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Adolescent inhalant use, abuse and dependence

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ABSTRACT

Aims To compare adolescent inhalant users without DSM-IV inhalant use disorders (IUDs) to youth with IUDs (i.e. abuse or dependence) across demographic, psychosocial and clinical measures. **Design** Cross-sectional survey with structured psychiatric interviews. **Setting** Facilities ($n = 32$) comprising the Missouri Division of Youth Services (MDYS) residential treatment system for juvenile offenders. **Participants** Current MDYS residents ($n = 723$); 97.7% of residents participated. Most youth were male (87%) and in mid-adolescence (mean = 15.5 years, standard deviation = 1.2, range = 11–20); more than one-third (38.6%, $n = 279$) reported life-time inhalant use. **Measurements** Antisocial behavior, temperament, trauma-exposure, suicidality, psychiatric symptoms and substance-related problems. **Findings** Among life-time inhalant users, 46.9% met criteria for a life-time DSM-IV IUD (inhalant abuse = 18.6%, inhalant dependence = 28.3%). Bivariate analyses showed that, in comparison to non-users, inhalant users with and without an IUD were more likely to be Caucasian, live in rural or small towns, have higher levels of anxiety and depressive symptoms, evidence more impulsive and fearless temperaments and report more past-year antisocial behavior and life-time suicidality, traumatic experiences and global substance use problems. A monotonic relationship between inhalant use, abuse and dependence and adverse outcomes was observed, with comparatively high rates of dysfunction observed among inhalant-dependent youth. Multivariate regression analyses showed that inhalant users with and without an IUD had greater levels of suicidal ideation and substance use problems than non-users. **Conclusions** Youth with IUDs have personal histories characterized by high levels of trauma, suicidality, psychiatric distress, antisocial behavior and substance-related problems. A monotonic relationship between inhalant use, abuse and dependence and serious adverse outcomes was observed.

Keywords Adolescents, delinquents, inhalant use disorders, solvent abuse, volatile solvent abuse.

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INTRODUCTION

Inhalant misuse is prevalent in the United States. Findings from the 2006 Monitoring the Future nationally representative survey of middle and high school youth indicated that 16.1% of 8th graders had used inhalants [1]. A somewhat lower life-time prevalence rate for inhalant use was reported for 12–17-year-olds (10.1%) participating in the National Survey on Drug Use and Health, a household survey [2].

Contemporary studies of juvenile justice and substance abuse treatment-seeking samples, although few in number, have documented high rates of inhalant use. For example, Howard & Jenson [3] identified histories of inhalant use in 34.4% of 475 juvenile probationers in the state of Utah. More recently, Howard and colleagues [4] determined that more than one-third of a state population of adolescents remanded to treatment for antisocial behavior had used inhalants. Howard & Jenson [3] and Howard *et al.* [4] found significantly elevated rates of psychiatric dysfunction, substance use problems and adverse environmental circumstances in life-time inhalant users compared to their non-inhalant-using peers.

Few studies have examined the abuse liability of inhalants or population burden of DSM-IV IUDs (i.e. inhalant abuse and dependence) among general or high-risk populations. Howard & Perron [5] identified high inhalant abuse liability for 279 adolescent inhalant users with histories of antisocial behavior, such that approximately half of all youth initiating inhalant use eventually met criteria for DSM-IV inhalant abuse or dependence. Latent class findings in this study [5] suggested that

inhalant abuse and dependence were distinct constructs. Subsequent analyses appeared to demarcate effectively inhalant use groups with lesser and greater levels of problematic involvement with inhalants, as assessed by responses to DSM-IV inhalant abuse and dependence criteria. However, no direct comparisons of inhalant users without IUDs to youth who had IUDs were performed and youth with inhalant use, abuse and dependence were not distinguished across a range of demographic and clinically relevant psychosocial factors. High inhalant abuse liability was also reported by Ridenour, Bray & Cottler [6]; however, other investigators have identified low inhalant abuse liability in samples of adolescent [7] and adult [8] inhalant users. Differences in sample composition, inhalant use and IUD ascertainment and assessment protocols and regional differences may account, in part, for these discrepant findings.

