

Prevalence, Correlates, and Characteristics of Gasoline Inhalation among High-Risk Youth: Associations with Suicidal Ideation, Self-Medication, and Antisociality

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ÖZET:

Gençler arasında benzin inhalasyonunun prevalansı, bağlantıları ve karakteristikleri: İntihar düşüncesi, self-medikasyon ve antisosyal davranış ile ilişkileri

Amaç: Benzin koklanması sonucunda zehirlenme durumunun ortaya çıkması küresel bir öneme sahip olmakla birlikte, çok az sayıda çalışma ergenlerde benzin kötüye kullanımının prevalansını, arasındaki ilişkileri ve özelliklerini incelemiştir. Bu çalışma, suç işleme davranışı nedeniyle yatılı olarak tedavi altında bulunan bir grup ergenle gerçekleştirilmiştir.

Yöntemler: Standardize edilmiş ölçekler, yapılandırılmış bir görüşme yöntemi aracılığıyla 723 ergene (çalışma örnekleminin %97.7'sine) uygulanmıştır.

Sonuçlar: Ergenlerin beşte birinden daha fazlası (%21.9'u) yaşam boyu benzin kötüye kullanımı bildirdi. Benzin kullanıcıları orantısız bir şekilde beyaz ırktan ve fakir, kırsal alanda oturan ergenlerden oluşmaktaydı. Benzin kötüye kullanımı olan ergenler, benzin dışında başka bir uçuşu madde kötüye kullananlar ya da uçuşu madde kullanmayanlar ile karşılaştırıldığında, daha fazla psikiyatrik eş tanı almaya, son dönemde daha yüksek oranda psikiyatrik sıkıntıya maruz kalma öyküsüne ve daha yüksek düzeyde geçirilmiş travma öyküsüne sahip olmaya, uçucuları kendi kendini sağaltım amaçlı kullanmaya eğilimliydi ve daha ciddi antisosyal kişilik özellikleri ve davranışlar sergilemekteydiler. Çok değişkenli analizler kullanıldığında, daha küçük yaşta katılımcıların, erkeklerin, küçük şehirlerde yaşayan gençlerin ve yoğun biçimde intihar düşüncesine sahip katılımcıların, akrabalarıyla karşılaştırıldıklarında daha yüksek düzeyde yaşam boyu benzin koklama davranışı gösterdiği saptanmıştır. Uçucuların kendi kendini iyileştirme amaçlı kullanılması ve tedaviye başlamadan önceki yıl süresince gözlenen suç davranışının sıklığı, benzin koklamanın yıllık sıklığını belirlemektedir.

Sonuç: Benzin koklama, antisosyal gençlerden oluşan bu örneklemden endemik ve ciddi psikiyatrik hastalıklara eşlik etmekteydi.

Anahtar sözcükler: Antisosyal davranış, benzin, uçucular, birlikte görülen bozukluklar, kendi kendine tedavi

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ABSTRACT:

Prevalence, correlates, and characteristics of gasoline inhalation among high-risk youth: associations with suicidal ideation, self-medication, and antisociality

Objective: Gasoline inhalation to achieve intoxication is a problem of global significance; however, few studies have examined the prevalence, correlates, and characteristics of gasoline abuse in adolescents. This study examined gasoline abuse in a sample of adolescents in residential treatment for delinquent conduct.

Methods: Standardized psychosocial instruments were administered via a structured interview to 723 adolescents (97.7% of the study population).

Results: More than one-in-five (21.9%) adolescents reported lifetime gasoline abuse. Gasoline users were disproportionately white, poor, and from rural areas. Gasoline abusers, benzin dışında başka bir uçuşu madde kötüye kullananlar ya da uçuşu madde kullanmayanlar ile karşılaştırıldığında, daha fazla psikiyatrik eş tanı almaya, son dönemde daha yüksek oranda psikiyatrik sıkıntıya maruz kalma öyküsüne ve daha yüksek düzeyde geçirilmiş travma öyküsüne sahip olmaya, uçucuları kendi kendini sağaltım amaçlı kullanmaya eğilimliydi ve daha ciddi antisosyal kişilik özellikleri ve davranışlar sergilemekteydiler. Çok değişkenli analizler kullanıldığında, daha küçük yaşta katılımcıların, erkeklerin, küçük şehirlerde yaşayan gençlerin ve yoğun biçimde intihar düşüncesine sahip katılımcıların, akrabalarıyla karşılaştırıldıklarında daha yüksek düzeyde yaşam boyu benzin koklama davranışı gösterdiği saptanmıştır. Uçucuların kendi kendini iyileştirme amaçlı kullanılması ve tedaviye başlamadan önceki yıl süresince gözlenen suç davranışının sıklığı, benzin koklamanın yıllık sıklığını belirlemektedir.

Conclusion: Gasoline abuse was endemic in this sample of antisocial youth and associated with serious psychiatric comorbidities.

