Caffeinated Cocktails: Energy Drink Consumption, High-risk Drinking, and Alcohol-related Consequences among College Students

Mary Claire O'Brien, MD, Thomas P. McCoy, MS, Scott D. Rhodes, PhD, Ashley Wagoner, BS, Mark Wolfson, PhD

Abstract

Objectives: The consumption of alcohol mixed with energy drinks (AmED) is popular on college campuses in the United States. Limited research suggests that energy drink consumption lessens subjective intoxication in persons who also have consumed alcohol. This study examines the relationship between energy drink use, high-risk drinking behavior, and alcohol-related consequences.

Methods: In Fall 2006, a Web-based survey was conducted in a stratified random sample of 4,271 college students from 10 universities in North Carolina.

Results: A total of 697 students (24% of past 30-day drinkers) reported consuming AmED in the past 30 days. Students who were male, white, intramural athletes, fraternity or sorority members or pledges, and younger were significantly more likely to consume AmED. In multivariable analyses, consumption of AmED was associated with increased heavy episodic drinking (6.4 days vs. 3.4 days on average; $p < 0.001$) and twice as many episodes of weekly drunkenness (1.4 days/week vs. 0.73 days/week; $p < 0.001$). Students who reported consuming AmED had significantly higher prevalence of alcohol-related consequences, including being taken advantage of sexually, taking advantage of another sexually, riding with an intoxicated driver, being physically hurt or injured, and requiring medical treatment ($p < 0.05$). The effect of consuming AmED on driving while intoxicated depended on a student's reported typical alcohol consumption (interaction $p = 0.027$).

Conclusions: Almost one-quarter of college student current drinkers reported mixing alcohol with energy drinks. These students are at increased risk for alcohol-related consequences, even after adjusting for the amount of alcohol consumed. Further research is necessary to understand this association and to develop targeted interventions to reduce risk.

ACADEMIC EMERGENCY MEDICINE 2008; 15:453–460 © 2008 by the Society for Academic Emergency Medicine

Keywords: energy drinks, alcohol, injury

From the Departments of Emergency Medicine (MCO), Social Sciences and Health Policy (MCO, SDR, AW, MW), Biostatistical Sciences (TPM), and Pediatrics (MW), Wake Forest University School of Medicine, Winston-Salem, NC.

Received November 27, 2007; revision received January 11, 2008; accepted January 13, 2008.

Presented at the Annual Meeting of the American Public Health Association, Washington, DC, November 4, 2007.

Supported by Grants R01 AA14007-2 and 2R01 AA014007-06A1 from the National Institute on Alcohol Abuse and Alcoholism (NIAAA) and North Carolina DHHS/OJJDP EUDL Award 2004-AH-FX-0014.

Address for correspondence and reprints: Mary Claire O'Brien, MD; e-mail: mobrien@wfubmc.edu.

Energy drinks are beverages that claim to provide a burst of energy by using a combination of caffeine (the principal active ingredient), other plant-based stimulants (e.g., guarana, yerba mate), simple sugars (e.g., glucose, fructose), glucuronolactone (a naturally occurring glucose metabolite), amino acids (e.g., taurine, carnitine, creatine), herbs (e.g., ginkgo biloba, ginseng), and vitamins. The effects of these ingredients are incompletely understood. A 6-ounce serving of brewed coffee contains 100 mg of caffeine; the caffeine content of energy drinks varies considerably, with some energy drinks containing more than 300 mg or more per serving.[1] In 2006, Americans spent more than $3.2 billion dollars on energy drinks.[2] Declining soda

doi: 10.1111/j.1553-2712.2008.00085.x
ISSN 1069-6563
PII ISSN 1069-6563583

sales have encouraged beverage companies to focus on this lucrative market[2] and increasingly to market energy drinks to specific segments of the population,[2] including women, herb and vitamin enthusiasts, the affluent, and youth.

Thirty-four percent of 18- to 24-year-olds are regular energy drink users.[2] Many energy drinks are marketed to young consumers through the careful selection of ''taboo'' drink names such as ''Daredevil,'' ''WhoopAss,'' and ''Cocaine,'' and catchy slogans that emphasize endurance and sexual prowess (e.g., ''You can sleep when you're 30''[3]; ''Get it up and keep it up''[4]). Energy drinks are selectively and aggressively marketed to college students. Red Bull, for example, enlists ''student brand managers,'' whose duties include distributing free samples and gathering information for Red Bull about individual college cultures to aid in targeted marketing.[5] The company also employs ''mobile energy teams'' to provide free energy drinks to the public and to ''educate'' consumers about the benefits of energy drinks. Young people are explicitly targeted at extreme sports events (e.g., race car driving, waterfall kayaking, parasailing), where energy drink sponsorships fuel a belief in the invincibility and stamina of the average energy drink consumer.