Studies comparing adolescent inhalant users with and without DSM-IV IUDs are largely absent from the scientific literature. Sakai *et al.* [7] completed structured diagnostic assessments with 847 adolescents drawn from a substance abuse treatment program and found a substantial rate of life-time inhalant use (but low rates of DSM-IV IUDs) and no significant differences between inhalant users with and without IUDs with regard to race, age, gender, prevalence of life-time DSM-IV substance use disorders, previous suicide attempt, conduct disorder, history of physical abuse, sexual abuse, neglect, abuse/neglect and major depression. In general, inhalant users evidenced significantly more impairment across the above-mentioned assessment domains than did inhalant non-users.

In light of limited reports distinguishing adolescent inhalant users with and without IUDs, we compared life-time adolescent inhalant users without IUDs to youth meeting life-time DSM-IV inhalant abuse or inhalant dependence criteria across a range of socio-demographic, psychiatric and substance use measures. Although, given Sakai *et al.*'s [7] findings, it is possible that adolescent inhalant users with and without IUDs do not differ systematically in clinically significant attributes (their most salient characteristic perhaps being the decision to seek intoxication via solvent inhalation that both groups share and factors associated with this decision), we hypothesized that a gradient of impairment would be observed, such that inhalant-dependent youth would exhibit greater dysfunction than youth who met only inhalant abuse criteria who, in turn, would be more impaired than youth with histories of inhalant use but no IUDs. In this vein, D'Abbs & MacLean [9] noted that some researchers regard intensive volatile solvent misuse as a marker of 'global vulnerability' or as part of a 'risk behavior syndrome' (p. xvii). If such is the case, we might expect youth with greater levels of problematic involvement with inhalants to differ significantly from their less involved and non-involved counterparts across a wide range of measures.

METHODS

Sampling frame and recruitment approach

Findings of the present study are based on a survey conducted in 2003 of the population of current residents across the 23 facilities of the Missouri Division of Youth Services (MDYS) residential treatment system. The 723 adolescents who completed interviews constituted 97.7% of MDYS residents at the time interviews were conducted. MDYS youth are representative of delinquent youth in state-mandated care nationally with regard to age, gender and number of state youth in residential care per 100 000 adolescents, and represent the full continuum of antisocial youth [9].

Sample description

Eighty-seven per cent of youth were male and approximately 40% reported that their family received public assistance. Youth ranged from 11 to 20 years of age [mean = 15.5, standard deviation (SD) = 1.2]; most lived in small towns or cities (78.6, $n = 569$) as opposed to suburban or rural areas (21.3%, $n = 154$). One-third ($n = 238$) reported an African American identification, 7.7% ($n = 56$) a bi/multi-racial identification, 3.9% ($n = 28$) a Latino/Latina identification and 55.4% ($n = 400$) a Caucasian racial identification. Prevalently used inhalants included gasoline (22%), permanent markers (15%), computer 'air duster' (15%) and spray paint (12%). One-third (38.6%; $n = 279$) of the sample reported life-time inhalant use. Detailed descriptions of this sample and their inhalant use have been reported previously [4].

Participation in the study was voluntary. Data were collected using structured interviews. Interviews were conducted in large rooms at each facility that provided private areas where confidential one-on-one interviews were conducted. This study was approved by the MDYS Institutional Review Board, Washington University Human Studies Committee Institutional Review Board, Federal Office of Human Research Protections, and was granted a Certificate of Confidentiality by the National Institute on Drug Abuse. Adolescents received $10.00 for their participation.

Measurement

Participants were administered two assessments, the Volatile Solvent Screening Inventory (VSSI) and the Comprehensive Solvent Assessment Interview (CSAI). All

participants completed the VSSI [4], which assesses demographic characteristics, medical history, life-time and past-year use of 55 volatile solvent inhalants, other drug use and substance-related problems, current psychiatric symptoms and psychosocial problems. Consistent with DSM-IV diagnostic guidelines, nitrite vasodilator and nitrous oxide use were not considered inhalant use for the purposes of this investigation.

