Article

Individual and Social Factors Related to Trajectories of Blackouts among Underage Drinkers in the Emergency Department

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Abstract

Aims: Alcohol-related blackouts can result in acute injuries and other negative outcomes. Among underage risky drinkers, we examined longitudinal trajectories of blackout frequency following an emergency department (ED) visit, and identified baseline characteristics associated with blackout trajectory membership.

Methods: Participants (ages 14–20; $N = 836$) attending an ED who screened positive for risky drinking and enrolled in a randomized-controlled trial of brief alcohol interventions were assessed at baseline, 3-, 6-, and 12-months. We used group-based trajectory modeling to determine characteristic trajectories of blackout frequency over 12-months in relation to baseline characteristics: demographics, substance use, delinquency, depression/anxiety symptoms, sexual assault, dating violence, and peer and sibling influences.

Results: We identified four groups: No/Low blackouts ($n = 248$; 29.7%), Declining blackouts ($n = 92$; 11.0%), Moderate blackouts ($n = 337$; 40.3%) and High blackouts ($n = 159$; 19.0%); group membership did not differ based on intervention receipt. In adjusted analyses, compared to the No/Low group all other groups had higher odds of having an alcohol-related baseline ED visit. Female sex, alcohol consumption, prescription drug misuse, sexual assault while incapacitated due to substances, and negative peer influences were positively associated with membership in the High group; College/Greek life involvement was also highest. Negative peer influences and being in high school (vs. College/Greek life) also distinguished the Moderate group.

Conclusion: Blackout frequency was largely stable over time and riskier trajectories were marked by risk factors such as negative peer influences and college/Greek life involvement. Findings may inform targeted interventions, particularly for women who were in higher risk trajectories.

INTRODUCTION

Underage binge drinking remains a critical public health concern given the risk for adverse consequences (Hingson and White, 2014; Squeglia *et al.*, 2014; Harding *et al.*, 2016). Blackouts, which involve memory loss during or just after drinking, are a dangerous outcome of binge drinking that increase risk for injury, psychiatric and neurobiological impairments, and social and emotional consequences (Wilhite and Fromme, 2015; Wetherill and Fromme, 2016). The prevalence of blackouts is approximately 50% among adolescents and emerging adults, although estimates vary by assessment periods; thus, lifetime prevalence may be higher (Wetherill and Fromme, 2016).

Binge drinking co-occurs with other risk behaviors (Donovan and Jessor, 1985; Willoughby *et al.*, 2004), compounding the risk for health and social consequences (e.g. unintentional injury, overdose due to other substances and victimization; Mundt *et al.*, 2012). For example, among binge drinking college women who reported any adolescent sexual victimization, recent blackouts were associated with increased odds of sexual victimization while incapacitated due to substances (Valenstein-Mah *et al.*, 2015). Next, undergraduates qualitatively described risky behaviors during blackouts (e.g. unplanned sexual experiences with known and unknown individuals, property damage, drug use and fights) as well as long-lasting relationship problems and emotional consequences (White *et al.*, 2004).

Much of the blackouts research examines cross-sectional risk and protective factors among college students, with unknown generalizability to clinical samples. Individual factors identified include female gender, heavier alcohol consumption, and other substance use (Hingson *et al.*, 2016). Peer behaviors are particularly robust correlates of drinking among youth (Simons-Morton and Farhat, 2010; Abadi *et al.*, 2011; Brechwald and Prinstein, 2011; Allen *et al.*, 2012; Burk *et al.*, 2012), with drinking game participation, characterized by high speed and volume consumption, being associated with blackout-related consequences (Ray *et al.*, 2014). Similarly, among youth surveyed one year post-high school, those residing in college dorms had higher rates of blackouts (Hingson *et al.*, 2016). Longitudinally, peer drug use (type of drug not specified) is positively associated with a relatively high, consistent pattern of alcohol-related blackouts (Schuckit *et al.*, 2015).