Consuming alcohol mixed with energy drinks (AmED) is common on college campuses.[6] The alcohol industry has been criticized for actively promoting the consumption of AmED, by creating brand confusion with nonalcoholic versions, pricing alcoholic energy drinks below nonalcoholic versions, marketing alcoholic drinks that use energy drinks as an ingredient (e.g., Jager Bombs, Red Bull and vodka), and using the student-based marketing strategies already exploited by energy drink companies.[7]

In two laboratory-based investigations, the consumption of a caffeinated beverage has been shown to lessen subjective intoxication in persons who also have consumed alcohol.[8,9] A small double-blinded study detected no significant differences in the physiologic and biochemical parameters of volunteers who drank alcohol compared to alcohol plus energy drink.[10] Caffeine has been shown to promote voluntary ethanol consumption in male rats.[11]

Alcohol is the major risk factor for injury. Emergency physicians have an opportunity and a responsibility to address unhealthy alcohol use with their patients. This study examines the relationships between energy drink use, high-risk drinking behavior, and alcohol-related consequences within a sample of college students. We hypothesized that college students who consumed AmED would have an increased risk of alcohol-related consequences.

METHODS

Study Design and Population

In Fall 2006, we invited a stratified random sample of undergraduate college students attending 10 universities (8 public and 2 private) in North Carolina to complete an online Internet-based survey of alcohol use and other risk behaviors. The survey was part of the Study to Prevent Alcohol-Related Consequences among college students (SPARC), a National Institute on Alcohol Abuse and Alcoholism (NIAAA)-funded randomized community trial to reduce high-risk drinking among college students. Campus sizes ranged from approximately 5,375 to 44,841 students (graduate and undergraduate students combined), with all universities having a graduate program.

Campus administrators were approached by the study team during the project protocol development and asked whether they wanted their students to participate. These administrators worked with the study team to ensure that the project adhered to university requirements as well as expectations for student recruitment and participation. Human subjects review and study oversight were provided by the Wake Forest University School of Medicine (WFUSM) institutional review board (IRB). The review boards of other universities participating in this study either approved this study or officially deferred to the WFUSM IRB. The registrar at each campus provided the e-mail addresses for each enrolled student.

Survey procedures have been described in detail elsewhere.[12–14] We first placed posters in common areas on each campus (e.g., residence halls and dorms, student unions, and cafeterias) encouraging students to check their e-mail accounts for an invitation to participate in the study. We then randomly selected students from each campus by academic classification (''freshman,'' ''sophomore,'' ''junior,'' and ''senior'') and sent postcards asking them to check their e-mail accounts for an invitation to complete the online Internet-based assessment. These same randomly selected students were sent messages by e-mail describing the study and encouraging them to complete the online Internet-based assessment. The e-mail messages contained a link to a secure uniform resource locator (URL) where the student completed the assessment. We sent nonrespondents up to four reminder e-mails. All students who completed the survey were sent e-mails awarding them $10.00 in PayPal® money. From the list of completions, one student from each school was randomly selected to receive $100.00 in PayPal® money.

The sample size varied between campuses based on the enrollment. However, a target response quota of 33% was assumed so that the selected samples would produce sufficient completed surveys to provide the statistical power necessary for the SPARC study.[14] The Web-site was shut down shortly after the target number from each school was achieved (i.e., 365 per school). A total of 4,271 students completed the survey. A description of the sample is provided in Table 1.

Survey Content and Administration

The Web-based survey was developed after reviewing the Harvard College Alcohol Survey,[15] the CORE questionnaire,[16] the Youth Survey questionnaire used in the National Evaluation of the Enforcing Underage Drinking Laws program,[17] DeJong's College Drinking Survey,[18] and the Youth Risk Behavior Survey.[19] The questionnaire had 307 items (with multiple skip patterns based on the absence of reported behaviors) and took between 17 and 24 minutes to complete.[14] The survey measured demographic variables, attitudes

Table 1
Characteristics of Students by Reporting of Mixing Alcohol and Energy Drinks (AmED) (N = 4,237)

