ORIGINAL RESEARCH

Energy Drinks, Soft Drinks, and Substance Use Among United States Secondary School Students

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Objectives: Examine energy drink/shot and regular and diet soft drink use among United States secondary school students in 2010-2011, and associations between such use and substance use.

Methods: We used self-reported data from cross-sectional surveys of nationally representative samples of 8th-, 10th-, and 12th-grade students and conducted multivariate analyses examining associations between beverage and substance use, controlling for individual and school characteristics.

Results: Approximately 30% of students reported consuming energy drinks or shots; more than 40% reported daily regular soft drink use, and about 20% reported daily diet soft drink use. Beverage consumption was strongly and positively associated with past 30-day alcohol, cigarette, and illicit drug use. The observed associations between energy drinks and substance use were significantly stronger than those between regular or diet soft drinks and substance use.

Conclusions: This correlational study indicates that adolescent consumption of energy drinks/shots is widespread and that energy drink users report heightened risk for substance use. This study does not establish causation between the behaviors. Education for parents and prevention efforts among adolescents should include education on the masking effects of caffeine in energy drinks on alcohol- and other substance-related impairments, and recognition that some groups (such as high sensation–seeking youth) may be particularly likely to consume energy drinks and to be substance users.

Key Words: adolescent, alcohol, energy drinks, illicit drugs, marijuana, soft drinks, tobacco

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Energy drinks (which typically contain high volumes/concentrations of caffeine [Babu et al., 2008; Reissig et al., 2009]) use marketing strategies claiming increased energy, concentration, and mental alertness (Committee on Nutrition and the Council on Sports Medicine and Fitness, 2011) and primarily target teenagers and young adults (Simon and Mosher, 2007). Young adult energy drink consumption has been associated with higher alcohol use frequency, volume, and dependence (Arria, 2009; Arria et al., 2011; Brache and Stockwell, 2011; Hull et al., 2011) and higher marijuana and tobacco use (Miller, 2008; Hull et al., 2011). Some studies indicate that such relationships may be found only among certain groups; Miller (2008) found energy drink use related to increased problems resulting from alcohol use, higher prescription drug use, and higher tobacco use among white college students, but not among black college students. Energy drink use has been found to predict later initiation of nonmedical prescription drug use among college students (Arria, 2009; Arria et al., 2010). Emergency department visits involving energy drinks increased almost 10-fold between 2005 and 2009; approximately half of such visits by young adults involved combined energy drink and substance use, including alcohol (Substance Abuse and Mental Health Services Administration, 2011).

Suggested explanations for observed relationships between energy drink consumption and substance use include the following: (*a*) glamorization/encouragement of substance use via marketing energy drinks for recreational and stimulant properties (Reissig et al., 2009); (*b*) considering energy drink use as part of behavioral patterns based on common psychological or social factors, including sensation-seeking or risk-oriented peer groups (Miller, 2008; Arria, 2009); (*c*) common genetic factors for polysubstance use (Reissig et al., 2009); and (*d*) cross-sensitization between caffeine and other substances (use of one substance enhances response to not only that substance but also other substances acting through the same neurobiological pathways; Temple, 2009). Cross-sensitization points to the value of including caffeine sources other than energy drinks—such as caffeinated soft drinks—in examinations of substance use relationships (Johnston et al., 1984).

Limited knowledge exists about relationships between *adolescent* caffeine consumption and substance use. National data from the 1980s among high school seniors indicated that the use of common caffeinated beverages (soft drinks, coffee, and tea) positively associated with illicit drug use (Johnston et al., 1984). Additional nationally representative research with

high school seniors indicated that over-the-counter stimulant use (eg, diet pills) correlated positively with cigarette, alcohol, and illicit drug use (Johnston, 2003). A smaller study indicated that caffeine consumption was significantly higher among adolescents with any drug abuse/dependence or marijuana dependence (Bernstein et al., 2002). Two recent nationally representative studies provided prevalence estimates of adolescent soft drink consumption: about 25% to 50% of secondary students reported daily regular soft drink use in 2010 and 2011, and about 10% to 20% reported daily diet soft drink use (Brener et al., 2011; Terry-McElrath et al., 2013). Little research has examined adolescent energy drink use (Miller, 2008). Marketing survey data from 2006 indicated that 31% of 12 to 17 year olds (28% of 12-14 year olds) were regular ("regular" was not defined) energy drink consumers (Simon and Mosher, 2007); national 2010 data showed that 24% of high school students reported drinking an energy drink in the past week (Centers for Disease Control and Prevention, 2010). Recent marketing data indicate that the energy drink market has experienced significant growth (Mintel International Group Ltd, 2011). However, to our knowledge, no nationally representative studies have reported on energy drink use among United States (US) middle and high school students in conjunction with soft drink and substance use.