Longitudinal research identifying patterns of blackout frequency can inform interventions designed to interrupt risk trajectories. Schuckit and colleagues (2015) examined latent growth curves of blackout prevalence among British 15–19-year-olds who had begun drinking by age 15 and identified four trajectories of blackout prevalence: none (5.1%), rapidly increasing (29.5%), gradually increasing (44.9%) and consistently high (20.5%). Extraversion and peer substance use at age 15 distinguished youth in the rapidly increasing group, and females comprised a large proportion of the consistent group. Schuckit and colleagues also identified four trajectories of self-reported blackout frequency among 18–25 year-olds (2017): consistent-low (42.5%), moderate-low (28.3%), moderate-high (22.9%) and consistent-high (6.3%). Older age, female gender, alcohol-related variables, cannabis use disorder, lower tobacco use and drinking to cope characterized the consistent-high group. Peer heavy drinking and drinking to cope also distinguished the moderate-low group. A study of blackout prevalence assessed biweekly (excluding summer) among college drinkers over 2 years from college entry (Merrill *et al.*, 2016) produced five trajectories: high-decreasing (10.9%), low-stable (22.3%), low-decreasing

(48.0%), moderate-stable (14.8%) and high-stable (4.1%). The higher and more stable classes were characterized by higher levels of peer drinking and/or approval of drinking; conformity motives for drinking were most pronounced among those with decreasing trajectories. Thus, several risk factors appear to distinguish longitudinal profiles of blackout drinking in broad samples of youth (e.g. gender, peers, drinking motives, other drugs).

We seek to extend longitudinal work on blackouts by analyzing data from clinically-recruited underage drinkers and examining individual and social correlates that have been under-explored in prior longitudinal studies (e.g. sexual assault, violence involvement, mental health, etc.), but may be particularly salient for preventing social and emotional consequences. We focus on risky-drinking youth participating in an Emergency Department-based (ED) randomized-controlled trial (RCT) of an alcohol-focused behavioral intervention (Cunningham *et al.*, 2015). The ED is an important setting for studying alcohol-related behaviors because youth attending EDs have higher rates of risk behaviors (Wilson and Klein, 2000), ED-based youth alcohol interventions are efficacious (Monti *et al.*, 2007), including among a broad sample presenting for any reason (Cunningham *et al.*, 2015), and blackouts predict ED utilization among college students (e.g. half of ED visits over two years attributable to blackouts; Mundt and Zakletskaia, 2012). By focusing on a high-risk and interveneable population, this work will inform prevention strategies for underage drinkers.

METHOD

Design

Data were collected during the Project UConnect (Clinicaltrials.gov #NCT01051141) conducted in the University of Michigan ED in Ann Arbor, Michigan. We received Institutional Review Board approval and a Certificate of Confidentiality from the National Institutes of Health.

Project UConnect used a 3×2 factorial design, randomizing participants to ED conditions (computer brief intervention [CBI], therapist brief intervention [TBI] or enhanced usual care [control]). Participants were also randomized to booster conditions (post-ED session or control) completed after a 3-month follow-up. Interventions employed Motivational Interviewing (MI) to address alcohol use (see Cunningham *et al.*, 2015).

The CBI and TBI addressed similar components (e.g. reasons to avoid/reduce drinking, handling risky situations, coping with negative affect). The CBI was a social media-styled self-administered program via audio-capable tablet. The TBI was an interactive session with a therapist who used a computerized workbook to guide the session. The post-ED session was delivered by a therapist using a touchscreen tablet guide. The control included review of a health brochure. In the CBI, blackouts were a response option for avoiding consequences of drinking and benefits of drinking less; also, blackouts were referenced in a chat room-like conversation. In the TBI, blackouts were listed as a potential consequence to avoid; also, blackouts could also be mentioned naturally by participants or therapists during the TBI or post-ED session. Based on fidelity coding, the TBI sessions, on average, met traditional fidelity thresholds for Motivational Interviewing global spirit (Cunningham *et al.*, 2015). Regarding primary RCT outcomes, relative to the control condition, the CBI and TBI resulted in reduced alcohol consumption and alcohol-related consequences at 3-months and alcohol-related consequences and prescription drug misuse at 12-months. The

post-ED session (for those receiving the control condition at baseline) reduced consequences at 6-months (Cunningham *et al.*, 2015).

Participants and recruitment

Procedures are previously published (Cunningham *et al.*, 2015; Voloshyna *et al.*, 2016). RCT eligibility was based on screening positive on the past 3-month Alcohol Use Disorders Identification Test-Consumption (AUDIT-C), with scores ≥ 3 for 14–17 year-olds and ≥ 4 for ages 18+ (Chung *et al.*, 2000). Between 9/2010–3/2013, research assistants (RAs) approached ED patients (ages 14–20) for screening unless they met one of the following exclusions: presenting with suicidal ideation, sexual assault or child abuse, altered mental status, non-English speaking and absence of a parent/guardian to provide consent (if under age 18). Participants/parents provided written assent (ages 14–17 years) and/or consent (adult participants; minors' parents), then completed computerized screening measures (~20 min) with compensation (\$1.00 gift). Those who screened eligible and enrolled in the RCT completed written consent/assent, self-administered computerized baseline surveys (\$20 compensation) and were randomized to condition (stratified based on age, gender and alcohol use disorder). Follow-up assessments occurred at 3-, 6- and 12-months.

