INHALANT USE DISORDER

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ABSTRACT

An inhalant use disorder is diagnosed according to criteria of the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) and includes use of traditional categories of inhalants, such as aerosols, gases, nitrites, and solvents. Inhalants are often used to describe volatile substances that the user inhales for a psychoactive effect. Chemicals misused as inhalants are often found in various household products that some United States jurisdictions have started to regulate. Identification and treatment of an inhalant use disorder requires partnership with professionals and community support persons. Inhalant use disorders require a unique approach by all members of the interdisciplinary health team to raise awareness of the risk, prevention, and available treatment of an addiction to solvents.

Statement of Learning Need

Clinicians need to be informed about how to identify and diagnose an inhalant use disorder according the DSM-5 criteria. To diagnose accurately, clinicians need to able to know of the physical and psychological effects of an inhalant use disorder and the available treatment for individuals with an acute solvent intoxication and an inhalant use disorder.
**Course Purpose**

To provide information about DSM-5 criteria to diagnose an inhalant use disorder as well as the treatment and ongoing support for those affected by it.

**Introduction**

An Inhalant use disorder is defined by the American Psychiatric Association as the “. . . problematic pattern of use of a hydrocarbon-based inhalant substance leading to clinically significant impairment or distress.” Still commonly known as solvent abuse or volatile substance abuse, this substance use disorder puts users at risk for significant acute and chronic clinical effects and long-term inhalant use can cause irreversible physical and psychiatric damage. Because inhalants are widely available and can be legally purchased they are often the first choice of adolescents who are beginning to experiment with altering consciousness and their use is associated with illicit drug use, as well.

Intoxication from commonly used inhalants is rapid in onset, dissipates quickly, and does not produce a marked hangover, and these qualities make inhalants a popular “starter” drug. Fortunately, inhalants have never been as popular as alcohol or marijuana and although adolescents may use them for a (relatively) brief period of time, the incidence of the disorder declines significantly after the teenage years,¹ and there is statistical evidence that in recent years inhalant use disorder has been declining.² However, these are dangerous substances. As mentioned previously the commonly used inhalants can cause significant clinical effects, including sudden death. Although long-term, chronic use is quite uncommon, it has been estimated that
at least 10% of American adolescents aged 13 have used an inhalant at least once. Given the nature of the risk, inhalant use disorder is a serious public health problem.

**Products And Solvents Commonly Used**

There are dozens of legal and commercially produced substances that are used for inhalant use. Examples include:

<table>
<thead>
<tr>
<th>Table 1: Substances Used For Inhalant Use</th>
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<tbody>
<tr>
<td>Air fresheners</td>
</tr>
<tr>
<td>Cleaning products</td>
</tr>
<tr>
<td>Computer keyboard cleaners</td>
</tr>
<tr>
<td>Fluorinated hydrocarbons, a.k.a., Freon</td>
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<tr>
<td>Gasoline</td>
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<tr>
<td>Glue</td>
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<tr>
<td>Hair spray</td>
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<tr>
<td>Lighter fluid</td>
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<tr>
<td>Nail polish remover</td>
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<tr>
<td>Nitrous oxide</td>
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<tr>
<td>Pain stripper</td>
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<tr>
<td>Paint thinner</td>
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<tr>
<td>Simple asphyxiant gases, <em>i.e.</em>, butane, propane</td>
</tr>
<tr>
<td>Spray paints</td>
</tr>
<tr>
<td>Typewriter correction fluid</td>
</tr>
<tr>
<td>Whipped cream dispensers</td>
</tr>
</tbody>
</table>

Many of the products listed in the table above differ in their ingredients and some are quite similar or almost identical to each other. Regardless of the differences or similarities, each one contains a
solvent or is a compound that can be used as a solvent. The solvent is volatile and can easily evaporate to form a vapor. In addition, many of these solvents are hydrocarbons. The definitions of these terms are important to remember.

