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RESEARCH ARTICLE

Trends in Energy Drink Consumption Among U.S. Adolescents and Adults, 2003–2016

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Introduction: Energy drinks refer to non-alcoholic beverages that contain caffeine, amino acids, herbs, and vitamins. Although energy drinks are marketed to reduce fatigue and improve physical/mental performance, frequent consumption of these beverages has been linked to negative health consequences. The purpose of this study is to provide timely, national estimates of the percentage of energy drink consumers in the U.S. and to analyze trends in energy drink intake between 2003 and 2016.

Methods: A total of 9,911 adolescents (aged 12–19 years); 12,103 young adults (aged 20–39 years); and 11,245 middle-aged adults (aged 40–59 years) were assessed using dietary data from the 2003–2016 National Health and Nutrition Examination Surveys. For each age group (adolescents, young adults, and middle-aged adults), logistic regression was used to estimate the proportion of energy drink consumers, and negative binomial regression was used to estimate per capita energy drink consumption, adjusting for covariates. Differences in total caffeine intake between energy drink consumers and non-consumers were examined by pooling all survey years together and using negative binomial regression. Analyses were conducted in 2018.

Results: From 2003 to 2016, the prevalence of energy drink consumption increased significantly for adolescents (0.2% to 1.4%, p=0.028); young adults (0.5% to 5.5%, p<0.001); and middle-aged adults (0.0% to 1.2%, p=0.006). Per capita consumption of energy drinks increased significantly from 2003 to 2016 only for young adults (1.1 to 9.7 calories, p<0.001). Pooled across years, energy drink consumers had significantly higher total caffeine intake compared with non-consumers for adolescents (227.0 mg vs 52.1 mg, p<0.001); young adults (278.7 mg vs 135.3 mg, p<0.001); and middle-aged adults (348.8 mg vs 219.0 mg, p<0.001).

Conclusions: These findings indicate that consumption of energy drinks has grown substantially and that these drinks are a major source of caffeine among those who consume them.

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INTRODUCTION

Energy drinks refer to non-alcoholic beverages that contain caffeine, other plant-based stimulants (e.g., guarana); amino acids (e.g., taurine); herbs (e.g., ginkgo biloba); and vitamins.[1] Introduced to the U.S. in 1997, energy drinks are marketed to reduce fatigue, improve athletic performance, and enhance mental functioning. Although some studies have found evidence that consumption of energy drinks by healthy adolescents and young adults can temporarily improve physical and mental stamina[2,3] and may not be harmful at low intake,[4] a larger and more rapidly expanding body of literature has linked frequent energy drink consumption to negative health consequences.[1,5–7] These adverse health outcomes are primarily related to excessive caffeine intake and include risk-seeking behaviors,

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poor mental health, caffeine toxicity, and adverse cardiovascular effects. Many energy drinks also contain added sugar, creating additional risk for obesity, type 2 diabetes, and dental caries.[8,9] There is also serious concern about the negative health effects associated with the practice of mixing energy drinks with alcohol, a combination that often leads to overconsumption of alcohol and incidence of alcohol-related events (e.g., car accidents).[10,11]

Although a number of studies have examined trends in sugar-sweetened beverage consumption,[12] little attention has been paid specifically to energy drinks. The primary purpose of this study is to provide timely, national estimates of the percentage of energy drink consumers in the U.S. by age group (adolescents, young adults, and middle-aged adults), as well as to analyze trends in energy drink consumption between 2003 and 2016. A secondary objective is to examine differences in the prevalence of energy drink consumption by demographic characteristics (age category, sex, race/ethnicity, and educational attainment). Given concerns about the high caffeine content of energy drinks, this study also aims to compare total caffeine intake between energy drink consumers and non-consumers.

METHODS

Study Population

The National Health and Nutrition Examination Survey (NHANES) is a repeated cross-sectional study designed to be representative of the U.S. non-institutionalized population.[13] A complete description of data collection procedures and analytic guidelines is available through NHANES.[13]

Data from seven survey cycles (2003–2016), which includes the most recently released data, were used in this analysis. The study sample consisted of adolescents (aged 12–19 years); young adults (aged 20–39 years); and middle-aged adults (aged 40–59 years) with a complete 24-hour dietary recall and data on all covariates. Individuals aged <12 or >60 years were not included because the low levels of energy drink consumption in these age groups would provide unreliable estimates.