Measures

Demographic and background characteristics

We adapted items from prior studies to assess: age, gender, race (dichotomized into White vs. Non-White), school enrollment, involvement in a Greek Fraternity/Sorority (i.e. Greek Life) and cohabitation with or without parents. Similar to prior work (Voloshyna *et al.*, 2016), we created a 4-level school and Fraternity/Sorority variable: in high school, not in college (post-high school), in college and involved with Greek Life, and in college, but not involved in Greek Life. Using medical record review, participants' chief complaint for ED presentation was coded as medical (e.g. abdominal pain) or injury (National Center for Health Statistics, 1978) and as alcohol-related or not.

Baseline and follow-up substance use

Participants completed the 10-item AUDIT (Saunders *et al.*, 1993) assessing the past 3-months. The item assessing blackouts was our dependent measure: "during the past 3 months, how often have you had blackouts, i.e. been unable to remember what happened the night before, because you had been drinking?" (response options: 0 = Never, 1 = Less than monthly, 2 = Monthly, 3 = Weekly and 4 = Daily/almost daily). To assess past 3-month alcohol consumption, we used the quantity-frequency index previously used in this RCT (Cunningham *et al.*, 2015) that included multiplying the AUDIT quantity and frequency items (range = 0–20; higher scores represent greater alcohol consumption). Items from the Alcohol, Smoking, and Substance Involvement Screening Test (ASSIST; Humeniuk *et al.*, 2010) assessed other drug use, including frequency past 3-month marijuana use (0 = Never to 6 = Daily or Almost Daily) and misuse of prescription drugs (i.e. sedatives, stimulants and opioids; sum of three items, possible range 0–18).

Baseline clinical risk factors

Using items adapted from the Youth Risk Behavior Surveillance System, we queried two types of sexual assault victimization (Centers for Disease Control and Prevention, 2006). Sexual assault

while incapacitated due to substances: 'In the past 12 months, did someone ever have sexual intercourse with you when you were unaware, or unable to give consent from drinking alcohol or using drugs?' Forced sex was based on a 'yes' to the question: 'In the past 12 months, have you ever been physically forced to have sexual intercourse when you did not want to?' We assessed past-week symptoms of depression ($\alpha = 0.90$) and anxiety ($\alpha = 0.88$) using subscales from the Brief Symptom Inventory (Derogatis and Spencer, 1982). Past 12-month delinquency included a 17-item total score ($\alpha = 0.87$) from the Flint Adolescent Study (FAS; Zimmerman *et al.*, 2002) querying frequency (0 = 1 to 5 = 4+ times) of several behaviors (e.g. fighting, stealing, etc.).

Baseline social influences and risk factors

Items from the FAS (Zimmerman *et al.*, 2002) assessed the number of friends who engage in negative/delinquent behaviors and positive/prosocial behaviors, separately (ratings from 1 = none of my friends to 5 = all of my friends). Negative influences ($\alpha = 0.81$) included a total of 10 items (e.g. getting drunk, shoplifting, smoking marijuana, fighting) and positive influences ($\alpha = 0.70$) comprised a total of four items (e.g. religious involvement, school club/athletics involvement). Siblings' drug use ($\alpha = 0.78$) involved a total score of four FAS items assessing how often the participant's siblings got drunk, had an alcohol problem, got high/stoned and used marijuana at least once a week with items ratings of 1 = Never to 5 = Very Often (participants' without siblings were coded as 'never' for all items). We assessed dating violence victimization and perpetration over the past 12 months with the Conflict in Dating Relationships Inventory (Wolfe *et al.*, 2001) with four items assessing frequency of perpetration ($\alpha = 0.90$; e.g. throwing something, kicking/hitting/punching, slapping/hair pulling, and pushed/shoved/shook) rated from 0 = Never to 3 = Often (six or more times) and four parallel items querying victimization ($\alpha = 0.91$); items on each subscale were summed.

