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Abstract

Background: Prior studies suggest a link between head injuries and substance use but do not routinely capture mechanisms connecting the two.

Objectives: The goal of the study was to explore whether past head injuries predicted current substance use among young adults, taking factors such as stress, self-esteem, temper, and risk-taking into consideration.

Methods: Data were drawn from a web-based survey conducted in 2014 and 2015 at a public university in the United States (n = 897). Questions were asked about history of head injuries as well as past 12-month binge drinking, marijuana use, and prescription drug misuse. To evaluate the association between head injury and substance use, two logistic regression models were performed for each substance. Head injury was first regressed on the outcome, then related risk factors were entered into the models to determine whether they explained any association between injury and outcome.

Results: A history of multiple head injuries was associated with increased odds of bingeing, marijuana, and prescription drug use. Prior delinquency and risk-taking accounted for the associations with bingeing and marijuana use. Taking all variables into consideration, multiple head injuries were associated with greater odds for prescription drug misuse.

Conclusions: Results suggest the need to give consideration to a range of concomitant variables when considering behavioral outcomes associated with head injury. Head injuries may be a marker of a constellation of risk-taking behaviors that contributes to substance use. For those with multiple injuries, misuse of prescription drugs may be an attempt to cope with lingering side effects.

Keywords: Head injury, binge drinking, marijuana use, prescription drug use

Head injury among adolescents has gained national attention, given their high risk (Centers for Disease Control [CDC], 2015). Research has indicated a tentative link between the occurrence of such injuries and later substance misuse (McKinlay, Corrigan, Horwood, & Fergusson, 2014) and has identified potential comorbidity between head injury and substance use (Graham & Cardon, 2008;Walker, Hiller, Staton, & Leukefeld, 2003). Substance misusers with a history of head injury may place an additional burden on the health care system (Walker, Staton, & Leukefeld, 2001). The burgeoning field of epidemiological criminology recognizes the dovetailing of issues that concern both public health and the criminal justice system (Akers & Lanier, 2009; Potter & Rosky, 2013; Vaughn, DeLisi, Perron, Beaver, & Abdon, 2012). If head injury, which has gained prominence as a public health concern, increases risk for later substance use, then there may be implications for criminal justice policy, such as drug intervention or treatment programs that are sensitive to the needs of clients with prior injuries.

As head injury research expands to address behavioral outcomes, several issues remain understudied. First, emphasis is often placed on concussive injuries received during sports or recreational activities (Centers for Disease Control and Prevention [CDC], 2007; Karlin, 2011; Sahler & Greenwald, 2012), although these may be underreported (Chrisman, Quitiquit, & Rivara, 2013; Kroshus, Garnett, Hawrilenko, Baugh, & Calzo, 2015). Less attention has been given to the broader occurrence of head injuries by other means, such as accidents (Langlois, Rutland-Brown, & Wald, 2006). Second, multiple injuries heighten risk for poor outcomes (Williams, Cordan, Mewse, Tonks, & Burgess, 2010), but research typically focuses on a singular incident or dichotomizes into none or any lifetime injury (Chrisman & Richardson, 2014; Stoddard & Zimmerman, 2011). Finally, research tends to focus on clinical cases in which individuals present to a medical setting after incurring injury (Massagli et al., 2004; Taylor, Barrett, McLellan, & McKinlay, 2015). Less is known about the effect of injuries in nonclinical or non-reporting samples, who likely represent a majority of cases (CDC, 2015; Laker, 2011). Indeed, most of the injuries incurred by youth are considered mild brain injuries, yet even these injuries increase risk for poorer outcomes (Rivara et al., 2012).

Various approaches using prospective or retrospective longitudinal designs suggest that a history of head injury is associated with poorer mental and behavioral health outcomes (Massagli et al., 2004; Orlovska et al., 2014; Timonen et al., 2002). Cross-sectional evidence from a population-based sample of Canadian adolescents demonstrated an association between head injury and psychological distress, alcohol use, binge drinking, marijuana use, and prescription drug misuse (Ilie et al., 2014, 2015). In a cohort-based longitudinal sample of New Zealanders, youth who had a head

injury-related inpatient episode in early life were at increased risk for alcohol and drug dependence in young adulthood; those who had an inpatient episode in late adolescence were also at increased risk for drug dependence (McKinlay et al., 2014). Similarly, among juvenile offenders and homeless youth, a history of head injury is associated with psychological distress and substance use (Mackelprang, Harpin, Grubenhoff, & Rivara, 2014; Perron & Howard, 2008; Vaughn, Salas-Wright, DeLisi, & Piquero, 2013; Williams, et al., 2010).

