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Injection drug use is associated with suicide attempts but not ideation or plans in a sample of adolescents with depressive symptoms

Richard T. Liu [a,c,*], Brady G. Case [b,c,d], Anthony Spirito [a,c]

[a] Adolescent Mood and Behavior Program, Emma Pendleton Bradley Hospital, United States
[b] Health Services Research Program, Emma Pendleton Bradley Hospital, United States
[c] Department of Psychiatry and Human Behavior, Alpert Medical School of Brown University, United States
[d] Department of Health Services, Policy, and Practice, Public Health Program of Brown University, United States

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ABSTRACT

Objective: Based on the interpersonal theory of suicide, pain habituation that occurs with injection substance use may raise risk for a suicide attempt. The current study tested whether injection substance use, relative to painless routes of substance administration, was related to greater risk for suicide attempts. We also assessed whether this risk was specific to suicide attempts and not suicidal ideation or suicide plans.

Methods: Data on 2095 substance-using adolescents aged 12–17 who endorsed clinically significant depression symptoms and answered questions on suicidal thoughts and behavior were drawn from the 2004–2011 National Survey on Drug Use and Health, a nationally representative household survey. Logistic regression analyses were conducted to assess the associations between injection substance use and suicidal ideation, plans, and attempts.

Results: Injection substance use was associated with suicide attempts (OR = 3.02, 95% CI = 1.75–5.23) but not ideation or plans. These findings were not accounted for by sex, age, race/ethnicity, family income, abuse and dependence symptoms, and depression symptoms. Among ideators, injection substance use was associated with suicide attempts (OR = 2.92, 95% CI = 1.58–5.06), but not plans. Among suicide planners, injection substance use was associated with suicide attempts (OR = 5.16, 95% CI = 1.88–14.17).

Conclusion: Consistent with the interpersonal theory of suicide, adolescent injection drug use was associated with specific risk for suicide attempts but not ideation or planning. Hence, consideration of the manner in which adolescents use substances is important in evaluating suicide risk in this population.

1. Introduction

Suicide is the third leading cause of death among US adolescents, and there is some evidence that suicide rates in children and adolescents have increased in recent years (Spirito and Esposito-Smythers, 2006; Dervic et al., 2008). Several risk factors for suicidal thoughts and behaviors have been found in prior epidemiological studies, among the most consistently identified of which is substance use (Goldston, 2004; Nock et al., 2013; Spirito and Esposito-Smythers, 2006; also see Pompili et al., 2012 for a recent review). Indeed, in one recent cross-sectional epidemiological study, adolescent suicidal thoughts and behavior were strongly associated with substance abuse and dependence (Nock et al., 2013). Support for this association in adolescents has also been reported in several longitudinal studies (Goldston et al., 2009; Goldstein et al., 2012; Rasic et al., 2013), and this relation has been observed to strengthen during the transition from late adolescence to early adulthood (Goldston et al., 2009). Indeed, the pronounced increase in adolescent suicide observed from 1960 to the 1980s has been attributed by some to the corresponding increase in substance use in this age group over this same time period (Institute of Medicine, 2002).

Prior studies have found several general suicide risk factors to be over-represented in substance-using adolescents, which may in part explain the association between substance use and suicidality. For example, maternal neglect (Icick et al., 2013) and childhood physical abuse (Darke and Torok, 2013) have been implicated in risk

* Corresponding author. Bradley Hospital, 1011 Veterans Memorial Parkway, East Providence, RI 02915, United States.
E-mail address: richard_liu@brown.edu (R.T. Liu).

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for suicide attempts in adolescent substance users. Anxiety, depression, and hopelessness have been observed to mediate the relation between substance use and suicidal thoughts and behavior in adolescents (Thompson et al., 2005). It has also been suggested that trait impulsivity, may also account for the shared prevalence between substance use and suicidal behavior (Javdani et al., 2011). In contrast, state impulsivity, and the potential indirect influence of other suicide risk factors, may be heightened by substance use (Mann, 2003; Erinoff et al., 2004; Goldston, 2004).

