Energy drink use patterns among young adults: Associations with drunk driving

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Abstract

Background—Highly caffeinated "energy drinks" (ED) are commonly consumed, and sometimes mixed with alcohol. Associations between ED consumption, risk-taking, and alcohol-related problems have been observed. This study examines the relationship between ED consumption—both with and without alcohol—and drunk driving.

Methods—Data were derived from a longitudinal study of college students assessed annually via personal interviews. In Year 6 (modal age 23; *n*=1,000), participants self-reported their past-year frequency of drunk driving, ED consumption patterns [frequency of drinking alcohol mixed with energy drinks (AmED) and drinking energy drinks without alcohol (ED)], alcohol use (frequency, quantity), and other caffeine consumption. Earlier assessments captured suspected risk factors for drunk driving. Structural equation modeling was used to develop an explanatory model for the association between ED consumption patterns and drunk driving frequency while accounting for other suspected risk factors.

Results—More than half (57%) consumed ED at least once during the past year. Among ED consumers, 71% drank AmED and 85% drank ED alone; many (56%) engaged in both styles of ED consumption while others specialized in one or the other (29% drank ED alone exclusively, while 15% drank AmED exclusively). After accounting for other risk factors, ED consumption was associated with drunk driving frequency in two ways. First, a direct path existed from ED frequency (without alcohol) to drunk driving frequency. Second, an indirect path existed from AmED frequency through alcohol quantity to drunk driving frequency.

Conclusions—Among this sample, ED consumption with and without alcohol was common, and both styles of ED consumption contributed independently to drunk driving frequency. Results call for increased attention to the impact of different patterns of ED consumption on alcohol-related consequences, such as drunk driving.

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Keywords

Alcohol; college students; drunk driving; energy drinks; young adults

INTRODUCTION

Products with high doses of caffeine designed to appeal to young people such as energy drinks (ED) (Reissig et al., 2009) have garnered attention from the public health community. Despite the regulatory actions which essentially resulted in the removal of alcoholic beverages that are sold pre-mixed with caffeine in the US, ED are still consumed with alcohol, either as a mixed cocktail or consumed during the same drinking session. Both behaviors are known collectively as drinking alcohol mixed with energy drinks (AmED). Typical motives for AmED use include decreasing the sedative effects of alcohol or extending the duration of an alcohol drinking session (Droste et al., 2014). Yet ED consumption also occurs frequently in the absence of alcohol, and represents an equally important part of the overall picture of ED consumption patterns.

Epidemiologic data on college students and other young adults highlight the popularity of ED consumption. However, because researchers have operationalized ED consumption differently, prevalence estimates vary. In two of the largest available studies, past-month prevalence was 38% among one sample of 602 college students (Miller, 2008a), whereas 48% consumed ED on a monthly basis among another sample of 1,234 young adults (Trapp et al., 2014). In the cohort of college students who are the subject of the present study, we previously reported that 13% consumed ED on a weekly or more basis, and 66% consumed ED at least once during the past year (Arria et al., 2011). However, these estimates reflect any ED consumption and do not differentiate between ED consumption with and without alcohol. National data from Monitoring the Future indicate that 25% of high school seniors (Martz et al., 2015), 34% of college students, and 34% of young adults (not in college) consumed AmED at least once during the past year (Miech et al., 2016). AmED has been the focus of several studies of college-student samples, with past-month prevalence consistently close to one in four (Brache and Stockwell, 2011; Marzell et al., 2014; O'Brien et al., 2008; Patrick et al., 2014).

Existing epidemiologic data make it difficult to distinguish between different ways of consuming ED. For instance, it is not known how prevalent it is (a) to consume ED exclusively in nonalcohol contexts, or (b) to consume ED exclusively as part of a mixed alcoholic drink or during an alcohol drinking session, or (c) to engage in both "styles" of consumption--that is, consume ED both "alone" and when consuming alcohol (AmED).

ED consumption, especially among younger individuals, is associated with adverse acute cardiovascular outcomes such as high blood pressure, arrhythmias, and tachycardia (Gunja and Brown, 2012; Higgins et al., 2015; Svatikova et al., 2015; Trabulo et al., 2011; Wolk et al., 2012). Nationally, the number of individuals presenting to an emergency department after consuming ED doubled between 2007 and 2011 (Drug Abuse Warning Network, 2013), and multiple cases of hospitalizations related to ED consumption have been reported (Center for Food Safety and Applied Nutrition, 2012a; Center for Food Safety and Applied

Nutrition, 2012b). During adolescence, caffeine is known to disrupt sleep patterns (Orbeta et al., 2006), which can contribute to daytime sleepiness and consequent deficits in academic performance (James et al., 2011).

Aside from the acute effects of caffeine, ED consumption is associated with multiple risk-taking behaviors among college students, including illicit and nonmedical prescription drug use, risky sexual behavior, and seatbelt omission (Arria et al., 2010; Miller, 2008a; Trapp et al., 2014; Woolsey et al., 2014). Of particular concern are the consistent linkages that have been observed between ED consumption and alcohol-related problems, including an increased risk for alcohol dependence, even controlling for the level of alcohol consumption and other risk factors (Miller and Quigley, 2011; Skewes et al., 2013; Snipes et al., 2015). Importantly, the risk for alcohol dependence increases with the frequency of ED consumption in an apparent dose-response relationship (Arria et al., 2011).

Still other consequences are specific to AmED. Chief among these concerns is the potential for high caffeine levels to mask the subjective feeling of alcohol-related impairment (Ferreira et al., 2006; Marczinski et al., 2012). Observational research suggests that AmED reduces alcohol's sedation effects while enhancing its stimulation effects (Peacock et al., 2014). Some laboratory evidence indicates that reaction times, motor coordination, information processing, and behavioral inhibition are equally impaired in AmED and alcohol-only conditions, despite significant differences in subjective feelings of impairment (Marczinski et al., 2011; Marczinski et al., 2012). Individuals in such a "wide-awake drunk" state are then at risk for consuming even greater amounts of alcohol (Marczinski et al., 2013; McKetin and Coen, 2014) and/or engaging in risky behaviors that they might otherwise have avoided given a more realistic self-appraisal of their impairment (Arria and O'Brien, 2011). Thus it is not surprising that AmED is associated with increased risk for risky sexual behaviors (Miller, 2012; O'Brien et al., 2008), sexual victimization among men (Snipes et al., 2014), aggression perpetration (Miller et al., 2016), riding with an intoxicated driver, and drunk driving (O'Brien et al., 2008; Woolsey et al., 2015b), even beyond the risks associated with alcohol consumption *per se*.