Neither the hypothetical mechanisms underlying these relationships nor potential confounding variables are routinely captured in these studies. Generally speaking, head injury is thought to disrupt brain processes related to executive functioning, including inhibition, self-regulation, and decision-making (Li & Liu, 2013; Ryan et al., 2015). Disruption of cognitive and emotional development may undermine socio-emotional processes and the ability to cope with stress (Ryan et al, 2015; Taylor et al., 2015; Tonks, Yates, Williams, Frampton, & Slater, 2010). A comprehensive review of the pediatric literature found that 20 to 40% of those who experience a brain injury between the age of 5 and15 years showed decreased executive functioning within the first year of injury (Li & Liu, 2013). Such disruptions place those who sustain even minor injury at greater risk for negative behaviors (Bjork & Grant, 2009; Hawley, Ward, Magnay, & Long, 2004; Li & Liu, 2013; Taylor et al., 2015).

Notably, these key constructs of self-regulation and cognitive and socio-emotional processing – often united under the umbrella of self-control – are employed in explaining negative behaviors, such as drug use and delinquency, in the general population (Hughes et al., 2015; Vaughn et al., 2013). Poor health and delinquency may be viewed as part of a nexus of problems rooted in poor self-control (Moffitt et al., 2011). Poor self-control and risky behavior profiles in adolescence are linked to poorer physical health in adulthood (Hair, Park, Ling, &Moore, 2009; Miller, Barnes, & Beaver, 2011). Head injury may itself be tied to risk-taking so that such injuries may be part of a broader pattern of behavior that culminates in poorer behavioral outcomes (Hughes et al., 2015). Research indicates that pre-injury neurocognitive functioning is an important predictor of post-concussion symptomology (Merritt & Arnett, 2014; Ryan et al., 2015). Further, patterns of substance use and externalizing behaviors prior to injury are connected with patterns of use after an injury (Graham & Cardon, 2008; Parry-Jones, Vaughan,& Cox, 2006; Rogers & Read, 2007). From this point of view, what remains unresolved is whether head injury itself adds another layer of risk beyond pre-existing factors.

The current study

The purpose of the current study was to explore the relationship between a history of head injuries and current substance use in a sample of young adults. In particular, the study used multivariate methods to test the hypothesis that lifetime head injuries predicted current binge drinking, marijuana use, and misuse of prescription drugs. Prior work posited that head injury impedes the ability to cope with stress, social-emotional processes, and self-regulation (Taylor et al., 2015). These mechanisms, operationalized in this study as stress experiences, self-esteem, preference for risk, and temper, were hypothesized to account for the relationship between head injury and substance use. Alternatively, if prior risky behavior such as delinquency and head injury are concomitant (Hair et al., 2009; Hughes et al., 2015), then such behavior may also account for the relationship between head injury and substance use.

Methods

Sample

Data were drawn from a web-based survey of young adults at a large public university in the United States, collected between September 2014 and October 2015 (n = 951). Participants were recruited by two means. First, information about the study and a link to the survey were posted on a research site maintained by the Psychology Department. Students in psychology classes used this site to volunteer for studies as required or suggested by their instructors. Students received either course credit or extra credit for participating in the study. Second, researchers visited several introductory-level sociology classes, ranging in size from 70 to 250 people. The researchers introduced the survey and provided a handout with the web link. The students also received emails with an embedded link to the survey. In exchange for completing the survey, these students received either a $5 gift card or extra credit. Both introductory psychology and introductory sociology satisfy university general education requirements, thus enrolling students from a variety of majors. Study procedures were approved by the university's Institutional Review Board. After removing surveys that were largely incomplete, surveys whose respondents were non-traditional students (age 30 years or older), and list-wise deletion, the analytic sample was 897. The sample was about two-thirds female, 80% White, with an average age of 19.34 years. Most (89%) had a parent with education beyond the high school diploma. Half reported at least one lifetime head injury.

