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Brief Motivational Interventions Are Associated with Reductions in Alcohol-Induced Blackouts Among Heavy Drinking College Students

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Background: Alcohol-induced blackouts, a form of anterograde amnesia that restricts the encoding of short-term memories into long-term ones, are among the most severe alcohol-related consequences. College students are at high risk of experiencing alcohol-induced blackouts, and there is a need to determine whether alcohol interventions can effectively reduce blackouts in this population. The current study uses data from 3 randomized clinical trials to examine the effect of various intervention approaches on alcohol-induced blackouts.

Methods: Four interventions were compared over 3 studies: (i) a computerized feedback intervention (electronic Check-Up To Go [e-Chug]; Study 1); (ii) a single-session brief motivational intervention (BMI; Study 1); (iii) a BMI plus behavioral economic session focused on increasing substance-free activities (BMI + Substance-Free Activity Session [SFAS]; Studies 2 and 3); and (iv) a BMI plus supplemental Relaxation Training session (BMI + Relaxation Training; Studies 2 and 3). Studies 1 and 3 also included an assessment-only control condition. For each study, participants reported whether they had experienced an alcohol-induced blackout at each time point; binary logistic regressions examined differential likelihood of experiencing an alcohol-induced blackout over time.

Results: Neither the single-session BMI nor e-Chug reduced alcohol-induced blackouts over assessment only; however, participants in the BMI + SFAS or BMI + Relaxation Training condition were significantly less likely to experience an alcohol-induced blackout compared to assessment only at 1-month (Wald = 4.77, odds ratio [OR] = 0.53, $p = 0.03$) and 6-month follow-ups (Wald = 5.72, OR = 0.52, $p = 0.02$). Study 2 also revealed a larger effect for the BMI + SFAS over the BMI + Relaxation Training condition at 6 months (Wald = 4.11 OR = 0.22, $p = 0.043$), although this was not replicated in Study 3. The effects for the 2-session BMIs lasted 6 months, at which point maturation effects diminished differences between assessment-only and intervention conditions.

Conclusions: Two sessions of BMI are a substantial enough dose to result in reductions in alcohol-induced blackouts among college student heavy drinkers.

Key Words: Alcohol-Induced Blackouts, Brief Motivational Interventions, College Students.

COLLEGE STUDENTS REPORT high rates of episodic heavy drinking (4/5 drinks for women/men) and are at particularly high risk of experiencing alcohol-induced blackouts (White and Hingson, 2013). Estimates vary, but most studies suggest that approximately 50% of college students have experienced an alcohol-induced blackout at least once in their lives (Mundt and Zakletskaia, 2012; Schuckit et al., 2015). Although memory formation is impaired during a blackout, other functioning remains intact, and individuals can still ambulate, make decisions, and continue drinking while under significantly disinhibited regulatory capacity (Lee et al., 2009), and alcohol-induced blackouts are therefore linked to alcohol-related injury (Mundt and Zakletskaia, 2012; Mundt et al., 2012). Not surprisingly, experiencing a blackout is the most significant risk factor for most other alcohol-related consequences, including having a hangover, missing class or work, arguing with friends, and seeing a doctor because of an overdose after drinking (Hingson et al., 2016). Although long-term effects on brain functioning have not been adequately assessed, preliminary studies suggest that alcohol-induced blackouts are associated with altered frontal lobe neurochemistry, specifically in the anterior cingulate cortex (Silveri et al., 2014). These alterations are associated with worsening executive functioning deficits and are present among individuals in alcohol-abusing populations, suggesting that high experience of alcohol-induced blackouts could serve as an early marker of alcohol

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dependence (Meyerhoff and Durazzo, 2008), especially considering that they are strong predictors of future alcohol consumption (Read et al., 2013).

Given the gravity of alcohol-induced blackouts and the frequency of occurrence among adolescent and young adult populations (Schuckit et al., 2015; Wetherill and Fromme, 2016), there is a need to identify or create policy and interventions that can effectively reduce the occurrence of alcohol-induced blackouts among college students. The National Institute on Alcohol Abuse and Alcoholism's *CollegeAIM* matrix, a document that summarizes the effectiveness and cost–utility of a wide range of potential interventions for college students, identifies brief motivational interventions (BMIs) as midrange in cost, but highly effective for reducing alcohol-related outcomes (National Institute on Alcohol Abuse and Alcoholism, 2015). BMIs often consist of 1 or 2 sessions (approximately 50 minutes each) delivered by a trained clinician (Carey, 2012; Neal and Carey, 2007) using a motivational interviewing style (Miller and Rollnick, 2012). These interventions are typically accompanied by alcohol education and personalized feedback that is derived from the student's response to questionnaires. Personalized feedback can include information about the student's drinking compared to college norms, their recent alcohol-related consequences (including blackouts if reported), and financial or health costs related to alcohol use (Miller et al., 2013). Although BMIs are considered among the most effective interventions for this age cohort, they require some financial commitment and level of expertise, and thus, computerized interventions have been developed to deliver personalized feedback (e.g., electronic Check-Up To Go [e-Chug]). These interventions generally have smaller effect sizes than in-person BMIs (Carey et al., 2009) but can theoretically reach more students and thus may be an effective and economic alternative.

