Adolescent Inhalant Use in the United States:

Examining Long-Term Trends and Evaluating the Applicability of Self-Determination Theory

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ABSTRACT

Inhalants are a critical, under-studied substance used by young adolescents in the United States (U.S.). Despite the serious negative consequences that can accompany use (most notably neuropsychological damage) the topic of inhalants has been neglected by clinicians and prevention scientists, particularly in comparison to other drugs. The present research focused on the etiology of U.S. adolescent inhalant use in two ways, both of which utilized large, nationally representative data sets for secondary data analysis. Study I examined long-terms trends in inhalant use prevalence rates and changing proportions of gender and ethnic groups among lifetime inhalant users. Study I also evaluated the effects of policies aimed at other drugs, including regional "three strikes laws" and national methamphetamine laws, on changing inhalant use prevalence rates among twelfth graders. Inhalant use increased during the early-1990s but has declined from the mid-1990s to the present day; lifetime inhalant users have increasingly become female and non-White. Importantly, "three strikes laws" and a national methamphetamine law were related to increases in annual inhalant use rates for twelfth graders. Study II evaluated the applicability of Self-Determination Theory (SDT)-related constructs, namely self-perceived autonomy, competence and parental relatedness, to concurrent and prospective inhalant use. Competence was consistently related to inhalant use and inhalant use severity; parental relatedness was related to concurrent but not prospective use and use severity. The findings from both studies are discussed in terms of their commonalities and differences, implications for clinicians and prevention scientists, overall strengths and limitations, and directions for future inhalant use research.

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Adolescent Inhalant Use in the United States:

Examining Long-Term Trends and Evaluating the Applicability of Self-Determination Theory

Chapter 1: General Introduction

Inhalants comprise a varied group of chemicals that are sometimes "huffed" or "sniffed" in order to achieve intoxication. Brouette and Anton (2001) define an inhalant as any substance that remains volatile at room temperature, is not already defined as a drug under another category (e.g., nicotine, cocaine), and is used by "sniffing, snorting, huffing, bagging, or spraying" the substance (pg. 79). Methods of consumption include sniffing from an open container, inhaling from a bag, huffing from a soaked rag, heating, and consuming directly into the mouth (Dinwiddie, 1994). Inhalants appear to be most popular among young adolescents (i.e., around 14 years of age) and their use commonly predates other drug use and risky behaviors for an individual (Garland, Howard, Vaughn, & Perron, 2011).

The present study contributes to scientific understanding of the etiology of adolescent inhalant use in two ways. Study I examined long-term trends in inhalant use on a national and regional level for the United States (U.S.). Study II used child-perceived characteristics based on Self-Determination Theory (SDT) to predict inhalant use, as well as the severity of that use. Both studies utilized longitudinal, nationally representative data sets for secondary data analysis.

Types of Inhalants

Two major classification systems for inhalant subtypes have been proposed, one by the National Institute on Drug Abuse (NIDA) and the other by Balster (1998). NIDA (2011) separates inhalants into four categories: aerosols, gases, nitrites, and solvents. Aerosols, which are sprays that contain propellants and solvents, include products such as fabric protector, hair spray, and spray paint. Gases are found in many common household and commercial products, including refrigerant gases, propane tanks, and medical anesthetics. Nitrites are manufactured exclusively for recreational use and include products designed for sexual enhancement, such as “Locker Room” and “Rush.” Solvents are liquids that vaporize at room temperature, such as gasoline, glue, and paint thinner. Balster (1998) had previously suggested a classification system consisting of three categories: volatile alkyl nitrites, nitrous oxide, and volatile solvents, fuels and anesthetics. Volatile alkyl nitrites include products that fall under NIDA’s nitrite category, such as amyl nitrite, which is commonly referred to as a “popper” because of the way in which the product can be opened and used recreationally; “poppers” and other nitrites are often used in sexual situations because of their vasodilatory and “smoothing” properties. Nitrous oxide, commonly referred to as “laughing gas,” has been reported as a drug of abuse for many health professionals and students working in the medical field (Balster, 1998) and it tends to produce a stimulating effect; this substance falls under NIDA’s gases category. Volatile solvents, fuels and anesthetics comprise a varied group of inhalants, including aerosols, butane, propane, and toluene; these substances fall under NIDA’s aerosols, gases, and solvents categories. Balster has since suggested that his final category may need to be divided to better define differences among the substances. NIDA’s system emerged after Balster’s and helps to address this suggestion.

Consequences of Inhalant Use

Inhalant users, including those experimenting with inhalants for the first time, can die if they are startled in the process of using an inhalant and suffer an arrhythmia as a result, a phenomenon known popularly as “sudden sniffing death” (Brouette & Anton, 2001). A number of other short-term consequences can also accompany inhalant use. Acute intoxication resembles that of drunkenness, including symptoms like blurred vision, slurred speech, slowed cognition, and impaired reflexes (Howard, Bowen, Garland, Perron, & Vaughn, 2011). Inhalant users can choke on their vomit if they lose consciousness during or after use; they can also suffocate if they pass out with a plastic bag over their heads (Sikes et al., 2011). Chemical burns can also occur. Internal damage can include reduced oxygen flow to the brain, trouble breathing, and toxicity of the liver and kidneys (Ridenour, 2005).

Neuropsychological research has revealed the deleterious effects of inhalant use on the brain. Takagi et al. (2010) found that adolescent inhalant users performed poorly on tests of immediate verbal memory, proactive interference, learning performance, and memory retrieval. Thus, inhalant use could be correlated with a loss in frontal lobe function. Though significant impulse control deficits have not been noted in adolescent inhalant users (Takagi et al., 2011), research indicates that cognitive difficulties related to brain damage caused by inhalant use may not emerge until later adult life (Lubman, Yücel, & Lawrence, 2008), suggesting that use by children and adolescents could limit developing capacity for executive control.

Many studies on inhalant users have used samples of youth who demonstrate antisocial behavior. An analysis of diagnostic criteria (American Psychiatric Association, 2000) among incarcerated adolescents with inhalant use disorder diagnoses revealed that the most prevalent criteria included use in hazardous situations, use despite having physical or psychological problems caused or exacerbated by use, loss of control over use, and tolerance. Inhalant dependence was more prevalent among users in this study than inhalant abuse. Among Caucasians (one of the largest groups to report inhalant use), family problems, early polydrug use, and delinquency have been related to inhalant use (McGarvey, Canterbury, & Waite, 1996). Additionally, delinquent adolescents who use inhalants appear to have a tendency to be arrested earlier and a higher likelihood of depression compared with delinquent youth who do not use inhalants (Jacobs & Ghodse, 1988). Criminal activity has been suggested to increase even with inhalant experimentation (Mackesy-Amiti & Fendrich, 1999). In sum, it appears that there is a correlational relationship between inhalant use and antisocial behavior; moreover, the two behaviors may interact to produce poor outcomes.

Those who do not cease inhalant use following early adolescence can expect additional physical and mental damage. Long-term abuse of inhalants can be accompanied by a variety of physical illnesses, including emphysema, leukemia, and renal failure (Brouette & Anton, 2001). Psychiatric disorders such as anxiety, depression, and attention-deficit/hyperactivity disorder often occur among inhalant users; as suggested earlier, neurological complications can accompany inhalant use, including lack of muscular control, speech difficulties, and numbness (Ridenour, 2005). In particular, "pure" inhalants like toluene appear to specifically target white brain matter, resulting in damage to processing speed, vigilance, memory, executive function, muscle control, and language (Lubman et al., 2008; Yamanouchi et al., 1995). These deficits may result, at least in part, from complications such as thinning of the corpus callosum and demyelination of the axons, which would impair inter-hemisphere communication and overall cognitive speed (Lubman et al., 2008). Fortunately, findings suggest that some cognitive recovery is possible with abstinence from inhalants—specific improvements have been demonstrated in the areas of muscular, visual, and cognitive functioning (Cairney, Maruff, Burns, Currie, & Currie, 2005).

Issues in Prevention and Treatment of Inhalant Use and Disorders

Despite the potential for serious, negative behavioral and health outcomes, the problem of inhalant use has received considerably less attention from prevention scientists and clinicians compared to other substances (Ridenour, 2005). Information on inhalant use has traditionally been collected from adolescents in juvenile detention centers (Howard, Balster, Cottler, Wu, & Vaughn, 2008) or medical settings (Sakai et al., 2004), though secondary analyses on existing national data sets have been performed (Perron, Howard, Maitra, & Vaughn, 2009). Current prevention efforts focus on providing information about inhalant use dangers to schools, parents, medical professionals, and communities (Anonymous, 2004). A combination of “twelve step” programs and substance abuse treatment has been recommended for inhalant users, who often present with other substance abuse and dependence diagnoses (Perron, Mowbray, Bier, Vaughn, Krentzman, & Howard, 2011).

Overall, little is known about risk and protective factors related to inhalant use or appropriate techniques for preventing and treating inhalant use, despite the fact that inhalants are relatively common among young adolescents and their use can be dangerous. Many common and inexpensive household substances can be used as inhalants (Brouette & Anton, 2001), so inhalant use is easy to hide and not always readily recognized by teachers and parents. In fact, some teachers and parents do not consider inhalants a drug like alcohol or marijuana (Sikes et al., 2011). More information about trends in inhalant use and predictors of use will add to current prevention efforts and allow both scientists and the public to better understand inhalant use.

Purpose of the Current Study

The present study had two major purposes: (a) to examine long-term trends in inhalant use, including trends separated by grade and time frame of use (i.e., lifetime, annual, thirty-day), trends in the gender and ethnic breakdown of those reporting lifetime use, and the effects of drug policy at the national and regional levels on changing rates of inhalant use; and (b) to evaluate the ability of child-perceived psychosocial variables based on SDT (i.e., adolescent autonomy, adolescent competence, relatedness to mother, relatedness to father) to concurrently predict lifetime inhalant use and prospectively predict past year use. Additionally, the second study concurrently and prospectively predicted inhalant use severity.

Chapter 2: Study I—Long-Term Trends in Adolescent Inhalant Use in the United States

According to the Substance Abuse and Mental Health Services Administration (SAMHSA), approximately 8% of people in the U.S. aged 12 or older reported lifetime inhalant use in 2011; 0.7% and 0.2% reported past year and past month use, respectively (SAMHSA, 2011). Importantly, levels of perceived risk of using inhalants assessed among eighth and tenth graders have declined since 2000; this finding could be due to the lack of inhalant-focused prevention campaigns since the 1990s (Johnston, O'Malley, Bachman, & Schulenberg, 2013). In contrast, disapproval ratings of inhalant use have also declined among eighth graders since 2001 but among tenth graders only between 2004 and 2007, though most still disapprove of experimenting with inhalants (Johnston et al., 2013). To date, there has been no systematic examination of changing inhalant use prevalence rates over long periods of time, though it could add to the literature in multiple ways. For example, information on changing gender and ethnic differences in lifetime inhalant use rates can help inform culturally sensitive treatment strategies for clinicians. In addition, a better understanding of the typical grade of first use can help prevention scientists determine the ideal time to implement their interventions. Further, given that drug use has been the target of national and regional legislation in the U.S., determining whether there is a connection between the passage of laws targeting other drugs and changing prevalence rates of inhalant use over time can help inform lawmakers about positive and negative unintended consequences of their efforts.

Demographic Trends in Inhalant Use

Prior research on inhalants has demonstrated that if gender differences exist in the risk for inhalant use, their direction is unclear: it has been suggested that females are more likely to report recent inhalant use (Collins, Pan, Johnson, Courser, & Shamblen, 2008), though it has also been reported that there are no significant differences between genders on inhalant use (Compton et al., 1994). Other findings have indicated that males are more likely to endorse severe inhalant use that requires hospital admission (Dinwiddie, 1994). Differences in inhalant use by gender may be moderated by ethnicity and age (Garland et al., 2011); in particular, Native American females appear more likely to use inhalants than males, and girls are apparently more likely than boys to use inhalants early on, though this trend seems to reverse or disappear by twelfth grade.

Native American, Latino, and Caucasian youth are more likely to use inhalants than adolescents in other groups (Edwards et al., 2007; Beauvais, Wayman, Jumper-Thurman, Plested, & Helm, 2002; Williams et al., 2007). Native American adolescents—particularly those living on reservations—report the highest rates of use, over three times the rates endorsed by other ethnic groups (Beauvais et al., 2002; Beauvais, Oetting, & Edwards, 1985; Young, 1987). Acculturation stress has been posited as a potential reason for relatively heavy inhalant use among Latinos (Barrett, Joe, & Simpson, 1991). Among other ethnic groups, religiosity, familial closeness, and a focus on academic achievement have all been suggested as motivators to stay away from inhalants and other drugs (Wallace, Jr., & Muroff, 2002; Salous & Omar, 2009; Thai, Connell, & Tebes, 2010). These findings on gender and ethnicity as risk factors for inhalant use have been replicated in prior studies; however, long-term trends in gender and ethnic differences among *inhalant users* have not been systematically studied. This information would help clinicians better target treatments for inhalant use and inhalant use disorders to the needs of their clients, particularly if certain treatments have been demonstrated to work better for different demographic groups.

The Potential Influence of Drug Policy on Inhalant Use

Just as substance use trends have shifted over the years, so have attempts to curb drug-related crime, including changing drug policies on the national and state levels. For instance, the founding of Mothers Against Drunk Driving (MADD) in 1980 contributed to tighter restrictions on underage drinking, increased penalties for drunk driving, and greater awareness of the dangers involved in driving while intoxicated (Fell & Voas, 2006). Awareness about the dangers of marijuana use became the target of the Bush (Sr.) and Clinton administrations after the 1980s movement to legalize medical marijuana (Ferraiolo, 2007). The 1996 Comprehensive Methamphetamine Control Act (MCA) regulated the sale of pseudoephedrine and phenylpropanolamine, and the 2005 Combat Methamphetamine Epidemic Act (CMEA) augmented the effects of the MCA by regulating the sale of over-the-counter products containing ephedrine (Dobkin & Nicosia, 2009). Generally speaking, legislative measures have been more effective in curbing alcohol and methamphetamine use than marijuana use (DiNardo & Lemieux, 2001; McKetin, Sutherland, Bright, & Norberg; Thies & Register, 1993; Yacoubian, Jr., 2007). It is unknown how these laws may have affected drugs not specifically targeted by the laws, like inhalants.

On the state level, "three strikes laws" have now been passed in over half of the U.S. The laws began in Washington in 1993, and 90% of convictions under the law have occurred in California (Vitiello, 2002). These policies impose a penalty of 25 years to life imprisonment for three-time felony offenders (Vitiello, 2002); although they have been most effective in reducing violent and property crime (Ramirez & Crano, 2003), they also apply to those who engage in drug-related felony crimes, including production of certain substances, possession, and distribution. As of 1998, adult drug offenders in California had not been deterred by "three strikes laws" (Ramirez & Crano, 2003). The present study expanded upon that research by looking at regional adolescent data from "three strikes"-affected areas all over the U.S.

An unintended consequence of increased alcohol and drug legislation is the "substitution" effect—the increased use of other substances in place of recently restricted ones. For example, marijuana use increased slightly following the restriction of alcohol consumption (Crost & Guerrero, 2012; DiNardo & Lemieux, 2001), and the reverse also occurred in the context of continued criminalization of marijuana use (Thies & Register, 1993). Perhaps inhalants, given their early appearance in the typical pattern of drug use, could emerge as an appropriate "substitute" drug when access to other drugs is limited by legal measures and reduced supply. In particular, the fact that inhalant use increased during periods when alcohol and marijuana were the primary targets of drug policy (Johnston et al., 2013) suggests that inhalants could have been used as a substitute for those drugs. This idea is further supported by the fact that the use of alcohol, marijuana, and methamphetamine has been linked to inhalant use (Ridenour, 2005; Sakai, Hall, Mikulich-Gilbertson, & Crowley, 2004; Brecht, Greenwell, & Anglin, 2007).

The Present Study

The ongoing Monitoring the Future (MTF) study provides an opportunity to examine trends in inhalant use across many years. These data were used to address the primary aims of the present study:

(1) **Examine long-term trends in adolescent inhalant use**. Prevalence rates of inhalant use from 1991 to 2011 for eighth, tenth, and twelfth grade cohorts were examined. It was hypothesized that lifetime, annual and thirty-day inhalant use rates would increase overall during this time frame for eighth, tenth and twelfth grade cohorts.