Although it is important to consider the above described factors in assessing suicide risk in adolescent substance users, they are general indices of risk for suicidal behavior in non-substance users (Evans et al., 2004; Spirito and Esposito-Smythers, 2006; Brent et al., 2009), and not uniquely characteristic of substance-using adolescents (Erinoff et al., 2004). That is, it is currently unclear whether there are specific aspects of substance-use behavior that inherently place certain adolescents who engage in this behavior at greater risk for suicide. Addressing this issue, some prior studies have found evidence that several indicators of substance use severity (e.g., frequency of use, degree of related impairment, use of "harder" drugs), are positively associated with adolescent suicidal behavior (Garrison et al., 1993; Goldston, 2004; Wong et al., 2013).

In addition to recognition of suicide risk associated with these aspects of adolescent substance use, however, there is a need for more nuanced research determining specific *qualitative* differences among substance users relevant to this risk. Given that only a portion of substance users engage in suicidal behavior, such work may be particularly clinically informative to the degree that it leads to better differentiation of those at low and high risk for suicidal behavior. Furthermore, although suicidal ideation and suicide plans are important public health concerns in their own right, studies are needed to uncover markers of risk specific to suicide attempts rather than suicidality in general. Research directly addressing this issue has yet to be conducted, but has the potential to inform our theoretical understanding of suicidal behavior, and is essential for advancing our ability to identify those individuals in greatest need of clinical prevention services (Klonsky and May 2014).

One theoretical model that may prove to be informative within this context is the interpersonal theory of suicide (Joiner, 2005; Van Orden et al., 2010). According to this theory, not all individuals with suicidal ideation act on these thoughts. Rather, only those who develop a reduced fear of death and an increased tolerance for physical pain (i.e., an acquired capability for suicide) transition from suicidal ideation to making a suicide attempt. In particular, those who experience painful and fear-provoking events (e.g., past suicide attempts) are at greater risk for attempting suicide because these experiences habituate them to the pain and fear normally associated with suicide. This theory also posits that suicidal desire and the acquired capability for suicide are relatively distinct constructs. In support of this theory, the acquired capability for suicide has been found to be associated with painful and fear-provoking experiences (Van Orden et al., 2008; Bender et al., 2011), and correlated with number of past suicide attempts (Van Orden et al., 2008). These studies also found the acquired capability for suicide to have a weak to no association with suicidal ideation. It should be noted, however, that the studies to date assessing these aspects of the interpersonal theory of suicide have primarily featured adult samples, and thus it is less clear to what degree painful and fear-provoking experiences can yield sufficient pain habituation to increase risk for suicidal behavior earlier in life, such as adolescence.

According to the interpersonal theory of suicide, intravenous substance use, relative to other methods of substance administration (e.g., orally or inhaling), may be more strongly associated with suicide attempts because of the physical pain inherent in this method of administration. With adults, injection substance use has been linked to suicidal ideation in one study (Dinwiddie, 1997), but not another (Havens et al., 2006). Substance use by injection has also been related to suicide plans (Dinwiddie, 1997), attempts (Dinwiddie, 1997; Hakansson et al., 2010; Kelly et al., 1998; but also see Dinwiddie et al., 1992 for an exception), and deaths in adults (Keiser et al., 2010). The one study that has examined injection substance use in relation to suicidal ideation and behavior in adolescents found substance use by injection to be positively associated with suicidal ideation, suicide plans, and attempts (Epstein and Spirito, 2010). Although these studies are important, a common limitation across the studies is that they do not separate "pure" ideators from those with suicide plans or attempts. Similarly, prior studies evaluating suicide plans dichotomously did not separate out those who had acted on their plans. Given that a quite substantial proportion of suicide attempts are preceded by suicidal ideation or plans (Nock et al., 2013), this is an important limitation, as any observed relation between injection substance use and ideation and plans may in some measure be an artifact of the relation between injection substance use and suicide attempts.

The current study is the first to examine whether substance administration by injection was differentially associated with adolescent suicide attempts relative to suicidal ideation and plans in the National Survey of Drug Use and Health (NSDUH), a nationally representative sample of US adolescents. Based on the interpersonal theory of suicide, we hypothesized that injection substance use, relative to other means of substance use, would be specifically related to attempted suicide, but not be associated with suicidal ideation or suicide plans in adolescents with a history of depression symptoms.