Measures

Although NHANES conducts two in-person 24-hour dietary recalls, only the first was included in this analysis because the second recall had a higher nonresponse rate and a differing mode of data collection (conducted via phone). The use of a single 24-hour recall is consistent with the methods of other studies analyzing trends in food and beverage consumption using NHANES data.[12,14,15] After the dietary interview, all reported food and beverage items were systemically coded using the Food and Nutrient Database for Dietary Studies to obtain caloric and caffeine information. Energy drinks were identified as any beverage that included the term "energy drink" in the Food and Nutrient Database for Dietary Studies main food description (e.g., "Red Bull Energy Drink"; Appendix Table 1 [available online] lists the energy drink beverage codes across all years). This definition included both full-calorie and diet energy drinks.

The calorie and caffeine content for each beverage consumed by an individual was obtained by using the Individual Foods files from the NHANES. If multiple energy drinks were consumed in a given day, the calorie and caffeine content of each beverage were summed together to create a daily total for each individual. Total caffeine intake, defined as caffeine obtained from all caffeine-containing food and beverage sources, was obtained from the Total Nutrient file from NHANES.

The following covariates were included: sex (male, female); age (12–19 years, 20–39 years, 40–59 years); race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, other race/ethnicity); and educational attainment (less than high school, high school graduate or GED, more than high school graduate). For adolescents, educational attainment refers to the educational attainment of the primary household respondent.

Statistical Analysis

All analyses were weighted to account for the multistage, clustered probability sampling of the NHANES. Logistic regression was used to estimate the proportion of the population who reported consuming an energy drink on a given day for each year. To estimate per capita consumption of energy drink calories, two models were fitted: (1) negative binomial regression including all participants and (2) negative binomial regression including only participants who reported consuming a full-calorie energy drink in the past 24 hours. A negative binomial regression model was chosen because the distribution of energy drink calorie consumption in this sample was heavily skewed and over-dispersed. To account for potential changes in population composition over time, all models were age stratified (12–19 years, 20–39 years, 40–59 years) and adjusted for sex, race/ethnicity, and educational attainment. For each model, p-values for the linear trend from 2003 to 2016 are reported.

To examine differences in the prevalence of energy drink consumption across sex, race/ethnicity, and educational attainment, it was necessary to pool data across the seven survey cycles to ensure a sufficient analytic sample. Controlling for survey year, age-stratified logistic regression was then used to estimate the proportion of the population who reported consuming an energy drink on a given day for each sex, race/ethnicity, and educational attainment category. Therefore, it was not possible to examine trends in consumption over time by these demographic characteristics; instead, differences in consumption were examined in a single pooled population, controlling for survey year.

To examine differences in total caffeine intake between energy drink consumers and non-consumers, it was also necessary to pool data across the seven survey cycles to ensure a sufficient analytic sample. Negative binomial regression models were fitted to predict total caffeine intake, with an indicator variable used to indicate energy drink consumers versus non-consumers on a given day. These age-stratified models were adjusted for sex, race/ethnicity, educational attainment, and survey year. The proportion of caffeine from energy drinks was calculated as caffeine from energy drinks (both full-calorie and diet) divided by total caffeine from all food and beverage sources.

All analyses were conducted in 2018 using Stata, version 14.2.

Table 1. Characteristics of Sample in NHANES 2003–2016

Characteristic	Adolescents (12–19 years) (*n*=9,911)	Young adults (20–39 years) (*n*=12,103)	Middle-aged adults (40–59 years) (*n*=11,245)
Sex			
Male	5,039	5,774	5,424
Female	4,872	6,329	5,821
Race/ethnicity			
Mexican American	2,577	2,325	1,854
Other Hispanic	790	1,065	1,032
Non-Hispanic white	2,749	4,867	4,771
Non-Hispanic black	2,922	2,538	2,542
Other race/ethnicity	873	1,308	1,046
Education status			
Less than high school	2,990	2,544	2,716
High school or GED	2,360	2,795	2,549
More than high school	4,561	6,764	5,980

Note: Education status of adolescents refers to highest education status of household respondent.
NHANES, National Health and Nutrition Examination Survey.

