

Classification of abused inhalants

Robert L. Balster¹, Silvia L. Cruz², Matthew O. Howard³, Colleen A. Dell⁴ & Linda B. Cottler⁵

Institute for Drug and Alcohol Studies, Virginia Commonwealth University, Richmond, VA, USA,¹ Departamento de Farmacobiología, Cinvestav, Sede Sur, México,² School of Social Work, University of North Carolina, Chapel Hill, NC, USA,³ University of Saskatchewan, Saskatoon, Saskatchewan, Canada⁴ and Epidemiology and Prevention Research Group, Department of Psychiatry, Washington University School of Medicine, St Louis, MO, USA⁵

ABSTRACT

Many hundreds of household and industrial products can be volatilized readily and are subject to abuse. Inhalant abuse research has been hampered by a lack of consensus on whether or not there are subclassifications of abused inhalants based on chemical structure, form or intended use of the product or pharmacological properties. This paper discusses strengths and weaknesses of various approaches to classification of inhalants and suggests areas for future research in this area. It is concluded that classification of inhalants by form or product types is not useful for scientific purposes; rather, subclassification of inhalants should be based on a yet-to-be-determined combination of chemical and pharmacological similarity and shared patterns of abuse. One of the ways in which we can improve our understanding of inhalant abuse is to obtain more detailed information on individual products and chemicals, their patterns of use and the geographical distribution of their use.

Keywords Epidemiology, inhalants, nitrous oxide, nitrites, nosology, solvents, volatile substance abuse.

Correspondence to: Robert L. Balster, Institute for Drug and Alcohol Studies, Virginia Commonwealth University, Box 980310, Richmond, VA 23298-0310, USA. E-mail: balster@vcu.edu

Submitted 10 April 2008; initial review completed 7 July 2008; final version accepted 26 November 2008

BACKGROUND

Inhalant abuse, also referred to as volatile substance abuse or solvent abuse, is a world-wide problem with major consequences for abusers, their families and society. Inhalant abuse is one of the least-understood and poorly studied substance abuse problems. It is particularly difficult to obtain information on specific national patterns of inhalant abuse and the cross-national similarities and differences in the nature and extent of these problems. One of the challenges contributing to this is lack of agreement on the classification of inhalants. Despite the fact that there are hundreds of legal products whose chemical components are subject to inhalant

abuse, there has been no agreement on whether they are a single group or whether subgroupings are warranted. Therefore, it is not uncommon to find in the literature subgroups based on consumer-oriented prevention models rather than on scientific research. This document discusses some of the issues related to the classification of abused inhalants and proposes some steps that might be taken to address the classification issue.

There has long been international consensus on the classification of drugs of abuse. For example, amphetamine-like stimulants, opiates, cannabis and hallucinogens are categories that appear in nearly every survey of drug abuse problems. Often, different groups of scientists are specialists in the study of one or another

The authors are part of the Inhalants Working Group, an *ad hoc* multi-national group of drug abuse researchers formed following the 2005 international meeting, *Inhalant Abuse Among Children and Adolescents*, whose 55 invited participants from 10 nations recommended that an international workgroup of pharmacologists and epidemiologists be created to classify substances and develop questions for use in screening instruments and surveys. That meeting was co-sponsored by the National Institute on Drug Abuse (NIDA) International Program and the John E. Fogarty International Center (FIC) from the United States; the Canadian Institute of Neurosciences, Mental Health and Addiction (INMHA) and the Institute of Aboriginal Peoples' Health (IAPH) at the Canadian Institute of Health Research (CIHR); and the Mexican Consejo Nacional Contra las Adicciones (CONADIC). The authors have worked together through the NIDA International Virtual Collaboratory to engage the international drug abuse research community to further investigate inhalant use. In addition to this paper, the group has presented workshops at the 2007 and 2008 NIDA International Forums and is working with other organizations to gather international data on inhalant abuse.

of these classifications and drug abusers themselves may prefer one class over another. There is evidence that etiological factors differ among classes of drugs as well, in that some separate risk factors have been identified for the abuse of alcohol, tobacco, opioids, stimulants, hallucinogens, inhalants, etc. Thus, there could be important advances in understanding if there were strong scientific support for the further subclassification of inhalants.

DEFINITION OF INHALANTS

There is generally good consensus on what constitutes inhalant abuse. 'Sniffing', 'snorting', 'huffing' (soaking a rag with the abused product and inserting it into the mouth to breathe fumes), 'bagging' (filling a plastic bag with the abused product and holding it over the nose and mouth) and 'spraying' (directly spraying the abused product into oral cavities) describe various routes of administration for inhalants. Inhalant abusers can be identified by clues such as organic solvent odors on the breath or clothes, chemical stains on the clothes or around the mouth and empty spray paint or solvent containers.