(2) **Examine long-term trends in demographic composition of inhalant users and determine when inhalant use is typically initiated**. Demographic trends among lifetime inhalant users were examined from 1991 to 2011; specifically, gender and ethnic differences over time were considered for eighth, tenth, and twelfth grade cohorts. Lifetime users were expected to be mostly White or Hispanic, and inhalant use initiation was expected to occur before ninth grade.

(3) **Examine the effects of selected national and regional drug-related legislation on changes in inhalant use prevalence rates over time**. National policies included the 1996 MCA and the 2005 CMEA; regional policies included "three strikes laws" in four regions of the U.S. Annual law implementation was examined for its effects on annual inhalant use among twelfth graders; twelfth graders were the focus of this analysis due to their proximity to adulthood and the fact that the laws were designed to affect individuals over age 18. It was hypothesized that inhalant use would increase when a legislative milestone was passed, as suggested by the increase in inhalant use during the period of heavy alcohol and marijuana regulation in the 1980s.

Method

The MTF study began in 1975 at the University of Michigan's Institute for Social Research as a response to "a widespread epidemic of illicit drug use" among teenagers that began in the 1960s; the study continues to impact U.S. policy in the present (Johnston, O'Malley, Bachman, & Schulenberg, 2012, p.1). MTF surveys are conducted in classrooms across the country each year (Gfroerer, Wright, & Kopstein, 1997) and focus on a variety of drugs and related constructs. Questions mostly concern prevalence of use, though items related to risk perception, disapproval of behaviors, and drug availability are given to younger students as well (Johnston et al., 2011). The primary purpose of the survey is to provide information about annual trends in drug use among adolescents in the U.S. (Johnston et al., 2012).

Participants. MTF uses a multistage probability protocol from the 48 contiguous states. General geographic areas are selected first, followed by schools in each area and classes in each school. On average, approximately 140 schools and 45,000 students (across eighth, tenth and twelfth grades) are selected each year for the study (Gfroerer et al., 1997). The sample for the current study is comprised of all eighth, tenth and twelfth graders who responded to MTF surveys from 1991 to 2011, for a total of 1,007,622 participants. 1991 is the year in which data were first gathered from eighth and tenth graders, though twelfth grade data existed before 1991.

Design and protocol. Approximately three weeks prior to the administration date, parents of the potential participants are contacted by the school principal via postal mail to announce the MTF survey and give the parents an opportunity to withdraw their child from participation if they choose. Administration of the paper-and-pencil, self-report survey is conducted in regular classrooms during normal class time whenever possible, though some schools occasionally require larger group administration. Survey administrators and their assistants, all of whom come from local branches of the Institute for Social Research, are trained in standardized administration protocol using an instruction manual (Johnston et al., 2011).

Measures

Inhalant use. Prevalence rates of lifetime, annual, and thirty-day inhalant use at each grade level from 1991 to 2011 were the outcomes of interest. Use was assessed with one question[1] that asked, "*On how many occasions (if any) have you sniffed glue, or breathed the contents of aerosol spray cans, or inhaled any other gases or sprays in order to get high?"*

[1]Type-specific inhalant use is an important area of study, as indicated by prior work (NIDA, 2011; Balster, 1998), but the MTF data do not allow for type-specific analysis.

within three time frames: one's lifetime, during the past twelve months, and during the past thirty days. Response options were measured on a 1-7 Likert scale with higher numbers indicating more frequent use (Johnston, O'Malley, Bachman, & Schulenberg, 2010), including "zero occasions," "one to two times," "three to five times," "ten to nineteen times," "twenty to thirty-nine times" and "forty or more times."

MTF asked about grade level of initiation of various drugs, including inhalants, with this question: "*When (if ever) did you do each of the following things? Don't count anything you took because a doctor told you to."* Response options included "grade four or below" and one option for each of the grades beyond grade four up through twelfth (Johnston et al., 2010).

Demographics. Demographic information included gender and ethnicity. Gender was assessed with one question and male and female response options were offered. Ethnicity was assessed with one question and three response options—Black, White, and Hispanic—were offered. Due to lower frequency of endorsement, responses indicating other or multiple ethnicities were recoded by MTF as missing data. In addition, the separate Hispanic category was not made available by MTF until 2005 for all three grade cohorts (Johnston, Bachman, O'Malley, & Schulenberg, 2004; Johnston, Bachman, O'Malley, & Schulenberg, 2005).

Law implementation. Several legislative milestones were examined in terms of the effect of their passage on changes over time in inhalant use prevalence rates. "Three strikes laws" were passed in 25 U.S. states between 1993 and 2006, with most of those states passing the laws in 1994 and 1995 (Chen, 2008). Two federal methamphetamine precursor regulation laws were also considered: the MCA, passed in 1996, and the CMEA, passed in 2005 (Dobkin & Nicosia, 2009). Figure 1 displays a timeline of all drug laws of interest in this study.

MTF breaks the U.S. up into four regions: Northeast, North Central, South, and West. Figure 2 displays the regional divisions of the U.S. according to MTF. Because MTF data do not allow for state-level analysis, a “three strikes law” was considered salient to a region once it affected 30% of the Census population in that region, making laws passed thereafter in that region already salient. The “three strikes laws” became salient in the Northeast region in 1995, in the South in 1994, and in the West in 1994; they never became salient in the North Central region. All legislative measures were considered to be effective the same year as their passage. Figure 3 displays the year-by-year implementation history of “three strikes laws.”

Analysis plan. To ensure national representation of all results, survey sampling weights were used for all analyses. To examine long-term trends in adolescent inhalant use, prevalence rates of lifetime, annual, and thirty-day use for eighth, tenth, and twelfth graders were calculated. Trends over time were graphed and examined descriptively. Means and confidence intervals for lifetime use for each grade cohort were also noted to determine when rates differed from the overall average. Mixed effects regression models were used for each grade cohort to evaluate the effect of time on inhalant use prevalence rates (lifetime, annual, thirty-day). These models allow for the inclusion of both fixed and random effects; the repeated measures over time (i.e., the effect of time) were treated as random. Linear, quadratic, and cubic trends were added into each of the models and tested for significance.

To examine long-term demographic trends, proportions of (a) males versus females out of all lifetime users and (b) Whites versus Blacks versus Hispanics (once they were included as a separate category) versus a missing data category including other ethnicities out of all lifetime inhalant users were calculated and examined descriptively for each grade cohort. Mixed effects regression models were used to evaluate the effect of time on the proportions of different genders and ethnicities for each grade cohort. To examine inhalant use initiation, median grade of initiation across the 21 years was calculated for the eighth, tenth, and twelfth grade cohorts[2].

To examine effects of drug laws, a mixed effects regression model was used for the twelfth grade cohort. This model tested the effects of time, MTF region, the presence or absence of a salient "three strikes law," and the presence or absence of each of the two national methamphetamine laws on annual inhalant use prevalence rates. In this model, the effect of time was treated as random, and the effects of all predictors were treated as fixed.

Results

Long-term trends in use. Figure 4 displays trends in inhalant use from 1991 to 2011 for each grade cohort, with one line each for lifetime, annual, and thirty-day use rates. Each line represents the proportion of participants who reported use for a given year out of the total number of people who answered inhalant questions for that year. The average lifetime use rate across all 21 years for each grade cohort is superimposed with confidence intervals. All of the rates in all grade cohorts showed a positive linear trend with a negative curvilinear component, though most were not significant. Interestingly, significant linear and quadratic trends emerged for lifetime use in the eighth grade cohort. This trend suggests that inhalant use among eighth graders increased until about the mid-1990s and then decreased. See Table 1 for parameter estimates of the mixed effects regression models. It is important to note that when quadratic trends were not included for tenth and twelfth graders, the linear trends were significant and negative for lifetime use, indicating that inhalant use decreased significantly over time for these two cohorts.

[2] Grade of initiation was used because age of initiation is not available in MTF data.

Gender and ethnicity differences in use. Out of the total sample of those reporting lifetime inhalant use, proportions of males versus females and proportions from each ethnic group surveyed are shown in Figures 5 to 7. Missing data for gender and ethnicity are included in the proportions due to the large proportions of missing data in the ethnicity analyses. Each figure represents demographic data for a single grade cohort. Mixed effects regression models were used to evaluate the effects of time on gender and ethnicity for each grade cohort, the results of which are presented in Table 2.

As shown in Figure 5, females generally made up a greater proportion of lifetime inhalant users than males in the eighth grade cohort. In the tenth grade cohort, as shown in Figure 6, gender differences do not appear until around 2000, when females began to make up a greater proportion than males. In contrast, in the twelfth grade cohort, as shown in Figure 7, males generally made up a greater proportion of lifetime inhalant users than females. Mixed effects regression models indicated that the proportion of females among lifetime inhalant users significantly increased from 1991 to 2011 for all three grade cohorts. Interestingly, this means that even among twelfth grade inhalant users, who were predominantly male, an increasing percentage of them were female.

Figures 5 through 7 also show that Whites made up the greatest proportion of those reporting lifetime inhalant use in the eighth, tenth and twelfth grade cohorts. In all three figures, the proportion of Whites appeared to decline slightly over time, particularly after 2005, when Hispanics were first included as a separate ethnic category. Mixed effects regression models confirmed that the proportion of Whites significantly decreased for all three grade cohorts, both in the period from 1991 to 2004 and again from 2005 to 2011 when Hispanics were included in the ethnicity breakdown. In contrast, the proportion of Hispanics significantly increased from

2005 to 2011 in the eighth and tenth grade cohorts, and the proportion of other uncategorized ethnicities also increased significantly from 1991 to 2004 and 2005 to 2011 in the tenth and twelfth grade cohorts.

Grade of first use. Table 3 details the median grade of first use of inhalants for each grade cohort. For tenth graders, the median grade of first use was broken into those who initiated use prior to or in eighth grade and those who initiated use prior to or in tenth grade. For twelfth graders, the median grade of first use was broken into those who initiated use prior to or in eighth grade, those who initiated use prior to or in tenth grade, and those who initiated use prior to or in twelfth grade. Not surprisingly, the median grade of initiation increased as grade level increased, a result of the ability of older individuals to initiate at later grades. Early initiators in the twelfth grade cohorts (those who began prior to or in eighth grade or prior to or in tenth grade) reported initiating use slightly later than their counterparts in the eighth and tenth grade cohorts. Generally, median initiation of inhalant use for all students surveyed began sometime in middle school or the early part of high school (i.e., prior to or in ninth grade).

Legislative milestones. Figure 8 displays trends in annual inhalant use for twelfth graders from 1991 to 2011 separated by MTF region, with milestones marked for each region. Mixed effects regression modeling indicated no significant differences among regions, but both salient "three strikes laws" (beta=1.1392, $t_{(76)} = 2.40$, $p = .0191$) and the CMEA of 2005 (beta=1.1045, $t_{(76)} = 2.15$, $p = .0346$) were significant predictors of increased inhalant use prevalence after controlling for the effect of passing time on annual inhalant use rates among twelfth graders from 1991 to 2011. The MCA of 1996, however, was not a significant predictor of inhalant use prevalence rates.

Discussion

All inhalant use prevalence rates in all grade cohorts showed a trend characterized by a positive linear component and a negative curvilinear component. However, most of these trends were not significant. Overall, then, findings were only partially consistent with the hypothesis that inhalant use would increase throughout the period of 1991 to 2011. Inhalant use among eighth graders increased initially and then leveled off and began to decrease later; inhalant use among tenth and twelfth graders decreased over all years. Reduced use over time could be due to a variety of historical factors. For example, students may report less inhalant use as public knowledge about what products actually qualify as inhalants increased.

There was a cohort-graded transition in gender differences among inhalant users. In eighth grade, females initially made up a larger proportion than males, whereas by twelfth grade, males made up a larger proportion of lifetime inhalant users than females. This finding could suggest that initiation among males occurs later than for females. It also may indicate a higher school dropout rate among females than males who use inhalants. Interestingly, the proportion of females among lifetime users significantly increased from 1991 to 2011. One plausible explanation may be an increase in cosmetic products that can be used as inhalants targeted to female youth during this time (Beauvais et al., 2002). Because female substance users tend to respond differently to treatment than males (Matthews & Lorah, 2005), this finding suggests a need to ensure clinicians who may treat inhalant use disorders are trained to handle female users. For example, a computer-assisted gender-specific substance use prevention program that relied heavily on mother-daughter interaction was effective in reducing substance use, including inhalant use, among adolescent girls (Schinke, Fang & Cole, 2009); similar measures may be critical for clinicians.

Whites made up the largest proportion of lifetime inhalant uses in all three grade cohorts, although the proportion of Whites did significantly decline over time. In contrast, the Hispanic proportion increased significantly (from 2005 to 2011) as did the proportion of other uncategorized ethnicities (from 1991 to 2004 and 2005 to 2011). To the extent that individuals of different ethnic backgrounds respond differently to clinical treatment (Matthews & Lorah, 2005), these findings suggest a need to develop clinical treatments for inhalant use that will work well for Hispanics and other minorities. For example, it may be beneficial to focus on motivational enhancement therapy to increase personal motivation to cease use of inhalants, given high levels of peer pressure in Hispanic and other minority cultures (Joe & Simpson, 1991) and the tendency for minority groups to sometimes experience powerlessness in America (Matthews & Lorah, 2005). Alternatively, cognitive behavioral therapy could be helpful in challenging erroneous or skewed cultural beliefs about how many people use inhalants or the health risks posed by use. Overall, these results were consistent with the hypothesis that Whites or Hispanics would make up the greatest proportion of lifetime inhalant users in all three grade cohorts.

The median grade of first use of inhalants was sixth for the eighth grade cohort, seventh for the tenth grade cohort, and eighth for the twelfth grade cohort. Users in the twelfth grade cohort reported initiating inhalant use slightly later than those in the younger cohorts when the effect of additional years being available for use initiation was controlled. This finding is supportive of early intervention for children in late elementary or early middle school, which may prevent inhalant use during the typical window of initiation. This result was also supportive of the hypothesis that typical inhalant initiation would begin around age 14, as reported by prior literature (Garland et al., 2011). It does, however, highlight a phenomenon common in the inhalant use literature where lifetime prevalence rates for older individuals are lower than for younger individuals. This issue is critical to inhalant use research and is discussed in detail in the general discussion (i.e., Chapter 4).

Importantly, results presented here suggest potential unintended negative consequences of laws aimed at other drugs for inhalant use during adolescence. Implementation of both the “three strikes laws” and the national CMEA in 2005 were related to significant increases in annual inhalant use among twelfth graders despite the overall declining trend in prevalence rates. The “three strikes laws” were considered salient to a region only once they impacted approximately 30% of the Census population in that region, and the CMEA was considered an augmentation to the restrictions implemented by the 1996 MCA. Thus, inhalant use rates may have been higher than expected as a response to high levels of legal pressure to cease production, distribution and use of other drugs. These results were consistent with the hypothesis that inhalants may have been used as a “substitute” drug when availability of other drugs was decreased due to new legislation targeting those drugs. It may be that the effect of the 1996 MCA on its own was not strong enough to influence drug users into switching substances. Interestingly, the regional results also indicated no significant differences in inhalant use rates among regions, suggesting that U.S. geographic location was not a risk factor for inhalant use. Previous studies have suggested that rural youth have higher use rates than suburban and urban youth (Perron & Howard, 2008).

Strengths and Limitations

This study was the first to systematically describe and examine inhalant use prevalence rates over time and also the first to examine the effects of national and regional drug-related legislation on inhalant use. Additionally, nationally representative data sets drawn from a non-clinical population were used for the analyses, which is a strength given that most prior work on inhalant use has used data drawn from clinical populations or those in juvenile detention centers. Further, the approach taken to examine gender and ethnicity differences in this study allowed for conclusions to be drawn about how clinical treatment for current inhalant users could potentially be improved.

However, this study also had several limitations. First, MTF also does not collect data on high school dropouts, which limits generalizability. Obtaining data on that population would provide important information about how inhalant use changes over the course of adolescence and into young adulthood. In particular, researchers have not yet collected adequate data from individuals who drop out of school but do not enter the juvenile justice system. Notably, however, MTF collects data from eighth graders, so only the most severe users who initiate very early and drop out are not represented in some way. Second, region and grade were used as proxies for state and age, respectively, due to limitations associated with secondary data analysis; these pieces of information are not provided by MTF. The present study should be extended with state level data to evaluate the effects of "three strikes laws" in a more detailed way. Third, the use of MTF data limited the detail of the ethnicity analyses by not including minority groups as separate categories and lumping many less represented groups into a missing data catch-all category. For instance, it would have been beneficial to include Native Americans in the ethnicity analysis due to their reportedly high prevalence of inhalant use, but they were not included as a separate category in the data. Finally, it is important to note that the approach taken to examine gender and ethnicity differences here made it so that those results are not directly comparable to prior findings in the literature. The current study examined gender and ethnicity conditional on inhalant use, whereas prior work has examined inhalant use conditional on gender and ethnicity. In other words, the current study allows for conclusions to be drawn about the proportion of different demographic groups among those reporting lifetime use, and the results of prior work allow for conclusions to be drawn about particular demographic groups' likelihood of inhalant use compared to other groups.

