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Behavioral and social correlates of methamphetamine use in a population-based sample of early and later adolescents

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ABSTRACT

This paper reports relationships between methamphetamine use and behaviors and social influences using data from a population-based survey of 8th- and 11th-grade students in Oregon for the 2001–2003 school years. We analyze methamphetamine use within a general problem behavior framework to identify malleable correlates of behavior for future prevention interventions. We specifically test two models of methamphetamine use employing logistic regression analysis: one comprised of behaviors and traits of the individual students and another focusing on peer and parental influences. This study finds adolescent methamphetamine use related to several problem behaviors. However, the specific problems vary by grade and are moderated by gender. Findings indicate the need for tailored interventions targeting gender/grade-specific behaviors or problems such as antisocial activities, risky sex, and depression, as well as social influences such as peers engaging in antisocial behaviors or using drugs and parents favoring drug use or poorly monitoring or setting limits for their children.

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1. Introduction

About five million Americans have tried methamphetamine (Anglin, Burke, Perrochet, Stamper, & Dawud-Noursi, 2000). Some states or parts of states—particularly rural areas—report epidemics of methamphetamine use, especially on the West Coast, in the Midwest and in the South (Booth, Leukefeld, Falck, Wang, & Carlson, 2006; Butterfield, Malliarakis, & Dotson, 2002; Colnar, Rawson, Marinelli-Casey, Gallagher, & Herrell, 1999; Glittenberg & Anderson, 1999; Haight et al., 2005; Lineberry & Bostwick, 2006; Rawson, Anglin, & Ling, 2002; Sexton et al., 2005). Methamphetamine use is now spreading across the United States although overall national prevalence may be leveling off (Office of National Drug Control Policy, 2006).

According to the National Survey of Drug Use and Health, *lifetime* use of methamphetamine by those 12 and older has ranged from 4.3% in 1999 to a peak of 5.3% in 2002 before falling to 4.9% in 2004 (Substance Abuse and Mental Health Services Administration, 2005). In terms of youth, The Monitoring the Future Study shows *past year* methamphetamine prevalence for high school seniors at 1.5% in 2001 with a slight decline to 1.1% in 2006 (Interuniversity Consortium for Political and Social Research, 2007). The Youth Risk Behavior Survey of 9th–12th graders shows *lifetime* prevalence declining from 9.8% in 2001 to 4.4% in 2007 (Centers for Disease Control and Prevention, 2008).

The Oregon Healthy Teen (OHT) survey indicated that *lifetime* use of methamphetamine by 8th and 11th graders was 5.1% for the 2000–2001 school year and 3.0% for the 2006–2007 school year. While Oregon once had an abundance of methamphetamine labs, the number of methamphetamine labs reported by Oregon law enforcement declined by 96% during a recent four-year period (from 473 in 2003 to just 17 in 2007). The decline was due mostly to tougher enforcement and stricter control of pseudoephedrine—an over-the-counter cold remedy that is a key ingredient for methamphetamine—under recent laws passed by the Oregon Legislature and Congress (National Drug Intelligence Center, 2007).

The proximal impact of methamphetamine use is disproportionate to its prevalence and typically has immediate adverse health effects, with some groups suffering more than others the consequences of its use and abuse. These include Native Americans (Freese, Obert, Dickow, Cohen, & Lord, 2000; Glittenberg & Anderson, 1999) and adolescent and young women of childbearing years (Freese et al., 2000; Haight et al., 2005; Morgan & Joe, 1996; Paschane, Fisher, Cagle, & Fenaughty, 1998). Other populations disparately affected include gay and bisexual men (Centers for Disease Control and Prevention, 2006;

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Freese et al., 2000; Halkitis, Parsons, & Stirratt, 2001; Sanello, 2005) and criminal justice populations (Freese et al., 2000; McCarthy & Waters, 2003; Stoops, Tindall, Mateyoke-Scrivner, & Leukefeld, 2005).

Methamphetamine addiction has major health and safety consequences in the U.S. and other countries (Banken, 2004; Kraus et al., 2003; Sattah et al., 2002; Suwanwela & Poshyachinda, 1986; Wada, Greberman, Konuma, & Hirai, 1999; Wilkins, Pledger, Bhatta, & Casswell, 2004). Serious cardiovascular problems are common among male users (Brecht, O'Brien, Mayrhauser, & Anglin, 2004; Chan, Chen, Lee, & Deng, 1994; Hong, Matsuyama, & Nur, 1991; Perez, Arsura, & Strategos, 1999; Richards, Johnson, Stark, & Derlet, 1999; Wijetunga, Bhan, Lindsay, & Karch, 2004; Wolkoff, 1997; Yu, Larson, & Watson, 2003), putting a strain on the budgets of local governments. Serious psychiatric disorders emerge or worsen due to its use (Brecht et al., 2004; Liebowitz, McGrath, & Bush, 1980; Meredith, Jaffe, Ang-Lee, & Saxon, 2005; Roberts, Yeager, & Siegel, 2003; Shoptaw, Peck, Reback, & Rotheram-Fuller, 2003; Zweben et al., 2004), including increased risk of suicidality (Yen & Shieh, 2005). Emergency care and first responders bear a considerable burden related to meth use (Centers for Disease Control and Prevention, 2000; Lineberry & Bostwick, 2006).