This article contributes to the literature by examining 4 research questions, using data from nationally representative samples of US secondary school students: (*a*) What are the grade-specific prevalence levels for energy drink/shot consumption in comparison with regular and diet soft drinks? (*b*) What are the associations between student- and school-level factors and energy drink/shot consumption? (*c*) What are the associations between energy drink/shot consumption and regular and diet soft drink consumption? (*d*) What are the associations between energy drink/shot use and substance use, and do the observed associations differ in strength from soft drink associations with substance use?

METHODS

The analyses use data from the Monitoring the Future (MTF) study; detailed information on design and procedures is available elsewhere (Bachman et al., 2011; Johnston et al., 2012). Monitoring the Future annually surveys nationally representative cross-sectional samples of 8th-, 10th-, and 12th-grade students in the coterminous US. Informed consent was obtained, and the University of Michigan Behavioral Sciences Institutional Review Board approved the study. Surveys were administered in classrooms by University of Michigan personnel; students self-completed questionnaires during a normal class period. Student response rates averaged 90%, 87%, and 84% for 8th, 10th, and 12th grades, respectively, in 2010 and 2011. Absenteeism was the primary reason for missing data; less than 1% of students refused to participate.

Measures

Beverage Consumption

Students self-reported beverage consumption by using 4 measures worded as follows:

1. "Energy drinks are nonalcoholic beverages that usually contain high amounts of caffeine, including such drinks as Red Bull, Full Throttle, Monster, and Rockstar. They are usually sold in 8- or 16-ounce cans or bottles. About how many (if any) energy drinks do you drink PER DAY, on average?"
2. "Energy drinks are also sold as small 'shots,' that usually contain just 2 or 3 ounces. How many (if any) energy drink shots do you drink PER DAY, on average?"
3. "Regular (nondiet) soft drinks include Coke, Pepsi, Mountain Dew, Dr. Pepper, etc. How many (if any) 12-ounce cans or bottles (or the equivalent) of regular (nondiet) soft drinks do you drink PER DAY, on average?"
4. "How many (if any) 12-ounce cans or bottles (or the equivalent) of diet soft drinks (like Diet Coke, Diet Pepsi, etc) do you drink PER DAY, on average?"

The same response scale was used for each beverage: none, less than 1, 1, 2, 3, 4, 5 or 6, and 7 or more. Because of relatively low energy shot use, responses for energy drinks and shots were combined and coded in 2 ways: continuous (0, 0.5, 1, 2, 3, 4, 5.5, and 7) using the most frequently reported choice; any use dichotomy (0,1). Regular and diet soft drinks were coded in 3 ways: continuous (0, 0.5, 1, 2, 3, 4, 5.5, and 7); any use dichotomy (0,1); daily use dichotomy (0,1).

Substance Use

Students self-reported past 30-day smoking as not at all, less than 1 cigarette per day, 1 to 5 cigarettes per day, about $\frac{1}{2}$ pack per day, about 1 pack per day, about 1 $\frac{1}{2}$ packs per day, 2 packs or more per day (coded in analysis as 0, 0.5, 3, 10, 20, 30, and 40, respectively). For alcohol, marijuana, and amphetamines, students self-reported past 30-day use as 0 occasions, 1 to 2, 3 to 5, 6 to 9, 10 to 19, 20 to 39, and 40 or more occasions (coded in analysis as 0, 1.5, 4, 7.5, 15, 30, and 40, respectively). For each of the 4 substance use measures, a dichotomy indicating any use in the past 30 days was also created (0,1).

Control Variables

Self-reported sex, race/ethnicity, the number of parents in the home, and parental education (a proxy for family socioeconomic status) were used as control variables in multivariate models; region, population density (standard metropolitan statistical area [SMSA] vs non-SMSA), and year were also used. Race/ethnicity was coded as black, Hispanic, white, or other. Parental education was coded on an 11-point scale representing student-reported average parental educational attainment for father and mother (missing data for 1 parent allowed).

Data Analyses

Survey commands in Stata 12 (Stata Press, 2011) were used to examine grade-specific beverage consumption rates and to explore multivariate linear regression models of beverage consumption frequency using student- and school-level control variables. Analyses addressing research questions focusing on correlations between (a) beverage consumption types and (b) between beverage consumption and substance use were conducted with path analysis using Mplus 6.11

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(Muthén and Muthén, 1998-2012) to obtain standardized correlations controlling for student- and school-level sociodemographic characteristics. Multivariate survey logistic models in Stata 12 were used to compare the relative strength of observed associations between beverage and substance use. Predicted probabilities were obtained using the margins command, and post hoc testing was used to determine whether obtained estimates differed significantly across beverage types. All analyses clustered by school and included weights to adjust for differential probability of selection.

