



Published in final edited form as:

J Am Acad Child Adolesc Psychiatry. 2004 October ; 43(10): 1206–1214.

Inhalant Abuse and Dependence Among Adolescents in the United States

LI-TZY WU, SC.D., DANIEL J. PILOWSKY, M.D., M.P.H., and WILLIAM E. SCHLENGER, Ph.D.
From RTI International (L.-T.W. and W.E.S.), Research Triangle Park, NC; and Columbia University (D.J.P.), New York.

Abstract

Objective—To examine the patterns of inhalant use and correlates of the progression from inhalant use to abuse and dependence among adolescents aged 12 to 17.

Method—Study data were drawn from the 2000 and 2001 National Household Surveys on Drug Abuse. Multinomial logistic regression was used to identify the characteristics associated with progression to inhalant abuse and dependence.

Results—Inhalant use was common among the studied adolescents. Among adolescents aged 12 to 17, 0.4% met *DSM-IV* inhalant abuse or dependence criteria in the past year. Inhalant abuse and dependence affected adolescents regardless of gender, age, race/ethnicity, and family income. The progression from inhalant use to abuse or dependence was related to early first use, use of multiple inhalants, and weekly inhalant use. Adolescents with inhalant use disorders reported coexisting multiple drug abuse and dependence, mental health treatment, and delinquent behaviors.

Conclusions—Adolescents with an inhalant use disorder may represent a subgroup of highly troubled youths with multiple vulnerabilities. Because early use is associated with progression to abuse and dependence, prevention programs should target elementary school-age children.

Keywords

drug abuse; drug dependence; inhalants

Inhalant use is the deliberate inhalation of volatile substances, via sniffing, snorting, bagging, or huffing, to induce a psychoactive or mind-altering effect (National Institute on Drug Abuse, 2000). It is a serious drug problem worldwide, particularly in disadvantaged populations and among adolescents (Kozel et al., 1995; Padilla et al., 1979; Tapia-Conyer et al., 1995).

National surveys of adolescents in the United States have found that, after marijuana, inhalants were the second most widely used class of illicit drugs for 8th and 10th graders and were the third most widely used for 12th graders (Johnston et al., 2001). The most commonly used inhalants are glue, shoe polish, and gasoline (McGarvey et al., 1999), and inhalant users typically report family problems (Jacobs and Ghodse, 1988; McGarvey et al., 1996; Morita et al., 1996). Young females are as likely as young males to use inhalants (Johnston et al., 2001; Neumark et al., 1998). Among all American racial/ethnic groups, African Americans and American Indians, respectively, are the least and most likely to use inhalants (Beauvais

Correspondence to Dr. Wu, Center for Risk Behavior and Mental Health Research, RTI International, P.O. Box 12194, Research Triangle Park, NC 27709; e-mail: liwu@rti.org..

This work was supported by the National Institute on Drug Abuse (R21DA015938). The Substance Abuse and Mental Health Data Archive (SAMHDA) and the Inter-university Consortium for Political and Social Research (ICPSR) are the providers of public use data files of the National Household Survey on Drug Abuse.

and Oetting, 1988; Mackesy-Amiti and Fendrich, 2000; McGarvey et al., 1996; Neumark et al., 1998; Oetting et al., 1980).

Inhalant use is a serious public health problem for several reasons. First, it is associated with the use of multiple illicit drugs and injection drug use (Dinwiddie et al., 1991; Schutz et al., 1994). In particular, adolescents who were incarcerated in juvenile detention facilities appear to be at high risk of starting inhalant use early and using multiple drugs (McGarvey et al., 1996; Young et al., 1999). Bennett et al. (2000) found that inhalant use before age 18 was associated with later use of hard drugs and binge drinking. Johnson et al. (1995) reported that using inhalants before age 16 predicted later heroin use, even after adjusting for known risk factors for heroin use.

Second, inhalant use is often associated with delinquency, depression, and suicidal behavior (Borges et al., 2000; Kelder et al., 2001; Mackesy-Amiti and Fendrich, 2000). Inhalants are often the first substance used by incarcerated youths (Young et al., 1999). Inhalant-using delinquents report greater antisocial attitudes, personal and familial dysfunction, peer deviance, suicidality, and substance abuse than their non-inhalant-using counterparts (Howard and Jenson, 1999). Compton et al. (1994) found a strong association between a history of inhalant use and antisocial personality disorder. Among middle-school students, inhalant use is associated with symptoms of depression (Kelder et al., 2001). Last, inhalant use may be associated with substantial cardiac, renal, hepatic, and neurological morbidity and mortality (American Academy of Pediatrics, 1996; Anderson and Loomis, 2003; Bowen et al., 1999).

Despite these findings, inhalants are one of the least studied or discussed groups of abused substances (Brouette and Anton, 2001; Kurtzman et al., 2001), and inhalant abuse and dependence among adolescents remain a widely neglected area of research. Little is known about the prevalence and characteristics associated with progression to abuse and dependence among young inhalant users.