Recent meta-analyses and mega-analyses have questioned the efficacy of BMIs due to the typically small magnitude reductions in alcohol consumption and general alcohol-related consequences across most BMI studies (Huh et al., 2015; Mun et al., 2015; Tanner-Smith and Lipsey, 2015) and have spurred efforts to supplement BMIs with additional content (Murphy et al., 2012). However, it is important to keep in mind that BMIs are a harm-reduction approach geared toward non–treatment seekers and thus have flexible goals based on the individual student's motivation. Many students are not motivated to reduce their weekly drinking or to avoid relatively minor alcohol consequences (e.g., having an argument with a friend, regretted behavior) but may be motivated to reduce more severe problems (Merrill et al., 2019). Thus, there is a need to specifically examine the influence of BMI on key drinking consequences. Consistent with this hypothesis, 1 previous study determined that single-session BMIs were associated with significant reductions in drinking and driving, another severe consequence that is often more of a central focus of BMIs compared to other relatively benign alcohol consequences that are included in feedback-based interventions and contribute to alcohol problem total score outcomes (Teeters et al., 2015).

Only 1 study has specifically examined the efficacy of BMIs in reducing the likelihood of alcohol-induced blackouts. With a sample of 188 freshmen college student drinkers, Kazemi and colleagues (2013) administered two 50-minute BMI sessions incorporating elements of alcohol education and personalized feedback, one following a baseline assessment and one after 2 weeks. These 2 sessions were followed up by 50-minute booster sessions at 3 months and 6 months postbaseline. None of the sessions focused specifically on blackout drinking. Results indicated a decrease in blackout drinking from baseline (40% reported a blackout) to the 6-month follow-up (16% reported a blackout). Although these results are promising, the study lacked a control group, which limits interpretability about whether the change was due to the direct effects of the intervention or due to maturation. The intervention duration (4 sessions over 6 months) also represents a significant burden for students and providers that may limit the disseminability of the intervention. There are a variety of intensities, or doses, within the general category of BMI that may be associated with differential effects.

Current Study

Alcohol-induced blackouts represent a serious public health concern for young adults both because of the direct neurocognitive effects of blacking out and because drinking to the point of blackout increases risk for a variety of other drinking consequences. Based on the heavy personal and societal toll of alcohol-induced blackouts, there is a need to appropriately examine the influence of brief interventions on alcohol-induced blackouts among heavy drinking college students. Thus, the current study uses data from 3 randomized clinical trials (Murphy et al., 2010; 2012, in press) conducted over the course of a decade to examine whether receiving different brief interventions (i.e., computerized personalized feedback, single-session BMI, or 2-session BMI) are followed by reductions in the experience of alcohol-induced blackouts. Alcohol-induced blackouts were examined in each of these trials; however, each study only reported reductions in combined, general alcohol-related problems or binge drinking rather than examining alcohol-induced blackouts individually. We hypothesized that all 3 intervention approaches would be associated with decreases in alcohol-induced blackouts. Further, we hypothesize that clinician-administered interventions will demonstrate a stronger effect than the computerized feedback intervention and that the 2-session clinician-administered BMI conditions would perform better than the single-session BMI condition. Finally, we will examine naturalistic changes in alcohol-induced blackouts across time using assessment-only groups.

MATERIALS AND METHODS

Parent Study Descriptions

The current study is a secondary data analysis of 3 randomized clinical trials. All 3 studies recruited non–treatment-seeking undergraduate students and compensated them with either course credit or cash for participating. See Table 1 for demographic information for each sample. Intervention conditions and their inclusion in each trial are described in Table 2. Information relevant to the CONSORT checklist for the initial studies can be referenced in the published outcome studies for each trial.

Study 1 (Murphy et al., 2010). Study 1 was a single-site randomized clinical trial (Fig. S1). The percentage of participants reporting alcohol-induced blackouts at each time point by condition for all 3 studies can be found in Fig. 1. Participants who reported at least 1 heavy-drinking episode in the past month were randomized into 1 of 3 groups: a single-session BMI (n = 46), e-Chug computerized personalized feedback (n = 45), or assessment only (n = 42). Participants in the 2 treatment groups completed the intervention (in a psychology laboratory setting) immediately following the baseline assessment, and all 3 groups completed follow-ups at 1, 6, and 12 months. Groups did not differ on typical drinks per week, or heavy drinking episodes at baseline. There was no differential attrition by condition. Participants in the 2 treatment groups demonstrated medium effect size reductions in heavy drinking episodes and typical weekly drinking at 1-month follow-up, while the assessment-only group showed no change.