RESULTS

After limiting the sample to cases having at least one beverage consumption measure, at least one substance use measure, and no missing control variable data, a total of 21,995 (unweighted) cases remained. The sample was 36% 8th-grade students, 35% 10th-grade students, and 29% 12th-grade students; 49% were adolescent boys. Racial/ethnic distribution was 60% white, 15% Hispanic, 11% black, and 14% other. Seventy-three percent of students reported having 2 parents in the home. Seventy-eight percent resided in an SMSA; regional distribution was 36% South, 25% Midwest, 23% West, and 17% Northeast.

Beverage Consumption

Beverage consumption and past 30-day substance use rates are reported in Table 1 by grade. Any energy drink/shot use was reported by 35% of 8th graders, 30% of 10th graders, and 31% of 12th graders. Daily regular soft drink use was reported by 51%, 46%, and 43% of 8th, 10th, and 12th graders, respectively. Considerably fewer students reported daily diet soft drink use: 23%, 21%, and 19% of 8th-, 10th-, and 12th-grade students.

Table 2 presents multivariate associations between student and school characteristics and energy drink/shot consumption frequency. Similar analyses have been published examining student and school characteristic associations with MTF regular and diet soft drink consumption (Terry-McElrath et al., 2013). Because the model combines all 3 grades, resulting in a large number of cases, a $P \leq 0.001$ will be considered significant. Eighth graders reported significantly higher energy drink/shot consumption frequency than 10th- or 12th-grade students. Consumption frequency was significantly higher for adolescent boys than for adolescent girls and showed significantly negative relationships with 2 parents in the home and average parental education. Energy drink/shot use frequency was higher among students residing outside of SMSAs. Neither race/ethnicity nor region associated with

TABLE 1. Secondary Student Beverage Consumption and Substance Use, 2010-2011

		8th Grade		10th Grade		12th Grade	
	Range	Mean/%*	SE	Mean/%*	SE	Mean/%*	SE
Beverage consumption							
Energy drinks/shots							
Use frequency†	0-7	0.473	0.020	0.329	0.014	0.323	0.018
Any use prevalence‡	0,1	35.4%	0.9%	30.2%	0.8%	31.3%	1.0%
Regular soft drinks							
Use frequency†	0-7	1.298	0.038	1.131	0.037	1.038	0.038
Any use prevalence‡	0,1	76.1%	0.7%	71.5%	0.9%	69.3%	1.1%
Daily use prevalence§	0,1	51.3%	1.3%	46.2%	1.2%	42.8%	1.5%
Diet soft drinks							
Use frequency†	0-7	0.576	0.019	0.500	0.019	0.460	0.019
Any use prevalence‡	0,1	40.8%	0.7%	36.9%	0.8%	35.3%	1.0%
Daily use prevalence§	0,1	23.3%	0.7%	20.6%	0.7%	19.0%	0.8%
Past 30-day substance use							
Alcohol							
Use frequency¶	0-40	0.588	0.046	1.386	0.068	2.379	0.138
Any use prevalence‖	0,1	13.1%	0.6%	29.3%	0.9%	38.8%	1.3%
Cigarettes							
Use frequency¶	0-40	0.252	0.036	0.534	0.041	0.865	0.078
Any use prevalence‖	0,1	6.5%	0.5%	12.8%	0.5%	16.9%	0.8%
Marijuana							
Use frequency¶	0-40	0.684	0.063	2.033	0.108	2.796	0.168
Any use prevalence‖	0,1	7.2%	0.5%	17.6%	0.6%	21.3%	0.9%
Amphetamines							
Use frequency¶	0-40	0.091	0.014	0.202	0.024	0.296	0.045
Any use prevalence‖	0,1	1.7%	0.1%	3.4%	0.2%	3.7%	0.4%

Notes: Unweighted cases by grade for measures listed ranged from 8517 to 8934 for 8th grade, from 8974 to 9243 for 10th grade, and from 4025 to 4461 for 12th grade.

*Means are reported for continuous use frequency measures; percentages are reported for dichotomous use prevalence measures.

†Beverage consumption frequency measured as 0, none; 0.5, less than 1 per day; 1, 1 a day; 2, 2 per day; 3, 3 per day; 4, 4 per day; 5.5, 5 or 6 per day; and 7, 7 or more per day.

‡Any beverage use prevalence indicates any consumption per day, on average (1) versus none (0).

§Daily beverage use prevalence indicates at least 1 per day, on average (1) versus less than 1 or none (0).