RESULTS

The study sample included 9,911 adolescents, 12,103 young adults, and 11,245 middle-aged adults with a reliable 24-hour dietary recall and complete data on all covariates in NHANES 2003–2016 (Table 1). From 2003 to 2016, the prevalence of energy drink consumption increased significantly for adolescents (0.2% to 1.4%, p=0.028); young adults (0.5% to 5.5%, p<0.001); and middle-aged adults (0.0% to 1.2%, p=0.006; Figure 1).

Per capita consumption of energy drinks across the whole sample increased significantly from 2003 to 2016 for young adults (1.1 to 9.7 calories, p<0.001). Over the same time period, per capita consumption of energy drinks increased, but not significantly, among adolescents (0.4 to 2.3 calories, p=0.386) and middle-aged adults (0.0 to 4.1 calories, p=0.061; Table 2). Caloric intake from calorie-containing energy drinks among energy drink consumers did not change significantly among adolescents (146.5 to 249.5 calories, p=0.140); young adults (227.5 to 228.8 calories, p=0.190); or middle-aged adults (252.9 to 169.7 calories, p=0.884).

Males consumed energy drinks at a significantly higher level than females across all age groups (adolescents: 2.5% vs 0.8%, young adults: 4.3% vs 2.0%, middle-aged adults: 1.6% vs 0.4%; Figure 2). Non-Hispanic white adolescents had a significantly higher prevalence of energy drink consumption (2.5%) compared with all other race/ethnicities, whereas non-Hispanic white young adults had a significantly higher prevalence of energy drink consumption (3.6%) compared with non-Hispanic blacks (2.2%). Mexican American middle-aged adults had significantly higher levels of consumption (2.1%) compared with non-Hispanic white middle-aged adults (0.8%). Young adults with more than a high school diploma or GED had a significantly lower prevalence of energy drink consumption (2.7%) compared with those with less than a high school education (4.3%) or with high school diploma or GED (3.9%). There were no significant differences in energy drink consumption by education status for adolescents or middle-aged adults.

Adjusting for survey year, sex, race/ethnicity, and educational attainment, energy drink consumers had significantly higher total caffeine intake compared with non-consumers for adolescents (227.0 mg vs 52.1 mg, p<0.001); young adults (278.7 mg vs 135.3 mg, p<0.001); and middle-aged adults (348.8 mg vs 219.0 mg, p<0.001). Among energy drink consumers, caffeine from energy drinks accounted for 73.4% of total caffeine content for adolescents, 66.8% for young adults, and 56.4% for middle-aged adults.

DISCUSSION

The findings of this study suggest that the prevalence of energy drink consumption has grown substantially over the past decade among U.S. adolescents, young adults, and middle-aged adults. Although there is some indication from this study that energy drink intake among adolescents and middle-aged adults has begun to level off or even decline in the most recent years, the consistently increasing trend among young adults is cause for concern. Although the proportion of individuals who consume energy drinks on a typical day across all groups