Early sexual behavior and frequent unprotected sex among heterosexual and homosexual users of methamphetamine result in higher rates of Hepatitis and HIV infection rates (Davis, Kalousek, & Rubenstein, 1970; Gorman, 2003; Greenwell & Brecht, 2003; Harkess, Gildon, & Istre, 1989; Hutin et al., 2000; Koester, Glanz, & Barón, 2005; Meyer, 2003; Molitor, Truax, Ruiz, & Sun, 1998; Urbina & Jones, 2004; Vogt et al., 2006). Methamphetamine use interferes with the efficacy of HIV medications and treatment (Anonymous, 2004; Boddiger, 2005; Jernigan et al., 2005). In many jurisdictions, the consequences of methamphetamine use overwhelm trauma systems (Embry, Lopez, & Minugh, 2005; Rockett, Putnam, Jia, & Smith, 2006; Schermer & Wisner, 1999; Tominaga, Garcia, Dzierba, & Wong, 2004).

Many newborns and infants are exposed to methamphetamine directly (toxic exposure) or indirectly (through abusive or neglectful parenting), with significant impact on child-protective services and healthcare in some jurisdictions (Buchi, Zone, Langheinrich, & Varner, 2003; Plessinger, 1998; Smith et al., 2003; Thadani, 1995; Won, Bubula, McCoy, & Heller, 2001). While research indicates that treatment outcomes for methamphetamine users are similar to those of other drug users (Luchansky, 2003; Otero, Boles, Young, & Dennis, 2006; Rawson et al., 2000), the lack of treatment opportunities leaves many users underserved.

Public safety issues loom large with methamphetamine use. Children of meth users are more likely to suffer abuse, neglect, and exposure to toxins besides methamphetamine (Cohen et al., 2003; Grella, Hser, & Huang, 2006). Child and adult homicides or other acts of violence attributable to methamphetamine are serious concerns in localities with high rates of the drug's use (Bailey & Shaw, 1989; Schermer & Wisner, 1999; Slade, Daniel, & Heisler, 1991; Tominaga et al., 2004; Zhu et al., 2000). Its manufacture and sale also create substantial risk of environmental toxin exposure for multiple parties (Allcott, Barnhart, & Mooney, 1987; Anonymous, 2003).

The political and economic impact of methamphetamine use is another concern. Some industries (e.g., trucking, mining, and mineral extraction) have high rates of methamphetamine use, which contributes to accidents and other losses (as demonstrated in Brazilian research by Silva, Greve, Yonamine, & Leyton, 2003). Forensic studies have shown the lifetime costs of methamphetamine exposure to adults and their children to exceed $1.5 million per user, when examining costs across special education, child-protective services, criminal justice, mental health, healthcare, and other domains (McDaniel & Embry, 2001).

Thus, the prevention of early use of methamphetamine could have many health, public safety, and political benefits (Greenwell & Brecht, 2003). Epidemiological analysis of methamphetamine initiation among adolescents could contribute to the development of prevention efforts. Researchers have published two such studies of youth thus far. Herman-Stahl, Krebs, Kroutil, and Heller (2006) used data from the 2002 National Survey of Drug Use and Health (Substance Abuse and Mental Health Services Administration, 2003) to examine the demographic, psychosocial, and behavioral correlates of illicit stimulant use among adolescents aged 12 through 17. They found mental health treatment utilization correlated with use of marijuana and other illegal drugs as well as nonmedical use of amphetamine. Females reporting low religiosity, binge drinking, and selling drugs were more likely to use methamphetamine than were males or individuals who did not report these attitudes or behaviors.

Springer, Peters, Shegog, White, and Kelder (2007) analyzed methamphetamine use among a nationally representative sample of high school students who completed the *Youth Risk Behavior Survey*. They found the prevalence of ever having used methamphetamine was comparable to that for cocaine, but double the rate for heroin. Males reported slightly higher use than females and the rates were higher among white and Hispanic students than among black students. Those who had used the drug more than four times were significantly more likely to report having engaged in risky sexual behavior. Springer et al. (2007) did not examine the relationship of methamphetamine use to other behaviors or other risk factors.

In the present study, we examined methamphetamine use in a population-based sample of 8th- and 11th-grade adolescents in the State of Oregon. In addition to analyzing the prevalence of use, we examined the relationship between methamphetamine use and a broad range of other problem behaviors, as well as several well-established risk factors for the use of other drugs. Based on extensive evidence of the relationship among diverse adolescent problem behaviors (Biglan et al., 2004), we expected that methamphetamine use would be related to engaging in other problem behaviors.

We also examined social factors one could relate to methamphetamine use, since they would point to malleable influences on use that prevention interventions could target. We selected both family and peer correlates for our analyses based on prior social ecological research on general environmental factors, especially family dynamics, associated with drug use (Dishion, Kavanagh, Schneiger, Nelson, & Kaufman, 2002) and on social developmental research focusing upon a specific array of risk factors related to a variety of problem behaviors (Hawkins et al., 1992; Hawkins, Van Horn, & Arthur, 2004). Specifically, we included peer antisocial behavior, peer drug use, parent attitudes favorable to antisocial behavior and drug use, family conflict, and inadequate parental rule setting, rule enforcement, and monitoring.