Measures

Substance use

Binge drinking was measured with one item that asked, "In the past 12 months, how often did you drink five or more alcoholic drinks in one sitting?" A one-item indicator for forms of alcohol misuse, such as bingeing, has been used effectively in previous work on problem of alcohol use (Bush, Kivlahan, McDonell, Fihn, & Bradley, 1998). *Marijuana use* was measured with one item that asked, "In the past 12 months, how often did you use marijuana (pot)?" *Prescription drug misuse* was measured with one item that asked, "In the past 12 months, how often did you use prescription drugs without a prescription, such as Adderall or painkillers?" For each of these items, the response categories ranged from 0 (never) to 3 (five or more times). Monitoring the Future also employs a one-item indicator for annual use, asking on how many occasions someone had used a substance, then collapsing responses into categories (e.g., Johnston, Bachman, O'Malley, Schulenberg, & Miech, 2014).

As with much research on substance use, the variables were not normally distributed. Both marijuana and prescription drug use were positively skewed, with about half reporting no marijuana use and three-quarters reporting no prescription drug use. Both of these were recoded so that 0 = never and 1 = at least once. Binge drinking was bimodally distributed, with about one-third reporting never and one-third reporting five or more incidents. The variable was recoded so that 0 = never to once or twice and 1 = three or more times.

Head injury

Head injury was defined as "a hit, blow, or shock to your head, which people can sustain different ways, such as accidents, combat, fights with another person, and when playing sports." Respondents were asked questions about how many times in their lives they had a head injury causing them to become dazed and confused but without losing consciousness or blacking-out; and how many times they had a head injury that caused them to lose consciousness or black-out, even if only for a minute (Diamond, Harzke, Magaletta, Cummins, & Frankowski, 2007). The response categories ranged from 0 (never) to 2 (two or more times).

For analytic purposes, three dummy variables were constructed with no injury serving as the reference group. The categories represented: only one head injury, either type; two head injuries, either one of each type or two or more without blackout; and multiple head injuries, comprising those who

reported two or more blackout injuries, reported one of one type and two or more of the others, or reported two or more of each type. The variables thus capture injury incidence, severity, and dosage effects (Kaba, Diamond, Haque, MacDonald, & Venters, 2014; Williams et al., 2010). Due to cell size, it was not possible to distinguish among type of injuries within these categories. Respondents were also asked a series of questions about the injuries, such as when and how these happened.

Related risk factors

Stress was a mean score of two items that asked how often in the past 12 months respondents were exposed to unpleasant experiences, and how often they felt in danger of losing things they liked or valued, with responses ranging from 1 (never or almost never) to 5 (most or all of the time; Cronbach's alpha= 0.66; Tittle, Broidy, & Gertz, 2008). *Self-esteem* was a mean scale of six items (alpha = 0.86), with response categories ranging from 1 (strongly disagree) to 5 (strongly agree; Rosenberg, Schooler, & Schoenbach, 1989). Items included "You have a lot of good qualities," and "You feel like you are doing everything just about right." Risk-taking and temper were derived from the Grasmick, Tittle, Bursik, and Arneklev scale (1993) for self-control, with response categories ranging from 1 (strongly disagree) to 5 (strongly agree). *Risk-taking* was a mean scale of three items (alpha = 0.85), such as "Sometimes I will take a risk just for the fun of it." *Temper* was a mean scale of four items (alpha=0.81), such as "I lose my temper pretty easily." Finally, a retrospective question was asked about *high school delinquency*. Respondents were asked, "Thinking about when you were in high school, how often did you do things that probably violated the law?" with response options from never (coded 0) to often (coded 3). Tittle et al. (2008) used a similar retrospective item, which focused on four specific crimes committed in the previous five years. Although not an ideal means of measuring past behavior, such an item serves as a proxy in cross-sectional designs.[1]

Control variables

The multivariate analyses controlled for several demographic variables. *Age* was reported in years. Given the emphasis on young adults, respondents aged 30 years or older were dropped. Gender was reported as *female* (coded 0) or *male* (coded 1). Race was a dummy variable, where White was

1. As might be expected theoretically, there was some correlation among the related risk factors. For example, high school delinquency was correlated ($p < .05$) with stress ($r = .14$), risk ($r = .28$), temper ($r = .08$).

the reference group and *non-White* was the category. *Parent's education* was coded as the highest level of education completed by a parent, with high school degree or less coded 0 and education past a high school degree coded 1. Finally, given the potential relationships among health, injury, and substance use (Ford, 2014; Stogner & Gibson, 2011), the analyses controlled for self-reported *general health* on a 5-point scale ranging from poor to excellent.