Study 2 (Murphy et al., 2012). Study 2 was a single-site randomized clinical trial (NCT02837315; Fig. S2). Participants were considered eligible if they reported at least 2 heavy drinking episodes in the past month. Eligible participants were assigned to either BMI + Substance-Free Activity Session (SFAS; see below for details; n = 41) or BMI + Relaxation Training (n = 41). Participants in both groups completed the BMI with a clinician in the laboratory immediately following the baseline assessment and returned 1 week later to complete the other intervention component (SFAS or Relaxation Training). Groups did not differ on any of the drinking-related measures at baseline. There was no differential attrition by condition. Participants completed follow-ups at 1 and 6 months postintervention. Participants who received the BMI + SFAS demonstrated greater reductions in alcohol-related problems than BMI + Relaxation Training participants at 1 and 6 months.

Study 3 (Murphy et al., in press). Study 3 was a multisite, randomized clinical trial (NCT02834949; Fig. S3). Procedures for this study were identical to those used in Murphy and colleagues (2012), other than the fact that this study included an assessment-only control group, a brief telephone booster session for the SFAS and Relaxation Training sessions, and a greater number of follow-up assessments. Participants with at least 2 past-month heavy drinking episodes were assigned to BMI + SFAS (n = 130), BMI + Relaxation Training (n = 125), or assessment only (n = 138) and completed assessments at baseline (prior to intervention), 1, 6, 12, and 16 months. Groups did not differ on any of the drinking-related measures at baseline. There was no differential attrition by condition. Compared to the assessment-only condition, participants in either the BMI + SFAS or BMI + Relaxation Training condition reported significant reductions in alcohol use and problems across all follow-ups.

Table 1. Demographic Information for Studies 1, 2, and 3

Demographics	Study 1: Murphy et al. (2010) (n = 133)	Study 2: Murphy et al. (2012) (n = 82)	Study 3: Murphy et al. (in press) (n = 393)
Age in years, *M* (SD)	18.57 (1.21)	18.51 (0.71)	18.77 (1.07)
Race (% White)	85 (63.9%)	66 (80.5%)	310 (78.9%)
Gender (% female)	66 (49.6%)	41 (50%)	239 (60.8%)
Years in school			
Freshman	130 (97.7%)	82 (100%)	244 (62.1%)
Sophomore	3 (2.3%)	–	149 (37.9%)
Junior	–	–	–
Senior	–	–	–
Typical drinks per week, *M* (SD)	16.19 (15.19)	16.87 (11.55)	17.03 (13.79)
Past-month binge drinking, *M* (SD)	5.65 (4.86)	6.02 (4.33)	6.19 (4.12)

Measures

Alcohol-induced blackouts were assessed across all 3 studies using 3 items from the Young Adult Alcohol Consequences Questionnaire (YAACQ; Read et al., 2006). Participants were asked to endorse or deny experiencing various alcohol-related problems over the past month. Three items taken from the preexisting Blackout subscale of the YAACQ (e.g., "I've not been able to remember large stretches of time while drinking heavily"; "I have awakened the day after drinking and found that I could not remember a part of the evening before"; and "I have had a blackout after drinking heavily [i.e., could not remember hours at a time]") were combined and coded dichotomously (y/n).

Interventions

Assessment Only. Elements included in each intervention condition can be found in Table 2. An assessment-only condition was included in Studies 1 and 3. In this condition, participants only completed the baseline and follow-up surveys.

e-Chug. The e-Chug condition was an intervention condition in Study 1. Participants in the e-Chug condition participated in an interactive Web-based program that presented them with personalized feedback after completing a brief drinking assessment. Participants were presented with the same 6 feedback components as the BMI with the addition of a family risk score based on familial history of problematic alcohol and drug use. No content, education, or feedback was provided specific to engagement in alcohol-induced blackouts. After interacting with the material for approximately 30 minutes, participants completed a brief comprehension check (Murphy et al., 2010).