Youth who reported life-time use of one or more volatile solvents included in the VSSI also completed the CSAI [4]. The CSAI includes an assessment of the settings, modalities, peer and family networks, acute medical and social consequences and other characteristics of adolescent inhalant use. Items from the Diagnostic Interview Schedule (DIS, version IV) were included to assess for the presence of DSM-IV inhalant abuse and dependence disorders. The DIS generally evidences good reliability for assessment of substance use disorders [10]. IUD diagnoses were assigned in accordance with DSM-IV guidelines.

Inhalant use and IUDs

Adolescent inhalant users were assigned a life-time inhalant abuse diagnosis if they met one or more of four DSM-IV criteria for inhalant abuse at some point in their life-time and had never met criteria for DSM-IV inhalant dependence. Inhalant users were assigned a life-time inhalant dependence diagnosis if they had met three or more of six DSM-IV inhalant dependence criteria within a 12-month period at some point in their life-times. A seventh generic DSM-IV substance dependence criterion—withdrawal symptoms—was not included in the inhalant dependence criteria set per specific DSM-IV guidelines ([11] cf. p. 258). Youth who reported any use of one or more volatile solvents for the purposes of intoxication [4] but who did not meet life-time criteria for inhalant abuse or dependence were classified as inhalant users without an IUD. Subjects with no reported history of inhalant use were classified as inhalant non-users.

Substance use problems

Life-time substance-related problems were assessed with the eight-item Alcohol/Drug Use Scale of the Massachusetts Adolescents Screening Instrument—2nd version (MAYSI-2) developed for use with juvenile justice populations [12]. It should be noted that this measure assesses substance use problems generically (i.e. not in relation to specific substances of abuse) and therefore includes problems due to alcohol, inhalant and other psychoactive drugs). The α coefficient in this study was 0.83.

Psychiatric symptom variables

Youth completed the Brief Symptom Inventory (BSI) [13]. Two BSI subscales were included in this study: depression and anxiety. Youth completed the five-item MAYSI-2 suicide ideation scale. Grisso & Barnum [12] reported a α reliability of 0.83 for this scale.

Trauma history

Adolescents also completed four items from the MAYSI-2 traumatic experiences scale, resulting in a scale range of 0–4. Reliability in this study was $\alpha = 0.69$.

Antisocial behavior and attitudes

The Self-Report of Delinquency (SRD) [14] was used to assess the number of times in the year before they were incarcerated youth engaged in delinquent behavior. Study participants also completed the 56-item Psychopathic Personality Inventory—short version (PPI-SV) [15]. Two subscales of the PPI-SV employed in this analysis were impulsive nonconformity and fearlessness.

Demographic and psychosocial variables

Gender, age, self-reported racial status, family receipt of public assistance and geographical area of family residence (i.e. urban/suburban, small town/rural) were recorded for each youth.

Data analysis

Less than 1% of the total data points were missing, which were imputed using the aregImpute function in the HMisc package for R [16]. χ^2 tests and one-way analysis of variance (ANOVA) were used to compare differences between inhalant user groups. Cramer's V was used as an effect size measure for associations based on χ^2 tests. R^2 summarized the effect size for associations for ANOVAs. Effect sizes were interpreted using the general rules suggested by Cohen [17]: ~0.10 was considered a small effect, ~0.30 a medium effect and ~0.50 and greater a large effect. An effect size of at least 0.20 was considered clinically significant [18]. Because R^2 is a squared correlation, clinical significance was based on the square of 0.20 (i.e. 0.04).

To help characterize the study sample, comparisons were also made with normed data for MAYSI-2 and BSI measures. For the MAYSI-2, the normed sample for comparison included committed youth in a secured facility of the Massachusetts Department of Youth Services ($n = 582$). For the BSI, the normed sample included adolescents ($n = 2408$) from a non-clinical setting.