In light of the scarce data about the epidemiology of inhalant use, we examined the prevalence and characteristics of inhalant use, abuse, and dependence among adolescents aged 12 to 17 who participated in the 2000–2001 National Household Surveys on Drug Abuse (NHSDAs). The 2000–2001 surveys represent the first 2 years in which inhalant abuse was assessed using *DSM-IV* criteria (American Psychiatric Association, 1994) and more detailed measures of dependence were included. We investigated inhalant use patterns and characteristics associated with progression to abuse and dependence.

We hypothesized that progression to abuse or dependence would be associated with early onset of inhalant use, use of multiple inhalants, and regular use of inhalants (Grant and Dawson, 1998; Howard and Jenson, 1999; Jacobs and Ghodse, 1988; Tapia-Conyer et al., 1995; Young et al., 1999). We further hypothesized that adolescents with an inhalant use disorder, compared with adolescents without the disorder, would be more likely to meet criteria for other substance use disorders, to report multiple delinquent behaviors, and to receive mental health treatment (Compton et al., 1994; Dinwiddie et al., 1991; Howard and Jenson, 1999; Kelder et al., 2001; Mackesy-Amiti and Fendrich, 1999; McGarvey et al., 1996). Last, we sought to explore differences between correlates of inhalant abuse and dependence.

METHOD

Data Source

This study was based on data from the public use file of the 2000 and 2001 NHSDAs (Office of Applied Studies, 2001, 2002a). The NHSDA is an annual national survey of the use of a variety of licit and illicit substances by Americans aged 12 and older. Civilian,

noninstitutionalized populations residing within the United States were selected for participating in the study via multistage area probability sampling methods. They include residents of households and noninstitutional group quarters (e.g., shelters, rooming houses, dormitories, group homes), and civilians residing on military bases. Persons who had no fixed household address at the time of the survey (homeless transients not in shelters) and residents of institutional group quarters (jails and hospitals) were excluded from the sampling frame.

Respondents were interviewed at their place of residence for about an hour. Interviewers requested the respondents to identify a private area in the home away from other household members to conduct the interview. The 2000 and 2001 surveys used a combination of computer-assisted personal interviewing and audio computer-assisted self-interviewing (ACASI) methodologies. The latter was used for questions of a sensitive nature. Respondents either read the questions on the computer screen or the questions were read to them through headphones. In either case, they entered their responses directly into the computer.

A total of 71,764 and 68,929 individuals aged 12 and older completed the 2000 survey and the 2001 survey, respectively. Weighted interview response rates were 74% in 2000 and 73% in 2001 and were consistently higher among adolescents aged 12 to 17 than among adults (Office of Applied Studies, 2002b). Analysis weights were developed to adjust for variation in household selection, nonresponse, and post-stratification of the selected sample to census data, a method used to ensure that certain groups (e.g., different ages and ethnicities) are represented in the NHSDA sample in the same proportion as in the census. Thus, each independent, cross-sectional NHSDA sample was representative of the U.S. general population aged 12 and older. NHSDA design and data collection procedures have been reported in detail elsewhere (Office of Applied Studies, 2001, 2002a).

Study Sample

We studied adolescents aged 12 to 17 who participated in both surveys (2000 and 2001). There was little yearly variation in the distribution of age, gender, race/ethnicity, family income, and population density across the two surveys. In the combined sample ($N = 36,859$), 49% were females, 33% were aged 12 to 13, 35% were members of nonwhite minority groups, 43% reported an annual family income of \$40,000 or less, and 23% resided in nonmetropolitan areas.

Study Variables

The primary outcome was inhalant abuse and dependence in the past year. Past-year inhalant users were categorized into three mutually exclusive subgroups: no diagnosis (without abuse or dependence), abuse, and dependence.

In the NHSDA, inhalant use was defined as any use of the following types of substances as well as any other substances that people sniffed or inhaled for kicks or to get high: (1) correction fluid, degreaser, or cleaning fluid; (2) gasoline or lighter fluid; (3) glue, shoe polish, or toluene; (4) ether, halothane, or other anesthetics; (5) lighter gases, butane, or propane; (6) nitrous oxide or whippets; (7) spray paints; (8) lacquer thinner and other paint solvents; (9) amyl nitrite, poppers, rush, or locker room deodorizers; and (10) aerosol sprays. An additional "other" group was defined to encompass all other inhalants not specified in the above categories.

Type of inhalants used was grouped into three categories (1, 2, ≥ 3). Years since first inhalant use referred to the number of years since the respondent's age at first inhalant use. Use of inhalants at least 1 day per week in the past year was considered weekly use.

Past-year inhalant abuse and dependence, as well as alcohol and other drug abuse and dependence, were assessed using *DSM-IV* criteria (American Psychiatric Association, 1994;

Office of Applied Studies, 2002a). Diagnostic assessments were based on the questions used in the National Comorbidity Survey (NCS) (Kessler et al., 1994) and were revised to meet the *DSM-IV* criteria. Inhalant abuse was considered present when one or more of the four *DSM-IV* inhalant abuse criteria were met in the past year, and criteria for inhalant dependence were not met. Inhalant dependence was considered present when at least three *DSM-IV* dependence criteria were met in the past year.