Brief Motivational Intervention. The BMI session was included in Studies 1, 2, and 3. The BMI was presented in a motivational intervention style (Miller and Rollnick, 2012) and was essentially identical across studies. Components included the following: (i) a discussion about confidentiality and student autonomy; (ii) an alcohol use decisional balance exercise; (iii) a personalized feedback related to alcohol use; and (iv) summary and goal-setting exercise. The personalized feedback included 6 elements: (i) a comparison of perceived versus actual college student drinking norms; (ii) a comparison of students actual drinking versus national gender-specific norms; (iii) a discussion about blood alcohol content (BAC), including personalized feedback about estimated BAC for the participant during their highest reported drinking night; (iv) personalized list of alcohol-related problems endorsed by the participant (including the blackout items if endorsed); (v) money spent on alcohol and cost of driving under the influence; and (vi) calories from alcohol. The goal-setting activity was only initialized if participants expressed interest. The BMI condition contained the same elements across all

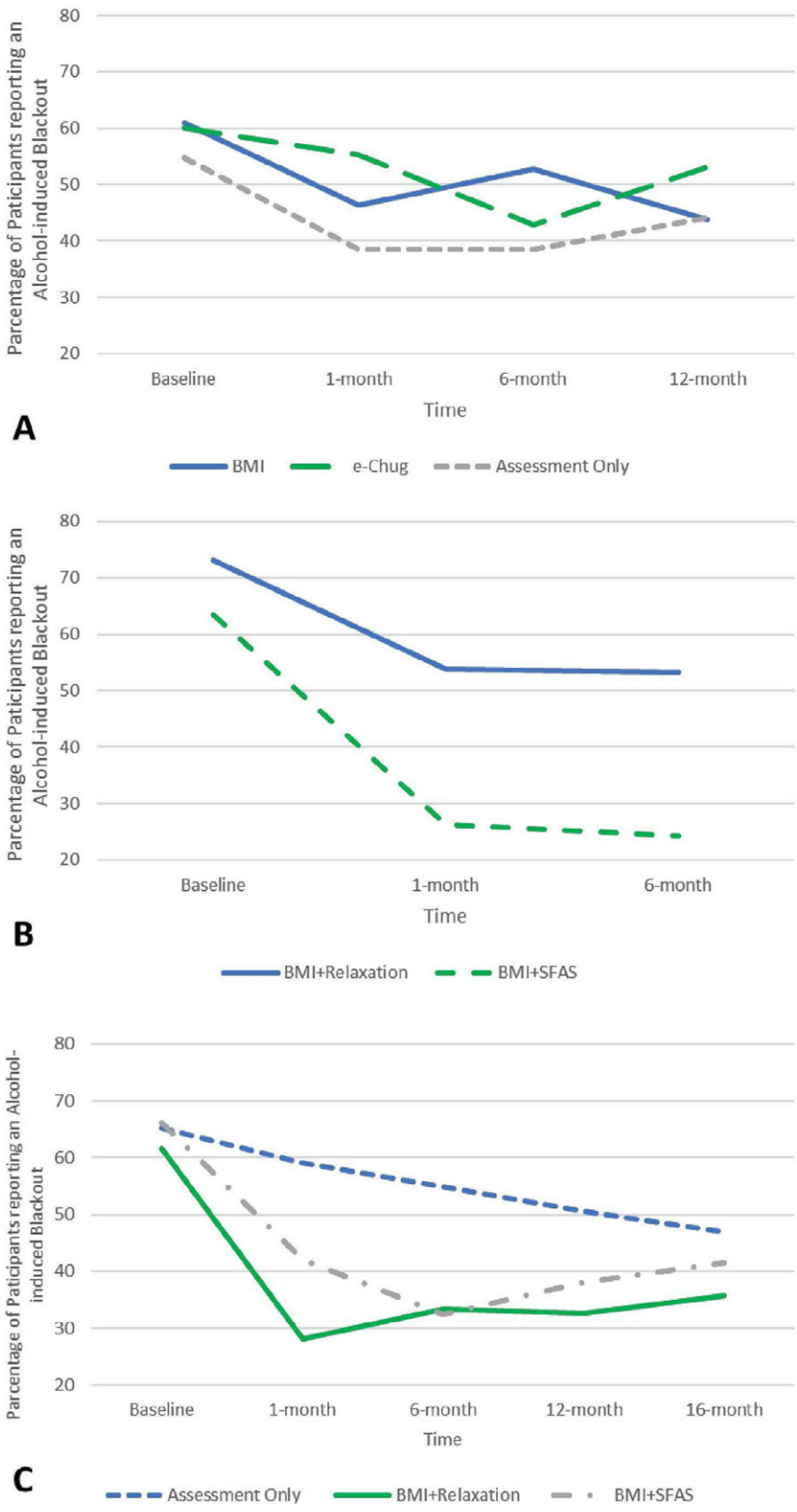

Fig. 1. Percentage of participants reporting alcohol-induced blackouts at each time point in (**A**) Study 1 (Murphy et al., 2010), (**B**) Study 2 (Murphy et al., 2012), and (**C**) Study 3 (Murphy et al., in press). In Study 1, there were no significant differences between any of the conditions. In Study 2, the BMI + SFAS condition resulted in significantly less likelihood of an alcohol-induced blackout at 1 month, but not 6 months, compared to the BMI + Relaxation Training condition. In Study 3, both BMI conditions were associated with a decreased likelihood of experiencing an alcohol-induced blackout out to 12 months compared to the assessment-only condition. BMI, brief motivational intervention; SFAS, Substance-Free Activity Session.

