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Re: Energy Drinks and Adolescents

This letter is written to support the recommendation of the Toronto Board of Health to regulate the sale of energy drinks to children and adolescents. I am strongly in favour of controlling access of energy drinks related to health concerns in children and youth.

I am the Professor and Chair/Chief of Paediatrics and a member of the Departments of Physiology & Pharmacology, and Medicine at the University of Western Ontario; and a member of Division of Clinical Pharmacology at the University of Western Ontario. I am a clinical pharmacologist with special interest and expertise in the area of adverse outcomes related to therapy. I also am a scientist at the Robarts Research Institute as well as an Associate Scientist as the Child Health Research Institute as well as the Chair of the Drug Therapy and Hazardous Substances Committee of the Canadian Paediatric Society.

Energy drinks are beverages containing stimulants, most frequently caffeine, as well as sugar or sweeteners plus a number of other ingredients including herbal extracts or amino acids. The caffeine content in energy drinks in Canada is typically between 80 and 180 mg per single use container. These beverages are often consumed to enhance performance and have been increasingly popular over the past decade. There is scant objective data supporting performance enhancement associated with energy drinks beyond the effects of caffeine alone.

As energy drinks have become more popular there have been increasing concerns as to their safety, notably in vulnerable populations such as children and youth. A number of behavioural and physiological adverse events have been described in adolescents using energy drinks, which are much more common than in adolescents using more traditional caffeine-containing beverages such as coffee, tea or soft drinks (*Clinical Toxicology* 2013; 51: 557-65). It is concerning that despite these adverse effects many adolescents have misconceptions as to the safety and purported desirable effects of energy drinks (*Pediatric Emergency Care* 2016; 32: 751-5).

As more data becomes available more problems come to light. A recent European study has found an association between energy drink consumption and a number of problems, including poor school performance. (*European Journal of Pediatrics* 2017; DOI 10.1007/s00431-017-2881-4). Recent Canadian data has shown that among adolescents 73% had consumed an energy beverage at some time and that 16% of those who had consumed an energy beverage continued to do so at an amount that exceeded the Health Canada recommended daily caffeine intake (*Preventive Medicine Reports* 2017;5:65–70).

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The fact that as many as 1 in 6 or 7 adolescents appear to be consuming energy drinks in a manner that exceeds the recommendations of Health Canada is concerning. Linked with the data from Europe and elsewhere on the potential for impacts not only on health but also on a number of important outcomes such as school performance strongly support the need to consider regulating – and restricting – sales of energy drinks to children and youth.

Please do not hesitate to contact me should you wish to discuss this in further detail.

Yours sincerely

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Clinical Symptoms and Adverse Effects Associated With Energy Drink Consumption in Adolescents

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Objective: The aims of the study were to determine the prevalence of energy drink consumption by adolescents, to identify associated clinical symptoms and adverse effects, and to gain an understanding to the motivation behind its consumption.

Methods: A prospective, questionnaire-based study was conducted at 2 emergency departments from June 2011 to June 2013. The questionnaire was distributed to a convenience sample of adolescents aged 12 to 18 years. Stratification was performed on the basis of frequency of consumption: frequent consumption (at least once a month) and infrequent consumption (less frequent than once a month).

Results: Data analysis was performed on 612 completed questionnaires. Two hundred two responders (33%) were considered frequent energy drink consumers. Frequent consumers were more likely to be involved in high-risk behaviors and more likely to consume other caffeinated drinks. In the previous 6 months, frequent energy drink consumers were more likely to report headache (76%), anger (47%), and increased urination (24%) and were more likely to require medical evaluation for headache (41%) and difficulty breathing (22%). Frequent energy drink consumers were more likely to believe that energy drinks "help me do better in school" (12%), "help me do better in sports" (35%), "are just for fun" (46%), "help me stay up at night" (67%), and "make me concentrate/focus better" (34%).

Conclusions: Clarifying common misconceptions associated with energy drink consumption, especially in high-risk adolescents and frequent energy drink consumers, may decrease the frequency of symptoms experienced by adolescents, such as headache and difficulty breathing, requiring medical evaluation.

Key Words: energy drinks, emergency department, adolescents

(*Pediatr Emer Care* 2016;32: 751–755)

Although the American Academy of Pediatrics has not endorsed the consumption of stimulant-containing energy drinks by children and adolescents, the inclusion of energy drinks in the diet of today's youth remains a health problem in this population.[1] Recent publications have indicated that approximately 30% to 50% of children, adolescents, and young adults reported consuming at least 1 energy drink per month[2–4] and approximately 75% of children consume caffeine on any given day, with energy drinks representing 6% of the caffeine intake in 2009-2010.[5]

Although the US Food and Drug Administration considers caffeine a "safe" substance, the caffeine content of energy drinks is not currently regulated, and thus, potential adverse effects may occur in children and adolescents who consume these products. The metabolism of high concentrations of caffeine, as well as other common additives such as taurine, ginseng, vitamins, and guarana, has not been well studied in children and adolescents, and thus, the effects of these products may be unpredictable or unexpected. In addition, children and adolescents may be more vulnerable to caffeine intoxication due to an absence of pharmacologic tolerance. Although clinical symptoms associated with caffeine intoxication, such as nervousness, irritability, anxiety, insomnia, tremor, tachycardia, palpitations, and gastrointestinal distress, have been reported in the literature, very few studies have examined the prevalence of these symptoms in the pediatric population.[6,7] Furthermore, severe adverse effects, such as increased intracranial pressure, cerebral edema, stroke, paralysis, altered consciousness, new-onset seizures, cardiac dysrhythmias, cardiac arrest, acute hepatitis, acute renal failure, and death, have been reported in young and older adults.[2,8,9] The growing popularity of energy drink consumption, resulting in clinical symptoms and severe adverse effects, has led to increased volume in emergency departments in the United States.[10]

Although there have been several studies examining the consumption of energy drinks in adolescents, there have been very few examining the reported symptoms and adverse effects associated with energy drink consumption and the motivation in adolescents for consuming these beverages. The aims of the study were to determine the prevalence of energy drink consumption by adolescents aged 12 to 18 years, to identify clinical symptoms and adverse effects that may be associated with energy drink consumption, and to gain an understanding to the motivation behind adolescent energy drink consumption.

METHODS

A prospective, observational, self-administered questionnaire-based study was conducted simultaneously at the Penn State Hershey Medical Center (Dauphin County, Pennsylvania) and the Children's Hospital at Montefiore (Bronx County, New York) from June 2011 to June 2013. Completed questionnaires from a convenience sample of patients were collected in the waiting areas of the emergency department at the Penn State Hershey Medical Center and the Children's Hospital at Montefiore. Research assistants (D.B., E.R.-S., T.S., and C.W.) distributed and collected questionnaires during random hours from noon to midnight on days that they were available during the study period. Adolescents aged 12 to 18 years were eligible for enrollment; those who presented with a change in mental status, with severe pain, who were developmentally delayed, who presented with acute psychiatric illness, who were non-English speaking, and who previously completed the questionnaire were excluded from enrollment. Informed consent was implied on the basis of the respondent's decision to complete the questionnaire.

The questionnaire, developed by the authors, focused on the following: (1) demographic information (age, sex, race, setting, participation in extracurricular activities, reported high-risk behaviors, frequency of energy drink consumption, and consumption of other caffeinated beverages); (2) symptoms reported and symptoms that required medical evaluation in the previous

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Disclosure: The authors declare no conflict of interest.

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6 months; and (3) perceived beliefs regarding energy drinks consumption. After development of the questionnaire, a pilot study was performed (the questionnaire was distributed to 20 adolescents who fulfilled inclusion and exclusion criteria), and subsequent revisions were made in response to their suggestions. In the questionnaire, required medical evaluation was defined as seeking medical assessment and treatment at either a primary care physician's office, an urgent care center, or emergency department for symptoms experienced within 12 hours of energy drink consumption.

The 2 locations were selected to reflect a representative population of the United States in terms of age, race, education, economic status, and setting classification, and data from the 2008-2012 American Community Survey 5-year estimates (http://factfinder2.census.gov/faces/nav/jsf/pages/index.xhtml) demonstrate this representation. Statistics from Dauphin County include the following: median age is 39.2 years, 52% female, race distribution (73% white, 18% African American, 3% Asian, 7% Hispanic), 89% have completed at least a high school degree, median household income is US $54,666, and 12.7% of families are below the poverty line. Statistics from Bronx County include the following: median age is 32.7 years, 53% female, race distribution (28% white, 37% African American, 4% Asian, 54% Hispanic), 69% have completed at least a high school degree, median household income is US $34,300, and 29.3% of families are below the poverty line. Overall statistics for the United States include the following: median age is 37.2 years, 51% female, race distribution (72% white, 13% African American, 5% Asian, 16% Hispanic), 86% have completed at least a high school degree, median household income is US $53,046, and 14.9% of families are below the poverty line.

Data organization and analysis were performed with the Epi Info System (Centers for Disease Control and Prevention, Atlanta, Georgia). Descriptive statistics were calculated for all response variables. Ninety-five percent confidence intervals were calculated by standard methods using an online calculator (http://www.graphpad.com/quickcalcs/index.cfm). In the analysis of the data, responders were considered frequent energy drink consumers if they reported consumption of an energy drink at least once a month, and infrequent energy drink consumers if they reported consumption of an energy drink less frequent than once a month. Significance of differences between frequent and infrequent energy drink consumers was determined by nonoverlapping 95% confidence intervals. The hospital's institutional review board at each of the 2 locations approved the study.

RESULTS

Data analysis was performed on 612 completed questionnaires (387 from Penn State Hershey Medical Center and 225 from the Children's Hospital at Montefiore); 202 responders (33%) were considered frequent energy drink consumers. Table 1 demonstrates the demographics of responders. Frequent consumers were less likely to be involved in academic activities compared with infrequent consumers, more likely to consider themselves as risk takers, more likely to be involved in high-risk behaviors (smoke cigarettes, drink alcohol, drink energy drinks with alcohol, carry or previously used a weapon, engage in physical fights often, and engage in sexual activity), and consume other caffeinated drinks (coffee, caffeinated soda) compared with infrequent consumers.

Table 2 demonstrates reported symptoms and symptoms that required medical evaluation in the previous 6 months, then stratified by energy drink consumption frequency. In the previous 6 months, frequent energy drink consumers were more likely to report headache, anger, and increased urination compared with infrequent energy drink consumers. Furthermore, frequent energy drink consumers were more likely to require medical evaluation for headache and difficulty breathing in the previous 6 months compared with infrequent drink consumers.

In the analysis of perceived benefits associated with energy drink consumption, frequent energy drink consumers were more likely to believe that energy drinks "help me do better in school," "help me do better in sports," "are just for fun," "help me stay up at night," and "make me concentrate/focus better" compared with infrequent energy drink consumers (Table 3).

DISCUSSION

Energy drink consumption by adolescents has evolved into a national health hazard for several identified reasons. Many of the manufacturers of energy drinks are not subject to the same US Food and Drug Administration regulation that governs over-the-counter drugs as well as the caffeine content of commonly sold beverages. Manufacturers of energy drinks claim that their products are dietary supplements and fall under the jurisdiction of the 1994 Dietary Supplement Health and Education Act, and thus, manufacturers are not required to divulge the caffeine content on their product's labels. Therefore, consumers of energy drinks may be unaware of the amount of caffeine they are ingesting and of the potential adverse effects they may experience. Furthermore, energy drinks are often marketed as performance enhancers and stimulants, oftentimes associated with advertising aimed at the pediatric population. Energy drink products are typically considered "edgy," with marketing focused on catchy phrases, names, and purported improved functioning. For these reasons, recent publications have recommended that pediatric health care providers advocate for improved regulations and proper labeling of energy drink products (listing caffeine content and risks associated with caffeine consumption), for more socially responsible advertisements clarifying and dispelling common myths associated with energy drink consumption, and for the increased education of adolescents and young adults to the potential adverse effects of energy drink consumption.[2,11] Similarly, a recently published commentary called for an increase in the research conducted on the health and safety effects associated with energy drink consumption, with the goal of developing recommendations for upper limits of caffeine content present in energy drink beverages.[12]

Emergency department visits related to energy drink consumption increased more than 10-fold between 2005 and 2009, from 1128 to 13,114 visits, and continued to substantially increase since 2009 to 20,783 in 2011.[10] These visits may be secondary to energy drink consumption, interactions with other medication use in children with chronic medical problems, or accidental or intentional overdoses. In a study assessing the prevalence of physiologic and behavioral adverse effects among adolescents and young adults presenting to the emergency department within 30 days of energy drink and/or caffeinated-only beverage consumption, Jackson et al[13] reported physiologic adverse effects in energy drink consumers, similar to those reported in our study sample, namely, palpitations (25.6%), trouble sleeping (71.1%), anxiety/panic attacks (28.9%), chest pains (32.2%), headaches (63.3%), trouble breathing (38.9%), and restlessness/jitteriness (46.7%).