Drunk driving is a particularly serious consequence that has been linked to both AmED and ED consumption in general (O'Brien et al., 2008; Spierer et al., 2014). Thombs et al. (2010) conducted the first study that investigated energy drink use in a naturalistic field setting, namely college bars. They observed that consumption of AmED during the evening was significantly associated with an increased risk for drunk driving intentions compared with drinking alcohol without ED, even after statistical adjustment for a number of potentially confounding variables.

Drunk driving is a serious problem among college students. National data indicate that 19% of young adults ages 21 to 25 drove under the influence of alcohol at least once during the past year, considerably more than among US adults ages 26 or older (11%), and college graduates are at substantially higher risk than individuals who only completed high school (15% vs. 9%; Center for Behavioral Health Statistics and Quality, 2015). Among the large sample of college students who are the subject of the present study, drunk driving prevalence peaked at 25% at age 21, after accounting for access to drive a car (Beck et al., 2010). A

recent cross-sectional analysis of Monitoring the Future data found significant associations between AmED consumption and unsafe alcohol-related driving behaviors among high school seniors (Martz et al., 2015). Similarly, it has been found that AmED consumption among college students was associated with an increased risk for high-risk driving behaviors, including driving even though they knew they had consumed excess amounts of alcohol (Woolsey et al., 2015a; Woolsey et al., 2015b).

Based on the evidence cited above, there are several plausible mechanisms by which ED consumption might contribute to drunk driving. First, it is reasonable to hypothesize that AmED might contribute to drunk driving at the event level by dampening the perception of alcohol-related impairment, increasing impulsivity around the decision to drive, or increasing the amount of alcohol consumed on a given occasion. Second, consuming ED without alcohol might be a marker for a general propensity for engaging in risky behaviors like drunk driving. Third, to the extent that ED consumption might contribute to increased risk for developing alcohol dependence, drunk driving might be emblematic of such risk. Given that the two main styles of ED consumption (i.e., with and without alcohol) are likely to occur within the same individuals, it is difficult to draw conclusions about their respective importance for drunk driving, and to date, no research has examined both behaviors simultaneously as independent risk factors for drunk driving.

The present study represents a first step toward addressing that gap in the literature. Specifically, the study had two main aims. First, we aimed to describe the heterogeneity of patterns of ED consumption among a young adult sample, with a particular emphasis on estimating the prevalence of ED consumption with and without alcohol. Second, we then examined the extent to which ED consumption patterns explained any unique variance in drunk driving behavior after accounting for alcohol use patterns and several background risk factors.

MATERIALS AND METHODS

Study Design

Data were collected as part of the College Life Study, a ten-year prospective longitudinal study of 1,253 young adults who were originally recruited as incoming first-year college students at one large public university (Arria et al., 2008; Vincent et al., 2012). After screening the entire incoming class of first-year students ages 17 to 19 during the summer prior to college entry in 2004 (89% response rate), a sample was selected for longitudinal follow-up, with oversampling for students who had used at least one illicit drug or nonmedically used a prescription drug prior to college. An initial two-hour personal interview was administered sometime during the first year of college in the 2004–2005 academic year (N=1,253; 87% response rate). Similar annual follow-up assessments were administered regardless of continued college attendance, with excellent follow-up rates (e.g., 80% in Year 6). Participants were paid for each assessment. Informed consent was obtained, and the study was approved by the university's Institutional Review Board. Interviewers were trained extensively in confidentiality protection procedures and a Certificate of Confidentiality was obtained.

Sample

For the present study, participants were the 1,000 individuals who completed the Year 6 assessment in which ED consumption patterns were measured, when participants were 22 to 25 years old (73% age 23). Analyses on drunk driving were further restricted to the 969 individuals who consumed alcohol at least once during the past year. Compared with the analysis sample, individuals who were excluded due to attrition were significantly more likely to be male (62% vs. 45%, $p<.001$) but were similar with respect to race/ethnicity and age at first intoxication.

Measures

Drunk Driving Frequency—In Year 6, participants were asked how often during the past year they "drove while drunk on alcohol." The ordinal response options were Never (0), 1 to 2 times (1), 3 to 6 times (2), 7 to 9 times (3), and 10 or more times (4).

Energy Drink (ED) Consumption Patterns—In Year 6, participants were asked separately how many times during the past year they consumed energy drinks that (a) were mixed with alcohol, and (b) were not mixed with alcohol. Participants were asked to consider "mixed with alcohol" to include any times they consumed the ED during the same drinking session as alcohol, whether or not they were consumed as a mixed beverage. Responses were given as the number of days during the past year.

Alcohol Use Patterns—Standard questions were asked to assess alcohol quantity and frequency. Typical alcohol quantity was assessed in Year 6 as the number of drinks that were consumed on a typical drinking day during the past year. Frequency of alcohol use was assessed as the number of days during the past year they had consumed any drink with alcohol in it. For the present analyses, the final alcohol use frequency variable was computed by subtracting the number of days on which ED was consumed with alcohol (see above) from the overall alcohol frequency, in order to minimize any redundancy between the two frequency measures.

Caffeine Consumption—Interviewers asked participants in Year 6 about their use of caffeinated products other than ED, namely coffee, tea, and soft drinks. Other caffeinated products such as over-the-counter supplements or medications were assessed in a separate question but were not a major source of caffeine among this sample. For each type of caffeinated product, participants were asked to estimate the number of ounces they would typically consume on days when they consumed that product. Weekly frequency of caffeine consumption (i.e., 0 to 7 days) was assessed in a separate question and later combined with the quantity data to compute total weekly caffeine consumption, in ounces, from beverages other than ED.

Background Characteristics and Suspected Risk Factors for Drunk Driving— Race and sex were self-reported. Race was later dichotomized into white and non-white due to the preponderance of non-Hispanic white individuals (72% of sample). Age at first alcohol intoxication was captured at baseline and later dichotomized as age 15 or younger and 16 or older, and individuals who had never been drunk by baseline were automatically

coded in the 16 or older category. Impulsive sensation-seeking was assessed at baseline via the 7-item subscale of the self-administered Zuckerman-Kuhlman Personality Questionnaire (Zuckerman, 2002). Childhood conduct problems were also assessed at baseline using an adapted version of the Conduct Disorder Screener; responses were later used to compute an index of conduct problem severity, following standard methods (Falls et al., 2011; Johnson et al., 1995). Baseline depressive symptoms were assessed using the Beck Depression Inventory (Beck et al., 1979), a 21-item self-administered questionnaire. Father's and mother's history of alcohol problems were assessed in Year 2 via a self-administered family tree questionnaire format (Mann et al., 1985). The five possible response options (definite problems, possible problems, drank without problems, did not drink, and don't know) were later recoded into a dichotomous variable (definite or possible problems vs. no problems). "Don't know" responses were conservatively coded as "no problems."