2. Methods

2.1. Design

This paper examines the variability of self-reported methamphetamine use by Oregon teenagers using data collected from population-based samples of 8th- and 11th-grade anonymous respondents. This and other information on adolescent wellbeing came from three consecutive years of assessments from the Oregon Healthy Teens survey (2001–2003).

We attempted to survey all of the 8th- and 11th-grade students in selected schools (see below) annually over the three-year period from 2001 to 2003. We assessed the same schools, but different birth cohorts, each year. Approximately four weeks before survey administration, project staff mailed parent notification letters to the students' homes, with instructions to notify the school if they wished their child not to participate. Research staff administered anonymous student questionnaires in classrooms during regular school periods, and students learned their participation was voluntary. Parents of 5% of the students wished their children not to

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Table 1
Sample characteristics: schools—Oregon Health Teen Survey: 2001–2003

Total population											
Overall				8th grade				11th grade			
No.		%		No.		%		No.		%	
211		100		123		58.3		88		41.7	
Community type											
Overall				8th grade				11th grade			
Urban		Rural		Urban		Rural		Urban		Rural	
No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
127	60.2	84	39.8	80	65.0	43	35.0	47	53.4	41	46.6

participate, and an additional 2% of the students chose not to participate. In addition, another 14% of the students listed on class rosters were absent the day of the survey, bringing the student participation rate to 79%. This participation rate did not vary systematically across communities.

2.2. Participants

We used a cluster-sampling frame compatible with existing state and federal surveillance systems to identify a set of Primary Sampling Units (PSUs) consisting of high schools and the middle, junior, or elementary schools feeding into them. For the 11th-grade surveys, school and PSU are equivalent, as the high school defined the PSU. However, in some cases, two or more middle schools fed into a single high school. For this reason, we modeled individual students within schools, not in PSUs, and we chose to analyze the overall dataset as well as to conduct separate analyses for the 8th and 11th grades.

In Table 1, we report the overall number of schools in the sample for 2001–2003. Also included are breakdowns for each grade (8th and 11th) and community type. There were more middle schools than high schools since all feeder schools to a given high school were included. There were also a greater number of urban than rural schools in the sample.

In Table 2, we report the overall number of individual respondents in the sample (each broken down by grade, gender, and if the student was white or nonwhite). As shown, whites, females, and eighth graders made up the greater numbers in our sample than nonwhite, males, and 11th graders.

The effective sample size for this analysis was a subset of the total sample, due to the modular approach taken for survey administration. The survey included a demographics section and six modules; each student received one of the 20 different versions of the survey, with each version including the demographics section and three modules. Research assistants varied module order so that missing values due to failure to reach the end would follow a random pattern. With this construction, about half of the students received any given item. Of those receiving an item, about 1.8 to 3.6% did not answer it. Since the number of students who failed to respond to individual items was very low, we did not attempt any methods to recover the missing data, such as imputation. We analyzed cases with complete data only.

2.3. Measures

Both theoretical and empirical considerations drove our model identification and specification. Theoretically, social ecological models of adolescent problem behaviors (Dishion, 1990; Dishion & Andrews, 1995; Dishion & McMahon, 1997; Dishion, Patterson, & Kavanagh, 1992; Dishion, Patterson, Stoolmiller, & Skinner, 1991), social developmental perspectives focused on risk and protective factors (Arthur, Hawkins, Pollard, Catalano, & Baglioni, 2002; Hawkins et al., 1992; Hawkins et al., 2004), and the functional contextualism approach (Biglan, Duncan, Ary, & Smolkowski, 1995; Biglan, Ary, Smolkowski, Duncan, & Black, 2000; Biglan et al., 2004; Metzler, Biglan, Ary, & Li, 1998) informed this analysis. We used inferential statistics including correlation and confirmatory factor analyses to identify distinct models containing sets of mutually exclusive independent variables that were deemed statistically and theoretically relevant.

2.3.1. Student behavior

The first model focuses on the behaviors and characteristics of the teenager as an individual. The dependent variable is lifetime use of methamphetamine and the independent variables include correlates

Table 2
Sample characteristics: Individual respondents—Oregon Health Teen Survey: 2001–2003

Total population											
Overall				8th Grade				11th Grade			
Count		%		Count		%		Count		%	
5298		100.0		2929		55.3		2369		44.7	
Gender											
Overall				8th Grade				11th Grade			
Male		Female		Male		Female		Male		Female	
Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
2435	47.5	2691	52.5	1326	46.3	1535	53.7	1109	49.0	1156	51.0
Race											
Overall				8th Grade				11th Grade			
White		Nonwhite		White		Nonwhite		White		Nonwhite	
Count	%	Count	%	Count	%	Count	%	Count	%	Count	%
4139	83.2	833	16.8	2240	82.7	468	17.3	1899	83.9	365	16.1

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Table 3
Use of methamphetamine—Oregon Health Teen Survey: 2001–2003

	Prevalence (%)		
Total population	Overall	8th Grade	11th Grade
2001	5.1	3.9	6.7
2002	4.2	3.1	5.6
2003	4.6	3.9	5.5
2001–2003	4.6	3.6	5.9
Males	Overall	8th Grade	11th Grade
2001	4.7	3.6	6.1
2002	4.1	2.8	5.7
2003	4.3	3.7	5.1
2001–2003	4.3	3.3	5.6
Females	Overall	8th Grade	11th Grade
2001	5.3	4.1	6.8
2002	4.3	3.4	5.5
2003	4.8	4.0	6.0
2001–2003	4.8	3.8	6.0

reflecting use of other substances (tobacco, alcohol, and marijuana), adolescent problem behaviors (antisocial activities and, initially, sensation seeking), academics (grades and truancy), and child traits/experiences (depression, suicide). We considered these intra-individual correlates statistically and theoretically distinct from the inter-individual variables we discuss in Model #2 (see below).