Furthermore, energy drink consumption, when coupled with chronic medical conditions or chronic medication use, may lead to symptoms that may prompt an acute medical visit. Children and adolescents with cardiovascular, pulmonary, renal, or liver disease, seizures, diabetes, hyperthyroidism, or behavioral/psychiatric conditions may be at a higher risk for experiencing adverse effects from energy drink consumption.[2,6,7] Similarly,

TABLE 1. Demographics of Responders

	All Responders	Responses in Frequent Energy Drink Consumers	Responses in Infrequent Energy Drink Consumers
Mean (SD, 95% CI) age, y	16 (2.04, 15.8–16.2)	16 (2.12, 15.7–16.3)	16 (1.67, 15.8–16.1)
Sex, male	258/612, 42 (38–46)	91/202, 45 (38–52)	167/410, 41 (36–46)
Race			
African American	115/602, 19 (16–22)	29/200, 14 (10–20)	86/402, 21 (18–26)
Hispanic	208/602, 34 (31–38)	73/200, 37 (30–43)	135/402, 34 (29–38)
White	227/602, 38 (34–42)	79/200, 39 (33–46)	148/402, 37 (32–42)
Asian	16/602, 3 (2–4)	5/200, 3 (1–6)	11/402, 3 (1–5)
Biracial	36/602, 6 (4–8)	14/200, 7 (4–11)	22/402, 5 (4–8)
Setting			
Inner city	244/602, 41 (37–45)	75/202, 37 (31–44)	169/400, 42 (38–47)
Rural	147/602, 24 (21–29)	52/202, 26 (20–33)	95/400, 24 (20–28)
Suburban	211/602, 35 (31–39)	76/202, 37 (32–45)	135/400, 34 (29–39)
Participation in extracurricular activities			
Organized or team sports	332/592, 56 (52–60)	109/195, 56 (49–62)	223/397, 56 (51–61)
Performance arts	241/592, 41 (37–45)	76/195, 39 (32–46)	165/397, 42 (37–47)
Academic activities	102/592, 17 (14–20)	18/195, 9 (6–14)	84/397, 21 (17–25)
Video games	213/592, 36 (32–40)	77/195, 39 (33–46)	136/397, 34 (30–39)
Extreme sports	78/592, 13 (11–16)	27/195, 14 (10–19)	51/397, 13 (10–17)
Consider themselves as a risk taker	296/602, 50 (46–54)	135/199, 68 (61–74)	161/403, 40 (35–45)
Involvement in high-risk behaviors			
Smoke cigarettes	102/600, 17 (14–20)	72/200, 36 (30-43)	30/400, 8 (5–11)
Drink alcohol	175/600, 29 (26–33)	88/200, 44 (37–51)	87/400, 22 (18–26)
Consume energy drinks with alcohol	49/600, 8 (6–11)	33/200, 17 (12–22)	16/400, 4 (2–6)
Consume energy drinks and smoke cigarettes	17/600, 3 (2–5)	12/200, 6 (3–10)	5/400, 1 (.004–3)
Carry or previously used a weapon	35/600, 6 (4–8)	22/200, 11 (7–16)	13/400, 3 (2–6)
Engage in physical fights often	171/600, 29 (25–32)	74/200, 37 (31–44)	97/400, 24 (20–29)
Drive while impaired	6/600, 1 (0.4–2)	4/200, 2 (1–5)	2/400, 1 (0.01–2)
Engage in sexual activity	223/600, 37 (33–41)	93/200, 47 (40–53)	130/400, 33 (28–37)
Consumption of other caffeinated drinks			
Coffee	295/601, 49 (45–53)	129/201, 64 (57–70)	166/400, 42 (37–46)
Caffeinated soda	534/601, 89 (86–91)	194/202, 96 (92–98)	340/399, 85 (81–88)
Tea	367/600, 61 (57–65)	138/200, 69 (62–75)	229/400, 57 (52–62)

All values are expressed as number of responses, % (95% CI), unless otherwise indicated.

adolescents taking selective serotonin reuptake inhibitors may present with serotonin syndrome when taken in conjunction with excess caffeine.[14]

Lastly, in a study examining energy drink exposures reported to the US National Poison Data System between 2010 and 2011, of the 1588 cases, 50.7% of cases involved children aged 0 to 5 years, 10.5% aged 6 to 12 years, and 17.6% aged 13 to 19 years, with 15.2% of cases resulting in "moderate-to-major toxicity" (seizures, ventricular dysrhythmias, tachypnea).[15]

Adolescent energy drink consumption may be secondary to the attention placed by media and advertising, focusing on the perceived benefits of consuming energy drinks, such as increases in energy, weight loss, stamina, athletic performance, and concentration.[2] In addition, O'Dea[16] suggested that some adolescents consume energy drinks for their perceived physiologic benefits, such as prevention of illness, improved immunity, energy boost, better sports performance, and improved diet, but most are unaware of potential risks and adverse effects associated with their consumption. In a study to understand current patterns of energy drink consumption in adolescents and young adults, Cotter et al[4] determined that the most highly cited reasons for energy drink consumption included "to play sports better," "to keep awake for school," "to keep awake for work," and "to do better at work," not unlike the perceived beliefs found in our study. Research on the motivations behind energy drink consumption in adolescents and young adults is needed to determine contributing factors to the increased use by this population, with the hope that these studies provide evidence-based educational strategies to dispel misconceptions and inform adolescents and young adults to the potential adverse effects of their consumption.

Our study has several limitations. Because our results reflect 2 specific adolescent populations in central Pennsylvania and New York City, our conclusions may not be generalizable to other populations or adolescent groups. A multicenter, national study, possibly involving a population of adolescents not presenting for medical care, should be conducted to determine whether our results reflect the overall adolescent population in the United States.

Secondly, our research design may have led to a systematic error because of differences in accuracy or completeness of recall to memory of past events or experiences, also known as recall bias. Responders may have been unable to accurately recall their precise energy drink consumption frequency or the occurrence

TABLE 2. Reported Symptoms and Symptoms That Required Medical Evaluation in the Previous 6 Months Stratified by Energy Drink Consumption Frequency

Symptom	Energy Drink Consumption Frequency	Reported in the Previous 6 mo	Required Medical Evaluation in the Previous 6 mo
Headache	Frequent	151/200, 76 (69–81)	83/201, 41 (35–48)
	Infrequent	237/397, 60 (55–64)	49/397, 12 (9–16)
Abdominal pain	Frequent	46/199, 23 (18–29)	35/200, 18 (13–23)
	Infrequent	89/389, 23 (19–27)	55/389, 14 (11–18)
Chest pain	Frequent	46/198, 23 (18–30)	30/199, 15 (11–21)
	Infrequent	99/396, 25 (21–30)	48/396, 12 (9–16)
Palpitations	Frequent	42/197, 21 (16–28)	15/200, 8 (5–12)
	Infrequent	69/395, 17 (14–22)	22/398, 6 (4–8)
Anger	Frequent	93/199, 47 (40–54)	11/200, 5 (3–10)
	Infrequent	125/395, 32 (27–36)	24/397, 6 (4–9)
Weakness	Frequent	67/200, 34 (27–40)	27/199, 14 (9–19)
	Infrequent	105/396, 27 (22–31)	36/393, 9 (7–12)
Tremors	Frequent	37/199, 19 (14–25)	16/197, 8 (5–13)
	Infrequent	49/393, 12 (10–16)	21/386, 5 (4–8)
Difficulty breathing	Frequent	51/199, 26 (20–32)	43/196, 22 (17–28)
	Infrequent	76/393, 19 (16–24)	47/388, 12 (9–16)
Anxiety	Frequent	13/182, 7 (4–12)	9/196, 5 (2–9)
	Infrequent	30/396, 8 (5–11)	30/388, 8 (5–11)
Increased urination	Frequent	47/198, 24 (18–30)	16/196, 8 (5–13)
	Infrequent	50/394, 13 (10–16)	21/396, 5 (3–8)
Dehydration	Frequent	46/199, 23 (18–29)	20/198, 10 (7–15)
	Infrequent	77/393, 20 (16–24)	28/386, 7 (5–10)
Sleep disturbance	Frequent	68/198, 34 (27–41)	13/195, 7 (4–11)
	Infrequent	91/393, 23 (19–28)	19/384, 5 (3–8)

All values are expressed as number of responses, % (95% CI).

of clinical symptoms and adverse effects. In addition, energy drink consumers may have been more likely to report adverse effects because of their background knowledge about these products. Furthermore, adolescents who present to an emergency department may be more likely to report or exaggerate symptoms when compared with adolescents with similar subjective complaints who do not seek emergent care. A prospective study, possibly implementing a daily energy drink consumption diary (recording consumption of energy drinks and subsequent symptoms/adverse effects), may improve the ability to accurately report the true occurrence of clinical symptoms and adverse effects based on the frequency of consumption of energy drinks.

Lastly, because of our small sample size, we were unable to perform analysis on potential confounders, such as smoking cigarettes and consuming alcohol or other caffeinated beverages, which may have increased the frequency of symptoms reported by our study sample, namely, headache, anger, increased urination, and difficulty breathing. In addition, because of our small

TABLE 3. Perceived Benefits Associated With Energy Drink Consumption

Belief	All Affirmative Responses	Affirmative Responses in Frequent Energy Drink Consumers	Affirmative Responses in Infrequent Energy Drink Consumers
Helps me do better in school	41/593, 7 (5–9)	25/197, 12 (9–18)	16/396, 4 (2–7)
Helps me do better at sports	124/595, 21 (18–24)	70/199, 35 (29–42)	54/396, 14 (11–17)
Are just for fun	182/591, 31 (27–35)	90/196, 46 (39–53)	92/395, 23 (19–28)
Helps me stay up at night	279/594, 47 (43–51)	132/198, 67 (60–73)	147/396, 37 (33–42)
Make me concentrate/focus better	114/593, 19 (16–23)	68/200, 34 (28–41)	46/393, 12 (9–15)
Makes me smart	5/590, 1 (0.3–2)	2/196, 1 (0.4–4)	3/394, 1 (0.1–2)
Makes me high	25/593, 4 (236)	12/197, 6 (3–10)	13/396, 3 (2–6)
Makes me stronger	47/591, 8 (6–10)	22/196, 11 (7–16)	25/395, 6 (4–9)
Helps me lose weight	11/5947, 2 (1–3)	5/201, 2 (0.9–6)	6/396, 2 (1–3)
Makes me healthier	14/593, 2 (1–4)	7/197, 4 (2–7)	7/396, 2 (1–4)

All values are expressed as number of responses, % (95% CI).

sample size, we were unable to further stratify frequency of energy consumption (daily, weekly, monthly, less frequent than monthly, never), which may have more accurately determined the true prevalence of reported symptoms and adverse effects associated with consumption frequency.

In conclusion, frequent energy drink consumers were more likely to report headache, anger, and increased urination and were more likely to require medical evaluation for headache and difficulty breathing. In addition, frequent energy drink consumers were more likely to believe that energy drinks "help me do better in school," "help me do better in sports," "are just for fun," "help me stay up at night," and "make me concentrate/focus better." Clarifying common misconceptions associated with energy drink consumption, especially in high-risk adolescents and frequent energy drink consumers, may decrease the frequency of symptoms experienced by adolescents prompting medical evaluation. Emergency department physicians should be familiar with symptoms and adverse effects associated with energy drinks to properly diagnose, manage, and provide counseling to adolescents who present with complaints that may be secondary to energy drink consumption. Lastly, we hope that our data, as well as previously published research reporting on the health and safety effects associated with energy drink consumption, convince manufacturer decision makers and the US Food and Drug Administration to improve regulations and proper labeling of energy drink products and to provide recommendations for upper limits of caffeine content present in energy drink beverages.