2. Method

2.1. Data source and sampling

Data were drawn from the NSDUH for the years 2004–2011. It is conducted annually on behalf of the Substance Abuse and Mental Health Services Administration (SAMHSA) to provide national estimates of substance use and disorders. The NSDUH utilizes a multistage area probability sampling design to arrive at a representative sample of the US population aged 12 years and older for all 50 states and the District of Columbia. Participants include individuals living in households, shelters, half-way houses, group homes, rooming or boarding houses, college dormitories, and military bases. Young participants, African-Americans, and Hispanics were intentionally oversampled to increase the precision of estimates for these groups. The sample for the current study was restricted to adolescents aged 12–17 who endorsed lifetime use of any injectable substance (i.e., cocaine, heroin, and stimulants) and clinically significant depression symptoms (unweighted $n = 2095$; weighted annual $n = 343{,}154$). For injectable stimulants, participants were asked specifically about methamphetamine, Desoxyn, and Methedrine. The current sample was restricted to adolescents with depression symptoms because items for suicidal ideation and behavior were only administered to those who screened positive for a history of depression symptoms.

2.2. Procedures

Interviewers administered survey items using computer-assisted personal interviewing (CAPI) and audio computer-assisted self-interviewing (ACASI). These procedures provide participants with a private means of responding to questions regarding potentially sensitive or illegal behaviors (e.g., suicide and substance

use), and have been found to increase openness in reporting of these behaviors, particularly in adolescents (Turner et al., 1998).

2.3. Study variables

Depression symptoms and suicidal ideation and behaviors were assessed using items adapted from the depression section of the National Comorbidity Survey-Replication (NCS-R; Kessler and Üstün, 2004) and the National Comorbidity Survey Replication Adolescent Supplement (NCS-A; Kessler et al., 2009; Merikangas et al., 2009). Adolescents were identified as meeting criteria for clinically significant symptoms of depression if they endorsed having had depressed mood or anhedonia almost every day for a period of at least two weeks during their lifetime. Those with depression symptoms were presented with additional questions regarding the presence of the remaining DSM-IV (American Psychiatric Association, 2000) depression symptoms, including suicidal ideation, suicide plans, and attempts, during their endorsed period of depressed mood or anhedonia.

Lifetime substance use and DSM-IV (American Psychiatric Association, 2000) symptoms of abuse and dependence for the past 12 months were assessed during the interview. Participants who endorsed having used cocaine, heroin, or stimulants within their lifetime were presented with an additional item regarding whether they had ever used a needle to inject the substance in question. They were also asked to report any other drugs that they have injected at least once. Participants were included in the current study if they endorsed using a substance that could be administered via injection (i.e., cocaine, heroin, and stimulants), irrespective of whether they had ever injected them. Restricting the study sample to users of injectable substances allowed for direct comparison of injection and non-injection substance users unconfounded by other aspects of the substances used (e.g., the possibility that injection substance users used "harder" substances than non-injection users).

2.4. Data analysis

A series of independent samples *t*-tests and χ^2 tests were conducted to assess differences between injection and non-injection substance users on sociodemographic and study variables. We conducted a series of multivariate logistic regression analyses with all study participants to assess the associations between injection substance use and suicidal ideation, plans, and attempts among substance-using adolescents. Models included gender, race/ethnicity, age, family income (*<$20,000, $20,000 to $50,000, $50,000 to $75,000, >$75,000*), substance use disorder symptom counts for injectable substances (i.e., cocaine, heroin, and stimulants), and depression symptom counts as covariates. We then conducted similar analyses in subsamples of study participants to assess injection substance use in differentiating mild to more severe forms of suicidality. Specifically, in the subsample of adolescents with suicidal ideation, we assessed the associations between injection substance use and suicide plans and attempts. In the subsample of adolescents with suicide plans, we assessed the association between injection substance use and suicide attempts. Two-tailed tests with α at 0.05 were used in all analyses. Analyses were conducted with SPSS 22.0 (IBM, Chicago, IL) using procedures to accommodate the complex sampling frame of the survey.

Sensitivity analyses were conducted with the sample restricted to adolescent injectable substance users meeting full criteria for major depressive disorder, with age of first depressive onset included as an additional covariate in all models. As the results for injection substance use remained essentially unchanged, we presented only findings for the full sample, as this allowed for greater generalizability.