DSM-IV [1] defines inhalant abuse and inhalant dependence disorders using the same diagnostic symptom criterion sets employed for other substance use disorders, with the exception that a characteristic withdrawal syndrome (or substance use for relief of withdrawal symptoms) is not included in the inhalant dependence disorder criteria set. The 2007 version of the International Classification of Diseases—10th Edition (ICD-10) similarly provides harmful use and dependence diagnoses for volatile solvent-related disorders [2].

There are historical examples of liquids that were both inhaled and consumed orally (e.g. ether) and there is a recent appearance of devices for alcohol inhalation, but these abused substances are not classified generally as inhalants. Drugs such as crack cocaine, which is aerosolized, and cannabis, which is smoked, are consumed by inhalation but are not generally, or usefully, classified as inhalants because they are part of other, well-defined pharmacological groups. None the less, the fact that cocaine and cannabis users may inhale their drugs introduces the first source of misunderstanding in the classification of inhalants. We offer the following definition of an abused inhalant:

Abused inhalants contain volatile substances that are self-administered as gases or vapors to induce a psychoactive or mind-altering effect. These volatile substances are available in legal, relatively inexpensive and common household products, which can be gases, liquids, aerosols or, in some cases, solids.

INHALANT USE RESEARCH AND POLICY STUDY

Although there is general consensus on what types of products are subject to inhalant abuse and there is evidence that inhalant abuse exists, in all probability, throughout the world, this problem has been overlooked consistently in drug abuse survey research and in setting national and international drug control policy. Inhalant abuse also is frequently ignored in drug abuse surveillance, prevention, education and treatment efforts. We believe that the scientific community can improve our understanding of inhalant abuse by obtaining more detailed information on individual products, their patterns of use and the geographical distribution of their use.

A large number of differing chemicals and products can be abused as inhalants. In the United States alone, some recent surveys attempting to obtain information on specific types of abused inhalants have generated lists of more than 60 different products or product types. If one adds all the many different brands of the same chemical products, the number becomes much larger. If we then consider the even wider variety of abusable products throughout the world, it becomes obvious that the diversity of abused inhalants is far greater than is true for any other form of substance abuse. Cross-national and language differences add another layer of complexity to international inhalant abuse research. Ethnographic research methods might be an approach to collect more detailed information on inhalant abuse practices in specific areas.

Establishing epidemiological patterns of inhalant use will allow researchers to identify differences and similarities in product availability, patterns of use (e.g. recreational versus functional use), different classes of users (e.g. street children, schoolchildren or indigenous populations) or other socio-economic factors that might influence inhalant abuse. There is some evidence that volatile nitrites might be preferred by special groups of users [3]; however, recent US studies estimate life-time nitrite prevalence use rates at between 1 and 2% [4,5]. If that holds true internationally, patterns of nitrite use might be distinctive but not very important. There is also some evidence that nitrous oxide may differ from other inhalants with regard to pharmacology and consequences of use [6–8]. Nitrous oxide is well known to be abused widely among health professionals, and may also have a unique demography of use among young people. However, more research is needed to establish firmly whether nitrous oxide represents a unique type of abused inhalant. In addition, more research is needed to determine if epidemiological methods can be used to determine if classes of inhalants can be found based on unique

patterns or consequences of use. Clinical and epidemiological studies of inhalant abusers have also begun to reveal differences in the abuse liability, symptoms and consequences of inhalants in individuals preferring one type of inhalant over another [7,9,10]. None the less, finding scientifically supportable subclassifications of inhalants should help considerably in the assessment and treatment of inhalant abusers.

CLASSIFICATION SYSTEMS FOR INHALANTS

As there is not a sufficient database on unique chemicals, their pharmacological properties and their patterns of abuse, we recommend caution in developing subclassifications of inhalants that are not built upon strong scientific evidence. This is particularly true for classifications that might have a tendency to create enduring groupings that are shown subsequently to be premature or that may apply only to one country or cultural group. There are several bases on which abused inhalants have been classified in various publications and by individual investigators:

- 1 Chemical, based on structure.
- 2 Form, such as gas, vapor, aerosol or liquid.
- 3 Product type, such as fuels, anesthetics, cleaners, glues, aerosol products, etc.
- 4 Pharmacological properties.

