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Reliability of Use, Abuse, and Dependence of Four Types of Inhalants in Adolescents and Young Adults

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Abstract

Inhalants, as a class of drugs, consists of heterogeneous substances that include some of the most dangerous drugs on a per use basis. Research on inhalant abuse has lagged behind other drugs partly because of the need for a diagnostic instrument of different types of inhalants. This study was conducted to obtain reliability estimates for the new Substance Abuse Module DSM-IV inhalants diagnoses for four types of inhalants: aerosols, gases, nitrites, and solvents as well as different diagnostic configurations of inhalant use. Participants were 162 community sample adolescents or young adults (mean age = 20.3 years, SD = 2.4). Two-thirds of the sample was male and 83.3% was Caucasian. Kappas and intraclass correlation coefficients were computed to estimate test-retest reliabilities. Results suggested (a) abuse was more common than dependence (34.6% vs. 12.3%), (b) reliabilities of abuse criteria and diagnosis were good to excellent across subtypes, and (c) reliabilities of dependence criteria and diagnoses were poor to good across subtypes. Alternative configurations of DSM-IV criteria that were consistent with previous research on adolescents provided excellent reliabilities across subtypes of inhalants. Moreover, 11.1% of participants experienced inhalants withdrawal.

Keywords

Inhalants; Abuse; Dependence; Epidemiology; Reliability

1. Introduction

Inhalant use increases the risk of numerous serious medical illnesses, even death. Inhalants can be especially dangerous to young adolescents. Monitoring the Future data indicate about 17% of U.S. eighth graders (about 14 years of age) have used an inhalant (Johnston et al., 2006). Moreover, inhalant addiction has been demonstrated to occur (Anthony et al., 1994;Howard et al., 2001). However, compared to other abused substances, research and treatment regarding inhalant abuse have advanced little and often are conducted as an adjunct to a different topic (Balster 1998;Ridenour, 2005;Sakai et al., 2004).

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Inhalants constitute a unique class of substances in several ways. They are legal for all ages. Inhalants are easily accessible in the home, school, and workplace. Trends in prevalence and use are dissimilar to other substances (Johnston et al., 2006). Diagnosis of inhalant use or even abuse may be impossible without the self-report of the user, although practical, efficient use of blood assays may be available soon (Broussard, 2000;Broussard et al., 2001;Wasfi et al., 2004). However, until this spectrometry technique is fully developed, diagnoses related to use of inhalants will rely on diagnostic interviews. Moreover, the class of substances called inhalants encompasses several types of substances that differ considerably.

1.1. Inhalants Classifications

The most widely-recognized classification of inhalants is endorsed by the National Institute on Drug Abuse: volatile solvents, aerosols, gases, and nitrites (NIDA, 2000). The NIDA categories are slightly more specific than DSM-IV nomenclature, which specifies inhalants as including aerosols and solvents; diagnoses consequent to use of gases and nitrites are allocated to “other” substances (APA, 1994). Volatile solvents are liquids that vaporize upon opening and include adhesives, correction fluids, felt-tip markers, fuels, and paint thinners and removers.

Aerosols consist of sprays that contain both propellants and solvents including personal hygiene products (e.g., deodorants and hair spray), spray paint, and household products (e.g., fabric protector or cooking oil). Gases include products that contain gases (butane lighters, propane tanks, and refrigerants) and medical anesthetics such as ether, chloroform, halothane and nitrous oxide. Nitrites (“poppers”) consist of cyclohexyl nitrite, amyl (or isoamyl) nitrite, or butyl (or isobutyl) nitrite. In contrast to the other inhalants, nitrites are believed to generate their effects as smooth muscle relaxants and are used primarily to enhance sexual experience. Some products are sold primarily for recreational use of nitrites including Rush, Locker Room, and Climax.

Balster (1998) offered an important alternative classification of inhalants based on their pharmacological and subjective effects: alkyl nitrites and nitrous oxide versus other volatile substances consisting of volatile solvents, gases, and anesthetics. Balster suggested that the grouping of volatile solvents, gases and anesthetics can be further subdivided when more is known about their neuropharmacological and behavioral effects (Paez-Martinez et al., 2003). The psychometrics may differ between NIDA, DSM-IV, and Balster’s classifications.

Solvents, aerosols, and gases are thought to generate their effects through the central nervous system whereas the effects of nitrites are primarily as smooth muscle relaxants and are most frequently used to enhance sexual experience (Balster, 1998;NIDA, 2000). Little research has been conducted to understand how the four types of inhalants differ in human subjective experience and addiction. Before such research can be conducted, sound assessments of each type of inhalant are needed. Such assessments are badly needed, considering the serious consequences that can occur from inhalant misuse.

1.2. Medical Consequences of Inhalant Use and Abuse

Numerous acute and chronic medical consequences can result from inhalant use (Anderson and Loomis, 2003). Bodily injury can be incurred to skin (e.g., burns, dermatitis, hypothermic injuries from propellants), cardiovascular tissue and function, the lungs (emphysema and pneumonia), and immune system functioning (Archibald et al., 1992;Moss et al., 1987;Pauk et al., 2000;Soderberg, 1994;1999;2004). Liver toxicity, metabolic acidosis or alkalosis, bone marrow suppression and anemia, leukemia, acute renal failure and Fanconi’s syndrome can result from long-term use of inhalants. Death can result from anoxia, aspiration, asphyxia, cardiac arrhythmias, respiratory depression and accidental trauma. “Sudden sniffing death

syndrome" can occur during inhalant intoxication when an inhalant user is startled. This appears to be due to release of large amounts of catecholamines, which induce ventricular fibrillation.