Characteristics, n (%) or mean ± SD	Overall	Nondrinkers, n = 1,351 (32%)	Non-AmED, n = 2,189 (52%)	AmED, n = 697 (16%)
Gender***				
Male	1,638 (39)	450 (33)	857 (39)	331 (47)
Female	2,572 (61)	895 (66)	1,317 (60)	360 (52)
No response	27 (<1)	6 (<1)	15 (<1)	6 (<1)
Academic classification				
Freshman	1,110 (26)	481 (36)	468 (21)	161 (23)
Sophomore	1,078 (25)	356 (26)	546 (25)	176 (25)
Junior	1,045 (25)	334 (25)	546 (25)	165 (24)
Senior	840 (20)	158 (12)	515 (24)	167 (24)
Other	129 (3)	16 (1)	91 (4)	22 (3)
No response	35 (<1)	6 (<1)	23 (1)	6 (<1)
Age**	20.4 ± 2.8	20.0 ± 2.9	20.7 ± 2.8	20.3 ± 2.2
Race*				
Non-Hispanic white	3,291 (78)	939 (70)	1,766 (81)	586 (84)
African American	353 (8)	184 (14)	140 (6)	29 (4)
Hispanic	161 (4)	58 (4)	77 (4)	26 (4)
Asian/Pacific Islander	228 (5)	94 (7)	109 (5)	25 (4)
Other	191 (5)	72 (5)	90 (4)	29 (4)
No response	13 (<1)	4 (<1)	7 (<1)	2 (<1)
Fraternity/sorority status**				
Pledge	143 (3)	20 (1)	85 (4)	38 (5)
Member	368 (9)	46 (3)	221 (10)	101 (14)
Neither	3,726 (88)	1,285 (95)	1,883 (86)	558 (80)
Athletic status***				
Intramural	936 (22)	242 (18)	471 (22)	223 (32)
Varsity	220 (5)	80 (6)	107 (5)	33 (5)
Nonathlete	3,081 (73)	1,029 (76)	1,611 (74)	441 (63)
Campus residence				
On-campus	2,401 (57)	911 (67)	1,154 (53)	336 (48)
Off-campus	1,813 (43)	435 (32)	1,023 (47)	355 (51)
No response	23 (<1)	5 (<1)	12 (<1)	6 (<1)

*$p < 0.05$, **$p < 0.01$, and ***$p < 0.001$ from mixed-effects logistic regression comparing AmED vs. non-AmED only.

about alcohol consumption, drinking behaviors, other substance use behaviors, consequences experienced from one's own drinking, and consequences experienced as a result of other students' drinking. Students were asked whether in the past 30 days they had experienced any of the following consequences as a result of their drinking or the drinking of others: being taken advantage of sexually, taking advantage of another sexually, driving under the influence of alcohol, riding with a driver who was under the influence of alcohol, being hurt or injured, or requiring medical treatment. Students were asked why they mix alcohol with energy drinks; they were permitted to select multiple reasons. Items to assess high-risk drinking included: 1) typical number of drinks in a drinking episode; 2) number of days of binge (or heavy episodic) drinking in the past 30 days (range = 0–30 days); 3) number of days drunk in a typical week (range 0–7 days); and 4) greatest number of drinks in a single episode in the past 30 days. Binge drinking was defined in the widely accepted manner as drinking four or more drinks in a row for females and five or more drinks in a row for males.[20] Students were also asked "In a typical week, how many days do you get drunk?" where drunk was defined in the standard way as "dizzy, unsteady, or sick to your stomach."[21] High-risk drinking was defined as either heavy episodic drinking or drinking to drunkenness.

Data Analysis

The goals of the statistical analysis were to: 1) estimate the prevalence of mixing alcohol with energy drinks among past 30-day drinkers, 2) examine the association of mixing alcohol with energy drinks and high-risk drinking, and 3) examine the association of mixing alcohol with energy drinks and alcohol-related consequences, after adjusting for drinking behaviors. We sought to examine the additional risk of adding energy drinks to alcohol; survey skip patterns restricted the questions about energy drink use to those students who reported that they had drunk alcohol at least once in the past 30- days (N = 2,886; 68% of all students).

Drinking outcomes were analyzed using multivariable linear mixed-effects modeling. These models adjusted for student gender, age, race, fraternity or sorority status (member, pledge, or neither), athlete status (varsity athlete, intramural, or neither), and within-campus clustering. Because students were nested within 10 universities, a mixed-model approach was used in the statistical analysis. Specifically, a random intercept model was fit to account for the within-university correlation of student responses so that students were considered nested within campus. Adjusted means and standard errors were calculated for consumption of AmED, where the observed marginals of the covariates were used in estimating. Mixed-effects logistic regression models were fit for the six alcohol-related

consequences. The logistic models were used to assess if there was a significant increase in the probability of reporting the given consequence in the past 30 days, adjusting for student age, gender, race, fraternity or sorority status, athlete status, typical number of drinks in a single episode (all as covariates), and within-campus clustering (school as random effect). The primary independent variable was the indicator variable for consuming energy drinks with alcohol on any day in the past 30 days (AmED; 1 = yes, 0 = no). In the models for alcohol-related consequences, the two-way interaction of AmED and typical alcohol consumption (No. of drinks) was first tested and retained in the model if significant at the 5% level. Predicted probabilities were calculated using observed marginals of the covariates. Analysis of the outcome ''driving while under the influence'' resulted in a significant interaction effect between energy drink consumption with alcohol and typical number of drinks. To illustrate the nature of this interaction effect, predicted probabilities were calculated for all combinations of these two variables (Figure 1). Univariate analysis for checking normality was assessed using box plots, Q-Q plots, and Shapiro-Wilk tests. Regression assumptions were assessed with residual analyses and influence diagnostics. Multicollinearity diagnostics, such as variance inflation factors (VIFs), were checked and modeling adequacy supported (all VIFs < 1.3, below the diagnostic cutoff of 10).[22,23]