¶Alcohol, marijuana, and amphetamine use frequency measured as the number of occasions of use in the past 30 days: 0 (0), 1.5 (1-2), 4 (3-5), 7.5 (6-9), 15 (10-19), 30 (20-39), 40 (40 or more). Cigarette use frequency measured as the number of cigarettes smoked per day in the past 30 days: 0 (0), 0.5 (<1 cigarette), 3 (1-5 cigarettes), 10 (1/2 pack), 20 (1 pack), 30 (1 and 1/2 packs), and 40 (2 or more packs).

‖Any substance use prevalence indicates any use in the past 30 days (1) versus none (0).

TABLE 2. Multivariate Model Relationships Between Student and School Characteristics and Energy Drink/Shot Consumption Among Secondary School Students, 2010-2011

| | Energy Drink/Shot Frequency | | | |
| | Multivariate | | | |
	Mean*	*b*	SE	*P*
Grade				
8th	0.473	Reference		
10th	0.329	−0.152	0.021	≤0.001
12th	0.323	−0.172	0.024	≤0.001
Sex				
Female	0.301	Reference		
Male	0.462	0.177	0.015	≤0.001
Race/ethnicity				
White	0.350	Reference		
Black	0.418	0.002	0.028	
Hispanic	0.446	0.035	0.028	
Other	0.404	0.046	0.024	
Parents in the home				
0-1	0.482	Reference		
2	0.341	−0.123	0.020	≤0.001
Average parental education		−0.007	0.001	≤0.001
Region				
South	0.422	Reference		
Midwest	0.362	−0.030	0.024	
Northeast	0.375	0.002	0.028	
West	0.333	−0.079	0.025	
Population density				
Non-SMSA	0.461	Reference		
SMSA	0.356	−0.086	0.022	≤0.001
Year				
2010	0.382	Reference		
2011	0.376	0.003	0.016	

Notes: Energy drink/shot frequency indicates average daily consumption, measured on a continuous scale of 0 (none), 0.5 (<1 per day), 1, 2, 3, 4, 5.5 (5-6), and 7 (7 or more per day). Model n (unweighted) = 21,983.

*Mean of specified beverage consumption per cell of categorical predictor.

b, unstandardized regression parameter estimate; SE, standard error; SMSA, *standard metropolitan statistical area*.

energy drink/shot use; energy drink/shot consumption did not significantly change between 2010 and 2011.

Beverage consumption types were significantly (*P* < 0.001) and positively correlated for all comparisons and all grades in path analyses simultaneously including all 3 continuous beverage frequency outcomes (controlling for student- and school-level variables). Standardized correlations between energy drink/shot and regular soft drink use were 0.35, 0.33, and 0.37 for 8th, 10th, and 12th grades, respectively; and between energy drinks/shots and diet soft drinks were 0.31, 0.30, and 0.39 for 8th, 10th, and 12th grades, respectively. Correlations between regular and diet soft drink use were 0.42, 0.36, and 0.40.

Associations Between Beverage Consumption and Substance Use

Table 3 presents standardized correlations from path analyses with one beverage use frequency measure and one substance use frequency measure (controlling for student- and school-level variables). Energy drink/shot use frequency significantly and positively correlated with past 30-day use frequency of all substance use measures (alcohol, cigarettes,

marijuana, and amphetamines) for all grades. Significant standardized correlations (*r*) ranged from 0.05 to 0.21.

Regular soft drink use frequency significantly and positively correlated with past 30-day use frequency of alcohol, cigarettes, and marijuana for all grades, and with amphetamines for 8th- and 10th-grade students (*r* values range: 0.10-0.11 for alcohol, 0.12-0.23 for cigarettes, 0.09-0.11 for marijuana, and 0.02-0.05 for amphetamines). Diet soft drinks showed significant and positive correlations across all 3 grades only with past 30-day cigarette use (*r* = 0.09-0.13). Among 8th- and 10th-grade students, diet soft drinks also significantly and positively correlated with past 30-day alcohol (*r* = 0.06-0.09) and marijuana use (*r* = 0.03-0.07). Significant correlations between diet soft drinks and past 30-day amphetamine use were found only among 8th graders (*r* = 0.04).

A second series of path analyses was then run with 4 continuous outcomes: 1 substance use frequency measure and all 3 beverage use frequency measures (controlling for student- and school-level variables). Results (not shown) included no substantive differences, indicating that the observed correlation between a beverage and substance use outcome was independent of other beverage-substance use associations.