Demographic characteristics included age, gender, race/ethnicity, total family income, and population density. The NHSDA classified population density as large metropolitan areas (with a population of one million or more), small metropolitan areas (with a population less than one million), and nonmetropolitan areas (outside a metropolitan statistical area).

We also examined the utilization of mental health services, history of foster care placement, delinquent behaviors, incarceration, past-year use of other drugs, past-year alcohol abuse and dependence, and past-year other drug abuse and dependence. Utilization of mental health services was defined as receiving treatment or counseling for emotional or behavioral problems that were *not* caused by alcohol or drug use at any service location in the previous year (e.g., hospital, private doctor's office, mental health clinic or program, general medical setting, school).

Those responding affirmatively to "Have you ever been in foster care?" and to "Have you ever been in a jail or detention center?" were considered to have a history of foster care placement and incarceration, respectively. The following past-year delinquency or conduct problems were assessed: (1) getting into a serious fight at school or work, (2) taking part in a group fight against another group, (3) carrying a handgun, (4) selling illicit drugs, (5) stealing anything worth more than \$50, and (6) attacking someone with the intent to seriously hurt him or her. These six types of delinquent behaviors were grouped into three categories (none, 1–2, ≥ 3 , corresponding to none, few, and multiple delinquent activities, respectively) to test a potential association between involvement in multiple delinquent activities and the severity of inhalant use (Howard and Jenson, 1999; Mackesy-Amiti and Fendrich, 2000).

The number of other drugs used in the past year (cocaine/crack, marijuana/hashish, heroin, hallucinogens, sedatives, tranquilizers, pain relievers, and stimulants) was summed and grouped into four categories (none, 1, 2, ≥ 3 classes of drugs). Abuse of or dependence on other illicit drugs in the past year was similarly categorized (none, 1, 2, ≥ 3 classes of drugs). Past-year alcohol abuse or dependence was dichotomized (yes versus no).

Data Analysis

To ensure the representativeness of the NHSDA sample, data were weighted and analyzed by SUDAAN software (Research Triangle Institute, 2002) that applies a Taylor series linearization method to account for the effects of the complex NHSDA design features (weighting). All percentages reported in this report are weighted estimates, whereas sample sizes are unweighted.

We examined the pattern of inhalant use behaviors and estimated the prevalence of inhalant abuse and dependence among users. Multinomial logistic regression procedures were used to identify characteristics associated with inhalant abuse and dependence, while controlling for sociodemographic variables. We report odds ratios (ORs) as the index of the strength of an association.

RESULTS

Descriptive Characteristics of Adolescent Inhalant Users

Among adolescents aged 12 to 17 ($N = 36,859$), 9% ($n = 3,332$) reported having ever used any inhalants in their lifetime. This represents approximately two million adolescents aged 12 to 17 annually. There were no significant yearly differences in the prevalence of lifetime inhalant use. Inhalant users were more likely than nonusers to be aged 14 and older; American Indians, Alaskan Natives, or of multiethnic origin; and to reside in nonmetropolitan areas (Table 1). Gender and family income were not associated with inhalant use.

Inhalant use was significantly associated with participation in mental health treatment, a history of incarceration, a history of foster care placement, delinquency, and the use of alcohol and other drugs. For example, 29% of adolescents who reported engaging in three or more types of delinquent behaviors had ever used inhalants compared with 5% of those who did not. The number of other drugs used was positively associated with lifetime inhalant use. About one-half of adolescents who reported using at least three or more classes of other drugs had ever used inhalants compared with 4% of those who reported no use of other drugs.

Type, Duration, and Onset of Inhalant Use

The most commonly used inhalants were glue/shoe polish and gasoline, which were used by 43% and 36%, respectively, of inhalant users (Table 2). About one-half (51%) of adolescent inhalant users had used two or more types of inhalants in their lifetime. Most (80%) inhalant users reported their first inhalant use before age 15. Males were more likely to have ever used gasoline and nitrous oxide, whereas females were more likely to have ever used glue/shoe polish, spray paints, correction fluid, and aerosol sprays.

Among inhalant users, 40% reported using at least one inhalant in the past year. This represented 4% of all adolescents aged 12 to 17 (4% of males; 3% of females). Among these past-year users ($n = 1,313$), there were few gender differences in the choice of inhalant use patterns. As was the case with adolescents reporting lifetime use, most (60%) past-year users reported using two or more inhalants, and 70% started their first use before age 15.

Past-Year Inhalant Abuse/Dependence

Among adolescents aged 12 to 17, 0.2% met the criteria for inhalant abuse and 0.2% for inhalant dependence. The prevalence of inhalant abuse and dependence among past-year inhalant users was 6% and 4%, respectively. There were no gender differences in the prevalence of inhalant abuse and dependence (Table 3).

We conducted multinomial logistic regression to identify correlates of progression into inhalant abuse and dependence among past-year inhalant users (use versus abuse; use versus dependence). We used backward elimination to exclude insignificant variables, and the final model included population density, utilization of mental health services, history of foster care placement, delinquent behaviors, other drug abuse or dependence, weekly inhalant use, onset of inhalant use, and use of multiple inhalants (Table 4). Age group, gender, race/ethnicity, and family income were not significantly associated with inhalant abuse or dependence and therefore were not included in this model.