The most commonly reported consequences of inhalant use are neurotoxicity and neuropsychiatric side effects (Anderson and Loomis, 2003). Additional psychological correlates of inhalant use are: increased risk for major depression and suicide (Sakai et al., 2004;Yip et al., 2004), "binge" drinking (Carlini-Marlatt et al., 2003), institutionalization in a shelter or delinquency (Carlini-Marlatt et al., 2003;Ferigolo et al., 2004;Howard and Jenson, 1999;Wu et al., 2005), impaired learning and memory (Cairney et al., 2002;Paez-Martinez et al., 2003), and inhalant addiction (Anthony et al., 1994;Howard et al., 2001). Adolescent inhalant use also is associated with having more substance use disorders, even compared to adolescents with addiction but do not use inhalants (Sakai et al., 2004;Wu and Howard, 2007;Wu et al., 2005).

Clearly, a need exists for psychometrically sound assessments of clinically significant inhalant use. Moreover, the neurological and psychiatric symptomotology experienced from inhalant abuse may interfere with accurate assessments (e.g., poor memory of inhalant criteria due to neurotoxicity or depression). Hence, results of psychometric studies with other drugs cannot be assumed to generalize to inhalants-related diagnoses.

1.3. Previous Evaluations of Inhalant Diagnostic Assessments

Little data exist to estimate the reliability of inhalants-related diagnoses. Cottler and colleagues (1989) reported the test-retest reliability of the Substance Abuse Module (SAM) DSM-III-R lifetime inhalant abuse or dependence for 39 adults recruited from St. Louis drug treatment centers. A single category of "inhalants" was described using examples of "glue, toluene, gasoline, paint" in the SAM. The sample was 74% males and 62% Caucasians. Neither abuse nor dependence was reported by 37 of the participants at both interview times and one of the diagnoses was reported by the remaining two participants at both interviews (suggesting perfect reliability). Using the DSM-IV Substance Use Field Trial dataset, Howard and colleagues (2001) reported the pairwise comparisons of SAM inhalant diagnoses between the DSM-III-R, DSM-IV, and ICD-10 nosologies for 76 inhalant users. Kappas for agreement in lifetime diagnoses between DSM-III-R and DSM-IV was .62 (.48–.76), DSM-III-R and ICD-10 was .76 (.64–.88), and DSM-IV and ICD-10 was .57 (.43–.71).

Even with these promising results, the SAM inhalants section could be improved. One illustration of how SAM questions could be improved for assessment of inhalant use-related disorders is that the formal examples provided for "inhalants" included glue, toluene, gasoline, and paint whereas amyl nitirite, poppers, and nitrous oxide (somewhat widely used inhalants) are listed under the category of "other drugs."

1.4. Need for Adolescent Samples

Inhalant use is most prevalent in young adolescents (Johnston et al., 2006) and decreases significantly more after early adulthood (Wu and Ringwalt, 2006). Recent studies have demonstrated that DSM-IV substance use-related criteria function differently in adolescents than in adults (Feingold and Rounsaville, 1995;Fulkerson et al., 1999;Muthen et al., 1993;Ridenour et al., 2002). Hence, research to estimate reliabilities of inhalant-related nomenclature optimally would involve inhalant use during adolescence.

1.5. Present Study

The present study was conducted to estimate the reliability of the SAM to assess use, abuse, and dependence of four types of inhalants as well as summative inhalants diagnoses. This study

is the first to our knowledge to test DSM-IV based diagnostic criteria for subtypes of inhalants. It also is the first to estimate reliabilities of DSM-IV inhalants nomenclature in adolescents. Given the discrepancies between abusers of inhalants and abusers of other drugs, it is possible that the SAM's good to excellent reliabilities of diagnoses associated with other drugs does not generalize to inhalant use-related diagnoses (Compton et al., 1996b;Cottler et al., 1989;Horton et al., 2000;Ridenour et al., 2002). Moreover, much less psychometric research has been conducted related to inhalant use compared to use of other drugs. The availability of a psychometrically good assessment of inhalants-related diagnoses will advance inhalants science and facilitate additional research on inhalants.

2. Methods

2.1 Participants

At the first assessment, data were collected from 162 community-recruited participants. Of these, 155 (95.7%) completed the time 2 assessment. Demographic characteristics of the sample are presented in Table 1. Males comprised 66.7% of the sample. The ethnic composition of the sample was 83.3% Caucasian, 3.7% Asian, 1.9% Hispanic/Latino, 1.2% African-American, and 9.9% other ethnicities or mixed ethnicities. Participants had a mean age of 20.3 years (SD=2.4), most were educated through the high school level (70.3%), and most had an annual income of less than $11,000 (69.6%). In addition, large proportions of this sample had experienced DSM-IV abuse or dependence consequent to use of tobacco (67.3%), alcohol (82.7%), and cannabis (84.0%).