Table 2. Elements Found in Each Intervention Condition for All Studies

Study conditions	Study 1	Study 2	Study 3
–	✓		
BMI—50 minutes			
Discussion of participant's autonomy			
Alcohol decisional balance			
Alcohol PF			
Perceived versus actual drinking norms			
Discussion of student's peak BAC			
Personalized list of alcohol problems			
Money spent on alcohol			
Calories consumed through drinking			
Goal Setting			
Review of Protective Strategies			
Substance-Free Activity Session (SFAS)—50 minutes		✓	✓
Discussion of academic and career goals			
Academic/Career-Focused Information			
College graduation rates			
Income by degree type and GPA			
GPA by time drinking versus in class			
Academic/Career-Focused PF			
Requirements for chosen major/career			
Career-specific list of activities			
Time allocation			
Coping strategies			
List of hobbies and leisure activities			
Relaxation Training supplement—30 minutes		✓	✓
Diaphragmatic breathing exercise			
Progressive muscle relaxation			
Discussion of reaction			
e-Chug	✓		
Brief drinking assessment			
Alcohol PF			
Quantity and frequency of drinking			
Comparison of drinking with actual norms			
Peak BAC; tolerance			
Alcohol-related consequences			
Money spent on alcohol			
Calories consumed from alcohol			
Family risk score			
Assessment only	✓		✓
Completed assessment measures at baseline and follow-ups			

BAC, blood alcohol content; BMI, brief motivational intervention; GPA, grade point average; PF, personalized feedback.

Five intervention conditions were examined: (i) a single-session brief motivational intervention (BMI; Study 1); (ii) a computerized feedback intervention (e-Chug; Study 1); (iii) a BMI plus supplemental session focused on increasing substance-free activities (BMI + SFAS; Studies 2 and 3); (iv) a BMI plus supplemental Relaxation Training session (BMI + Relaxation Training; Studies 2 and 3); and (v) assessment-only control condition (Studies 1 and 3).

3 studies. However, in Studies 2 and 3 the BMI was followed by 1 of 2 supplemental sessions.

Relaxation Training. The Relaxation Training condition was a supplemental intervention condition in Studies 2 and 3. One week following the BMI, participants in this condition completed a 30-minute relaxation training session that was intended to instruct relaxation and stress reduction strategies (i.e., diaphragmatic breathing and progressive muscle relaxation). Relaxation Training was selected as an active control condition because it is a common wellness strategy and has previously been used as an alcohol treatment element (Klajner et al., 1984; Murphy et al., 2012). Due to the high levels of stress and anxiety present among college populations that are often associated with drinking severity (American College Health Association, 2015), relaxation training may be a beneficial supplement to BMI content.

Substance-Free Activity Session. The SFAS was a supplemental intervention condition in Studies 2 and 3. One week following the BMI, participants in the SFAS condition completed a 1-hour behavioral economic session that was intended to increase future orientation and substance-free activity engagement. The overarching goals of the SFAS are to increase engagement in enjoyable and meaningful alternatives to drinking; identify short-term, intermediate, and long-term goals; increase the extent to which behavior is motivated by long-term goals; explore how drinking interferes with goal achievement; and provide practical advice related to college adjustment, all while maintaining a motivational interviewing style. Feedback elements included the following: (i) income differences for college versus high school graduates; (ii) income differences by GPA; (iii) personalized information about career requirements for a previously specified occupational field; (iv) personalized career-related activities relevant to successful completion of these goals; (v) personalized feedback about how the participant spends their time; (vi) a discussion about personalized substance-free recreational activity options available throughout the community based on previously described interests; and (vii) a goal-setting activity. More details can be found in Murphy and colleagues (in press). For all studies, BMI and SFAS conditions were coded for fidelity (Murphy et al., 2010, 2012, in press).

Data Analysis

All variables containing outliers were winsorized per recommendations of Tabachnick and Fidell (2013). Chi-square tests were conducted to evaluate differential attrition by baseline alcohol-induced blackouts for all 3 studies at each follow-up. Logistic regression analyses were conducted separately for each study to determine whether alcohol-induced blackouts were significantly less likely between groups at each follow-up. The dependent variable was report of an alcohol-induced blackout (no/yes). Each regression controlled for gender baseline alcohol-induced blackouts, baseline typical drinks per week, and drinks per week for the time point contemporaneous with the outcome time point of the regression (i.e., change in typical drinks per week). For all regressions that are significant, reductions in alcohol-induced blackouts for each time point compared to the baseline assessment were reported.