Items on drug use included cigarette smoking, alcohol (with a separate item for binge drinking), and marijuana use. Items came from the *Youth Risk Behavior Survey* (Kann et al., 2000), the *Communities That Care* assessment (Arthur et al., 2002), and surveys developed at the Oregon Research Institute in previous studies of tobacco (Biglan et al., 2000) and other substance use (Metzler et al., 1998). The substance use measures included as independent variables in this analysis assess use within the past month. Our dependent variable, use of methamphetamine, is a lifetime rather than 30-day measure.

We based the antisocial behavior measure on multiple items first used by Elliott, Busse, and Gresham (1993). Students answered questions about school suspensions, stealing something worth over $10, stealing a motor vehicle, attacking someone, having the police stop or arrest them, and fighting with a weapon. This measure reflects a self-reported number of these events in the past three months. We based sensation seeking on multiple items also. Students answered questions about how often they had done small dangerous things, how often they had done things because of a dare, and how often they had done things just because it felt good to do them.

After multiple analyses, we decided to replace the sensation-seeking correlate with a measure of risky sexual behavior. We did this for two reasons. There was a high correlation between sensation seeking and a number of other variables in the model. Second, risky sexual behavior was associated with larger odds ratios than sensation seeking was, especially for 11th graders. The risky sexual behavior measure consisted of multiple items: students reported if they had engaged in sex during the past three months, if they had used a condom or other form of birth control, and if they had made someone pregnant or had become pregnant themselves.

Students' self-reported grades consisted of responses to single items asking them to indicate how they would describe their grades in the past 12 months. Choices included “mostly As” through “mostly Fs” plus “none of these” and “not sure.” Students' self-reports of grades have been shown to provide a reasonably valid estimate of objectively measured grades (Crockett, Schulenberg, & Petersen, 1987). Truancy has its basis in a single item: teenagers reported how many times they had skipped school the past four weeks.

Our depression measure had four items from the Center for Epidemiological Studies, Depression (CES-D) scale, shown to predict a depression diagnosis among adolescents (Seeley, Rohde, Lewinsohn, & Clarke, 2002). Teenagers responded if, during the past week, they had a poor appetite, felt depressed, felt sad, or had low energy. The suicide measure consisted of one item: if students had made an actual suicide attempt in the past year.

2.3.2. Parent and peer influences

The second model focuses on the familial and peer environment of the teens. The dependent variable again is use of methamphetamine, and the independent variables include contextual correlates reflecting the teens' families (poor management, high conflict, and favorable attitudes to drug use or to antisocial behavior) and peers (antisocial activities, drug use). We considered these inter-individual correlates statistically and theoretically distinct from the intra-individual variables included in Model #1.

The family domain included six measures: high family conflict, parental attitudes favorable to drug use, parental attitudes favorable to antisocial behavior, and, initially, a measure of poor family management. The high family conflict measure included three items: if the teen's family members frequently insulted each other, had serious arguments, or argued about the same things repeatedly. The *parental attitudes favorable to drug use* measure consisted of two items: if the parent/parents thought it was wrong to drink alcohol or to smoke marijuana. *Parental attitudes favorable to antisocial behavior* included three items: whether their parent(s) thought it was wrong to steal, to draw graffiti, or to pick a fight with someone.

After multiple analyses, we decided the poor family management index was simply too complex to yield useful findings. We split this index into three separate parental measures: unclear rule setting, inconsistent rule enforcement, and poor monitoring. The *unclear parental rule setting* measure consisted of one item regarding the clarity of rules in the teen's family. We measured parental rule enforcement based on student report of the parents' response to breaking a rule using a 7-item scale: (1) noticed but did nothing in response, (2) raised their voice (scolded, yelled), (3) made the teen correct the problem, (4) threatened to punish the teen (but did nothing), (5) spanked the teen, (6) slapped or hit the teen (other than spanking), and/or (7) discussed the problem with the teen and asked questions. The *poor parental monitoring* measure consisted of three items: if parents asked if the teen completed his/her homework, if parents knew if the teen came home late, and/or if parents knew where the teen was when not at home.