3. Results

3.1. Sample characteristics

Of the entire study sample, 75.4% were female, the average age was 15.70 (SE = 0.04), and 6.8% endorsed a lifetime history of substance use by injection. In terms of racial/ethnic composition, 70.7% were non-Hispanic white, 19.0% were Hispanic, 4.6% were non-Hispanic black, 3.0% self-identified as multiracial, 2.1% were Asian, Hawaiian, or Pacific Islander, and 0.6% were Native American. Among participants, 81.6% endorsed a history of suicidal ideation, 39.9% had a history of suicide plans, and 37.0% had made a suicide attempt. Among adolescents with suicidal ideation, 49.0% made a suicide plan and 45.4% made a suicide attempt. Of those with a suicide plan, 81.7% also made an attempt.

3.2. Bivariate contrasts between injection and non-injection substance users

Compared with non-injection substance users, injection users were found to have a greater number of abuse and dependence symptoms for cocaine, heroin, and stimulants (Table 1). A greater proportion of injection substance users had made a suicide plan and suicide attempt. In fact, more than half (61.8%) had attempted suicide. No differences were observed between injection and non-injection substance users in terms of gender, age, racial/ethnic

Table 1
Demographic and clinical characteristics of the total study sample (n = 2095).

Characteristic	Injection substance users		Non-injection substance users		t/χ^2
	Mean (SE)	%	Mean (SE)	%	
Gender					1.07
Female		70.6		75.8	
Male		29.4		24.2	
Age (years)	15.56 (0.16)		15.71 (0.04)		−0.88
Race/Ethnicity					2.06
Non-Hispanic White		76.4		70.3	
Non-Hispanic Black		0.4		4.9	
Hispanic		18.3		19.1	
Asian, Hawaiian/Pacific Islander		0.1		2.2	
Native American		0.7		0.6	
Multiracial		4.1		3.0	
Family income					0.18
<$20,000		13.6		15.9	
$20,000–$50,000		36.3		33.9	
$50,000–$75,000		18.9		17.5	
>$75,000		31.2		32.6	
Cocaine abuse and dependence symptoms	1.34 (0.28)		0.39 (0.05)		3.42***
Heroin abuse and dependence symptoms	0.96 (0.24)		0.02 (0.01)		3.96***
Stimulant abuse and dependence symptoms	0.96 (0.24)		0.51 (0.05)		2.69**
Depression symptoms[a]	7.00 (0.016)		6.70 (0.04)		1.83
Suicidal ideation		89.1		81.0	2.68
Suicide plan		53.0		38.9	6.68*
Suicide attempt		61.8		35.2	18.92***

Note. SE = Standard Error.
*$p < .05$, **$p < .01$, ***$p < .001$, CI = confidence interval.
[a] Suicidal ideation and behavior were excluded from the depression symptom count.

composition, family income, depression symptom severity, and suicidal ideation.

3.3. Adjusted associations of injection use with suicidal ideation, suicide plans, and attempts

Among adolescents with a lifetime history of injectable substance use, those who had injected these substances were more likely to attempt suicide than adolescents who had never injected substances, but did not differ in terms of suicidal ideation and suicide plans (Table 2). More specifically, the adjusted odds of suicide attempts in injection substance users were three times that of non-injection substance users. These results held after accounting for the effects of gender, race/ethnicity, age, family income, substance use disorder symptom severity, and concurrent depression symptom severity.

A consistent pattern of findings emerged when assessing injection substance use as being differentially associated with suicide plans versus attempts among suicidal ideators, and of suicide attempters versus non-attempters among those with suicide plans. Specifically, the odds of suicide attempt was approximately three times as high among adolescent suicidal ideators with a lifetime history of using substances by injection as among those who used the same substances through different methods (e.g., orally, inhaling). Injection and non-injection substance users who were also suicidal ideators did not differ, however, in likelihood of progressing from ideation to suicide plans. Among adolescents with suicidal plans and a lifetime history of injectable substance use, the odds of carrying out suicide plans among injection substance users was five times that of non-injection substance users, after adjusting for gender, race/ethnicity, age, family income, substance use disorder symptom severity, and concurrent depression symptoms. These findings are presented in Table 3.