REFERENCES

1. Committee on Nutrition and the Council on Sports Medicine and Fitness. Sports drinks and energy drinks for children and adolescents: are they appropriate? *Pediatrics*. 2011;127:1182–1189.
2. Seifert SM, Schaechter JL, Hershorin ER, et al. Health effects of energy drinks on children, adolescents, and young adults. *Pediatrics*. 2011;127:511–528.
3. Oddy WH, O'Sullivan TA. Energy drinks for children and adolescents. *BMJ*. 2009;339:b5268.
4. Cotter BV, Jackson DAE, Merchant RC, et al. Energy drink and other substance use among adolescent and young adult emergency department patients. *Pediatr Emerg Care*. 2013;29:1091–1097.
5. Branum AM, Rossen LM, Schoendorf KC. Trends in caffeine intake among U.S. children and adolescents. *Pediatrics*. 2014;133:386–393.
6. Wolk BJ, Ganetsky M, Babu KM. Toxicity of energy drinks. *Curr Opin Pediatr*. 2012;24:243–251.
7. Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks - a growing problem. *Drug Alcohol Depend*. 2009;99:1–10.
8. Wolk BJ, Babu KM, Church RJ, et al. Energy drinks: the new eye-opener for adolescents. *Clin Pediatr Emerg Med*. 2009;9:35–42.
9. Nordt S, Vilke G, Clark R, et al. Energy drink use and adverse effects among emergency department patients. *J Community Health*. 2012;37:976–981.
10. Substance Abuse and Mental Health Services Administration, Center for Behavioral Health Statistics and Quality. January 10, 2013. The DAWN Report: update on emergency department visits involving energy drinks: a continuing public health concern. Available at: http://www.samhsa.gov/data/2k13/DAWN126/sr126-energy-drinks-use.pdf. Accessed July 24, 2014.
11. Pennington N, Johnson M, Delaney E, et al. Energy drinks: a new health hazard for adolescents. *J Sch Nurs*. 2010;26:352–359.
12. Arria AM, O'Brien MC. The "high" risk of energy drinks. *JAMA*. 2011;305:600–601.
13. Jackson DAE, Cotter BV, Merchant RC, et al. Behavioral and physiologic adverse effects in adolescent and young adult emergency department patients reporting use of energy drinks and caffeine. *Clin Toxicol (Phila)*. 2013;51:557–565.
14. Bramstedt KA. Caffeine use by children: the quest for enhancement. *Subst Use Misuse*. 2007;42:1237–1251.
15. Seifert SM, Seifert SA, Schaechter JL, et al. An analysis of energy-drink toxicity in the National Poison Data System. *Clin Toxicol (Phila)*. 2013;51:566–574.
16. O'Dea JA. Consumption of nutritional supplements among adolescents: usage and perceived benefits. *Health Educ Res*. 2003;18:98–107.

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ORIGINAL ARTICLE

Regular energy drink consumption is associated with the risk of health and behavioural problems in adolescents

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Abstract Consumption of energy drinks has become popular and frequent among adolescents across Europe. Previous research showed that regular consumption of these drinks was associated with several health and behavioural problems. The aim of the present study was to determine the socio-demographic groups at risk for regular energy drink consumption and to explore the association of regular energy drinks consumption with health and behavioural problems and negative school experiences in adolescents. Data from the Health Behaviour in School-aged Children Study conducted in 2014 in Slovakia were analysed. We assessed socio-demographic characteristics, energy drink consumption, health and behavioural problems and negative school experiences based on self-reports from 8977 adolescents aged 11–15 years (mean age/standard deviation 13/1.33; 50.0% boys). The prevalence of regular energy drink consumption in the present sample was 20.6% (95%CI: 20%–21%). Regular energy drink consumption was more frequent among boys and older adolescents. Adolescents with a medium-level family affluence were less likely to drink energy drinks regularly. Adolescents who consumed energy drinks regularly had more health and behavioural problems and negative school experiences.

Conclusion: Adolescents drinking energy drinks are at risk of a wide range of negative outcomes and should be specifically addressed by preventive interventions.

What is Known
- *Energy drink consumption has become popular and frequent among adolescents across Europe.*
- *There is growing evidence that energy drink consumption is related to negative social, emotional and health outcomes, but only a few studies have explored this relationship in adolescents.*

What is New
- *Regular energy drink consumption was more frequent among boys and adolescents reporting low family affluence and increased with age.*
- *Adolescents reporting regular energy drink consumption were in higher risk to suffer from health and behavioural problems and negative school experiences.*

Keywords Adolescents · Energy drinks · Health and behavioural problems · Negative school experience

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Abbreviations

CIs	Confidence intervals
ED	Energy drinks
FAS	Family Affluence Scale
HBSC	Health Behaviour of School-aged Children
ORs	Odds ratios
SPSS	Statistical Package for the Social Sciences

Introduction

Health experts have given numerous warnings on the unsuitability of energy drinks (ED) for adolescents [30, 38], but despite this the consumption of these drinks has become popular and frequent among adolescents across Europe. Several studies from Europe and the USA confirm that the prevalence of adolescents reporting ED consumption vary from 20 to 50% [10, 31, 38].

ED are beverages which contain large doses of caffeine, sugar and a variety of other stimulants and substances such as guarana, taurine or vitamins [14]. Caffeine is considered as the main substance which is associated with adverse health consequences among adolescents [29, 34]. Also, the high amounts of sugar contained in these beverages have previously been linked to adverse health and behavioural outcomes in adolescence [15, 29]. The effect of other ingredients contained in ED on health and behaviour of adolescents remains unclear [31]. In addition, information lacks on a potentially synergistic effect of the ED content—caffeine, sugar and other substances—on negative health and behavioural outcomes in adolescents.

Evidence indicating adverse health effects of ED consumption is growing. Regular ED consumption among adolescents was found to be associated with cardiovascular problems, diabetes [12, 19, 31, 36] and depression [2]. Behavioural correlates were also found, with ED consumption being associated with more video game use [21], attention deficit hyperactivity disorder symptoms, delinquency, violent behaviours [19, 20], physiological symptoms such as problems with breathing, headaches, an upset stomach, insomnia, anxiety, agitation, heart palpitations, visual disturbance [3, 7, 18], sensation seeking, risk-taking behaviour [1, 24] substance use [2, 6, 10, 23, 27, 35], stress, sleep dissatisfaction, mood and suicidality [26]. Adolescents consuming ED are at risk for later alcohol use [25]. Furthermore, it has been suggested that ED consumption in adolescence may serve as a gateway to other forms of drug dependence [28].

The worldwide prevalence of ED consumption is high and a growing body of evidence has documented the potential adverse effects of these drinks on health and behaviour. General awareness of the adverse effects of ED consumption is increasing, but evidence on this topic regarding young adolescents is limited. Therefore, the aim of present study was to determine the socio-demographic groups at risk for regular energy drink consumption and to explore the associations of regular energy drink consumption with negative health and behavioural outcomes and negative school experiences in adolescents. These findings should help making a choice between preventive programs and implement evidence-based practices that will better target adolescents.

Materials and methods

Sample and procedure

We used data from the Health Behaviour in School-aged Children (HBSC) Study conducted in 2014 in Slovakia. To obtain a representative sample, we used two-step sampling. In the first step, 151 larger and smaller elementary schools located in rural as well as in urban areas from all regions of Slovakia were asked to participate. These were randomly selected from a list of all eligible schools in Slovakia obtained from the Slovak Institute of Information and Prognosis for Education. School response rate (RR) was 86.1%. In the second step, we obtained data from 8977 adolescents from the fifth to ninth grades of elementary schools in Slovakia in the target group of 11–15 years old, one from each grade per school.

The study was approved by the Ethics Committee of the Medical Faculty at the P. J. Safarik University in Kosice. Parents were informed about the study via the school administration and could opt out if they disagreed with their child's participation. Participation in the study was fully voluntary and anonymous with no explicit incentives provided for participation.

Measures

Data for the present analyses were collected using questionnaires from the standardized research protocols for the 2014 WHO-collaborative HBSC study.

Energy drink consumption was measured by the question: "How many times a week do you usually drink energy drinks, for example Red Bull?" with the following as response options: never; less than once a week; once a week; 2–4 days a week; 5–6 days a week; once a day, every day and every day, more than once. The European Food Safety Authority has identified adolescents consuming ED once a week and more as chronic users of this beverage [38]. In line with this policy, we dichotomised responses on use of energy drinks to obtain two groups of adolescents—regular (chronic) energy drinks consumers (once a week and more) and the other ones.

Daily health complaints were measured by the HBSC symptom checklist (HBSC-SCL): "In the last 6 months: how often have you had the following…?" With the following

options: "headache, stomach-ache, backache, feeling low, irritability or bad temper, feeling nervous, difficulties in getting to sleep, feeling dizzy" with the following response options: about every day, more than once a week, about every week, about every month, rarely or never. We dichotomised the response options to obtain two groups of adolescents: those who reported daily health complaints and others.

Self-rated health assesses the general health of adolescents and was measured by the question "Would you say your health is…?" with the following response options: excellent, good, fair or poor. The response options were dichotomised to get two groups of adolescents: those who reported fair or poor health and other ones consistently with previous research [5].

School liking is an item assessing the emotional and psychological connectedness to school in terms of liking school: "How do you feel about school at present?" The following are the response options: I like it a lot, like it a bit, not very much and not at all. We dichotomised the response options to get the group of adolescents who liked school a bit or a lot.

Physical fight involvement was measured by the question "During the past 12 months, how many times were you in a physical fight?" with the following response options: I have not been in a physical fight in the past 12 months, 1 time, 2 times, 3 times and 4 times or more. We dichotomised the response options to obtain the category of adolescents who were involved in a physical fight more than 3 times in the past 12 months.

Bullying behaviour of adolescents was measured using the revised Olweus Bully/Victim Questionnaire. After having read a standard definition of bullying, respondents were asked about their involvement in bullying—how often they had bullied others in school in the last few months with the following response options: I haven't bullied other students at school in the past couple of months, only once or twice, two or three times a month, about once a week and several times a week. We chose "two or three times a month" as a cut-off point and dichotomised the responses to get two categories of bullying behaviour.

Truancy was measured by asking: "How many days have you skipped classes or school (without permission) this term?" with the following response options: never, 1, 2, 3 days or 4 days or more. We dichotomised the responses to distinguish those who skipped school more than once from the others.

Current smoking status was defined on the basis of the question "How often do you smoke tobacco at present?" with the following response options: every day; at least once a week but not every day; less than once a week; or never. We focused on adolescents smoking at least once a week.

Drunkenness was assessed with the question: "Have you ever had so much alcohol that you were really drunk?" with the following response options: never, once, two or three times, four to ten times and more than ten times. We identified adolescents being drunk more than once in the last 30 days.

Perceived school performance was measured by the item "In your opinion, what does your class teacher(s) think about your school performance compared to your classmates?" with the following response options: very good, good, average and below average. Responses were dichotomised to obtain the group of adolescents reporting academic achievement below average.

Family affluence was measured using the Family Affluence Scale III (FAS III), which consists of six questions: "Does your family own a car, van or truck?" "Do you have your own bedroom for yourself?" "How many computers does your family own?" "How many bathrooms (room with a bath/shower or both) are in your home?" "Does your family have a dishwasher at home?" "How many times did you and your family travel out of Slovakia for a holiday/vacation last year?" We converted the FAS summary scores to a final score, which has a consistent, normal distribution and a range from 0 to 1. We then created groups of low (0–.333), middle (.334–.666) and high (.667–1) socio-economic position [9].

Statistical analyses

In the first step, the socio-demographic characteristics of the sample were described: the prevalence of gender and family affluence was computed for the total sample and stratified by category of ED consumption. Moreover, prevalence of several types of negative outcomes such as health complaints, self-rated health, fighting, bullying, smoking, drunkenness, school dislike, low academic achievement and truancy were described for the total sample and stratified by category of ED consumption. Differences between regular and irregular consumers of ED were tested using Chi-square tests (Table 1). Second, associations between regular ED consumption and gender, age and family affluence were assessed (Table 2). Third, the associations (crude–model 1 and adjusted for potential confounders–model 2) of regular ED consumption with health and behavioural outcomes were assessed using a multiple logistic model to estimate crude and adjusted ORs and corresponding 95% confidence intervals (Table 3). Statistical analyses were performed using IBM SPSS statistics 20.0 for Windows.

Results

The study sample consisted of 8977 adolescents aged 11–15 years (mean age/standard deviation 13.49/1.33; 50.0% boys). Regular consumption of ED was reported by 20.6% of adolescents (95%CI: 20%–21%) (Table 1).

Regular ED consumption was more frequent among boys and increased with age, and adolescents reporting family affluence at a medium level were at a lower risk to drink ED regularly than those reporting low family affluence (Table 2).