Key words: Antisocial behavior, gasoline, inhalants, co-occurring disorders, self-medication

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INTRODUCTION

Although inhalation of volatile substances to achieve intoxication began in the Victorian era with the use of nitrous oxide, ether, and chloroform, 1934 marked the first official report of gasoline inhalation as a specific form of volatile substance abuse in the U.S. (1,2). By the 1960s,

gasoline abuse was prevalent in many countries, particularly among the native peoples of the U.S., Canada, Australia, Polynesia, and New Zealand (3,4). Although gasoline abuse is prevalent in the general population, poor, indigenous, and otherwise vulnerable populations continue to be at elevated risk for gasoline abuse (1,3).

It is difficult to precisely determine the prevalence and

incidence of gasoline use as opposed to inhalant use in general. According to the most recent National Survey on Drug Use and Health, 8.9% of the U.S. population, approximately 22.3 million people, aged 12 and older reported lifetime inhalant use (5). Described in the literature as the preferred inhalant choice among inner-urban adolescents irrespective of culture (1,3), it is probable that a substantial proportion of inhalant users engage in gasoline abuse. In 2009, the average age at initiation of inhalant use among the U.S. populace was 16.9, the youngest average age for initiation of any psychoactive substance (5). In 2008, first time inhalant users accounted for approximately 2 million people with 640,000 reporting past month usage (5).

The accessibility and low cost of gasoline make this inhalant especially attractive to poor, geographically- and socially-isolated persons, as well as young persons without the financial resources needed to procure other psychoactive substances (1,3,6). Peer and familial factors may also influence gasoline use as parental, and particularly paternal, alcohol use is linked to adolescent gasoline use (3,7).

Volatile aromatic hydrocarbons in gasoline include benzene, hexane, toluene, and xylene. Lipophilic in nature, they absorb rapidly across the pulmonary epithelium, convert to hydrophilic metabolites, and remain in the body for several hours (3,6). These hydrocarbons may contribute to the acute effects of gasoline intoxication, which include euphoria, slurred speech, ataxic gait, and impulsive and disinhibited behavior (3,8,9). In larger doses, users may experience hallucinations, delirium, unconsciousness, coma, and death (3,10).

Gasoline inhalation has been associated with a number of serious health conditions, including cerebellar ataxia, myopathy, peripheral neuropathy, encephalopathy, and sudden death (7,11). Gasoline users may exhibit abnormalities of cerebral cortex, cerebellum, hippocampus, basal ganglia, and brainstem coupled with cognitive deficits, tremors, brisk deep reflexes, palmomental reflexes, myoclonus, chorea, pyramidal signs, and motor impairment (1,3,9,12). The chronic gasoline user may also suffer serious psychiatric symptoms such as apathy, labile mood, hostility, aggression, depression, paranoia, and extreme irritability (6,9,12).

Prior studies indicate that antisocial youth have high rates of lifetime exposure to inhalants, but few investigations have specifically examined the prevalence, correlates, and characteristics of gasoline abuse (13,14). Thus, we aimed to:

- 1) establish the prevalence of annual and lifetime gasoline abuse in a large and well characterized sample of antisocial adolescents,
- 2) identify demographic, psychosocial, and psychiatric correlates of adolescent gasoline abuse in bivariate and multivariate analyses,
- 3) examine predictors of annual frequency of gasoline abuse within the sample of gasoline abusers, and
- 4) characterize features of gasoline abuse including the primary modality of abuse, the proportion of abusers reporting perceived intoxication following gasoline inhalation, and the abuse liability of gasoline (i.e., percentage of users with 100 or more occasions of use).

METHODS

The present investigation is an analysis of gasoline-specific data collected in a study of adolescents residing in 32 Division of Youth Services (DYS) treatment facilities (13) in Missouri, U.S.A. DYS provides residential care to youth ages 13 to 17 who are committed by state juvenile court judges for treatment of antisocial behavior. The adolescents (N = 723) completed structured psychiatric interviews; the number who participated in the interviews comprised 97.7% of DYS residents at the time interviews were completed. The present sample is nearly a census of the DYS treatment population at the time of data collection. DYS regions and the residential facilities located within them were surveyed sequentially. At each facility, all residents were recruited for interviews conducted by trained social work graduate students. Study procedures were approved by the Washington University and Missouri DYS Institutional Review Boards. The project was granted a Certificate of Confidentiality by the National Institute on Drug Abuse and approved by the federal Office of Human Research Protection. The study was conducted in accordance with the ethical standards of the Helsinki Declaration of 2000. Informed consent was obtained from all subjects after the procedure had been fully explained.

Participants

Gasoline Users (N= 159): Lifetime users of gasoline averaged 15.4 years of age, and were predominately white (n= 126, 79.7%). Black (n= 7, 4.4%) and Hispanic (n= 8, 5.1%) youth accounted for a comparatively small proportion of gasoline users. Most gasoline users were male (n= 403, 88.4%), and the preponderance resided in small towns (n=

97, 61.0%), with the remainder residing in urban areas (n= 35, 22.0%), suburban areas (n= 16, 10.1%), or rural areas (n= 11, 6.9%).