**Table 2: Definitions**

<table>
<thead>
<tr>
<th><strong>Solvent</strong></th>
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<tr>
<td>A solvent is defined as a substance that is capable of dissolving. Solvents are valued for this capability and are often used as a carrier vehicle for other chemicals or compounds. <em>Examples</em> include: simple petroleum distillates are often used as a carrier vehicle in household pesticides and alcohol is used as a solvent/carrier vehicle in products such as mouthwashes and solid deodorants. <em>Toluene</em> is one of the most common solvents and is often found in the products such as glue that are used for inhalant use.</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Volatile</strong></th>
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<tbody>
<tr>
<td>Volatility is defined as the ability to evaporate and form a vapor.</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Vapor</strong></th>
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<tbody>
<tr>
<td>A vapor is defined as the gaseous form of a liquid.</td>
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</table>

<table>
<thead>
<tr>
<th><strong>Hydrocarbon</strong></th>
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<tbody>
<tr>
<td>A hydrocarbon is an organic compound that contains carbon and hydrogen only. Hydrocarbons are derived from petroleum (oil), they can be gases or liquids, and hydrocarbon-based products are perhaps the most common solvent used. Hydrocarbons are in use everywhere; gasoline, lighter fluid, kerosene, and paint thinner are hydrocarbons.</td>
</tr>
</tbody>
</table>

Substances that are used for solvent use rarely involve a single compound. In addition, some of the products in Table 1 may: 1) not contain a hydrocarbon, 2) be a mixture of many hydrocarbons, 3) be a mixture of hydrocarbons and non-hydrocarbon compounds; and, 4) not be used as solvents. For example, gasoline and the simple asphyxiants are hydrocarbons, they are volatile and they are often used, but they are not solvents. Glues themselves are not solvents, but they typically contain hydrocarbons such as hexane and toluene that are used as solvents, and they often contain acetone, a ketone
which is not a hydrocarbon but that forms a vapor that can cause intoxication.

This complexity in nomenclature and in the nature of the products that may be inhaled can make understanding solvent use difficult. But if the definitions in Table 2 and the definition of solvent use are kept in mind, understanding the problem of an inhalant use disorder becomes simpler. An example is typewriter correction fluid, which contains a hydrocarbon, petroleum naphtha. The petroleum naphtha is used as a solvent for the other ingredients of the correction fluid, and the chemical properties of petroleum naphtha allow it to easily form a vapor. It is the vapor from the petroleum naphtha that is inhaled and produces intoxication; and, an inhalant use disorder is the deliberate inhalation of the vapors from volatile organic compounds for the purposes of altering consciousness.

Table 3: Commonly Used Solvents/Products

- Acetone: Glues, nail polish removers, paint removers
- Amyl nitrite: Vasodilator, cyanide antidote
- Butane: Fuels for lighters, stoves, etc.
- Fluorocarbons: Propellants in many aerosol cans
- Hexane: Glues
- Hydrocarbons: Gasoline, lighter fluid, paint thinner
- Ketones: Adhesives, paints
- Methanol: Automotive products
- Methylene chloride: Paint strippers
- Mineral spirits: Paints, paint thinner
- Naphtha: Glues, paint thinner
- Nitrous oxide: Propellant in some whipped cream canisters
- Toluene: Glues, lacquer thinner
Pharmacology

Although Table 1 is a list of products that are very different, they all are or contain compounds that have similar properties that make them attractive for the purposes of inhalant use. These properties are summarized below.⁴,⁶,⁷

Rapid absorption:

The substances or products used for inhalant use are volatile compounds, or they have a high concentration of a volatile compound. These volatile compounds are very rapidly absorbed through the lungs and they move quickly and efficiently into the pulmonary circulation.

High lipid solubility:

The volatile compounds that are used for inhalant use are very lipid soluble. This property (in combination with their rapid absorption through the lungs and into the pulmonary circulation) allows them to readily reach organs and tissues that have high lipid content, i.e., the brain, kidneys, and the liver. In particular, the volatile inhalants easily cross the blood-brain barrier and enter the nervous system and they do so almost immediately.

Rapid metabolism:

The volatile inhalants are quickly metabolized and excreted. These specifics about the volatile compounds that are used for inhalation use
clearly illustrate why they are so attractive to people who want to get high. No special equipment or techniques are needed to use them, and intoxication begins within seconds of use and is relatively brief. The inhalant use disorder offers a cheap simple high with a relatively low commitment and an immediate and dramatic change in consciousness.