To compare relative association strength between beverage consumption and substance use, and to produce predicted probabilities for graphical comparison, multivariate logistic regression models were run in which the dependent variable was any past 30-day use of a specified substance; the 3 beverage use prevalence measures were simultaneously included as independent variables, and all student- and school-level variables were included as controls. Results allow association strength comparisons and do not indicate causality. Table 4 reports odds ratios and 95% confidence intervals; Figure 1 provides graphical presentation of results. For all grades and substances, the estimate obtained for any energy drinks/shots was significantly higher than for daily use of either regular or diet soft drinks. Differences between regular and diet soft drinks were observed only for 8th grade alcohol use and 10th grade cigarette use (where estimates for daily regular soft drink use were significantly higher than for daily diet soft drink use).

DISCUSSION

Energy drink/shot use was reported by almost one-third of US secondary students and strongly associated with sex, the number of parents in the household, and average parental education. Beverage consumption and substance use were strongly and positively correlated. Energy drink/shot use was positively correlated with all substance use measures for all grades; cigarette use frequency was correlated with use frequency of all beverages for all grades. Comparisons of relationship strength indicated that associations between energy drinks/shots and substance use were significantly stronger than for either regular or diet soft drinks.

Although this study has a number of strengths, including large nationally representative samples, some limitations should be noted. Data were cross-sectional (thus, cannot be used to draw causal inferences) and self-reported. Reliability and validity of the substance use data have been discussed elsewhere; conclusions are that the data are sufficiently reliable and valid for research purposes (Bachman et al., 2011;

TABLE 3. Multivariate Path Analysis Correlations Between Beverage Consumption and Past 30-Day Substance Use Frequency Among Secondary School Students, 2010-2011

	8th Grade		10th Grade		12th Grade	
	r*	P	r*	P	r*	P
Energy drink/shot frequency						
Alcohol use frequency	0.203	<0.001	0.122	<0.001	0.132	<0.001
Cigarette use frequency	0.186	<0.001	0.194	<0.001	0.205	<0.001
Marijuana use frequency	0.154	<0.001	0.097	<0.001	0.056	<0.01
Amphetamine use frequency	0.073	<0.01	0.050	<0.01	0.072	<0.05
Regular soft drink frequency						
Alcohol use frequency	0.108	<0.001	0.103	<0.001	0.107	<0.001
Cigarette use frequency	0.115	<0.001	0.192	<0.001	0.230	<0.001
Marijuana use frequency	0.088	<0.001	0.106	<0.001	0.105	<0.001
Amphetamine use frequency	0.046	<0.01	0.024	<0.05	0.025	
Diet soft drink frequency						
Alcohol use frequency	0.090	<0.001	0.059	<0.001	0.043	
Cigarette use frequency	0.121	<0.001	0.130	<0.001	0.091	<0.01
Marijuana use frequency	0.074	<0.001	0.034	<0.01	0.022	
Amphetamine use frequency	0.035	<0.05	0.013		− 0.012	

Notes: Each model contained 2 continuous outcomes: 1 beverage frequency measure and 1 substance use frequency measure. All models included direct paths between the following specified controls and each outcome: sex, white race/ethnicity, whether both parents resided in the home, average parental education, region (using a dichotomy for South), population density (using a dichotomy for *standard metropolitan statistical area* vs other), and year (using a dichotomy for 2011).
*Standardized values shown for correlations.

TABLE 4. Multivariate Logistic Regression Relationships Between Any Past 30-Day Substance Use and Beverage Consumption Among Secondary School Students, 2010-2011

	Drug Use Outcome											
	Any Alcohol Use			Any Cigarette Use			Any Marijuana Use			Any Amphetamine Use		
	OR	P	95% CI	OR	P	95% CI	OR	P	95% CI	OR	P	95% CI
8th grade												
Any energy drink/shot use	3.29	<0.001	2.77-3.92	3.75	<0.001	2.98-4.72	3.16	<0.001	2.47-4.04	3.94	<0.001	2.58-6.02
Daily regular soft drink use	1.34	<0.001	1.15-1.56	1.42	<0.01	1.12-1.81	1.09		0.87-1.35	1.18		0.71-1.95
Daily diet soft drink use	1.02		0.86-1.22	1.36	<0.01	1.09-1.71	1.06		0.86-1.31	1.65	<0.05	1.06-2.56
Energy vs regular*		<0.001			<0.001			<0.001			<0.01	
Energy vs diet†		<0.001			<0.001			<0.001			<0.01	
Regular vs diet‡		<0.05										
10th grade												
Any energy drink/shot use	2.12	<0.001	1.84-2.44	2.73	<0.001	2.36-3.16	2.14	<0.001	1.85-2.46	3.05	<0.001	2.24-4.15
Daily regular soft drink use	1.24	<0.001	1.10-1.40	1.51	<0.001	1.29-1.76	1.21	<0.01	1.05-1.40	1.16		0.87-1.55
Daily diet soft drink use	1.06		0.90-1.25	1.17		0.99-1.37	1.01		0.85-1.19	1.10		0.81-1.50
Energy vs regular*		<0.001			<0.001			<0.001			<0.001	
Energy vs diet†		<0.001			<0.001			<0.001			<0.001	
Regular vs diet‡					<0.05							
12th grade												
Any energy drink/shot use	2.07	<0.001	1.74-2.46	3.18	<0.001	2.59-3.91	1.75	<0.001	1.47-2.08	3.12	<0.001	1.91-5.11
Daily regular soft drink use	1.16		0.96-1.39	1.32	<0.05	1.02-1.69	1.22	<0.05	1.01-1.47	1.33		0.84-2.11
Daily diet soft drink use	1.02		0.82-1.27	1.42	<0.01	1.12-1.80	1.03		0.81-1.31	0.84		0.50-1.39
Energy vs regular*		<0.001			<0.001			<0.01			<0.05	
Energy vs diet†		<0.001			<0.001			<0.01			<0.01	
Regular vs diet‡												