All analyses were performed using Stata v9.2 (Stata Corp, College Station, TX) and the Generalized Linear Latent and Mixed Models (GLLAMM) package (http://www.gllamm.org/).[24] The criterion for statistical significance was a two-sided p-value of <0.05.

RESULTS

A total of 4,271 students completed the survey. A total of 4,237 students answered questions about past 30-day drinking and consuming AmED (99.2%); 61% of these students were female. The average student age was 20.4 years (range = 17–30 years). Of the 4,237 students, 2,886 (68%) reported drinking alcohol at least once in the past 30 days. Eighty-seven percent of past 30-day student drinkers were between the ages of 18 and 22 years. Among drinkers, 24% (697 students) reported consuming AmED on at least 1 day in the past 30 days. All subsequent analyses are restricted to past 30-day drinkers.

In the bivariate analyses, students who were male ($p < 0.001$), white ($p = 0.040$), intramural athletes ($p < 0.001$), fraternity or sorority members or pledges ($p < 0.01$), and younger ($p < 0.01$) were more likely to consume AmED (see Table 1). The average age of first drink was younger among students who reported consuming AmED (15.1 years vs. 16.0 years; $p < 0.001$). Students who reported consuming AmED had more drinking days on average during their last year of high school than those who did not report consuming AmED (1.7 days vs. 1.2 days; $p < 0.001$).

Fifty-five percent of students who consumed AmED said they did so to hide the flavor of the alcohol (48% of male mixers and 61% of female mixers.) Fifteen percent of students reported mixing alcohol with energy drinks to drink more and not feel as drunk; 5% reported they mix to drink more alcohol and not look as drunk. Seven percent of students reported mixing energy drinks and alcohol so as not to get a hangover. Forty-one percent of students provided other reasons (e.g., ''It was being served at a party''; ''It was the only mixer available''; ''That's how you make Jager Bombs.'')

In multivariable analyses, the consumption of AmED was strongly associated with all six high-risk drinking behaviors (see Table 2). Compared to current drinkers who did not report consuming AmED, students who reported consuming AmED drank significantly more during a typical drinking session (5.8 drinks vs. 4.5 drinks/typical session; $p < 0.001$). They reported almost twice as many heavy episodic drinking days in the past 30 days, as defined by the gender-specific measure of four or more alcoholic beverages in a row for females and five or more alcoholic drinks in a row for males (6.4 days vs. 3.4 days; $p < 0.001$). They reported twice as many episodes of weekly drunkenness (1.4 days/week vs. 0.73 days/week; $p < 0.001$). Among students who reported mixing alcohol and energy drinks, the greatest number of drinks in a single episode of drinking was 36% higher, compared to drinking students who did not report mixing alcohol with energy drinks (8.3 drinks vs. 6.1 drinks; $p < 0.001$).

Students who reported consuming AmED had increased prevalence of all six alcohol-related consequences due to their own drinking (see Table 3). They were more likely to be taken advantage of sexually (adjusted odds ratio [AOR] = 1.77; $p < 0.002$), take advantage of someone else sexually (AOR = 2.18; $p < 0.002$), ride with a driver who was under the influence of alcohol (AOR = 2.20; $p < 0.001$), be hurt or injured (AOR 2.25; $p < 0.001$), or require medical treatment (AOR = 2.17; $p = 0.007$). For driving in a car under the influence of alcohol, the effect of mixing alcohol and energy drinks depended upon the typical number of drinks the student drank (AmED AOR = 2.96, $p < 0.001$; typical number of drinks AOR = 1.23, $p < 0.001$; interaction AOR = 0.93, $p = 0.027$). There were significant main effects of consuming AmED ($p < 0.001$) and typical number of drinks ($p < 0.001$), but the risk for driving a car under the influence of alcohol was greater at lower number of typical drinks for those students who consumed AmED, compared to those students who drank alcohol alone (see Figure 1).

DISCUSSION

Studies of college students have demonstrated that the risk of alcohol-related consequences is greatly increased at five or more drinks in a row for men and four or more drinks in a row for women.[25] Serious injury, sexual assault, drunk driving, and death are all associated with heavy episodic drinking.[26] However, even after adjusting for alcohol consumption, students who consumed AmED had dramatically higher rates of serious alcohol-related consequences. This is the first study to suggest that consuming AmED constitutes ''high-risk drinking'' for college students, independent of the quantity of alcohol consumed.