As shown in Table 4, different characteristics were associated with abuse and dependence. For example, although age at first use was associated with dependence, it was not associated with abuse. Adolescents who reported first use at age 13 to 14 were six times more likely to be dependent on inhalants than those who started using at age 15 to 17 (adjusted OR 6.0, $p < .01$).

Similarly, using inhalants weekly, compared with less than weekly, was associated with increased odds of dependence (adjusted OR 2.6, $p < .05$) but not with abuse.

Adolescents with a history of foster care placement were five times more likely to become dependent than those never placed away from home (adjusted OR 4.9, $p < .001$). By comparison, history of incarceration was not associated with abuse and dependency once history of foster care placement, other drug abuse or dependence, mental health service utilization, and delinquent behaviors were held constant. The use of multiple inhalants was significantly associated with greater odds of abuse but not with dependence.

Receiving mental health treatment and the presence of other drug abuse or dependence were associated with both abuse and dependence. Adolescents who received mental health treatment in the past year were two times more likely to receive a diagnosis of abuse and dependence than those who did not. Adolescents who abused or were dependent on two other drugs (other than inhalants) were about four times (adjusted OR 3.7, $p < .01$) and nine times (adjusted OR 8.9, $p < .001$), respectively, more likely to receive the diagnosis of inhalant abuse and dependence than those who did not.

DISCUSSION

The two main goals of this study were to provide new and more detailed estimates of inhalant use, abuse, and dependence in a nationally representative sample of adolescents aged 12 to 17 and to examine factors associated with progression from use to abuse and dependence. Overall, 0.4% of adolescents aged 12 to 17 met the criteria for past-year inhalant abuse or dependence. Among adolescents who used inhalants in the past year, 11% met the criteria for abuse or dependence in that year. These findings represent new estimates of adolescent inhalant abuse and dependence in the general population.

Four percent of past-year inhalant users met *DSM-IV* criteria for past-year inhalant dependence. Using data from the NCS, Anthony et al. (1994) estimated a lifetime inhalant dependence prevalence of 0.6% (8% of all lifetime inhalant users) among NCS respondents aged 15 to 24. Because they ascertained criteria for lifetime dependence and we focused on past-year dependence, the estimates are not comparable. Our prevalence estimates of any inhalant use are somewhat similar to those of NCS respondents aged 15 to 24 (Anthony et al., 1994) but were lower than those of the Monitoring the Future (MTF) study (Johnston et al., 2003). However, the direction of prevalence trends of inhalant use between the NHSDA and the MTF surveys has been similar (Office of Applied Studies, 2002b). The lower prevalence of inhalant use in the NHSDA may have resulted from methodological differences in the two surveys (Office of Applied Studies, 2002b). The MTF does not assess inhalant abuse and dependence.

Consistent with other studies (McGarvey et al., 1999), the most commonly used inhalants were glue, shoe polish, and gasoline. A high proportion (60%) of past-year inhalant users reported using multiple types of inhalants. Using inhalants weekly or more (20%) and for more than 1 year (35%) were not uncommon. Given the substantial morbidity and mortality associated with inhalant use (American Academy of Pediatrics, 1996), the duration and frequency of use among adolescents in this study are noteworthy and constitute a significant public health concern.

To understand further the progression from inhalant use to abuse and dependence, we compared inhalant users who did and did not progress to abuse and dependence. We found a significant association between other drug abuse or dependence and progression to inhalant abuse or dependence. Other investigators have reported an association between inhalant use and the use of other drugs (Bennett et al., 2000; Dinwiddie et al., 1991).

Inhalant use is often associated with impaired family functioning (Tapia-Conyer et al., 1995). We found a higher prevalence of inhalant use and an increased likelihood of progression to dependence among adolescents with a history of foster care placement compared with those never placed away from home. Foster care is an indicator of a likely history of neglect and abuse and is associated with multiple adverse outcomes, including homelessness (Susser et al., 1991).

Because the literature suggests that inhalant use is associated with delinquent activities, we examined associations between delinquency and progression to abuse and dependency. We found that adolescents presenting with three or more delinquent behaviors were more likely than those without any delinquent behaviors to abuse inhalants. This is important because inhalant users who are delinquent may be especially vulnerable to severe drug abuse and mental health problems (Howard and Jenson, 1999; Jacobs and Ghodse, 1988).

Limitations

Several limitations to this study are noteworthy. First, our findings are based on reports by adolescents, which are subject to recall and reporting biases. Although studies have found that adolescent self-reports of drug use are generally valid and reliable, drug use may be underreported (Gfroerer et al., 1997; Needle et al., 1983; Winters et al., 1990–91). Nonetheless, the NHSDA methodology has been found to produce more valid reports of drug use than telephone surveys (Turner et al., 1992). Estimates of drug abuse and dependence may be more valid than estimates of use because the validity of self-report is higher among individuals who report drug-related problems or the use of multiple drugs than among those who do not (Colon et al., 2002). Second, the cross-sectional nature of the NHSDA design precludes interpreting associations as causal. Third, a small but high-risk group (incarcerated, homeless, and transient adolescents) were not included in the NHSDA. Hence, we may have underestimated the prevalence of inhalant abuse and dependence.