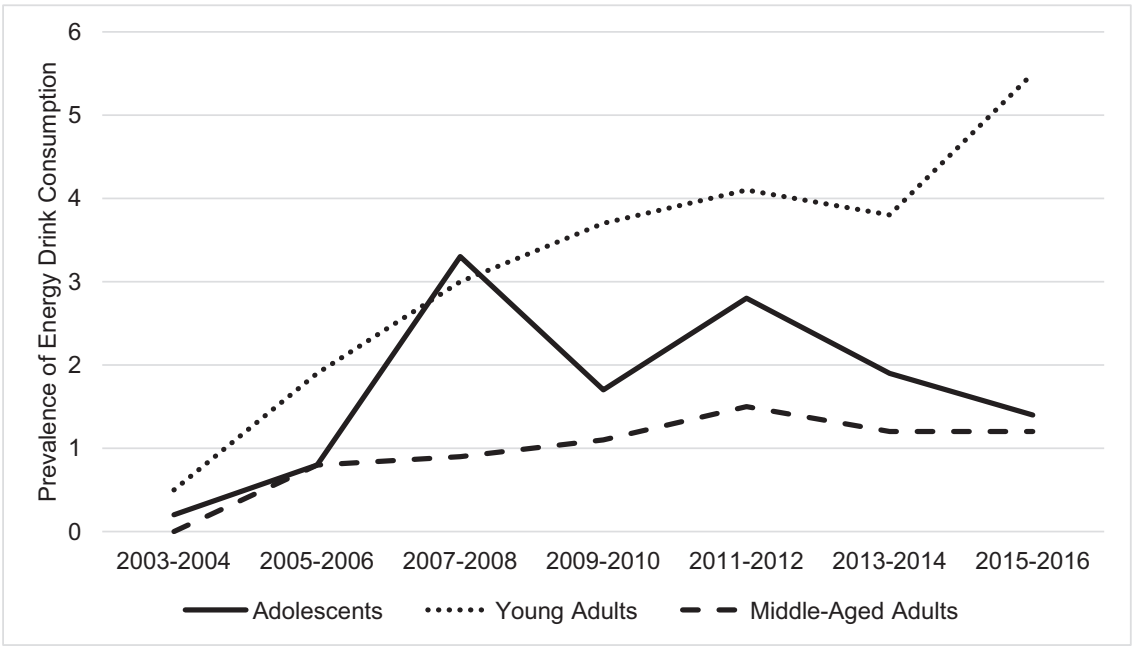

Figure 1. Prevalence of energy drink consumption for adolescents, young adults, and middle-aged adults, 2003–2016.
Note: Prevalence includes consumption of both full-calorie and diet energy drinks. The following covariates were included in all age-stratified models: sex (male, female); race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, other race/ethnicity); and education status (less than high school, high school graduate or GED, more than high school graduate). For adolescents, education status refers to the education of the primary household respondent.

Table 2. Per Capita Consumption of Energy Drink Calories Among U.S. Adolescents, Young Adults, and Middle-Aged Adults

Survey year	Adolescents (12–19 years)	Young adults (20–39 years)	Middle-aged adults (40–59 years)
Per capita consumption (unconditional, full sample)			
n	9,911	12,103	11,245
2003–2004	0.4 (0.0, 1.0)	1.1 (0.0, 2.2)	0.0 (0.0, 0.0)
2005–2006	1.5 (0.5, 2.4)	3.0 (1.1, 4.8)	4.7 (0.0, 13.1)
2007–2008	9.4 (3.4, 15.4)	6.4 (3.0, 9.8)	5.4 (0.0, 13.7)
2009–2010	4.4 (1.3, 7.4)	7.1 (3.6, 10.6)	9.9 (0.0, 26.2)
2011–2012	5.1 (1.0, 9.2)	8.0 (4.0, 12.0)	7.4 (0.0, 23.2)
2013–2014	3.8 (0.5, 7.0)	7.8 (2.8, 12.9)	7.1 (0.0, 18.3)
2015–2016	2.3 (0.3, 4.2)	9.7 (5.6, 13.8)	4.1 (0.0, 11.2)
p-value for linear trend	0.386	**<0.001**	0.061
Per capita consumption (conditional on being an energy drink consumer)			
n	93	305	103
2003–2004	146.5 (102.6, 190.5)	227.5 (165.4, 289.7)	252.9 (198.1, 307.8)
2005–2006	191.4 (123.7, 259.2)	166.1 (120.3, 212)	167.2 (96.9, 237.5)
2007–2008	226.0 (161.0, 291.1)	231.7 (156.1, 307.4)	214.5 (160.0, 268.9)
2009–2010	206.9 (112.8, 301.0)	195.3 (157.1, 233.5)	215.3 (180.3, 250.3)
2011–2012	262.8 (147.1, 378.4)	183.9 (155.4, 212.3)	242.8 (153.4, 332.2)
2013–2014	280.3 (147.6, 413.0)	239.0 (200.6, 277.3)	249.1 (199.9, 298.2)
2015–2016	249.5 (177.4, 321.5)	228.8 (191.3, 266.2)	169.7 (128.5, 210.9)
p-value for linear trend	0.140	0.190	0.884

Note: Reported as point estimate (95% CI), in calories. Boldface indicates statistical significance ($p<0.05$). The following covariates were included in all age-stratified models: sex (male, female); race/ethnicity (non-Hispanic white, non-Hispanic black, Mexican American, other Hispanic, other race/ethnicity); and education status (less than high school, high school graduate or GED, more than high school graduate). For adolescents, education status refers to the education of the primary household respondent.

