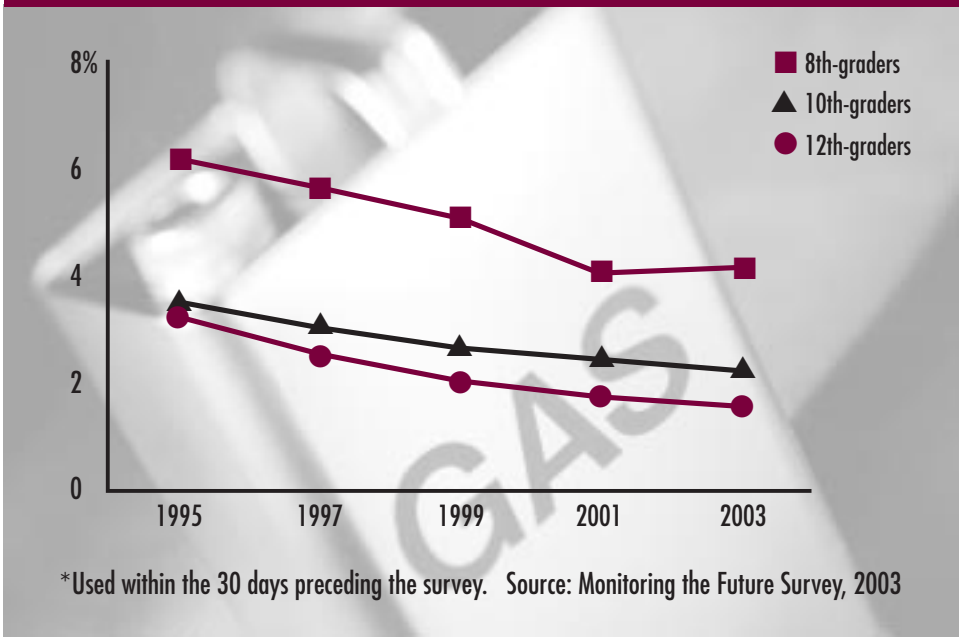
Students who have ever used inhalants versus other commonly abused drugs, percent

Source: Monitoring the Future Survey, 2003

Gender differences in inhalant abuse have been identified at different points in childhood. The 2003 MTF indicates that 9.6 percent of 8th grade females reported using inhalants in the past year compared with 7.7 percent of 8th grade males. Among 12th-graders, 2.9 percent of females and 5.2 percent of males reported using inhalants in the past year. The National Survey on Drug Use and Health (NSDUH), an annual survey of drug use among the Nation's noninstitutionalized civilians, reports that similar percentages of 12- to 17-year-old boys and girls abused inhalants in 2002. However, the percentage of 18- to 25-year-old males who abused inhalants within the past month and within the past year was more than twice that of females in that age group, suggesting that sustained abuse of inhalants is more common among males.

People who abuse inhalants are found in both urban and rural settings. Research on factors contributing to inhalant abuse suggests that adverse socioeconomic conditions, rather than racial or cultural factors per se, may account for most reported racial and ethnic differences in rates of inhalant abuse. Poverty, a history of childhood abuse, poor grades, and dropping out of school all are associated with inhalant abuse.

Trends in current use* of inhalants, 1995-2003



*Used within the 30 days preceding the survey. Source: Monitoring the Future Survey, 2003

What is the scope of inhalant abuse?

Past-year inhalant abuse among the Nation's 10th- and 12th-graders declined in 2003, continuing an apparent gradual decline that began in 1996, according to the latest MTF data. However, past year use among 8th-graders increased between 2002 and 2003. For example:

- The number of high school seniors who abused any inhalants in the past year declined to 3.9 percent in 2003 from a peak of 8.0 percent in 1995.
- Abuse of all inhalants by 10th-graders declined to 5.4 percent in 2003, down from a high of 9.6 percent in 1995.
- Among 8th-graders, 2003 abuse figures, at 8.7 percent, were down overall from the 1995 peak of 12.8 percent, but were up from the 2002 rate of 7.7 percent.