Notes: All 3 beverage consumption measures entered simultaneously. All models controlled for sex, white race/ethnicity, whether both parents resided in the home, average parental education, region (using a dichotomy for South), population density (using a dichotomy for *standard metropolitan statistical area* vs other), and year (using a dichotomy for 2011).
*Post hoc comparison of equality between estimate obtained for regular soft drinks and energy drinks/shots.
†Post hoc comparison of equality between estimate obtained for diet soft drinks and energy drinks/shots.
‡Post hoc comparison of equality between estimate obtained for regular soft drinks and diet soft drinks.
CI, confidence interval; OR, odds ratio.

Johnston et al., 2012). Specific data on reliability and validity of the MTF beverage measures are not available; other research has found adequate reliability and validity for similar measures among adolescents (Neuhouser et al., 2009). Soft drink consumption measures did not specifically identify only caffeinated soft drinks (although only caffeinated examples were listed, and responses may have been biased toward caffeinated sodas); student responses may include some noncaffeinated drinks. Data on caffeinated beverage consumption other than soft drinks and energy drinks/shots (eg, coffee, teas) were not available. Such limitations notwithstanding, the current study's representative national sample of secondary
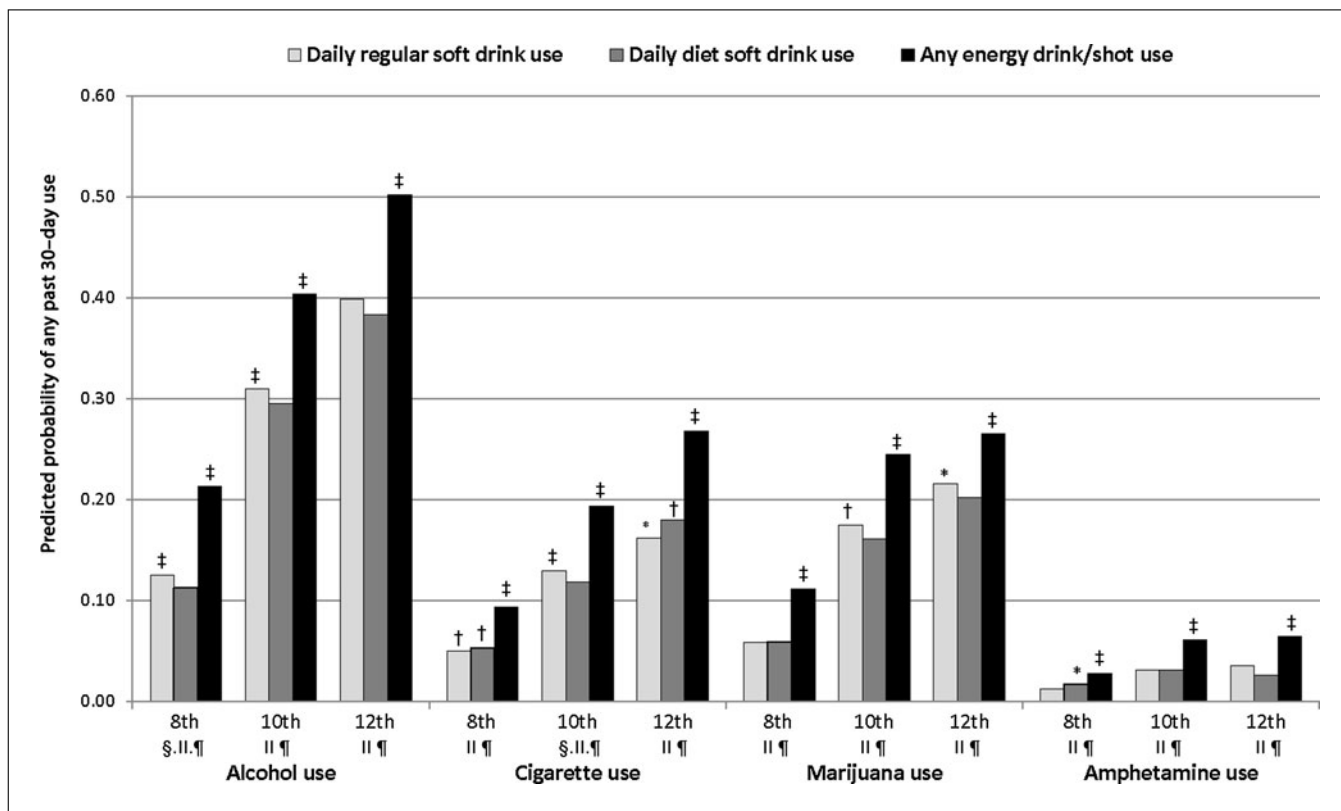
FIGURE 1. Predicted probabilities of any past 30-day substance use by grade and type of beverage consumption among secondary students, 2010-2011. *Notes*: All models simultaneously included all 3 beverage consumption measures, sex, white race/ethnicity, whether both parents resided in the home, average parental education, region (using a dichotomy for South), population density (using a dichotomy for *standard metropolitan statistical area* vs other), and year (using a dichotomy for 2011). Post hoc contrasts used to examine equality of beverage consumption estimates on substance use. Bar heights show the estimated probability of use of the indicated substance (alcohol, cigarettes, marijuana, or amphetamines) by type of beverage use (energy drinks/shots, regular soft drinks, or diet soft drinks), based on models that included all 3 beverage use measures and all control variables. Footnote symbols (*, †, ‡) above each bar indicate the significance of difference between the specific beverage type and the relevant substance. Footnote symbols (§, ‖, ¶) below each grade indicator show which specific contrasts were significant. *$P <$ 0.05; †$P <$ 0.01; ‡$P <$ 0.001 for associations between beverage consumption and substance use in multivariate logistic regression models. §Significant ($P <$ 0.05) difference between estimate for regular soft drinks and diet soft drinks. ‖Significant ($P <$ 0.05) difference between estimate for regular soft drinks and energy drinks/shots. ¶Significant ($P <$ 0.05) difference between estimate for diet soft drinks and energy drinks/shots.