Analytic Strategy

A series of structural models were specified *a priori*, and were evaluated to test the hypothesized direct and indirect associations between ED consumption patterns and drunk driving frequency (scored 0 to 4; see above). Alcohol quantity and frequency served as possible mediating variables between ED consumption and drunk driving, after accounting for the effects of risk factors (i.e., sex, race, early onset of alcohol intoxication, paternal and maternal alcohol problems, impulsive sensation-seeking, early conduct problems, depression symptoms).

Our initial hypothesized model (see Figure 1) included (a) direct paths from alcohol quantity and frequency to drunk driving, (b) direct paths from each of the two ED variables (i.e., with alcohol, without alcohol) to both alcohol quantity and frequency, and (c) direct paths from each of the background variables to each of the ED variables.

Our approach was to first test our most restrictive model representing the hypothesized indirect paths from the ED variables to alcohol quantity and frequency to drunk driving, and then test our alternative models after adding direct paths in two stages: first from the ED variables to drunk driving, and second, from the background variables to the alcohol variables. The resulting model was then further refined through use of a non-recursive strategy in which all non-significant (p>.05) paths were omitted from the previous model, and all paths whose modification index was significant (p<.05) were re-admitted into the model, until the cycling produced no more non-significant paths to be omitted, and no more significant paths to be re-admitted. In all models, the ED variables were allowed to correlate with each other, as were the alcohol variables. Other caffeine consumption was treated as a control variable with direct paths to both of the ED variables as well as alcohol quantity and frequency. Count variables were rescaled as needed to facilitate interpretation of results (i.e., weekly caffeine consumption and alcohol frequency were divided by 10).

Multiple criteria were used to evaluate model fit, following Hu and Bentler (1999). Cutoffs for acceptable model fit were ≥.95 for Bentler's comparative fit index (CFI; Bentler, 1990), ≤.08 for the root mean square error of approximation (RMSEA), and ≤.09 for the standardized root mean square residual (SRMR).

Descriptive statistics were computed in SPSS. The structural equation model was fit in M*plus*®. Missing data were minimal (<5% for any given variable).

RESULTS

Sample Characteristics

Among the 969 individuals who consumed alcohol during the past year at Year 6, nearly half were male (45%) and a majority were white (72%; see Table 1). On average, ED were consumed more frequently without alcohol than with alcohol (11.2 versus 4.9 days during the past year). One in four participants (25%) reported that they drove drunk at least once during the past year (14% once or twice, 6% 3 to 6 times, 2% 7 to 9 times, and 3% 10 or more times). Parental alcohol problems were more commonly reported for fathers (10% possible and 7% definite) than mothers (5% possible and 2% definite; data not shown in a table).

Prevalence of ED Consumption Patterns

Tables 2A and 2B describe the heterogeneity of patterns of alcohol and ED consumption. More than half of the sample (57%) consumed ED at least once during the past year. Among the 566 ED consumers, 56% drank AmED and also drank ED alone, 27% drank alcohol and ED alone but not AmED, and 15% drank AmED but not ED alone. The remaining 2% drank ED alone but abstained from alcohol altogether. Overall, AmED was a highly prevalent practice, being reported by 71% of all ED consumers and 40% of the overall sample. As shown in Table 2B, individuals who consumed ED both with and without alcohol (row F) engaged in both patterns of consumption more frequently relative to individuals who only engaged in one such pattern (rows D and E). Among alcohol drinkers, average alcohol frequency and quantity were consistently lowest for individuals who never consumed ED (row C), somewhat higher for those who consumed ED exclusively without alcohol (row D), and highest for those who consumed AmED (rows E and F). Drunk driving prevalence increased in a "stair step" fashion from 14%, 18%, 29%, to 41% from non-users (row C) to individuals who consumed both AmED and ED alone (row F). In contrast, typical alcohol quantity and frequency did not appear to be different among AmED consumers who consumed ED exclusively with alcohol versus AmED consumers who also drank ED without alcohol. Thus, the substantial differences in drunk driving between individuals in rows E and F were not accompanied by a corresponding difference in alcohol consumption patterns, suggesting the possible importance of other explanatory variables.

Correlates of Drunk Driving and ED Consumption

Drunk driving frequency was significantly correlated with frequency of ED consumption both with and without alcohol, and, not surprisingly, with quantity and frequency of alcohol use (see Table 1). With respect to the suspected risk factors for drunk driving frequency, significant positive associations were observed for male sex, early age of alcohol intoxication, father's alcohol problems, impulsive sensation-seeking, childhood conduct problems, and caffeine consumption other than ED. However, drunk driving frequency was not significantly associated with race, mother's alcohol problems, or depression symptoms. The two ED frequency variables correlated moderately with each other (r=.45) and were

significantly associated with alcohol quantity and most of the same risk factors as for drunk driving; however, neither of the ED variables were significantly related to alcohol frequency.

Structural Models

Model fit was reasonably good for the original hypothesized model and improved considerably with the introduction of direct paths from the background variables to the alcohol variables (see Table 3). After pruning 25 non-significant paths and adding two new paths based on model fit indices, the final model provided superior fit to the data [X^2(11)=19.18, p=.058, CFI=.99, RMSEA=.03, SRMR=.02]. Parents' alcohol problems, childhood conduct problems, and depression symptoms made no significant contributions to the model, and therefore all their respective paths were omitted in the model fitting process.

Predictors of Drunk Driving

The final best-fitting model included direct paths to drunk driving frequency from five different variables: alcohol quantity, alcohol frequency, frequency of ED consumption without alcohol, early intoxication, and race (see Figure 2). There was also a direct path from AmED use to alcohol quantity. Thus, results reflected two distinct pathways from ED consumption to drunk driving: first, a direct path from ED consumption without alcohol, and second, an indirect path from AmED use to alcohol quantity to drunk driving frequency. Additionally, four risk factors (i.e., sex, race, early alcohol intoxication, impulsive sensation-seeking) contributed indirectly to drunk driving frequency via their direct paths to the ED and alcohol variables; those paths were omitted from Figure 2 for ease of presentation but are depicted in Table 4.

DISCUSSION

Among this sample of young adults, 57% consumed ED at least once during the past year, with most of those ED consumers mixing ED with alcohol (71%). For many others, their ED consumption was confined to occasions when they were not drinking alcohol (29%). Moreover, most ED consumers (56%) engaged in both styles of consumption—that is, they drank ED with and without alcohol. Among the overall sample, individuals who used ED without alcohol at least once outnumbered those who used AmED at least once (48% vs. 40%).