Chapter 3: Study II—Applying Self-Determination Theory to Adolescent Inhalant Use

Whereas Study I focused on long-term trends in inhalant use, Study II examined the roles played by constructs based on Self-Determination Theory (SDT), a theory of motivation based on personality and interpersonal styles, in inhalant use. SDT-related constructs have been linked to a variety of types of substance use in the past (e.g., Chassin, Pitts, & DeLucia, 1999) but never to inhalant use specifically. The present study examined lifetime use (predicted concurrently by the variables of interest), past year use (predicted prospectively by the variables of interest), and use severity (predicted both concurrently and prospectively), the last of which is rarely covered in the existing literature.

Self-Determination Theory

SDT posits that feelings of autonomy, competence, and relatedness promote good psychological health (Deci & Ryan, 2008). *Autonomy* refers to the feeling that one's own behavior is freely decided (Ryan & Deci, 2000a). *Competence* refers to a feeling of self-efficacy for adopting a goal and attempting to fulfill it (Ryan & Deci, 2000a). *Relatedness* refers to a sense of belonging or connection to other people or entities (Ryan & Deci, 2000a). An individual who feels autonomous, competent, and related to others is more likely to be intrinsically motivated (Deci & Ryan, 2000). People with high intrinsic motivation also tend to develop stronger internal loci of control (Deci & Ryan, 1987).

Previous work by Ryan and Deci (1987) indicated that the development of intrinsic motivation is facilitated by behavior choice, or autonomy, rather than rewards or punishments for behavior performance. Intrinsically motivated behavior also tends to yield greater enjoyment, higher creativity and cognitive flexibility, more positive emotional tone, and more effective behavior maintenance (Ryan & Deci, 1987). Children who develop intrinsic motivation for goals tend to seek mastery and greater well-being rather than perform in pursuit of rewards or avoidance of punishments (Ryan & Deci, 2000b). Securely attached adolescents with high levels of autonomy are less likely to engage in deviant behavior, perhaps due to an increased likelihood of developing adaptive social skills (Allen et al., 2002). Hence, we might expect children who perceive themselves to be autonomous to be less influenced by negative peer pressure.

Intrinsically motivating activities can facilitate feelings of competence via feelings of mastery, particularly if there is a lack of external performance judgment (Ryan & Deci, 2000a). Competence is related to feeling a sense of control over one's environment as well as an ability to derive valued outcomes from that environment (Deci & Ryan, 2000). A study conducted among middle school students indicated that social competence was important for the development of social problem-solving skills and positive feelings toward school; these were seen as protective factors against depression and deviant behavior (Wang, 2009). Thus, we may expect children with low perceived competence to strive for other ways to achieve control and satisfy psychological needs, which could include seeking validation among peers. If those peers engage in deviant behavior, the child in question may also try to be involved.

Early child development research demonstrated the importance of parental support and relatedness in encouraging children's curiosity and desire to explore their environment (Ryan & Deci, 2000b). In particular, relatedness has been called a "fundamental need" (Deci & Ryan, 2000, p. 231); a child who feels accepted by his or her parents, teachers, and peers has the freedom to make autonomous choices and develop competence, paving the way for the cultivation of intrinsic motivation. Parental support has also been correlated with increased motivation for mastery in children (Ryan & Deci, 2000a). Preoccupation with attachment experiences, on the other hand, has been suggested to interrupt the process of normative autonomy development, sometimes leading adolescents to try on deviant behaviors as a cry for attention (Allen, Moore, Kuperminc, & Bell, 1998). Relatedness, especially to parents, can be conceptualized as essential for the growth of competence and autonomy in children.

Self-Determination Theory, Problem Behavior, and Substance Use

Limited development of adolescent autonomy, competence, and relatedness has been linked to substance use and other problem behaviors. It has been suggested that adolescents who conceded arguments with their parents prematurely—conceptualized as a marker of limited autonomy development—do the same with friends, indicating susceptibility to peer pressure in favor of substance use (Allen, Chango, Szwedo, Schad, & Marston, 2012). Excessive maternal attempts at adolescent psychological control have been linked with increased desires for peer acceptance, which could also lead to substance use (Chan & Chan, 2011). Perceived competence in positive activities has been associated with lower levels of adolescent alcohol and drug use, particularly for males (Chassin et al., 1999). Emotional detachment from parents has been shown to significantly predict substance use (Turner, Irwin, Tschann, & Millstein, 1993).

Thus, autonomy, competence, and relatedness appear to be important in helping adolescents to avoid substance use: autonomy is important for the development of self-control under peer pressure, competence in positive activities seems to lower motivation to use substances, and parental relatedness and attachment are major factors in whether an adolescent uses substances. Common reasons for using inhalants include peer pressure and dealing with family stress (Perron, Vaughn, & Howard, 2008), as well as trying to make friends and reacting to the perception of inadequate affection from parents (Siegel, Alvaro, Patel, & Crano, 2009). People who use inhalants may be doing so because they have little power to resist peer pressure, they want to gain social competence or cope better with stress, or they feel frustrated by lackluster relationships with their parents.

SDT in particular has been used to explain problem behavior outcomes in prior literature. Vallerand, Fortier, and Guay (1997) modeled high school dropout using SDT; they found that dropout students perceived less support from teachers, parents and school administrators and also felt less academically competent and autonomous, leading to a decrease in intrinsic motivation. Vansteenkiste and Shelton (2006) suggested a marriage between SDT and motivational interviewing, which is an empirically supported set of techniques designed to encourage self-reflection and positive change for clients with drug and alcohol use disorders, in order to improve substance abuse outcomes. They found motivational interviewing techniques like mutual agenda setting, reflective listening, and summarizing of points made by the client support autonomy: using these techniques increased the client's feelings that he or she was in control of treatment. Additionally, they pointed out that SDT is currently under-utilized in clinical psychology; if SDT constructs were found to be related to inhalant use, treatment of inhalant users and users of other substances could be tailored to incorporate promotion of autonomy, competence, and relatedness.

To summarize, adolescents who believe they have free choice in setting goals, feel competent to achieve those goals, and are supported by parents and other loved ones may be less motivated to seek out deviant peers and activities—like inhalant use—in an attempt to satisfy psychological needs. They may also be less likely to continue using inhalants as a way for compensating for perceived incompetence in positive activities or because they do not feel like they have control over their use. If found to be significantly predictive of inhalant use, SDT may provide a framework based on individual differences that can translate easily into clinical treatment goals and help motivate an individual to avoid using inhalants or cease using them.

The Present Study

Data from the National Longitudinal Study of Adolescent Health (Add Health) were used in the present study. The data were collected over several waves and allow for the examination of adolescent behavior over time. There were two primary aims of the present study:

(1) **Evaluate whether self-perceived autonomy, competence, and parental relatedness *concurrently* predict *lifetime* inhalant use and use severity**. It was hypothesized that lower levels of autonomy, competence, and relatedness would be related to a higher likelihood of reporting lifetime inhalant use and a higher count of lifetime inhalant use instances, with use data coming from the same time point as that of the SDT constructs.

(2) **Evaluate whether self-perceived autonomy, competence, and parental relatedness *prospectively* predict *past year* inhalant use and use severity**. It was hypothesized that lower levels of autonomy, competence, and relatedness would be related to a higher likelihood of reporting past year inhalant use and a higher count of past year inhalant use instances, with use data coming from a later time point than that of the SDT constructs.

Method

Add Health was developed as a response to a mandate by the U.S. Congress to collect nationwide data on adolescent health. Data collection began in 1994 with in-school and at-home surveys and interviews of seventh through twelfth graders. Four waves of longitudinal data are currently available: Wave I in 1994-95, Wave II in 1996, Wave III in 2001-02, and Wave IV in 2008. Information about education, family, relationships, health, sexual experiences, drug use, violence, delinquency, and other topics was collected (see Harris et al., 2009 for a list). Though

Add Health did not include items specifically drawn from SDT, relevant items were drawn from the wide variety of topics included in the survey and adapted for the purposes of this study.

Participants. Data from the self-weighting Add Health core Wave I and II samples of in-home interviews were used. Although Wave I included participants in seventh through twelfth grade, Wave II followed only participants who were originally in seventh through eleventh grade. The sample for the present study was based on 6072 participants in seventh through twelfth grade at Wave I, 4595 of whom were followed-up at Wave II. The mean age of the sample at Wave I was 16.1 years (standard deviation = 1.8); 44.5% of participants were male and the majority were White (70.6%). At Wave I, 5.9% of participants reported lifetime inhalant use (1.6% missing data); at Wave II, 2.3% reported past year inhalant use (24.9% missing data).

Two outlying responses, one for Wave I inhalant use severity (500) and one for Wave II inhalant use severity (222), were removed due to being substantially higher than other responses; the inclusion of these responses caused difficulty with model estimation. In addition, two participants were removed because they were missing some data needed to calculate age. After the removal of these data, the final sample used for the analyses comprised 6068 participants at Wave I and 4591 participants at Wave II.

Design and protocol. Students in grades seven through twelve from 132 representative schools were surveyed at school using a self-administered questionnaire that took approximately one hour to complete. Then, students in each school were stratified by grade and sex, and 17 students from each stratum were randomly selected for the in-home sample. In-home participants included the core sample and special oversamples based on ethnicity, twin status, and disability. At-home surveys took about one to two hours to complete (Harris et al., 2009).

Measures

Inhalant use. The outcome variables were lifetime (collected at Wave I) and past year (collected at Wave II; i.e., use between Wave I and Wave II) inhalant use*,* each of which was assessed using two questions. At Wave I, the first asked, *"How old were you when you tried inhalants, such as glue or solvents, for the first time?"* The question had the option of entering zero for "never" and options for ages 1 through 18. Responses were dichotomized to indicate lifetime use (yes or no). The second asked, *"During your life, how many times have you used inhalants, such as glue or solvents?"* Participants indicated amount of use as a count of total instances. Participants who responded "never" to the first question skipped this question and their responses were logically recoded as "no use." At Wave II, the first question asked, "*Since Wave I, have you tried or used inhalants, such as glue or solvents?"* Again, responses were dichotomized (yes or no). The second question asked, *"Since Wave I, how many times have you used inhalants?"* Again, participants indicated amount of use as a count of total instances. Participants who responded "no" to the first question skipped this question and were logically recoded as "no use" (Harris & Udry, 1994-2008 [Add Health web site]).

SDT-related constructs. Perceived autonomy was comprised of the sum of seven items. For all of these items, the question asked was, *"Do your parents let you make your own decisions about…"* with one item for each of seven different areas: weekend curfew, diet, amount of television watched, types of television shows watched, clothing, weeknight bedtime, and friend selection (yes/no for all seven items; Harris & Udry, 1994-2008). Higher scores indicated greater perceived autonomy. These items distinguished between participants whose parents made most of their everyday decisions and those who made most of their own everyday decisions, as an indication of overall adolescent independence. The standardized Cronbach's alpha for this measure was .64, suggesting moderately good reliability.

Two items assessed perceived competence. The first was, *"when you get what you want, it's usually because you worked hard for it,"* and the other was, *"you feel like you are doing everything just about right,"* Responses were on a Likert scale ranging from (1) strongly agree to (5) strongly disagree, and responses were reverse-coded and averaged. Higher scores indicated greater perceived competence (Harris & Udry, 1994-2008). These items represent a generalized measure of overall competence; competence in particular areas, fields or goals was not assessed in Add Health. Cronbach's alpha was not used as a reliability coefficient for this scale because the scale had two items; the Spearman correlation coefficient was .20, suggesting poor reliability.

Perceived relatedness was separated into maternal and paternal relatedness. Each of these was composed of four items: *"how much do you think your mother/father cares about you"* (1-5 Likert scale; 1 = not at all, 5 = very much), *"how close do you feel to your mother/father"* (1-5 Likert scale; 1 = not at all, 5 = very much), *"most of the time, your mother/father is warm and loving toward you"* (1-5 Likert scale; 1 = strongly agree, 5 = strongly disagree; reverse-coded), and *"overall you are satisfied with your relationship with your mother/father"* (1-5 Likert scale; 1 = strongly agree, 5 = strongly disagree; reverse-coded; Harris & Udry, 1994-2008). These items were selected because they focused on the emotions related to the participants' relationships with their central mother and father figures. In keeping with prior precedents in the Add Health literature, the composite variables for maternal and paternal relatedness were comprised of averages of the scores across the four items (Wolff & Crockett, 2011; Gault-Sherman, 2012). Higher scores on each measure indicated a higher degree of perceived relatedness toward the parent. The standardized Cronbach's alphas for maternal and paternal relatedness were .80 and .86, respectively, suggesting good reliability. Notably, these items were both skewed and leptokurtic, indicating that the reliability estimates should be interpreted with caution.

Control variables. These included ethnicity, gender, and age. Count of inhalant use at Wave I was also used as a control variable for the Wave II analyses. Ethnicity was assessed with one question that asked the interviewer to code the participant's race as White, Black or African American, American Indian or Native American, Asian or Pacific Islander, or Other. Ethnicity was dummy coded so that there were four codes (one for each non-White ethnic group) with Whites used as the reference group. Gender was assessed with one question that asked the interviewer to code the participant's gender as male or female (Harris & Udry, 1994-2008); males were coded as the reference group. Age was calculated using the participant's birth date and the interview date (Harris et al., 2009).

Analysis plan. Four models were constructed: a dichotomous use/non-use model for lifetime (collected at Wave I) and past year inhalant use (collected at Wave II) and a count model for lifetime (Wave I) and past year (Wave II) inhalant use severity. Logistic regression was used for the dichotomous use outcomes. For the severity outcomes, several count models (Poisson, zero-inflated Poisson, negative binomial, and zero-inflated negative binomial) were compared for fit. Poisson models assume that the mean and variance of the count are equal. Negative binomial models add an extra parameter to the Poisson distribution to account for over-dispersion, which occurs when the variance is larger than the mean. Zero-inflated versions of Poisson and negative binomial distributions are often appropriate for modeling behaviors that are rarely endorsed, like inhalant use, because they allow for a preponderance of zeros. Here, the zero-inflated models included predictors only in the count portion of the model that assessed severity; prediction of the zero-inflation included only an intercept because the presence or absence of a count was examined in the logistic regression models. The four count models were compared using the AIC and BIC, with lower AIC and BIC values indicating a better balance between model fit and parsimony, to determine which was optimal for inhalant use severity.

Due to low rates of use, a stepwise approach was used to examine prediction of inhalant use from the SDT-related constructs and control variables. The SDT-related variables were first entered one at a time (except maternal and paternal relatedness, which were entered together) in separate models to see if they individually predicted inhalant use. Then, a model was built with just the four control variables. In the final model, significant SDT-related and control variables were combined. Figure 9 shows a conceptual diagram of the overall model of interest that was tested.

Results

Table 4 contains means and standard deviations for the SDT-related variables and inhalant severity variables. Table 5 contains the correlations between all variables. Notably, of the SDT-related constructs, only autonomy was not significantly correlated with all inhalant use variables and all other SDT-related constructs.

Inhalant Use vs. Non-Use

Table 6 shows the stepwise model building process for concurrently predicting lifetime inhalant use at Wave I. Of the four SDT-related constructs, adolescent competence, paternal relatedness and maternal relatedness significantly predicted lifetime inhalant use. Whites were significantly more likely than Blacks to report lifetime inhalant use. In the final model, adolescent competence and maternal relatedness were significant predictors of lifetime inhalant use, and Whites were significantly more likely than Blacks and Asians to report lifetime use.

Table 7 shows the stepwise model building process for prospectively predicting past year inhalant use at Wave II. Of the SDT-related constructs, only adolescent competence at Wave I significantly predicted past year inhalant use. Of the four control variables, only Wave I count of use was significant. Both adolescent competence and Wave I count of use significantly predicted past year inhalant use in the final model.