Despite the declines in abuse among schoolchildren in recent years, inhalants are still being abused at high rates, according to the NSDUH. The 2002 survey indicates that lifetime, past year, and past month inhalant use among persons aged 12 to 17 were 10.5 percent, 4.4 percent, and 1.2 percent, respectively. The number of new inhalant users increased from 627,000 new users in 1994 to 1.2 million in 2000. During this period, more males than females initiated inhalant use. The number of new inhalant users in 2001 was similar to the number in 2000

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 of a serious inhalant abuse problem:

- 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

(1.1 million). Inhalant initiates in 2001, as well as in prior years, were predominantly under age 18 (71 percent in 2001).

MTF's lifetime prevalence figures indicate that the percentages of students who have tried inhalants continue to decrease steadily for 10th- and 12th-graders. In 2003, 12.7 percent of 10th-graders and 11.2 percent of 12th-graders said they have abused inhalants at least once in their lives. For 8th-graders, lifetime prevalence peaked at 21.6 percent in 1995. For 10th-graders, the peak was 19.3 percent in 1996. For seniors, rates were highest in 1994 at 17.7 percent. These data raise a question: How can fewer 12th-graders than 8th-graders consistently report they have ever abused inhalants? Possibly, many 12th-graders fail to recall their much earlier use of inhalants or, more troubling, many 8th-grade inhalant abusers may have dropped out of school by the 12th grade and are no longer included in the survey population.

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.

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

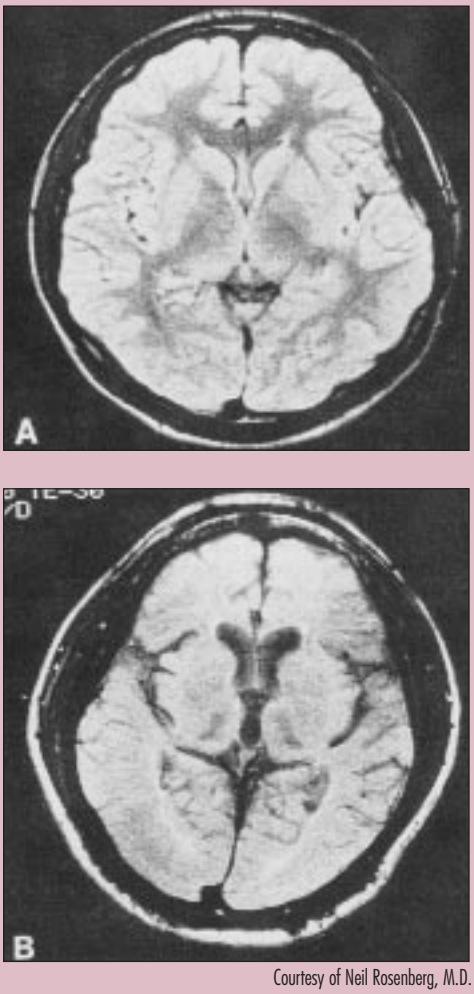
Because intoxication lasts only a few minutes, abusers frequently seek to prolong the high by continuing to inhale repeatedly over the course of several hours, a very dangerous practice. With successive inhalations, abusers can suffer loss of consciousness and death. At the least, they will feel less 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. 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 recent study indicates that toluene, a solvent found in many commonly abused inhalants, including 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 many drugs of abuse. Nitrites, in contrast, dilate and relax blood vessels rather than acting as anesthetic agents.

Brain damage in a toluene abuser



Courtesy of Neil Rosenberg, M.D.

Brain images show marked atrophy (shrinkage) of brain tissue in a toluene abuser (B) compared to a nonabusing individual (A). Note the smaller size and the larger empty (dark) space within the toluene abuser's brain. (The white outer circle in each image is the skull.)

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, then drowsiness, disinhibition, lightheadedness, and agitation. If sufficient amounts are inhaled, nearly all solvents and gases produce anesthesia, a loss of sensation, and even 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. Dizziness, drowsiness, slurred speech, lethargy, depressed reflexes, general muscle weakness, and stupor are other possible effects. For example, research shows that toluene can produce headache, euphoria, giddy feelings, and inability to coordinate movements. Exposure to high doses can cause confusion and delirium. Nausea and vomiting are other common side effects.

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. Unlike other inhalants, which are abused mainly for their intoxicating effects, nitrites are abused primarily because they are believed to enhance sexual pleasure and performance.

