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## Energy drinks and escalation in drug use severity: An emergent hazard to adolescent health

Wanda E. Leal<sup>a,\*</sup>, Dylan B. Jackson<sup>b</sup>

<sup>a</sup> Department of Social Sciences, College of Arts & Sciences, Texas A&M University – San Antonio, 1 University Way, San Antonio, TX 78224, United States

<sup>b</sup> Department of Criminal Justice, College of Public Policy, University of Texas – San Antonio, 501 W. Cesar E. Chavez Blvd., San Antonio, TX 78207, United States

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## ABSTRACT

The aim of the current study is to determine whether energy drink consumption contributes to drug use and, more specifically, an escalation in the severity of drug use. We first examine the association between energy drink use and hard drug use, and subsequently investigate whether soft drug use mediates this relationship. Potential moderating influences are also investigated by testing whether the degree of mediation varies by age, gender, and race. The current study uses a nationally representative sample of 8th (ages 13–14), 10th (ages 15–16), and 12th (ages 17–18) grade adolescents from the 2015 Monitoring the Future survey. Negative binomial regression is employed to examine associations between energy drink consumption and soft and hard drug use. Mediation results indicate that energy drink consumption is significantly associated with increased soft drug use, which is, in turn, associated with significant increases in hard drug use. This cascading effect of energy drink consumption on drug use appears to be stronger among younger females and older males. Results for the moderating effect of race are mixed. Energy drinks appear to pose an important threat to adolescent health in the form of soft and hard drug use. The United States may want to consider adopting energy drink policies similar to European countries and Canada, which require warning labels on beverages with high caffeine content.

### 1. Introduction

In recent years, the widespread use of energy drinks has become an issue of notable public health concern. These seemingly harmless drinks can contain as much as 500 mg of caffeine, which is nearly five times higher than the caffeine concentration of typical caffeinated beverages (Arria and O'Brien, 2011). While the concern over the consequences of energy drinks is not new, it was reawakened in April 2017 with the death of a 16-year-old student from South Carolina, who died from a caffeine overdose brought on by coffee, soda, and energy drinks (Lynch and Goldschmidt, 2017). Since 2004, the Food and Drug Administration has linked 34 deaths to energy drink consumption (Center for Science in the Public Interest, 2014).

Research has revealed that energy drink consumption is harmful for the following three reasons (Arria and O'Brien, 2011). First, caffeine, which energy drinks often possess in abundance, has been associated with many negative health consequences for vulnerable populations, including adolescents. To illustrate, regular consumption of caffeine has been shown to result in various health problems, including elevated blood pressure and sleep disturbances among youth (Temple, 2009). Second, the growing trend of mixing energy drinks with alcohol has

been shown to produce more adverse effects than alcohol alone (Brache and Stockwell, 2011; Snipes and Benotsch, 2013; Martz et al., 2015). The combination of alcohol with energy drinks often decreases users' perception of intoxication, leading users to overestimate their ability to perform tasks that require fine motor skills (such as driving) (Snipes and Benotsch, 2013), which in turn could endanger others (e.g., vehicular manslaughter). Third, energy drink consumption has been linked to a higher risk of alcohol abuse and/or dependence, and the use of illegal drugs (Arria et al., 2010; Arria et al., 2011; Velazquez et al., 2012; Gallimberti et al., 2013; Terry-McElrath et al., 2014; Woolsey et al., 2014; Miyake and Marmorstein, 2015). According to Arria and O'Brien (2011), however, "the mechanisms underlying these associations are unclear". Even so, research indicates that adolescents do not typically begin drug use with hard drugs, such as heroin or cocaine, but rather they are initiated into drug use with softer drugs, such as cigarettes, alcohol, or marijuana (Yamaguchi and Kandel, 1984a; Yamaguchi and Kandel, 1984b; Kandel, 1975). Though soft drugs may not necessarily be safer to ingest than hard drugs, they are perceived by adolescents and society to be more socially acceptable (Shiner and Newburn, 1997). Energy drink use among youth has also become increasingly socially acceptable and void of stigma, as evidenced by the

\* Corresponding author.

E-mail addresses: [Wanda.leal@tamusa.edu](mailto:Wanda.leal@tamusa.edu) (W.E. Leal), [Dylan.Jackson@utsa.edu](mailto:Dylan.Jackson@utsa.edu) (D.B. Jackson).

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growing prevalence and widespread popularity of energy drinks (Brache and Stockwell, 2011). Considering the commonalities in some of the features of energy drink use and soft drug use, and the established process of escalation from soft to hard drugs, the current study asks if energy drink use is significantly associated with both soft and hard drug use, and whether the link between energy drink use and hard drug use is mediated by soft drug use. If energy drink consumption is indeed linked to an escalating severity in drug use, then the public health consequences of energy drink consumption among youth might be more severe than initially presumed.

Therefore, the present study investigates whether energy drink consumption contributes to an increased risk in the severity of drug use. Specifically, we examine whether adolescents who consume energy drinks are more likely to use hard drugs compared to those who do not consume them. We then examine the potential mediating role of soft drug use across age, gender, and race groups. Prior literature suggests that males (Friis et al., 2014; Trapp et al., 2014; Barrense-Dias et al., 2016; Polak et al., 2016; Evren and Evren, 2015; Poulos and Pasch, 2015; Holubcikova et al., 2017), older adolescents (Holubcikova et al., 2017), and non-minorities (Poulos and Pasch, 2015; Miller, 2008) are more likely to consume energy drinks and consume them more often. However, no study has examined whether the influence of energy drink use on adolescent drug use varies by age, gender, or race. Consequently, the current study explores the key mediating hypothesis separately for groups defined by age, race, and gender.