Table 2
Association of Energy Drink/Alcohol Mixers and Drinking Behaviors (n = 2,886)*

Drinking Behavior	Non-AmED, n = 2,189 (76%)	AmED, n = 697 (24%)	b† 95% CI	z Statistic	p-Value‡
Typical No. of drinks in single episode	4.5 ± 0.15	5.8 ± 0.17	1.4 (1.1, 1.6)	11.69	<0.001
No. of days with 5/4 heavy episodic drinking in past 30 days	3.4 ± 0.17	6.4 ± 0.23	2.9 (2.5, 3.3)	14.21	<0.001
No. of days drunk in a typical week	0.73 ± 0.04	1.4 ± 0.05	0.70 (0.61, 0.79)	15.44	<0.001
Most No. of drinks in single episode in past 30 days	6.1 ± 0.15	8.3 ± 0.19	2.2 (1.9, 2.5)	14.28	<0.001

Numbers given in first two columns are adjusted means ± SE from multivariable linear mixed-effects regression model adjusting for student gender, age, race, fraternity or sorority status, athlete status, and within-campus clustering.
AmED = alcohol mixed with energy drinks; SE = standard error.
*Students who reported drinking in past 30 days only.
†b is the regression coefficient of the indicator variable comparing AmED to non-AmED drinkers.
‡p-value is from comparing AmED vs. non-AmED for each drinking behavior outcome.

Table 3
Association of Consuming Alcohol Mixed with Energy Drinks (AmED) and Alcohol-related Consequences (n = 2,886)*

Consequences	Non-AmED, n = 2,189 (76%) (95% CI)	AmED, n = 697 (24%) (95% CI)	AOR (95% CI)	z Statistic	p-Value†
Was taken advantage of sexually	3.7% (2.9, 4.8)	6.4% (4.7, 8.7)	1.77 (1.23, 2.55)	3.05	0.002
Took advantage of another sexually	1.7% (1.2, 2.4)	3.7% (2.5, 5.4)	2.18 (1.34, 3.55)	3.13	0.002
Rode with a driver who was under the influence of alcohol‡	22.5% (18.6, 26.9)	38.9% (32.7, 45.6)	2.20 (1.81, 2.68)	7.83	<0.001
Was hurt or injured	5.9% (4.8, 7.2)	12.3% (9.9, 15.3)	2.25 (1.70, 2.96)	5.74	<0.001
Required medical treatment	1.2% (0.8, 1.8)	2.6% (1.7, 4.1)	2.17 (1.24, 3.80)	2.70	0.007

AOR = adjusted odds ratio; CI = confidence interval.
*Students who reported drinking in past 30 days only.
†p-value is from comparing AmED users to Non-AmED for each drinking behavior outcome in a multivariable mixed-effects logistic regression model adjusting for student gender, age, race, fraternity or sorority status, athlete status, typical number of drinks in an episode, and within-campus clustering.
‡Drove a car while under the influence of alcohol not reported in this table due to significant interaction effect of AmED use and typical number of drinks.

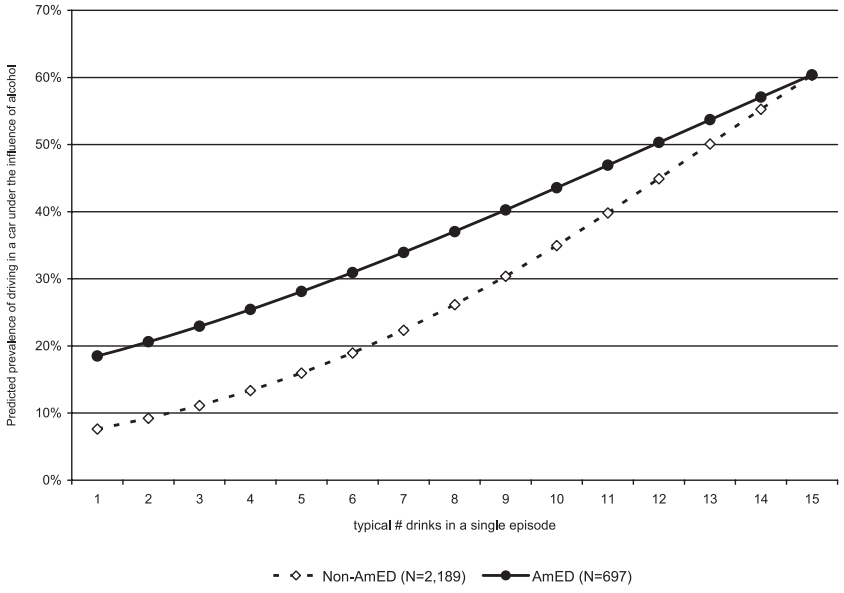

Figure 1. Association of consuming alcohol mixed with energy drinks (AmED) and driving a car under the influence of alcohol.