Analysis

The research questions guiding the analysis were as follows: First, whether lifetime head injuries predict recent substance use, and second, whether risk factors related to incurring injury account for this relationship. To address the questions, the analysis proceeded in three stages. First, cross-tabulation was used to determine whether there were variations in substance use patterns across the head injury categories in the sample. Second, to determine whether related risk factors varied by head injury categories in patterns suggested by the literature, ANOVAs were performed. Finally, two logistic regression models were tested for each substance. In the baseline model, the substance use variable was regressed on the control variables and head injury categories, offering a test of the hypothesized relationship between head injury and substance use. In the full model, substance use was regressed on the control variables, head injury, and the related risk factors to determine whether the risk factors accounted for any association between head injury and substance use detected in the baseline model. Given the cross-sectional design, the analyses should be considered exploratory in nature.

Results

Table 1 displays the descriptive statistics for the sample. As noted, half of the respondents had experienced a lifetime head injury. In the sample, 22% had experienced one injury, 15% had experienced at least two injuries, and 13% had experienced multiple injuries. Most of these injuries happened in the five years prior to the survey; many were related to sports or recreational activities, followed by accidents. Turning to substance use in the past year, 41% of the sample reported binge drinking three or more times, 32% reported using marijuana for at least once, and 17% reported using a prescription drug without a prescription more than once. These numbers are comparable to national statistics for past year use among young adults (Johnston, O'Malley, Schulenberg, & Miech, 2015).

Table 1. Descriptive statistics (n = 897).

Variables	*Mean/proportion*	*SD*	*Min/Max*
Age	19.34	1.61	17/29
Male	0.32	0.46	0/1
Nonwhite	0.20	0.40	0/1
Parent education	0.89	0.31	0/1
General health	3.82	0.82	1/5
One head injury	0.22	0.42	0/1
Two head injuries	0.15	0.36	0/1
Multiple head injuries	0.13	0.34	0/1
Stress	2.38	0.72	1/5
Self-esteem	3.81	0.71	1/5
Risk-taking	2.75	0.97	1/5
Temper	2.08	0.85	1/5
High school delinquency	1.04	0.98	0/3
Binge drinking	0.41	0.49	0/1
Marijuana use	0.32	0.47	0/1
Prescription drug use	0.17	0.37	0/1

The top portion of Table 2 illustrates statistically significant variation across head injury status for each measure of substance use. For example, while 35% of the respondents with no head injury reported binge drinking, the proportion increases with each category such that 61% of the respondents with multiple injuries reported bingeing. Similarly, 27% of the respondents with no head injury reported marijuana use, increasing with each category to 42% of respondents with multiple injuries using marijuana. The pattern for prescription drug use is different, with respondents with no or two injuries having similar levels of use (13% and 12%, respectively), compared with 18% of the respondents with one injury and 32% of the respondents with multiple injuries reporting use.

The bottom portion of Table 2 depicts statistically significant differences across head injury categories in the related risk factors. There were significant differences in reported stress, risk-taking, and temper but not self-esteem. The pattern was consistent with the literature: those with head injuries reported higher mean levels of stress, risk-taking, and temper. For stress and temper, the differences were particularly pronounced between those with no injury and those with multiple injuries. For risk-taking, there were marked differences between those with no injury and those with two or multiple injuries. There were also differences in high school delinquency such that the mean level of past delinquency was larger with each level of head injury.

Table 2. Differences in variables of interest across head injury categories.