Finally, we examined the importance of separating out more severe forms of suicidality when assessing more mild forms as criterion variables. When suicide plans and attempts were not excluded from the multivariate analysis with suicidal ideation as the outcome variable, a trend towards significance emerged for the relation between injection substance use and ideation (OR = 2.07, 95% CI = 0.92–4.69). Likewise, when suicide attempters were retained in the multivariate analysis with suicide plans as the criterion variable, injection substance use trended towards significance (OR = 1.46, 95% CI = 0.93–2.29).

4. Discussion

Accurately predicting risk for suicide attempts has proven to be an enduring challenge, even in populations generally perceived as being at high risk for this behavior, such as adolescent substance users. Although suicidal ideation and suicide plans are themselves significant public health concerns, the identification of risk factors that differentiate risk for suicide attempts from risk for these forms of suicidality is important for identifying those at greatest need for clinical intervention. To address this issue, the current study provided a nuanced analysis of injection substance use as a risk factor specific to suicide attempts. Consistent with our hypotheses based on the interpersonal theory of suicide, we found injection substance use to be associated specifically with risk for suicide attempts, but not suicidal ideation or suicide plans in a nationally representative sample of substance using adolescents with a history of depression symptoms. As hypothesized, we also found an association between injection substance use and the progression from suicidal ideation to suicide attempts, but not ideation to suicide plans. Injection substance use was likewise related to the risk of acting on suicide plans with suicide attempts. Finally, it is important be note that injection substance use was consistently the

Table 2
Multivariate associations of injection substance use with suicidal ideation ($n = 1084$), suicide plans ($n = 1291$), and attempts ($n = 2095$) among substance-using adolescents with a history of depressive symptoms.

Variable	Suicidal ideation[b]	Suicide plan[c]	Suicide attempt
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Injection substance use	1.50 (0.59–3.82)	0.42 (0.14–1.27)	3.01 (1.74–5.20)***
Cocaine abuse and dependence symptoms	1.21 (1.06–1.39)**	1.10 (0.99–1.23)	0.98 (0.90–1.07)
Heroin abuse and dependence symptoms	0.82 (0.61–1.10)	0.88 (0.62–1.23)	0.95 (0.80–1.12)
Stimulant abuse and dependence symptoms	0.92 (0.81–1.05)	1.07 (0.92–1.23)	1.04 (0.97–1.11)
Depression symptoms[a]	1.34 (1.17–1.53)***	1.56 (1.29–1.90)***	1.47 (1.33–1.63)***
Age	0.84 (0.71–0.98)*	1.03 (0.86–1.24)	0.92 (0.83–1.03)
Gender			
Female	1.17 (0.83–1.65)	1.04 (0.66–1.66)	1.42 (1.02–1.97)*
Male (reference)	1.00	1.00	1.00
Race/Ethnicity			
Non-Hispanic Black	1.87 (0.84–4.15)	0.70 (0.21–2.34)	0.44 (0.22–0.90)*
Native American	1.20 (0.31–4.7)	3.81 (0.85–17.18)	0.53 (0.21–1.29)
Asian, Hawaiian and Pacific Islander	1.59 (0.45–5.58)	1.02 (0.22–4.65)	2.60 (0.97–6.98)
Multiracial	1.29 (0.52–3.17)	0.61 (0.29–1.25)	1.07 (0.64–1.79)
Hispanic	1.04 (0.63–1.73)	0.81 (0.43–1.51)	0.92 (0.67–1.26)
Non-Hispanic White (reference)	1.00	1.00	1.00
Family income			
<$20,000	0.74 (0.44–1.25)	0.67 (0.33–1.36)	1.78 (1.23–2.58)**
$20,000–$50,000	0.80 (0.51–1.26)	1.20 (0.70–2.06)	1.27 (0.97–1.67)
$50,000–$75,000	0.86 (0.53–1.39)	0.79 (0.38–1.66)	1.45 (1.01–2.07)*
>$75,000 (reference)	1.00	1.00	1.00

Note. Each column represents a separate multivariate logistic regression model. Total sample ($n = 2095$). All n values are unweighted.
*$p < .05$, **$p < .01$, ***$p < .001$, CI = confidence interval.
[a] Suicidal ideation and behavior were excluded from the depression symptom count so as to avoid confounding the latter with the dependent variables.
[b] Excluding adolescents with suicide plans or attempts.
[c] Excluding adolescents with suicide attempts.