2.2 Procedures

All procedures were approved by the Washington University School of Medicine and the Pennsylvania State University Institutional Review Committees prior to recruiting any participants. The full protocol was described at the screening stage and again at the time 1 interview. Prior to participation, respondents were informed of the confidentiality issues and told that no information would be shared with family, treatment providers or anyone else outside of the research office. All participants signed IRB-approved informed consent forms, after the forms were read. Data were protected using a NIDA Certificate of Confidentiality. Different interviewers conducted time 1 and time 2 interviews for each participant to prevent interviewer bias from interfering with reliability estimates. However, assignments of interviewers were otherwise unsystematic. Respondents were told that since interviewers would be blind to answers from previous interviews, questions should be answered as if they were hearing them for the first time. Eligibility criteria were: (a) an inhalant user, defined as a lifetime use of any type of inhalant more than 5 times, (b) 15 to 25 years of age, (c) signed parental permission for non-emancipated respondents less than 18 years of age, (d) English speaking, and (e) willingness to participate in potentially 3 interviews within a 10 day period.

The community sample of inhalant users was recruited from the St. Louis, Missouri region. Recruitment occurred using three techniques, including community flyers (n=131), friend referrals (n=27), and from addiction treatment settings (n=4). Flyers described the study, the required consents (e.g., minors had to have parental permission), and provided contact information to enroll and determine study eligibility. Flyers were strategically placed in locations, based on previous successful recruitment of users of other types of drug users.

Persons who were interested in participating were screened to include only persons who met eligibility criteria. Interviews were conducted by telephone from the Epidemiology and Prevention Research Group research offices of Washington University for the convenience of study participants. Notably, recruitment of inhalant users required more effort than same-age users of other drugs recruited by the Epidemiology and Prevention Research Group for their

past studies. Participants were told that they had to not be using substances at the time of the interview, however, it is possible that substance use or even intoxication went undetected by interviewers. Participants were remunerated $10 at the time 1 interview and $40 at the time 2 interview.

2.3 Instrument

2.3.1 Substance Abuse Module (SAM)—The SAM is a revised and expanded version of the substance abuse section of the Composite International Diagnostic Interview (Cottler and Compton, 1993;Cottler et al., 1989). The SAM assesses substance use disorder criteria based on the DSM-III-R, DSM-IV and ICD-10 nomenclatures. Diagnoses for lifetime or preceding 12 months can be assessed for tobacco, alcohol, prescription psychoactive medications, amphetamines, caffeine, cannabis, "club" drugs, cocaine, hallucinogens, inhalants, opiates, PCP, stimulants, sedatives and other, miscellaneous substances. The SAM includes questions regarding ages of onset and most recent occurrence of each criterion, individual withdrawal symptoms for each substance, and quantity and frequency of use.

The SAM provides excellent reliabilities for DSM-IV substance use related criteria, good to excellent reliabilities for substance use dependence, and fair to excellent reliabilities for ICD-10 dependence diagnoses (Compton et al., 1996a,b;Cottler et al., 1989;Horton et al., 2000). Reliability estimates have been obtained for samples of African Americans, Caucasians, drug users in treatment, and community samples (Compton, et al., 1996b;Cottler et al., 1989;Horton et al., 2000). The SAM has been used in numerous nosological studies of substance use classification (e.g., Cottler et al., 1995;Cottler, et al., 1995;Langenbucher, et al., 1997;Langenbucher, et al., 2000).

One area that could be improved in the SAM is to expand the inhalants section to obtain more detailed information about subtypes of inhalants. Given the history of SAM diagnoses being reliable and valid, wording of inhalant questions were highly similar to questions used for other substances. Hence, the greatest revision to the version of the SAM used here was separation of specific types of inhalants into four categories (aerosols, gases, nitrites, and solvents). This alteration distinguishes the SAM as the only assessment to diagnose abuse and dependence related to the four individual types of inhalants. Algorithms for general categories of abuse and dependence across all inhalant types, as well as for specific types of inhalants, were generated using the same methods that have been used with 12 other categories of substances for over 15 years.

2.3.2 Discrepancy Interview Protocol (DIP)—DIPs (Cottler et al., 1994) were conducted using 17 representative items of the SAM inhalants questions. The DIP is used to query participants who provide discrepant responses in test-retest studies to clarify reasons for the discrepancies. After the retest interview was completed, the interviewer (who was blinded to the information given at time 1) opened a file that contained the time 1 responses to the 17 pre-determined questions. (S)he then compared time 1 and 2 responses for concordance. For each inconsistent response, the time 2 interviewer reminded the respondent of both answers and asked the respondent to estimate the correct answer as they knew it at that time. No data from either interview are changed in the database. After this reconciliation, the interviewer asks respondents for the reason(s) that responses were different. The reasons were then coded. In past studies, the most common reasons have been: "I didn't understand the question" and "I thought about this question since my last interview".

2.4 Analyses

Internal consistency estimates were Cronbach's alpha (Cronbach and Shavelson, 2004). Two estimates of test-retest reliability were computed, kappa and intraclass correlation (ICC). It has

been argued that kappa estimates are unstable when the proportion of a sample with the characteristic is either high or low (Spitznagel and Helzer, 1985). It has been argued that Yule's Y provides more robust estimates than kappa when prevalence of a diagnosis is very high or very low in a sample (Spitznagel and Helzer, 1985). However, Yule's Y appears to be as unstable as kappa for characteristics that are high or low in prevalence (Shrout et al., 1987). Because kappa is the commonly used statistic for psychiatric diagnostic interviews of substance use disorders, kappas were used presently. Kappas of 0.76 or greater are excellent, 0.4 to 0.75 are good, and 0.39 or less are poor (Bishop et al., 1975).