Table 1 Background characteristics of the sample—gender, family affluence and the prevalence of health and behavioural problems—overall and by category of energy drinks consumption

		Total *N* = 8977 (100%)	Regular energy drink consumption *N* = 1849 (20.6%)	Irregular energy drink consumption *N* = 7128 (79.4%)	Regular vs. irregular energy drink consumption *p* value
Gender	Boys	4490 (50.0)	1239 (27.6)	3251 (72.4)	<0.001
	Girls	4487 (50.0)	610 (13.6)	3877 (86.4)	
Family affluence	Low	3148 (39.7)	650 (20.6)	2498 (79.4)	Ns
	Middle	2237 (28.2)	413 (18.5)	1824 (81.5)	
	High	2548 (32.1)	506 (19.9)	2042 (80.1)	
Health complaints (daily)	Head ache	1707 (19.2)	486 (26.8)	1221 (17.3)	<0.001
	Stomach-ache	1166 (13.1)	332 (18.2)	834 (11.8)	<0.001
	Back ache	1261 (14.4)	372 (20.8)	889 (12.7)	<0.001
	Feeling low	1728 (19.6)	474 (26.3)	1254 (17.9)	<0.001
	Irritability or bad temper	2489 (28.1)	654 (36.0)	1835 (26.0)	<0.001
	Feeling nervous	2538 (28.7)	673 (37.2)	1865 (26.5)	<0.001
	Difficulties with sleeping	1413 (16.0)	389 (21.6)	1024 (14.5)	<0.001
	Feeling dizzy	885 (10.0)	277 (15.3)	608 (8.6)	<0.001
Self-rated health (fair and poor)		983 (11.1)	280 (15.4)	703 (10.0)	<0.001
Fighting (three times and more)		1143 (13.0)	450 (25.1)	693 (9.9)	<0.001
Bullying (two or three times a week)		1159 (13.2)	358 (20.0)	801 (11.4)	<0.001
Smoking (more than once a week)		407 (4.6)	280 (15.4)	127 (1.8)	<0.001
Drunkenness (more than once in last 30 days)		651 (7.7)	334 (20.4)	317 (4.6)	<0.001
School dislike (not very much or not at all)		3511 (39.3)	1087 (59.0)	2424 (34.1)	<0.001
Academic achievement (below average)		338 (3.8)	164 (8.9)	174 (2.5)	<0.001
Truancy (once and more)		1466 (16.6)	533 (29.6)	933 (13.2)	<0.001

Only the percentages of valid answers are presented; missing values: Energy drink consumption 0 (0), Gender 0 (0), Family affluence 1044 (11.6), Head ache 88 (1.0), Stomach-ache 96 (1.1), Back ache 190 (2.1), Feeling low 161 (1.8), Irritability or bad temper 111 (1.2), Feeling nervous 121 (1.3), Difficulties with sleeping 134 (1.5), Feeling dizzy 102 (1.1), Self-rated health 106 (1.2), School dislike 36 (0.4), Fighting 155 (1.7), Bullying 185 (2.1), Truancy 127 (1.4), Smoking 103 (1.1), Drunkenness 516 (5.7), Academic achievement 66 (0.7)

Ns non-significant

Results of logistic models showed that regular ED consumption among adolescents was related to negative health and behavioural outcomes and negative school experiences and problem behaviours. Adolescents reporting regular ED consumption were at higher risk suffering from various health complaints, reporting unfavourable self-rated health and disliking school. In addition, these adolescents were more likely to fight, bully others, skip the school lessons, smoke, drink alcohol and report low academic achievement. Adding gender, age and family affluence to the models did not affect the strength of the association of regular ED consumption with the examined types of negative outcomes (Table 3).

Discussion

The aim of this study was to explore the relationship between regular ED consumption among adolescents and health and behavioural outcomes. We found that regular consumers of ED were more likely to report a wide range of damaging health and behavioural outcomes and negative school experiences, such as daily health complaints, poor self-rated health, school dislike, low academic achievement, truancy, fighting, bullying, smoking and drunkenness.

ED consumption was more prevalent among boys and older adolescents which fits with previous evidence [10]. In general, boys and older adolescents were identified as being more vulnerable to having unhealthy eating habits [33]. Adolescents reporting low family affluence showed higher ED consumption than their peers. Generally, a low socio-economic status was previously associated with higher consumption of ED as a part of an unhealthy dietary pattern [4, 11].

Present study showed that adolescents reporting regular ED consumption were at a higher risk of several health and behavioural problems such as daily health complaints, poor self-rated health, school dislike, low academic achievement, truancy, fighting, bullying, smoking and drunkenness. Our results are in line with previous evidence on the association of ED with physiological symptoms [3, 7, 18], substance use [2, 6, 10, 23, 27, 35] or aggressive behaviour [19, 24] in

Table 2 The association of regular energy drink consumption with age, gender and family affluence among adolescents; odds ratios (OR) and 95% confidence intervals (CI) in parentheses

		Crude model 1 OR (95%CI)	Adjusted model 2 OR (95%CI)
Gender			
	Girl	1 (ref)	1 (ref)
	Boy	2.42 (2.17–2.69)***	2.43 (2.17–1.74)***
Age		1.25 (1.20–1.30)***	1.26 (1.20–1.31)***
Family affluence	Low	1 (ref)	1 (ref)
	Medium	0.87 (0.75–0.99)*	0.84 (0.73–0.97)*
	High	0.95 (0.83–1.08)	0.91 (0.80–1.04)

Crude model 1: crude effect of gender, age and family affluence separately on energy drink consumption. Adjusted model 2: combined effect of gender, age and family affluence on regular energy drink consumption

*p<0.05, ***p<0.001

adolescents. Moreover, we found that adolescents consuming ED on a regular basis were more vulnerable to have problems in school. They reported school dislike, low academic achievement and truancy more frequently than their peers. Taken together, the results of the present study based on the large and representative sample of adolescents point out that regular ED consumption in adolescence is associated with a higher risk for several negative outcomes ranging from health problems to problems in school.

Given the cross-sectional design of the present study, we cannot make causal inferences regarding the association of ED consumption with health and behavioural problems in adolescents. Three explanations may hold. Firstly, there is growing evidence that ED consumption in childhood and adolescence may have adverse physiological effects [13] due to the high amount of caffeine [34]. Other substances, such as sugar (glucose and fructose), have also been identified as the metabolically deleterious ingredients. In combination with caffeine, it has the greatest metabolic impact and potential influence on overall health [32]. A recent study on adolescents' consumption of sugary and caffeinated drinks suggested the possible explanation that adolescents reporting regular consumption of these drinks are more likely to report mood deviations and subsequently aggressive behaviour [15]. This can be caused by fluctuations in blood glucose levels, which has been found to be related to behavioural deviations.

A second explanation is that ED consumption might be a part of a broader cluster of adverse behaviours [37]. According to this hypothesis, adolescents vulnerable to behave in a risky manner might prefer these beverages. More specifically, previous research has found that a significant number of young adults mix energy drinks with alcohol [16,

Table 3 The association of regular energy drink consumption in adolescents (independent variable) with a wide range of health and behavioural problems, crude and adjusted for age, gender and family affluence; odds ratios (OR) and 95% confidence intervals (CI) in parentheses

	Crude model OR (95%CI)	Number of cases included in the crude model *N* (%)	Adjusted model OR (95%CI)	Number of cases included in the adjusted model *N* (%)
Health complaints (daily)				
Head ache	1.75 (1.55–1.98)***	8889 (99.0)	2.12 (1.85–2.44)***	7865 (87.6)
Stomach-ache	1.66 (1.44–1.91)***	8881 (98.9)	2.00 (1.71–2.35)***	7852 (87.5)
Back ache	1.81 (1.58–2.07)***	8787 (97.9)	1.97 (1.70–2.29)***	7778 (86.6)
Feeling low	1.63 (1.45–1.84)***	8816 (98.2)	2.12 (1.84–2.43)***	7808 (87.0)
Irritability or bad temper	1.59 (1.43–1.78)***	8866 (98.8)	1.84 (1.63–2.08)***	7854 (87.5)
Feeling nervous	1.64 (1.47–1.83)***	8856 (98.7)	1.80 (1.60–2.04)***	7843 (87.4)
Difficulties with sleeping	1.61 (1.41–1.83)***	8843 (98.5)	1.88 (1.63–2.17)***	7834 (87.3)
Feeling dizzy	1.91 (1.64–2.23)***	8875 (98.9)	2.13 (1.79–2.53)***	7861 (87.6)
Self-rated health (fair and poor)	1.63 (1.41–1.90)***	8871 (98.8)	1.80 (1.52–2.12)***	7847 (87.4)
Fighting (three times and more)	3.06 (2.68–3.49)***	8822 (98.3)	2.62 (2.26–3.04)***	7867 (87.6)
Bullying (two or three times a week)	1.93 (1.68–2.21)***	8792 (97.9)	1.78 (1.53–2.07)***	7825 (87.2)
Smoking (more than once a week)	9.92 (7.99–12.32)***	8874 (98.9)	9.07 (7.11–11.58)***	7848 (87.4)
Drunkenness (more than once in last 30 days)	5.25 (4.45–6.19)***	8461 (94.3)	4.71 (3.91–5.68)***	7526 (83.8)
School dislike (not very much or not at all)	2.78 (2.50–3.08)***	8941 (99.6)	2.46 (2.19–2.76)***	7904 (88.0)
Academic achievement (below average)	3.89 (3.12–4.85)***	8911 (99.3)	3.43 (2.67–4.41)***	7890 (87.9)
Truancy (once and more)	2.76 (2.44–3.12)***	8850 (98.6)	2.63 (2.29–3.01)***	7881 (87.8)

Model 1: crude effect of energy drinks consumption on problem behaviour. Model 2: effect of regular energy drinks consumption on each variable separately adjusted for gender, age and family affluence

***p<0.001

22]. This habit —mixing alcohol with energy drinks—may be a main motivation and a gateway to future alcohol use [28].

Thirdly, ED consumption as part of a broader cluster of adverse behaviours could be determined by other psychosocial factors, such as family background, peers or wider environmental factors. In this case, a common cause of these outcomes exists. Practically, this may also be associated with the second explanation, as such, a common cause might lead to a clustering of the outcomes. This has been documented for a number of causes of adverse health-behaviours in adolescents, with e.g. norms of friend [8] and parenting practices [17] being such common causes.

Strengths and limitations

As far as we know, this is the first study on the prevalence and correlates of ED consumption on a large and representative sample of adolescents 11–15 years old, which represents a major strength. In addition, we used measures which have been well validated and extensively used in a variety of reports and peer-reviewed publications at the cross-national level. A limitation of the present study is its cross-sectional design, which hampers making causal inferences. In addition, the present data were based on self-reports, which can be inaccurate or influenced by social desirability, though previous research has shown them to be valid. Our results might be affected by assessing multiple comparisons which might have caused some associations to spuriously significant. However, we used a level of statistical significance of $p < 0.001$, to avoid this effect.

Implications

The present study provides important evidence related to the patterns of adolescents' ED consumption. Regular ED consumption may serve as a screening indicator to identify adolescents at risk for problem behaviour and for a large number of health problems.

Future studies should explore the causality of the relationship between adolescents' ED consumption and negative health and behavioural outcomes via a longitudinal study or randomized controlled trials. Further research is needed to examine the effect of the ingredients of ED on physiology, health and behaviour of adolescents and the factors entering into this relationship. Finally, the topic of the ease of buying ED should be studied to explore the possibilities of price policies.

Conclusion

In conclusion, ED consumption was very frequent among adolescents, especially among boys and older adolescents. Regular ED consumption was found to be associated with a wide range of negative health and behavioural outcomes and negative school experience. Our findings provide evidence about the importance of preventive actions aimed at reducing adolescents' consumption of ED. Longitudinal studies are needed to explore the causal relationships between ED consumption and health and behavioural outcomes among adolescents and to explore the possibilities of price policies.

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Authors' contributions Jana Holubcikova drafted the initial manuscript, carried out the initial analyses and revised the final manuscript as submitted. Jitse P van Dijk revised the manuscript and approved the final manuscript as submitted. Andrea Madarasova Geckova, Sijmen A Reijneveld and Peter Kolarcik revised the analyses and the final manuscript and approved the final manuscript as submitted.

Compliance with ethical standards

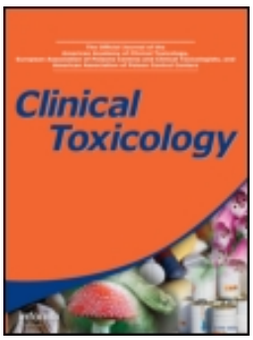
Ethical standards The study was approved by the Ethics Committee of the Medical Faculty at the Pavol Jozef Safarik University in Kosice and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Parents of respondents were informed about the study via the school administration, they gave their informed consent prior to inclusion of their children in the study and could opt out if they disagreed with their child's participation. Participation in the study was fully voluntary and anonymous with no explicit incentives provided for participation.

Conflict of interest The authors declare that they have no conflict of interest.