Logistic regression and multinomial logistic regressions were used to identify factors discriminating inhalant non-users, inhalant users without IUDs and inhalant users with IUDs. Variables that were statistically significant at the bivariate level were included in multivariate analyses. To increase the interpretability of the odds ratios for the primary multinomial regression model, a simula-

tion analysis was conducted using the Zelig package for R [19]. Additional simulation analyses for other models are available from the first author upon request. The simulation procedure gives probabilities for an outcome for the variable of interest that can be easily interpreted.

RESULTS

Bivariate associations with inhalant use and DSM-IV IUDs

Among life-time inhalant users, 46.9% met criteria for a life-time DSM-IV IUD (inhalant abuse = 18.6%, inhalant dependence = 28.3%). χ^2 tests indicated that gender, age, and receipt of public assistance were not associated significantly with inhalant use group membership (see Table 1). However, adolescents who used inhalants or who had IUDs were significantly more likely to identify as Caucasian and live in rural areas/small towns than non-inhalant users. Inhalant-dependent youth had significantly greater frequency of past-year delinquency than did inhalant non-users, users or youth diagnosed with inhalant abuse. Inhalant users and youth with IUDs had significantly higher scores than inhalant non-users on measures of impulsive non-conformity and fearlessness. Inhalant users and youth with IUDs also exhibited greater impairments than non-users on the MAYSI-2 measures of suicidality, global substance use problems and trauma.

Inhalant-dependent youth had significantly higher BSI anxiety and depression scale scores relative to other groups of inhalant users and non-users. With respect to severity of suicidal ideation, trauma exposure and substance use problems, graded relationships were observed. Although differences were greatest between inhalant-dependent youth and inhalant non-users, inhalant-dependent youth also differed significantly from youth with inhalant abuse on measures of anxious and depressive symptoms, past-year delinquent conduct and suicidal ideation.

Comparisons with normed data

Youth with a history of inhalant use, especially those who met DSM-IV criteria for inhalant dependence, exhibited higher scores on MAYSI-2 measures and BSI measures than the normed samples. For example, on measures of suicidality, life-time inhalant-dependent youth had a mean score of 4.4, compared to 0.3 among the normed sample. This trend was also similar on measures of global substance use problems (mean = 6.5 versus 2.7), traumatic experiences (mean = 3.2 versus 2.5), depression (mean = 1.3 versus 0.8) and anxiety (mean = 1.4 versus 0.8). Similar trends are also present when comparing inhalant users without an IUD and those with abuse to the normed sample (cf. Table 1).

Multinomial logistic regression analysis distinguishing inhalant non-users, inhalant users without an IUD and inhalant users with an IUD

In light of the significant bivariate differences observed among the non-inhalant and inhalant user groups, a multinomial logistic regression with simultaneous entry of variables listed in Table 1 was conducted to identify factors distinguishing inhalant users with and without an IUD from inhalant non-users (the reference group). The overall model exhibited a good fit with the data (residual deviance = 985, log-likelihood = –492.8, df = 1424). Table 2 summarizes adjusted odds ratios (AOR) and 95% confidence intervals (CI) for this model. This model indicated that inhalant users without an IUD and inhalant users with an IUD were significantly different than non-users on measures of ethnicity, urbanicity, impulsive non-conformity (inhalant users without IUDs only), trait fearlessness, suicidal ideation and life-time substance use problems.

Table 3 summarizes predicted probabilities (pp) of class membership, derived from simulation procedures. After holding all other values constant, the predicted probabilities showed that white youth were almost twice as likely as non-white youth to be inhalant users without an IUD (pp = 0.24 versus 0.13) and with an IUD (0.08 versus 0.04). Fearlessness was also associated strongly with inhalant use. Specifically, youth with high levels of fearlessness were more than twice as likely have an IUD compared to youth with low levels of fearlessness (pp = 0.11 versus 0.05). This trend was also true with respect to suicidal ideation (pp = 0.15 versus 0.05). Substance use problems were associated with a significantly higher predicted probability of an IUD compared to low substance use problems (pp = 0.39 versus 0.01).