Table 3. Percentage of Participants Experiencing Alcohol-Induced Blackouts for Each Study by Condition at Each Time Point

Study 1

	Alcohol consumption	Blackouts			
		%			
	Mean (SD) Baseline	Baseline	1 month	6 months	12 months
Full sample	16.19 (15.19)	58.6	46.6	44.5	46.9
Assessment only	14.90 (10.80)	54.8	38.5	38.5	44.1
e-Chug	17.48 (15.32)	60.0	55.3	42.9	53.1
BMI	16.10 (18.38)	60.9	46.3	52.8	43.8

Study 2

	Alcohol consumption	Blackouts		
		%		
	Mean (SD) Baseline	Baseline	1 month	6 months
Full sample	16.87 (11.55)	68.3	40.3	37.3
BMI + Relaxation Training	17.68 (11.89)	73.2	53.8	53.3
BMI + SFAS	16.06 (11.29)	63.4	26.3[a]	24.3

Study 3

	Alcohol consumption	Blackouts				
		%				
	Mean (SD) Baseline	Baseline	1 month	6 months	12 months	16 months
Full sample	16.76 (11.98)	61.8	40.3	36.5	36.1	38.7
Assessment only	17.63 (12.55)	63.8	55.9	49.6	44.8	44.7
BMI + Relaxation Training	14.14 (8.89)	60.8	26.5[c]	31.5	26.8	34.0
BMI + SFAS	18.35 (13.51)	60.8	37.2[b]	27.0[b]	36.3	37.6

BMI, brief motivational intervention; SD, standard deviation; SFAS, Substance-Free Activity Session.
[a]Significant difference between BMI + SFAS and BMI + Relaxation Training.
[b]Significant difference between BMI + SFAS and assessment only.
[c]Significant difference between BMI + Relaxation Training and assessment only.

RESULTS

Study 1 (Murphy et al., 2010)

For all 3 studies, descriptive data of occurrence of alcohol-induced blackouts over time in each condition can be found in Table 3. Endorsement of baseline alcohol-induced blackouts was not associated with differential attrition at 1-month ($\chi^2 = 0.10$, $p = 0.76$), 6-month ($\chi^2 = 0.09$, $p = 0.76$), or 12-month ($\chi^2 = 0.09$, $p = 0.77$) follow-up. There were no significant differences between an active intervention condition and the assessment-only group in the likelihood of experiencing an alcohol-induced blackout at 1-month (Wald = 1.68 odds ratio [OR] = 0.50, $p = 0.20$), 6-month (Wald = 0.70 OR = 0.63, $p = 0.40$), or 12-month (Wald = 0.23 OR = 1.30, $p = 0.63$) follow-up. Similarly, there were no significant differences between the BMI or e-Chug and assessment-only condition at any time point.

Study 2 (Murphy et al., 2012)

Endorsement of baseline alcohol-induced blackouts was not associated with differential attrition by condition at 1-month ($\chi^2 = 3.00$, $p = 0.39$) or 6-month ($\chi^2 = 1.93$, $p = 0.59$) follow-up. There was a nonsignificant trend-level effect of intervention on likelihood of experiencing an alcohol-induced blackout at 1-month follow-up (Wald = 3.49, OR = 0.29, $p = 0.06$) and a significant effect at the 6-month follow-up (Wald = 4.11 OR = 0.22, $p = 0.043$), suggesting that those in the BMI + SFAS condition were less likely to report experiencing an alcohol-induced blackout than those in the BMI + Relaxation Training condition. In the BMI + SFAS condition, 26 participants reported an alcohol-induced blackout at baseline compared with 10 and 9 at 1- and 6-month follow-ups (61.5% and 65.3% reduction, respectively). In the BMI + Relaxation Training condition, 30 participants reported an alcohol-induced blackout at baseline compared with 21 and 16 at 1- and 6-month follow-ups (30.0% and 46.6% reduction, respectively).

Study 3 (Murphy et al., in press)

Endorsement of baseline alcohol-induced blackouts was not associated with differential attrition at 1-month ($\chi^2 = 1.18$, $p = 0.28$), 6-month ($\chi^2 = 0.58$, $p = 0.45$), 12-month ($\chi^2 = 0.07$, $p = 0.80$), or 16-month ($\chi^2 = 0.18$, $p = 0.67$) follow-up. At the 1-month (Wald = 4.77,