ICCs were computed for estimation of test-retest reliability within a psychological assessment context, based on the assumption that responses are ordinal. ICC has been promoted as the best reliability estimate (Cicchetti, 1994) and specifies measurement variance due to between-person differences (Fleiss, 1981). ICC corrects for chance agreement, requires not only consistent rank order of scores but also consistency in scores, and is more conservative than correlation based estimates such as Pearson *r* (Cicchetti, 1994). ICCs of 0.76 or greater are excellent, 0.6 to 0.74 are good, 0.4 to 0.59 are fair, and 0.39 or less are low (Cicchetti, 1994). Reliabilities were estimated separately for individual criteria, diagnoses of the four inhalants types, and for a pooled set of criteria and diagnoses that could be met by experiencing them related to use of any one the four types of inhalants.

It should be noted that under the circumstances of this study, kappa and ICC estimates are expected to be similar (and were), based on methodological and statistical comparisons of the two techniques (Fleiss and Cohen, 1973;Jakobsson and Westergren, 2005;Nam, 2003;Schuster and Smith, 2005). Importantly, the two estimates of reliability provide professionals from disparate orientations with a metric that they are familiar and can readily compare results of this study to their own fields' bodies of research. For simplicity of presentation, only the kappa coefficients were presented, noting that ICC estimates are very similar.

To identify reasons for inconsistent responses between time 1 and 2 interviews, DIP responses were analyzed. Reasons for discrepant responses were summarized in terms of the total number of times and total number of items (out of 17 items) for which each reason was given for discrepancies.

3. Results

Sample demographics and lifetime disorders related to the three most common substances (alcohol, cannabis, and tobacco) are reported in Table 1. Given past findings that males more frequently use inhalants than females, it was not surprising that 2/3 of the sample was male. However, it was surprising that the proportion of participants who were African-American (1.2%) was much less than the prevalence of at least 50% African-American in the greater St. Louis region (stlouis.missouri.org/census/Census2000Report1.pdf). Mean annual income and age of the sample probably reflected the sampling design as well as the population of inhalant users. The mean age of first use of an inhalant was 15.8 years (SD=2.79). Among study participants, experiencing addiction related to use of tobacco, alcohol, and cannabis was far more common than not experiencing these disorders.

3.1 Use and Diagnoses Frequencies

Included in the sample were 142 users of gases, 75 aerosol users, 59 solvent users, and 19 users of nitrites. A mean of 6.92 days (SD = 1.43 days) separated test and retest interviews. The range of period between interviews was 4 to 13 days, 94.2% were completed between 5 and 10 days. Most participants used more than inhalant. Seven used only aerosols and 56 used only gases; the remaining participants used two or more of the four types of inhalants. Zero participants used only nitrites.

Table 2 presents the proportions of the users of groupings of inhalants with each DSM-IV abuse or dependence criterion and diagnosis. DSM-IV abuse diagnosis (excluding persons who also qualified for dependence diagnosis) was met by 27.9% of the sample related to use of any inhalant. Qualifying for abuse diagnosis regardless of whether dependence criteria were met (i.e., dismissing the "exclusion criterion") occurred in 34.6% of the sample.

Differences in the proportions of the sample meeting abuse criteria for the four types of inhalants resembled the differences in the number of users of each type. Use of inhalants in hazardous situations was the most prevalent abuse criterion for each inhalant type as well as when criteria were collapsed across inhalant types (29.0%). Legal problems resulting from inhalant use was the rarest criterion (1.9% across inhalants).

Inhalant dependence diagnoses were met by 12.4% of the sample. Differences in the proportions of the sample with dependence for the four types of inhalants were roughly proportional to the number of users of each inhalant type. Withdrawal or tolerance was experienced by more participants (19.8%) than those who met criteria for dependence.

Certain dependence criteria were more prevalent than other criteria and the rank order of prevalences of dependence criteria generally was consistent across inhalant types. Use of inhalants in spite of a known physical or psychological problem that is caused by inhalant use was the most prevalent dependence criterion (58.6%). The second most prevalent dependence criterion was using inhalants in greater quantity or for a longer time than was planned (30.3%). Reduction in important activities in order to use inhalants was the least prevalent dependence criterion (1.9%).

3.2 Internal Consistencies of DSM-IV Inhalant Nomenclature

Few nitrite users were recruited (n=19). Consequently, nitrite-related nomenclature was excluded from reliability analyses. Internal consistencies of psychological measures traditionally are estimated using Cronbach's alpha (Cronbach and Shavelson, 2004). Alpha results of this study reflect one of the shortcomings of alpha for estimating internal consistency (Cronbach and Shavelson, 2004;Nunnally and Bernstein, 1994), which is that alpha is penalized heavily when a measure has fewer than eight items (Table 3). Compared to the traditional level of acceptable alpha (between 0.60 and 0.70), internal consistencies of the entire set of criteria were acceptable whereas the dependence criteria alone and abuse criteria alone were lower. However, after accounting for the number of criteria used for each diagnosis (e.g., using mean interitem correlations), internal consistencies of abuse and dependence criteria resembled those of all criteria. Alphas of criteria related to use of gases were slightly greater than alphas related to use of aerosols or solvents.

Internal consistencies of diagnostic criteria also can be examined using a common psychometric statistic, the item-total correlation, which routinely is computed with alpha to identify specific items that are inconsistent with other items. No standard threshold exists to identify items that do not load onto the same construct as other items in an instrument. For the purposes of this study, coefficients less than 0.20 were considered "low." As results in Table 4 demonstrate, a single dependence criterion, giving up important activities to use inhalants, had coefficients less than 0.20 consistently across inhalant type when only dependence criteria were analyzed. This result did not occur when all inhalants criteria were analyzed, suggesting that inhalants criteria align onto a single latent construct.