This association may be a result of changes in the drinker's perception of intoxication. Ferreira and colleagues[8] evaluated the effects of energy drink ingestion on alcohol intoxication in 26 healthy male volunteers.[8] On three separate occasions, subjects received a weight-based serving of alcohol alone, energy drink alone, or alcohol plus energy drink. The doses of alcohol and energy drink chosen for the study approximated that usually ingested on a single occasion: between 2.5 and 4 alcoholic drinks and 1 can of energy drink. In this small double-blinded study, breath alcohol concentration was not changed by the ingestion of an energy drink. However, participants reported that the subjective signs of intoxication (dizziness, fatigue, headache, trouble walking) were ameliorated when an energy drink was ingested along with the alcohol. Most significantly, performance on tests of motor coordination and visual reaction times was not different among those who drank alcohol, whether or not they had also ingested an energy drink. The subjective *symptoms* of drunkenness were reduced, but not the drunkenness.

Students whose motor skills and visual reaction times are impaired by alcohol ingestion may not perceive that they are intoxicated as readily as a result of concomitant energy drink ingestion. This phenomenon may be responsible for an increased risk of alcohol-related consequences. Students who drank AmED were twice as likely to report being hurt or injured compared to students who did not consume AmED and twice as likely to report that they required medical treatment, even after adjusting for the amount of alcohol consumed. Students who reported drinking AmED had a greatly increased risk of being taken advantage of sexually, independent of the amount of alcohol consumed. The ability to gauge one's level of intoxication may be an important component of risk assessment. Moreover, among men, alcohol contributes to misperceptions about a woman's sexual interest.[27] It may affect the willingness to act aggressively; intoxication may be seen as a justification for inappropriate sexual behavior.[28] Students who reported consuming AmED had more than twice the likelihood of taking sexual advantage of someone else, independent of the amount of alcohol consumed.

Students who reported consuming AmED were more than twice as likely to report riding with an intoxicated driver. We suggest that consuming AmED may impair not only students' ability to judge their own intoxication, but also their ability to judge intoxication in someone else. Our results suggest that the association of energy drink ingestion with alcohol on driving a car under the influence was heightened at lower levels of alcohol consumption. The Scientific Committee on Food of the European Commission notes that extensive animal and human studies indicate a ''modest'' antagonistic effect of caffeine on the depressant effects of alcohol, which is only seen at lower blood alcohol concentrations.[29]

Worldwide, different strategies have been employed in efforts to discourage the mixing of alcohol with energy drinks. A growing number of countries require manufacturers to have a label warning consumers not to drink AmED. Ireland,[30] Australia,[31] Sweden,[32] Finland,[33] and France[34] have all issued statements about the health risks of consuming AmED. The United States Food and Drug Administration (FDA) has not issued such a statement.

LIMITATIONS

This study used cross-sectional data, which limits our ability to assess causal relationships. In addition, the relationships between consumption of AmED, high-risk drinking, and alcohol-related consequences may be result of selection effects; specifically, sensation-seeking individuals may be drawn to energy drinks, heavy alcohol consumption, and risky behaviors. Seventy-eight percent of students in this study identified themselves as non-Hispanic whites, and 61% of the respondents were female. Although this limits the generalizability of our results, *post hoc* analyses confirmed that the sample reflected the ethnic, racial, and gender compositions of the 10 study campuses.[35] Furthermore, the demographic profile of this sample reflects that of undergraduate students in the United States.[36] The study was limited to college students from a particular geographic area. There is regional variation in alcohol use among college students.[37] Students may have under- or overestimated their alcohol use. Although self-report data have been validated in previous studies of alcohol use in college students,[38,39] different patterns or levels of drinking might be associated with different response biases. Internet surveys are an efficient method for collecting survey data on college students' alcohol use,[40] but several demographic and technologic criteria introduce variability in the response rate in Web-based surveys, including gender, school year, and the prevalence of computer use in everyday campus life. Finally, Kerr and colleagues,[41] in a summary of three national cross-sectional surveys, found that gender, age, and ethnicity were related to the amount of alcohol necessary for subjective drunkenness. Although we statistically accounted for gender, age, and ethnicity in measuring the association of consuming AmED and alcohol-related consequences, it is not known whether demographic variables affect subjective drunkenness when energy drinks are consumed concomitantly.