A strong need to continue using inhalants has been reported among many individuals, particularly those who abuse inhalants for prolonged periods over many days. Compulsive use and a mild withdrawal syndrome can occur with long-term

inhalant abuse. Additional symptoms exhibited by long-term inhalant abusers include weight loss, muscle weakness, disorientation, inattentiveness, lack of coordination, irritability, and depression.

What are the medical consequences of inhalant abuse?

Inhalant abusers risk an array of devastating medical consequences. Prolonged sniffing of the highly concentrated chemicals in solvents or aerosol sprays can induce irregular and rapid heart rhythms and lead to heart failure and death 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 particularly associated with the abuse of butane, propane, and chemicals in aerosols. Inhalant abuse also can cause death by:

- Asphyxiation—from repeated inhalations, which lead to high concentrations of inhaled fumes displacing the available oxygen in the lungs;
- Suffocation—from blocking air from entering the lungs when inhaling fumes from a plastic bag placed over the head;
- Choking—from inhalation of vomit after inhalant use; or
- Fatal injury—from accidents, including motor vehicle fatalities, suffered while intoxicated.

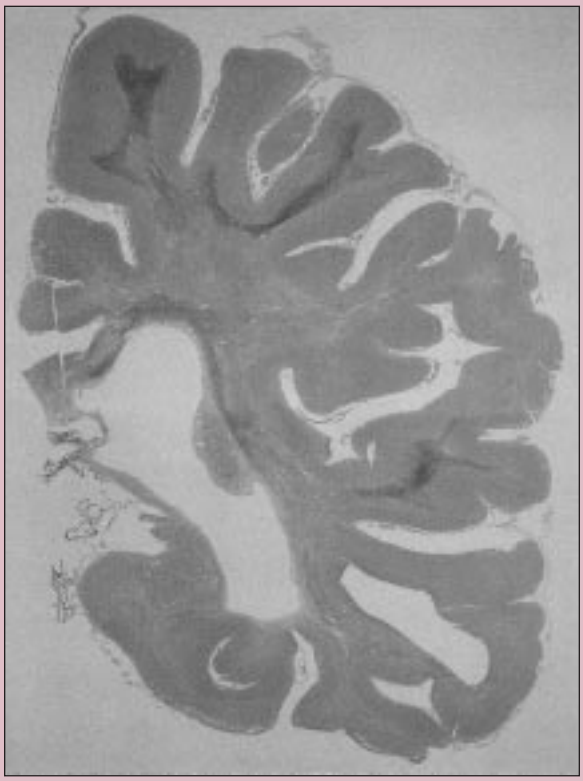
Animal and human research shows that most inhalants are extremely toxic. Perhaps the most significant toxic effect of chronic exposure to inhalants is widespread and long-lasting damage to the brain and other parts of the nervous system. For example, both animal research and human pathological studies indicate that chronic abuse of volatile solvents such as toluene 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. Other effects can include difficulty coordinating movement, spasticity, and loss of feeling, hearing, and vision.

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

Nerve fiber deterioration in an inhalant abuser



Reproduced with permission from the *Journal of Neuropathology & Experimental Neurology*.

Dark-stained patches show areas where nerve fibers have lost their protective sheath in a specimen of brain tissue removed from a deceased inhalant abuser.

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

trichlorethylene *(found in spot removers, degreasers)*
sudden sniffing death syndrome, cirrhosis of the liver, reproductive complications, hearing and vision damage

studies designed to simulate human patterns of inhalant abuse suggest that prenatal exposure to toluene or trichlorethylene (TCE) can result in reduced birth weights, occasional skeletal abnormalities, and delayed neurobehavioral development. 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 specific chemical to a specific birth defect or developmental problem.

What are the special risks for nitrite abusers?

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 such infectious diseases as HIV/AIDS and hepatitis.

Animal research raises the possibility that there may be a link between abuse of nitrite inhalants 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 immune system mechanisms that fight infectious diseases. A recent study found that even a relatively small number of exposures to butyl nitrite can produce dramatic increases in tumor incidence and growth rates in animals.

Where can I get further scientific information about inhalant abuse?

To learn more about inhalants and other drugs of abuse, contact the National Clearinghouse for Alcohol and Drug Information (NCADI) at 1-800-729-6686. Information specialists are available to help

you locate information and resources.