These characteristics explain why these volatile compounds produce intoxication so quickly and easily, but it is not known exactly how they do so. However, the similarities between the clinical effects of the used volatile compounds closely resemble the clinical effects of barbiturates, benzodiazepines, and ethanol, and it is possible that they work in the same way. The barbiturates, benzodiazepines, and ethanol all have receptors that are in close proximity to gamma-aminobutyric acid (GABA) receptors. These drugs produce central nervous system depressant effects by increasing the activity of GABA, and there is evidence and a logical mechanistic explanation - but no proof - that the intoxication of the volatile compounds is mediated by GABA, as well.\(^3,4,6,8\)

It has also been speculated that the volatile compounds identified in solvent use may decrease the activity of \(N\)-methyl-\(D\)-aspartate, NMDA, which is part of the glutamate excitatory neurotransmitter system. Inhalants may also affect dopamine, glycine, nicotine, and serotonin receptors.

Gamma-aminobutyric acid binds to specific post-synaptic cell receptors and hyperpolarizes cell membranes by increasing the duration and frequency of Knowledge Check:

*Gamma-aminobutyric acid - also called GABA, or \(\gamma\)-aminobutyric acid - is one of the two primary inhibitory neurotransmitters.*
the opening of chloride ion channels. Because of the hyperpolarization, the affected cells are less able to depolarize in response to a stimulus. *N*-methyl-\(d\)-aspartate (NMDA) is an amino acid derivative, which is not naturally occurring. NMDA refers to a specific glutamate receptor that is stimulated by this compound and the term NMDA is used to identify that type of glutamate receptor.

Another substance that is popular for inhalant use is amyl nitrite and this compound has a well defined and understood mechanism of action. Amyl nitrite relaxes smooth muscle and acts as a vasodilator, and it also promotes the formation of methemoglobin (discussed later in this learning module). Amyl nitrite is supplied in small glass capsules covered with gauze. The capsule is crushed, held directly underneath the nose and the vapors inhaled. Amyl nitrite was once popular as an emergency treatment for angina, and it still has a limited role as a cyanide antidote.

**How Solvents Can Lead To A Solvent Use Disorder**

Solvent use is not limited to any specific geographical area. It is generally, but certainly not exclusively, more popular among pre-teens and teens and in lower socio-economic groups.\(^1\)\(^-\)\(^4\) Males are more likely to try solvents but whether solvents are used by males or females, chronic, long-term inhalant use is the exception; most people who use solvents experience this as a “phase” and stop completely by their late ’20s. Solvent use is more common in pre-teens and younger teens and many will go on to try illicit drugs. It may be that as the user gets older and becomes more affluent and mobile, more expensive and difficult to obtain drugs such as cocaine and marijuana become popular.
Selling or distributing to minors any products that contain commonly used solvents, *i.e.*, spray paint, is illegal almost everywhere in the United States.\textsuperscript{6} The laws regarding the use of these products for the purposes of intoxication, or being intoxicated from a solvent vary from state to state. Driving under the influence (DUI) laws can be applied to solvent use in certain states, as well. In many states the law prohibits sale, transfer to, or offer to sell to a minor any vapor containing substance that contains a toxic ingredient. In some states these laws are quite specific and in others they are not.\textsuperscript{9}

Solvents are usually used by one of three methods. *Sniffing* is simply inhaling the product directly from the container. *Huffing* is saturating a piece of cloth or paper with the product, placing this over the mouth and nose, and inhaling. *Bagging* involves pouring or spraying the product into a paper or plastic bag and then periodically inhaling the vapors from the bag, closing the bag between inhalations, and then opening again to inhale. People who use solvents often inhale very large concentrations of vapor. Glue sniffers may inhale a concentration of vapor that is hundreds of times higher than what would be allowed by the Occupational Safety and Health Administration (OSHA) in a workplace.