The peer domain included two measures: interaction with antisocial peers and friends' use of drugs. The measure assessing interaction with antisocial peers consisted of six items. Students were asked how many of their four best friends during the past year had (1) been suspended, (2) carried a handgun, (3) sold illegal drugs, (4)

Table 4
Problem behaviors by methamphetamine use—Oregon Health Teen Survey: 2001–2003

	Methamphetamine use—prevalence		
Problem behaviors	Yes	No	Significance
Antisocial behavior	28.8%	3.9%	$p<.001$
Risky sex	67.4%	18.6%	$p<.001$
Depression	45.6%	20.9%	$p<.001$
Suicide attempt	25.4%	5.6%	$p<.001$
Tobacco use	62.9%	11.9%	$p<.001$
Alcohol use	80.5%	30.0%	$p<.001$
Binge drinking	60.8%	14.0%	$p<.001$
Marijuana use	70.7%	14.0%	$p<.001$
Interaction with antisocial peers	85.7%	40.1%	$p<.001$
Peers' use of drugs	85.1%	33.8%	$p<.001$
Parents favor antisocial behavior	69.1%	47.4%	$p<.001$
Parents favor drug use	66.9%	36.2%	$p<.001$
High family conflict	56.1%	36.9%	$p<.001$
Rule setting	34.0%	15.2%	$p<.001$
Rule enforcement	59.0%	40.1%	$p<.001$
Parental monitoring	60.7%	33.8%	$p<.001$

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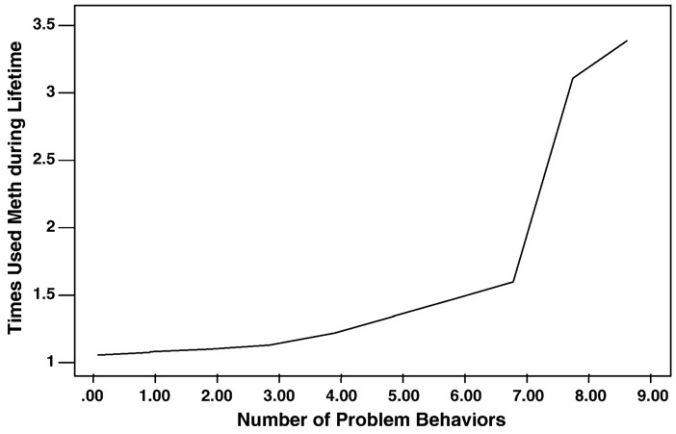

Fig. 1. Rate of methamphetamine use by number of problem behaviors oregon healthy teens survey: 2001–2003.

stolen a car, (5) dropped out of school, or (6) been arrested. The friends' use of drugs measure included four items. Teenagers indicated if, during the past year, their best friend(s) had smoked tobacco, tried alcohol, smoked marijuana, or used LSD.

3. Results

3.1. Prevalence of methamphetamine use

To describe trends in methamphetamine use among Oregon teens during 2001–2003, we report prevalence rates for the overall sample and for grade and gender subsamples. Table 3 shows that prevalence declined very slightly over the three years for both grades and both genders. Note that females have self-reported prevalence rates slightly higher than those for males, something uncommon for many of the other substance use measures we track (though at $p=.088$, gender differences were marginally significant statistically).

3.2. Methamphetamine use in relation to other problem behaviors and risk factors

Table 4 shows prevalence rates for numerous problem behaviors and risk factors categorized by whether or not respondents reported using methamphetamine. As shown, prevalence is often four to five times higher for those who report using methamphetamine than for those reporting no use. Of particular interest is that nearly half (45.1%) of those reporting methamphetamine use also report using other hard drugs (cocaine, heroin, ecstasy, or LSD).

In addition to the relationship of methamphetamine use to specific problem behaviors, we were interested in the association between methamphetamine use and the total number of distinct problem behaviors.

Fig. 1 shows the relationship of methamphetamine use to the total number of other problem behaviors. As shown, the probability of methamphetamine use increases dramatically for young people with six or more other problems.

3.3. Analysis of models

We used two models in an attempt to explain the variance at the individual level in methamphetamine use: one that focuses on behaviors and characteristics of the teenager as an individual and another that focuses on familial and peer influences that may be