Users of Inhalants Other Than Gasoline (N= 108): The demographic characteristics of this sub-group were similar to those of lifetime gasoline users; users of inhalants other than gasoline were predominately white (n= 74, 68.5%), male (n= 86, 79.6%), likely to reside in a small town (n= 45 (41.7%), with a mean age of 15.6 (SD= 1.1). Fewer users of inhalants other than gasoline were black (n= 13, 12.0%), Hispanic (n= 12, 11.1%), and resided in urban (n= 35, 32.4%), suburban (n= 18, 16.7%), or rural areas (n= 10, 9.3%).

Inhalant Nonusers (N= 456): The mean age of inhalant nonusers was 15.5 (SD= 1.3). Nearly half of all inhalant nonusers were black (n= 218, 47.8%), and white subjects accounted for 43.9% (n= 200). Most inhalant nonusers were male (n= 403, 88.4%) and resided in urban areas (n= 213, 46.7%), with the remainder residing in small towns (n= 144, 31.6%), suburban areas (n= 66, 14.5%), or rural areas (n= 33, 7.2%).

Interview

Participants completed a 45-minute, structured interview assessing demographic characteristics, inhalant and other psychoactive substance use and substance-related problems, psychiatric symptoms, trauma history, and antisocial attitudes and behaviors.

Inhalant use patterns. Participants completed the Volatile Solvent Screening Inventory (VSSI) (13), an instrument assessing lifetime/annual use of 55 inhalants, primary mode of inhalant self-administration, and a variety of inhalant intoxication experiences. Consistent with current diagnostic practices (15), nitrite and nitrous oxide use were not included in this study but have been investigated in this sample and the results reported elsewhere (16,17). Youth were queried about their motivations for inhalant abuse. A prior latent class analysis of reasons for inhalant abuse among youth (18) identified six items assessing motivations for inhalant use that were endorsed by youth with self-medication motives: “to relax,” “to forget your troubles,” “because you were sad, lonely or depressed,” “because you were having family problems,” “because you felt angry or frustrated at someone else,” and “because you felt angry or frustrated at yourself.” These items were summed to produce a total self-

medication scale score ($\alpha = .89$). A single, Likert-type item asked inhalant users to rate the degree to which they perceived their own inhalant use as problematic.

Clinical correlates of inhalant use. The Brief Symptom Inventory (BSI) (19), a well-validated questionnaire yielding subscale scores for primary psychiatric symptom dimensions as well as a global severity index ($\alpha = .96$), was used to measure severity of distress associated with current psychiatric symptoms. In addition, a single, dichotomous item assessed whether youth had been formally diagnosed with a psychiatric disorder by a non-psychiatric physician or psychiatrist. Youth completed the Antisocial Process Screening Device (APSD, $\alpha = .70$), a 20-item scale assessing trait narcissism, impulsivity, and callousness (20). With regard to antisocial behavior, the Self-Report of Delinquency (SRD; $\alpha = .84$) was used to assess how many times in the year before they entered residential care youth engaged in each of 7 nonviolent and 10 violent crimes (21). Lifetime substance-related problems, exposure to traumatic experiences, and suicidal ideation were assessed with pertinent subscales of the Massachusetts Youth Screening Instrument—2nd Version (22). Lastly, the prevalence and frequency of lifetime use of 20 categories of non-inhalant psychoactive substances (e.g., cocaine) was assessed. For each psychoactive agent, youth reported whether or not they had ever used the drug. Total lifetime number of substances used was computed by summing the number of affirmative responses across all 20 categories of use.

Statistical Analysis

For the purpose of conducting bivariate and adjusted comparisons across the measures listed above, we formed the following three subgroups: youth who reported lifetime use of gasoline (including possible use of one or more other inhalants, i.e., gasoline users), youth who reported use of one or more of 55 inhalants but no prior gasoline inhalation (i.e., users of inhalants other than gasoline), and youth who reported no use of any of the 55 inhalants (i.e., inhalant nonusers).

Patterns of lifetime and annual abuse of gasoline were examined, including frequency and common modalities of use. We selected a bivariate approach to describe differences between gasoline users, users of inhalants other than gasoline, and inhalant nonusers, using analyses of variance (ANOVAs) and t-tests for continuous variables and χ^2 for

categorical variables. We selected a multivariate approach to predict status as a lifetime gasoline user and frequency of gasoline abuse in the year prior to treatment, using multiple logistic and ordinal regression analyses with a set of demographic and psychosocial variables (see Results). Homogeneity of variance assumptions were tested and effect sizes presented as odds ratios, Cramer's V, partial eta squared, or Cohen's d.

RESULTS

Characteristics of Gasoline Abuse

The prevalence and patterns of gasoline abuse in the present sample are described in Table 1. More than one-in-five (N = 159, 21.9%) youth reported lifetime gasoline use. Of the lifetime gasoline users, a majority (69.2%) had abused gasoline in the year prior to incarceration, and most (82.3%) reported experiencing intoxication as a result of inhaling gasoline vapors. Many lifetime users "huffed" gasoline directly from a container (72.3%) as their primary

mode of abuse, but some inhaled vapors from a cloth saturated with gasoline (11.9%), sprayed vapors directly into their nose or mouth (5.0%), inhaled gasoline from a plastic bag (2.5%), or used other modes of inhalation (8.2%). A majority (67.3%) of users reported an experimental pattern of gasoline use, having inhaled gasoline on fewer than 10 occasions; however, 20.8% and 11.9% of users reported occasional (11 to 99 occasions of use) or heavy (100 or more occasions of use) use, respectively.