**Diagnosis Of An Inhalant Use Disorder**

The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition uses specific criteria for diagnosing an inhalant use disorder. The individual in question has a problematic pattern of use of a hydrocarbon-based inhalant substance that leads to clinically
significant impairment or distress, and is accompanied by at least two of the following in a 12-month period.

1. The inhalant is often used in larger amounts or over a longer period than the user intended.
2. The user has a persistent desire or makes unsuccessful efforts to cut down or control his/her use.
3. Significant time is expended obtaining the inhalant, using it, or recovering from intoxication.
4. He/she has a craving or strong or urge to use the inhalant substance.
5. Inhalant use is the cause of failure to meet important obligations at home, school, or work.
6. Inhalant use continues despite persistent or recurrent social or interpersonal problems caused or exacerbated by its effects.
7. Occupational, social, or recreational activities are stopped or reduced because of inhalant use.
8. The inhalant is repeatedly used in physically dangerous situations.
9. Inhalant use continues despite knowing that persistent physical or psychological problems that are likely to have been caused or exacerbated by the substance.
10. Tolerance is present, this being defined as either:
   a. Needing greater amounts to become intoxicated, or
   b. A decreased level of intoxication from the same amount of inhalant.

If possible the specific inhalant should be identified and it should be determined if the patient is in early or sustained remission. (See the DSM-5 for definitions).
Acute inhalant intoxication is defined in DSM-5 as: “Inhalant intoxication is an inhalant-related, clinically significant mental disorder that develops during, or immediately after, intended or unintended inhalation of a volatile hydrocarbon substance.”¹ Acute intoxication from an inhalant is diagnosed using the following criteria.¹

1. The patient has recent intended or unintended short-term, high-dose exposure to inhalant substances, including volatile hydrocarbons such as toluene or gasoline.
2. He/she has clinically significant behavioral or psychological changes that are maladaptive and problematic such as belligerence, assaultive behavior, apathy, impaired judgment that developed during, or shortly after, exposure to inhalants.
3. The patient has two or more of the following signs or symptoms that occur during or shortly after use of an inhalant.
   a. Dizziness.
   b. Nystagmus.
   c. Incoordination.
   d. Slurred speech.
   e. Unsteady gait.
   f. Lethargy.
   g. Depressed reflexes.
   h. Psychomotor retardation.
   i. Tremor.
   j. Generalized muscle weakness.
   k. Blurred vision or diplopia.

Other inhalant-induced disorders described in the DSM-5 are 1) inhalant-induced psychotic disorder, 2) inhalant-induced depressive disorder, 3) inhalant-induced anxiety disorder, 4) inhalant-induced
major or mild neurocognitive disorder, and 5) inhalant intoxication delirium.

Primary Acute Clinical Effects

The primary acute clinical effects of inhalant intoxication are neurological and cardiac. However, other organ systems can be affected as well and every effort should be made to identify the product as there are specific problems associated with some of the less commonly used inhalants.

Neurological

The most common neurological effect of solvent inhalation is central nervous system depression. This can range from mild drowsiness to coma, and it is usually preceded by a mild level of excitation and euphoria. Patients can also develop ataxia, confusion, diplopia, dizziness, hallucinations, headache, euphoria, seizures, slurred speech, tremor, and weakness. The intensity of the central nervous system effects can be mild and they can be profound. The duration of the neurological effects - the high - is typically an hour or two, but depending on the pattern of use it may be more or less.

Cardiovascular

Tachycardia is common. Conversely, reflex bradycardia caused by vagal stimulation is possible, and atrioventricular block and other conduction abnormalities, cardiomyopathy, and myocardial infarction have been reported. Deadly ventricular arrhythmias and sudden death caused by solvent use are well described in the medical literature but given the enormous number of incidents of huffing, sniffing, and bagging these are very, very uncommon.
The mechanism by which sudden death from inhalant use occurs is not completely understood, but it may involve sensitization of the myocardium to catecholamines, QT prolongation, increased level of catecholamines, or inhibition of the potassium and/or sodium in channels of the myocardium.\textsuperscript{4,6,15,16} If the solvent user experiences a catecholamine surge, for example, in a situation of running to avoid police custody or arrest, the sudden and intense increase in circulating levels of epinephrine and norepinephrine will stimulate the vulnerable myocardium and produce an arrhythmia. On the other hand, vagal stimulation and bradycardia that has been reported in solvent use may be due to cold stimulation of the larynx and throat. These situations have been well documented and are called “sudden sniffing death.”\textsuperscript{3,6,17,18} Sudden sniffing death can happen to a first-time solvent user or to someone who chronically inhales solvents, and although it most often happens very soon after inhalation of a solvent, ventricular fibrillation can occur hours after an exposure.\textsuperscript{16}