Data Analysis

Group-based trajectory modeling (Nagin and Odgers, 2010) was used to identify trajectories of blackout frequency. Individuals are assumed to reside in one of a pre-set number of latent classes, which determines their mean trajectory. Inference focuses on determining the number of latent classes and the mean trajectories within each class. We made no parametric constraints on the mean trajectories, allowing any pattern of change over time. We fitted the model assuming 1–6 latent classes, and chose the specification that minimized the Bayesian Information Criterion (BIC), as recommended (Nylund *et al.*, 2007). Each model was refit 200 times from different random starting values to ensure convergence to the global maximum likelihood estimator. To prevent overfitting and ensure that the groups would be large enough to allow between-group comparisons, we constrained our models so that all class prior probabilities were ≥ 0.1 , as in prior work (Walton *et al.*, 2017). Class separation was evaluated using the relative entropy, with values >0.8 indicating good separation (Ram and Grimm, 2009).

Using posterior probabilities produced by the selected model, we placed individuals into their most likely trajectory group. We then used chi-square tests, Fisher's exact test, and analyses of variance to analyze unadjusted between-group differences on demographics, clinical risk factors and social influences. Based on the unadjusted analysis and practical considerations, we selected variables for entry into a subsequent multinomial logistic model, where we estimated

adjusted covariate effects on group membership. We conducted the multinomial logistic regression model using the No/Low, Declining and Moderate Groups as separate referents. Finally, we descriptively analyzed mean trajectories of blackout frequency, alcohol consumption, marijuana use and prescription drug misuse at each follow-up within each group. We used SAS Version 9.4 to fit the multinomial logistic models and the R package flexmix (Grun and Leisch, 2008) to fit the group-based trajectory models.

RESULTS

Sample characteristics

We screened 4,389 ED patients, 1054 (24.0%) were eligible for the RCT. Analyses focused on the 836 (80.3%) enrolled (see Cunningham *et al.*, 2015), whom baseline past 3-month blackout frequency was: no blackouts = 48.2% ($n = 403$), less than monthly = 34.8% ($n = 291$), monthly = 12.8% ($n = 107$), weekly = 4.1% ($n = 34$) and daily/almost daily = 0.1% ($n = 1$). The mean age was 18.6 years; 51.6% were male, and most (79.4%) were White (9.5% African American, 11.1% of other backgrounds; 5.5% Hispanic ethnicity) (see Table 1). Most participants' ED visits were not alcohol-related (88.6%).

Blackout trajectory groups

The four-group solution yielded substantially lower BIC than the more parsimonious solutions ($BIC_1 = 7116.57$; $BIC_2 = 5071.74$; $BIC_3 = 4712.21$; $BIC_4 = 4297.13$). No solutions with >4 groups that were consistent with the prior probability constraint were identified (i.e. all five-group solutions that obeyed the prior probability constraint produced lower likelihoods than the optimal four-group solution). The four-group solution produced a relative entropy of 0.84, indicating acceptably separated classes.

Figure 1 displays the mean frequency of blackouts at each assessment among members of each group. One group ($N = 248$; 29.7%) consistently reported few/no blackouts at each assessment (No/Low group). The second group ($N = 92$, 11.0%) had a decline in reported blackouts from baseline to 3-months and few blackouts at 6- and 12-months (Declining group). The third group ($N = 337$, 40.3%) consistently experienced blackouts, albeit at low to moderate levels, over 12 months (Moderate group). The final group ($N = 159$, 19.0%) consistently had the highest reports of blackouts, with some decline from baseline to 6-months (High group).

Unadjusted analyses examining baseline differences in blackout trajectories

Regarding *background and demographic factors*, age, race, and college/Greek Life status significantly differed across groups, but gender and cohabitation with parents did not (Table 1). Specifically, the Moderate group ($M = 18.7$ years) was significantly older than the Declining group ($M = 18.2$) and those in the High group were significantly older ($M = 18.9$) than those in all other groups (No/Low group, $M = 18.5$). White individuals had the highest representation in the Moderate and High groups (82.2% and 83.7%, respectively; both significantly greater than then 71.7% in the Declining group, the Low/No group did not differ from any groups). College attendance with Greek Life involvement was highest in the High group (36.7%) and lowest in the No/Low group (15.7%). High school students comprised the smallest portion of the High group (8.2%). Neither baseline ED visit reason (medical vs. injury) or intervention group distinguished trajectory groups; however, the No/Low group

had a significantly lower proportion with alcohol-related baseline ED visits than each other group.