Structural equation modeling results indicated that both styles of ED consumption contributed significantly to drunk driving frequency, albeit through two distinct pathways. First, more frequent AmED consumption contributed to heavier alcohol use (i.e., typical number of drinks consumed in a drinking session), which in turn contributed to more frequent drunk driving. Second, more frequent consumption of ED without alcohol contributed directly to more frequent drunk driving, even in the context of alcohol quantity and frequency and several background risk factors. Thus, individuals who consumed ED both with and without alcohol had considerably higher risk for drunk driving relative to individuals who consumed ED exclusively with alcohol (41.3% vs. 28.7%), even though their alcohol drinking patterns were similar.

Results shed light on the complexity of the relationship between ED consumption patterns and an important public health problem: drunk driving. Results are consistent with other research linking ED consumption to a variety of health risk behaviors such as illicit and nonmedical prescription drug use, seat belt omission, and sexual risk-taking (Arria et al., 2010; Miller, 2008a; Trapp et al., 2014; Woolsey et al., 2014). Yet prior research on the possible contribution of ED consumption to alcohol-related harms—such as drunk driving—has focused solely on the practice of mixing alcohol with ED. The present finding that ED consumption without alcohol contributed to drunk driving, even independent of AmED use and other dimensions of alcohol drinking patterns, extends that body of evidence by disentangling the effects of ED consumption *per se* from those of alcohol. Moreover, the finding that AmED use contributed indirectly to drunk driving through its influence on increased alcohol quantity is consistent with the notion that AmED use might lead to alcohol dose escalation (Marczinski et al., 2013) and thereby to any number of alcohol-related consequences.

The finding that the positive bivariate associations between our ED consumption variables and impulsive sensation-seeking did not translate into direct effects in our structural model was unexpected, given prior research linking these constructs (Miller, 2008b), and might be attributable to our decision to focus on identifying the paths from ED consumption to drunk driving, rather than allowing for all possible reciprocal associations amongst the ED and alcohol variables. Alternative models should be explored in future research and might reveal indirect paths from sensation-seeking to ED consumption via one or more alcohol variables.

The present findings must be interpreted in light of certain limitations. Because participants were recruited from one university, generalizability to other young adult populations is unknown. Reliance on self-report data, while widely accepted for substance use measures, might be particularly problematic for studying drunk driving, given how stigmatized drunk driving is, as well as the high level of subjectivity in evaluating one's own level of intoxication. Because we did not ask participants to explain what "drove while drunk" meant to them, we cannot say how many individuals chose not to mention occasions when they drove while "buzzed" or "tipsy" but not subjectively "drunk." The cross-sectional nature of the analytic design prevents us from making inferences about the relationship between ED consumption and changes in drinking patterns and/or drunk driving over time. Finally, because we did not ask participants whether they had been consuming ED on any of the occasions when they drove drunk, we cannot draw any inferences about whether ED consumption might have contributed to their decision to drive drunk.

An important strength of this study is the ability to account for many explanatory variables that might explain drunk driving behavior. Although prior studies have suggested that ED consumption might contribute to increased risk for drunk driving due to increased alcohol consumption or decreased perception of being drunk or impaired (Woolsey et al., 2015a; Woolsey et al., 2015b), the present finding that drunk driving was associated with ED consumption independent of alcohol use patterns and several background risk factors suggests that other mechanisms might also be at play. This study also demonstrates the utility of a novel method for assessing ED consumption in multiple contexts. A large sample size and the ability to control for other caffeine consumption are additional strengths of this

study. The present findings highlight the importance of understanding the complexity of ED consumption patterns. Rather than focusing narrowly on how ED are used with alcohol, researchers should strive for a more comprehensive picture of ED consumption by including other (i.e., non-alcohol) contexts of ED consumption.

The finding that ED consumption without alcohol was positively associated with drunk driving frequency is intriguing and suggests that ED consumption in general might be a marker for underlying risk factors that increase the propensity for drunk driving. For example, although our model accounted for sensation-seeking and general deviance (i.e., childhood conduct problems), it is plausible that other unmeasured attributes such as a heightened sense of invincibility might account for the observed relationship between ED consumption and drunk driving. Another possibility is that the observed finding could be an artifact of self-report bias, in that the attribute of willingness to admit to or even embrace a stigmatized behavior (i.e., drunk driving) might be overrepresented among the target-market of ED products. A third possibility is that our measure of ED consumption without alcohol might be confounded by frequency of alcohol hangovers. Although our ED consumption frequency measures did not distinguish between any motives for such use, it is likely that occasions when ED were used for hangover coping would have been counted as ED consumption without alcohol. More research is needed to understand the variety of motives associated with ED use, such as attempting to relieve symptoms of alcohol-induced hangovers.

Further research is also needed to understand the psychosocial characteristics of ED consumers that might account for the observed association with drunk driving, and the extent to which these two behaviors might be emblematic of a behavioral prototype that is influential among young adults. Based on typical ED marketing messages, it is reasonable to assume that such a prototype might be characterized by an idealized notion of an exciting, active lifestyle with a proudly carefree and undaunted attitude of "living for the moment." In that case, it would be plausible that individuals who identify with such a prototype might also be at risk for drunk driving because they tend to dismiss any potential for harm. Perceived prototypes are influential on other health risk behaviors like smoking and drinking (see van Lettow et al., 2016) and therefore might be helpful in understanding ED consumption and associated risk behaviors.

Lastly, findings extend prior concerns raised by the public health and medical communities regarding ED consumption (Arria et al., 2014; Arria and O'Brien, 2011; Thorlton et al., 2014). College students who consume ED might represent a key target audience for drunk driving prevention activities, regardless of whether such consumption occurs before, during, or after their alcohol drinking sessions. Parents, clinicians, and college administrators should be encouraged to regard ED consumption as a marker for high-risk substance use patterns (Arria et al., 2011; Terry-McElrath et al., 2014), and in particular to caution against consuming ED with alcohol.

Acknowledgments

References

Arria AM, Bugbee BA, Caldeira KM, Vincent KB. Evidence and knowledge gaps for the association between energy drink use and high-risk behaviors among adolescents and young adults. Nutr Rev. 2014; 72(Supplement S1):87–97. [PubMed: 25293548]

Arria AM, Caldeira KM, Kasperski SJ, O'Grady KE, Vincent KB, Griffiths RR, Wish ED. Increased alcohol consumption, nonmedical prescription drug use, and illicit drug use are associated with energy drink consumption among college students. J Addict Med. 2010; 4(2):74–80. [PubMed: 20729975]

Arria AM, Caldeira KM, Kasperski SJ, Vincent KB, Griffiths RR, O'Grady KE. Energy drink consumption and increased risk for alcohol dependence. Alcohol Clin Exp Res. 2011; 35(2):365–375. [PubMed: 21073486]

Arria AM, Caldeira KM, O'Grady KE, Vincent KB, Fitzelle DB, Johnson EP, Wish ED. Drug exposure opportunities and use patterns among college students: Results of a longitudinal prospective cohort study. Subst Abus. 2008; 29(4):19–38.