\textit{Pulmonary}

Many of the inhaled solvents act as irritants so cough, dyspnea, and wheezing are common pulmonary effects. Because the volatile solvents are simple asphyxiants and centrally acting respiratory depressants, hypoxia is one of the primary acute effects of solvent use.\textsuperscript{3,6} Freezing injuries from inhalation of fluorinated hydrocarbon propellants and acute upper airway obstruction after volatile substance inhalation have been reported.\textsuperscript{19,20} Airway obstruction caused by angioedema has been reported, as well.\textsuperscript{21,22} Aspiration of a liquid hydrocarbon can cause chemical pneumonitis, and people who indulge in long sessions of bagging may develop hypercapnia.\textsuperscript{6}
**Metabolic and Hematologic**

Except for toluene exposure metabolic effects are not common after use of the common inhalants, but there are some products that can produce metabolic derangements or have the capability of doing so. Paint strippers can contain methylene chloride. Methylene chloride is converted in *vivo* to carbon monoxide and carbon monoxide poisoning has been reported after accidental exposure to or improper use of paint strippers.\(^{23}\) Some automotive products contain ethylene glycol and/or methanol, toxic alcohols that can cause metabolic acidosis.\(^{24,25}\)

The nitrites, amyl nitrite, butyl nitrite, and isobutyl nitrite, act as oxidative stressors and convert hemoglobin to methemoglobin. Methemoglobin is hemoglobin that has lost an electron from its iron atom. Methemoglobin is normally produced as the body encounters oxidative stressors, but reducing mechanisms normally maintain the methemoglobin level at 1-3%. The iron molecule in methemoglobin is in the ferrous Fe\(^{2+}\) state instead of its normal ferric Fe\(^{3+}\) state and ferrous iron cannot combine with oxygen. Symptomatic methemoglobinemia has been reported after nitrite use.\(^{26}\) Acute toluene intoxication can cause hypokalemic paralysis and a normal anion gap metabolic acidosis.\(^{27-29}\)

**Gastrointestinal**

Abdominal pain, diarrhea, nausea and vomiting are possible as a result of inhalant use. Hydrocarbons are well known to be very irritating to the gut.
Dermal

The gases that are in aerosol cans are compressed and under high pressure. When they are released and they rapidly expand, the gases are cooled and can cause cold thermal injuries to the skin and the respiratory tract, in some cases significant enough to require endotracheal intubation.\(^3\) Many of the solvents and hydrocarbons act as de-fattting agents (they “dissolve” the normal surface oils on the skin) and if there is dermal contact the skin can become dry and cracked. Prolonged skin contact can cause first degree and more serious burns.\(^3\)

Fatalities

It is not possible to form an accurate estimate of the number of fatalities caused by an inhalant use disorder, but deaths caused by use of these substances appear to be very unusual. The American Association of Poison Control Centers (AAPCC) publishes a yearly reporting of overdose and accidental poisonings called into poison control centers, and the number of deaths attributed to or caused by inhalants is very small.\(^3\) The mechanisms by which inhalants can kill are listed in Table 4.\(^5\),\(^6\),\(^3\)\textsuperscript{2-34}