Inhalant Use Severity

Table 8 shows the comparison of four count models and the stepwise modeling building process for concurrently predicting lifetime inhalant use severity. The AIC and BIC for the negative binomial model and zero-inflated negative binomial model were both low and similar, and though the negative binomial model's BIC value was slightly lower, the zero-inflated negative binomial model was ultimately chosen due to the high rate of zero responses. Of the SDT-related constructs, competence and maternal and paternal relatedness significantly predicted lifetime inhalant use severity. Males reported significantly more severe use than females, and Whites reported significantly more severe use than Blacks and Asians. In the final model, maternal relatedness and paternal relatedness were significant predictors of severity, males reported significantly more severe use than females, and Whites reported significantly more severe use than Asians.

Table 9 shows the comparison of four count models and the stepwise model building process for prospectively predicting past year inhalant use severity. Of the four count models examined, the zero-inflated negative binomial model had the lowest AIC and BIC and was selected as optimal. Of the SDT-related constructs, only competence significantly predicted past year inhalant use severity. Of the control variables, Wave I count of use significantly predicted past year inhalant use severity, and Whites reported significantly more severe use than Asians. In the final model, competence was no longer a significant predictor of past year inhalant use severity after controlling for Wave I count of use and ethnicity.

Additional Analyses

Given the interest in finding and describing clinical treatment recommendations for inhalant users, particularly those in specific populations based on demographic characteristics, post-hoc analyses were conducted to determine whether limiting the sample to only male or female students altered the relation between maternal/paternal relatedness and inhalant use. These analyses were only conducted for models in which maternal and/or paternal relatedness were significant predictors of inhalant use. In the final model for lifetime use for only males, maternal but not paternal relatedness was significant ($p = 0.0004$), and for only females, paternal but not maternal relatedness was significant ($p = 0.0048$). In the final model for lifetime use severity, neither relatedness variable remained significant for only males; for females, paternal but not maternal relatedness was significant ($p = 0.0109$).

Discussion

SDT-related constructs were demonstrated to predict inhalant use in different ways depending on whether use was predicted concurrently or prospectively. Additionally, predicting inhalant use severity was different from predicting use. For lifetime use, adolescent competence and maternal relatedness were key predictors, and for past year use adolescent competence was the key predictor. For lifetime severity, maternal and paternal relatedness were key predictors, and for past year severity none of the SDT-related constructs were key after controlling for demographic characteristics. Generally, competence emerged as being salient for both lifetime and past year use, and maternal relatedness emerged as being salient for both lifetime use and lifetime use severity. These findings suggest that low competence may be key in perpetuating inhalant use across time (i.e., adolescents with low competence are more likely to experiment with inhalants during their lifetimes, but also to continue to use instead of stopping with lifetime experimentation like many of their peers). In comparison, relatedness, especially to the mother, may contribute to the baseline risk for inhalant use but it is not a significant risk factor for continued use over time. SDT-related constructs should continue to be considered in terms of how they contribute both to overall risk for inhalant use and to continued use over time because these constructs may not all contribute to risky behavior in the same way or at the same time.

Lower self-perceived competence and lower maternal relatedness were related to higher odds of lifetime inhalant use. For every one-unit increase in competence, the odds of lifetime inhalant use changed by a factor of $e^{(-.4763)} = 0.62$; for every one unit increase in maternal relatedness, the odds of lifetime inhalant use changed by a factor of $e^{(-.3814)} = 0.68$. This pattern was consistent with the hypothesis that increases in SDT-related variables would predict a lower likelihood of using inhalants, meaning that individuals with higher competence and greater relatedness to mothers were less likely to report lifetime inhalant use concurrently. These findings also ring true with what has been reported previously about low competence and relatedness relating to an increased likelihood of substance use (Chassin et al., 1997; Turner et al., 1993). Interestingly, relatedness to the parent of the opposite gender seemed to be more important than relatedness to the parent of the same gender when the participants were separated into male-only and female-only groups.

In addition, adolescents with lower Wave I self-perceived competence were more likely to endorse past year inhalant use at Wave II (a one-unit increase in competence changed past year inhalant use by a factor of $e^{(-.5104)} = 0.60$). Thus, individuals who did not generally feel competent or had lower self-perceived competence in positive activities were more likely to report inhalant use in the following year. Taken together, these results suggest that treatment strategies for preventing future inhalant use should include approaches for building feelings of competence in constructive or positive outlets, as well as discussing how inhalant use can negatively impact one's performance in other areas. However, these results must be considered in the light of the poor reliability of the competence measure.

In comparison, lower maternal (a one unit increase in maternal relatedness increased lifetime inhalant use severity by a factor of $e^{(-.6955)} = 0.5$) and paternal (a one unit increase in paternal relatedness increased lifetime inhalant use severity by a factor of $e^{(-.3933)} = 0.67$) relatedness were associated with higher levels of lifetime inhalant use severity. This finding could be rooted in parental monitoring of adolescents' activities or adolescents' concern with parents' feelings toward inhalant use. A possible treatment strategy, then, would be to include parents in therapy for adolescents who use inhalants in order to enhance parental presence and emphasize the impact of inhalant use on parent-child relationships. Additionally, specifying the participant gender altered the effects of the relatedness variables in a way that suggests paternal relatedness is especially important for females; clinicians may want to encourage fathers to participate in treatment of daughters with inhalant use.

Interestingly, adolescent autonomy did not significantly predict inhalant use in any of the models. This finding may be due to the autonomy measure selected, which focused on independence in everyday decision-making and did not directly target issues related to peer pressure and cognitive or emotional self-perception of a participant's autonomy. This finding may also be a reflection of the typically young age of inhalant users (Garland et al., 2011), suggesting that adolescents around age 14 may be more focused on making progress toward goals and maintaining good relationships with their parents than developing autonomy.

However, these results disagree with prior literature relating low autonomy to an increased likelihood of substance use and propensity for delinquent behavior (Allen et al., 2012). Notably, the items selected for autonomy may better reflect the construct of parental permissiveness, given their focus on which behaviors parents allowed the adolescent to regulate. Thus, the failure of autonomy to emerge as a significant predictor of inhalant use may have been due to problems with construct validity.

Strengths and Limitations

This study was the first to evaluate the applicability of SDT-related constructs to inhalant use and thus builds on the existing literature relating SDT to other delinquent behaviors and substance use. This study is unique in that both dichotomous use/non-use and use severity were examined; existing literature has not investigated predictors of inhalant use severity. In addition, similar to Study I, this study utilized a nationally representative, non-clinical data set, which is important because most of the existing data on inhalant users are drawn from treatment populations (e.g., Bigler, 1979) or individuals incarcerated in juvenile detention centers (e.g., Jacobs & Ghodse, 1988). Further, most of the SDT-related measures used here demonstrated moderate to good reliability, with the exception of adolescent competence.

This study, however, also has several limitations. Again, the measurement of adolescent competence demonstrated poor reliability, which limits the validity of conclusions drawn regarding the influence of adolescent competence on inhalant use. This issue stems from the lack of appropriate competence-related items found in the Add Health dataset. Measures of adolescent competence that are more directly related to specific tasks (e.g., avoiding substance use) may provide better information about how adolescent competence is related specifically to inhalant use. Additionally, due to the structure of the Add Health data, twelfth graders from

Wave I were not re-interviewed at Wave II, so their data are missing from the Wave II analyses. However, this is not viewed as a significant limitation given that inhalant use has traditionally been more popular among younger students (Garland et al., 2011). Finally, similar to Study I, this study was unable to study school dropouts due to the nature of Add Health data collection.

Chapter 4: General Discussion

The two studies described here took two different approaches to examining the etiology of inhalant use among adolescents in the U.S. Study I was focused on long-term trends. The results indicated that inhalant use trends increased at first but leveled off and declined over the years. Gender and ethnic differences suggested a need to tailor treatment based on demographic groups, a finding already reflected in the literature (Matthew & Lorah, 2005; Schinke, Fang & Cole, 2009). Specifically, the proportion of males decreased significantly over time, as did the proportion of Whites, indicating a need to look at treatment approaches specific to female and Hispanic and other minority adolescents. As expected, the median grade of first use occurred during middle school, supporting the use of early prevention and intervention strategies for inhalant use. This age was commensurate with the average age of users as reported by Garland et al. (2011). Salient "three strikes laws" and the second of two national methamphetamine laws predicted significant increases in regional annual inhalant use, suggesting that heavy pressure to reduce or stop use of other drugs may result in an increased prevalence of inhalant use. This finding was reflective of prior research that detected a "substitution effect," meaning that the use of some drugs decreased in the wake of restricted access to other drugs (Crost & Guerrero, 2012; DiNardo & Lemieux, 2001; Thies & Register, 1993). Interestingly, no differences between regions emerged here, though regional differences have been found in prior research (Perron & Howard, 2008).

Study II was focused on using SDT-related constructs to concurrently and prospectively predict inhalant use. Of the three constructs examined, adolescent competence and parental relatedness were related to inhalant use and severity, whereas autonomy was unrelated. In addition, as has been found with other substances, one of the best predictors of future use and severity was amount of current use. Interestingly, post-hoc analyses revealed that relatedness to the opposite gender parent may be more important than the same gender parent in predicting concurrent use, and paternal relatedness may be more important for females in predicting concurrent use severity.

In general, the results of Study II were similar to those of other studies showing that males are more likely to endorse inhalant use (Dinwiddie, 1994) and Whites are more likely than Blacks or Asians to endorse use (Edwards et al., 2007; Thai et al., 2010). Additionally, the results of Study II support prior literature that linked low competence and relatedness to substance use (Chassin et al., 1999; Turner et al., 1993).

Both studies focused on predictors of inhalant use; Study I showed that certain legislative measures predicted *increases* in inhalant use, whereas Study II identified competence and parental relatedness as individual predictors of *decreased* inhalant use. Important gender and ethnic differences were also found in both studies. Though Whites and males were more likely to use inhalants as evidenced by the results of Study II, Study I showed that proportions of these groups have decreased over time among *lifetime* users of inhalants. Taken together, these results support the call to tailor treatment for inhalant use and inhalant use disorders to specific types of inhalant users, particularly Hispanics and females.

Paradoxically, older students reported lower rates of lifetime use than their younger counterparts. This finding is fairly common in inhalant use research, and is not explained by the tendency to initiate and cease inhalant use early (Garland et al., 2011). A variety of explanations have been posited in the literature. For example, this paradox could stem from inhalant users dropping out of school; more information is needed about the inhalant use patterns of school dropouts, particularly those who do not go to juvenile detention centers or enter psychiatric treatment for mental illness or substance use. Other possible reasons for this paradox include higher rates of forgetting about sporadic lifetime use of inhalants from years ago compared to other more recognizable substances, or possibly older adolescents having a better understanding of what products actually qualify as inhalants. Because inhalants take the form of common household products that have an off-label use for intoxication (NIDA, 2011), it can be more difficult to identify and track use of these products on individual and societal levels. Fortunately, with growing public awareness about the dangers of inhalant use, it is becoming more difficult for adolescents to conceal their inhalant use or remain ignorant of the dangers posed by inhalants.

Implications for Clinicians and Prevention Scientists

Studying inhalant use etiology on a large-scale population level is important because it maximizes generalizability of the findings and helps to ensure that clinicians and prevention scientists in many different locations can make use of the information. By studying inhalant use etiology from multiple angles, several implications can be discussed, some of which apply to clinical intervention and some that are more appropriate for prevention.

First, given that gender and ethnic trends have been demonstrated to change over time and as a function of grade cohort, clinicians can try to focus their treatments based on the specific demographic groups that seem to be growing among those reporting lifetime use. Female users may benefit from therapies that focus on relationships or emotional processing, as well as those that involve fathers as an influence. Hispanic or other minority groups may benefit from treatments that confront beliefs or assumptions common to cultures more accepting of drug use or those that target stigma and acculturation stress in order to build competence or parental relatedness. Broadly speaking, all inhalant users may benefit from treatment that incorporates building competence and parental relatedness; for example, clinicians may want to help inhalant users build feelings of competence in positive activities or emphasize how inhalant use can negatively affect a teenager's relationship with his or her parents.

Second, these results provide prevention scientists with a greater understanding of how inhalant use has changed over time, and these trends can now be compared to long-term trends established in the literature for better-known substances. By comparing inhalants to other substances whose use has declined over time, like alcohol and tobacco, and whose use may be increasing, like marijuana, prevention scientists can begin to investigate contextual factors that have affected substances differently. For example, this study suggests that potential unintended negative consequences of legislative milestones on other substances need to be considered. These conclusions could be strengthened, for instance, by conducting a natural experiment if more states pass "three strikes laws" in the future or if new federal laws that affect drugs commonly used by inhalant users (e.g., methamphetamine, marijuana) are implemented. Further, similar to the implications for clinicians, prevention scientists may want to include modules on increasing feelings of competence and parental relatedness in programs designed to reduce inhalant use. In addition, these programs should be implemented well before high school.

Overall Strengths and Limitations

The current research addressed the critical, under-studied question of U.S. adolescent inhalant use etiology from several novel angles. Both studies used large nationally representative data sets, which provided a different perspective from treatment samples and samples drawn from juvenile detention centers; these clinical samples have been used for the majority of research conducted thus far on inhalant users. Given that the existing literature on inhalant use is very limited, the current research provides important information that can be used as a starting point for future research across the country. An important strength of the use of nationally representative data is that results can be applied to clinical treatment and intervention planning as well as policy-making and prevention efforts.

However, the current research also had some important limitations. First, neither the MTF nor Add Health studies captured information from school dropouts who might be more likely to use inhalants. Not including these individuals somewhat limits generalizability of the findings. However, MTF collects data from individuals as early as eighth grade and Add Health as early as seventh grade, so only the most severe users who initiated very early and dropped out are not represented in some way in the present studies.

Second, both MTF and Add Health rely on self-report data, which may be subject to measurement error from a variety of sources. Criticisms of the validity of self-reported substance use include individuals being able to retract reports within a survey or over time, or individuals forgetting or deliberately incorrectly reporting use (e.g., providing socially desirable responses). Both MTF and Add Health use skip patterns to reduce or eliminate issues with report retraction but do not have validity checks to ensure accurate responding.

Third, as with any other secondary data analysis, choices made during the original data collection introduced some limitations when addressing the aims of the present study. For example, MTF does not provide several pieces of information that would have improved our ability to address the aims of Study I. Ideally, research on the effects of "three strikes laws" would utilize state-level data, but only regional information was provided by MTF. As another example, the measurement of adolescent competence in Add Health was not ideal; the scale score used in Study II suffered from poor reliability and probably did not assess the most relevant aspects of competence for inhalant use. Secondary data analysis is a powerful tool to accelerate the pace of research, particularly when large national datasets are available to address the questions of interest, but compromises often must be made in terms of construct measurement. Care should be taken to balance the desire for maximally generalizable data with making sure selected datasets include good measurement of the constructs under study; sometimes it may be more appropriate to collect new data. Another noteworthy limitation of using national data instead of a smaller and more focused data set of mostly inhalant users is that using a nationally representative sample can make it harder to apply results to treatment. Given that inhalant use has a low prevalence rate in the general population, using a clinical sample of inhalant users may provide more salient information about how inhalant users typically respond to treatment and what kinds of techniques are most appropriate for that specific population.

Finally, though high power to detect an effect may be expected due to the large sample sizes in the nationally representative data sets used here, the present research may have suffered from low power due to the low endorsement of inhalant use, particularly at Wave II of Study II. Low power may be partially responsible for some of the non-significant findings in Study II. For example, depending on the predictor, post-hoc power for the lifetime use logistic regression analyses ranged from .27 to .90; for the annual use logistic regression analysis, it ranged from .15 to .70. Non-significant results, particularly those from Study II about adolescent autonomy, should be interpreted with caution and perhaps examined with a sample of individuals at high-risk for inhalant use.

Directions for Future Research

One possible direction for future research is to evaluate more fully why inhalant use showed a decreasing trend over the period of 1991 to 2011. Given its legal status, inhalant use is an interesting and unorthodox substance and trends in its use have not always followed those of other illicit drugs. The current research showed that legislative milestones can be salient to inhalant use despite not directly affecting inhalants, and future research could augment this finding by using state-level data to replicate the analyses and test other relevant legal milestones to see if they show a relation with changes in inhalant use trends.

Future research should also apply SDT to inhalant use using measures or data specifically designed for SDT constructs. In particular, given that no SDT-related constructs were significantly predictive of Wave II use severity in the current research, a goal of future research could be to find a theory that better explains prospective inhalant use severity. Research in that vein would, like the current research, go beyond the existing literature on predicting inhalant use and provide important information about what variables predict the *extent* or level of use.