Clinical Implications

The findings of this study have important implications for researchers and clinicians. Adolescents who met criteria for inhalant abuse or dependence reported coexisting delinquent behaviors, multiple drug abuse and dependence, and utilizing mental health services for other emotional problems. Thus, inhalant abuse and dependence may be a marker of global vulnerability rather than an isolated problem. This vulnerability may be influenced by individual as well as family factors, as evidenced by the association between foster care and inhalant use disorder.

In this study, progression from inhalant use to abuse or dependence was associated with early first use and repeated use. Consequently, drug abuse prevention curricula should start early, during the elementary school years. Delaying the age at first inhalant use may help reduce the risk of progressing to abuse or dependence. Preventing this progression is important because treatment of inhalant abuse is difficult and expensive (American Academy of Pediatrics, 1996). To implement secondary prevention (i.e., preventing the progression from use to abuse or dependence), pediatricians and mental health professionals need to be aware of the clinical manifestations of inhalant use. A thorough history may reveal episodes consisting of euphoria after the use of household solvents, interest in gaining access to solvents (e.g., paint thinner, glue), and injuries associated with the acute effects of inhalant use (e.g., falls, burns, frostbite). No specific laboratory test confirms solvent inhalation (Anderson and Loomis, 2003).

References

American Academy of Pediatrics. Inhalant abuse. *Pediatrics* 1996;97:420–423. [PubMed: 8604284]

- American Psychiatric Association (1994), *Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV)*. Washington, DC: American Psychiatric Association
- Anderson CE, Loomis GA. Recognition and prevention of inhalant abuse. *Am Fam Physician* 2003;68:869–874. [PubMed: 13678134]
- Anthony JC, Warner LA, Kessler RC. Comparative epidemiology of dependence on tobacco, alcohol, controlled substances, and inhalants: basic findings from the National Comorbidity Survey. *Exp Clin Psychopharmacol* 1994;2:244–268.
- Beauvais F, Oetting ER (1988), Indian youth and inhalants: an update. In: *Epidemiology of Inhalant Use: An Update*, Crider RA, Rouse BA, eds. NIDA Research Monograph 85, DHHS publication no. ADM 89–1577. Rockville, MD: National Institute on Drug Abuse, pp 34–48
- Bennett ME, Walters ST, Miller JH, Woodall WG. Relationship of early inhalant use to substance use in college students. *J Subst Abuse* 2000;12:227–240. [PubMed: 11367601]
- Borges G, Walters EE, Kessler RC. Associations of substance use, abuse, and dependence with subsequent suicidal behavior. *Am J Epidemiol* 2000;151:781–789. [PubMed: 10965975]
- Bowen SE, Daniel J, Balster RL. Deaths associated with inhalant abuse in Virginia from 1987 to 1996. *Drug Alcohol Depend* 1999;53:239–245. [PubMed: 10080050]
- Brouette T, Anton R. Clinical review of inhalants. *Am J Addict* 2001;10:79–94. [PubMed: 11268830]
- Colon HM, Robles RR, Sahai H. The validity of drug use self-reports among hard core drug users in a household survey in Puerto Rico: comparison of survey responses of cocaine and heroin use with hair tests. *Drug Alcohol Depend* 2002;67:269–279. [PubMed: 12127198]
- Compton WM III, Cottler LB, Dinwiddie SH, Spitznagel EL, Mager DE, Asmus G. Inhalant use: characteristics and predictors. *Am J Addict* 1994;3:263–272.
- Dinwiddie SH, Reich T, Cloninger CR. The relationship of solvent use to other substance use. *Am J Drug Alcohol Abuse* 1991;17:173–186. [PubMed: 1862791]
- Gfroerer J, Wright D, Kopstein A. Prevalence of youth substance use: the impact of methodological differences between two national surveys. *Drug Alcohol Depend* 1997;47:19–30. [PubMed: 9279494]
- Grant BF, Dawson DA. Age of onset of drug use and its association with DSM-IV drug abuse and dependence: results from the National Longitudinal Alcohol Epidemiologic Survey. *J Subst Abuse* 1998;10:163–173. [PubMed: 9854701]
- Howard MO, Jenson JM. Inhalant use among antisocial youth: prevalence and correlates. *Addict Behav* 1999;24:59–74. [PubMed: 10189973]
- Jacobs AM, Ghodse AH. Delinquency and regular solvent abuse: an unfavourable combination? *Br J Addict* 1988;83:965–968. [PubMed: 3167252]
- Johnson EO, Schutz CG, Anthony JC, Ensminger ME. Inhalants to heroin: a prospective analysis from adolescence to adulthood. *Drug Alcohol Depend* 1995;40:159–164. [PubMed: 8745138]
- Johnston LD, O'Malley PM, Bachman JG (2003), *Monitoring the Future National Results on Adolescent Drug Use: Overview of Key Findings, 2002* NIH publication no. 03–5374. Rockville, MD: National Institute on Drug Abuse
- Johnston LD, O'Malley PM, Bachman JG (2001), *Monitoring the Future National Survey Results on Drug Use, 1975–2000: Secondary School Students* NIH publication no. 01–4924, Vol. I, Rockville, MD: National Institute on Drug Abuse
- Kelder SH, Murray NG, Orpinas P, et al. Depression and substance use in minority middle-school students. *Am J Public Health* 2001;91:761–766. [PubMed: 11344884]
- Kessler RC, McGonagle KA, Zhao S, et al. Lifetime and 12-month prevalence of DSM-III-R psychiatric disorders in the United States. Results from the National Comorbidity Survey. *Arch Gen Psychiatry* 1994;51:8–19. [PubMed: 8279933]
- Kozel N, Sloboda Z, De La Rosa M (1995), *Epidemiology of Inhalant Abuse: An International Perspective*. NIDA Research Monograph 148, NIH publication no. 95–3831. Rockville, MD: National Institute on Drug Abuse
- Kurtzman TL, Otsuka KN, Wahl RA. Inhalant abuse by adolescents. *J Adolesc Health* 2001;28:170–180. [PubMed: 11226839]