Multinomial logistic regression analysis distinguishing inhalant users, inhalant users with life-time inhalant abuse and inhalant users with life-time inhalant dependence

The first multinomial logistic regression model was followed with an analysis intended to identify factors distinguishing inhalant users without IUDs from those with life-time abuse (without dependence) and life-time dependence. The outcome variable was re-specified to reflect these groups. All independent variables that were significant at the bivariate level were included in the model. The overall regression model exhibited a good fit with the data (residual deviance = 449.7, log-likelihood = –224.8, df = 536).

In comparison to inhalant users without an IUD, youth with inhalant dependence had significantly higher delinquency scores (AOR = 1.03, 95% = 1.01–1.05), suicide ideation (AOR = 1.29, 95% CI = 1.10–1.51) and

Table 1 Comparisons of inhalant non-users, users without inhalant abuse or dependence, users with inhalant abuse and users with inhalant dependence across demographic, psychosocial and clinical measures.

	Subsample comparison					
Variables	*Full sample* $n = 723$	*Inhalant non-user* $n = 444$	*User without inhalant disorder* $n = 148$	*User with inhalant abuse* $n = 52$	*User with inhalant dependence* $n = 79$	*Statistical test*
Gender: % (*n*)						
Male	87.0 (629)	88.7 (394)	85.1 (126)	84.6 (44)	82.3 (79)	$\chi^2_{(3)} = 3.5$, $P = 0.326$
Female	13.0 (94)	11.3 (50)	14.9 (22)	15.4 (8)	17.7 (14)	Cramer's V = 0.07
Ethnicity: % (*n*)						
Non-white	44.7 (323)	57.0 (253)^{abc}	23.6 (35)^{a}	25.0 (13)^{b}	27.8 (22)^{c}	$\chi^2_{(3)} = 70.9$, $P < 0.001$
White	55.3 (400)	43.0 (191)	76.4 (113)	75.0 (39)	72.2 (57)	Cramer's V = 0.32
Age: mean (SD)$_{11–20}$	15.5 (1.2)	15.5 (1.3)	15.5 (1.2)	15.6 (1.1)	15.7 (1.1)	$F_{(3, 719)} = 0.7$, $P = 0.580$ $R^2 = 0.00$
Urbanicity: % (*n*)						
Rural/small town	47.0 (340)	39.2 (174)^{ab}	62.2 (92)^{a}	53.8 (28)	58.2 (46)^{b}	$\chi^2_{(3)} = 29.5$, $P < 0.001$
Urban/suburban	53.0 (383)	60.8 (270)	37.8 (56)	46.2 (24)	41.8 (33)	Cramer's V = 0.20
Public assistance: % (*n*)						
No	59.3 (429)	58.6 (260)	59.5 (88)	67.3 (35)	59.5 (47)	$\chi^2_{(3)} = 1.5$, $P = 0.687$
Yes	40.7 (294)	41.4 (184)	40.5 (60)	32.7 (17)	40.5 (32)	Cramer's V = 0.04
Total delinquency: mean (SD)$_{0–107}$	28.1 (20.3)	25.9 (19.8)^{a}	25.0 (18.2)^{b}	31.3 (18.8)^{c}	43.4 (21.4)^{abc}	$F_{(3, 719)} = 19.6$, $P < 0.001$ $R^2 = 0.07$
Impulsive non-conformity: mean (SD)$_{7–28}$	14.8 (5.3)	14.0 (3.7)^{abc}	16.0 (4.6)^{a}	15.6 (4.4)^{b}	16.6 (4.4)^{c}	$F_{(3, 719)} = 15.8$, $P < 0.001$ $R^2 = 0.07$
Fearlessness: mean (SD)$_{7–28}$	17.1 (5.3)	15.7 (5.0)^{abc}	19.0 (4.7)^{a}	18.9 (4.9)^{b}	20.4 (4.7)^{c}	$F_{(3, 719)} = 34.2$, $P < 0.001$ $R^2 = 0.12$
BSI anxiety: mean (SD)$_{0–4}$	0.7 (0.8)	0.6 (0.7)^{a}	0.8 (0.8)^{b}	0.8 (0.9)^{c}	1.4 (0.9)^{abc}	$F_{(3, 719)} = 24.6$, $P < 0.001$ $R^2 = 0.09$
BSI depression: mean (SD)$_{0–4}$	0.8 (0.8)	0.6 (0.8)^{ab}	0.9 (0.9)^{ac}	0.9 (1.0)^{d}	1.3 (0.9)^{bcd}	$F_{(3, 719)} = 16.7$, $P < 0.001$ $R^2 = 0.06$
MAYSI-2 suicide ideation: mean (SD)$_{0–6}$	2.2 (2.4)	1.6 (2.1)^{abc}	2.7 (2.4)^{ad}	3.0 (2.5)^{be}	4.4 (2.2)^{cde}	$F_{(3, 719)} = 45.8$, $P < 0.001$ $R^2 = 0.16$
MAYSI-2 trauma: mean (SD)$_{0–4}$	2.4 (1.4)	2.3 (1.4)^{ab}	2.3 (1.5)^{c}	2.8 (1.2)^{a}	3.2 (1.1)^{bc}	$F_{(3, 719)} = 11.7$, $P < 0.001$ $R^2 = 0.04$
MAYSI-2 substance use problems: mean (SD)$_{0–8}$	3.9 (2.4)	3.0 (2.2)^{abc}	4.3 (2.1)^{ade}	5.8 (2.0)^{bd}	6.5 (1.3)^{ce}	$F_{(3, 719)} = 81.8$, $P < 0.001$ $R^2 = 0.25$