Regarding *substance use and clinical risk factors*, baseline alcohol consumption was significantly higher in the High group ($M = 6.7$) compared to other groups ($M_{\text{No/Low}} = 3.5$; $M_{\text{Moderate}} = 4.1$; $M_{\text{Declining}} = 3.5$). Isolating the AUDIT-C item assessing binge drinking reveals universally high rates across groups. Frequency of marijuana consumption and prescription drug misuse were also significantly higher in the High group versus other groups. Delinquency was significantly higher in the High group ($M = 16.6$) versus the No/Low and Moderate groups ($M = 13.9$ and 14.0 , respectively). Depression and anxiety symptoms did not differ across groups, nor did rates of forced sex. Prevalence of sexual assault while incapacitated due to substances was higher in the Declining group (10.9%) versus the No/Low group (3.7%) and higher in the High group (15.2%) versus the Moderate (6.3%) and No/Low groups.

Regarding *social influences*, groups differed on negative peer influences, but not positive peer influences or substance use-related sibling influences. Negative peer influences were significantly higher in the Moderate ($M = 20.6$) and Declining ($M = 20.3$) versus No/Low group ($M = 19.1$) and in the High group ($M = 23.1$) compared to all other groups. Dating violence victimization was not different across groups, but perpetration was higher in the High group ($M = 0.7$) and the Declining group ($M = 0.6$) versus the No/Low group ($M = 0.3$).

Adjusted analyses examining baseline predictors of blackout trajectories

Using the No/Low group as the referent (Table 2), having a baseline alcohol-related ED visit was also associated with membership in the other groups. The Moderate group (vs. No/Low) was also characterized by greater negative peer influences. Characteristics that distinguished the High and No/Low groups were: female sex, and greater alcohol consumption, prescription drug misuse, sexual assault under the influence of substances, and negative peer influences. Examining the education/Greek life categories, members of the College/Greek life group were most likely to be in the High group (compared to other education/Greek life categories).

We also conducted the logistic regression model using the Declining and Moderate Groups as referents (full models not shown for parsimony). Compared to the Declining group, the Moderate group members were older (RRR = 1.37, 95% CI = 1.08–1.74, $P < 0.05$). Age (RRR = 1.41, 95% CI = 1.06–1.89, $P < 0.05$), not in college (vs. College/Greek life, RRR = 0.23, 95% CI = 0.09–0.61, $P < 0.01$), and had greater alcohol consumption (RRR = 1.35, 95% CI = 1.21–1.52, $P < 0.001$) distinguished the High versus the Declining group. Variables distinguishing the High and Moderate groups were: being in high school (RRR = 0.29, 95% CI = 0.11–0.78, $P < 0.05$) or in college, but not in Greek life (RRR = 0.60, 95% CI = 0.36–0.97, $P < 0.05$), alcohol consumption (RRR = 1.24, 95% CI = 1.15–1.32, $P < 0.001$), and prescription drug misuse (RRR = 1.09, 95% CI = 1.00–1.18, $P < 0.05$).

Substance use trajectories in blackout groups

Across Figs 2–4, the High blackouts group consistently had the highest levels of alcohol consumption, marijuana use and prescription drug misuse. Although alcohol and marijuana use decrease over 12 months in the High group, prescription drug misuse decreases, then increases to baseline levels at 12-months. For the other groups,

Table 1. Baseline sample characteristics and unadjusted analyses examining trajectory group membership