OR = 0.53, $p = 0.03$) and 6-month follow-ups (Wald = 5.72, OR = 0.52, $p = 0.02$), those in either BMI condition (BMI + SFAS or BMI + Relaxation Training) were significantly less likely to report an alcohol-induced blackout compared to the assessment-only control. When examining effects separated by BMI conditions, the BMI + SFAS condition remained the same; the BMI + Relaxation Training condition, however, was only significant at 1-month follow-up. There was no treatment effect at 12-month (Wald = 1.24, OR = 1.72, $p = 0.27$) or 16-month follow-up (Wald = 0.001, OR = 1.01, $p = 0.97$). There were no significant differences between the SFAS and the Relaxation Training groups at any time point. Across both BMI conditions, 155 participants reported an alcohol-induced blackout at baseline, compared with 76 at 1 month (50.1% reduction), 64 at 6 months (58.7% reduction), 71 at 12 months (54.1% reduction), and 74 at 16 months (52.2% reduction). In the assessment-only condition, 88 participants reported an alcohol-induced blackout compared with 71 at 1 month (19.3% reduction), 61 at 6 months (30.7% reduction), 52 at 12 months (40.1% reduction), and 46 at 16 months (47.7% reduction).

DISCUSSION

Although the efficacy of BMIs in reducing general alcohol problems is well established, only 1 study has examined the effect of BMIs on the likelihood of experiencing alcohol-induced blackouts over time (Kazemi et al., 2013). The present study replicates and extends this area of research using data from 3 randomized clinical trials. The findings from Study 1 indicated that there were no significant differences between the assessment-only, single-session BMI, or e-Chug conditions in reducing the likelihood of experiencing an alcohol-induced blackout. Study 2 compared 2 supplemental sessions to BMIs to examine whether increasing the dose could increase the efficacy of the BMI for reducing alcohol-induced blackouts. Study 2 revealed that participants in the BMI + SFAS condition were significantly less likely to report an alcohol-induced blackout at 6 months compared to those in the BMI + Relaxation Training group. Study 3 compared these 2 groups with an assessment-only condition in a larger, multisite sample of heavy drinking college students and found that participants receiving any 2-session BMI were significantly less likely to experience an alcohol-induced blackout at 1- and 6-month follow-ups compared to the assessment-only control (Fig. 1).

In the previous study examining the influence of BMI sessions on reducing alcohol-induced blackouts among heavy drinking college students (Kazemi et al., 2013), all participants engaged in four 1-hour sessions over the course of 6 months, and the results suggested that participants reduced alcohol-induced blackouts, albeit without a comparison group. Our results extend this finding by comparing the effect of the BMI with a control group over a longer follow-up period. Our results suggest that 2 sessions may be adequate to observe significant short-term reductions in the likelihood of alcohol-induced blackouts. The sample generally demonstrated maturation effects, as all conditions experienced reductions over time. Given the dose effect found in the current study, we suspect that the Kazemi and colleagues (2013) findings are also the result of increased BMI dose, although the effect cannot be parsed apart from maturation effects.

Our results are also consistent with previous research demonstrating the influence of BMIs on alcohol consumption and alcohol-related problems more generally (Murphy and Dennhardt, 2016; Murphy et al., 2012; Tanner-Smith and Lipsey, 2015). The results lasted approximately 6 months, which is a shorter time frame than for reductions in general problems after a BMI (Tanner-Smith and Lipsey, 2015). These results accounted for changes in drinking over time, suggesting that the reductions in alcohol-induced blackouts occurred over and above any decrease in drinking accounted for by the intervention. Instead of reducing consumption levels, the effect of the 2-session BMIs might be through shifting *patterns* in drinking that result in lower overall BAC values, resulting in fewer blackouts (e.g., drinking the same amount over an extended period of time, avoiding shots or hard alcohol). Thus, although previous work has demonstrated that single-session BMIs reduce alcohol consumption and problems, our results suggest more intensive approaches may be needed to reduce blackouts. It is important to note, however, that the single-session BMI in Study 1 was associated with changes in alcohol consumption but not in general alcohol problems (secondary data analysis). Other research suggests that another risky behavior, driving after drinking, is reduced following single-session BMIs (Teeters et al., 2015), and it has more recently been shown to reduce following a text message intervention (Teeters et al., 2018). Perhaps driving after drinking is conceptualized as a riskier behavior within the student's motivational framework before the BMI begins, which leads to a greater likelihood of decreases in this behavior postintervention. Reductions in driving after drinking may also be achieved without changing drinking behavior, whereas reductions in alcohol-induced blackouts require some change in drinking.

Considering the high prevalence rate of alcohol-induced blackouts (62% or greater in all 3 samples), the profound implications associated with this phenomenon, and the cost efficiency of BMIs, these results are promising and suggest that brief contact (approximately 2 hours) can drastically decrease the occurrence of alcohol-induced blackouts among heavy-drinking college students until at least 6 months, at which point maturation effects reduce the difference between the BMI and control conditions. Even so, the BMIs accelerate the natural downward-sloping trajectory of maturation, which may lead to enhanced gains in alcohol-free areas (e.g., school) and reductions in other alcohol-related problems, highlighting the need for more intervention to increase the duration of the effects. Previous research suggests that individuals who experience blackouts

may show greater overall response to BMIs (Miller et al., 2018a,b), which suggests that there may be utility in specifically identifying students for BMIs on the basis of a recent blackout experience.