Variables	*No head injury* *Proportion*	*One head injury* *Proportion*	*Two head injuries* *Proportion*	*Multi head injuries* *Proportion*	X^2
Binge drinking	0.35	0.39	0.46	0.61	27.32***
Marijuana use	0.27	0.32	0.39	0.42	13.90**
Prescription drug use	0.13	0.18	0.12	0.33	28.80***
	Mean	*Mean*	*Mean*	*Mean*	*F*
Stress	2.30	2.46	2.38	2.53	4.49**
Self-esteem	3.85	3.70	3.86	3.79	2.18
Risk-taking	2.62	2.71	2.92	3.08	9.27***
Temper	2.05	2.03	2.07	2.28	2.67*
High school delinquency	0.89	1.05	1.17	1.42	10.35***

*** $p \leq .001$; ** $p < .01$; * $p < .05$

Like risk-taking, there were noticeable differences between those with no injury and those with two or multiple injuries. Taken together, these results are consistent with expectations about the impact of head injury on stress-related issues and cognitive processes. The variation in past delinquency is consistent with expectations regarding a potential concomitant relationship between head injury and behavioral health.

Table 3 presents logistic regressions on substance use. Model 1 was the baseline model for binge drinking, which included the demographic and health controls and the head injury variables. Males and White respondents were more likely to report bingeing. Compared with those without injuries, those with multiple injuries were at 118% greater odds for binge drinking. Model 2, in which all variables were regressed on binge drinking, indicated that risk-taking and past delinquency increased the odds of binge drinking, while bad temper decreased the odds. Head injury, however, was reduced to non-significance by the inclusion of these variables such that a penchant for taking risks and a history of delinquency accounted for the association between experiencing multiple injuries and binge drinking.

Model 3 was the baseline model for marijuana use and included the controls and the head injury variables. White respondents were more likely to report marijuana use. Compared with those without injuries, those with two injuries were at 63% greater odds of marijuana use, and those with multiple injuries, 71% greater odds for use. Model 4, which included all variables, indicated that risk-taking and past delinquency increased the

Table 3. Logistic regressions on substance use.

	Binge drinking		*Marijuana use*		*Prescription drug use*	
	Model 1	*Model 2*	*Model 3*	*Model 4*	*Model 5*	*Model 6*
Male	1.79***	1.62**	1.31	1.06	1.47*	1.23
Age	1.06	1.07	0.96	0.95	1.04	1.05
Nonwhite	0.40***	0.46***	0.61 *	0.76	0.76	0.92
Parent education	0.71	0.74	0.92	1.11	0.87	1.05
General health	1.10	1.19	0.84	0.90	0.83	0.90
One head injury	1.04	0.93	1.19	1.06	1.43	1.31
Two head injuries	1.33	1.00	1.63*	1.33	0.88	0.69
Multiple head injuries	2.18***	1.44	1.71*	1.04	2.87***	2.01**
Stress		1.06		1.20		0.98
Self-esteem		1.27		1.02		0.92
Risk-taking		1.44***		1.43***		1.28*
Temper		0.79*		0.94		1.12
High school delinquency		3.28***		2.65***		2.04***
Model χ^2	66.88***	307.70***	24.00 **	207.46***	32.17***	103.52***

Standardized coefficients (odds ratios) presented.

*** $p \leq .001$; *-* $p \leq .01$; * $p < .05$

odds of marijuana use. The head injury variables did not retain significance. Similar to the model for binge drinking, prior delinquency and a preference for risk-taking accounted for the relationship between head injury and marijuana use. Taken together, the results for binge drinking and marijuana use lend support to the hypothesis that preference for risk and risky behavior may explain the association between head injury and common forms of substance use.

Model 5 was the baseline model for prescription drug misuse and included the control and head injury variables. Males were more likely to report use. Compared with those without injuries, those with multiple injuries were at 187% greater odds for prescription drug misuse. Model 6 included all variables regressed on prescription drug misuse. Unlike the full models for other substances, in this model head injury remained significant; risk-taking and prior delinquency were also significant. Taking into consideration the significant effects for risk-taking and past delinquency, those with multiple injuries were at 101% greater odds for misuse of prescription drugs compared with those with no injuries. In this case, the results are consistent with the hypothesis that head injuries may be a specific risk factor for prescription drug misuse alongside preference for risk-taking and prior behavior.