Arria AM, O'Brien MC. The "high" risk of energy drinks. JAMA. 2011; 305(6):600–601. [PubMed: 21266673]

Beck, AT.; Rush, AJ.; Shaw, BF.; Emery, G. Cognitive therapy of depression. The Guilford Press; New York, NY: 1979.

Beck KH, Kasperski SJ, Caldeira KM, Vincent KB, O'Grady KE, Arria AM. Trends in alcohol-related traffic risk behaviors among college students. Alcohol Clin Exp Res. 2010; 34(8):1472–1478. [PubMed: 20528819]

Bentler PM. Comparative fit indexes in structural models. Psychol Bull. 1990; 107(2):238–246. [PubMed: 2320703]

Brache K, Stockwell T. Drinking patterns and risk behaviors associated with combined alcohol and energy drink consumption in college drinkers. Addict Behav. 2011; 36(12):1133–1140. [PubMed: 21840130]

Center for Behavioral Health Statistics and Quality. 2014 National Survey on Drug Use and Health: Detailed Tables. Substance Abuse and Mental Health Services Administration; Rockville, MD: 2015.

Center for Food Safety and Applied Nutrition. Voluntary and mandatory reports on 5-Hour Energy, Monster Energy, and Rockstar energy drink. Food and Drug Administration; Washington, DC: 2012a.

Center for Food Safety and Applied Nutrition. Voluntary reports on Red Bull energy drink. Food and Drug Administration; Washington, DC: 2012b.

Droste N, Tonner L, Zinkiewicz L, Pennay A, Lubman DI, Miller P. Combined alcohol and energy drink use: Motivations as predictors of consumption patterns, risk of alcohol dependence, and experience of injury and aggression. Alcohol Clin Exp Res. 2014; 38(7):2087–2095. [PubMed: 24846819]

Drug Abuse Warning Network. The DAWN Report. Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality; Rockville, MD: 2013. Update on emergency department visits involving energy drinks: A continuing public health concern; p. 1-5.

Falls BJ, Wish ED, Garnier LM, Caldeira KM, O'Grady KE, Vincent KB, Arria AM. The association between early conduct problems and early marijuana use in college students. J Child Adolesc Subst Abuse. 2011; 20(3):221–236. [PubMed: 21887087]

Ferreira SE, de Mello MT, Pompeia S, de Souza-Formigoni ML. Effects of energy drink ingestion on alcohol intoxication. Alcohol Clin Exp Res. 2006; 30(4):598–605. [PubMed: 16573577]

Gunja N, Brown JA. Energy drinks: health risks and toxicity. Med J Aust. 2012; 196(1):46–49. [PubMed: 22256934]

Higgins J, Yarlagadda S, Yang B. Cardiovascular complications of energy drinks. Beverages. 2015; 1(2):104–126.

Hu L-T, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Struct Equ Modeling. 1999; 6(1):1–55.

James JE, Kristjansson AL, Sigfusdottir ID. Adolescent substance use, sleep, and academic achievement: Evidence of harm due to caffeine. J Adolesc. 2011; 34(4):665–673. [PubMed: 20970177]

Johnson EO, Arria AM, Borges G, Ialongo N, Anthony JC. The growth of conduct problem behaviors from middle childhood to early adolescence: Sex differences and the suspected influence of early alcohol use. J Stud Alcohol. 1995; 56(6):661–671. [PubMed: 8558898]

Mann RE, Sobell LC, Sobell MB, Pavan D. Reliability of a family tree questionnaire for assessing family history of alcohol problems. Drug Alcohol Depend. 1985; 15(1–2):61–67. [PubMed: 4017879]

Marczinski CA, Fillmore MT, Bardgett ME, Howard MA. Effects of energy drinks mixed with alcohol on behavioral control: Risks for college students consuming trendy cocktails. Alcohol Clin Exp Res. 2011; 35(7):1282–1292. [PubMed: 21676002]

Marczinski CA, Fillmore MT, Henges AL, Ramsey MA, Young CR. Effects of energy drinks mixed with alcohol on information processing, motor coordination and subjective reports of intoxication. Exp Clin Psychopharmacol. 2012; 20(2):129–138. [PubMed: 22023670]

Marczinski CA, Fillmore MT, Henges AL, Ramsey MA, Young CR. Mixing an energy drink with an alcoholic beverage increases motivation for more alcohol in college students. Alcohol Clin Exp Res. 2013; 37(2):276–283. [PubMed: 22724427]

Martz ME, Patrick ME, Schulenberg JE. Alcohol mixed with energy drink use among U.S. 12th-grade students: Prevalence, correlates, and associations with unsafe driving. J Adolesc Health. 2015; 56(5):557–563. [PubMed: 25907654]

Marzell M, Mallett K, Ray AE, Scaglione NM. Combining alcohol and energy drinks: An examination of psychosocial constructs and alcohol outcomes among college students using a longitudinal design. Addict Res Theory. 2014; 22(2):91–97. [PubMed: 25346654]

McKetin R, Coen A. The effect of energy drinks on the urge to drink alcohol in young adults. Alcohol Clin Exp Res. 2014; 38(8):2279–2285. [PubMed: 25041069]

Miech, RA.; Johnston, LD.; O'Malley, PM.; Bachman, JG.; Schulenberg, JE. Monitoring the Future: National survey results on drug use, 1975–2015: Volume I: Secondary school students. Institute for Social Research, The University of Michigan; Ann Arbor, MI: 2016.

Miller KE. Energy drinks, race, and problem behaviors among college students. J Adolesc Health. 2008a; 43(5):490–497. [PubMed: 18848678]

Miller KE. Wired: Energy drinks, jock identity, masculine norms, and risk taking. J Am Coll Health. 2008b; 56(5):481–490. [PubMed: 18400659]

Miller KE. Alcohol mixed with energy drink use and sexual risk-taking: Casual, intoxicated, and unprotected sex. J Caffeine Res. 2012; 2(2):62–69. [PubMed: 24761266]

Miller KE, Quigley BM. Energy drink use and substance use among musicians. J Caffeine Res. 2011; 1(1):67–73.