Table 4: Causes of Death from Solvent Use

<table>
<thead>
<tr>
<th>Aspiration, Asphyxia</th>
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<tbody>
<tr>
<td>Allergic reaction</td>
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<tr>
<td>Central nervous system depression</td>
</tr>
<tr>
<td>Ventricular arrhythmias</td>
</tr>
<tr>
<td>Hypoxia</td>
</tr>
<tr>
<td>Respiratory depression</td>
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<tr>
<td>Trauma</td>
</tr>
</tbody>
</table>
Intoxication from a volatile solvent may last for 15-30 minutes or for several hours, and the recovery is rapid. Chronic users develop a tolerance and a withdrawal syndrome has been described.\textsuperscript{35-37}

**Assessment For Inhalant Intoxication**

Unless use of an inhalant is witnessed, obvious signs of use (\textit{i.e.}, paint residue around the mouth or nose), chemical odor on the patient’s breath, or the patient admits to using, determining the presence of an acute inhalant intoxication depends on non-specific signs or symptoms. Table 5 lists some common physical and behavioral signs of inhalant use.\textsuperscript{5} Some of the commonly used substances can be detected in blood or urine by laboratory testing but not in a timely manner. Primary care providers or other healthcare professionals that screen patients for the presence of inhalant use can utilize the Volatile Solvent Screening Inventory (VSSI) or the Comprehensive Solvent Assessment Interview (CSAI).\textsuperscript{38}

**Table 5: Signs of Inhalant Use**

<table>
<thead>
<tr>
<th>Behavior changes</th>
<th>Conjunctivitis</th>
<th>Chronic fatigue</th>
<th>Confusion</th>
<th>Decreased appetite</th>
<th>Drowsiness</th>
<th>Epistaxis</th>
<th>Frostbite or burns in/around the mouth or nose</th>
</tr>
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<tbody>
<tr>
<td>(\textit{i.e.}, apathy, depression, hostility, paranoia, social withdrawal)</td>
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</tbody>
</table>
Poor hygiene and grooming
Weight loss
Wheezing

**Chronic Clinical Effects**

If solvent use is sporadic and the duration of use is brief, there are no sequelae. However, long-term use of a solvent can cause multi-organ system damage. Some of the organ damage can be reversible, but the cardiac and neurological changes may become permanent. The nervous system is especially at risk. As mentioned previously, inhaled solvents are highly lipophilic and because of that they accumulate in myelin (75% lipid) and in neuronal membranes (up to 45% lipids).

**Cardiovascular**

Myocardial infarction,¹⁰ cardiomyopathy with depressed ejection fraction,⁶,¹² congestive heart failure,¹⁰ and chronic myocardial inflammation and fibrosis⁶ have been reported after chronic inhalant use.

**Neurological**

Chronic solvent inhalation can cause serious, significant and irreversible neurological damage, cognitive, motor, and visual impairment.⁵,⁶,³⁸-⁴¹ Cerebellar damage, cortical atrophy, dementia, peripheral neuropathy, and optic nerve damage have all been reported as consequences of chronic solvent use, and there is a wide range of clinical effects that these injuries produce, *i.e.*, ataxia, depression, headache, intellectual impairment, memory loss, mood changes, sensory disorders, spasticity, tremor - the list is long.¹⁰ It is not clear
how long solvent use must continue before neurological damage becomes permanent, and there is no clear dose-response relationship.

Chronic solvent use is also associated with increased risk for suicide and suicidal ideation, psychosis, attention deficit hyperactivity disorder, concurrent use of alcohol, tobacco, and illicit drugs, anxiety, depression, and other mental health disorders.\(^5,42\)

**Pulmonary**

Long-term solvent use has been associated with Goodpasture’s syndrome, panacinar emphysema, decreased vital capacity, decreased exercise tolerance, cough, recurrent epistaxis, chronic rhinitis, and other pulmonary abnormalities.\(^6,43-45\)

**Renal**

Toluene is often used as a solvent in glue. Chronic toluene inhalation is a well-known cause of renal tubular acidosis.\(^6,46-48\).

**Hepatic**

Exposure to carbon tetrachloride, toluene, and trichloroethylene has been associated with liver damage.\(^6\) Fortunately, the risk of liver damage from exposure to these substances - carbon tetrachloride in particular - is well recognized and their availability in over-the-counter products is much less than previously. Exposure to toluene has been reported to cause hepatorenal syndrome.\(^48\)

**Caring For An Individual With An Inhalant Use Disorder**
Individuals with an inhalant use disorder may seek help for acute medical problems or chronic problems. The care will differ somewhat for each situation, but in either case a careful history should be taken. The clinician should be sure to ask the individual the following during a history and physical.