Table 5
Logistic regression analysis (Y=Methamphetamine), Model #1

Eighth Grade					Eleventh Grade				
Model fit					Model fit				
Cases	1400				Cases	1213			
AIC	260.508				AIC	422.994			
Chi-square	160.333				Chi-square	124.767			
Significance	0.000				Significance	0.000			
Pseudo R^2	0.108				Pseudo R^2	0.098			
Independent variables	Odds Ratio: Exp (B)	Statistical significance	C.I.		Independent variables	Odds Ratio: Exp (B)	Statistical significance	C.I.	
			Lower	Upper				Lower	Upper
Antisocial behavior	3.62	0.000	1.87	7.02	Antisocial Behavior	1.76	0.074	0.95	3.29
Risky sex	1.45	0.112	0.92	2.29	Risky Sex	2.41	0.000	1.68	3.47
Depression	1.28	0.300	0.80	2.06	Depression	1.36	0.086	0.96	1.93
Suicide	1.35	0.119	0.93	1.96	Suicide	0.70	0.239	0.39	1.27
Smoked, last 30 days	2.11	0.081	0.91	4.90	Smoked, last 30 Days	2.52	0.002	1.39	4.56
Drank alcohol, last 30 days	3.11	0.022	1.18	8.20	Drank alcohol, last 30 days	0.69	0.369	0.31	1.54
Binge drinking, last 30 days	0.58	0.259	0.23	1.49	Binge drinking, last 30 days	1.23	0.584	0.59	2.54
Smoked marijuana last 30 days	3.14	0.012	1.29	7.64	Smoked marijuana last 30 days	2.44	0.007	1.28	4.66
Gender: 0=female, 1=male	1.63	0.231	0.73	3.64	Gender: 0=female, 1=male	1.13	0.663	0.64	2.00
Female *antisocial behavior	7.43	0.001	2.22	14.81	Female * antisocial behavior	5.70	0.017	1.36	13.84
Male *antisocial behavior	2.60	0.024	1.13	5.98	Male * antisocial behavior	1.38	0.387	0.66	2.87
Female * risky sex	1.89	0.061	0.97	3.68	Female * risky sex	3.43	0.000	1.90	6.18
Male * risky sex	1.13	0.733	0.56	2.29	Male * risky sex	2.32	0.000	1.45	3.70
Female * depression	1.35	0.355	0.72	2.53	Female * depression	0.97	0.901	0.60	1.56
Male * depression	1.44	0.285	0.74	2.83	Male * depression	2.20	0.003	1.31	3.72
Female * suicide	1.01	0.974	0.60	1.70	Female * suicide	0.83	0.641	0.39	1.79
Male * suicide	1.86	0.027	1.07	3.23	Male * suicide	0.67	0.344	0.29	1.54
Female * tobacco	2.09	0.218	0.65	6.73	Female * tobacco	2.55	0.034	1.07	6.08
Male * tobacco	2.32	0.200	0.64	8.44	Male * tobacco	2.68	0.022	1.15	6.26
Female * alcohol	1.86	0.344	0.51	6.78	Female * alcohol	0.79	0.634	0.29	2.11
Male * alcohol	7.92	0.010	1.65	17.95	Male * alcohol	0.51	0.341	0.13	2.02
Female * binge drinking	0.70	0.571	0.20	2.43	Female * binge drinking	0.78	0.609	0.30	2.04
Male * binge drinking	0.42	0.238	0.10	1.76	Male * binge drinking	2.27	0.180	0.69	7.52
Female * marijuana	3.39	0.073	0.89	12.84	Female * marijuana	1.27	0.619	0.49	3.27
Male * marijuana	2.75	0.120	0.77	9.85	Male * marijuana	4.86	0.001	1.84	12.84

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manipulable. We began our analysis initially using a multilevel modeling approach to determine if there was significant variation in methamphetamine use between schools. However, we abandoned school-level analysis once multilevel analysis revealed that we could attribute more than 98% of the variance in methamphetamine use to individual-level variation (Smolkowski, Biglan, Dent, & Seeley, 2006) and less than 2% occurred at the school level. For this reason, we determined that a more traditional statistical approach, logistic regression, was appropriate for the individual-level analysis (Cox & Snell, 1989; DeMaris, 1992; Forrester, Biglan, Severson, & Smolkowski, 2007; Hosmer & Lemeshow, 1989; Jaccard, 2001; McKelvey & Zavoina, 1994; Menard, 2002; Pampel, 2000). For this set of analyses, we used the Statistical Package for the Social Sciences, Windows Version 15.0, Release 15.0.0.249 (SPSS, 2006).

3.4. Model 1: Relationship of other problem behaviors to methamphetamine use

Table 5 presents the results of logistic regression analyses relating methamphetamine use to other problem behaviors. Inspection of the results indicates that correlates of methamphetamine use differed according to both gender and grade. We therefore present results separately for each grade using gender as a factor in the analyses.

Model #1 focusing on individual-level problem behaviors and characteristics provided a better fit for the 8th-grade data as opposed to the 11th-grade data. In terms of the main effects, antisocial behavior was an important covariate for methamphetamine use in both grades (though marginally significant in the 11th grade at $p=.074$). Use of alcohol and use of marijuana were also critical correlates in the 8th grade, with marijuana significant for 11th graders as well. Variables that were significant for 11th graders, but not for eighth graders, included risky sex and use of tobacco, two behaviors considerably more prevalent among older students. Alcohol use, which had been an important correlate for eighth graders, was not a significant covariate for 11th graders.

Also shown in Table 5 are effects for each gender, based on analysis of the interaction between gender and each variable in predicting methamphetamine use. Interaction effects for the most part exhibited similar patterns as the main effects for eighth graders, with both females and males more likely to use methamphetamine if they also engaged in antisocial behavior (though this relationship was much stronger for females). Alcohol use was a significant covariate for methamphetamine use for males, but not for females. Suicide attempts showed a significant correlation to meth use for males, but not for females.

Interaction effects for 11th graders differed somewhat from the pattern for eighth graders, with both genders more likely to use methamphetamine if they engaged in risky sexual behaviors or used tobacco. Although antisocial behavior had been a major correlate of methamphetamine use for 8th-grade females and males, it remained a key covariate only for females in the 11th grade. In addition, although suicide attempts and alcohol were important covariates for 8th-grade males, depression and marijuana use were significant for 11th-grade males.

3.5. Model 2: Relationship of social risk factors to methamphetamine use

Table 6 presents results for relationships between methamphetamine use and peer and parent variables. Here too, we present results separately for each grade with gender as a factor in the analyses.