References

1. Arria AM, Bugbee BA, Caldeira KM, Vincent KB (2014) Evidence and knowledge gaps for the association between energy drink use and high-risk behaviors among adolescents and young adults. Nutr Rev 72:87–97
2. Azagba S, Langille D, Asbridge M (2014) An emerging adolescent health risk: caffeinated energy drink consumption patterns among high school students. Prev Med 62:54–59
3. Bashir D, Reed-Schrader E, Olympia RP, Brady J, Rivera R, Serra T, Weber C (2016) Clinical symptoms and adverse effects associated with energy drink consumption in adolescents. Pediatr Emerg Care 32:751–755
4. Beckford K, Grimes CA, Riddell LJ (2015) Australian children's consumption of caffeinated, formulated beverages: a cross-sectional analysis. BMC Public Health 15:1–10
5. Cavallo F, Zambon A, Borraccino A, Raven-Sieberer U, Torsheim T, Lemma P (2006) Girls growing through adolescence have a higher risk of poor health. Qual Life Res 15:1577–1585

6. Cofini V, Cecilia MR, Giacomo D, Binkin N, Orio F (2016) Energy drinks consumption in Italian adolescents: preliminary data of social, psychological and behavioral features. Minerva Pediatr
7. Costa BM, Hayley A, Miller P (2016) Adolescent energy drink consumption: an Australian perspective. Appetite 105:638–642
8. Dusseldorp E, Klein Velderman M, Paulussen TWGM, Junger M, van Nieuwenhuijzen M, Reijneveld SA (2014) Targets for primary prevention: cultural, social and intrapersonal factors associated with co-occurring health-related behaviours. Psychol Health 29:598–611
9. Elgar FJ, Pförtner T, Moor I, De Clercq B, Stevens GWJM, Currie C (2015) Socioeconomic inequalities in adolescent health 2002–2010: a time-series analysis of 34 countries participating in the Health Behaviour in School-aged Children study. Lancet 385: 2088–2095
10. Gallimberti L, Buja A, Chindamo S, Vinelli A, Lazzarin G, Terraneo A, Scafato E, Baldo V (2013) Energy drink consumption in children and early adolescents. Eur J Pediatr 172:1335–1340
11. Grandner MA, Knutson KL, Troxel W, Hale L, Jean-Louis G, Miller KE (2014) Implications of sleep and energy drink use for health disparities. Nutr Rev 72:14–22
12. Grasser E, Yepuri G, Dulloo A, Montani J (2014) Cardio- and cerebrovascular responses to the energy drink Red Bull in young adults: a randomized cross-over study. Eur J Nutr 53:1561–1571 11p
13. Harris JL, Munsell CR (2015) Energy drinks and adolescents: what's the harm? Nutr Rev 73:247–257
14. Higgins JP, Tuttle TD, Higgins CL (2010) Energy beverages: content and safety. Mayo Clin Proc 85:1033–1041
15. Holubcikova J, Kolarcik P, Madarasova Geckova A, Reijneveld SA, van Dijk JP (2015) The mediating effect of daily nervousness and irritability on the relationship between soft drink consumption and aggressive behaviour among adolescents. Int J Public Health 60:699–706
16. Holubcikova J, Kolarcik P, Madarasova Geckova A, Joppova E, van Dijk JP, Reijneveld SA (2016) Young adolescents who combine alcohol and energy drinks have a higher risk of reporting negative behavioural outcomes. Int J Public Health. doi:10.1007/s00038-016-0862-4
17. Klein Velderman M, Dusseldorp E, van Nieuwenhuijzen M, Junger M, Paulussen TGWM, Reijneveld SA (2015) Cultural, social and intrapersonal factors associated with clusters of co-occurring health-related behaviours among adolescents. Eur J Pub Health 25:31–37
18. Koivusilta L, Kuoppamäki H, Rimpelä A (2016) Energy drink consumption, health complaints and late bedtime among young adolescents. Int J Public Health 61:299–306
19. Kristjansson AL, Sigfusdottir ID, Frost SS, James JE (2013) Adolescent caffeine consumption and self-reported violence and conduct disorder. J Youth and Adolesc 42:1053–1062
20. Kristjansson AL, Sigfusdottir ID, Mann MJ, James JE (2014) Caffeinated sugar-sweetened beverages and common physical complaints in Icelandic children aged 10–12 years. Prev Med 58: 40–44
21. Larson N, Dewolfe J, Story M, Neumark-Sztainer D (2014) Adolescent consumption of sports and energy drinks: linkages to higher physical activity, unhealthy beverage patterns, cigarette smoking, and screen media use. J Nutr Educ Behav 46:181–187
22. Malinauskas BM, Aeby VG, Overton RF, Carpenter-Aeby T, Barber-Heidal K (2007) A survey of energy drink consumption patterns among college students. Nutr J 6:35–35
23. Meredith SE, Sweeney MM, Johnson PS, Johnson MW, Griffiths RR (2016) Weekly energy drink use is positively associated with delay discounting and risk behavior in a nationwide sample of young adults. J Caffeine Res 6:10–19
24. Miller KE (2008) Energy drinks, race, and problem behaviors among college students. J Adolesc Health 43:490–497
25. Miyake ER, Marmorstein NR (2015) Energy drink consumption and later alcohol use among early adolescents. Addict Behav 43: 60–65
26. Park S, Lee Y, Lee JH (2016) Association between energy drink intake, sleep, stress, and suicidality in Korean adolescents: energy drink use in isolation or in combination with junk food consumption. Nutr J 15:1–8
27. Polak K, Dillon P, Koch JR, Miller WG, Thacker L, Svikis D (2016) Energy drink use is associated with alcohol and substance use in eighth, tenth, and twelfth graders. Prev Med Rep 4:381–384
28. Reissig CJ, Strain EC, Griffiths RR (2009) Caffeinated energy drinks: a growing problem. Drug Alcohol Depend 99:1–10
29. Ruxton CHS (2014) The suitability of caffeinated drinks for children: a systematic review of randomised controlled trials, observational studies and expert panel guidelines. J Hum Nutr Diet 27:342–357
30. Schneider MB, Benjamin HJ (2011) Clinical report-sports drinks and energy drinks for children and adolescents: are they appropriate? Pediatrics 127:1182–1189 8p
31. Seifert SM, Schaechter JL, Hershorin ER, Lipschultz SE (2011) Health effects of energy drinks on children, adolescents, and young adults. Pediatrics 127:511–528
32. Shearer J (2014) Methodological and metabolic considerations in the study of caffeine-containing energy drinks. Nutr Rev 72:137–145
33. Taut D, Baban A, Giese H, Matos MG, Schupp H, Renner B (2015) Developmental trends in eating self-regulation and dietary intake in adolescents. Appl Psychol Health Well-Being 7:4–21
34. Temple JL (2009) Caffeine use in children: what we know, what we have left to learn, and why we should worry. Neurosci Biobehav Rev 33:793–806
35. Terry-McElrath Y, O'Malley PM, Johnston LD (2014) Energy drinks, soft drinks, and substance use among United States secondary school students. J Addict Med 8:6–13
36. Van Batenburg-Eddes T, Lee NC, Weeda WD, Krabbendam L, Huizinga M (2014) The potential adverse effect of energy drinks on executive functions in early adolescence. Front Psychol 5
37. Van Nieuwenhuizen M, Junger M, Klein Velderman M, Wiefferink KH, Paulussen TWGM, Hox J, Reijneveld SA (2009) Clustering of health-compromising behavior and delinquency in adolescents and adults in the Dutch population. Prev Med 48:572–578
38. Zucconi S, Volpato C, Adinolfi F, Gandini E, Gentile E, Loi A, Fioriti L (2013) Gathering consumption data on specific consumer groups of energy drinks. Supporting Publications:EN-394. http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/394e.pdf. Accessed 1 Mar 2016



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CRITICAL CARE

Behavioral and physiologic adverse effects in adolescent and young adult emergency department patients reporting use of energy drinks and caffeine

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Introduction. This pilot study assessed the prevalence of physiologic and behavioral adverse effects among adolescent (13–17 years) and adult (18–25 years) emergency department patients who reported energy drink and/or caffeinated-only beverage use within the 30 days prior to emergency department presentation. It was hypothesized that energy drink users would report more adverse effects than those who used only traditional caffeinated beverages such as coffee, tea, or soft drinks. *Methods.* This cross-sectional pilot study was conducted in two urban emergency departments, one adult and one pediatric. Eligible patients were enrolled during a 6-week period between June and August 2010. Participants completed a tablet computer-based, self-administered, anonymous questionnaire about their past 30-day energy drink and/or caffeinated-only beverage use, substance use, and experience of 10 physiologic and 10 behavioral symptoms. Multivariable logistic regression and negative binomial regression models, adjusted for age, gender, and substance use, were created to compare the occurrence of each adverse effect between energy drink and caffeinated-only beverage users. Odds ratios (ORs) and incidence rate ratios (IRRs) were estimated. *Results.* Of those enrolled, 53.3% reported consuming energy drinks, 39.1% caffeinated-only beverages, and 7.6% no energy drinks or caffeinated-only beverages within the past 30 days. In multivariable logistic regression models, energy drink users were more likely than caffeinated-only beverage users to report having "gotten into trouble at home, school, or work" in the past 30 days (OR: 3.12 [1.24–7.88]). In the negative binomial regression multivariable models, more behavioral effects were reported among drug users (IRR: 1.50 [1.18–1.93]), and more physiologic effects were reported among tobacco users (IRR: 1.42 [1.13–1.80]) and females (IRR: 1.48 [1.21–1.80]), but not among energy drink users. *Conclusions.* Energy drink users and substance users are more likely to report specific physiologic and behavioral adverse effects. Emergency department clinicians should consider asking patients about energy drink and traditional caffeine usage and substance use when assessing patient symptoms.

Keywords Emergency medicine; Side-effects

Introduction

Energy drinks are beverages containing relatively high concentrations of caffeine and other stimulants such as sugars, amino acids, herbs, and other plant-based compounds.[1–4] The amount of caffeine in energy drinks varies from 80 to 500 mg.[5] In comparison, a standard 5-ounce cup of coffee contains 100 mg of caffeine, while a 12-ounce can of a caffeinated soft drink contains 50 mg.[6]

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The stimulatory and performance-enhancing effects of energy drinks are aggressively marketed to adolescents and young adults.[3] In the US, energy drink consumption is most common among individuals under 35 years of age. Data from the Simmons Teen Survey (an analysis of adolescent purchasing), show that 31% of 12- to 17-year-olds and 34% of 18- to 24-year-olds report consuming energy drinks on a regular basis.[3,7,8]

Most energy drinks are classified by the US Food and Drug Administration (FDA) as dietary supplements, because many of the ingredients in energy drinks are derived from herbs and natural sources.[9] The FDA currently neither regulates the content of energy drinks nor requires energy drink manufacturers to list the potential adverse effects of their products on their labels. Although the FDA requires soft

drink manufacturers to limit the amount of caffeine in beverages to 0.02% (~65–71 mg per 12-ounce soft drink), no such regulation exists for energy drinks in the dietary supplement product classification.[10,11] Instead, energy drink manufacturers are required only to list the contents of their drinks, but not the quantity of each ingredient.[11,12] Recently, Monster Beverage Corporation and Rockstar announced their decisions to voluntarily reclassify their products as beverages rather than dietary supplements; the beverage products classification carries stricter labeling and safety requirements.[13]

There is no established recommended daily allowance (RDA) for caffeine, as it not considered a nutrient. However, it is generally recommended that adults consume no more than 200–300 mg of caffeine per day and adolescents limit their consumption to less than 100 mg per day.[7] According to US Department of Health and Human Services and US Department of Agriculture guidelines, adults should consume no more than 32 grams or eight teaspoons of added sugar per day as part of a standard 2000-calorie diet.[14] This amount is surpassed by most energy drinks, which contain upwards of 35 grams of sugar per eight-ounce bottle and 60–90 grams per 16- to 24-ounce bottle.[15] The RDAs of other ingredients found in energy drinks have not yet been established. Due to the absence of universally recommended daily intake guidelines for energy drinks, consumers might ingest high doses of caffeine and other stimulants, unknowingly placing themselves at increased risk for adverse effects. In fact, the American Academy of Pediatrics recommends that children and adolescents not consume energy drinks because of the potential health risks posed by the stimulant ingredients of these products.[16]

The high caffeine, stimulant, and caloric content of energy drinks might cause behavioral and physiologic adverse effects that could impact presentation to emergency departments. The Drug Abuse Warning Network (DAWN) data from US Substance Abuse and Mental Health Services Administration report that emergency department visits related to energy drinks increased ten-fold between 2005 and 2009 (from 1,128 to 13,114).[5] During this time period, approximately 92% of emergency department visits related to energy drink use were due to adverse reactions, while 8% involved misuse or abuse of energy drinks.[5] In January 2013, an updated DAWN report stated that the number of emergency department visits related to energy drinks had doubled between 2007 and 2011 (from 10,068 to 20,783).[17] Energy drink consumption can cause elevated blood pressure, dehydration, dysrhythmias, insomnia, and anxiety, as well as worsen the clinical presentation of cardiac conditions, diabetes, anxiety disorders, and interactions with prescription drugs.[5] Emergency department clinicians who are unaware of the adverse effects of energy drink use might not screen patients for energy drink consumption, thereby missing an opportunity to pinpoint this potential cause of a patient's emergency department presentation.