Fact sheets, including InfoFacts, on the health effects of inhalants, other drugs of abuse, and other drug abuse topics are available on the NIDA Web site (www.drugabuse.gov), and can be ordered free of charge in English and Spanish from the National Clearinghouse for Alcohol and Drug Information (NCADI) at www.health.org.

Access information on the Internet

- **What's new on the NIDA Web site**
- **Information on drugs of abuse**
- **Publications and communications (including *NIDA NOTES*)**
- **Calendar of events**
- **Links to NIDA organizational units**
- **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.steroidabuse.org
www.clubdrugs.org

NCADI
Web Site: www.health.org
Phone No.: 1-800-729-6686

Glossary

Anesthetic: An agent that causes insensitivity to pain.

Central nervous system: The brain and spinal cord.

Dementia: A condition of deteriorated mentality.

Dopamine: A neurotransmitter present in regions of the brain that regulate movement, emotion, motivation, and feeling of pleasure.

Epidemiology: The sum of the factors controlling the presence or absence of a disease or condition.

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

Withdrawal: A variety of symptoms that occur after use of an addictive drug is reduced or stopped.

References

Balster, R.L. Neural basis of inhalant abuse. Drug and Alcohol Dependence 51(1-2):207-214, 1998.

Bowen, S.E.; Wiley, J.L.; Evans, E.B.; Tokarz, M.E.; and Balster, R.L. Functional observational battery comparing effects of ethanol, 1,1,1-trichlorethane, ether, and flurothyl. Neurotoxicology and Teratology 18(5):577-585, 1996.

Edwards, R.W., and Oetting, E.R. Inhalant use in the United States. In: Kozel, N.; Sloboda, Z.; and De La Rosa, M. (eds.), Epidemiology of Inhalant Abuse: An International Perspective. National Institute on Drug Abuse Research Monograph 148. DHHS Publication No. NIH 95-3831. Washington, DC: U.S. Government Printing Office, 8-28, 1995.

Fendrich, M.; Mackesy-Amiti, M.E.; Wislar, J.S.; and Goldstein, P.J. Childhood abuse and the use of inhalants: Differences by degree of use. American Journal of Public Health 87(5):765-769, 1997.

Jones, H.E., and Balster, R.L. Inhalant abuse in pregnancy. Obstetrics and Gynecology Clinics of North America 25(1):153-167, 1997.

National Institute on Drug Abuse. National Survey Results on Drug Use From the Monitoring the Future Study, 2003 (www.monitoringthefuture.org).

National Institute on Drug Abuse. NIDA InfoFacts, Inhalants, 2003.

PRIDE Surveys National Summary for Grades 4 thru 6, 2002-2003.

Riegel, A.C., and French, E.D. Acute toluene induces biphasic changes in rat spontaneous locomotor activity which are blocked by remoxipride. Pharmacology, Biochemistry and Behavior 62(3):399-402, 1999.

Sharp, C.W., and Rosenberg, N.L. Inhalants. In: Lowinson, J.H.; Ruiz, P.; Millman, R.B.; and Langrod, J.G. (eds.), Substance Abuse: A Comprehensive Textbook, 3d. ed. Baltimore: Williams and Wilkins, 246-264, 1996.

Sharp, C.W., and Rosenberg, N. Inhalant-related disorders. In: Tasman, A.; Kay, J.; and Lieberman, J.A. (eds.), Psychiatry, Vol. 1. Philadelphia: W.B. Saunders, 835-852, 1997.

Substance Abuse and Mental Health Services Administration. National Findings From the 2002 National Survey on Drug Use and Health. SAMHSA, 2002.

Soderberg, L.S. Immunomodulation by nitrite inhalants may predispose abusers to AIDS and Kaposi's sarcoma. Journal of Neuroimmunology 83(1-2):157-161, 1998.

Soderberg, L.S. Increased tumor growth in mice exposed to inhaled isobutyl nitrite. Toxicology Letters 101(1-2):35-41, 1999.

Woody, G.E.; Donnell, D.; Seage, G.R.; et al. Non-injection substance use correlates with risky sex among men having sex with men: Data from HIV/NET. Drug and Alcohol Dependence 53(3):197-205, 1999. 279(6): 22-26, 1998.

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