- Mackesy-Amiti ME, Fendrich M. Trends in inhalant use among high school students in Illinois: 1993–1995. *Am J Drug Alcohol Abuse* 2000;26:569–590. [PubMed: 11097193]
- Mackesy-Amiti ME, Fendrich M. Inhalant use and delinquent behavior among adolescents: a comparison of inhalant users and other drug users. *Addiction* 1999;94:555–564. [PubMed: 10605851]
- McGarvey EL, Canterbury RJ, Waite D. Delinquency and family problems in incarcerated adolescents with and without a history of inhalant use. *Addict Behav* 1996;21:537–542. [PubMed: 8830913]
- McGarvey EL, Clavet GJ, Mason W, Waite D. Adolescent inhalant abuse: environments of use. *Am J Drug Alcohol Abuse* 1999;25:731–741. [PubMed: 10548445]
- Morita N, Satoh S, Oda S, et al. Relationship between solvent inhalation and antisocial behavior: special emphasis on two types of violence seen in solvent abusers. *Psychiatry Clin Neurosci* 1996;50:21–30. [PubMed: 9201767]
- National Institute on Drug Abuse (2000), *Inhalant Abuse* DHHS publication no. 00–3818. Rockville, MD: National Institute of Health
- Needle R, McCubbin H, Lorence J, Hochhauser M. Reliability and validity of adolescent self-reported drug use in a family-based study: a methodological report. *Int J Addict* 1983;18:901–912. [PubMed: 6605944]
- Neumark YD, Delva J, Anthony JC. The epidemiology of adolescent inhalant drug involvement. *Arch Pediatr Adolesc Med* 1998;152:781–786. [PubMed: 9701138]
- Oetting ER, Edwards R, Goldstein GS, Garcia-Mason V. Drug use among adolescents of five Southwestern Native American tribes. *Int J Addict* 1980;15:439–445. [PubMed: 7380602]
- Office of Applied Studies (2001), *Summary of Findings from the 2000 National Household Survey on Drug Abuse*. DHHS publication no. SMA 01–3549. Rockville, MD: Substance Abuse and Mental Health Services Administration
- Office of Applied Studies (2002a), *Results From the 2001 National Household Survey on Drug Abuse: Volume I. Summary of National Findings*. DHHS publication no. SMA 02–3758. Rockville, MD: Substance Abuse and Mental Health Services Administration
- Office of Applied Studies (2002b), *Results From the 2001 National Household Survey on Drug Abuse: Volume II. Technical Appendices and Selected Data Tables*. DHHS publication no. SMA 02–3759. Rockville, MD: Substance Abuse and Mental Health Services Administration
- Padilla ER, Padilla AM, Morales A, Olmedo EL, Ramirez R. Inhalant, marijuana, and alcohol abuse among barrio children and adolescents. *Int J Addict* 1979;14:945–964. [PubMed: 511397]
- Research Triangle Institute (2002), *SUDAAN User's Manual: Release 8.0*. Research Triangle Park, NC: Research Triangle Institute
- Schutz CG, Chilcoat HD, Anthony JC. The association between sniffing inhalants and injecting drugs. *Compr Psychiatry* 1994;35:99–105. [PubMed: 8187483]
- Susser ES, Lin SP, Conover SA, Struening EL. Childhood antecedents of homelessness in psychiatric patients. *Am J Psychiatry* 1991;148:1026–1030. [PubMed: 1853951]
- Tapia-Conyer R, Cravioto P, De La Rosa B, Velez C. Risk factors for inhalant abuse in juvenile offenders: the case of Mexico. *Addiction* 1995;90:43–49. [PubMed: 7888978]
- Turner CF, Lessler JT, Gfroerer JC eds. (1992), *Survey Measurement of Drug Use: Methodological Studies*. DHHS publication no. ADM 92–1929. Rockville, MD: National Institute on Drug Abuse
- Winters KC, Stinchfield RD, Henly GA, Schwartz RH. –91), Validity of adolescent self-report of alcohol and other drug involvement. *Int J Addict* 1990;25:1379–1395. [PubMed: 2132719]
- Young SJ, Longstaffe S, Tenenbein M. Inhalant abuse and the abuse of other drugs. *Am J Drug Alcohol Abuse* 1999;25:371–375. [PubMed: 10395166]