Bivariate Findings

Lifetime gasoline users differed significantly from users of other inhalants and inhalant nonusers with regard to sociodemographic, medical, psychological, and substance-use characteristics (see Table 2). A higher proportion of gasoline-using youth were white, resided in small towns, and came from families receiving public assistance than youth who used inhalants other than gasoline and inhalant nonusers. Gasoline users evidenced significantly higher levels of suicidal ideation, prior traumatic experiences, and current psychiatric symptoms than users of other inhalants and inhalant nonusers. In addition, gasoline users were significantly more likely than users of other inhalants and nonusers to report having been diagnosed with a formal psychiatric disorder, and were significantly more likely than inhalant nonusers to report having experienced a head injury leading to loss of consciousness. With regard to antisocial traits and behaviors, gasoline-inhaling youth were significantly more impulsive, narcissistic, and callous, and reported engaging more frequently in delinquent acts (including violent offenses and property crimes) than users of other inhalants or nonusers. Gasoline users also exhibited the most severe substance use profiles, reporting prior use of a comparatively large number of inhalants and other drug classes, high levels of substance-related problems, and high levels of self-medication and problematic use of inhalants.

Multivariate Regression Analyses of Lifetime Gasoline Use and Frequency of Annual Gasoline Inhalation

Based on our bivariate findings, we selected the following predictors of lifetime gasoline abuse: age, gender, race, geographic area of family residence, suicidal

Table 1: Prevalence, frequency, and modalities of gasoline abuse among 723 adolescents in residential treatment.

Variable	N (%)
Lifetime gasoline abuse	159 (22.0)
Perceived intoxication due to gasoline inhalation	130 (82.3)*
Lifetime frequency of gasoline abuse	
< 5 times	68 (42.8)
5-10 times	39 (24.5)
11-99 times	33 (20.8)
>100 times	19 (11.9)
Frequency of gasoline abuse in year prior to treatment entry	
None	49 (30.8)*
1 time	32 (20.1)
2-4 times	22 (13.8)
5-10 times	21 (13.2)
1 time per month	11 (6.9)
Every 2-3 weeks	3 (1.9)
1 time per week	10 (6.3)
2-3 times per week	3 (1.9)
1 time per day	5 (3.1)
2-3 times per day	3 (1.9)
Primary modality of gasoline abuse	
Inhaled from container	115 (72.3)*
Inhaled from gas-soaked cloth	19 (11.9)
Other	13 (8.2)
Sprayed in oral cavity	8 (5.0)
Inhaled from plastic bag	4 (2.5)

*The percentages reported reflect the proportion of lifetime gasoline users (N = 159) evidencing these characteristics.

Table 2: Unadjusted bivariate contrasts of lifetime gasoline users (N = 159), users of inhalants other than gasoline (N = 108), and inhalant nonusers (N = 456) across demographic, medical history, mental health, antisociality behavior/attitudes, and substance use measures.