Discussion

Head injury among children and adolescents and its impact on long-term functioning and behaviors have received a good deal of attention in both public and research circles. The current study, based on cross-sectional survey of a history of self-reported injuries among a sample of young adults, suggests that the purported relationship requires more scrutiny. In particular, when it came to more common forms of substance use, binge drinking and marijuana use, the key predictors were not a history of head injury but a history of delinquent behavior as well as a preference for risk-taking. Indeed, research has routinely demonstrated an association between risk-taking and delinquency that begins in childhood and continues into adulthood (Moffitt et al., 2011). A preference for risk-taking may put young people at increased likelihood for both head injury and delinquent behavior in adolescence, contributing to bingeing and marijuana use in young adulthood (Hughes et al., 2015; Ilie et al., 2015;McKinlay et al., 2014).To that extent, a prospective longitudinal design in which early preference for risk and conduct problems can be identified is important in determining whether head injury has an independent effect, or whether it is instead reflective of higher-order risk factors for bingeing and marijuana use (Bjork & Grant, 2009).

The results for prescription drug misuse revealed a similar complex story, keeping in mind the limitations on interpretation imposed by a relatively small cell size. Similar to the full models for bingeing and marijuana use, the full model for prescription drug misuse (Table 2, Model 6) indicated that past delinquency and risk-taking were key factors in increased odds for prescription drug misuse. However, neither preference for risk nor past delinquency fully accounted for the association between a history of head injury and prescription drug misuse. Instead, the direct effect of having multiple injuries contributed to the misuse of prescription drugs even when the related risk factors were taken into consideration. Although additional information would be needed to understand why individuals are using, these individuals may be using prescription drugs illicitly in an attempt to cope with pain, improve concentration, or address other on-going effects from their injuries (Messina et al., 2016).

The nature of the sample, a cross-sectional self-report survey among college students at one institution, should not be considered a representative and imposes several limitations; as such, the results of the study should be interpreted conservatively. First, although nearly half the sample reported at least one lifetime injury, a college sample may represent those who were best supported, academically and personally, in receiving treatment and/or rehabilitation for injury. Second, self-report, particularly of head injuries, is subject to recall error, so respondents may misestimate the number

of injuries and their severity. To the former point, a subsample of respondents both with and without reported injuries was re-interviewed as part of the data collection protocol, and there were no significant differences in their initial and subsequent reports. To that latter point, although standard definitions of severity were used, a clinical confirmation would be ideal. Finally, cross-sectional design limits the ability to tease out causal ordering; as noted above, a prospective design would be necessary, for example, to untangle the relationships among preference for risk, head injury, and illicit behavior, including substance use and delinquency.

In spite of the potential errors associated with self-reports, an advantage of the sample is that it did not rely on clinical or special populations. Instead, the survey was able to capture a range of injuries that may or may not have come to the attention of medical professionals. The sample was also large enough to compare those with no history of head injury to several groups of those who reported injuries. Further, given that these respondents may typify those young people most likely to receive support following injury, the results of the study could indicate even greater struggles for those without such support.

For researchers, the results presented here indicate the need to give consideration to a range of concomitant variables when considering behavioral outcomes associated with head injury, whether cross-sectionally or longitudinally (McKinlay et al, 2014). For example, without including past delinquency as a covariate in the current study, the independent effect of head injury on substance use in young adulthood would have been overstated. For practitioners, these results suggest that addressing head injuries should extend beyond the injury with which a young person presents to the patient's pattern of previous behaviors and injuries (Ilie et al., 2015). In other words, the injury with which a patient presents may be a marker of a constellation of behavior problems and risk-taking that ultimately contributes to substance use (Hughes et al., 2015; Perron & Howard, 2008; Vaugh et al., 2013; Williams et al., 2010). Likewise, interventions for substance users should be attuned to the comorbidity of head injuries (Graham & Cardon, 2008; Walker et al., 2003). Substance use after a head injury may also impede recovery (Bjork& Grant, 2009; Rogers & Read, 2007). Fully assisting young people who have experienced multiple head injuries to manage the on-going symptoms of their injuries in a legitimate fashion may prevent them from seeking illicit means of doing so, such as using medications without a prescription.

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