One under-studied population of inhalant users was highlighted during this research: early initiating dropouts outside the juvenile justice system. Attempting to gather inhalant use data from this population would augment the literature on inhalant use in a meaningful way by bridging the gap between nationally representative studies and those conducted on clinical populations with severe inhalant use. Given the new lines of research begun in this project, inhalant use researchers interested in dropouts and other groups of inhalant users could add to the important but presently sparse literature on U.S. adolescent inhalant use.

Inhalant use has been understudied despite its potential for seriously negative consequences for cognitive development and physical and neuropsychological health. It is important to add to the existing literature on inhalant use because of inhalants' unusual characteristics, such as being easy to obtain and conceal and tendency to be perceived as less risky than they actually could be. The present research examined long-term trends in inhalant use and SDT-related predictors of inhalant use. The results of the present research added to the current literature on inhalant use and opened several avenues for future research that could help clinicians and prevention scientists better understand, treat, and prevent adolescent inhalant use.

References

Allen, J. P., Moore, C., Kuperminc, G., & Bell, K. (1998). Attachment and adolescent psychosocial functioning. *Child Development, 69*(5), 1406-1419.

Allen, J. P., Marsh, P., McFarland, C., McElhaney, K. B., Land, D. J., Jodi, K. M., & Peck, S. (2002). Attachment and autonomy as predictors of the development of social skills and delinquency during midadolescence. *Journal of Consulting and Clinical Psychology, 70*(1), 56-66.

Allen, J. P., Chango, J., Szwedo, D., Schad, M., & Marston, E. (2012). Predictors of susceptibility to peer influence regarding substance use in adolescence. *Child Development, 83*(1), 337-350.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders* (4th ed., text rev.). Washington, DC: Author.

Anonymous. (2004). Inhalant abuse becomes focus of SAMHSA guidelines, prevention efforts. *Alcoholism and Drug Abuse Weekly, 16*(12), 1-3.

Balster, R. L. (1998). Neural basis of inhalant use. *Drug and Alcohol Dependence, 51*, 207-214.

Barrett, M. E., Joe, G. W., & Simpson, D. D. (1991). Acculturation influences on inhalant use. *Hispanic Journal of Behavioral Sciences, 13*(3), 276-296.

Beauvais, F., Oetting, E. R., & Edwards, R. W. (1985). Trends in the use of inhalants among American Indian adolescents. *White Cloud Journal of American Indian Mental Health, 3*(4), 3-11.

Beauvais, F., Wayman, J. C., Jumper-Thurman, P., Plested, B., & Helm, H. (2002). Inhalant abuse among American Indian, Mexican American, and non-Latino white adolescents. *American Journal of Drug and Alcohol Abuse, 28*(1), 171-187.

Bigler, E. D. (1979). Neuropsychological evaluation of adolescent patients hospitalized with chronic inhalant abuse. *Clinical Neuropsychology, 1*(1), 8-12.

Brecht, M., Greenwell, L., & Anglin, M. D. (2007). Substance use pathways to methamphetamine use among treated users. *Addictive Behaviors, 32*, 24-38.

Brouette, T., & Anton, R. (2001). Clinical review of inhalants. *American Journal on Addictions, 10,* 79-94.

Cairney, S., Maruff, P., Burns, C. B., Currie, J., & Currie, B. J. (2005). Neurological and cognitive recovery following abstinence from petrol sniffing. *Neuropsychopharmacology, 30,* 1019-1027.

Chan, S. M., & Chan, K. W. (2011). Adolescents' susceptibility to peer pressure: Relations to parent-adolescent relationship and adolescents' emotional autonomy from parents. *Youth and Society, 45*(2), 286-302.

Chassin, L., Pitts, S. C., & DeLucia, C. (1999). The relation of adolescent substance use to young adult autonomy, positive activity involvement, and perceived competence. *Development and Psychopathology, 11*, 915-932.

Chen, E. Y. (2008). Impacts of "three strikes and you're out" on crime trends in California and throughout the United States. *Journal of Contemporary Criminal Justice, 24*(4), 345-370.

Collins, D., Pan, Z., Johnson, K., Courser, M., & Shamblen, S. (2008). Individual and contextual predictors of inhalant use among eighth graders: A multilevel analysis. *Journal of Drug Education, 38*(3), 193-210.

Compton, W. M., Cottler, L. B., Dinwiddie, S. H., Spitznagel, E. L., Mager, D. E., & Asmus, G. (1994). Inhalant use: Characteristics and predictors. *American Journal on Addictions, 3*, 263-272.

Crost, B., & Guerrero, S. (2012). The effect of alcohol availability on marijuana use: Evidence from the minimum legal drinking age. *Journal of Health Economics, 31,* 112-121.

Deci, E. L., & Ryan, R. M. (1987). The support of autonomy and control of behavior. *Journal of Personality and Social Psychology, 53*(6), 1024-1037.

Deci, E. L., & Ryan, R. M. (2000). The "what" and "why" of goal pursuits: Human needs and the self-determination of behavior. *Psychological Inquiry, 11*(4), 227-268.

Deci, E. L., & Ryan, R. M. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology, 49*(3), 182-185.

DiNardo, J., & Lemieux, T. (2001). Alcohol, marijuana, and American youth: The unintended consequences of government regulation. *Journal of Health Economics, 20,* 991-1010.

Dinwiddie, S. H. (1994). Abuse of inhalants: A review. *Addiction, 89*, 925-939.

Dobkin, C., & Nicosia, N. (2009). The War on Drugs: Methamphetamine, public health, and crime. *American Economic Review, 99*(1), 324-349.

Edwards, R. W., Stanley, L., Plested, B. A., Marquart, B. S., Chen, J., & Thurman, P. J. (2007). Disparities in young adolescent inhalant use by rurality, gender, and ethnicity. *Substance Use and Misuse, 42*, 643-670.

Erikson, E. H. (1968). *Identity: Youth and Crisis.* New York, N.Y.: Norton.

Fell, J. C., & Voas, R. B. (2006). Mothers Against Drunk Driving (MADD): The first 25 years. *Traffic Injury Prevention, 7*, 195-212.

Ferraiolo, K. (2007). From killer weed to popular medicine: The evolution of American drug control policy, 1937-2000. *The Journal of Policy History, 19*(2), 147-179.

Garland, E. L., Howard, M. O., Vaughn, M. G., & Perron, B. E. (2011). Volatile substance misuse in the United States. *Substance Use and Misuse, 46*, 8-20.

Gault-Sherman, M. (2012). It's a two-way street: The bidirectional relationship between parenting and delinquency. *Journal of Youth and Adolescence, 41*, 121-145.

Gfroerer, J., Wright, D., & Kopstein, A. (1997). Prevalence of youth substance use: The impact of methodological differences between two national surveys. *Drug and Alcohol Dependence, 47*, 19-30.

Harris, K. M., & Udry, J. R. (1994-2008). National Longitudinal Study of Adolescent Health (Add Health). ICPSR21600-v9. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2012-05-08. doi: 10.3886/ICPSR21600.v9

Harris, K. M., Halpern, C. T., Whitsel, E., Hussey, J., Tabor, J., Entzel, P., & Udry, J. R. (2009). The National Longitudinal Study of Adolescent Health: Research Design [WWW Document]. URL: http://www.cpc.unc.edu/projects/addhealth/design

Howard, M. O., Balster, R. L., Cottler, L. B., Wu, L. T., & Vaughn, M. G. (2008). Inhalant use among incarcerated adolescents in the United States: Prevalence, characteristics, and correlates of use. *Drug and Alcohol Dependence, 93,* 197-209.

Howard, M. O., Bowen, S. E., Garland, E. L., Perron, B. E., & Vaughn, M. G. (2011). Inhalant use and inhalant use disorders in the United States. *Addiction Science and Clinical Practice, 6*(1), 18-31.

Jacobs, A. M., & Ghodse, A. H. (1988). Delinquency and regular solvent abuse: An unfavourable combination? *British Journal of Addiction, 83*, 965-968.

Joe, G. W., & Simpson, D. D. (1991). Reasons for inhalant use. *Hispanic Journal of Behavioral Sciences, 13*(3)*,* 256-266.

Johnston, Lloyd D., Jerald G. Bachman, Patrick M. O'Malley, and John E. Schulenberg. Monitoring the Future: A Continuing Study of American Youth (8th- and 10th-Grade Surveys), 2004. ICPSR04263-v2. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2010-02-24. doi:10.3886/ICPSR04263.v2.

Johnston, Lloyd D., Jerald G. Bachman, Patrick M. O'Malley, and John E. Schulenberg. Monitoring the Future: A Continuing Study of American Youth (8th- and 10th-Grade Surveys), 2005. ICPSR04537-v2. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2010-03-12. doi:10.3886/ICPSR04537.v2.

Johnston, L. D., Bachman, J. G., O'Malley, P. M., & Schulenberg, J. E. Monitoring the Future: A continuing study of American youth (8^{th}- and 10^{th}-grade surveys), 2010. ICPSR30984-v1. Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 2011-10-26. doi: 10.3886/ICPSR30984-v1.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2011). *Monitoring the Future national survey results on drug use, 1975-2010. Volume I: Secondary school students.* Ann Arbor: Institute for Social Research, The University of Michigan, 744 pp.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2012). *Monitoring the Future national results on adolescent drug use: Overview of key findings, 2011.* Ann Arbor: Institute for Social Research, The University of Michigan.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2013). *Monitoring the Future national results on drug use: 2012 overview, key findings on adolescent drug use*. Ann Arbor: Institute for Social Research, The University of Michigan.

Lubman, D. I., Yücel, M., & Lawrence, A. J. (2008). Inhalant abuse among adolescents: Neurobiological considerations. *British Journal of Pharmacology, 154*, 316-326.

Matthews, C. R., & Lorah, P. (2005). An examination of addiction treatment completion by gender and ethnicity. *Journal of Addictions and Offender Counseling, 25,* 114-125.

McGarvey, E. L., Canterbury, R. J., & Waite, D. (1996). Delinquency and family problems in incarcerated adolescents with and without a history of inhalant use. *Addictive Behaviors, 21*(4), 537-542.

McKetin, R., Sutherland, R., Bright, D. A., & Norberg, M. M. (2011). A systematic review of methamphetamine precursor regulations. *Addiction, 106,* 1911-1924.

Mackesy-Amiti, M. E., & Fendrich, M. (1999). Inhalant use and delinquent behavior among adolescents: A comparison of inhalant users and other drug users. *Addiction, 94*(4), 555-564.

National Institute on Drug Abuse (NIDA). (2011, December). *NIDA Infofacts: Inhalants.* Retrieved May 29, 2012, from NIDA web site: http://www.drugabuse.gov/publications/infofacts/inhalants

Perron, B. E., & Howard, M. O. (2008). Perceived risk of harm and future intentions of inhalant use among adolescent inhalant users. *Drug and Alcohol Dependence, 97,* 185-189.

Perron, B. E., Howard, M. O., Maitra, S., & Vaughn, M. G. (2009). Prevalence, timing, and predictors of transitions from inhalant use to inhalant use disorders. *Drug and Alcohol Dependence, 100*, 277-284.

Perron, B. E., Mowbray, O., Bier, S., Vaughn, M. G., Krentzman, A., & Howard, M. O. (2011). Service use and treatment barriers among inhalant users. *Journal of Psychoactive Drugs, 43*(1), 69-75.

Perron, B. E., Vaughn, M. G., & Howard, M. O. (2008). Reasons for using inhalants: Evidence for discrete classes in a sample of incarcerated adolescents. *Journal of Substance Abuse Treatment, 34,* 450-455.

Ramirez, J. R., & Crano, W. D. (2003). Deterrence and incapacitation: An interrupted time-series analysis of California's three-strikes law. *Journal of Applied Social Psychology, 33*(1), 110-144.

Ridenour, T. A. (2005). Inhalants: Not to be taken lightly anymore. *Current Opinion in Psychiatry, 18*, 243-247.

Ryan, R. M., & Deci, E. L. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54-67.

Ryan, R. M., & Deci, E. L. (2000b). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist, 55*(1), 68-78.

Sakai, J. T., Hall, S. K., Mikulich-Gilbertson, S. K., & Crowley, T. J. (2004). Inhalant use, abuse, and dependence among adolescent patients: Commonly comorbid problems. *Journal of the American Academy of Child and Adolescent Psychiatry, 43*(9), 1080-1088.

Salous, A., & Omar, H. A. (2009). Substance use among adolescents: A cross-cultural review. *International Journal on Disability and Human Development, 8*(2), 155-158.

Schinke, S. P., Fang, L., & Cole, K. C. (2009). Computer-delivered, parent-involvement intervention to prevent substance use among adolescent girls. *Preventive Medicine, 49*, 429-435.

Siegel, J. T., Alvaro, E. M., Patel, N., & Crano, W. D. (2009). "…you would probably want to do it. Cause that's what made them popular": Exploring perceptions of inhalant utility among young adolescent nonusers and occasional users. *Substance Use and Misuse, 44*, 597-615.

Substance Abuse and Mental Health Services Administration, *Results from the 2011 National Survey on Drug Use and Health: Summary of National Findings*, NSDUH Series H-44, HHS Publication No. (SMA) 12-4713. Rockville, MD: Substance Abuse and Mental Health Services Administration, 2012.

Sikes, A., Walley, C., McBride, R., Fusco, A., Cole, R. F., & Lauka, J. (2011). Inhalant and prescription medication abuse among adolescents: An inexpensive, accessible, and misperceived trend. *Journal of Child and Adolescent Substance Abuse, 20*(3), 237-252.

Takagi, M., Yücel, M., Cotton, S. M., Baliz, Y., Tucker, A., Elkins, K., & Lubman, D. I. (2010). Verbal memory, learning, and executive functioning among adolescent inhalant and cannabis users. *Journal of Studies on Alcohol and Drugs, 72,* 96-105.

Takagi, M., Lubman, D. I., Cotton, S., Fornito, A., Baliz, Y., Tucker, A., & Yücel, M. (2011). Executive control among adolescent inhalant and cannabis users. *Drug and Alcohol Review, 30,* 629-637.

Thai, N. D., Connell, C. M., & Tebes, J. K. (2010). Substance use among Asian American adolescents: Influence of race, ethnicity, and acculturation in the context of key risk and protective factors. *Asian American Journal of Psychology, 1*(4), 261-274.

Thies, C. F., & Register, C. A. (1993). Decriminalization of marijuana and the demand for alcohol, marijuana, and cocaine. *The Social Science Journal, 30*(4), 385-399.

Turner, R. A., Irwin, Jr., C. E., Tschann, J. M., & Millstein, S. G. (1993). Autonomy, relatedness, and the initiation of health risk behaviors in early adolescence. *Health Psychology, 12*(3), 200-208.

Vallerand, R. J., Fortier, M. S., & Guay, F. (1997). Self-determination and persistence in a real-life setting: Toward a motivation model of high school dropout. *Journal of Personality and Social Psychology, 72*(5), 1161-1176.

Vansteenkiste, M., & Sheldon, K. M. (2006). There's nothing more practical than a good theory: Integrating motivational interviewing and self-determination theory. *British Journal of Clinical Psychology, 45,* 63-82.

Vitiello, M. (2002). Three Strikes Laws: A real or imagined deterrent to crime? *Human Rights, 29*(2), 3-5.

Wallace, Jr., J. M., & Muroff, J. R. (2002). Preventing substance abuse among African American children and youth: Race differences in risk factor exposure and vulnerability. *The Journal of Primary Prevention, 22*(3), 235-261.

Wang, M. T. (2009). School climate support for behavioral and psychological adjustment: Testing the mediating effect of social competence. *School Psychology Quarterly, 24*(4), 240-251.

Williams, J. F., Storck, M., & The Committee on Substance Use and Committee on Native American Child Health. (2007). Inhalant abuse. *Pediatrics, 119*(5), 1009-1017.

Wolff, J. M., & Crockett, L. J. (2011). The role of deliberative decision making, parenting, and friends in adolescent risk behaviors. *Journal of Youth and Adolescence, 40*, 1607-1622.

Yacoubian, Jr., G. S. (2007). Assessing the relationship between marijuana availability and marijuana use: A legal and sociological comparison between the United States and the Netherlands. *Journal of Alcohol and Drug Education, 51*(4), 17-34.