TABLE 1
Lifetime Prevalence of Inhalant Use Among Adolescents Aged 12–17 ($N = 36,859$)

Characteristics	Total Sample	Prevalence of Inhalant Use	χ^2 (df) <i>p</i> Value
Age group			
12–13 yr	12,417	6.3	98.0 (2) <.001
14–15 yr	12,655	10.1	
16–17 yr	11,787	9.8	
Gender			
Male	18,650	8.7	NS
Female	18,209	8.8	
Race/ethnicity			
White	24,584	9.5	97.6 (5) <.001
Black	4,960	5.3	
Hispanic	5,014	9.0	
American Indian/Alaskan Native	371	13.2	
Asian/Pacific Islander	1,289	6.5	
More than one race	641	11.2	
Family income			
\$0–\$19,999	6,466	8.1	NS
\$20,000–\$39,999	9,473	9.1	
\$40,000–\$74,999	12,422	9.1	
\$75,000+	8,498	8.4	
Population density			
Large metro areas	14,033	7.9	19.2 (2) <.001
Small metro areas	13,013	8.9	
Nonmetro areas	9,813	10.1	
Mental health service utilization			
Yes	6,111	16.2	244.5 (1) <.001
No	30,748	7.3	
History of incarceration			
Yes	1,820	21.5	131.5 (1) <.001
No	35,039	8.1	
History of foster care placement			
Yes	945	15.8	27.1 (1) <.001
No	35,914	8.6	
No. of delinquent behaviors			
None	25,561	5.3	622.4 (2) <.001
1–2	9,413	14.3	
≥ 3	1,885	29.1	
Lifetime alcohol use			
Yes	15,640	16.2	936.3 (1) <.001
No	21,219	3.3	
Lifetime use of other drugs			
None	27,912	4.2	950.6 (3) <.001
1 drug	5,406	13.2	
2 drugs	1,769	27.2	
≥ 3 drugs	1,772	48.7	
Survey year			
2000	19,430	8.8	NS
2001	17,429	8.7	

Note: NS = $p > .05$.

TABLE 2
 Characteristics of Inhalant Use Among Lifetime Inhalant Users Aged 12–17 ($N = 3,332$)

Type of Inhalant Use	Total	Male (n = 1,655)	Female (n = 1,677)	χ^2 (df) p value
Glue, shoe polish, toluene	42.7	38.7	46.9	15.7 (1) <.001
Gasoline, lighter fluid	36.0	38.1	33.9	4.1 (1) .044
Spray paints	23.4	20.5	26.4	11.7 (1) <.001
Correction fluid, degreaser	21.7	18.0	25.5	17.9 (1) <.001
Nitrous oxide, whippets	21.7	24.2	19.0	8.3 (1) .004
Aerosol sprays	18.8	16.4	21.2	8.2 (1) .004
Amyl nitrite, poppers, rush	17.6	16.1	19.1	NS
Paint solvents, lacquer thinner	16.7	16.8	16.6	NS
Lighter gases, butane, propane	10.6	11.4	9.7	NS
Ether, halothane, anesthetic	5.1	5.6	4.7	NS
Other inhalants	8.8	6.7	11.0	14.9 (1) <.001
No. of different types of inhalants used ^a				
1	49.1	51.3	46.9	
2	20.7	20.8	20.6	
≥ 3	30.2	27.9	32.6	
Recency of inhalant use				NS
Past year use	39.7	40.5	38.9	
Prior to past year use	60.3	59.5	61.1	
Age at first inhalant use (yr)				NS
<13	46.4	47.5	45.3	
13–14	34.2	32.4	36.0	
15–17	19.5	20.1	18.8	
Years since first inhalant use				NS
1	43.5	41.2	46.0	
2	23.5	24.3	22.6	
≥ 3	33.0	34.5	31.4	

Note: NS = $p > .05$.

^a A total of 36 inhalant users (18 males and 18 females) did not report type of inhalants used and were excluded from the analysis.

TABLE 3
 Past-Year Prevalence of Inhalant Abuse and Dependence Among Adolescents Aged 12–17 ($N = 36,859$)

Past-Year Prevalence (%)	Overall	Male	Female
Prevalence among all adolescent respondents			
Dependence	0.2	0.2	0.1
Abuse	0.2	0.2	0.2
Prevalence among past-year inhalant users			
Dependence	4.3	4.4	4.2
Abuse	6.3	5.9	6.8

Note: There was no significant gender difference in the prevalence of abuse and dependence.