Chemical classification

Abused inhalants comprise many distinct chemical types, such as volatile nitrites, nitrous oxide, linear and branched alkanes, halogenated aliphatic hydrocarbons, aromatic hydrocarbons, ethers, etc. With a few exceptions [11,12], there is little evidence to support the idea that chemical structure alone can confer differences in the abuse-related effects of inhalants. The clear exception to this is the volatile nitrites, which differ both chemically and pharmacologically from other inhalants. Historically, different types of users prefer nitrites rather than volatile solvents; however, this demographic difference may be eroding with time and may not apply throughout the world. None the less, many studies of inhalants have considered volatile nitrites as a separate subclassification and there is reasonable scientific support for this approach. Additionally, neither DSM-IV nor ICD-10 defines nitrite-related disorders as inhalant abuse. For example, DSM-IV classifies nitrite abuse under the 'other (or unknown) substance-related disorders'. As discussed above, it may be possible that nitrous oxide represents a unique chemical class of abused inhalants, but beyond these two possible exceptions, there is not sufficient scientific basis for

providing a useful classification of inhalants based on chemical types.

Form

A classification based on the form in which a product is obtained is common in the inhalant abuse field. For example, gases, vapors and aerosols represent different forms of abused inhalants. It may be most useful for inhalant abuse prevention where parents and children are told what types of products require abuse prevention. On the other hand, classifications based on form are uncommon in the substance abuse field, and the few examples demonstrate how problematic the practice can be. For instance, cocaine in salt form can be abused orally or by injection and the base form is usually volatilized and inhaled, but the same active chemical substance is used regardless of the form or route of administration. Heroin is used in several forms, as are many other drugs, but they are not classified in different groups because of it.

As with other drugs, the same inhalant can be found in many different products in different forms. Toluene, for example, is available as a pure liquid, dissolved in solvents for aerosolization, or in other mixtures. In aerosol products, two separate entities are mixed under pressure: the commercial product dissolved in solvents and the propellant gas. Aerosols, in fact, are small droplets of chemicals that typically vaporize as they pass into the air, so abusers of aerosols obtain both the vapor and some of the solvent used to dissolve the active substance. Thus, the distinction between liquids, aerosols, gases and vapors is artificial.

Product type

Many types of products are abused by inhalation including adhesives, cleaning products, paint thinners, cosmetics, water repellents, anti-anginal medications, room odorizers, etc. Indeed, the term 'solvent abuse' refers to the fact that many, but not all, the inhalants can be used as solvents. Many of the same problems with classification by form also apply to classification by product type or intended use. The same chemical may be in many types of products with many intended uses. There may also be too many product types for useful classification. On the other hand, inhalant users and consumers are most likely to know these products by their type and intended use, so questionnaires attempting to obtain detailed information about individual products will necessarily need to include lists of product types.

Pharmacological properties

Most other classes of drugs of abuse are based on grouping together those chemicals that share pharmacological

effects that are related to their abuse. Thus, the ability to produce a similar intoxication, cross-tolerance and cross-dependence and distinctive patterns of abstinence symptoms serves as the primary basis for the classification of drugs of abuse. It is also well established that such a pharmacological classification often predicts epidemiological patterns of abuse. For example, hallucinogen and opiate abuse occurs typically in quite different populations. Unfortunately, there has not been sufficient research to clearly identify pharmacological groupings of inhalants, with the major exception of nitrites. Generally, many inhalants produce pharmacological effects similar to those of alcohol and central nervous system depressant drugs. Volatile general anesthetics also produce effects similar to many abused inhalants and to depressant drugs [8], and these chemicals, too, have been subject to abuse. In addition, different inhalants have been shown to be associated with different patterns of toxicity based on their cellular sites of action [13]. It is interesting to note that the target organs and cellular sites for the chronic toxicity of inhalants differ from those sites where these chemicals produce their abuse-related effects. This is not like the case for many other classes of drugs of abuse where their toxicity is an extension of their pharmacology (e.g. amphetamines, opioids) and more like the case of alcohol, where liver toxicity, for example, is via entirely different mechanisms than its intoxicating effects. More research is needed on pharmacological and toxicological differences among inhalants if progress is to be made on inhalant classification based on pharmacology and shared effects.

Multiple bases for classification

There are strengths and weaknesses to each of these classification schemes. Ideally, several of these classification schemes could be merged to identify, for example, chemical groups that share pharmacological properties and have distinctive patterns of use. Developing such a scheme can be viewed only as a future goal, dependent upon research into unique chemicals, their pharmacological properties and their patterns of abuse.