Variable	Lifetime Users of Gasoline & Other Inhalants N = 159	Lifetime Users of Inhalants Other than Gasoline N = 108	Inhalant Nonusers N = 456	Test Statistic/Effect Size
Demographics				
Age (M, SD)	15.4 (1.2)	15.6 (1.1)	15.5 (1.3)	F(2,722) = .65, p > .10, $\eta^2 = .00$
Gender N (%)				$\chi^2(2) = 6.11, p < .05, V = .09$
Male	140 (88.1)	86 (79.6)	403 (88.4)	
Female	19 (11.9)	22 (20.4)	53 (11.6)	
Race N (%)				$\chi^2(8) = 140.32, p < .001, V = .31$
White	126 (79.7)	74 (68.5)	200(43.9)	
Black	7 (4.4)	13 (12.0)	218 (47.8)	
Hispanic	8 (5.1)	12 (11.1)	8 (1.8)	
Biracial	12 (7.6)	7 (6.5)	26 (5.7)	
Other	5 (3.2)	2 (1.9)	4 (0.9)	
Geographic area of family residence N (%)				$\chi^2(6) = 48.75, p < .001, V = .18$
Urban	35 (22.0)	35 (32.4)	213 (46.7)	
Suburban	16 (10.1)	18 (16.7)	66 (14.5)	
Rural	11 (6.9)	10 (9.3)	33 (7.2)	
Small town	97 (61.0)	45 (41.7)	144 (31.6)	
Familial receipt of public assistance N (%)	74 (48.6)	34 (32.7)	179 (39.9)	$\chi^2(2) = 5.4, p = .07, V = .07$
Medical Conditions				
History of loss of consciousness due to head injury N (%)				$\chi^2(2) = 9.09, p = .01, V = .11$
Yes	39 (24.5)	25 (23.1)	68 (15.0)	
No	120 (75.5)	83 (76.9)	385 (85.0)	
Mental Health M(S.D.)				
BSI-Global Severity Index	59.1 (37.6)	48.0 (36.6)	37.4 (31.5)	F(2, 722) = 25.40, p < .001 ^{a,b,c} , $\eta^2 = .07$
MAYSI-Traumatic experiences	3.4 (1.5)	3.0 (1.6)	2.8 (1.6)	F(2, 722) = 21.07, p < .001 ^b , $\eta^2 = .02$
MAYSI-Suicide ideation	3.7 (2.4)	2.8 (2.4)	1.6 (2.1)	F(2, 721) = 58.07, p < .001 ^{a,b,c} , $\eta^2 = .14$
Physician-diagnosed psychiatric disorders				$\chi^2(2) = 42.46, p < .001, V = .24$
Yes	114 (72.2)	62 (57.4)	194 (42.7)	
No	44 (27.8)	46 (42.6)	260 (57.3)	
Delinquent Behavior and Attitudes M(S.D.)				
SRD (Total Delinquency)	30.6 (20.5)	23.8 (16.2)	22.4 (17.8)	F(2, 722) = 12.00, p < .001 ^{a,b} , $\eta^2 = .03$
Property crimes	18.1 (12.3)	15.1 (11.8)	12.3 (11.3)	F(2, 722) = 15.04, p < .001 ^b , $\eta^2 = .04$
Violent Offenses	12.5 (11.1)	8.7 (7.0)	10.0 (9.2)	F(2, 722) = 5.99, p < .01 ^{a,b} , $\eta^2 = .02$
Antisocial personality traits				
-APSD total score	18.7 (5.3)	16.3 (5.2)	15.4 (5.4)	F(2, 721) = 21.84, p < .001 ^{a,b} , $\eta^2 = .06$
Impulsivity	7.5 (1.9)	6.8 (2.0)	6.1 (2.1)	F(2, 721) = 31.31, p < .001 ^{a,b,c} , $\eta^2 = .08$
Narcissism	2.5 (1.4)	1.9 (1.3)	2.1 (1.4)	F(2, 721) = 6.18, p < .01 ^{a,b} , $\eta^2 = .02$
Callousness	8.7 (3.2)	7.6 (3.2)	7.3 (3.0)	F(2, 721) = 11.74, p < .001 ^{a,b} , $\eta^2 = .03$
Substance Use M(S.D.)				
MAYSI-Alcohol/Drug problems	5.4 (1.8)	4.8 (2.1)	3.4 (5.2)	F(2, 705) = 13.15, p < .001 ^{b,c} , $\eta^2 = .04$
Lifetime # of drug types used	6.1 (2.7)	5.6 (3.1)	2.9 (2.1)	F(2, 720) = 133.46, p < .001 ^{b,c} , $\eta^2 = .27$
Self-medication with inhalants	9.3 (6.4)	7.6 (5.8)		t(264) = 2.50, p < .05, d = .28
Lifetime # of inhalants used	4.0 (1.5)	2.5 (1.4)		t(265) = 8.13, p < .001, d = 1.03
Perceived problem with inhalants	0.9 (1.1)	0.5 (0.8)		t(260.96) = 3.36, p = .001, d = .41

Effect size estimates: η^2 = partial eta squared; V = Cramer's V.

^a= Lifetime Users of Gasoline and Other Inhalants are significantly different than Lifetime Users of Inhalants other than Gasoline; ^b= Lifetime Users of Gasoline and Other Inhalants are significantly different than Inhalant Nonusers; ^c= Lifetime Users of Inhalants other than Gasoline are significantly different than Inhalant Nonusers

BSI= Brief Symptom Inventory

MAYSI= Massachusetts Youth Screening Inventory

SRD= Self-Report of Delinquency

APSD= Antisocial Process Screening Device

Table 3: Logistic regression and ordinal regression analyses (with simultaneous entry of covariates¹) examining correlates of lifetime gasoline abuse and annual frequency of gasoline abuse in a sample of adolescents in residential care.

Variable	Lifetime gasoline abuse (N = 723)			Annual frequency of gasoline abuse (N = 159)		
	B	SE	OR (95% CI)	B	SE	(95% CI)
Demographic						
Age	-.28*	.14	.75 (.58, .98)	-.27	.14	(-.54, .01)
Sex	-1.06**	.38	.35 (.16, .74)	.51	.47	(-.42, 1.44)
Race	.03	.14	1.03 (.87, 1.35)	1.12	1.13	(-1.10, 3.35)
Small Town Residence	1.03***	.28	2.81 (1.62, 4.89)	.10	.33	(-.54, .73)
Mental Health						
BSI Global Severity Index	.00	.01	1.00 (.99, 1.01)	.00	.01	(-.01, .01)
MAYSI-2 Traumatic Experiences Index	-.01	.10	.99 (.81, 1.21)			
MAYSI-2 Suicidal Ideation	.13*	.07	1.14 (1.01, 1.30)	.03	.07	(-.11, .17)
Antisocial Behavior & Traits						
Self-Report Delinquency Total Score	.01	.01	1.01 (.99, 1.03)	.02*	.01	(.00, .04)
Antisocial Personality - APSD Total Score	.04	.03	1.05 (.99, 1.11)	.02	.03	(-.04, .08)
Substance Use						
MAYSI Alcohol/Drug Problems Scale	.11	.09	1.11 (.93, 1.33)	.11	.12	(-.12, .34)
Lifetime total number of drug types used	.04	.06	1.04 (.92, 1.18)	-.00	.07	(-.14, .13)
Self-medication with inhalants	.04	.03	1.04 (.99, 1.10)	.07**	.03	(.02, .13)