Model #2′s collection of contextual or environmental variables provided a better fit for the data than did Model #1, with Model #2′s fit for 8th graders better than for 11th graders. In terms of the main effects across genders, peers' antisocial behavior and drug use were

Table 6
Logistic regression analysis (Y=Methamphetamine), Model #2

Eighth Grade					Eleventh Grade				
Model fit					Model fit				
Cases	1462				Cases	1051			
AIC	209.890				AIC	338.392			
Chi-square	214.123				Chi-square	81.565			
Significance	0.000				Significance	0.000			
Pseudo R^2	0.136				Pseudo R^2	0.075			
Independent variables	Odds Ratio: Exp (B)	Statistical Significance	C.I.		Independent variables	Odds Ratio: Exp (B)	Statistical Significance	C.I.	
			Lower	Upper				Lower	Upper
Interaction with antisocial peers	1.91	0.004	1.23	2.96	Interaction with antisocial peers	1.65	0.048	1.00	2.70
Peers use of drugs	2.47	0.000	1.74	3.51	Peers use of drugs	2.15	0.000	1.48	3.13
Parents favor antisocial behavior	1.39	0.237	0.80	2.41	Parents favor antisocial behavior	0.79	0.548	0.37	1.69
Parents favor drug use	1.92	0.005	1.22	3.02	Parents favor drug use	1.40	0.155	0.88	2.24
High family conflict	1.12	0.608	0.73	1.71	High family conflict	0.84	0.429	0.55	1.29
Rule setting	1.06	0.778	0.70	1.60	Rule setting	1.51	0.070	0.97	2.35
Rule enforcement	1.18	0.606	0.63	2.20	Rule enforcement	0.60	0.133	0.31	1.17
Parental monitoring	1.20	0.499	0.71	2.05	Parental monitoring	1.75	0.054	0.99	3.10
Gender (0=female, 1=male)	1.38	0.365	0.69	2.78	Gender (0=female, 1=male)	2.08	0.029	1.08	4.03
♀* interact w/ antisocial peers	2.77	0.005	1.36	5.65	♀* interact w/ antisocial peers	1.74	0.106	0.89	3.39
♂* interact w/ antisocial peers	1.63	0.126	0.87	3.03	♂* interact with antisocial peers	1.53	0.261	0.73	3.20
♀*peers use of drugs	2.43	0.000	1.52	3.90	♀* peers use of drugs	1.71	0.026	1.07	2.75
♂* peers use of drugs	2.45	0.001	1.42	4.24	♂* peers use of drugs	3.17	0.000	1.71	5.86
♀*parents favor antisocial beh.	2.18	0.056	0.98	4.84	♀* parents favor antisocial beh.	1.52	0.401	0.57	4.06
♂*parents favor antisocial beh.	0.96	0.928	0.44	2.11	♂*parents favor antisocial beh.	0.35	0.090	0.10	1.18
♀* parents favor drug use	1.63	0.120	0.88	3.01	♀* parents favor drug use	1.23	0.514	0.66	2.30
♂ parents favor drug use	3.29	0.002	1.57	6.89	♂ parents favor drug use	1.61	0.218	0.76	3.42
Female * parents favor drug use	0.84	0.574	0.45	1.55	Female * parents favor drug use	0.92	0.764	0.53	1.60
Male * parents favor drug use	1.38	0.310	0.74	2.55	Male * parents favor drug use	0.83	0.593	0.41	1.66
Female * rule setting	0.97	0.909	0.53	1.75	Female * rule setting	1.75	0.071	0.95	3.21
Male * rule setting	1.40	0.296	0.75	2.61	Male * rule setting	1.32	0.423	0.67	2.60
Female * rule enforcement	2.17	0.051	1.00	4.72	Female * rule enforcement	0.62	0.261	0.27	1.42
Male * rule enforcement	0.48	0.131	0.19	1.25	Male * rule enforcement	0.40	0.133	0.12	1.32
Female * parental monitoring	0.71	0.425	0.31	1.64	Female * parental monitoring	1.36	0.415	0.65	2.83
Male * parental monitoring	1.86	0.096	0.89	3.87	Male * parental monitoring	2.66	0.043	1.03	6.86

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significant correlates of methamphetamine use for both grades. Having parents with favorable attitudes toward drug use was important for eighth graders, while parental monitoring was modestly associated with use for 11th graders.

Though gender was not a significant direct factor for eighth graders, there were gender differences in some of the relationships between methamphetamine use and these social influences. Females who had friends who engaged in antisocial behavior were more likely to use meth, but that was not true for males. Males who had parents with favorable attitudes toward drugs had higher rates of methamphetamine use, but this was not true for females. One measure without a significant main effect did have an important gender-based interaction effect for eighth graders: females were more likely to use methamphetamine if their parents did not enforce family rules or if enforcement was inconsistent, but that was not true for males.

For 11th graders, gender had a significant main effect with females nearly twice as likely as males to use methamphetamine. Peers' use of drugs was a better predictor of methamphetamine use among males (OR=3.17, $p<.001$) than among females (OR=1.71, $p=.026$). Parental monitoring had a significant relationship to male, but not to female, use of meth.

4. Discussion

We are aware of only a handful of published studies of adolescent methamphetamine use. Regarding the prevalence of methamphetamine use, only one study has reported on the prevalence of adolescent use in a population-based sample. Springer et al. (2007) used nationwide data from the 2003 Youth Risk Behavior Survey, which assesses 9th- through 12th-grade students anonymously (Centers for Disease Control and Prevention, 2004). They reported national rates of lifetime use of methamphetamine of 8.3% for boys and 6.8% for girls (overall, national prevalence in 2003 was 7.6%, a decline from 9.8% in 2001). Using the OHT survey for 2001–2003, our rates for 11th grade were 5.6% for boys and 6.0% for girls.