students contributes significantly to knowledge about adolescent soft drink and energy drink/shot consumption and about relationships between such consumption and substance use.

The current study indicated that both soft drink and energy drink consumption decreased with grade level—a finding that may be counterintuitive. National data from the Youth Risk Behavior Surveillance System (which uses in-school surveys of high school students) also report that soda consumption prevalence decreases as grade level increases (Centers for Disease Control and Prevention, 1991-2011). Reliability and validity of reporting food and beverage consumption do increase with age among adolescents (Field et al., 1999; McPherson et al., 2000; van Assema et al., 2002); 8th graders may overestimate consumption. Alternatively, adolescents with high soda and energy drink consumption may have higher school dropout risk, thus resulting in lower prevalence rates by 12th grade. Previous research (Terry-McElrath et al., 2013) and the cur-

rent analyses indicate that soda and energy drink consumption are highest among youth residing in families with low average parental education and single-parent households, both of which are associated with school dropout (Suh et al., 2007; Chapman et al., 2011).

Analyses showed that adolescents reported consuming more energy drinks than diet soft drinks. Energy drinks contain significantly more nonnutritive stimulants (caffeine, guarana, taurine, etc) (Committee on Nutrition and the Council on Sports Medicine and Fitness, 2011) than soft drinks, which are regulated by US Food and Drug Administration–imposed limits of 71 mg per 12-ounce serving (Heckman et al., 2010; Arria and O'Brien, 2011). In contrast, energy drinks/shots have been found to contain nonnutritive stimulants that range from 2.5 to 171 mg per ounce (Reissig et al., 2009). Although the current study did not investigate reasons for adolescent energy drink use, 1 small study reported that the most common reasons for

college students' use included counteracting insufficient sleep, needing energy in general, and mixing with alcohol while partying (Malinauskas et al., 2007). Malinauskas et al. (2007) showed the average number of energy drinks consumed for sleep and energy was 1 drink; however, 3 to 4 drinks were reported when partying. Young adult focus group research indicated that a primary reason for combining energy drinks with alcohol was to extend the ability to party (Jones and Barrie, 2009). The current study was unable to determine to what extent adolescents used energy drinks simultaneously with other substances. Prior research indicates that some adolescents participate in simultaneous drug use to obtain unique highs from combined psychopharmacological effects (Terry-McElrath et al., 2013). The extent of correlation between energy drink consumption and substance use may differ between adolescents who do and do not engage in simultaneous energy drink and substance use.