All percentages are reported as column percentages unless otherwise noted. Values in subscripts represent the observed range of values for continuous variables. All contrasts for one-way analysis of variance were tested using Tukey's *post-hoc* contrast test at $P < 0.05$; contrasts for χ^2 tests involved pairwise comparisons with χ^2 tests at $P < 0.05$; groups that share a common superscript are significantly different. BSI: Brief Symptom Inventory; MAYSI-2: Massachusetts Youth Screening Instrument, version 2; SD: standard deviation.

Table 2 Multinomial regression comparing inhalant users with ($n = 148$) and without ($n = 131$) an inhalant use disorder (IUD) to inhalant non-users ($n = 444$).

Variable	*AOR*	*95% CI*
Ethnicity, white (versus non-white)		
Inhalant user	**2.29**	1.27–4.13
IUD	**2.06**	1.14–3.72
Urbanicity, urban/suburban (versus rural/small town)		
Inhalant user	**0.56**	0.36–0.88
IUD	**0.51**	0.30–0.88
Impulsive non-conformity$_{7–28}$		
Inhalant user	**1.06**	1.01–1.12
IUD	1.01	0.94–1.08
Fearlessness$_{7–28}$		
Inhalant user	**1.09**	1.04–1.14
IUD	**1.10**	1.04–1.16
Total delinquency$_{0–107}$		
Inhalant user	0.99	0.98–1.01
IUD	1.01	0.99–1.02
BSI anxiety$_{0–4}$		
Inhalant user	0.92	0.63–1.33
IUD	1.38	0.89–2.14
BSI depression$_{0–4}$		
Inhalant user	1.14	0.80–1.62
IUD	0.84	0.55–1.29
MAYSI-2 suicide ideation$_{0–6}$		
Inhalant user	**1.12**	1.01–1.23
IUD	**1.28**	1.14–1.44
MAYSI-2 trauma$_{0–4}$		
Inhalant user	0.92	0.78–1.09
IUD	1.06	0.85–1.33
MAYSI-2 substance use problems$_{0–8}$		
Inhalant user	**1.27**	1.14–1.41
IUD	**2.10**	1.77–2.49