Strengths, Limitations, and Future Directions

The current study has several notable strengths. We used 3 samples of heavy drinking college students, representative of the college population that often engages in high levels of alcohol consumption that result in alcohol-induced blackouts. We also examined several different interventions (computer-delivered, BMI, BMI + SFAS, BMI + Relaxation Training) over the course of multiple studies that enhance our confidence in the current findings. The final study included a large sample and examined outcomes out to 16 months.

Despite these strengths, several limitations should be noted. First, we used an aggregate and retrospective measure of blackout drinking from the YAACQ. Although the YAACQ produces reliable and valid indices of alcohol problems (Read et al., 2006), blackout drinking represents periods of short-term memory loss, which may or may not be accurately recalled by heavy drinking college students. Second, our samples were restricted to heavy drinking college students, which may not generalize to other populations. Despite this, we suggest that this high-risk sample is necessary to study the phenomenology of this high-risk outcome. Third, our study did not differentiate between blackout (en bloc) and brownout (fragmentary) drinking, which are conceptually different and demonstrate differences within the literature (Miller et al., 2018c). We used the higher threshold en bloc definition of blackouts which likely missed many fragmentary (brownout) episodes and resulted in an underestimation of the number of individuals who are blacking out. Future studies should explore the effects of BMIs on fragmentary blackouts, which are considered less serious but occur more frequently and still result in higher levels of problems. Finally, different aspects of study design (i.e., small sample size and lack of control group) for Studies 1 and 2 leave some room for error in findings and suggest that future research should examine these separate interventions with larger sample sizes and adequate controls. A study examining 1-session interventions for alcohol-induced blackouts among college students with more power may find differential results.

Despite these limitations, these results have clear clinical implications and extend BMI and alcohol-induced blackout literatures. The results suggest that 2-session BMIs are associated with substantial reductions in the report of alcohol-induced blackouts. BMIs are typically 1 session long. Although they consistently result in decreases in problematic alcohol use, a greater dose may be necessary to address alcohol-induced blackouts. Based on the outcome of Study 3, an increased time spent with a counselor focused on alcohol use generally may impact patterns of consumption just enough to reduce blackout rates overall. Further, the BMI + SFAS condition outperformed the BMI + Relaxation Training condition in Study 2 and lasted longer in Study 3, although the Study 2 differences were not replicated. The content of the BMI + SFAS, focused on increasing substance-free reward and enhancing consideration of the future, may work additively with increased counselor dose to account for the duration of the effect. The studies also had notable differences in sample characteristics, including different gender and college class differences. Given the lack of specific alcohol-induced blackout content in these interventions, the dose may also be effectively increased through a single session focused specifically on reducing alcohol-induced blackouts, rather than general sessions with feedback elements relevant to different aspects of drinking. Considering that alcohol-induced blackouts are highly predictive of all other consequences (Hingson et al., 2016), an intervention focused on decreasing alcohol-induced blackouts may reduce all other consequences as well and result in significant reductions in the public health burden over time. The relation between alcohol-induced blackouts and other consequences has not been established as causal, however, and alcohol-induced blackouts may serve as a marker of heavy drinking rather than a cause of alcohol-related problems.

These findings also highlight that alcohol-induced blackout drinking may be more difficult to reduce than other outcomes. Interestingly, recent research demonstrates that reporting an alcohol-induced blackout at baseline results in better treatment response (Miller et al., 2018a,b). Theoretically, these individuals are drinking at a high level and thus have a higher potential for reduction. However, these studies did not report on those who continue to experience alcohol-induced blackouts at follow-ups, nor the effect on future blackout drinking. A subset of these individuals that are resistant to change, and thus continue to drink to black out, could account for a significant proportion of null effects among this population. An important research priority should include the identification of predictors of *stable* blackout drinking over time. Some research suggests that those who experience a blackout may be more susceptible to future blackouts (Marino and Fromme, 2018), partly because of inhibitory processing difficulties (Silveri et al., 2014). These individuals may be the ones resistant to change. Identifying and targeting variables like this could potentially increase the overall efficacy of BMIs, particularly in light of our findings.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Fig. S1. Flow diagram for Study 1 (Murphy et al., 2010). This flow diagram was initially published in the *Psychology of Addictive Behaviors*.

Fig. S2. Flow diagram for Study 1 (Murphy et al., 2012). This flow diagram was initially published in the *Journal of Consulting and Clinical Psychology*.

Fig. S3. Flow diagram for Study 1 (Murphy et al., in press). This flow diagram has been submitted in conjunction with the associated manuscript at the *Journal of Consulting and Clinical Psychology*.