It seems reasonable to apply research on energy drink use risks among young adults to adolescents. As noted previously, energy drink use has been found to relate significantly and positively to increased use of various drugs (Bernstein et al., 2002; Miller, 2008; Arria et al., 2010; Arria et al., 2011; Brache and Stockwell, 2011; Hull et al., 2011). Young adult energy drink use has also been associated with higher levels of intentions to drive while intoxicated (Thombs et al., 2010), sexual risk behaviors, serious physical fights, seat belt omission, and other risk behaviors (Miller, 2008). Caffeine use reduces an individual's perception of being drunk but does not diminish alcohol-related impairment, thus possibly leading to both increased alcohol consumption and increased participation in high-risk behaviors such as driving while intoxicated (Thombs et al., 2010; Arria and O'Brien, 2011). Prevention efforts among adolescents should include education on the masking effects of caffeine in energy drinks on alcohol- and other substance-related impairment.

As noted previously, energy drink use may be part of behavioral patterns based on common psychological or social factors such as sensation-seeking or risk-oriented peer groups (Miller, 2008; Arria, 2009). Young adult energy drink use has been found to be positively associated with sensation-seeking (Arria, 2009; Arria et al., 2010; Brache and Stockwell, 2011), a trait also associated with substance use (D'Silva et al., 2001; Horvath et al., 2004). It is possible that, after controlling for sensation-seeking, observed associations between energy drink and substance use might attenuate.* However, among individuals who report simultaneous energy drink and alcohol use, increased risk has been shown to persist after controlling for sensation-seeking/risk-taking. After controlling for risk-taking propensity, young adults who combined alcohol and energy drinks were more likely to be heavy drinkers, and individuals who frequently combined alcohol and energy drinks experienced more negative consequences (impaired driving and injuries) than individuals who less frequently combined alcohol and energy drinks (Brache and Stockwell, 2011).

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*MTF measures of energy drink consumption and sensation-seeking/risk-taking are not on the same questionnaire form; thus, the current analyses cannot investigate this question.

The current study indicated adolescent regular and diet soft drink use also associated with substance use—particularly cigarette smoking. Such results may reflect something as simple as a healthy lifestyle: youth who choose not to use soft drinks may also be likely to choose not to participate in substance use. Also possible is that some adolescent soft drink users and substance users share other similar personal characteristics and/or peer groups (Arria, 2009) or underlying disorders such as depression (Kendler et al., 2006). It is less likely that soft drink use can be considered similar to energy drink use in terms of either glamorizing/encouraging substance use via marketing (Reissig et al., 2009) or being part of a problem behavior syndrome based on sensation-seeking or risk-oriented peer group membership (Miller, 2008). An unobserved measure, such as parental control/monitoring, may associate with energy drink, soft drink, and substance use. Higher levels of parental control have been associated with lower adolescent substance use (Kiesner et al., 2010) and lower adolescent soft drink consumption (Nickelson et al., 2010); it is likely that parental control also associates with energy drink use. Thus, low parental control may result in higher prevalence of all of the aforementioned behaviors, rather than a causal link existing between energy drinks and substance use.

Caffeine also may play a role in the current study's findings. An early study indicated that caffeinated soft drink consumption showed possibly stronger associations with illegal drug use than noncaffeinated soft drink consumption (Johnston et al., 1984). Research does support the possibility of neuropharmacological effects of caffeine on other substance use (Arria and O'Brien, 2011). Caffeine reinforces the effects of nicotine; cigarette smokers consume caffeine in higher amounts than do nonsmokers (Reissig et al., 2009). The current study indicated that cigarette smoking frequency was the only substance use measure significantly and positively associated with beverage use frequency for all grades. A similar pattern was observed between *any* past 30-day cigarette use and any energy drink/shot use, and daily regular and diet soft drink use (excluding daily diet soft drink use among 10th grade students).

CONCLUSIONS

In 2011, the American Academy of Pediatrics stated, "... the caffeine and other stimulant substances contained in energy drinks have no place in the diet of children and adolescents" (Committee on Nutrition and the Council on Sports Medicine and Fitness, 2011; p.1182). The current study indicates that adolescent consumption of energy drinks/shots is widespread and that energy drink users also report heightened risk for substance use. This study does not establish causation between the behaviors. Yet, education for parents and prevention efforts among adolescents should include education on the masking effects of caffeine in energy drinks on alcohol- and other substance-related impairments, and recognition that some groups (such as high sensation–seeking youth) may be particularly likely to consume energy drinks and to be substance users.

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