TABLE 4
Unadjusted Odds Ratios and Adjusted Odds Ratios of Past-Year Inhalant Abuse and Dependence Among Past-Year Inhalant Users Aged 12–17 ($N = 1,313$)

Multinomial Logistic Regression	Unadjusted Model		Final Adjusted Model ^a	
	Abuse OR (95% CI)	Dependence OR (95% CI)	Abuse AOR (95% CI)	Dependence AOR (95% CI)
Age group				
12–13 yr vs. 16–17 yr	1.0 (0.5–2.0)	2.0 (0.9–4.7)	—	—
14–15 yr vs. 16–17 yr	1.1 (0.6–2.2)	1.8 (0.7–4.7)		
Gender				
Male vs. female	0.9 (0.5–1.5)	1.1 (0.6–2.2)	—	—
Race/ethnicity				
White vs. black	1.0 (0.3–3.1)	0.5 (0.2–1.4)	—	—
Hispanic vs. black	1.8 (0.5–6.7)	0.7 (0.2–2.4)		
Others vs. black	1.2 (0.3–5.6)	0.6 (0.2–3.3)		
Family income				
\$0–\$19,999 vs. \$75K+	1.6 (0.7–3.7)	3.9 (1.0–15.3)	—	—
\$20K–\$39,999 vs. \$75K+	1.4 (0.6–3.1)	5.1 (1.4–18.2)		
\$40K–\$74,999 vs. \$75K+	1.4 (0.7–3.0)	3.6 (0.9–14.5)		
Population density				
Large metro vs. nonmetro	2.0 (1.0–3.8)*	1.0 (0.4–2.3)	2.4 (1.1–5.2)*	0.9 (0.4–2.1)
Small metro vs. nonmetro	1.4 (0.7–2.9)	1.0 (0.5–2.0)	1.3 (0.5–3.3)	0.9 (0.4–2.1)
Use of mental health services				
Yes vs. no	2.5 (1.4–4.5)**	4.5 (2.3–8.9)***	1.9 (1.0–3.7)*	2.4 (1.2–4.7)**
History of incarceration				
Yes vs. no	1.2 (0.7–2.3)	2.7 (1.0–7.0)*	—	—
History of foster care placement				
Yes vs. no	2.7 (1.0–7.2)	12.5 (4.9–31.9)***	1.3 (0.4–3.7)	4.9 (1.9–13.1)***
No. of delinquent behaviors				
1–2 vs. none	2.6 (1.2–5.8)*	1.3 (0.4–3.6)	2.1 (0.9–5.1)	1.4 (0.6–3.4)
≥ 3 vs. none	5.9 (2.7–12.9)***	3.6 (1.1–11.4)*	2.9 (1.1–7.6)*	1.7 (0.6–4.5)
Alcohol abuse/dependence				
Yes vs. no	3.0 (1.7–5.2)***	4.3 (2.2–8.4)***	—	—
Past-year use of other drugs				
1 drug vs. no	1.7 (0.8–3.7)	1.4 (0.5–4.1)	—	—
2 drugs vs. no	2.6 (1.1–6.1)*	4.1 (1.2–14.1)*		
≥ 3 drugs vs. no	3.7 (1.8–7.7)***	4.7 (1.9–11.6)***		
Other drug abuse/dependence				
1 drug vs. no	2.1 (1.0–4.3)	2.3 (1.0–5.5)	1.6 (0.7–3.6)	2.0 (0.8–5.1)
2 drugs vs. no	4.8 (2.0–11.5)***	12.0 (4.3–33.6)***	3.7 (1.4–9.9)**	8.9 (2.8–28.3)***
≥ 3 drugs vs. no	17.9 (8.0–40.3)***	24.2 (9.6–61.3)***	8.4 (3.6–19.7)***	11.8 (3.3–42.4)***
Use of inhalants weekly				
Yes vs. no	2.0 (1.1–3.6)*	4.4 (2.1–9.1)***	1.4 (0.7–2.6)	2.6 (1.1–5.8)*
Age at first inhalant use				
<13 yr vs. 15–17 yr	0.9 (0.5–1.9)	5.3 (1.9–14.5)***	0.8 (0.4–1.8)	5.1 (1.4–18.0)**
13–14 yr vs. 15–17 yr	1.1 (0.6–2.3)	5.1 (1.7–15.9)**	1.1 (0.4–1.8)	6.0 (1.7–21.3)**
No. of inhalants used				
2 vs. 1	4.0 (1.7–9.5)**	0.9 (0.2–3.7)	4.2 (1.5–11.4)**	1.0 (0.3–3.2)
≥ 3 vs. 1	4.5 (2.1–9.5)***	3.0 (1.0–8.5)*	3.7 (1.4–9.3)**	1.4 (0.5–3.8)
Survey year				
2000 vs. 2001	1.3 (0.6–2.6)	0.7 (0.4–1.2)	—	—

Note: OR = odds ratio; AOR = adjusted odds ratio; 95% CI = 95% confidence interval.

* $p \leq .05$;

** $p \leq .01$;

*** $p \leq .001$.

^aThe adjusted logistic regression model includes the variables that were found to be associated with inhalant abuse or dependence.