	Total sample (<i>n</i> = 836)	No/Low (<i>n</i> = 248; 29.7%)	Declining (<i>n</i> = 92; 11.0%)	Moderate (<i>n</i> = 337; 40.3%)	High (<i>n</i> = 159; 19.0%)
<i>Background Characteristics</i>					
Age***	18.6 (1.4)	18.5 (1.4) ^c	18.2 (1.6) ^{a,c}	18.7 (1.4) ^{a,f}	18.9 (1.1) ^{c,e,f}
Female (vs. male)	405 (48.4%)	105 (42.3%)	51 (55.4%)	174 (51.6%)	75 (47.1%)
<i>Race*</i>					
White	664 (79.4%)	188 (75.8%)	66 (71.7%) ^{a,f}	277 (82.2%) ^a	133 (83.7%) ^f
African American and others	172 (20.6%)	60 (23.2%)	26 (28.3%)	60 (17.8%)	26 (16.4%)
Live with Parents (vs. not)	361 (43.4%)	119 (48.2%)	42 (45.7%)	143 (42.7%)	57 (36.1%)
<i>School/Greek life status*</i>					
In high school	145 (17.4%)	50 (20.2%) ^{b,c}	22 (23.9%) ^{a,e}	60 (17.9%) ^{a,b,f}	13 (8.2%) ^{c,e,f}
Not in college	134 (16.1%)	45 (18.2%)	20 (21.7%)	38 (11.3%)	31 (19.6%)
In college, not in Greek life	355 (42.6%)	114 (46.0%)	33 (35.9%)	152 (45.4%)	56 (35.4%)
In college, in Greek life	199 (23.9%)	39 (15.7%)	17 (18.5%)	85 (25.4%)	58 (36.7%)
<i>Reason for baseline ED visit</i>					
Medical	531 (63.5%)	161 (64.9%)	59 (64.1%)	208 (61.7%)	103 (64.8%)
Injury	305 (36.5%)	87 (35.1%)	33 (35.9%)	129 (38.3%)	56 (35.2%)
Alcohol-related baseline ED visit***	65 (11.4%)	3 (1.2%) ^{b,c,d}	9 (9.9%) ^d	30 (8.9%) ^b	23 (14.5%) ^c
<i>Baseline Treatment Group</i>					
Computer Brief Intervention	277 (33.1%)	84 (33.9%)	31 (33.7%)	110 (32.6%)	52 (32.7%)
Therapist Brief Intervention	278 (33.3%)	87 (35.1%)	30 (32.6%)	109 (32.3%)	52 (32.7%)
Control	281 (33.6%)	77 (31.0%)	31 (33.7%)	118 (35.0%)	55 (34.6%)
<i>Alcohol and Drug Use</i>					
Alcohol consumption***	4.4 (3.0)	3.5 (2.3) ^c	3.5 (2.1) ^c	4.1 (2.7) ^f	6.7 (3.9) ^{c,e,f}
Marijuana use frequency***	2.5 (2.2)	2.3 (2.2) ^c	2.4 (2.2) ^c	2.4 (2.1) ^f	3.1 (2.1) ^{c,e,f}
Prescription drug use frequency***	1.1 (2.5)	0.7 (1.8) ^c	1.0 (2.2) ^c	1.0 (2.3) ^f	2.1 (3.7) ^{c,e,f}
Binge drinking (five or more)	814 (97.4%)	237 (95.6%)	92 (100%)	328 (97.3%)	157 (98.7%)
<i>Clinical Risk Factors</i>					
Depression symptoms	5.1 (5.2)	5.1 (5.3)	5.8 (5.9)	4.6 (4.9)	5.6 (5.3)
Anxiety symptoms	3.8 (4.4)	3.4 (3.8)	4.5 (4.9)	3.7 (4.6)	4.1 (4.5)
Delinquency***	14.1 (4.9)	13.9 (4.5) ^c	14.5 (5.2)	14.0 (5.0) ^f	16.6 (7.0) ^{c,f}
Sex assault under the influence***	64 (7.7%)	9 (3.7%) ^{c,d}	10 (10.9%) ^d	21 (6.3%) ^f	24 (15.2%) ^{c,f}
Forced sexual assault	60 (7.2%)	17 (6.9%)	6 (6.5%)	22 (6.6%)	15 (9.4%)
<i>Social Influences and Risk Factors</i>					
Dating violence victimization	0.5 (1.6)	0.5 (1.7)	0.7 (1.7)	0.4 (1.3)	0.7 (2.0)
Dating violence perpetration*	0.4 (1.4)	0.3 (0.9) ^{c,d}	0.6 (1.7) ^d	0.4 (1.3)	0.7 (2.1) ^c
Positive peer influences	12.0 (2.9)	12.1 (3.1)	11.9 (3.1)	12.2 (2.7)	11.7 (2.9)
Negative peer influences***	20.6 (5.4)	19.1 (5.0) ^{b,c,d}	20.3 (5.4) ^{d,e}	20.6 (5.2) ^{b,f}	23.1 (5.8) ^{c,d,f}
Sibling drug use	7.0 (3.4)	6.7 (3.9)	6.5 (3.8)	6.5 (3.8)	7.3 (4.0)

Note. Columns that are significantly different from one another share a superscript, such that: a = Moderate vs. Declining, b = Moderate vs. No/Low, c = High vs. No/Low, d = Declining vs. No/Low, e = High vs. Declining, and f = High vs. Moderate.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Fig. 1. Average past 3-month blackout frequency among trajectory group members over 12 months. Note. Response options comprising Y-axis are: 0 = Never, 1 = Less than Monthly, 2 = Monthly, 3 = Weekly, and 4 = Daily/almost daily.

substance use patterns are relatively similar over time, except that the Moderate group does maintain higher alcohol consumption over 12-months, relative to the No/Low and Decreasing groups.