SUMMARY AND CONCLUSIONS

Inhalant abuse is an important world-wide problem. Knowledge of the extent and nature of the problem has been hampered by the failure to include inhalants in many surveys and other studies of substance abuse around the world. Inhalant abuse is rarely identified as a unique class of abused drugs and therefore rarely included in drug abuse policy discussions or in local, national or international strategies for drug abuse prevention, education, treatment or control. This situation

needs to change, but inhalant abuse research must utilize scientifically supported systems of subclassification. Classification of inhalants by form or product types is not useful for scientific purposes; rather, subclassification of inhalants should be based on a yet-to-be-determined combination of chemical and pharmacological similarity and shared patterns of abuse. One of the ways in which we can improve our understanding of inhalant abuse is to obtain more detailed information on individual products and chemicals, their patterns of use and the geographical distribution of their use.

RECOMMENDATIONS

- We recommend that all countries of the world support research on inhalant abuse and utilize evidence-based policies and practices to address the problem.
- We recommend that all substance abuse experts include inhalant abuse systematically among their general work in the field.
- Although naming representative products or forms of products may be useful for consumer-oriented inhalant abuse prevention and education efforts, the distinction between liquids, aerosols, gases and vapors is artificial and we do not recommend that this be the basis for subclassification in other areas of scientific research.
- We recommend that more research be conducted on the pharmacological effects of inhalants to understand more clearly which groups of inhalants produce a similar intoxication, cross-tolerance and cross-dependence and distinctive patterns of abstinence symptoms.
- We recommend that more research be conducted on the epidemiology, etiology and clinical presentation of the abuse of specific inhalant products in a wide variety of cultures, countries and specific populations to help inform our understanding of inhalants based on widely varying demographics of use. For example, it would be useful to know to what extent users of one inhalant use other inhalants or use other drugs.

Declarations of interest

None.

Acknowledgements

The authors appreciate the comments on an earlier draft by attendees at a workshop at the NIDA International Forum held in Quebec City, Canada, in June 2007; the logistical support of the NIDA International Program; and the technical support provided by J. G. Perpich under contract to the NIDA International Program. Charles W. Sharp, of the National Institute on Drug Abuse, worked closely with the Inhalant Working Group and provided

invaluable input into this paper, as did two consultants to the NIDA International Program, M. Patricia Needle and Judy McCormally.

References

1. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition*. Washington, DC: American Psychiatric Press; 2000.
2. World Health Organization. *International Classification of Diseases and Health-Related Problems*, 2nd edn. Geneva, Switzerland: World Health Organization; 2005.
3. Haverkos H. W., Kopstein A. N., Wilson H., Drotman P. Nitrite inhalants: history, epidemiology and possible links to AIDS. *Environ Health Perspect* 1994; **102**: 858–61.
4. Wu L. T., Schlenger W. E., Ringwalt C. L. Use of nitrite inhalants ('poppers') among American youth. *J Adolesc Health* 2005; **37**: 52–60.
5. Johnston L. D., O'Malley P. M., Bachman J. G., Schulenberg J. E. *Monitoring the Future National Survey Results on Drug Use, 1975–2007*, vol. 1. NIH Publication no. 08-6418A. Bethesda, MD: National Institute on Drug Abuse; 2008.
6. Ruiz P., Strain E. C., Langrod J. G. Inhalants. In: Ruiz P., Strain E. C., Langrod J. G., editors. *The Substance Abuse Handbook*. Philadelphia, PA: Lippincott Williams & Wilkins; 2008, p. 102–12.
7. Brouette T., Anton R. Clinical review of inhalants. *Am J Addict* 2001; **10**: 79–94.
8. Balster R. L. Neural basis of inhalant abuse. *Drug Alcohol Depend* 1998; **51**: 207–14.
9. Howard M. O., Balster R. L., Cottler L. B., Wu L. T., Vaughn M. G. Inhalant use among incarcerated adolescents: prevalence, characteristics, and predictors of use. *Drug Alcohol Depend* 2008; **93**: 197–209.
10. D'Abbs P., MacLean S. *Volatile Substance Misuse: A Review of Interventions*. Australian Government, Department of Health and Ageing; 2008.
11. Sharp C. W., Rosenberg N. Inhalant-related disorders. In: Tasman A., Kay J., Lieberman J., editors. *Psychiatry*, vol. I. Philadelphia, PA: W. B. Saunders Company, 1996. p. 835–52.
12. Sharp C. W., Rosenberg N. L. Inhalants. In: Lowinson J. H., Ruiz P., Millman R. B., Langrod J. G., editors. *Substance Abuse: A Comprehensive Textbook*, 4th ed. Baltimore, MD: Williams & Wilkins, 2004. p. 336–66.
13. Bowen S. E., Batis J. C., Paez-Martinez N., Cruz S. L. The last decade of solvent research in animal models of abuse: mechanistic and behavioral studies. *Neurotoxicol Teratol* 2006; **28**: 636–47.

This document is a scanned copy of a printed document. No warranty is given about the accuracy of the copy. Users should refer to the original published version of the material.