Table 3
Multivariate associations of injection substance use with suicide plans and attempts among substance-using adolescents with suicidal ideation and suicide plans.

Variable	Among adolescents with Suicidal ideation ($n = 1731$)		Among adolescents with suicide plans ($n = 869$)
	Suicide plan[b]	Suicide attempt	Suicide attempt
	Odds ratio (95% CI)	Odds ratio (95% CI)	Odds ratio (95% CI)
Injection substance use	0.43 (0.16–1.16)	2.89 (1.68–4.98)***	5.18 (1.90–14.12)**
Cocaine abuse and dependence symptoms	1.07 (0.95–1.20)	0.95 (0.88–1.04)	0.92 (0.82–1.03)
Heroin abuse and dependence symptoms	0.91 (0.65–1.26)	0.97 (0.83–1.15)	1.05 (0.71–1.55)
Stimulant abuse and dependence symptoms	1.09 (0.94–1.26)	1.06 (0.98–1.14)	1.01 (0.88–1.16)
Depression symptoms[a]	1.40 (1.15–1.70)***	1.31 (1.16–1.47)***	1.00 (0.84–1.20)
Age	1.08 (0.89–1.31)	0.96 (0.86–1.08)	0.87 (0.70–1.08)
Gender			
Female	0.99 (0.62–1.58)	1.37 (0.97–1.93)	1.29 (0.79–2.11)
Male (reference)	1.00	1.00	1.00
Race/Ethnicity			
Non-Hispanic Black	0.59 (0.17–2.07)	0.39 (0.19–0.82)*	0.40 (0.12–1.34)
Native American	3.68 (0.77–17.52)	0.48 (0.17–1.37)	0.19 (0.03–1.13)
Asian, Hawaiian and Pacific Islander	0.92 (0.19–4.52)	2.42 (0.82–7.15)	1.55 (0.29–8.20)
Multiracial	0.56 (0.24–1.30)	0.97 (0.54–1.73)	1.33 (0.65–2.71)
Hispanic	0.83 (0.45–1.55)	0.93 (0.65–1.32)	0.95 (0.49–1.85)
Non-Hispanic White (reference)	1.00	1.00	1.00
Family income			
<$20,000	0.76 (0.37–1.54)	1.95 (1.34–2.85)***	2.54 (1.28–5.05)**
$20,000–$50,000	1.25 (0.71–2.18)	1.31 (0.96–1.78)	1.28 (0.77–2.13)
$50,000–$75,000	0.83 (0.39–1.77)	1.50 (1.03–2.17)*	2.01 (1.00–4.04)*
>$75,000 (reference)	1.00	1.00	1.00

Note. Each column represents a separate multivariate logistic regression model. All *n* values are unweighted.
*$p < .05$, **$p < .01$, ***$p < .001$, CI = confidence interval.
[a] Suicidal ideation and behavior were excluded from the depression symptom count so as to avoid confounding the latter with the dependent variables.
[b] Excluding adolescents with suicide attempts.

most strongly associated variable with suicide attempts in all of our analytical models of this behavior, and exceeded the effects of depression and substance use severity.

Injection substance use was positively associated with the severity of substance use disorder symptoms for all injectable substance types (cocaine, heroin, and stimulants), with effect sizes falling in the small-medium to medium range. Although there is evidence in prior research of an association between substance use severity and adolescent suicidal behavior (Garrison et al., 1993; Goldston, 2004), this was unlikely to be an explanatory confound for the relation between injection substance use and suicide attempts for several reasons. First, the relation between injection substance use and suicide attempts was significant after including substance use disorder symptoms for all injectable substance types as covariates in our analytical models. Second, to our knowledge, there is no theoretical or empirical reason to expect specificity in the relation between substance use severity and suicide attempts relative to suicidal ideation and suicide plans. Indeed, with the exception of cocaine abuse and dependence symptoms being positively associated with suicidal ideation, symptom severity for none of the injectable substance types was associated with any form of suicidality. Finally, our decision to restrict the study sample to users of injectable substances, rather than to include all substance users more broadly, helped to ensured that any observed relation between injection substance use and the outcomes of interest was not simply a function of differences in the nature of injectable relative to non-injectable substance types.