Yamanouchi, N., Okada, S-C., Kodama, K., Hirai, S., Sekine, H., Murakami, A., Komatsu, N., Sakamoto, T., & Sato, T. (1995). White matter changes caused by chronic solvent abuse. *American Journal of Neuroradiology, 16,* 1643-1649.

Young, T. J. (1987). Inhalant use among American Indian youth. *Child Psychiatry and Human Development, 18*(1), 36-46.

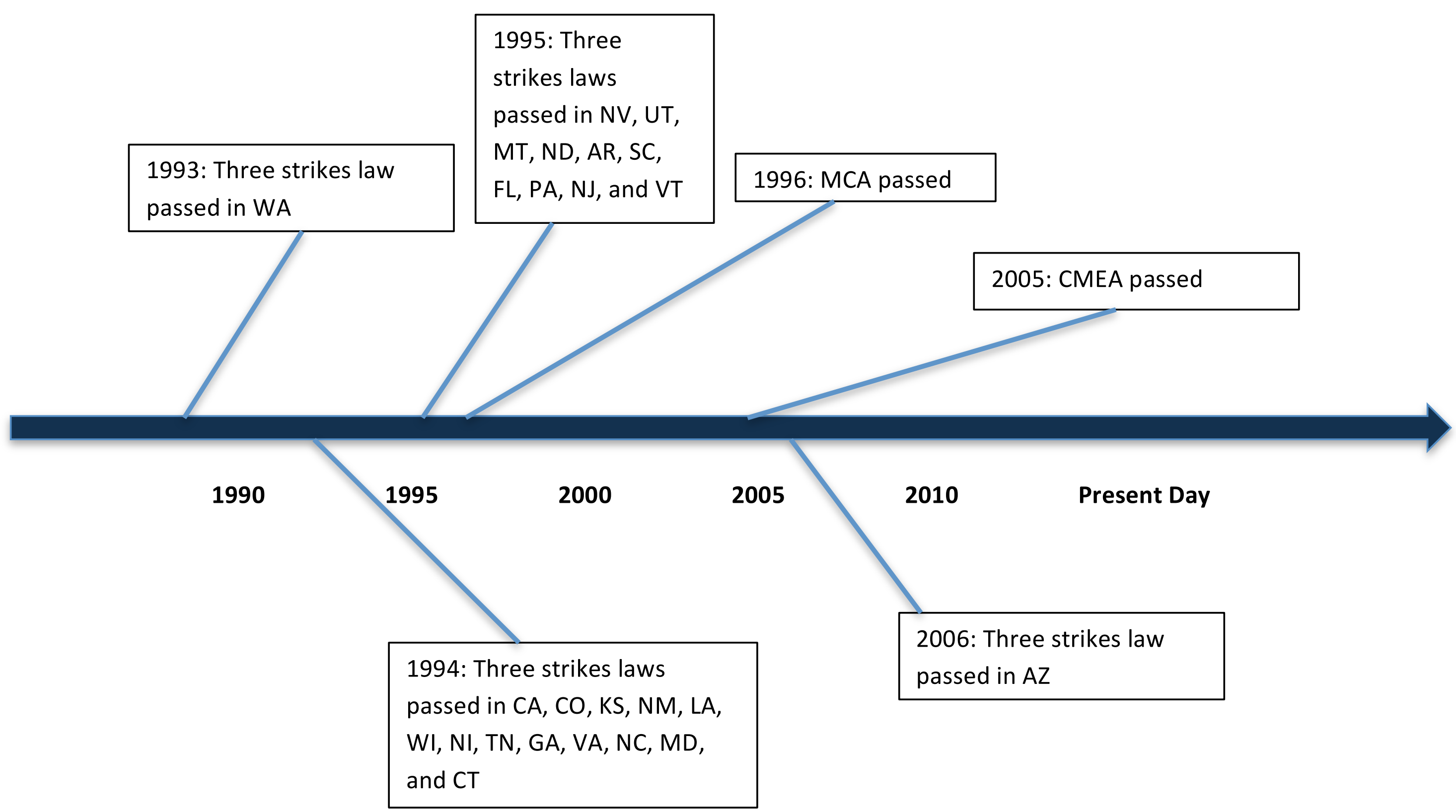


Figure 1. Timeline of U.S. drug-related legislation of interest for inhalant use. The 1996 Comprehensive Methamphetamine Control Act (MCA) and 2005 Combat Methamphetamine Epidemic Act (CMEA) were both national methamphetamine laws.

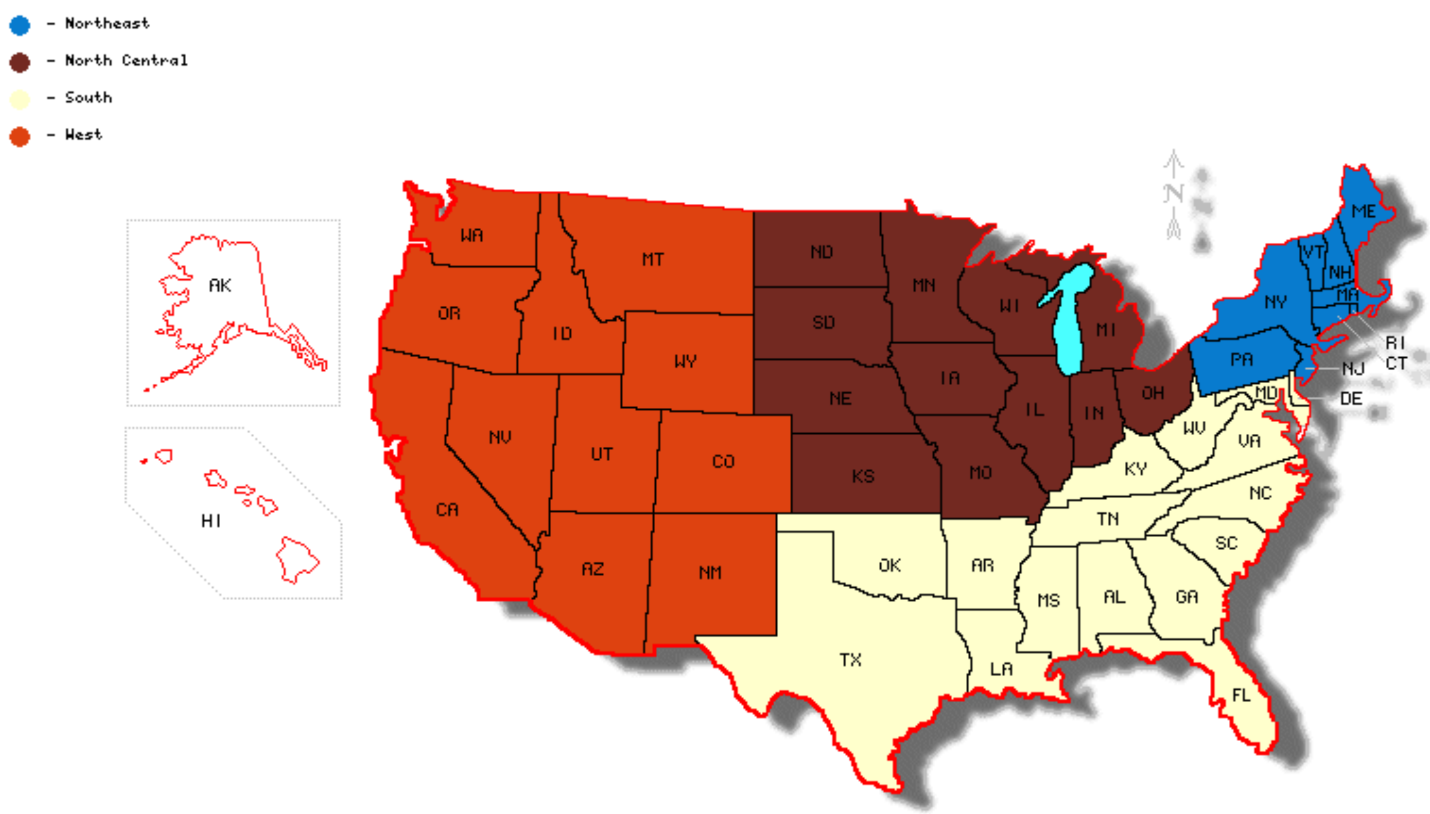


Figure 2. Monitoring the Future regional division of the U.S. Map constructed using https://diymaps.net and adapted from Johnston et al. (2011).

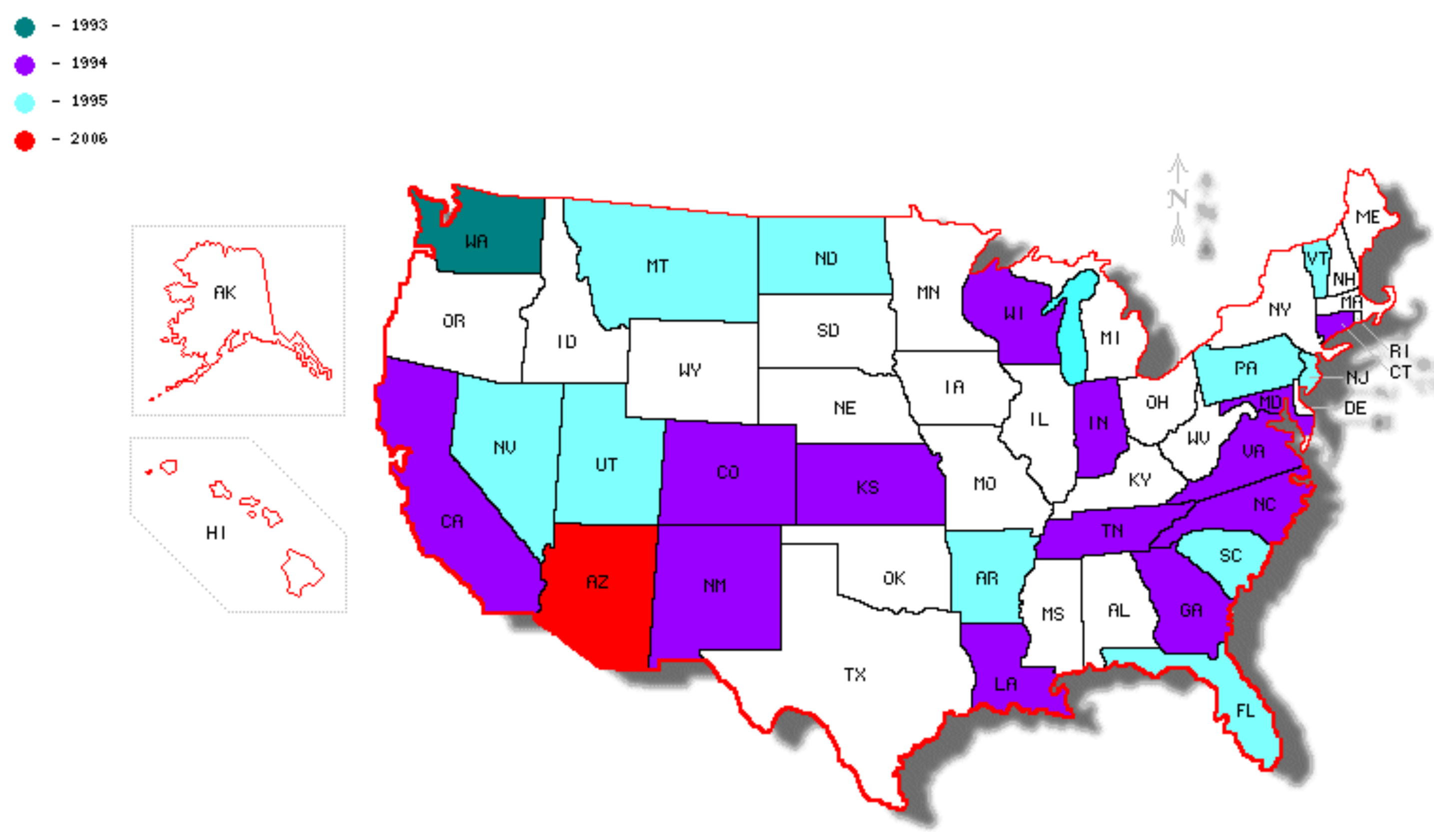


Figure 3. U.S. states affected by "three strikes laws," 1991-2011. Map constructed using https://diymaps.net.

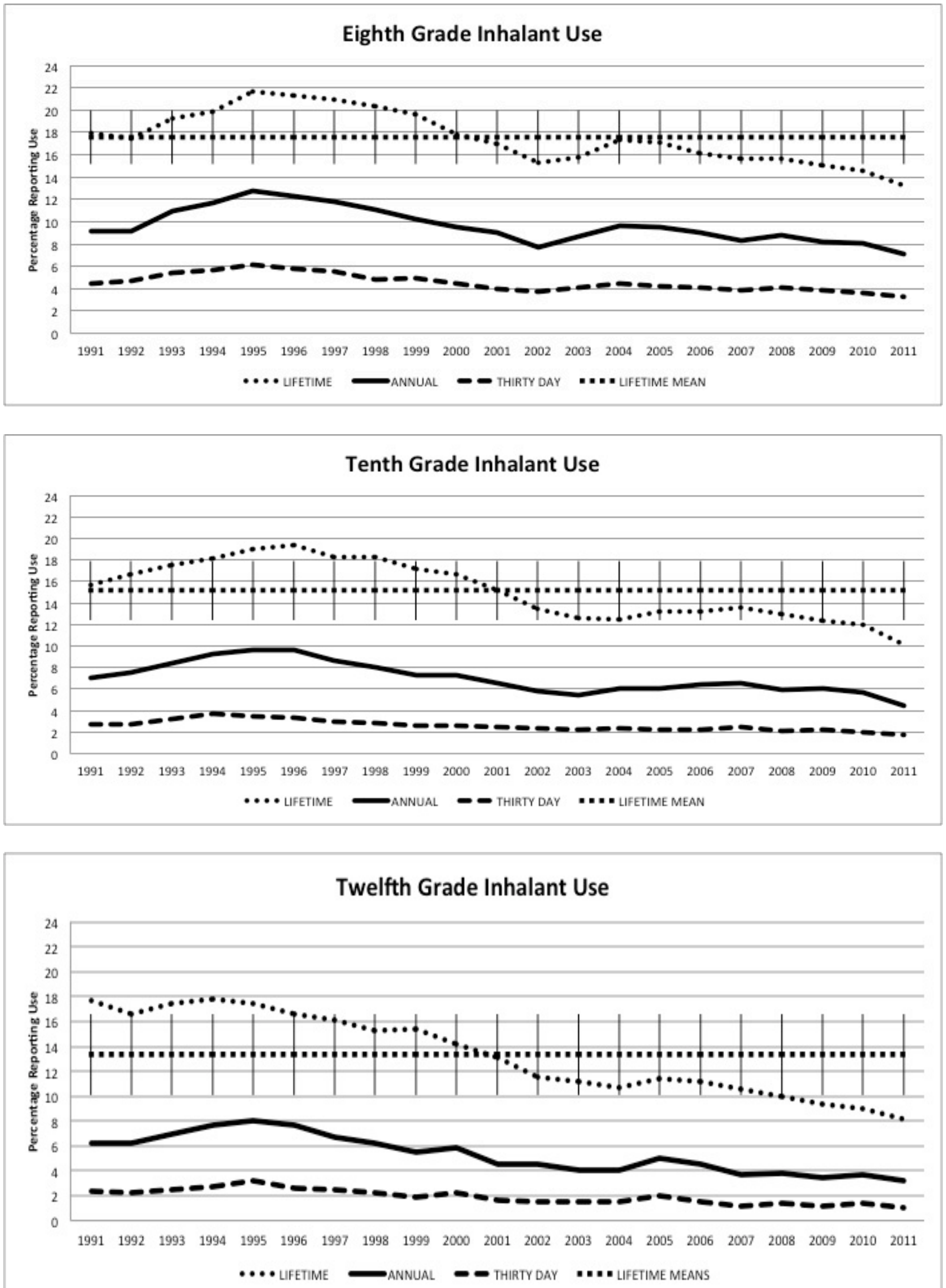
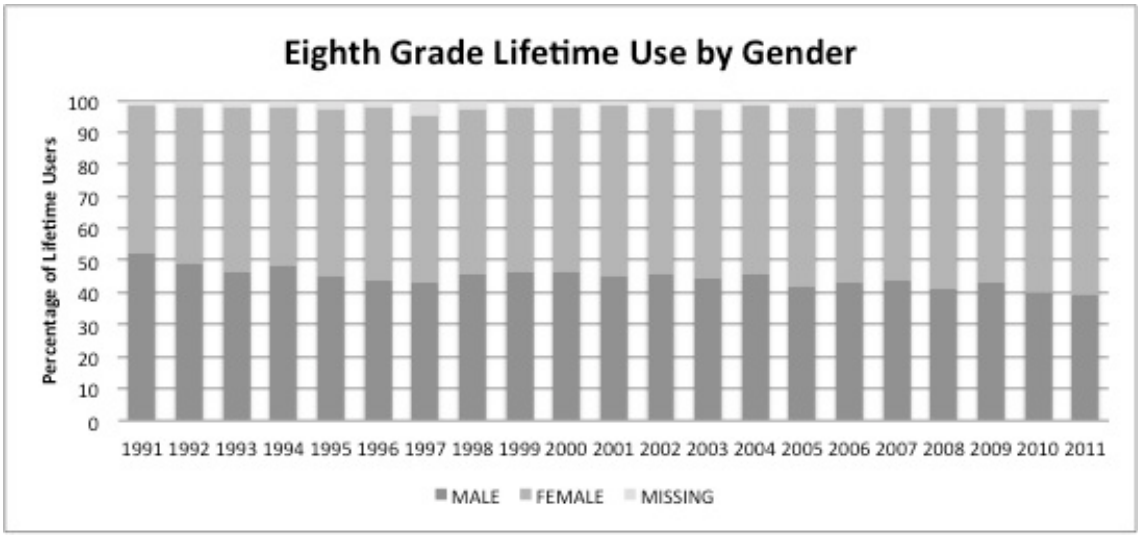