Additional research is necessary to examine the health risks of drinking AmED. In addition, policy measures may be warranted, such as requiring that energy drinks sold in the United States carry a warning label regarding the danger of consuming these beverages with alcohol. College administrators and staff should inform students about the risks of mixing alcohol with energy drinks as part of an overall program to reduce high-risk drinking and its consequences. Health care providers in emergency departments and campus health centers should ask college students whether they consume AmED, as part of routine conversations about unhealthy alcohol use. Finally, the free distribution of energy drinks at campus-sponsored events, which is common in the United States, should be reconsidered.

CONCLUSIONS

Almost one-quarter of college student current drinkers reported mixing alcohol with energy drinks. These

students are at increased risk for alcohol-related consequences, even after adjusting for the amount of alcohol consumed. Further research is necessary to understand this association and to develop targeted interventions to reduce risk.

References

1. Energy Fiend. The Caffeine Database, 2007. Available at: http://www.energyfiend.com/the-caffeine-database. Accessed Aug 5, 2007.
2. Energy Drinks. Chicago, IL: Mintel International Group Ltd., 2007.
3. Merrett N. Caffeinated Alcohol-Craze Stimulates Industry Attacks. Available at: http://beveragedaily.com. Accessed Aug 27, 2007.
4. Littmann M. Club Soda - Beverage Promotion to Young Adults in Nightclubs. Available at: http://findarticles.com/p/articles/mi_m3289/is_3_170/ai_72119738. Accessed Sep 17, 2007.
5. Red Bull. Student Brand Manager. http://www.redbulljobs.it/html/people/people_sfoglia_annunci.asp?cmdRS=open&UID=8471108&nPage=1 [Italian]. Accessed May 22, 2007.
6. Kapner DA. Ephedra and Energy Drinks on College Campuses. The Higher Education Center for Alcohol and Other Drug Abuse and Violence Prevention. Available at: http://www.higheredcenter.org/pubs/factsheets/energy-drinks.pdf. Accessed Sep 9, 2007.
7. Simon M, Mosher J. Alcohol, Energy Drinks, and Youth: A Dangerous Mix. San Rafael, CA: Marin Institute, 2007.
8. Ferreira SE, de Mello MT, Pompéia S, de Souza-Formigoni ML. Effects of energy drink ingestion on alcohol intoxication. Alcohol Clin Exp Res. 2006; 30:598–605.
9. Marczinski CA, Fillmore MT. Clubgoers and their trendy cocktails: implications of mixing caffeine into alcohol on information processing and subjective reports of intoxication. Exp Clin Psychopharmacol. 2006; 14:450–8.
10. Ferreira SE, de Mello MT, Rossi MV, Souza-Formigoni ML. Does an energy drink modify the effects of alcohol on a maximal effort test? Alcohol Clin Exp Res. 2004; 28:1408–12.
11. Kunin D, Gaskin S, Rogan F, Smith BR, Amit Z. Caffeine promotes ethanol drinking in rats. Examination using a limited-access free choice paradigm. Alcohol. 2000; 21:271–7.
12. O'Brien MC, McCoy TP, Champion H, et al. Single question about drunkenness to detect college students at risk for injury. Acad Emerg Med. 2006; 13:629–36.
13. DuRant RH, Champion H, Wolfson M, et al. Date fighting experiences among college students: are they associated with other health-risk behaviors? J Am Coll Health. 2007; 55:291–6.
14. Mitra A, Champion H, Wagoner KG, Wolfson M. Differences in rate of response to web-based surveys among college students. Int J E-Learning. In Press.
15. Wechsler H, Davenport A, Dowdall G, Moeykens B, Castillo S. Health and behavioral consequences of binge drinking in college. A national survey of students at 140 campuses. JAMA. 1994; 272:1672–7.
16. Presley CA, Meilman PW, Lyerla R. Development of the Core Alcohol and Drug Survey: initial findings and future directions. J Am Coll Health. 1994; 42:248–55.
17. Preisser JS, Young ML, Zaccaro DJ, Wolfson M. An integrated population-averaged approach to the design, analysis and sample size determination of cluster-unit trials. Stat Med. 2003; 22:1235–54.
18. DeJong W, Schneider SK, Towvim LG, et al. A multisite randomized trial of social norms marketing campaigns to reduce college student drinking. J Stud Alcohol. 2006; 67:868–79.
19. Kolbe LJ. An epidemiological surveillance system to monitor the prevalence of youth behaviors that most affect health. Health Educ. 1990; 21:44–8.
20. National Institute on Alcohol Abuse and Alcoholism. NIAAA Council Approves Definition of Binge Drinking. National Institute on Alcohol Abuse and Alcoholism Newsletter. Available at: http://pubs.niaaa.nih.gov/publications/Newsletter/winter2004/Newsletter_Number3.htm. Accessed May 22, 2007.
21. Wechsler H, Lee JE, Kuo M, Seibring M, Nelson TF, Lee H. Trends in college binge drinking during a period of increased prevention efforts. Findings from 4 Harvard School of Public Health College Alcohol Study surveys: 1993–2001. J Am Coll Health. 2002; 50:203–17.
22. Allison PD. Logistic Regression Using the SAS System: Theory and Application. Cary, NC: SAS Institute, 2007.
23. Kleinbaum DG, Kupper LL, Muller KE, Nizam A. Applied regression analysis and other multivariable methods. Pacific Grove, CA: Duxbury Press, 1998.
24. Rabe-Hesketh S, Skrondal A, Pickles A. Reliable estimation of generalized linear mixed models using adaptive quadrature. Stata J. 2007; 1:1–21.
25. Wechsler H, Lee JE, Kuo M, Lee H. College binge drinking in the 1990s: a continuing problem. Results of the Harvard School of Public Health 1999 College Alcohol Study. J Am Coll Health. 2000; 48:199–210.
26. Hingson R, Heeren T, Winter M, Wechsler H. Magnitude of alcohol-related mortality and morbidity among U.S. college students ages 18–24: changes from 1998 to 2001. Annu Rev Public Health. 2005; 26:259–79.
27. Abbey A. Alcohol-related sexual assault: a common problem among college students. J Stud Alcohol Suppl. 2002; (14):118–28.
28. Abbey A, Clinton-Sherrod AM, McAuslan P, Zawacki T, Buck PO. The relationship between the quantity of alcohol consumed and the severity of sexual assaults committed by college men. J Interpers Violence. 2003; 18:813–33.
29. Opinion of the Scientific Committee on Food on Additional information on ''energy'' drinks. European Commission Health & Consumer Protection Directorate-General 2007. Available at: http://ec.europa.eu/food/fs/sc/scf/out169_en.pdf. Accessed Aug 9, 2007.