3.3 Test-retest Reliabilities of DSM-IV Inhalants Nomenclature

Test-retest estimates for criteria and diagnoses were similar for kappa and ICC estimates (Table 5). Only kappa coefficients were presented to avoid having readers digest twice the number of

coefficients while providing no additional information. ICC estimates were within two 100ths of the coefficients presented in Table 5. Test-retest reliabilities for abuse diagnosis (not using the exclusion criterion for dependence) were good to excellent, except for solvents, which was fair. Test-retest reliabilities for dependence diagnoses, when collapsed across all inhalant types, collapsed across non-nitrites, and for use of gases were in the low good range. For solvents and aerosols, test-retest reliability of dependence was poor. However, test-retest estimates for the dependence diagnoses partly were due to the low prevalence of dependence in this sample (Shrout et al., 1987;Spitznagel and Helzer, 1985). An example of this point was that lower reliabilities were observed for solvents, which also had the lowest prevalences of criteria and diagnoses in the sample.

Test-retest reliabilities varied considerably between criteria. Many test-retest estimates for individual criteria were less than adequate, primarily for dependence-related nomenclature (Table 5). Lower estimates generally corresponded with criteria and diagnoses that were lower in prevalence. For example, abuse diagnosis related to use of any inhalant was experienced by 34.6% of participants and had test-retest reliabilities of 0.78 (excellent). In contrast, only 12.3% of the sample experienced dependence related to use of any inhalant and the test-retest reliability for dependence diagnoses was 0.47 (low good). Patterns in results were similar when the types of inhalants were categorically combined according to the DSM nomenclature, as non-nitrites, or as a single summative category.

3.4 Reliabilities of Alternative Inhalant Use Nomenclatures

Except for solvents, test-retest reliabilities of having any diagnosis (i.e., qualifying for either abuse or dependence) related to specific types of inhalants or across any combination of inhalant were good to excellent (Table 5). Test-retest reliabilities of abuse and total criteria counts were good to excellent except for solvents, which were high fair. For counts of dependence criteria, test-retest reliabilities were high fair to good, except for solvents, which was fair. The test-retest reliabilities of the age of onset of use were excellent for all categories of inhalants.

3.5 Sources of Unreliability

Table 6 presents the reasons given by participants for discrepancies in responses between time 1 and 2 interviews. A total of 177 discrepant responses were given on the 17 DIP items. The most common reasons given for discrepant responses were that the participant could not recall the correct answer at one interview (n=37 or 20.9%) or misunderstood the question at one interview (n=37 or 20.9%). The second most common reason cited for discrepant answers was misunderstanding the question at both times (n=22 or 12.4%) with not being able to specify a reason for discrepant responses given almost as frequently (n=21 or 11.9%). The fifth most common reason given for a discrepant answer was inattention during an interview.

A variety of miscellaneous reasons not listed in the standard DIP protocol were cited by participants (n=41 or 23.2% total). Nineteen of the 41 miscellaneous reasons consisted of recall difficulties (memory) during the first interview, poor concentration, or confusion. Other reasons included not being able to determine if the effect was due to inhalants or some other drug (n=10), was high at one of the interviews (n=2), or being fatigued by that time in the interview (n=3).

4. Discussion

This study was the first to estimate the psychometrics of DSM-IV nomenclature for different types of inhalants. It also was the first to estimate psychometrics of DSM inhalants-related nomenclature in adolescents. By far, the most prevalent criterion in this sample was a

dependence criterion, inhalant use in spite of known physical or psychological problems related to use (58.6%). The third most prevalent criterion was an abuse criterion, use of inhalants in hazardous situations (29.0%). These results suggest that inhalants users commonly exhibit thrill seeking or a disregard for harmful consequences of their behavior. The "hazardous use" criterion may partly be due to inhalant users' perceptions, although examples appear with the question. A commonly used supplemental datum about a person's substance use history is age of onset of use. Age of first use of inhalants had excellent reliabilities for all inhalants types.

Many dependence criteria had low prevalences, which appeared to interfere with reliability estimates. However, this result also may reflect the experience of inhalant users. Perhaps dependence is much rarer among inhalant users than dependence occurs in users of other substances. In focus groups conducted partly toward preparation of the version of the SAM used in this study, inhalant users stated they used inhalants primarily in three scenarios (Chandler-Ezell et al., 2005). First, inhalants were used on rare occasions as a fun activity. Second, inhalants were used either in place of another substance until that substance could be obtained or to alter the subjective effect of that substance. Third, inhalants were used in day-long binges (and not on the next day nor for the next several days). Inhalant bingers explained that it required at least one day to recover and they felt physically slow and "stupid" in the sense that their thinking was slow and inaccurate. Perhaps it is difficult to use inhalants frequently enough to experience DSM-IV defined dependence either for physical reasons or because more subjectively preferable substances are available.

Another finding of this study was that, from a psychometric perspective, nomenclatures other than DSM-IV might better diagnose inhalant use-related pathology. In addition to the low prevalences and consequential low reliabilities of diagnoses, much better reliabilities were found for (a) composite diagnoses (i.e., qualifying for either abuse or dependence), (b) symptom counts, and (c) abuse diagnoses ignoring whether an individual qualified for dependence. Of the 20 participants who qualified for dependence on any type of inhalant, 12 of them also qualified for abuse. Hence, although the abuse diagnoses provided superior reliability, they were insufficient for capturing all persons with pathological inhalant use.