The purpose of this pilot study was to assess the prevalence of behavioral and physiologic adverse effects experienced by adolescent and young adult (13–25 years) emergency department patients who reported past 30-day energy drink and/or caffeinated-only beverage use and to compare the prevalence of these effects between energy drink users and those who only consume traditional caffeinated beverages (soft drinks, coffee, and/or tea), as well as by age group and gender. Furthermore, as a pilot study, it was utilized to further assess the patterns of caffeinated-only beverage and energy drink use among adolescents and young adults, and to refine the survey instrument for use in a larger study. Due to the typically higher caffeine content of energy drinks and the potential synergistic effects of caffeine and other stimulants present in most energy drinks, it was hypothesized that energy drink users would report more adverse effects than those who only use traditional caffeinated beverages.

Methods

Study design

The *Hearing Young Perspectives on Energy Drink Use* cross-sectional pilot study enrolled a convenience sample of 13- to 25-year-old subcritically ill or injured emergency department patients on a random sample of dates. This age range was chosen to reflect previous research indicating that energy drink use is most common among individuals of these ages.[3,8] Participants were surveyed about their energy drink and/or caffeinated-only beverage use and the occurrence of select behavioral and physiologic adverse effects during the preceding 30 days. A 30-day period was chosen as we believed that participants would be less likely to remember their consumption patterns over a longer period of time. Additionally, if a smaller period of time was chosen (e.g. 7 days), we believed that some participants who only rarely consumed caffeinated-only beverages or energy drinks would not report use of these products, thereby further limiting the ability to discern meaningful differences. The Rhode Island Hospital institutional review board approved the study protocol and verbal consent (and assent if applicable) was required for patient participation.

Study setting and population

The study was conducted at an urban adult emergency department (Rhode Island Hospital) and a pediatric emergency department (Hasbro Children's Hospital) affiliated with the Alpert Medical School of Brown University during a 6-week period between June and August 2010. A 6-week period was considered appropriate for this short pilot study. During this period, there were 996 visits by 13- to 17-year-olds in the pediatric emergency department and 2,104 visits by 18- to 25-year-olds in the adult emergency department. Both emergency departments are level-one trauma centers, providing medical care to more than 100,000 patients per year in the adult emergency department and more than 50,000 patients per year in the pediatric emergency department.

Two research assistants (RAs) collected data during a random sample of 46 eight-hour shifts on 32 days over this 6-week period. The distribution of shifts on those dates reflected the typical patient volume in the emergency

department during a 24-hour period. Approximately 10% of the shifts were classified as overnight (11 pm to 7 am), 50% as evening (3 pm to 11 pm) and 40% as daytime (7 am to 3 pm) shifts. Shifts were assigned to each RA in an alternating pattern, with each RA completing approximately four shifts per week. During each shift, RAs reviewed the medical records of all 13- to 25-year-old patients present in both emergency departments and assessed them for study eligibility. Patients were eligible for the study if they were 13–25 years of age (those under 18 years required parental consent), English-speaking, and subcritically ill or injured. Patients were excluded if they were prison inmates, under arrest, or undergoing home confinement; intoxicated; physically or mentally unable to provide consent; or under 18-years-old and not accompanied by an adult capable of giving consent. If potential suitability for the study was unclear, RAs consulted emergency department nursing staff and clinicians to confirm that the patient was not critically ill or injured, intoxicated, or physically or mentally unable to provide consent. Potentially eligible patients, as determined via medical record review, were then approached for further in-person assessment. No incentives were offered to participants and emergency department staff was not permitted to suggest patients for the study.

Study instrument and study protocol

The study authors devised a brief questionnaire that queried participants about their demographic characteristics, health history, medication use, supplement use, substance use, past 30-day energy drink and caffeinated-only beverage usage, and occurrence of 10 behavioral and 10 physiologic adverse effects related to energy drink or caffeinated-only beverage usage. Questions for this investigation are provided in the appendix to be found online at http://informahealthcare.com/doi/abs/10.3109/15563650.2013.820311. In a previous manuscript, we reported on the extent of energy drink use, substance use, and co-occurrence of energy drink and substance use in the study population.[18] The authors selected the 10 physiologic and 10 behavioral adverse effects based on reviews of prior research on the effects of energy drinks and caffeine stimulant use.[19–21] The total number of reported adverse effects participants could report ranged from 0 to 20. Participants were not asked to indicate whether these effects were related to their energy drink and/or caffeinated-only beverage usage. Participants were not informed and the questions did not suggest that these behavioral and physiologic adverse effects could be related to energy drink or caffeinated-only beverage use. Cronbach's α for each of the subscales were as follows: $\alpha = 0.77$ for behavioral effects, $\alpha = 0.82$ for physiologic effects, and $\alpha = 0.87$ for behavioral and physiologic effects together, indicating that these scales have acceptable to good internal consistency. Participants completed the questionnaire on the DatStat® Survey system (DatStat, Inc., Seattle, WA) via a tablet computer while waiting for medical care. Completion of the questionnaire typically took between 10 and 20 minutes.

Data analysis

Participant enrollment and eligibility were summarized according to the Strengthening the Reporting of Observational Studies in Epidemiology statement recommendations.[22] Participant demographic characteristics, health history, medication use, supplement use, and substance use were reported according to those who consumed only traditional caffeinated beverages, those who consumed energy drinks, and those who consumed neither over the previous 30 days. Summary statistics were calculated as appropriate to the form of the data (percentage or median and interquartile range [IQR]). For the purpose of this study, participants who consumed both energy drinks and traditional caffeinated beverages were classified as energy drink users. Because those who used caffeine pills ($n = 3$) only reported caffeinated beverage use and not energy drink use, these users were classified as caffeinated beverage-only users. The percentages of respondents reporting each of the 10 physiologic and 10 behavioral effects were summarized according to whether they reported energy drink use or caffeinated-only beverage use or had not consumed these substances. For this investigation, participants who had not consumed caffeinated beverages, caffeine pills, or energy drinks within the past 30 days were not included further in the analyses, as the intent of the investigation was to compare energy drink users to caffeinated-only beverage users, and due to the small number of participants who had not used these substances (which would render unstable or incalculable estimates).

Univariable logistic regression models were created to compare the occurrence of each physiologic or behavioral effect according to energy drink versus caffeinated-only beverage user status. Univariable logistic regression models also were created to examine the relationship of possible confounders of the relationship between energy drink versus caffeinated-only beverage use and each physiologic or behavioral effect. The covariates for these models were participant demographic characteristics, health history, medication use, supplement use, and substance use. Using the results of these univariable analyses, candidate covariates associated with the outcome of each physiologic or behavioral effect were considered jointly in multivariable logistic regression models with the main effect of energy drink versus caffeinated-only beverage use. Those covariates that remained associated with the outcomes were considered further. Final multivariable logistic regression models were constructed to compare each of these physiologic and behavioral effects for energy drink versus caffeinated-only beverage users as adjusted for age group, gender, tobacco use, alcohol use, and any drug use. Odds ratios (ORs) with corresponding 95% confidence intervals (CIs) were estimated.

Participant responses to questions about the frequency of each adverse effect over the 30 days prior to emergency department presentation were used to generate separate five-point response scales, one for each behavioral effect and one for each physiologic effect. Based on their responses, participants could score between zero points (did not experience the effect over the previous 30 days) to five points

(has experienced the effect every day over the previous 30 days). The number of adverse events reported was summed for each participant. Negative binomial regressions models were constructed to examine the effects of energy drink use versus caffeinated-only beverage use on the number of reported behavioral and physiologic adverse effects, as adjusted for age group, gender, tobacco use, alcohol use, and any drug use. Incidence rate ratios (IRRs) with corresponding 95% CIs were estimated. STATA/SE 11.1 (version 11.1; StataCorp LP, College Station, Texas) statistical software was used for all analyses.

Results

Demographic characteristics of enrolled participants

Figure 1 summarizes the results of the eligibility assessments and reports the major reasons for study ineligibility, refusing eligibility assessment, accepting or declining study enroll-

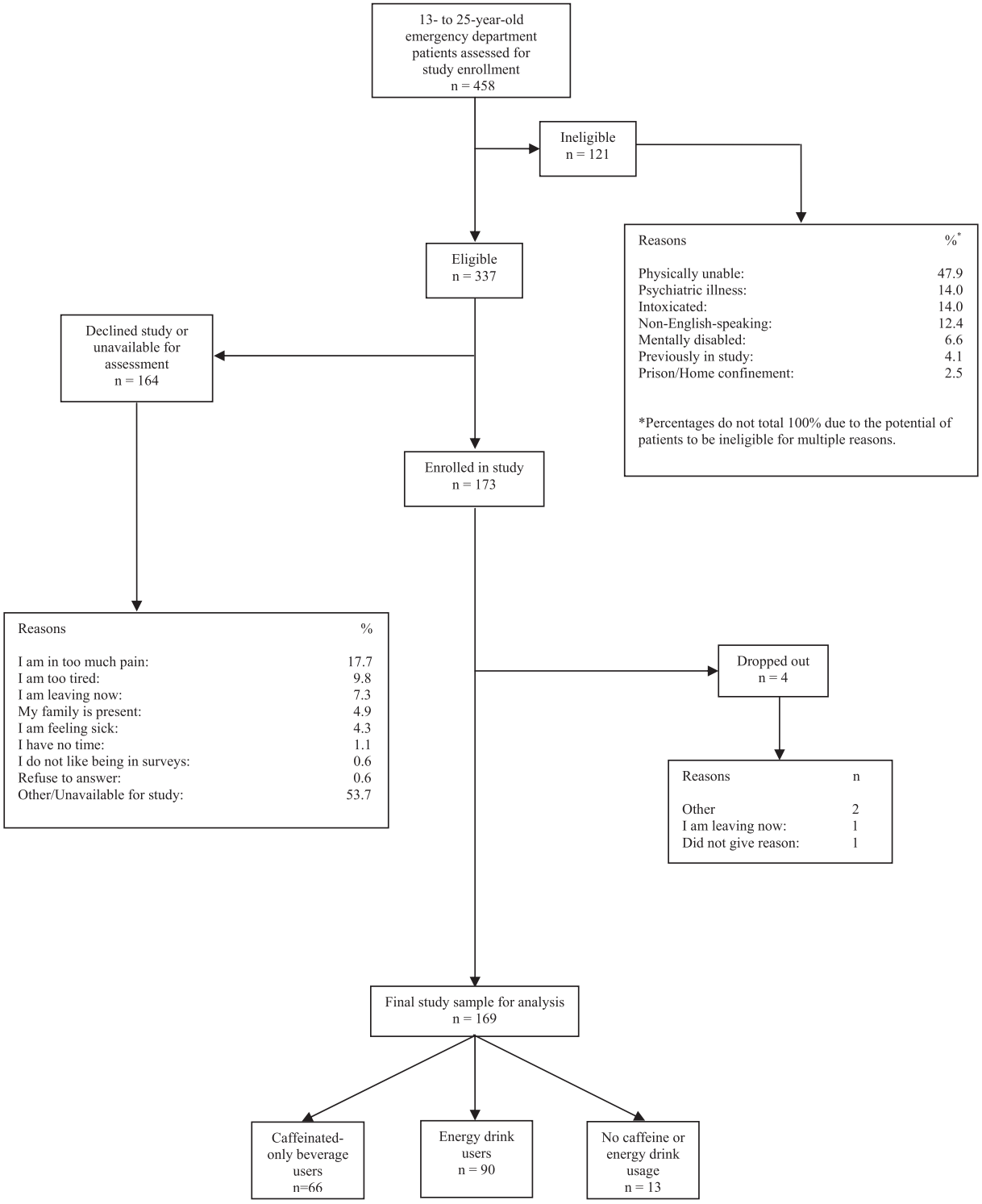

Fig. 1. Eligibility and enrollment diagram.

ment, and post-enrollment dropout. During the 6-week study period, 173 of 337 eligible patients (51.3%) enrolled in the study, with 169 patients completing the study (97.7%).

Table 1 depicts the demographic characteristics of enrolled participants stratified by caffeinated-only beverage, energy drink, and no caffeinated beverage or energy drink usage. Most of the participants were male, White, never married/single students. The median age of all participants was 20-years-old (IQR: 17–23 years). Of those enrolled, 90 (53.3%) reported energy drink use, 66 (39.1%) reported caffeinated-only beverage use, and 13 (7.6%) consumed neither energy drinks nor caffeinated-only beverages within the 30 days prior to emergency department presentation. Table 2 shows the distribution of responses to the health history, medication use, supplement use, and substance use questions.