30. Committee of the Food Safety Promotion Board of the Republic of Ireland, Food Safety Promotion Board. A Review of the Health Effects of Stimulant Drinks. Available at: http://www.safefoodonline.com/safefood/Uploads/health_effects.pdf. Accessed Aug 9, 2007.
31. Government of Western Australia. Drug and Alcohol Office, Prevention Directorate. Caffeine: The Facts. Available at: http://www1.drugaware.com.au/docs/Caffine.pdf. Accessed Sept 9, 2007.
32. Decision News Media SAS. National Food Administration warns about ''energy'' drinks. Available at: http://www.food-decisions.com/news/ng.asp?id=41118-national-food-administration. Accessed Aug 9, 2007.
33. Finnish Food Safety Authority. Are energy drinks safe? Available at: http://www.evira.fi/portal/en/food/information_on_food/energy_drinks/are_energy_drinks_safe_/. Accessed Sep 7, 2007.
34. Briand P. AVIS de l'Agence française de sécurité sanitaire des aliments relatif à l'évaluation des risques liés à la consommation d'une boisson présentée comme « énergisante » additionnée de substances autres qu'additifs technologiques: taurine, D-glucuronolactone, inositol, vitamines B2, B3, B5, B6 et B12. Agence Française de Sécurité Sanitaire des Aliments 2007 [French]. http://www.afssa.fr/Ftp/Afssa/38331-38332.pdf. Accessed Sep 17, 2007.
35. The University of North Carolina. Statistical Abstract of Higher Education 06-07. Available at: http://www.northcarolina.edu/content.php/assessment/reports/abstract-current.htm. Accessed Apr 16, 2007.
36. U.S. Department of Education. Digest of Educational Statistics 2005. Washington, DC: National Center for Educational Statistics, 2006.
37. National Institute on Alcohol Abuse and Alcoholism. Task Force on College Drinking. A Call to Action: Changing the Culture of Drinking at U.S. Colleges, April 2002. Available at: http://www.collegedrinkingprevention.gov/media/TaskForceReport.pdf. Accessed Jan 13, 2003.
38. Dowdall GW, Wechsler H. Studying college alcohol use: widening the lens, sharpening the focus. J Stud Alcohol Suppl. 2002; (14):14–22.
39. Del Boca FK, Darkes J. The validity of self-reports of alcohol consumption: state of the science and challenges for research. Addiction. 2003; 98(Suppl. 2):1–12.
40. McCabe SE, Couper MP, Cranford JA, Boyd CJ. Comparison of Web and mail surveys for studying secondary consequences associated with substance use: evidence for minimal mode effects. Addict Behav. 2006; 31:162–8.
41. Kerr WC, Greenfield TK, Midanik LT. How many drinks does it take you to feel drunk? Trends and predictors for subjective drunkenness. Addiction. 2006; 101:1428–37.