Also worth noting is that the current study examined "pure" ideation, suicide plans, and suicide attempts as distinct and mutually exclusive outcomes. Although this distinction is not often observed in prior research, it is an important one because of the frequent co-occurrence of these three forms of suicidal ideation and behavior. More specifically, examining putative risk factors for more mild forms of suicidality (e.g., suicidal ideation) without first separating out more severe forms of these phenomena (e.g., suicide attempts) may yield a misleadingly significant association that is better accounted for by the relation between the risk factor of interest and the more severe forms of suicidality. In the current study, not excluding suicide attempters from analyses resulted in trends towards significance in the associations between injection substance use and suicidal ideation and suicide plans. Maintaining the distinction between different forms of suicidal ideation and behavior is also essential insofar as clinically meaningful differences exist between ideators who engage in more severe forms of suicidality and those who do not. Consistent with this view, in one recent epidemiological study, the majority of adolescent ideators did not transition to forming a plan (66.6%) or making an attempt (66.1%), and a substantial proportion of adolescents with suicide plans did not progress to attempt (39.2%; Nock et al., 2013).

Despites the strengths of the current study, it is not without its limitations. First, the study was cross-sectional in nature, and thus cannot exclude the possibility that suicide attempts may have temporally preceded rather than followed injection substance use. Longitudinal studies examining injection substance use behavior preceding suicide attempts are required before greater confidence can be reached regarding the temporal nature of their relation. Second, other possible explanatory mechanisms underlying the link between injection substance use and suicide attempts were not tested in this study. For example, given evidence of an association between impulsivity and suicide attempts in adolescents (Dougherty et al., 2009), prior findings of a relation between impulsivity and adolescent substance use (Castellanos-Ryan et al., 2013), and given that substance administration by injection produces a more immediate effect than do other methods of substance

use, it may be possible that injection substance users are more likely than non-injecting counterparts to attempt suicide in some measure because they are more impulsive. If this were the case, injection substance use may reasonably be expected to be associated with *lower* risk for suicide plans in addition to higher risk for attempts. In the two multivariate models with suicide plans as the outcome variable, however, the relation with injection substance use was not significant. Nonetheless, future research directly assessing impulsivity, injection substance use, and the acquired capability for suicide, as conceptualized in the interpersonal theory of suicide, is required directly to clarify the exact nature of the relation between injection substance use and suicide attempts. Third, although the observed pattern of results is congruent with our hypothesis that the physical pain associated with injection substance use habituates the individual to the pain associated with death, and thus reduces the innate inhibitions against making a suicide attempt, the current study does not include measures of habituation which precludes direct assessment of this hypothesized mechanism. Alternative processes may exist that account for the observed relation. Third, the current analyses were conducted with adolescents who endorsed a lifetime history of at least one depressive symptom. Consequently it was predominantly female and a very high percentage endorsed suicidal ideation. Thus, caution should be taken in generalizing the present findings to other populations. In particular, it would be important for future studies to replicate the current findings in a randomized sample not selected based on the presence of depressive symptoms.

These limitations notwithstanding, the findings of the current study may still be of potential clinical utility. Arriving at a better understanding of potential markers of risk for suicide attempts in adolescent substance users is important to the development of prevention programs for this at-risk population. Such information may lend greater precision to identifying and targeting those most at risk for attempting suicide (Erinoff et al., 2004), a decidedly pressing issue given the modest success of existing interventions for decreasing suicide reattempts in adolescents (Bridge et al., 2006; Brent, 2011).

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Contributors

Dr. Liu conceived of the study, conducted the literature search and statistical analyses, and composed the first draft of the manuscript. Dr. Case assisted with the statistical analyses and final draft of the manuscript. Dr. Spirito assisted with the final draft of the manuscript. All authors were involved in revising the manuscript and approved the manuscript in its final form.

Conflict of interest

All authors declare that they have no conflicts of interest.

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