It would be helpful in future research to examine an alternative configuration of criteria for inhalants. For example, perhaps recategorizing the seventh dependence criterion (use in spite of knowing a physical or psychological problem is caused by inhalants) as an abuse criterion would permit the abuse diagnosis to capture all pathological users. In the 12 participants qualifying for dependence related to use of gases, nine experienced the seventh dependence criterion. In the six participants who qualified for dependence related to use of aerosols, five experienced the seventh dependence criterion.

4.1 Implications for Assessment of Harmful Inhalant Use

The well-documented psychometrics of SAM diagnoses for other substances begs the question of why lower reliabilities of dependence diagnoses were found for inhalants. The following reasons were cited by many participants as causes of discrepant responses at the two interviews: failing to recall the correct answer at one interview, misunderstanding the question at one or both interviews, inattention, confusion, and not being able to specify a reason for discrepant responses. All of these sources of unreliability implicate cognitive or neuropsychological deficits. The role of neuropsychological deficits as a specific source of measurement error in inhalant-related pathology should be clarified, especially in light of the documented neuropsychological damage caused by inhalant abuse such as memory and inattention (Cairney et al., 2002;Paez-Martinez et al., 2003). Cognitive functioning was not assessed as part of this study. Post hoc analyses for Table 5 were repeated only with participants who experienced one or more criteria to estimate if severity of inhalant involvement impacted test-retest reliabilities, however, results resembled those in Table 5. Other possible factors were the telephone

interview format, a younger sample than other studies, or possible drug use during interviews (although the latter was denied by all but 2 in debriefings).

4.2 Implications for Inhalants-related Diagnoses in Adolescents

These results suggest that alternatives to the DSM-IV inhalants-related dependence diagnoses are needed, at least for adolescents. A number of alternatives are suggested by these results. Use of a diagnosis that could be met either by DSM-IV abuse or dependence provides better test-retest reliability than either the abuse or dependence diagnoses alone. A continuous alternative with good to excellent test-retest reliability was a count of the criteria related to inhalant use. Given the dangers associated with inhalant use, perhaps binging or number of uses within a certain period of time could serve to identify pathological use of inhalants.

Similar revisions have been recommended for adolescents related to other drugs. Several studies have led researchers to recommend combining DSM-IV abuse and dependence criteria into a single category for adolescents and differentiating abuse from dependence in terms of the number of criteria experienced (Feingold and Rounsaville, 1995;Fulkerson et al., 1999;Muthen et al., 1993). Factor analyses, latent class analyses, and item response theory analyses of DSM-IV substance use criteria consistently suggest a single factor underlies DSM-IV substance use criteria (Fulkerson et al., 1999;Chung and Martin, 2001;Storr et al., 2004;Wells et al., 2004).

An important implication of the present study extends to diagnostic nomenclature beyond adolescents. DSM-IV criteria mention a withdrawal syndrome that is unique to inhalant users 24–48 hours after cessation of use, a time period resembling the binge recovery period described by participants in this study (Section 4.0). However, in contrast to the conclusion drawn in the DSM-IV that a withdrawal syndrome does not occur related to inhalant use (p. 238), 11.1% of participants in this study reported experiencing withdrawal symptoms.

The more common withdrawal symptoms reported by participants from aerosol use were headaches (n=9), nausea or vomiting (5), hallucinations (4), runny eyes or nose (4), and 3 each for craving, fast heart beat, depressed mood, anxiety, and trembling or twitching. These data pertaining to use of gases were headache (18), craving (10), hallucinations (8), fatigue (6), anxiety (6), nausea or vomiting (5), and trouble concentrating (5). Regarding solvents, withdrawal symptoms reported included headaches (9), nausea or vomiting (8), fatigue (6), trouble concentrating (6), runny eyes or nose (6), and anxiety (6). In addition, five participants reported using gases to avoid withdrawal symptoms. These data suggest withdrawal can occur consequent to inhalants use, although compared to other drugs, it results from contiguous use over a shorter time (one day of binging) and lasts for a shorter period (one or two days).

4.3 Limitations

Results and implications of this study should be considered in light of its limitations. Data were retrospective. At this stage in research on DSM-IV diagnoses pertaining to types of inhalants, it would be unwise to conduct longitudinal research. Nevertheless, obtaining data similar to those reported here over the course of longitudinal design could strengthen time-related findings, such as the age-of-onset data. The sample largely consisted of Caucasians and males and was recruited from urban and suburban areas. Perhaps inhalants are used much less frequently by African-Americans in the St. Louis region than by Caucasians (a small prevalence of Latinos reside in the St. Louis region). It is possible that recruiting techniques led to under-representation of African-American inhalant users. If this is the case, this effect of recruiting method on reduced inclusion of minority participation is likely restricted to inhalants (cf. other drugs), given the past success of this research team in recruiting minority users of other substances. How well these results generalize to other ethnic groups (e.g., Hispanics), females,

and adolescents in rural locations will be important to delineate. It also will be important to obtain similar data from clinical populations likely to use inhalants more than the general population (e.g., abusers of other substances, youth exhibiting antisocial behaviors).