Miller KE, Quigley BM, Eliseo-Arras RK, Ball NJ. Alcohol mixed with energy drink use as an event-level predictor of physical and verbal aggression in bar conflicts. Alcohol Clin Exp Res. 2016; 40(1):161–169. [PubMed: 26727532]

O'Brien MC, McCoy TP, Rhodes SD, Wagoner A, Wolfson M. Caffeinated cocktails: Energy drink consumption, high-risk drinking, and alcohol-related consequences among college students. Acad Emerg Med. 2008; 15(5):453–460. [PubMed: 18439201]

Orbeta RL, Overpeck MD, Ramcharran D, Kogan MD, Ledsky R. High caffeine intake in adolescents: Associations with difficulty sleeping and feeling tired in the morning. J Adolesc Health. 2006; 38(4):451–453. [PubMed: 16549311]

Patrick ME, Evans-Polce RJ, Maggs JL. Use of alcohol mixed with energy drinks as a predictor of alcohol-related consequences two years later. J Stud Alcohol Drugs. 2014; 75(5):753–757. [PubMed: 25208192]

Peacock A, Pennay A, Droste N, Bruno R, Lubman DI. 'High' risk? A systematic review of the acute outcomes of mixing alcohol with energy drinks. Addiction. 2014; 109(10):1612–1633. [PubMed: 24846217]

Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks-A growing problem. Drug Alcohol Depend. 2009; 99(1–3):1–10. [PubMed: 18809264]

Skewes MC, Decou CR, Gonzalez VM. Energy drink use, problem drinking and drinking motives in a diverse sample of Alaskan college students. Int J Circumpolar Health. 2013; 72(21204):1–6.

Snipes DJ, Green BA, Javier SJ, Perrin PB, Benotsch EG. The use of alcohol mixed with energy drinks and experiences of sexual victimization among male and female college students. Addict Behav. 2014; 39(1):259–264. [PubMed: 24157423]

Snipes DJ, Jeffers AJ, Green BA, Benotsch EG. Alcohol mixed with energy drinks are robustly associated with patterns of problematic alcohol consumption among young adult college students. Addict Behav. 2015; 41:136–141. [PubMed: 25452057]

Spierer DK, Blanding N, Santella A. Energy drink consumption and associated health behaviors among university students in an urban setting. J Community Health. 2014; 39(1):132–138. [PubMed: 23959655]

Svatikova A, Covassin N, Somers KR, Somers KV, Soucek F, Kara T, Bukartyk J. A randomized trial of cardiovascular responses to energy drink consumption in healthy adults. JAMA. 2015; 314(19): 2079–2082. [PubMed: 26547226]

Terry-McElrath YM, O'Malley PM, Johnston LD. Energy drinks, soft drinks, and substance use among United States secondary school students. J Addict Med. 2014; 8(1):6–13. [PubMed: 24481080]

Thombs DL, O'Mara RJ, Tsukamoto M, Rossheim ME, Weiler RM, Merves ML, Goldberger BA. Event-level analyses of energy drink consumption and alcohol intoxication in bar patrons. Addict Behav. 2010; 35(4):325–330. [PubMed: 19954894]

Thorlton J, Colby DA, Devine P. Proposed actions for the US Food and Drug Administration to implement to minimize adverse effects associated with energy drink consumption. Am J Public Health. 2014; 104(7):1175–1180. [PubMed: 24832439]

Trabulo D, Marques S, Pedroso E. Caffeinated energy drink intoxication. BMJ Case Rep. 2011; 28(8): 712–714.

Trapp GSA, Allen KL, O'Sullivan T, Robinson M, Jacoby P, Oddy WH. Energy drink consumption among young Australian adults: Associations with alcohol and illicit drug use. Drug Alcohol Depend. 2014; 134(1):30–37. [PubMed: 24120855]

van Lettow B, Burdorf A, van Empelen P, de Vries H. Quantifying the strength of the associations of prototype perceptions with behaviour, behavioural willingness and intentions: A meta-analysis. Health Psychology Review. 2016; 10(1):25–43. [PubMed: 25166958]

Vincent KB, Kasperski SJ, Caldeira KM, Garnier-Dykstra LM, Pinchevsky GM, O'Grady KE, Arria AM. Maintaining superior follow-up rates in a longitudinal study: Experiences from the College Life Study. Int J Mult Res Approach. 2012; 6(1):56–72.

Wolk BJ, Ganetsky M, Babu KM. Toxicity of energy drinks. Curr Opin Pediatr. 2012; 24(2):243–251. [PubMed: 22426157]

Woolsey CL, Barnes LB, Jacobson BH, Kensinger WS, Barry AE, Beck NC, Resnik AG, Evans MW. Frequency of energy drink use predicts illicit prescription stimulant use. Subst Abus. 2014; 35(1): 96–103. [PubMed: 24588300]

Woolsey CL, Jacobson BH, Williams RD, Barry AE, Davidson RT, Evans MW, Beck NC. A comparison of the combined-use of alcohol and energy drinks to alcohol-only on high-risk drinking and driving behaviors. Subst Use Misuse. 2015a; 50(1):1–7. [PubMed: 25268401]

Woolsey CL, Williams RD Jr, Housman JM, Barry AE, Jacobson BH, Evans MW Jr. Combined use of alcohol and energy drinks increases participation in high-risk drinking and driving behaviors among college students. J Stud Alcohol Drugs. 2015b; 76(4):615–619. [PubMed: 26098038]