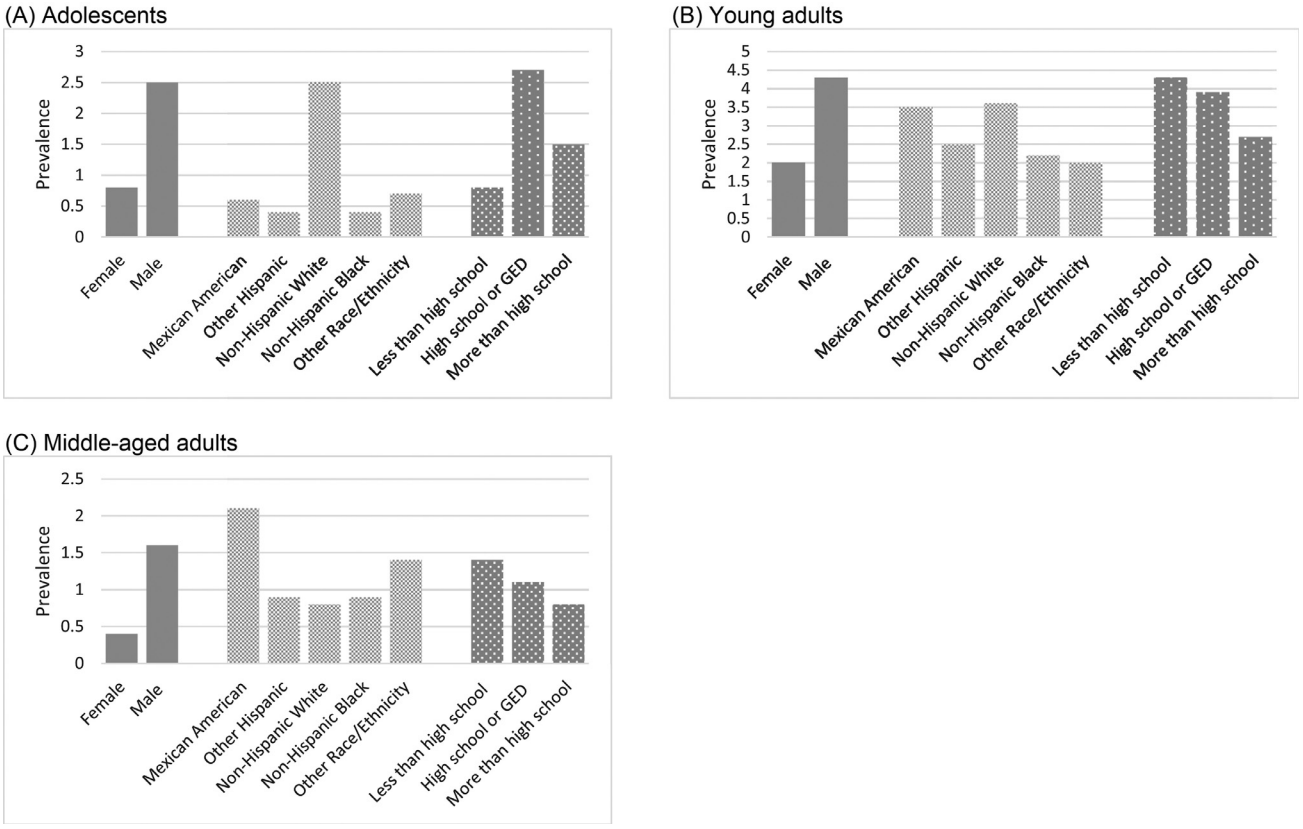

Figure 2. Prevalence of energy drink consumption by demographic characteristics for (A) adolescents; (B) young adults; (C) middle-aged adults.

Note: To examine differences in the prevalence of energy drink consumption across sex, race/ethnicity, and educational attainment, it was necessary to pool data across the seven survey cycles to ensure a sufficient analytical sample. Hence, it was not possible to examine trends over time in consumption by these demographic characteristics. For adolescents, education status refers to the education of the primary household respondent.

is small, high levels of sugar and caffeine, combined with limited understanding of the health effects of other ingredients (e.g., L-carnitine), suggest that energy drink consumption is potentially problematic and should be monitored closely. Moreover, those who drink energy drinks consume approximately 200 calories from energy drinks daily, which is considerably higher than other sugar-sweetened beverages like soda,[12] and may contribute to excess weight gain.[9]