Recent studies of DSM nomenclature related to use of other substances have utilized more sophisticated and specialized analytical techniques than reliability (e.g., Chung & Martin, Langenbucher et al., 2004;Ridenour et al., 2005;2003;Storr et al., 2004;Wells et al., 2004). Such studies test aspects of nomenclature such as addiction severities, (dis)similarities between substances, and (dis)advantages of alternative diagnostic configurations. The present study documents reliabilities of inhalant diagnoses and criteria, setting the stage for more advanced nosological research. Thus this study is a necessary, however, not sufficient, start toward comprehensively addressing inhalant use-related nomenclature.

4.4 Study Strengths

This study also had a number of strengths. It provided data from a large number of inhalant users compared to past research. Inhalants assessment was based on the SAM, which has well-documented psychometrics for other substances. For speculation about why dependence criteria and diagnoses were low, the item wording, format, and mode of administration could be eliminated as possible sources of unreliability. Alternative nomenclatures with good psychometrics were identified that may be useful in lieu of dependence diagnoses. Psychometric results were consistent across different types of inhalants. Input from participants for the causes of discrepant time 1 and time 2 responses were obtained.

In sum, abuse diagnoses and many abuse and dependence criteria provide good or better reliability related to use of specific types of inhalants. Caution is warranted regarding inhalants-related dependence diagnoses and certain dependence criteria for adolescents and young adults, based on their low or poor reliabilities in this sample. However, results for dependence nomenclature may be partly due to their low prevalences or consequences of harmful inhalant use (e.g., neuropsychological impairment). Alternative diagnostic configurations with good to excellent reliabilities found in this study included use of an “any diagnosis” category (abuse or dependence) as well as a count of dependence or abuse or all criteria. This study provides a basis for using these alternatives to identify and gauge pathological inhalant use at least for use with adolescents and young adults.

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Table 1

Sample Demographics and Other Drug Disorders

		Percent or Mean (SD)
Gender (Males)		66.7%
Age in Years		20.3 (2.38)
Ethnicity	Caucasian	83.3%
	African-American	1.2
	Other	15.5
Annual household income	$ 0 – 10,999	69.6%
	11,000 – 24,999	21.1
	25,000 +	9.3
Age of 1st Inhalant Consumption		15.8 (2.79)
Tobacco Use Disorder		67.3%
Alcohol Use Disorder		82.7%
Cannabis Use Disorder		84.0%

Note: Percents of categories within a demographic may not sum to 100 due to rounding error. Proportion of sample with a substance use disorder includes abuse, dependence, or both.

Table 2

Proportions of Users of Types of Inhalants Meeting DSM-IV Inhalant Use-related Criteria and Diagnoses for Alternative Groupings of Inhalants

	Combined	Non-nitrites	DSM	Aerosols	Gases	Nitrites	Solvents
A: Role failure	7.4%	7.5%	8.9%	10.7%	4.9%	5.3%	6.8%
A: Hazardous use	29.0	28.1	24.8	20.0	21.1	26.3	20.3
A: Law problems	1.9	1.3	0.0	0.0	1.4	0.0	0.0
A: Social problems	8.6	8.1	8.9	8.0	3.5	5.3	8.5
Abuse-only Diagnosis	27.9	26.9	23.8	25.3	16.9	26.3	17.0
Any Abuse Diagnosis	34.6	33.8	31.7	29.3	23.2	26.3	27.1
D: Tolerance	10.5	10.0	6.9	4.0	6.3	5.3	6.8
D: Withdrawal	11.1	10.0	8.9	6.7	8.5	5.3	11.9
D: More than planned	30.3	29.4	23.8	16.0	21.1	15.8	22.0
D: Failure to control	6.8	6.3	5.0	5.3	3.5	5.3	3.4
D: Requires much time	15.4	15.0	7.9	5.3	13.4	0.0	8.5
D: Activities reduced	1.9	1.9	2.0	0.0	1.4	0.0	3.4
D: Physical or psychological problem	58.6	57.5	41.6	40.0	51.4	42.1	33.9
Dependence Diagnosis	12.4	11.9	10.9	8.0	7.8	0.0	10.2
Physiological Dependence	19.8	18.1	13.9	10.7	14.1	10.5	15.3
Number of Users	162	160	101	75	142	19	59

Note: Except for the row of Number of Users, cell entries are proportions of users at Time 1 (indicated in the bottom row) with the criterion or diagnosis. Any Abuse Diagnosis refers to the proportion of participants that qualified for abuse diagnosis regardless of whether they qualified for dependence. “DSM” consists of a combined category matching DSM-IV defined inhalant disorders (i.e., criteria related to use of aerosols or solvents). “A” indicates a DSM-IV abuse criterion. “D” indicates a DSM-IV dependence criterion. “Non-nitrites” includes DSM-IV criteria related to use of either aerosols, gases, or solvents based on their chemical and pharmacological similarities (Balster, 1998).