Behavioral and physiologic adverse effects

Table 3 provides the results of the comparisons of the behavioral and physiologic adverse effects reported by participants. The most frequently reported behavioral symptoms (>50%) among energy drink users were "running short of money", "gotten into arguments with people", and "felt stressed or overwhelmed". The most frequently reported physiologic symptoms (>50%) among energy drink users were "trouble sleeping", "mind racing", "headaches", and "nausea". Among caffeinated-only beverage users, common behavioral effects were "gotten into arguments with people" and "felt stressed or overwhelmed"; common physiologic effects were "trouble sleeping" and "headaches".

In the univariable logistic analysis (Table 3), behavioral effects more commonly reported by energy drink users than caffeinated-only beverage users were "running short of money" and "getting into trouble at home, school, work". Physiologic effects more commonly reported by energy drink users than caffeinated-only beverage users were "mind racing" and "restlessness or jitteriness". In the multivariable logistic analysis (Table 4), the only behavioral effect more commonly reported by energy drink users than caffeinated-only beverage users after adjusting for age, gender, and other substance use was "getting into trouble at home, school, work". Physiologic effects were not more commonly reported by energy drink users than caffeinated-only beverage users after adjusting for the other covariates. As depicted in Table 4, some behavioral and physiologic adverse effects were associated with age, gender, and substance use.

The median number of physiologic adverse effects reported by study participants was four (IQR: 2–7); the median number of behavioral adverse effects reported was three (IQR: 1–5). In the negative binomial analysis, the number of adverse effects reported by energy drink users was compared to the number reported by caffeinated-only beverage users. In the univariable analyses, energy drink users reported more behavioral (IRR: 1.32 [1.05–1.65]) and physiologic (IRR: 1.24 [1.01–1.54]) adverse effects

Table 1. Demographic characteristics of participants.

	Caffeinated-only beverage users (*n = 66*)	Energy drink users (*n = 90*)	Nonusers (*n = 13*)
Median age, years (IQR)	20 (17–23)	20 (18–23)	16 (14–20)
	n (%)	*n (%)*	*n (%)*
Sex			
Male	30 (45.4%)	60 (66.7%)	6 (46.1%)
Female	36 (54.6%)	30 (33.3%)	7 (53.9%)
Ethnicity/race			
White, non-hispanic	35 (53.0%)	46 (51.1%)	8 (61.5%)
Black, non-hispanic	10 (15.1%)	12 (13.3%)	0 (0.0%)
Hispanic	18 (27.3%)	27 (30.0%)	5 (38.5%)
Other	3 (4.6%)	5 (5.6%)	0 (0.0%)
Partner status			
Married	4 (6.1%)	5 (5.6%)	2 (15.4%)
Divorced/widowed/separated	1 (1.5%)	1 (1.1%)	0 (0.0%)
Never married	47 (71.2%)	67 (74.4%)	11 (84.6%)
Unmarried couple	14 (21.2%)	17 (18.9%)	0 (0.0%)
Insurance status			
Private	27 (40.9%)	30 (33.3%)	8 (61.5%)
Governmental	23 (34.9%)	28 (31.1%)	3 (23.1%)
None	14 (21.2%)	32 (35.6%)	2 (15.4%)
Don't know	2 (3.0%)	0 (0.0%)	0 (0.0%)
Years of formal education			
Fewer than 12 years	30 (45.5%)	40 (44.4%)	9 (69.2%)
12 years or greater	36 (54.5%)	50 (55.6%)	4 (30.8%)
Education/employment status			
Student	27 (40.9%)	21 (23.3%)	10 (76.9%)
Employed	11 (16.7%)	25 (27.8%)	0 (0.0%)
Student & employed	18 (27.3%)	21 (23.3%)	1 (7.7%)
Neither	10 (15.1%)	23 (25.6%)	2 (15.4%)

IQR: Interquartile range.

Table 2. Participant health history and past 30-day medication, supplement, and substance use.

	Caffeinated-only beverage users (*n = 66*) *n (%)*	Energy drink users (*n = 90*) *n (%)*	Nonusers (*n = 13*) *n (%)*
Health history			
Asthma	15 (22.7%)	20 (22.2%)	1 (7.7%)
Attention deficit hyperactivity disorder	4 (6.1%)	19 (21.1%)	1 (7.7%)
Anxiety disorder/Panic attacks	18 (27.3%)	24 (26.7%)	3 (23.1%)
Bipolar disorder	5 (7.6%)	7 (7.8%)	2 (15.4%)
Dysrhythmias	7 (10.6%)	7 (7.8%)	2 (15.4%)
Migraines	16 (24.2%)	14 (15.6%)	2 (15.4%)
Seizures	2 (3.0%)	2 (2.2%)	0 (0.0%)
Medication use			
Buproprion	1 (1.5%)	3 (3.3%)	0 (0.0%)
Dextroamphetamine	0 (0.0%)	3 (3.3%)	0 (0.0%)
Methylphenidate	1 (1.5%)	3 (3.3%)	1 (7.7%)
Modafinil	0 (0.0%)	0 (0.0%)	0 (0.0%)
Supplement use			
Dexatrim®	0 (0.0%)	1 (1.1%)	0 (0.0%)
Hydroxycut®	0 (0.0%)	0 (0.0%)	0 (0.0%)
Stacker®	0 (0.0%)	0 (0.0%)	0 (0.0%)
Stacker II®	0 (0.0%)	1 (1.1%)	0 (0.0%)
Substance use			
Alcohol	20 (30.3%)	43 (47.8%)	4 (30.8%)
Tobacco	17 (25.8%)	49 (54.4%)	2 (15.4%)
Drugs	12 (18.2%)	30 (33.3%)	1 (7.7%)
Marijuana	12 (18.2%)	28 (31.1%)	1 (7.7%)
Cocaine/crack	0 (0.0%)	6 (6.7%)	0 (0.0%)
Crystal methamphetamine	0 (0.0%)	0 (0.0%)	0 (0.0%)
Ecstasy	0 (0.0%)	3 (3.3%)	0 (0.0%)
Inhalants	0 (0.0%)	0 (0.0%)	0 (0.0%)
Prescription stimulants	0 (0.0%)	4 (4.4%)	0 (0.0%)

Table 3. Behavioral and physiologic adverse effects associated with past 30-day energy drink versus caffeinated-only beverage use.

	Percent reported			Univariable logistic regression
	Caffeinated-only beverage users (*n = 66*) *n (%)*	Energy drink users (*n = 90*) *n (%)*	Nonusers *(n = 13) n (%)*	Energy drink users vs. caffeinated-only beverage users (*n = 156*) *OR*
Behavioral adverse effects				*(95% CI)*
Failed to do things expected of you	19 (28.8%)	35 (38.9%)	3 (23.1%)	1.57 (0.80–3.11)
Run short of money	25 (37.9%)	51 (56.7%)	3 (23.1%)	2.14 (1.12–4.10)
Gotten into arguments with people	36 (54.6%)	56 (62.2%)	8 (61.5%)	1.37 (0.72–2.62)
Gotten into physical fights	7 (10.6%)	15 (16.7%)	0 (0.0%)	1.68 (0.65–4.40)
Gotten into trouble at home, school, work	9 (13.6%)	27 (30.0%)	2 (15.4%)	2.71 (1.18–6.26)
Felt sad or depressed	25 (37.9%)	42 (46.7%)	4 (30.8%)	1.44 (0.75–2.74)
Felt stressed or overwhelmed	37 (56.1%)	60 (66.7%)	3 (23.1%)	1.56 (0.81–3.02)
Missed school	10 (15.2%)	19 (21.1%)	1 (7.7%)	1.50 (0.65–3.48)
Missed work	11 (17.2%)	15 (17.4%)	0 (0.0%)	1.20 (0.37–3.82)
Taken careless risks	18 (27.3%)	30 (33.3%)	3 (23.1%)	1.33 (0.66–2.68)
Physiologic adverse effects				
Palpitations	11 (16.7%)	23 (25.6%)	1 (7.7%)	1.72 (0.77–3.83)
Trouble sleeping	41 (62.1%)	64 (71.1%)	8 (61.5%)	1.50 (0.76–2.95)
Mind racing	32 (48.5%)	58 (64.4%)	3 (23.1%)	1.93 (1.01–3.68)
Anxiety/panic attacks	17 (25.8%)	26 (28.9%)	2 (15.4%)	1.17 (0.57–2.40)
Chest pains	20 (30.3%)	29 (32.2%)	0 (0.0%)	1.09 (0.55–2.17)
Headaches	41 (62.1%)	57 (63.3%)	6 (46.2%)	1.05 (0.55–2.03)
Nausea	31 (47.0%)	53 (58.9%)	4 (30.8%)	1.62 (0.85–3.07)
Trouble breathing	16 (24.2%)	35 (38.9%)	0 (0.0%)	1.99 (0.98–4.02)
Hands shaking	23 (34.9%)	39 (43.3%)	2 (15.4%)	1.43 (0.74–2.75)
Restlessness or jitteriness	19 (28.8%)	42 (46.7%)	4 (30.8%)	2.16 (1.10–4.25)

OR: Odds ratio; CI: Confidence interval.

Table 4. Behavioral and physiologic side effects associated with energy drink versus caffeinated-only beverage use, adjusted for demographic characteristics and substance use.

	Multivariable logistic regression					
	Energy drink users vs. caffeinated-only beverage users	Young adults vs. adolescents	Females vs. Males	Tobacco use vs. no tobacco use	Alcohol use vs. no alcohol use	Any drug use vs. no drug use
n = 156	*OR (95% CI)*					
Behavioral adverse effects						
Failed to do things expected of you	1.48 (0.70–3.13)	0.49 (0.20 1.20)	1.14 (0.55–2.37)	0.65 (0.26–1.58)	1.86 (0.82–4.23)	3.24 (1.33–7.86)
Run short of money	1.61 (0.79–3.26)	2.12 (0.87–5.18)	0.87 (0.43–1.76)	1.44 (0.64–3.22)	1.36 (0.64–2.92)	1.93 (0.82–4.56)
Gotten into arguments with people	1.13 (0.56–2.30)	0.62 (0.26–1.44)	1.25 (0.61–2.55)	1.45 (0.64–3.31)	1.28 (0.59–2.81)	3.46 (1.35–8.89)
Gotten into physical fights	1.26 (0.44–3.59)	0.23 (0.07–0.78)	0.59 (0.20–1.71)	2.32 (0.68–7.94)	1.34 (0.42–4.23)	1.78 (0.57–5.62)
Gotten into trouble at home, school, work	3.12 (1.24–7.88)	0.20 (0.07–0.55)	1.20 (0.52–2.77)	0.82 (0.29–2.35)	1.54 (0.58–4.07)	2.18 (0.77–6.17)
Felt sad or depressed	1.35 (0.65–2.81)	0.51 (0.21–1.23)	2.49 (1.20–5.19)	2.02 (0.86–4.73)	0.93 (0.41–2.09)	2.95 (1.23–7.09)
Felt stressed or overwhelmed	1.34 (0.65–2.79)	1.88 (0.81–4.37)	2.13 (1.00–4.54)	1.98 (0.85–4.67)	1.52 (0.67–3.44)	1.33 (0.52–3.39)
Missed school	1.67 (0.67–4.17)	0.33 (0.12–0.90)	1.15 (0.48–2.76)	1.08 (0.37–3.16)	1.09 (0.40–2.97)	1.17 (0.39–3.50)
Missed work	1.42 (0.41–4.93)	5.22 (0.61–44.4)	1.04 (0.31–3.47)	0.41 (0.09–1.82)	0.89 (0.24–3.26)	0.99 (0.21–4.63)
Taken careless risks	0.65 (0.27–1.55)	0.32 (0.10–0.97)	0.61 (0.26–1.46)	2.08 (0.78–5.59)	3.09 (1.20–7.94)	7.52 (2.91–19.4)
Physiologic adverse effects						
Palpitations	1.34 (0.54–3.33)	1.47 (0.42–5.12)	2.54 (1.04–6.17)	5.66 (1.95–16.4)	0.79 (0.31–2.02)	0.82 (0.30–2.24)
Trouble sleeping	1.46 (0.70–3.04)	0.58 (0.24–1.42)	2.02 (0.95–4.30)	2.16 (0.91–5.14)	1.10 (0.49–2.48)	1.11 (0.44–2.79)
Mind racing	1.51 (0.73–3.13)	1.40 (0.59–3.29)	1.45 (0.69–3.06)	1.36 (0.59–3.15)	2.64 (1.18–5.95)	2.57 (0.98–6.70)
Anxiety/panic attacks	0.89 (0.40–2.00)	0.63 (0.23–1.68)	1.81 (0.83–3.96)	2.41 (0.95–6.14)	1.17 (0.49–2.81)	2.23 (0.91–5.47)
Chest pains	0.95 (0.44–2.05)	1.48 (0.54–4.02)	2.67 (1.24–5.73)	2.59 (1.05–6.34)	1.16 (0.51–2.64)	1.01 (0.41–2.50)
Headaches	1.05 (0.51–2.19)	0.78 (0.33–1.84)	3.21 (1.50–6.89)	2.03 (0.86–4.74)	1.80 (0.80–4.05)	0.95 (0.39–2.34)
Nausea	1.61 (0.80–3.28)	0.64 (0.27–1.49)	2.46 (1.19–5.07)	1.79 (0.75–3.85)	1.20 (0.55–2.61)	1.91 (0.80–4.58)
Trouble breathing	1.81 (0.84–3.90)	0.66 (0.26–1.68)	1.89 (0.89–4.02)	3.15 (1.29–7.70)	0.99 (0.44–2.26)	0.88 (0.36–2.17)
Hands shaking	1.43 (0.69–2.97)	0.86 (0.36–2.08)	2.90 (1.39–6.02)	1.62 (0.70–3.78)	1.71 (0.77–3.77)	1.21 (0.51–2.88)
Restlessness or jitteriness	1.99 (0.93–4.27)	0.38 (0.15–0.96)	2.60 (1.19–5.64)	1.45 (0.60–3.50)	3.53 (1.52–8.18)	2.16 (0.88–5.29)