One of the most important aspects of energy drinks to consider is their high caffeine content, which is highly variable and ranges from 50 to 500 mg per serving (for comparison, an 8-ounce cup of coffee has approximately 95 mg). Across all age groups, this study found that energy drink consumers had significantly higher total caffeine intake compared with non-consumers and that—among those who consume energy drinks—caffeine from these beverages comprises a majority of total daily caffeine content. Although regulations require that energy drink labels indicate that the product contains caffeine, the U.S. Food and Drug Administration does not enforce a caffeine limit on energy drinks (when classified as a dietary supplement) and does not require the actual amount of caffeine to be reported on the product label.[16] Although moderate intake of caffeine (up to 400 mg/day for adults and up to 100 mg/day for children and adolescents) is considered to be safe,[17,18] higher volumes increase the risk of caffeine toxicity and other caffeine-related health effects (e.g., increased blood pressure).[19,20] This suggests that both requiring caffeine labeling on energy drinks and establishing an evidence-based upper caffeine limit for these beverages may be important to reduce the potential negative health impact on consumers.

The increase in energy drink consumption highlighted in this study is consistent with growth in the energy drink market documented by reports from the beverage industry. For example, one report cited that the number of energy drink products launched globally grew by nearly 30% between 2010 and 2015, with the U.S. recognized as the top energy drink market in terms of volume sales (3.3 billion liters in 2015).[21] Moreover, the global energy drink market is forecasted to increase by 7% by

2025, reaching a net worth of more than $84 billion.[22] In light of this expected growth, close surveillance of energy drink consumption by researchers and public health professionals in the coming years is warranted.

Prior studies have primarily examined energy drink consumption among adolescents and young adults, with previous research estimating that 20% of high school students and 51% of college students consume one or more energy drink per month.[23,24] Although this study reports daily consumption and therefore is not directly comparable with past studies that have examined monthly intake, together the research signals that a meaningful number of adolescents and young adults are incorporating energy drinks into their diet. There is particular concern about energy drink consumption among this demographic given the growing trend of mixing energy drinks with alcohol, a combination that often leads to overconsumption of alcohol and alcohol-related incidents (e.g., car accidents, sexual assault).[5,10] The results of this analysis also indicated that middle-aged Mexican Americans and young adults with low educational attainment have the highest prevalence of energy drink consumption, an important finding as racial/ethnic minorities and individuals with low SES are already at a heightened risk for negative health outcomes (e.g., obesity, diabetes).[25,26] The notable differences in energy drink consumption by age, educational attainment, and race/ethnicity found in this study signal the need for targeted policy and programmatic efforts to reduce disparities in consumption.

Limitations

This study has several limitations. First, the small number of energy drink consumers in the analytic sample reduced precision and stability of estimates and did not allow for the analysis of trends in consumption over time by sex, race/ethnicity, and educational attainment category. Because it was necessary to pool data across the seven survey cycles to ensure a sufficient analytic sample, it was only possible to examine differences in the prevalence of energy drink consumption by sex, race/ethnicity, and educational attainment category for all years combined and not over time. Second, the reliance on a single 24-hour recall may have increased random error because of within-person differences in consumption. Third, the use of a 24-hour recall as a measure of dietary assessment facilitated the estimation of population mean intakes but did not allow estimation of usual intake for energy drink consumers (e.g., number of energy drinks in a given week or month).

Future research should examine patterns of usual energy drink intake among energy drink consumers (e.g., frequency of intake in a given week or month) and explore other demographic characteristics that may be related to excess energy drink consumption (e.g., attending college, night shift work). There is also a need for a better understanding of the marketing of energy drinks, particularly with respect to its rapid rise in recent years and the extent to which energy drink marketing is targeted at certain high-risk groups. Additional research is also needed to improve the quality of evidence examining the relationship between energy drink consumption and health effects, including utilization of longitudinal studies with sufficient follow-up periods and conducting studies among more generalizable study populations as well as higher-risk sub-groups. There is a particular need to examine the health effects of understudied energy drink constituents (e.g., L-carnitine).

CONCLUSIONS

Energy drink consumption in the U.S. has increased substantially over the past decade and represents a majority of daily caffeine for all age groups among those who consume these drinks. Continued surveillance of energy drink consumption is important because of the potential negative impact of these drinks on health.

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SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2018.12.007.

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