DISCUSSION

Among this clinical sample of underage drinkers followed for 12-months after an ED visit, nearly 1-in-5 had consistent blackouts. Although blackouts in this High group may be considered relatively infrequent, hovering between 'monthly' and 'less than monthly' over time, the acute risks associated with blackout incidents are of great concern. This finding is particularly troubling given participants' underage status, which could result in higher risk trajectories as participants gain legal access to alcohol, which is consistent with epidemiological research indicating that prevalence of binge drinking and daily drinking is higher for 21–22-year-olds than 19–20-year-olds (Schulenberg *et al.*, 2018). The High group also demonstrated

Table 2. Multinomial logistic regression analysis examining correlates of blackout trajectory group membership (No/Low as reference)

	Declining vs. No/Low Relative risk ratio (95% CI)	Moderate vs. No/Low Relative risk ratio (95% CI)	High vs. No/Low Relative risk ratio (95% CI)
Age	0.81 (0.64–1.05)	1.11 (0.93–1.33)	1.15 (0.90–1.48)
Female (vs. male)	1.45 (0.85–2.47)	1.42 (0.98–2.07)	2.11 (1.25–3.58)*
African American and others (vs. white)	1.18(0.66–2.10)	0.68 (0.44–1.05)	0.71 (0.39–1.29)
School/Greek life status			
In high school vs. college & Greek life	0.84 (0.34–2.04)	0.37 (0.19–0.72)**	0.19 (0.08–0.44)***
Not in college vs. college & Greek life	0.71 (0.24–2.08)	1.02 (0.48–2.18)	0.29 (0.10–0.88)*
College, no Greek life vs. college & Greek life	0.69 (0.34–1.41)	0.72 (0.45–1.16)	0.43 (0.24–0.76)**
Alcohol-related baseline ED visit	10.59 (2.72–41.27)***	8.66 (2.56–29.37)***	11.17 (3.07–40.65)***
Alcohol consumption	0.98 (0.87–1.11)	1.08 (1.00–1.16)	1.33 (1.22–1.45)***
Marijuana use frequency	0.97 (0.84–1.11)	0.98 (0.89–1.08)	1.03 (0.91–1.17)
Prescription drug misuse frequency	1.06 (0.94–1.21)	1.09 (0.99–1.20)	1.18 (1.06–1.32)**
Delinquency	0.96 (0.92–1.02)	0.96 (0.93–1.00)	0.98 (0.94–1.03)
Sexual assault under the influence	2.58 (0.95–7.02)	1.72 (0.74–4.01)	3.19 (1.27–8.01)**
Dating violence perpetration	1.15 (0.95–1.40)	1.11 (0.94–1.31)	1.13 (0.94–1.36)
Negative peer influences	1.06 (0.99–1.13)	1.09 (1.04–1.15)***	1.11 (1.05–1.13)**

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$. **Fig. 2.** Average past 3-month alcohol consumption among trajectory group members over 12 months. *Note.* Alcohol consumption possible range is 0–20 with higher scores indicating greater consumption.

higher substance use over time, suggesting that ongoing polysubstance use could contribute to blackouts. The Moderate group, who experienced blackouts consistently, but less frequently than the High group (less than monthly on average), are also of concern. Younger age distinguished the Declining group from the Moderate and High groups, suggesting that declining patterns of blackouts could indicate the beginning of an aging out of high-risk drinking for this sub-group of youth, relative to those in the higher risk groups who continue to drink to blackout states at older ages. This interpretation is consistent with data indicating that some young people age out of high-risk drinking behaviors (Arria *et al.*, 2016), while others continue or escalate such behaviors (Schulenberg *et al.*, 2018).

In adjusted analyses, the High group was demarcated by higher alcohol consumption, as expected, but also by involvement in the Greek life system in college, female sex, prescription drug misuse, negative peer influences and sexual victimization while incapacitated due to substances. These findings speak to the need for targeted interventions, particularly for women who may be at heightened risk for blackouts due to physiological reasons (e.g. BMI, metabolic factors). Further, the Moderate group was also distinguished by

negative peer influences, suggesting interventions that address peer norms and encourage prosocial activities could have an impact. Examination of substance use patterns show that, on average, High group members demonstrated the most elevated alcohol and marijuana consumption and prescription drug misuse over time. Future research using event-level or ecological momentary methods is needed to provide more fine-grained detail regarding simultaneous substance use and blackouts.