*p<.05, **p≤ .01, ***p < .001

¹Regression analysis of lifetime gasoline use and annual frequency of gasoline use involved simultaneous entry of the following variables: age, sex (reference group is male), race (reference group is white), small town residence (yes/no), Brief Symptom Inventory (BSI) Global Severity Index, Massachusetts Youth Screening Inventory-2 (MAYSI-2) Traumatic Experiences Index, Massachusetts Youth Screening Inventory-2 (MAYSI-2) Suicidal Ideation Index, Self-Report Delinquency total score, Antisocial Process Screening Device (ASPD) total score, (MAYSI) Massachusetts Youth Screening Inventory Alcohol/Drug Problems Scale total score, lifetime total number of drug types used, and tendencies toward self-medication with inhalants.

ideation, traumatic experiences, current distress in relation to psychiatric symptoms (BSI-global severity index), antisocial attitudes, frequency of delinquent behavior in the year prior to treatment entry, substance-related problems, lifetime number of psychoactive drug classes used, and degree of self-medication use of inhalants. Multiple logistic regression analyses with simultaneous entry of these demographic and psychosocial covariates indicated that gasoline users were significantly younger, more likely to be male and reside in small towns, and to have higher levels of suicidal ideation than users of inhalants other than gasoline and inhalant nonusers (see Table 3). For every one standardized unit increase in suicidal ideation observed among youth in the present sample, the likelihood of their ever having engaged in gasoline abuse was increased by 14%.

Next, multivariate ordinal regression analyses with simultaneous entry of the same set of covariates listed above revealed that greater self-medication use of inhalants and greater frequency of delinquent behaviors in the year prior to treatment were significantly positively associated with annual frequency of gasoline abuse (see Table 3). In a secondary analysis controlling for the same set of covariates listed above

in addition to the lifetime number of inhalant classes used other than gasoline, frequency of delinquent behaviors in the year prior to treatment remained statistically significantly associated with annual frequency of gasoline inhalation (B=.024, S.E.= .01, Wald= 7.81, 95% C.I.= .01, .04, p=.005).

DISCUSSION

Nearly one-quarter of this sample of youth in residential care for antisocial behavior reported lifetime gasoline abuse. Most gasoline abusers reported intoxication following gasoline inhalation, which typically involved inhaling vapors directly from a container (e.g., a gas can). Over half of users reported lifetime use on 11 or more occasions, more than one-in-ten users reported 100 or more occasions of use and weekly or more frequent gasoline use in the year prior to treatment. Gasoline abuse was prevalent among adolescents in the present sample, which is likely representative of youth housed in state-run residential treatment facilities (13). Many gasoline abusers identified in this study reported recurrent use at levels that may pose significant health and neuropsychiatric risks.

Like gasoline users worldwide, users in this U.S.

sample tended to reside outside of urban areas, where other psychoactive drugs are often difficult to access and gasoline is ubiquitous in the physical environment. Nearly half of this sample of gasoline users was from families receiving public assistance; thus, the poverty associated with gasoline use in this sample is congruent with the social and economic characteristics of indigenous users of gasoline worldwide. Socioeconomic stress coupled with geographic isolation may render such youth especially prone to seek intoxication via gasoline, which is inexpensive and comparatively easy to use in a covert fashion while eluding detection by parents, teachers, and law enforcement.

Gasoline-abusing youth reported significantly greater past trauma and current psychiatric symptoms, as well as a greater prevalence of psychiatric diagnosis, than inhalant nonusers and users of inhalants other than gasoline. Similarly, gasoline users reported significantly higher levels of suicidal ideation than users of other inhalants and inhalant nonusers. Clearly, youth who use gasoline as an intoxicant exhibit more severe psychiatric dysfunction than other inhalant users and inhalant nonusers. These findings are consistent with our finding of greater self-medication use of inhalants among gasoline abusers than users of other inhalants, which, in turn, was significantly associated with higher frequency gasoline abuse. Gasoline may be an especially potent agent of self-medication, particularly with regard to its capacity to produce relaxation, dissociation, and amnesia (8). Such effects, alone or in combination, may temporarily allay negative emotions and obliterate intrusive memories stemming from traumatic experiences. Yet, in a recent investigation of the phenomenology of inhalant intoxication among adolescents, Garland and Howard (8) found that high-frequency gasoline inhalation was associated with states of intoxication characterized by depressed mood and suicidal ideation. Gasoline abuse, like the use of alcohol and other psychoactive substances, may provide an apparent means of palliative coping with stressors, while actually increasing vulnerability to stress and negative emotion over time, due to allostatic dysregulation of affective circuitry in the brain (23,24).