AOR: adjusted odds ratio; CI: confidence interval. Values in subscripts represent the observed range of values for continuous variables. Inhalant non-users were the reference group in all analyses. 'Inhalant users' were youth with a life-time history of inhalant use who never met DSM-IV criteria for an IUD. IUD refers to subjects who met life-time DSM-IV criteria for inhalant abuse or dependence. All values in bold type are statistically significant based on a 95% CI that does not bound 1.0. BSI: Brief Symptom Inventory; MAYSI-2: Massachusetts Youth Screening Instrument, version 2.

substance use problems (AOR = 1.74, 95% CI = 1.38–2.19). Substance use problems discriminated inhalant users without a disorder from youth with inhalant abuse (AOR = 1.43, 95% CI = 1.17–1.75). No additional variables besides delinquency and substance use problems were statistically significant.

Logistic regression analysis distinguishing inhalant users with life-time abuse from users with life-time dependence

A final multivariate model was specified to identify factors distinguishing life-time inhalant abusers from life-time

Table 3 Predicted probability of inhalant user type class membership based on simulations from multinomial logistic regression.

Variable and inhalant user type	*Predicted probability of inhalant user type class membership*	*95% CI*
Ethnicity, white		
Non-user	0.69	0.61–0.76
Non-disorder	0.24	0.17–0.31
Disorder	0.08	0.04–0.12
Ethnicity, non-white		
Non-user	0.83	0.76–0.88
Non-disorder	0.13	0.09–0.18
Disorder	0.04	0.02–0.07
Urbanicity, rural/small town		
Non-user	0.55	0.48–0.62
Non-disorder	0.34	0.27–0.40
Disorder	0.11	0.08–0.17
Urbanicity, urban/suburban		
Non-user	0.69	0.61–0.76
Non-disorder	0.24	0.17–0.31
Disorder	0.07	0.04–0.12
Fearlessness, high (85th percentile)		
Non-user	0.57	0.47–0.66
Non-disorder	0.32	0.24–0.42
Disorder	0.11	0.06–0.18
Fearlessness, low (15th percentile)		
Non-user	0.79	0.70–0.86
Non-disorder	0.17	0.10–0.24
Disorder	0.05	0.02–0.08
Suicidal ideation, high (85th percentile)		
Non-user	0.56	0.43–0.68
Non-disorder	0.29	0.19–0.41
Disorder	0.15	0.09–0.25
Suicidal ideation, low (15th percentile)		
Non-user	0.75	0.67–0.82
Non-disorder	0.20	0.14–0.28
Disorder	0.05	0.03–0.08
Substance use problems, high (85th percentile)		
Non-user	0.36	0.26–0.45
Non-disorder	0.26	0.18–0.35
Disorder	0.39	0.28–0.50
Substance use problems, low (15th percentile)		
Non-user	0.84	0.76–0.90
Non-disorder	0.15	0.09–0.23
Disorder	0.01	0.00–0.03

CI: confidence interval. Predicted probabilities were computed by taking random draws from the posterior distribution of the multinomial logistic regression model. All predicted probabilities were adjusted for ethnicity, urbanicity, impulsive non-conformity, fearlessness, total delinquency in prior 12 months, Brief Symptom Inventory (BSI) anxiety, BSI depression, Massachusetts Youth Screening Instrument, version 2 (MAYSI-2) suicide ideation, MAYSI-2 trauma, and MAYSI-2 substance use problems; adjustments excluded the variable that was modeled.

inhalant dependants. Again, all variables significant at the bivariate level were included in the model. The overall model exhibited a good fit (residual deviance = 149.0, log-likelihood = −74.49, df = 120). Two variables distinguished inhalant abusers from inhalant dependants: youth with inhalant dependence had significantly higher scores on measures of delinquency (AOR = 1.74, 95% CI = 1.38–2.19), and suicide ideation (AOR = 1.23, 95% CI = 1.03–1.47) than youth diagnosed with only inhalant abuse.