Several variables distinguishing High or Moderate groups in unadjusted analyses warrant further attention, including: dating violence victimization and perpetration, marijuana use, misuse of prescription drugs and delinquency. These findings are consistent with theories of risk behavior clustering, suggesting the need for early interventions that address multiple risks. Given the rates of prescription drug misuse, prevention of overdose is a key concern. Based on adjusted analyses, the relationship of prior unwanted sexual intercourse while incapacitated due to substances, College/Greek Life status, prescription drug misuse, and membership in the High group suggests the need for campus-based alcohol and sexual assault prevention programs to address reduction of high-risk alcohol consumption and prevention of blackouts (due to high intensity drinking or co-consumption with other substances). Further, this suggestion is underscored by data that prior sexual victimization predicts future victimization and high-risk alcohol consumption (Valenstein-Mah *et al.*, 2015). Given that non-Greek affiliated college students also comprised a large portion of the Moderate and High groups, and 20% of those in the High group were not in college, prevention programs are needed for these groups prior to escalation into high-risk blackout drinking.

Although prior studies describing blackout trajectories among high-risk youth (e.g. college students [Merrill *et al.*, 2016], youth who began drinking before age 15 [Schuckit *et al.*, 2015]) provide important data and are perhaps generalizable to larger populations, we extend the literature by focusing on a clinical sample. Understanding blackouts among underage drinkers in the ED can serve facilitate delivery of interventions during a teachable moment of heightened health concern; particularly for those presenting to the ED for an alcohol-related reason. Our blackout groupings differed somewhat from others' (Schuckit *et al.*, 2015, 2017; Merrill *et al.*, 2016), perhaps due to sample differences, the longitudinal time

Fig. 3. Average past 3-month marijuana use frequency among trajectory group members over 12 months. *Note.* Response options comprising Y-axis are 0 = Never to 6 = Daily/Almost Daily.

Fig. 4. Average past 3-month prescription drug misuse frequency among trajectory group members over 12 months. *Note.* Y-axis range is from 0–18.

periods examined, and the examination of frequency versus prevalence. Data from similar-aged British youth identified a group with increasing blackout prevalence from ages 15–19 (Schuckit *et al.*, 2015), an increase that may have been less likely to occur over one year in our sample. Some important consistencies across studies also emerged, namely that female sex and negative peer influences were correlates of higher risk trajectories, which could support the use of peer-based interventions for blackout prevention.

Regarding limitations, although our trajectory groups were constructed using longitudinal data, the primary independent variables were observed at a single time point, overlapping with the time period for the baseline blackouts measurement, thereby limiting causal interpretations. Longitudinal studies using daily/event-based assessment methods are needed to better capture relationships between behaviors such as discordant consumption (e.g. few blackouts, but high consumption, potentially signifying tolerance) as well as simultaneous use alcohol with other substances. Participants were recruited from a single ED, requiring additional studies in other settings to enhance generalizability of findings. Although these findings are not representative of all underage drinkers, the use of an ED-based sample has implications for enhancing delivery of efficacious ED-based interventions. While we

acknowledge the confound between age and our coding of education and Greek life status, we focused on contrasts between categories such as College and Greek life involved (vs. not involved), which were not affected by such confounding. Note also that measures of sexual assault were limited by focusing only on intercourse and not other acts, such as unwanted touching. Finally, data were generated through self-report, which despite assurances of confidentiality and use of validated measures, may be subject to response biases.

In summary, nearly 1-in-5 underage risky drinkers consistently reported blackouts over one year, which also was not affected by receipt of a brief intervention for alcohol use, underscoring the need for more intensive interventions. These youth may represent an especially high-risk sample given they were presenting to an ED for care (Wilson and Klein, 2000), which is consistent with our finding that an alcohol-related ED visit distinguished members of the higher risk groups (versus those with few or no blackouts in the following year). Despite the findings emphasizing higher risk among college students, particularly those involved in Greek Life, ~25% of the Moderate and High groups comprised individuals not in college, suggesting the need for interventions outside colleges or prior to college enrollment. EDs present a unique setting to reach these groups. The finding that groups with more frequent blackouts were distinguished by a number of risk factors at multiple levels of social ecology underscores the importance of public health efforts to reduce risky alcohol consumption and co-occurring risk behaviors, such as involvement with other drug use.

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CONFLICT OF INTEREST STATEMENT

None declared.

FINANCIAL DISCLOSURES

The authors report no relevant financial conflicts.

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