## 2. Methods

### 2.1. Study design

The current study uses data from the 2015 Monitoring the Future (MTF) survey (Johnston et al., 2015a; Johnston et al., 2015b). MTF employed a multi-stage random sampling technique to generate a nationally representative sample of adolescents. The sampling took place in three stages: 1) selection of geographic area, 2) selection of schools in each geographic area, and 3) selection of classes within each school. Approximately 350 students were surveyed in each school. Typically, questionnaires were administered in classrooms during a normal class period, but were at times administered in larger groups if necessary. These surveys contained a wide array of questions pertaining to adolescent drug use, education, work, leisure, sexual activity, family, interpersonal relationships, religion, happiness, deviance, victimization, and health.

### 2.2. Participants

Participants from 8th, 10th, and 12th grade were included in this study. The sample size varies by grade. The 8th grade sample has 2821 participants, the 10th grade sample has 3490 participants, and the 12th grade sample has 1427 participants. The current study uses adolescents from these three grade cohorts to test whether the degree of mediation due to soft drug use in the link between energy drink use and hard drug use varies by age group. In addition, these adolescents are also grouped by gender and race to examine the possibility that these mediating effects may vary by gender and race.

### 2.3. Measures

Energy drink consumption is the key independent variable in the current study. Adolescents were asked how many energy drinks they drink per day, on average. Response options ranged from *none* to *seven or more*. If the adolescent responded none, they were assigned a value of 0, otherwise they were assigned a value of 1. Importantly, the coding of this variable is consistent with previous literature (Snipes and Benotsch, 2013; Arria et al., 2010; Terry-McElrath et al., 2014; Trapp et al., 2014; Poulos and Pasch, 2015).

The number of soft drugs an adolescent has tried in their lifetime was used as the mediating variable in this study. In line with prior research (Gallimberti et al., 2013; Azagba et al., 2014), the drugs that are categorized as soft drugs in the current study are cigarettes, alcohol, and marijuana. The scores on the soft drug use variable range from 0 to 3, representing the number of soft drugs an adolescent has tried during their lifetime. Thus, a score of 0 indicates that the adolescent has never tried any soft drugs, while a score of 3 indicates that the adolescent has tried all 3 soft drugs.

The dependent variable for the current study is the number of hard drugs an adolescent has tried in their lifetime. In line with prior research (Martz et al., 2015; Trapp et al., 2014; Azagba et al., 2014), the drugs that were categorized as hard drugs are heroin, cocaine, methamphetamine, LSD, hallucinogens other than LSD (PCP, mescaline, peyote, “shrooms” or psilocybin), amphetamines (and other stimulant drugs), sedatives (including barbiturates), and tranquilizers. The scores on the hard drug use variable range from 0 to 8. A score of 0 indicates that the adolescent has never tried any of these hard drugs, while a score of 8 means that the adolescent has tried all 8 hard drugs at some point in their life. Furthermore, in order to produce more accurate estimates, and minimize the occurrence of omitted variable bias, the current study includes controls for various health behaviors (i.e., soda consumption, diet soda consumption, and amount of exercise) and demographic characteristics (i.e., gender, race, and parental education, which is an index made up of the highest level of education of the adolescent's mother and father).

### 2.4. Statistical analyses

The current study investigates whether energy drinks contribute to an escalation in the severity of the drug consumed. In order to test this possibility, we first calculate the predicted probability of soft drug use by energy drink consumption across age groups. Subsequently, we employ negative binomial regression to study whether adolescents in these age cohorts who consume energy drinks use more hard drugs than adolescents who do not consume energy drinks. We then include soft drug use as a mediating variable to explore whether energy drink consumption is associated with increased usage of soft drugs, and whether increased usage of soft drugs, in turn, is linked to heightened hard drug use. After examining substance use escalation across age groups, we further investigate the generalizability of this escalation pattern across age cohorts partitioned by gender and race. Negative binomial regression was employed because the hard drug count variable was both zero-inflated and over-dispersed.

## 3. Results

We began our analysis by examining basic univariate statistics pertaining to our key variables of interest. About 24% of 8th graders, 19% of 10th graders, and 24% of 12th graders consume energy drinks. Soft drug use was found to increase with age, as 30% of 8th graders, 53% of 10th graders, and 71% of 12th graders had tried at least one soft drug in their life. Hard drug use has a similar pattern with 11% of 8th graders, 17% of 10th graders, and 19% of 12th graders trying at least one hard drug in their lifetime. Additionally, bivariate correlations between energy drinks consumption, hard drug use, and soft drug use are statistically significant for all grade cohorts.

In light of the bivariate findings indicating significant associations between energy drink use, soft drug use, and hard drug use, we proceeded to analyze the predicted probability of lifetime soft drug use among 8th, 10th, and 12th grade adolescents who do and do not consume energy drinks (with covariates set to their means). The results of these analyses are illustrated in Fig. 1. As displayed in the figure, the general pattern of findings suggest that energy drink consumption is most relevant to soft drug use among the youngest cohort of adolescents. Specifically, the predicted probability of soft drug use among 8th

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