Figure 4. Lifetime, annual, and thirty-day inhalant use prevalence rates for eighth, tenth, and twelfth graders, 1
Missing data proportions ranged from 2.12% (2004) to 4.89% (1992) for eighth graders, 1.45% (1995) to 2.46
graders, and 2.41% (1992) to 4.69% (2011) for twelfth graders. Lifetime means (and 95% confidence bars) for



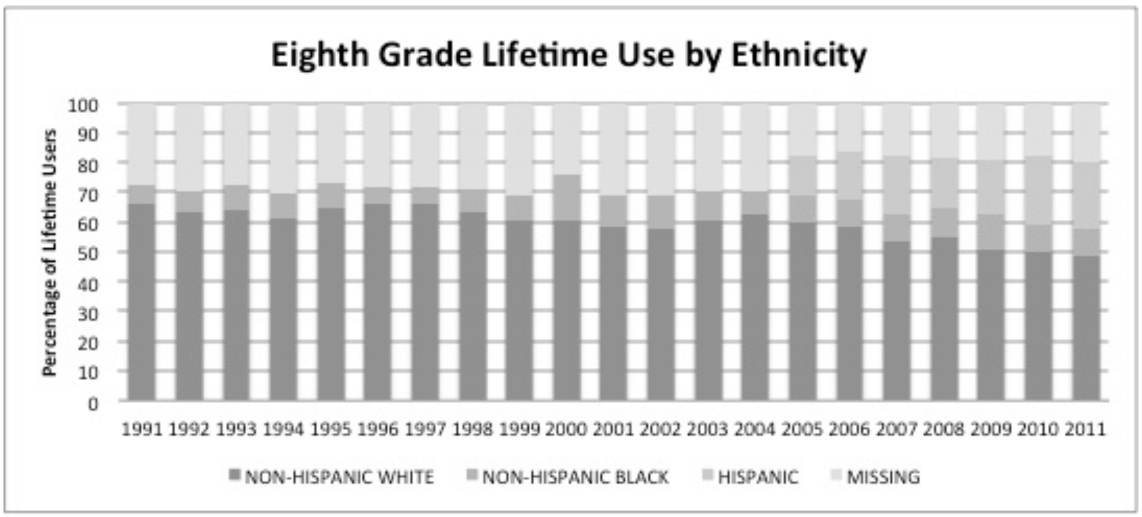
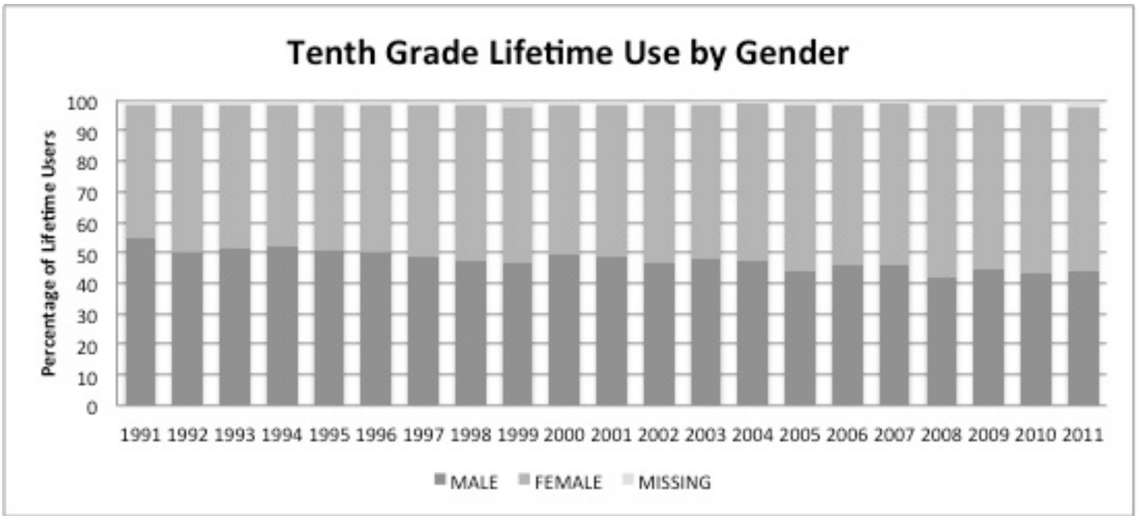


Figure 5. Demographic breakdown of eighth grade lifetime inhalant users by year. Missing data proportions for gender ranged from 1.59% (2004) to 4.58% (1997), and proportions for ethnicity ranged from 17.74% (2005) to 31.33% (1999).



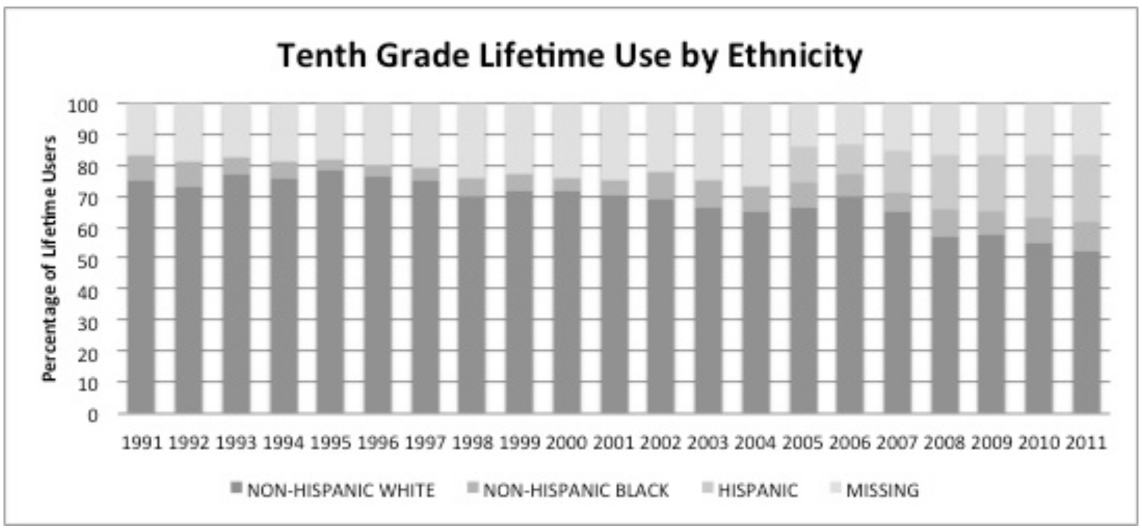
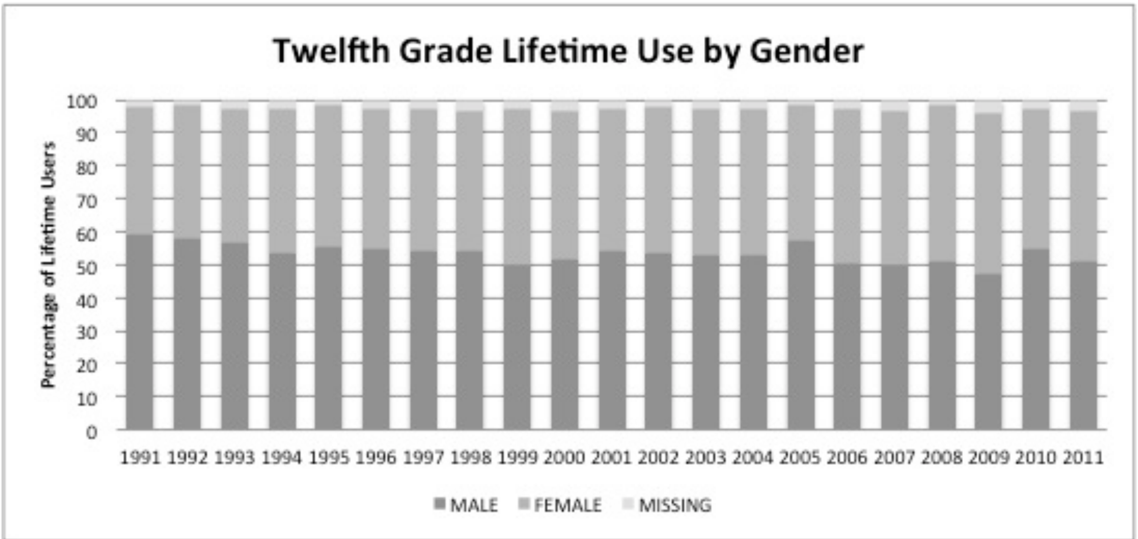


Figure 6. Demographic breakdown of tenth grade lifetime inhalant users by year. Missing data proportions for gender ranged from 1.02% (2007) to 2.48% (1999), and proportions for ethnicity ranged from 13.69% (2006) to 27.07% (2004).



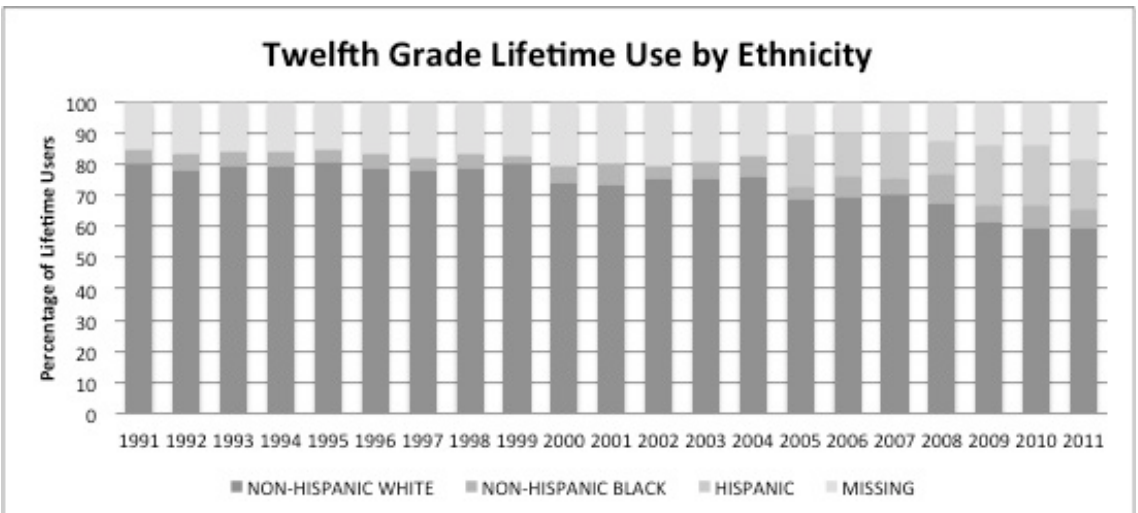
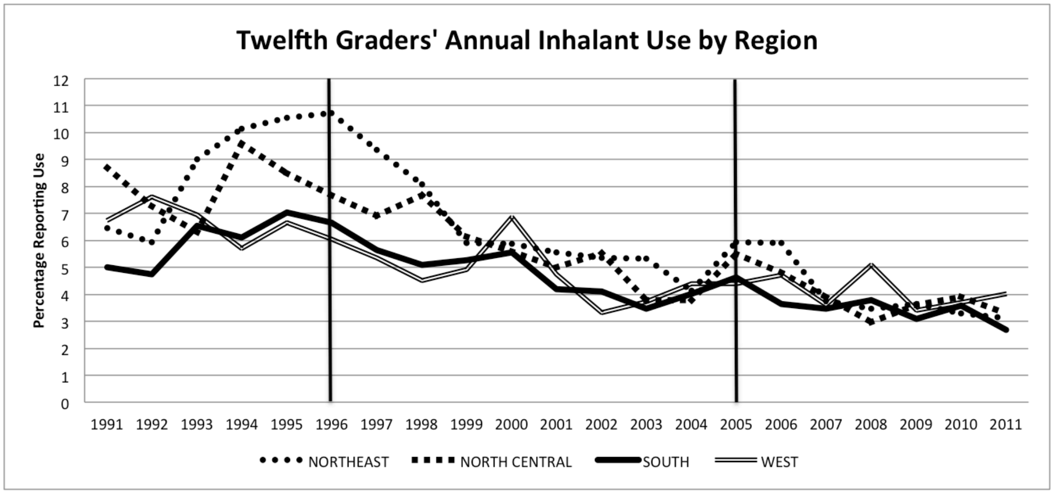


Figure 7. Demographic breakdown of twelfth grade lifetime inhalant users by year. Missing data proportions for gender ranged from 1.52% (2008) to 3.78% (2009), and proportions for ethnicity ranged from 10.01% (2006) to 20.87% (2000).

National Laws



Regional Laws

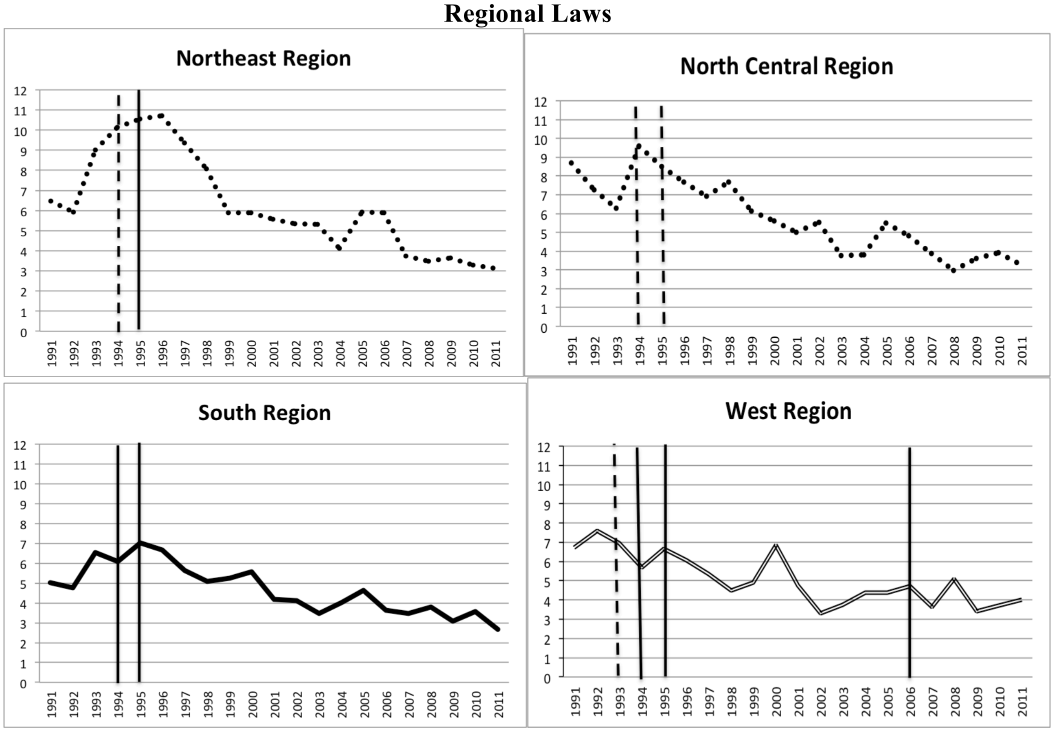


Figure 8. Twelfth graders' annual inhalant use from 1991 to 2011 by Monitoring the Future regional division. The top graph displays the 1996 MCA and 2005 CMEA, both national methamphetamine laws that affected all regions. The bottom graphs display each of the four regions and "three strikes laws", with salient laws appearing as solid lines and non-salient laws appearing as dashed lines. Missing data proportions ranged from 2.52% (1992) to 4.62% (2011).