Youth reporting lifetime use of gasoline had significantly higher levels of antisocial traits and attitudes, property offenses, and violent crimes than users of other inhalants and inhalant nonusers. We offer two speculative interpretations of the elevated rates of antisociality observed among youth in this study. First, coupled with the

allostatic load incurred by self-medication through gasoline abuse, the neuropharmacologic effects of inhaled gasoline vapors may disrupt normal function of brain structures associated with impulse control, including corticolimbic regions mediating sensitization to rewards and consequences (25), leading to disinhibition, further impulsivity, and impaired decision-making (26). Moreover, gasoline abuse in the present sample was associated with loss of consciousness leading to possible head trauma, which has been shown to be predictive of cerebral atrophy, executive function impairments, and impulsive behavior observed an average of four years after the original childhood trauma (27,28). Lesions in the prefrontal cortex sustained in childhood are associated with later risk-taking (27), providing an additional potential physiological substrate for the severe antisocial and delinquent behavior evidenced by the youth in our sample.

Second, youth with genetic loading towards impulsivity and emotion dysregulation who are raised in impoverished social environments characterized by high rates of familial and peer violence and substance use are more likely to exhibit psychological distress and engage in a range of high-risk behaviors, including substance abuse (29). Thus, the etiology of gasoline abuse and its correlates may be traced back to pathogenic gene-environment interactions and early experiences of adversity. It is, of course, possible that gasoline use causes or exacerbates these psychosocial problems, resulting in positive feedback loops between adverse life circumstances, psychiatric symptoms, self-medication via gasoline inhalation, and high-risk behavior.

The current investigation is limited by its cross-sectional design, which precludes causal inference. Hence, it is unclear whether youth develop problems as a result of their abuse of gasoline, or whether gasoline abuse is one among many potential indicators of a dispositional propensity towards polysubstance use, sensation-seeking, risk taking, and psychological problems, or an outcome of early life adversities involved in the etiology of gasoline abuse and associated comorbidities. In the present study sample, only five out of the 159 gasoline misusing youth reported lifetime abuse of gasoline but no use of other inhalants. This finding is remarkable in that it suggests that gasoline use in isolation is quite rare among antisocial youth. Due to the lack of statistical power stemming from the small size of this subsample, we did not undertake comparisons between this group and the other study

groups. In the absence of these contrasts, differences in antisociality, delinquency, and psychiatric symptoms observed between users of gasoline (and other inhalants) and users of other inhalants (but not gasoline) may either be due to the pharmacologic properties of gasoline or simply due to greater polyinhalant use or both. Yet, after statistically controlling for polyinhalant use, past-year frequency of gasoline inhalation remained significantly associated with antisocial behavior, suggesting that higher frequency gasoline abusers exhibit elevated risk for disinhibited, aggressive, and criminal acts. In the future, it would be useful for researchers to compare large samples of gasoline-only abusers to gasoline and other inhalant abusers, users of other inhalants but not gasoline, and to inhalant nonusers. A final study limitation relates to the antisocial nature of the study sample, which may limit the generalizability of these findings; that said, antisocial youth are an important population in their own right and known to be at high risk for inhalant abuse. At the least, the findings of this study suggest that a positive response to a single screening question assessing lifetime gasoline inhalation for the purposes of intoxication might serve as a “red flag” to aid in the identification of youth with serious dysfunction requiring clinical intervention.

In conclusion, study findings indicate that gasoline abuse among antisocial youth is a public health threat associated with psychiatric and substance use problems, antisocial behavior and attitudes, and traumatic life experiences. Although gasoline is one of the most deleterious of psychoactive agents and its abuse is prevalent

worldwide, relatively little is known about this substance of abuse. The current study fills a gap in the literature by highlighting the severe psychological comorbidities that, in conjunction with gasoline abuse, present a heightened danger to the troubled youth who choose to inhale the toxic vapors of this commonplace substance. Intentional inhalation of gasoline vapors exerts complex pharmacologic effects on the nervous system (3), resulting in a broad array of cognitive, affective, and somatic responses (8) that have serious implications for psychiatric function (30). Therefore, the study of gasoline abuse in the United States and in the international community at-large is of considerable significance to the field of clinical psychopharmacology, as evidenced by recent, relevant publications in the psychopharmacological literature (8,31). Studies like the present one detailing the predictors and correlates of gasoline abuse may help elucidate risk mechanisms associated with the neuropsychological propensity to seek intoxication via gasoline inhalation. Hence, in addition to studies of the short- and long-term health consequences of gasoline abuse, more research is needed to understand what motivates youth to seek intoxication via such hazardous substances (18) and, ultimately, what motivates them to desist (32).