Table 3

Internal Consistency (Cronbach's Alpha) Estimates for DSM-IV Inhalant Use-related Criteria and Diagnoses for Alternative Groupings of Inhalants

	All	Non-Nitrites	DSM	Aerosols	Gases	Solvents
Abuse Criteria	0.46	0.44	0.46	0.34	0.51	0.36
Dependence Criteria	0.57	0.57	0.54	0.53	0.51	0.44
All Criteria	0.69	0.68	0.64	0.59	0.67	0.60
Number of Users	162	160	101	75	142	59

Table 4

Item-Test Correlation Coefficient Estimates for DSM-IV Inhalant Use-related Criteria and Diagnoses

	All	Non-nitrites	DSM	Aerosols	Gases	Solvents
Abuse Criteria:						
A: Role failure	0.35	0.38	0.38	0.34	0.52	0.24
A: Hazardous use	0.23	0.21	0.28	0.08	0.25	0.23
A: Law problems A:	0.30	0.25	NA	NA	0.34	NA
Social problems	0.35	0.31	0.24	0.20	0.38	0.19
Dependence Criteria:						
D: Tolerance	0.18	0.21	0.21	0.13	0.19	0.18
D: Withdrawal	0.32	0.28	0.27	0.14	0.25	0.25
D: More than planned	0.46	0.46	0.46	0.50	0.42	0.29
D: Failure to control	0.26	0.25	0.19	0.33	0.21	0.02
D: Requires much time	0.48	0.44	0.36	0.33	0.45	0.32
D: Activities reduced	0.14	0.15	0.13	NA	0.16	0.21
D: Phys/psych problem	0.25	0.28	0.32	0.32	0.17	0.20
All Criteria:						
A: Role failure	0.42	0.42	0.39	0.41	0.51	0.36
A: Hazardous use	0.38	0.35	0.36	0.20	0.41	0.41
A: Law problems	0.27	0.21	NA	NA	0.28	NA
A: Social problems	0.45	0.41	0.27	0.17	0.42	0.23
D: Tolerance	0.21	0.23	0.23	0.19	0.20	0.15
D: Withdrawal	0.39	0.32	0.32	0.32	0.30	0.23
D: More than planned	0.50	0.51	0.52	0.40	0.45	0.48
D: Failure to control	0.34	0.31	0.19	0.30	0.31	0.10
D: Requires much time	0.51	0.49	0.37	0.40	0.50	0.37
D: Activities reduced	0.25	0.26	0.20	NA	0.32	0.30
D: Phys/psych problem	0.23	0.24	0.28	0.26	0.18	0.18
Number of Users	162	160	101	75	142	59

Note: Item-total correlations reflect how closely a criterion aligns with the overall count of the group of criteria. Such estimates are commonly computed for psychometric evaluations of instruments.).
"A" indicates a DSM-IV abuse criterion. "D" indicates a DSM-IV dependence criterion.

Table 5

Test-retest Reliabilities for DSM-IV Inhalant Use Criteria and Diagnoses for Alternative Groupings of Inhalants: Kappa and Intraclass Correlation

	All	Non-Nitrites	DSM	Aerosols	Gases	Solvents
A: Role failure	0.61	0.61	0.50	0.64	0.38	0.40
A: Hazardous use	0.77	0.76	0.69	0.72	0.77	0.52
A: Law problems	0.85	0.80	NA	NA	0.80	NA
A: Social problems	0.78	0.77	0.59	0.79	0.65	0.55
Abuse Diagnosis (any)	0.78	0.77	0.63	0.78	0.81	0.44
D: Tolerance	0.56	0.58	0.47	0.79	0.47	0.19
D: Withdrawal	0.43	0.47	0.59	0.31	0.65	0.77
D: More than planned	0.43	0.43	0.21	0.12	0.48	0.07
D: Failure to control	0.12	0.13	0.32	0.39	−0.02	NA
D: Requires much time	0.49	0.50	0.29	0.17	0.58	0.50
D: Activities reduced	−0.02	−0.02	NA	NA	−0.01	NA
D: Physical or psychological problem	0.50	0.48	0.48	0.36	0.46	0.28
Dependence Diagnosis	0.47	0.49	0.39	0.36	0.47	0.16
Any Diagnosis	0.76	0.75	0.59	0.69	0.82	0.36
Age of Onset of Use*	0.95	0.95	0.96	0.94	0.87	0.91
Count of Abuse Criteria*	0.83	0.76	0.65	0.77	0.78	0.56
Count of Dependence Criteria*	0.65	0.66	0.51	0.55	0.68	0.42
Count of All Criteria*	0.76	0.75	0.59	0.72	0.75	0.51

Note: Cell entries are kappa estimates, except for the starred (*) variables whose cell entries are intraclass correlation coefficients. Kappa interpretation: 0.76 or greater = excellent; 0.4 to 0.75 = good; 0.39 or less = poor. Intraclass correlation coefficient interpretation: 0.76 or greater = excellent; 0.6 to 0.75 = good; 0.4 to 0.59 = fair; 0.39 or less = low. “A” indicates a DSM-IV abuse criterion. “D” indicates a DSM-IV dependence criterion.

Table 6

Study Participants' Reasons for Discrepant Responses to 17 SAM Items

Reasons for Discrepant Responses	Total Times Reason for Discrepancy Cited	%	Total Items for which Discrepancy Occurred	%
Didn't understand the question	22	0.12	11	0.65
Couldn't remember answer at that time	37	0.21	13	0.76
Situation changed between assessments	0	0.00	0	0.00
Response miscoded or misunderstood	0	0.00	0	0.00
Not paying attention on one occasion	11	0.06	7	0.41
Said "no" to shorten the interview	2	0.01	2	0.12
Embarrassed	0	0.00	0	0.00
Doesn't really know the right answer	6	0.03	4	0.24
Understanding of question changed	37	0.21	11	0.65
Don't know	21	0.12	10	0.59
Other	41	0.23	12	0.71
Total	177		17	