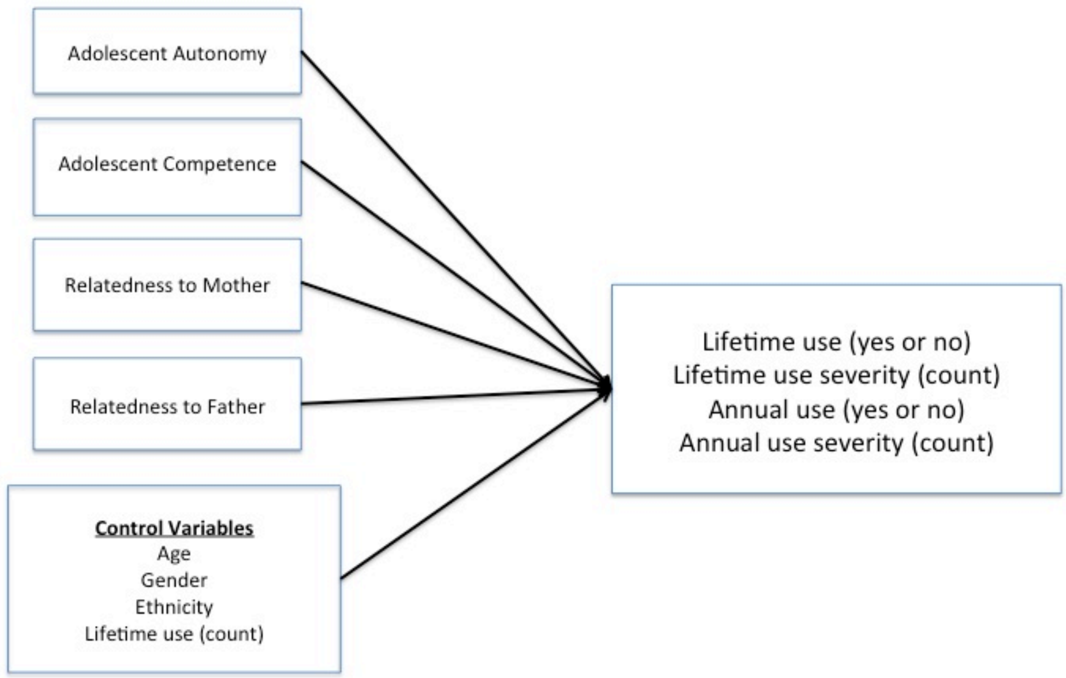


Figure 9. Conceptual diagram of model used to test the application of Self-Determination Theory to inhalant use.

Table 1

Mixed Effects Regression Models for Changes in Inhalant Use Rates over Time

Grade Cohort	Prevalence Rate Time Frame	Trend Type	Parameter Estimate	Standard Error	*p*-value
Eighth	Lifetime	Linear	85.60	37.09	.0324*
		Quadratic	-0.02	0.01	.0319*
	Annual	Linear	47.59	30.18	.1300
		Quadratic	-0.02	0.008	.1313
	Thirty-Day	Linear	14.68	13.85	.3023
		Quadratic	-0.003	0.003	.2992
Tenth	Lifetime	Linear	70.30	36.97	.0725
		Quadratic	-0.02	0.01	.0711
	Annual	Linear	20.81	24.65	.4089
		Quadratic	-0.01	0.01	.4049
	Thirty-Day	Linear	5.49	8.00	.5008
		Quadratic	-0.001	0.001	.4957
Twelfth	Lifetime	Linear	8.52	20.62	.6843
		Quadratic	-0.002	0.005	.6665
	Annual	Linear	12.48	19.97	.5395
		Quadratic	-0.003	0.005	.5325
	Thirty-Day	Linear	4.67	8.34	.5820
		Quadratic	-0.001	0.002	.5753

Note. Cubic trends were tested but none were significant, and they are not shown. *Denotes significant at $p < .05$.

Table 2

Mixed Effects Regression Models for the Effect of Time on Gender and Ethnicity Among Lifetime Inhalant Users

Grade	Demographic Group	Time Period	Parameter Estimate	Standard Error	*p*-value
Eighth	Male	1991-2011	-0.40	0.06	<.0001*
	Female	1991-2011	0.40	0.06	<.0001*
	Whites	1991-2004	-0.42	0.16	.0194*
		2005-2011	-1.96	0.24	.0005*
	Blacks	1991-2004	0.28	0.16	.0969
		2005-2011	0.19	0.19	.3735
	Hispanics	2005-2011	1.40	0.35	.0105*
	Other	1991-2004	0.14	0.12	.2878
		2005-2011	0.37	0.16	.0650
Tenth	Male	1991-2011	-0.48	0.05	<.0001*
	Female	1991-2011	0.49	0.05	<.0001*
	Whites	1991-2004	-0.83	0.18	.0006*
		2005-2011	-2.78	0.53	.0034*
	Blacks	1991-2004	0.10	0.14	.4924
		2005-2011	0.20	0.23	.4298
	Hispanics	2005-2011	2.00	0.29	.0009*
	Other	1991-2004	0.73	0.10	<.0001*
		2005-2011	0.58	0.17	.0168*
Twelfth	Male	1991-2011	-0.32	0.09	<.0001*
	Female	1991-2011	0.29	0.07	<.0001*
	Whites	1991-2004	-0.41	0.11	.0034*
		2005-2011	-2.07	0.43	.0050*
	Blacks	1991-2004	0.09	0.07	.1995
		2005-2011	0.34	0.29	.2954
	Hispanics	2005-2011	0.50	0.56	.4130
	Other	1991-2004	0.32	0.09	.0033*
		2005-2011	1.23	0.27	.0061*

Note. *Denotes significant at $p < .05$.

Table 3

Median Grade Level at First Inhalant Use

	MTF Cohort		
Initiated	Eighth	Tenth	Twelfth
Prior to or in 8th Grade	Grade 6	Grade 7	Grade 8
Prior to or in 10th Grade		Grade 8	Grade 8
Prior to or in 12th Grade			Grade 9

MTF Cohort	Missing Data Ranges[3] (Inflated and Un-Inflated)
Eighth	13.56 (2011) – 89.73 (2001)
	13.56 (2011) – 23.11 (1995)
Tenth	9.56 (2010) – 89.39 (2001)
	9.56 (2010) – 13.13 (1995)
Twelfth	19.09 (2006) – 93.41 (2001)
	19.09 (2006) – 26.68 (1997)

[3]Missing data proportions for select years include both "never used" and "missing data" due to errors in datasets for certain years. In a personal communication (G. Maggio, June 17, 2013), it was stated that these errors would likely not be fixed in the near future. The ranges are presented as "inflated" with the erroneous sets included and also as "un-inflated" with those sets excluded.

Table 4

Descriptive Statistics for SDT-Related Constructs and Inhalant Count Variables

Variable	Mean (SD)	% Missing Data
Adolescent Autonomy	5.17 (1.56)	2.59%
Adolescent Competence	3.83 (0.68)	0.44%
Maternal Relatedness	4.52 (0.59)	6.13%
Paternal Relatedness	4.32 (0.73)	29.30%
Wave I Count of Use	0.37 (3.38)	1.71%
Wave II Count of Use	0.15 (2.34)	24.37%

Note: The final sample size used for these analyses was 6068 participants, the full sample at Wave I.

Table 5

Correlations Among SDT-Related Constructs, Control Variables, and Inhalant Use Variables

	Autonomy	Competence	M. Relatedness	P. Relatedness	Age	M vs. F	NB vs. B	NNA vs. NA	NA vs. A	NO vs. O
Autonomy		0.01	-0.05*	-0.08*	0.39*	0.01	-0.05*	0.01	0.01	-0.06*
Competence			0.30*	0.32*	0.02	-0.08*	-0.03*	-0.01	-0.02	-0.02
Maternal Relatedness				0.54*	-0.14*	-0.10*	-0.01	0.01	-0.05	-0.01
Paternal Relatedness					-0.17*	-0.07*	-0.02	0.02	-0.03*	-0.05*
Age						-0.04*	0.02	-0.02	0.02	0.01
Males vs. Females							0.01	0.01	-0.01	0.01
Whites vs. Blacks								-0.05*	-0.10*	-0.11*
Whites vs. Native Americans									-0.02	-0.02
Whites vs. Asians										-0.04*

	Lifetime Use	Lifetime Use Severity	Annual Use	Annual Use Severity
Autonomy	0.01	0.01	-0.01	0.01
Competence	-0.11*	-0.10*	-0.05*	-0.05*
Maternal Relatedness	-0.09*	-0.09*	-0.03*	-0.04*
Paternal Relatedness	-0.07*	-0.08*	-0.04*	-0.04*
Age	-0.02	-0.03	-0.03*	-0.03
Males vs. Females	-0.02	-0.02*	0.01	-0.01
NB vs. Blacks	-0.07*	-0.07	-0.02	-0.02*
NNA vs. Native Americans	0.02	0.02	0.02	0.02
NA vs. Asians	-0.02	-0.02	-0.02	-0.02
NO vs. Other	0.01	0.01	0.01	0.01

Note. *Denotes significant at $\alpha < .05$. All inhalant use variable inter-correlations (not shown) are significant at $\alpha < .0001$. Pearson correlations were used for all continuous variables except maternal and paternal relatedness (due to skew and kurtosis). For the relatedness variables and the severity variables, Spearman correlations were deemed more appropriate. Point-biserial correlations were used for all dichotomous variables. Ethnicity dummy codes were entered individually for this analysis (Non-blacks [NB] vs. blacks; Non-Native Americans [NNA] vs. Native Americans; Non-Asians [NA] vs. Asians; Non-Other Race [NO] vs. Other), though they were put in as a block for all regression models.

Table 6

Parameter Estimates for Stepwise Logistic Regression Model for Lifetime Inhalant Use (at Wave I)

Variable	Parameter Estimate	Standard Error	*p*-value	Odds Ratio
Individual SDT variables				
Autonomy	0.0287	0.0363	0.4287	1.029
Competence	-0.6593	0.0759	<0.0001*	0.517
Maternal Relatedness	-0.4698	0.1098	<0.0001*	0.625
Paternal Relatedness	-0.2276	0.0919	0.0132*	0.796
Control Variables				
Age	-0.0528	0.0315	0.0936	0.949
Males vs. Females	-0.2034	0.1099	0.0642	0.816
Whites vs. Blacks	-0.9293	0.1894	<0.0001*	0.395
Whites vs. Native Americans	0.5306	0.3804	0.1631	1.700
Whites vs. Asians	-0.5832	0.3456	0.0916	0.558
Whites vs. Other	-0.0094	0.2454	0.9694	0.991
Final Model				
Competence	-0.4763	0.1032	<0.0001*	0.621
Maternal Relatedness	-0.3814	0.1125	0.0007*	0.683
Paternal Relatedness	-0.1798	0.0943	0.0567	0.835
Whites vs. Blacks	-0.6593	0.2531	0.0092*	0.517
Whites vs. Native Americans	-0.2393	0.7347	0.7446	0.787
Whites vs. Asians	-1.0546	0.4627	0.0226*	0.348
Whites vs. Other	-0.4524	0.3554	0.2031	0.636

Note. *Denotes significant at $\alpha < .05$.

Table 7

Parameter Estimates for Stepwise Logistic Regression Model for Past Year Inhalant Use (at Wave II)

Variable	Parameter Estimate	Standard Error	*p*-value	Odds Ratio
Individual SDT variables				
Autonomy	-0.0245	0.0648	0.7054	0.976
Competence	-0.4922	0.1359	0.0003*	0.611
Maternal Relatedness	-0.2956	0.2020	0.1434	0.744
Paternal Relatedness	-0.2614	0.1640	0.1072	0.768
Control Variables				
Age	-0.1250	0.0666	0.0605	0.833
Males vs. Females	0.1511	0.2073	0.4661	1.163
Whites vs. Blacks	-0.4101	0.3027	0.1756	0.664
Whites vs. Native Americans	0.8153	0.6078	0.1798	2.260
Whites vs. Asians	-1.3171	1.0102	0.1923	0.268
Whites vs. Other	0.2178	0.4310	0.6134	1.243
Wave I Count of Use	0.0684	0.0168	<0.0001*	1.071
Final Model				
Competence	-0.5104	0.1403	0.0003*	0.600
Wave I Count of Use	0.0652	0.0158	<0.0001*	1.067

Note. *Denotes significant at $\alpha < .05$.

Table 8

Fit Criteria and Parameter Estimates for Stepwise Regression Models for Lifetime Inhalant Use Severity (at Wave I)

Count Model	Log Likelihood	AIC	BIC
Poisson	-2466.0187	9033.8286	9090.4952
Zero-Inflated Poisson	105.9059	3891.9794	3954.9423
Negative Binomial	599.7379	2904.3154	2967.2784
Zero Inflated Negative Binomial	***-1442.1577***	***2906.3154***	***2975.5747***

Variable	Parameter Estimate	Standard Error	*p*-value
Individual SDT variables			
Autonomy	0.0413	0.0597	0.4898
Competence	-0.3933	0.1383	0.0045*
Maternal Relatedness	-0.6439	0.2382	0.0069*
Paternal Relatedness	-0.3251	0.1640	0.0474*
Control Variables			
Age	-0.0777	0.0615	0.2062
Males vs. Females	-0.7887	0.1909	<0.0001*
Whites vs. Blacks	-0.7505	0.2443	0.0021*
Whites vs. Native Americans	-0.7075	0.8390	0.3991
Whites vs. Asians	-1.0239	0.4989	0.0401*
Whites vs. Other	-0.2432	0.4373	0.5781
Final Model			
Competence	-0.2517	0.1812	0.1559
Maternal Relatedness	-0.6955	0.2358	0.0032*
Paternal Relatedness	-0.3933	0.1624	0.0155*
Males vs. Females	-0.7965	0.2300	0.0005*
Whites vs. Blacks	0.3340	0.3410	0.3283
Whites vs. Native Americans	0.9948	1.0769	0.3556
Whites vs. Asians	-1.8661	0.5994	0.0019*
Whites vs. Other	-0.1741	0.5138	0.7348

Note. *Denotes significant at $\alpha < .05$. Fit statistics are only for the final model; selected count model is bolded and italicized.

Table 9

Fit Criteria and Parameter Estimates for Stepwise Regression Models for Past Year Inhalant Use Severity (at Wave II)

Count Model	Log Likelihood	AIC	BIC
Poisson	-1923.7708	6773.4129	6811.9818
Zero-Inflated Poisson	0.5420	2074.9105	2126.2318
Negative Binomial	706.6985	1514.4743	1559.4713
Zero Inflated Negative Binomial	***-658.7069***	***1335.4137***	***1393.1502***

Variable	Parameter Estimate	Standard Error	*p*-value
Individual SDT variables			
Autonomy	0.1286	0.1205	0.2859
Competence	-0.7279	0.3295	0.0272*
Maternal Relatedness	-0.5107	0.3671	0.1642
Paternal Relatedness	-0.1864	0.3213	0.5619
Control Variables			
Age	-0.0740	0.1306	0.5710
Males vs. Females	0.0458	0.3859	0.9055
Whites vs. Blacks	0.4129	0.5122	0.4202
Whites vs. Native Americans	1.5881	1.3116	0.2260
Whites vs. Asians	-2.8425	1.3554	0.0360*
Whites vs. Other	0.1574	0.7984	0.8437
Wave I Count of Use	-1.2072	0.4529	0.0077*
Final Model			
Competence	-0.4902	0.2635	0.0628
Whites vs. Blacks	0.8347	0.4620	0.0708
Whites vs. Native Americans	1.7812	1.2875	0.1665
Whites vs. Asians	-2.6580	1.3462	0.0483*
Whites vs. Other	0.5598	0.7657	0.4648
Wave I Count of Use	-1.1948	0.4526	0.0083*

Note. *Denotes significant at $\alpha < .05$. Fit statistics are only for the final model; selected count model is bolded and italicized.