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References:

- Byard RW, Chivell WC, Gilbert JD. Unusual facial markings and lethal mechanisms in a series of gasoline inhalation deaths. *Am J Foren Med Path* 2003;24(3):298-302.
- Nunn JA, Martin FM. Gasoline and kerosene poisoning in children. *JAMA* 1934;103: 472-4.
- Cairney S, Maruff P, Burns C, Currie B. The neurobehavioral consequences of petrol (gasoline) sniffing. *Neurosci Biobehav Rev* 2002; 26(1): 81-9.
- McGrath J. Petrol sniffing and lead encephalopathy. *Med J Australia* 1986; 144(4): 221.
- Substance Abuse and Mental Health Services Administration. The NSDUH Report. Rockville, MD: Office of Applied Studies; 2010.
- Maruff P, Burns CB, Tyler P, Currie BJ, Currie J. Neurological and cognitive abnormalities associated with chronic petrol sniffing. *Brain* 1998;121(10):1903-17.
- Fortenberry JD. Gasoline sniffing. *Amer J of Med* 1985;79(6):740-4.
- Garland EL, Howard MO. Phenomenology of adolescent inhalant intoxication. *Exp Clin Psychopharm.* 2010; 18(6):498-09.
- Shah R, Vankar GK, Upadhyaya HP. Phenomenology of gasoline intoxication and withdrawal symptoms among adolescents in India: A case series. *Amer J of Addict* 1999;8(3):254-7.
- Bass M. Death from sniffing gasoline. *N Engl J Med.* 1978;299(4):203.
- Morrow LA, Robin N, Hodgson MJ, Kamis H. Assessment of attention and memory efficiency in persons with solvent neurotoxicity. *Neuropsychologia* 1992;30(10):911-22.
- Ehle AL, McKee DC. Neuropsychological effect of lead in occupationally exposed workers: a critical review. *Crit Rev Toxicol* 1990;20(4):237-55.

13. Howard MO, Balster RL, Cottler LB, Wu LT, Vaughn MG. Inhalant use among incarcerated adolescents in the United States: Prevalence, characteristics, and correlates of use. *Drug Alcohol Depend* 2008;93(3):197-09.
14. Howard MO, Jenson JM. Inhalant use among antisocial youth: Prevalence and correlates. *Addict Behav* 1999;24(1):59-74.
15. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. Washington, D.C: American Psychiatric Association Press, 2004.
16. Garland EL, Howard MO, Perron BE. Nitrous oxide inhalation among adolescents: Prevalence, correlates, and co-occurrence with volatile solvent inhalation. *Journal of Psychoactive Drugs* 2009;41(4):337-47.
17. Hall MT, Howard MO. Nitrite inhalant abuse in antisocial youth: Prevalence, patterns, and predictors. *J Psychoactive Drugs* 2009;41(2):135-43.
18. Perron BE, Vaughn MG, Howard MO. Reasons for using inhalants: Evidence for discrete classes in a sample of incarcerated adolescents. *J Subst Abuse Treat* 2008;34(4):450-55.
19. Derogatis LR, Melisaratos N. The Brief Symptom Inventory: An introductory report. *Psychol Med*. 1983;13(3):595-05.
20. Vitacco MJ, Rogers R, Neumann CS. The Antisocial Process Screening Device: An examination of its construct and criterion-related validity. *Assessment* 2003;10(2):143-50.
21. Elliott DS, Huizinga D, Menard S. *Multiple Problem Youth: Delinquency, Substance Use, and Mental Health Problems*. New York: Springer-Verlag, 1989.
22. Grisso T, Barnum R. *Massachusetts Youth Screening Instrument-Second Version. User's Manual and Technical Reports*. Boston, MA: University of Massachusetts Medical School, 2000.
23. Garland EL, Boettiger CA, Howard MO. Targeting cognitive-affective risk mechanisms in stress-precipitated alcohol dependence: An integrated, biopsychosocial model of automaticity, allostasis, and addiction. *Med Hypotheses* 2011;76(5):745-54.
24. Koob GF, Le Moal M. Drug addiction, dysregulation of reward, and allostasis. *Neuropsychopharmacol* 2001;24(2):97-29.
25. Crews FT, Boettiger CA. Impulsivity, frontal lobes and risk for addiction. *Pharmacol Biochem & Behav*. 2009; 93(3):237-47.
26. Lubman DI, Yucel M, Lawrence AJ. Inhalant abuse among adolescents: neurobiological considerations. *Brit J Pharmacol*. 2008;154(2):316-26.
27. Floden D, Alexander MP, Kubu CS, Katz D, Stuss DT. Impulsivity and risk-taking behavior in focal frontal lobe lesions. *Neuropsychologia* 2008;15;46(1):213-23.
28. Slawik H, Salmund CH, Taylor-Tavares JV, Williams GB, Sahakian BJ, Tasker RC. Frontal cerebral vulnerability and executive deficits from raised intracranial pressure in child traumatic brain injury. *J Neurotrauma*. 2009;26(11):1891-903.
29. Enoch MA. The role of early life stress as a predictor for alcohol and drug dependence. *Psychopharm. (Berl) Psychopharmacology*. 2011;214(1):17-31.
30. Wu LT, Howard MO. Psychiatric disorders in inhalant users: Results from the National Epidemiologic Survey on Alcohol and Related Conditions. *Drug Alcohol Depend* 2007;88(2-3):146-55.
31. Garland EL, Howard, MO. Adverse consequences of acute inhalant intoxication. *Exp Clin Psychopharmacol* 2011;19(2):134-44.
32. Garland EL, Howard MO. Desistance motivations among adolescent inhalant users: Latent class and profile analyses. *Addict Res Theory* 2011;19(3):189-98.