Zuckerman, M. Zuckerman-Kuhlman Personality Questionnaire (ZKPQ): An alternative five-factorial model. In: de Raad, B.; Perugini, M., editors. Big five assessment. Hogrefe & Huber; Seattle, WA: 2002. p. 377-396.
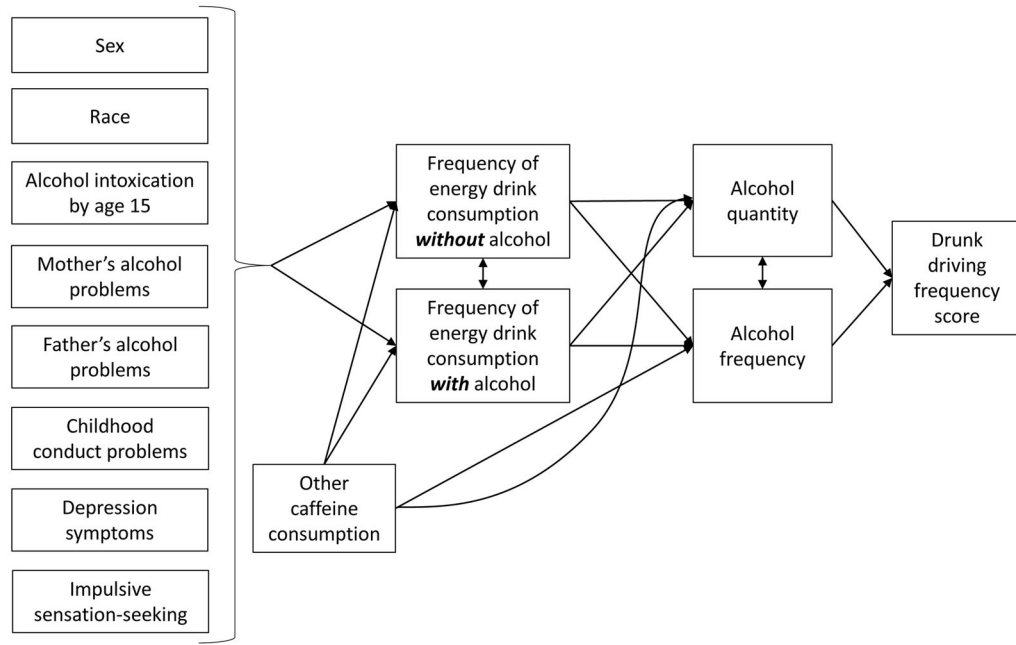
Fig. 1.
Schematic depiction of hypothesized model
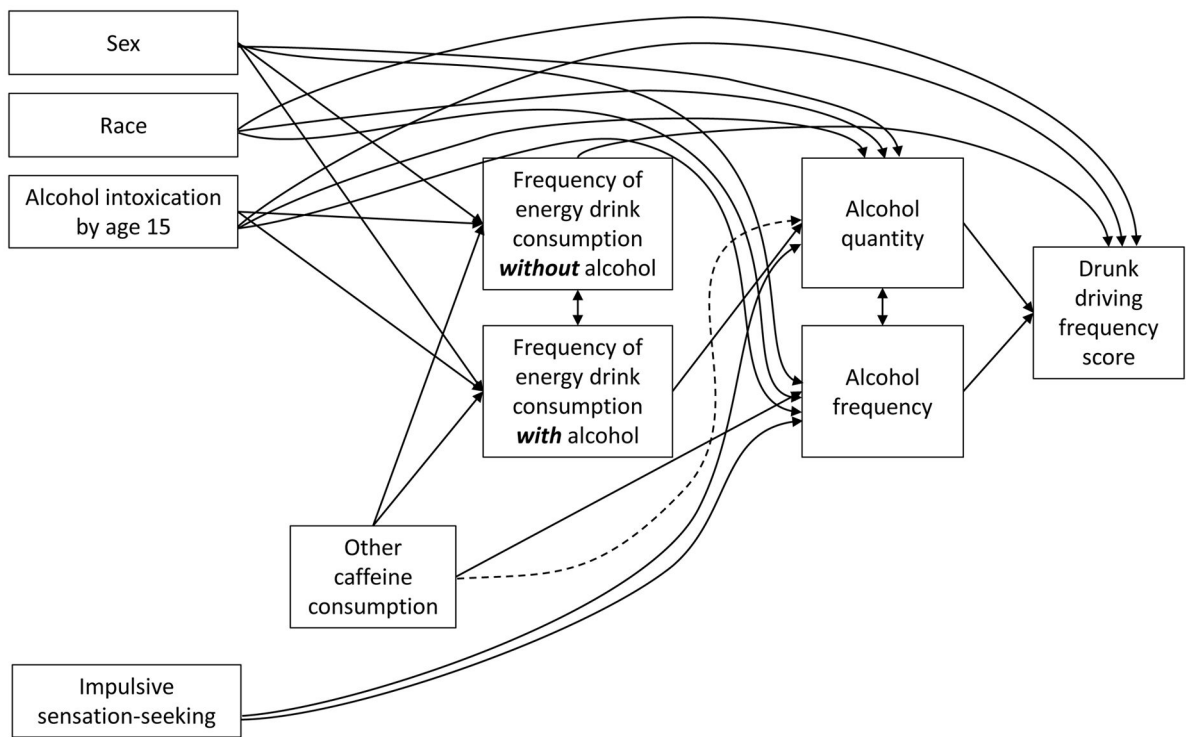
Fig. 2.
Schematic representation of final structural equation model (*n*=969)

Note. All paths depicted were statistically significant (*p*<.05) with the sole exception of the path from other caffeine consumption to alcohol quantity. See Table 4 for direct and indirect path results. Drunk driving frequency was scored as Never (0), 1 to 2 times (1), 3 to 6 times (2), 7 to 9 times (3), and 10 or more times (4).

Table 1

Sample Characteristics and Intercorrelations (*n*=969)

| Variables	Overall % or Mean (*SD*)						Correlation Matrix							
		1	2	3	4	5	6	7	8	9	10	11	12	13
1 Sex (% Male)	45%													
2 Race (% white)	72%	.06												
3 Alcohol intoxication by age 15	37%	**.08**	**.18**											
4 Mother's alcohol problems	0.1 (0.3)	–.03	**.09**	.02										
5 Father's alcohol problems	0.2 (0.6)	–.03	–.01	–.02	**.16**									
6 Impulsive sensation-seeking	3.5 (2.2)	**.09**	.05	**.24**	.05	.05								
7 Childhood conduct problems	6.6 (4.7)	**.34**	–.03	**.23**	.04	.05	**.23**							
8 Depression symptoms	5.3 (5.0)	**–.14**	**–.08**	.01	**.10**	**.09**	.02	**.13**						
9 Other caffeine consumption [(ounces/week)*10]	15.8 (11.6)	–.04	**.12**	.04	.05	.05	.05	.01	.04					
10 Frequency of energy drink consumption without alcohol (days/year)	11.2 (30.3)	**.13**	<.01	**.09**	.03	.02	**.12**	**.09**	.04	**.16**				
11 Frequency of energy drink consumption with alcohol (days/year)	4.9 (12.9)	**.10**	**.07**	**.15**	<.01	.01	**.11**	**.07**	–.03	**.09**	**.45**			
12 Alcohol frequency [(days/year)*10]	8.9 (6.5)	**.13**	**.19**	**.15**	–.01	.01	**.19**	**.13**	–**.07**	**.09**	.03	.04		
13 Alcohol quantity (typical number of drinks per drinking day)	3.3 (2.5)	**.32**	**.16**	**.21**	.02	<.01	**.21**	**.14**	–**.10**	.03	**.18**	**.36**	**.33**	
14 Drunk driving frequency score	0.4 (0.9)	**.16**	–.01	**.15**	.03	**.06**	**.13**	**.13**	.02	**.07**	**.20**	**.19**	**.29**	**.32**

Note. Results reported as Pearson correlation coefficients. All |*r*| .069 were statistically significant (*p*<.05) and are denoted in **bold**. Sex was coded as 0 (female) and 1 (male); race as 0 (non-white) and 1 (white); first drunk as 0 (age 16 or older) and 1 (age 15 or younger); and parents' alcohol problems as 0 (none), 1 (possible) and 2 (definite). Other caffeine consumption and alcohol use frequency were both rescaled by a factor of 10.