The finding of higher use among girls is consistent with other research reporting gender differences in methamphetamine use. In a review of publications on methamphetamine over the past 30 years, Dluzen and Liu (2008) found that women tend to begin methamphetamine use at earlier ages, appear more dependent on it, but also respond better to treatment than do men. Methamphetamine use appears to be associated with depression in women, and women seem more committed to the drug, whereas men are more likely to use other drugs in the absence of access to methamphetamine. There is also evidence that methamphetamine use on the part of females is due in part to the desire to lose weight. In a study focusing on gender differences in drug use history among a broad cross-section ($N=350$) of former clients from a large publicly funded treatment system, Brecht et al. (2004) found that five times the percentage of females than males attributed initial methamphetamine use to a desire to lose weight (36% vs. 7%).

Lack of significant diversity in Oregon (and therefore our sample) prevents any broad generalizations regarding racial/ethnic variation in the prevalence of methamphetamine use.

There are distinct limitations to what one can infer from concurrent relationships. However, the analyses show that, as expected, methamphetamine use relates to other problem behaviors. Perhaps the strongest evidence comes from the fact that not a single adolescent reported methamphetamine use and no other problem. The amount of use rises significantly as the number of adolescents' other problem behaviors increase.

The specific problems related to methamphetamine use differed according to grade and were moderated by gender. Consistent correlates of methamphetamine use included antisocial behavior and substance use (both self-reported behavior and use and peer-reported behavior and use), although there were distinct gender differences. Though antisocial behavior was important for each gender, females in both grades were much more likely than males to use methamphetamine if they also engaged in these types of activities. Having friends who engaged in deviant behaviors was a significant influence, but was not as important as engaging in these behaviors themselves. Females in the 8th grade were more likely to use methamphetamine if they also reported using marijuana. For males, antisocial behavior of their own (or on the part of friends) was an important correlate of methamphetamine use in both grades. However, it was their substance use (or that of their friends) that had a more important influence, with self-reported alcohol use especially playing a role for 8th-grade males and self-reported marijuana use for 11th-grade males. (Peers' use of drugs was a significant covariate for males in both grades.)

Risky sex was associated with methamphetamine use for females in the 8th grade and for both females and males in the 11th grade. Springer et al. (2007) also found a relationship between risky sexual behavior and methamphetamine use. Depression was a correlate of use for 11th-grade males, but not for other subgroups. Sussman, Dent, and Stacy (1999) found a strong relationship between methamphetamine use and alcohol use, depression, and having friends who use drugs, which is consistent with our findings regarding the importance of alcohol for 8th-grade males and depression for 11th-grade males. Herman-Stahl et al. (2006) also found that alcohol use, especially binge drinking, was an important correlate. This was contrary to our findings where alcohol was a significant correlate for 8th graders in general and 8th-grade males in particular, but not for 11th graders of either gender. Binge drinking seemed to play no important role for either grade or either gender.

The results are generally consistent with the oft-reported finding that adolescent problem behaviors are inter-related (Biglan et al., 2004; Boles, Biglan, & Smolkowski, 2006). They suggest that we may prevent some methamphetamine use if we prevent antisocial behavior, depression, and risky sexual behavior. However, more specifically, the diversity of correlates across subgroups points to the value of preventing the entire range of problems experienced by youth. That, in turn, requires that we focus on how we can change adolescents' environments.

In terms of environmental correlates, it was not surprising to find that adolescents are more likely to use methamphetamine if their peers engage in antisocial behavior or use drugs. As mentioned above, 8th-grade females in particular were more likely to use methamphetamine if they had antisocial or drug-using peers. Based on other studies (Biglan, 1996; Hankins & Biglan, submitted for publication), we suspect these early adolescent females are involved with older antisocial males. Preventing such associations may be particularly valuable for preventing other problems.

Parental influences did not have especially strong relationships to self-reported methamphetamine use. There was a significant overall relationship between parents' favorable attitudes toward drug use and methamphetamine use for eighth graders, especially for males. We could relate poor family rule setting and parental monitoring to methamphetamine use among 11th graders, with poor rule setting a correlate for females and inadequate parental monitoring a correlate for males. These findings may indicate that parents cannot have much influence on methamphetamine use. However, the evidence that parental monitoring and limit setting affect multiple problems of adolescents is so overwhelming (e.g., Biglan et al., 2004; Dishion et al., 2002) that this conclusion is hardly credible. Since we can correlate the use of methamphetamine with many problems that parental monitoring and setting limits do prevent, it seems premature to conclude that these parental practices will not reduce methamphetamine use.

In conclusion, this study shows that adolescent methamphetamine use is related to other problem behaviors, but that the specific problems to which it is related vary by grade and are moderated by gender. The results suggest that efforts to prevent antisocial behavior, risky sex, and depression may be of particular value. However, more

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generally, since methamphetamine use co-occurs with a host of other problems and in the context of peer drug use, any efforts to prevent youth problems will probably be productive. We cannot account for the relatively moderate relationships between parenting practices and methamphetamine use, but given the benefits of parenting interventions for other problems (related to methamphetamine use), we should still encourage efforts to promote better monitoring and limit setting.

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