DISCUSSION

Prior studies have documented functional impairments, including high rates of substance use and psychiatric disorders, in life-time inhalant users compared to inhalant non-users in the general population [20,21] and various subpopulations [3,4] of adolescents. However, only one previous investigation, to our knowledge, examined impairments across a gradient of problematic inhalant use involvement. Unlike Sakai *et al.* [7], we found some evidence of a monotonic relationship between severity of inhalant use problems, as reflected in formal DSM-IV diagnoses of inhalant abuse and dependence and indices of psychiatric symptoms, substance abuse, antisociality and other dysfunctions. It is notable that Sakai *et al.* [7] reported differences between inhalant users with and without IUDs for prevalence of life-time DSM-IV major depression (39% versus 23%), prior suicide attempt (32% versus 27%), life-time conduct disorder (96% versus 93%), alcohol use disorder (93% versus 83%), nicotine dependence (79% versus 73%) and amphetamine use disorders (36% versus 27%). Although these values did not show statistically significant differences, they were consistent in direction with the findings of this report. Perhaps the use of continuous measures of depression, sucidality and other variables permitted a more sensitive test of differences between inhalant use groups in the current study than the categorical variables employed by Sakai *et al.* [7]. The life-time prevalence of inhalant use in the Sakai *et al.* sample (i.e. 18%) was approximately half that observed in this study and the proportion of youth progressing from inhalant initiation to IUDs was much lower in the Sakai *et al.* study than in the current investigation. It is probable, therefore, that the statistical power to detect differences between inhalant use groups was not as high in the Sakai *et al.* investigation as in the current study, given the much lower rates of IUDs in the former study. In any case, it is notable that significant differences between inhalant use groups were identified in the current study, given that youth were sampled from a population with presumably restricted range across a number of assessed variables.

The reported levels of IUD identified in this sample, although significantly higher than those reported in most prior studies of adolescent inhalant users, are not entirely unprecedented. Ridenour *et al.* [6] recently studied the prevalence of DSM-IV IUDs in a sample of 162 community-residing inhalant users living in St Louis. A total of 40.2% (27.9% abuse; 12.3% dependence) of inhalant users (average age = 20.3, SD = 2.4) met criteria for IUDs. It is unclear whether the high abuse liability of inhalants reported by Ridenour *et al.* [6] and in the current study reflects prevalent use of inhalants in the Missouri state region of the United States, or regional differences in the pattern of inhalant use or products used which favor development of inhalant abuse and dependence. It is important to recognize that inhalant users in the current study were identified using a comprehensive instrument. It is also possible that the delinquent client population studied in this report was significantly enriched for inhalant use.

Our finding that IUDs were correlated commonly with measures of substance use problems, psychiatric symptoms and antisocial characteristics is consistent with d'Abbs & MacLean's [9] reference to volatile solvent misuse as an indicative of a 'risk behavior syndrome' or 'global vulnerability marker' (p. xvii). Thus, it is likely that clinicians encountering youth with IUDs will, in practice, be working with youth with multiple disorders requiring extensive intervention and rehabilitation. Further, our findings suggest that as the severity of inhalant-related problems increases, so too will the severity of co-occurring psychiatric and substance-related conditions. Thus, social and health authorities, particularly those charged with working with youth in the juvenile justice system, should consider screening routinely for IUDs using an extensive (although brief to administer) screen for inhalant use and IUDs.

Although the finding of graded differences between inhalant users, abusers and dependants with regard to psychosocial characteristics and various functional impairments is noteworthy, our results should be interpreted cautiously. We relied on youths' self-reports of unverified validity and the antisocial nature of the sample may itself limit the generalizabilty of reported findings. However, antisocial youth are an important client population in their own regard. The use of structured psychiatric interviews, high rate of youth participation, understudied youth population and infrequently investigated psychoactive agents are key strengths of this research. This study also builds on the strengths of existing work by maintaining consistency with DSM-IV diagnostic guidelines, such that nitrite vasodilator and nitrous oxide were not included as inhalant use. Further, the population of youth we studied was heterogeneous with regard to prior antisocial behavior

and not untypical of many juvenile and criminal justice treatment populations.

Declarations of interest

None.

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