Table 2A

Patterns of Energy Drink (ED) and Alcohol Consumption among the Overall Sample (*N*=1000)

	Alcohol	ED alone	AmED	n	% of Alcohol Drinkers (*n*=969)	% of ED Consumers (*n*=566)	% of Overall Sample (*N*=1000)
Mutually exclusive categories:							
A. Drank neither alcohol nor ED	−	−	−	22	a	a	2.2
B. Did not drink alcohol, but drank ED	−	+	−	9	a	1.6	0.9
C. Drank alcohol, but not ED	+	−	−	412	42.5	a	41.2
D. Drank alcohol and ED on separate occasions, but did not mix them	+	+	−	155	16.0	27.4	15.5
E. Drank alcohol and sometimes mixed it with ED, but never drank ED without alcohol	+	−	+	87	9.0	15.4	8.7
F. Drank alcohol and ED, sometimes separately and sometimes mixed	+	+	+	315	32.5	55.7	31.5
Combined categories:							
G. Drank ED mixed with alcohol (E+F)	+/−	+/−	+	402	41.5	71.0	40.2
H. Drank ED without alcohol, among alcohol drinkers (D+F)	+	+	+/−	470	48.5	a	47.0
I. Drank ED without alcohol, among overall sample (B+D+F)	+/−	+	+/−	479	a	84.6	47.9
J. Drank ED in any pattern (B+D+E+F)	+/−	ED alone+ and/or AmED+		566	a	100.0	56.6

Note. Patterns of ED and alcohol consumption are categorized as different combinations of engaging (+) or not engaging (−) in each of the following three specific behaviors: (1) drank alcohol at least once during the past year; (2) consumed energy drinks without alcohol at least once during the past year (ED alone); and (3) consumed alcohol mixed with energy drinks at least once during the past year, either as a mixed beverage or as separate beverages that were consumed during the same drinking session (AmED).

[a] Percentage not computed due to incompatible denominator.

Table 2B

Mean (SD) Alcohol and Energy Drink (ED) Consumption Characteristics and Drunk Driving, by ED and Alcohol Consumption Category (*N*=1000)

| | n | Frequency of use | | | Typical alcohol quantity | Drunk driving | |
		Alcohol without ED	ED alone	AmED		Frequency score	% (*n*) at least once
Mutually exclusive categories:							
A. Drank neither alcohol nor ED	22	--	--	--	--	0.0 (0.0)	0.0 (0)
B. Did not drink alcohol, but drank ED	9	--	17.9 (18.6)	--	--	0.0 (0.0)	0.0 (0)
C. Drank alcohol, but not ED	412	75.2 (63.4)	--	--	2.4 (2.0)	0.21 (0.61)	14.3 (59)
D. Drank alcohol and ED on separate occasions, but did not mix them	155	91.9 (70.2)	17.3 (33.0)	--	2.7 (2.1)	0.27 (0.72)	18.1 (28)
E. Drank alcohol and sometimes mixed it with ED, but never drank ED without alcohol	87	99.6 (65.8)	--	9.8 (11.0)	4.3 (2.6)	0.52 (0.95)	28.7 (25)
F. Drank alcohol and ED, sometimes separately and sometimes mixed	315	103.1 (61.6)	26.0 (43.1)	12.2 (19.4)	4.6 (2.6)	0.78 (1.16)	41.3 (130)

Note. AmED=consumed alcohol mixed with energy drinks at least once during the past year, either as a mixed beverage or as separate beverages that were consumed during the same drinking session.

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Table 3

Summary of Model Fit

Model	χ^2 (df)	p	CFI	RMSEA	SRMR
1 Hypothesized model with indirect paths from energy drink consumption variables (with alcohol, without alcohol) to alcohol use variables (quantity, frequency) to drunk driving frequency	249.56 (27)	<.0001	.75	.08	.06
2 Add direct paths from energy drink consumption variables to drunk driving frequency	221.20 (25)	<.0001	.78	.08	.05
3 Add direct paths from background variables to alcohol quantity and frequency	26.30 (9)	.0018	.98	.04	.02
4 Final model after the refitting process, which resulted in the following modifications.	19.18 (11)	.0579	.99	.03	.02
25 non-significant paths were dropped:					

- energy drinks without alcohol to alcohol (a) quantity and (b) frequency
- energy drinks with alcohol to (a) alcohol frequency and (b) drunk driving
- race to energy drinks (a) with and (b) without alcohol
- sensation seeking to (a) drunk driving and energy drinks (b) with and (c) without alcohol
- all 16 paths from (a) mother's and (b) father's alcohol problems, (c) childhood conduct problems, and (d) baseline depression to energy drinks (e) with and (f) without alcohol, and to alcohol (g) quantity and (h) frequency

2 significant paths were added:

- race to drunk driving
- early intoxication to drunk driving

Table 4

Total, Direct, and Specific Indirect Effects of Explanatory Variables on Drunk Driving Frequency

Explanatory variable Type of path	b (SE) p
Alcohol quantity	
Total (direct only)	.082 (.012) <.001
Alcohol frequency	
Total (direct only)	.031 (.004) <.001
Frequency of energy drink consumption without alcohol	
Total (direct only)	.004 (.001) <.001
Frequency of energy drink consumption with alcohol	
Total	.005 (.001) <.001
Direct	n/a
Specific indirect through: Alcohol quantity	.005 (.001) <.001
Caffeine consumption	
Total	.003 (.001) .001
Direct	n/a
Specific indirects through:	
Alcohol quantity	<.001 (<.001) .716
Alcohol frequency	.001 (.001) .033
Frequency of energy drink consumption without alcohol	.002 (.001) <.001
Frequency of energy drink consumption with alcohol → Alcohol quantity	<.001 (<.001) .013
Sex	
Total	.194 (.027) <.001
Direct	n/a
Specific indirects through:	
Alcohol quantity	.106 (.019) <.001
Alcohol frequency	.042 (.014) .003
Frequency of energy drink consumption without alcohol	.035 (.011) .001
Frequency of energy drink consumption with alcohol → Alcohol quantity	.012 (.004) .007
Race	
Total	−.098 (.064) .127
Direct	−.212 (.061) .001
Specific indirects through:	
Alcohol quantity	.046 (.015) .001
Alcohol frequency	.068 (.017) <.001
Early age at first intoxication	
Total	.251 (.061) <.001
Direct	.139 (.057) .015
Specific indirects through:	
Alcohol quantity	.043 (.014) .002
Alcohol frequency	.031 (.014) .027
Frequency of energy drink consumption without alcohol	.020 (.009) .034

Explanatory variable Type of path	b (SE) p
Frequency of energy drink consumption with alcohol → Alcohol quantity	.018 (.005) <.001
Baseline sensation-seeking	
Total	.026 (.005) <.001
Direct	n/a
Specific indirects through:	
Alcohol quantity	.011 (.003) <.001
Alcohol frequency	.014 (.004) <.001