1. When he/she was last inhaling.
2. If he/she was experimenting or solvent use is a chronic behavior.
3. How he/she is using the inhalant; if solvent use is being done by bagging, huffing, or inhaling.
4. What is being inhaled, for example, whether it is a liquid (i.e., paint thinner) or an aerosol (i.e., an aerosolized computer keyboard cleaner). Also the patient should be asked if he/she has been using any illicit drugs or drinking alcohol.

Most importantly, it should be determined what the patient has been using and what it contains. It is not enough to simply know what the patient has been inhaling, for example, an automotive brake cleaner; a list of the ingredients that the patient has been inhaling must be obtained. Although many of the clinical effects produced by solvent inhalation are common to all of the typically used products, the patient may be inhaling something that can cause a distinct pathology; for example, carbon monoxide poisoning from paint strippers that contain methylene chloride, glues that contain toluene can cause renal damage, etc.

If the patient cannot inform the clinician what he/she was inhaling (doesn’t remember, is incapacitated, etc.), someone not directly involved in patient care should try to obtain this information. There are
four ways to get a list of ingredients for a commercially manufactured product. These are listed here from the simplest to the most difficult:

1. Call the local poison control center. Poison control centers all have a database that contains detailed information about millions of commercial products, and a local center may be able to quickly provide information of what is in the product that a person has been using. Many poison control centers still maintain a local number, but all poison control centers use the national number, and this number will connect callers to the closest poison control center: 1-800-222-1222.

2. Look for the material safety data sheet (MSDS) on line. This can be done by going to the manufacturer’s website (if the manufacturer of the product is known) and checking to see if they have the MSDS, or by doing a simple on line search using any search engine; i.e., type in “Amazing Automotive Heavy Duty Brake Cleaner, MSDS”.

3. Check with Chemtrec. Chemtrec is a free service that provides emergency assistance to HAZMAT teams, first responders, etc., who are dealing with a hazardous materials incident such as a chemical spill. In addition, Chemtrec also has a database of manufacturers and access to the MSDS of their products. Chemtrec is available 24 hours at 1-800-424-9300.

4. Call the manufacturer and have the MSDS emailed or faxed. This last option is by far the slowest and least reliable. The company may be closed (if the call is placed on the weekend or at night) or
it may take someone in the company a long time to find the information. Locating current contact information can be challenging, as well.

The Basics of Acute Care

When an individual arrives to an acute care setting due to a serious outcome related to inhaling a substance, care begins with an assessment of the patient’s airway, breathing, and circulation, and the individual should be checked for any signs of a traumatic injury. As this assessment is being done, any contaminated clothing should be removed and health team responders should decontaminate the skin if needed. A close examination of the oral cavity and the surrounding area should be done for evidence of obstruction or thermal injury (due to edema or cold thermal injury), and the lungs carefully auscultated and the oxygen saturation checked using pulse oximetry; the clinician should be looking for signs of aspiration and/or hypoxia and hypercapnia.

If there are abnormalities in the assessment of the airway and breathing, or if the patient is complaining of dyspnea, the following should be obtained: a chest x-ray, an arterial blood gas, and measurement of serum carbon monoxide and methemoglobin levels. A 12-lead ECG should be obtained and the patient placed on continuous cardiac monitoring. Serum electrolytes, a complete blood count, liver transaminases, blood urea nitrogen (BUN) level and a creatinine level should be obtained. The volatile solvents and their metabolites are not detected in urine drug screens and although they can be detected in the blood by using chromatography, this type of testing cannot be done stat or immediately; the results would take several days to be available.
There are no specific treatments for acute solvent intoxication. Treatment is essentially symptomatic and supportive. If the patient is having respiratory distress, the following approach should be followed.