OR: Odds ratio; CI: Confidence interval.

than caffeinated-only beverage users. However, in the multivariable models, there were no differences in the number of effects between these two groups after adjusting for age, gender, and tobacco, alcohol, and drug use. In these multivariable models, more behavioral effects were reported among drug users (IRR: 1.50 [1.18–1.93]), and more physiologic effects were reported among tobacco users (IRR: 1.42 [1.13–1.80]) and females (IRR: 1.48 [1.21–1.80]).

Discussion

These results support existing data detailing the ubiquity of energy drink use among young adults and adolescents.[3,7] Previous research has demonstrated the potential for adverse reactions associated with energy drink use, such as case reports of cardiac dysrhythmias, cardiac arrest, new-onset seizures, psychosis, and even death.[2,7,23,24] In addition, the potential connection between energy drink use and other high-risk behaviors such as sexual risk taking, fighting, smoking, alcohol co-ingestion, marijuana use, and other illicit drug use is of particular concern.[22]

Unlike previous studies and case reports which have solely reported adverse effects secondary to caffeine use or secondary to energy drink use, this pilot study is the first to indicate that among adolescent and young adult emergency department patients, energy drink users reported a greater number and frequency of adverse effects when compared to caffeinated-only beverage users. Whether this difference is due to the high amount of caffeine in energy drinks, the presence of other stimulatory ingredients, or possible synergistic effects between energy drink ingredients is unknown. However, as noted when adjusting for age, gender, and other substance use, the association of energy drink use and these adverse effects is less compelling. Nevertheless, these results indicate the need for emergency department clinicians to question their patients about energy drink and other substance usage, particularly when the symptoms described or reasons for presentation could be related to caffeine or other stimulants.

This study has several limitations. We did not assess the dose-response between caffeine and associated adverse events in our population. As a result, a heavy coffee drinker in our sample may consume more caffeine than an occasional energy drink user. We could not undertake quantitation of caffeine use for the following reasons. First, there are no standards that accurately identify the caffeine content of energy drinks, and no standard method of quantifying consumption across brands. As a result of differences in caffeine content across brands, we could not accurately quantify the amount of caffeine consumed. We subsequently used the

number of drinks consumed as a proxy measure in keeping with other studies of energy drink use.[21,25,26] Second, energy drinks often contain co-formulated stimulants that may potentiate caffeine's adverse effects, which also cannot be readily quantified, and vary by product. Third, we did not differentiate sugar-containing or diet energy drinks; concomitant effects of sugar and caffeine have been previously shown to increase heart rate and improve performance on memory and attention testing.[27]

The relatively small sample size limited the ability to detect smaller differences in behavioral and physiologic adverse effects, which is a common limitation of pilot studies. Additionally, participants' reasons for presenting to the emergency department were not recorded, making it possible that the adverse effects reported were related to patients' chief complaints and not to patients' energy drink or caffeinated-only beverage use. Because the study was conducted during the summer, it is possible that the consumption patterns of patients, particularly students, might not reflect their consumption of energy drinks during the academic year, and subsequent adverse effects during that period. Since knowledge about potential adverse effects of energy drinks is evolving, it is possible that the effects targeted in this study were incomplete and might not reflect other adverse effects associated with these products. As the content of energy drinks varies by product, can be changed by manufacturers without notice to consumers, and usage patterns vary by consumer, the precise adverse effect profiles are in aggregate, and cannot reflect specifically on any particular product. Participants may have been unable to accurately recall their precise energy drink usage or the occurrence of adverse effects. It is also possible that energy drink users were more likely to report adverse effects due to background knowledge about these products; however, this effect was minimized by not informing participants about the intent of the questions regarding adverse effects or implying a possible connection to energy drinks. Further, given the high frequency of caffeine use (coffee, tea, and/or soft drinks) among energy drink users, it can be difficult to know if adverse effects were related to energy drink usage alone, caffeine usage alone, or a combination of these substances. Cross-sectional studies such as these only can measure association within the same time period, and therefore cannot assume a temporal order or causation. Also, we recognize that the list of behavioral and physiological adverse effects measured in this study is not exhaustive and is putative, but is reasonable given the current state of knowledge on this topic and previous case studies and reports of adverse effects associated with energy drink, caffeine, and other stimulant use. Finally, these results might not be reflective of other populations and settings outside of these two emergency departments and might not be generalizable to other emergency departments with patients of different demographic distributions.

Further research is needed to explore the potential causal relationship between energy drink use and adverse physiologic and behavioral effects, and to explore whether these effects are related to caffeine or to the co-ingestion of caffeine and other stimulants found in energy drinks. Additionally, further research is needed to determine if there is a dose-dependent relationship between energy drink consumption and adverse effects. Future studies should address the limitations of this pilot study in order to better assess the prevalence of adverse effects reported by energy drink users compared to caffeinated-only beverage users. The reclassification of Monster and Rockstar beverages provides an opportunity for quantitation of caffeine intake by energy drink users, and comparison with caffeinated-only beverages.[13] Additionally, the ability to obtain quantitative caffeine-related dose-response relationships will be helpful in understanding the contribution of additives to energy-drink related adverse events. To address the limitations of this study and answer important questions about the relationship between energy drink consumption and health and psychological well-being among adolescents and young adults, we intend to conduct a longitudinal study on this topic. In a larger, prospective, longer-term study, we can address issues of adequate sample size, causation, seasonality and other limitations.

Conclusions

The results of this study indicate some differences in the amount and frequency of behavioral and physiologic adverse effects reported by emergency department energy drink users as compared to caffeinated-only beverage users, as well as by age, gender, and substance use. It is important for emergency department clinicians to be aware that some common complaints that necessitate emergency department presentation might be related to energy drink use or other substance use. Additionally, emergency department clinicians should be ready to educate patients about the potential complications of excessive energy drink consumption.

Declaration of interest

The authors report no declarations of interest. The authors alone are responsible for the content and writing of the paper.

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References

1. Higgins JP, Tuttle TD, Higgins CL. Energy beverages: content and safety. Mayo Clin Proc 2010; 85:1033–1041.
2. Nordt S, Vilke G, Clark R, Lee Cantrell F, Chan T, Galinato M, et al. Energy drink use and adverse effects among emergency department patients. J Commun Health 2012; 37:1–6.
3. Heckman MA, Sherry K, De Mejia EG. Energy drinks: an assessment of their market size, consumer demographics, ingredient profile, functionality, and regulations in the United States. Compr Rev Food Sci Food Saf 2010; 9:303–317.

4. Rath M. Energy drinks: what is all the hype? The dangers of energy drink consumption. J Am Acad Nurse Pract 2012; 24:70–76.
5. Substance Abuse and Mental Health Services Administration (SAMHSA). The Drug Abuse Warning Network (DAWN) report: Emergency department visits involving energy drinks [database on the Internet] 2011 [cited 12 July 2012]. Available from: http://www.samhsa.gov/data/2k11/WEB_DAWN_089/WEB_DAWN_089_HTML.pdf.
6. US Food and Drug Administration (FDA). 2007. Caffeine and Your Body. Washington, DC: US Food and Drug Administration.
7. Seifert SM, Schaechter JL, Hershorin ER, Lipshultz SE. Health effects of energy drinks on children, adolescents, and young adults. Pediatrics 2011; 127:511–528.
8. Marin Institute. Alcohol, energy drinks, and youth: A dangerous mix [database on the Internet]. 2007 [cited 2 September 2012]. Available from: http://www.health.state.ga.us/pdfs/prevention/summit/energy_drink_report-marin_institute.pdf.
9. US Food and Drug Administration (FDA). 2012. Energy "Drinks" and Supplements: Investigations of Adverse Event Reports. Washington, DC: US Food and Drug Administration (FDA).
10. US Food and Drug Administration (FDA). 2012. Code of Federal Regulations Title 21, Volume 3, Part 182: Substances Generally Recognized as Safe. Subpart B. Multiple Purpose GRAS Food Substances. Washington, DC: US Food and Drug Administration.
11. US Food and Drug Administration (FDA). 2009. Why Isn't the Amount of Caffeine a Product Contains Required on a Food Label? Washington, DC: US Food and Drug Administration.
12. US Food and Drug Administration (FDA). 2009. Draft Guidance for Industry: Factors that Distinguish Liquid Dietary Supplements from Beverages, Considerations Regarding Novel Ingredients, and Labeling for Beverages and Other Conventional Foods. Washington, DC: US Food and Drug Administration (FDA).
13. Meier B. 2013. In a new aisle, energy drinks sidestep some rules. New York Times.
14. US Department of Agriculture and US Department of Health and Human Services. Dietary guidelines for Americans, 2010. 7th ed. Washington, DC: US Government Printing Office.
15. Clauson KA, Shields KM, McQueen CE, Persad N. Safety issues associated with commercially available energy drinks. J Am Pharm Assoc 2008; 48:e55–e63; quiz e4–e7.
16. American Academy of Pediatrics Committee on Nutrition and the Council on Sports Medicine and Fitness. Sports drinks and energy drinks for children and adolescents: are they appropriate? Pediatrics 2011; 127:1182–1189.
17. Substance Abuse and Mental Health Services Administration (SAMHSA). The Drug Abuse Warning Network (DAWN) report: Update on emergency department visits involving energy drinks: a continuing public health concern [database on the Internet]. 2013 [cited 13 March 2013]. Available from: http://www.samhsa.gov/data/2k13/DAWN126/sr126-energy-drinks-use.pdf.
18. Cotter BV, Jackson DAE, Merchant RC, Babu KM, Baird JR, Nirenberg T, et al. Energy drink and other substance usage among adolescent and young adult emergency department patients. Pediatric Emergency Care (in press).
19. Reissig CJ, Strain EC, Griffiths RR. Caffeinated energy drinks–a growing problem. Drug Alcohol Depend 2009; 99:1–10.
20. Babu KM, Church RJ, Lewander W. Energy drinks: the new eye-opener for adolescents. Clin Pediatr Emerg Med 2008; 9:35–42.
21. Miller KE. Energy drinks, race, and problem behaviors among college students. J Adolesc Health 2008; 43:490–497.
22. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008; 61: 344–349.
23. Babu KM, Zuckerman MD, Cherkes JK, Hack JB. First-onset seizure after use of an energy drink [corrected]. Pediatr Emerg Care 2011; 27:539–540.
24. Wolk BJ, Ganetsky M, Babu KM. Toxicity of energy drinks. Curr Opin Pediatr 2012; 24:243–251.
25. Malinauskas BM, Aeby VG, Overton RF, Carpenter-Aeby T, Barber-Heidal K. A survey of energy drink consumption patterns among college students. Nutr J 2007; 6:35.
26. Miller KE. Wired: energy drinks, jock identity, masculine norms, and risk taking. J Am Coll Health 2008; 56:481–489.
27. Scholey AB, Kennedy DO. Cognitive and physiological effects of an "energy drink": an evaluation of the whole drink and of glucose, caffeine and herbal flavouring fractions. Psychopharmacology (Berl) 2004; 176:320–330.

Supplementary material available online

Appendix: Questionnaire to be found online at http://informahealthcare.com/doi/abs/10.3109/15563650.2013.820311.