**Respiratory Distress**

If there is evidence of airway constriction, it should be determined where the problem is; it could be in the upper airway structures (*i.e.*, thermal damage from an inhalant) or it could be in the lower airway structures (*i.e.*, response to the irritating nature of a solvent or from an aspiration). Supplemental oxygen should be administered and if the airway constriction is in the lower airway structures, *carefully* consider the benefits and risks of an inhaled bronchodilator such as albuterol (discussed later in this learning module).

If the patient is having respiratory distress and has an abnormal chest X-ray, aspiration and chemical pneumonitis are likely. The treatment includes supplemental oxygen and consultation with a poison control center or a pulmonologist about the use of antibiotics and systemic corticosteroids; these are not typically needed or useful but may be in certain circumstances.

In a situation of a high carbon monoxide level, supplemental oxygen and time should be sufficient treatment.

If the patient has been inhaling a product that causes methemoglobinemia and he/she is having respiratory distress or has a methemoglobin level that is >30%, supplemental oxygen should be administered and consideration given to the use of methylene blue.
Methylene blue is the antidotal therapy for an elevated methemoglobin level. It is given intravenously (IV) at a dose of 1-2 mg/kg of a 1% solution slowly over 5 minutes. The dose can be repeated as in 30-60 minutes as needed.

If the arterial blood gas reveals a metabolic acidosis, the patient may have been inhaling a product that contains ethylene glycol or methanol (it should be noted that toluene exposure is also possible). Blood samples should be sent for measurement of ethylene glycol and methanol, and for close monitoring of acid-base status and renal function. The patient should also be assessed for visual deficits. Intravenous hydration should be started and if exposure to ethylene glycol or methanol is confirmed or strongly suspected, the use of fomepizole or hemodialysis should be considered. There should be consultation with the local poison control center for advice.

**Cardiovascular Abnormalities**

A 12-lead ECG should be done for every patient who is using inhalants and measurement of serum calcium, magnesium, and potassium should be done, as well. If the patient is having an arrhythmia, it should be treated with established protocols; consultation with a poison control center toxicologist should be obtained, as well. Sympathomimetic drugs such as epinephrine, isoproterenol, or norepinephrine should not be used to treat ventricular fibrillation (VF), and catecholamines and drugs that are adrenergic stimulants should only be used after a careful risk-benefit analysis\(^6,\text{15}\) and after consultation with a toxicologist or a cardiologist. Hypotension can be treated with fluids.
**Chronic Solvent User**

Chronic solvent users should be evaluated for neurological, cardiovascular, renal, hepatic, and hematologic problems, so the appropriate testing should be ordered and consultation made. There is no specific treatment for health problems caused by chronic solvent use; patients should be treated with symptomatic and supportive care and the appropriate consultations. Neurological and cardiac damage is likely to be permanent whereas damage to other organs will usually resolve and repair over time.

Patients who have an inhalant use disorder will need psychological support and counseling. Unfortunately there is a dearth of good research on the medical, pharmacological, and psychological interventions for this problem and no clear conclusions as to which approach is best. The interested clinician is advised to read two relatively recent literature reviews by Howard, et al. (2011) and MacLean, et al. (2012) for more information.

**Summary**

Inhalant use disorder is defined as the problematic pattern of use of a hydrocarbon-based inhalant substance leading to clinically significant impairment or distress. Also known as solvent abuse or volatile substance abuse, the use of solvent-based inhalants can cause serious and irreversible complications and death. Inhalant use disorder is a (relatively) common phenomenon in pre-teen and adolescent populations, and its popularity can be explained in part because the inhalants are cheap and legal and the high is relatively brief.
The effects of inhalant intoxication typically last for one to two hours and central nervous system depression and tachycardia are the most commonly seen clinical signs. More serious effects such as airway compromise or damage, hypoxia, respiratory depression, metabolic acidosis, methemoglobinemia, carbon monoxide poisoning, renal tubular acidosis, and deadly cardiac arrhythmias are possible, as well. Chronic use of inhalants can cause irreversible cognitive effects and neurological damage, cardiomyopathy, hepatic and renal damage, and myocardial damage. The treatment of acute inhalant intoxication and inhalant use disorder is essentially symptomatic and supportive.

References


