ORIGINAL ARTICLE

Combined alcohol and energy drinks: consumption patterns and risk behaviours among European students

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Abstract

Background With the growing popularity of energy drinks, a new consumption trend has emerged represented by the mixing of alcohol and energy drinks (AmED). The current study sought to examine AmED use among 16-year-old students in Europe, as well as the associations with social and behavioural characteristics. By examining all these potential relationships from a cross-country perspective, we aim to estimate potential cross-national differences.

Method Sixteen-year-old students were drawn from the 2019 European School Survey Project on Alcohol and Other Drugs cross-sectional survey. Self-reported AmED use in the past 12 months was the dependent variable. Key predictors comprised substance use, other individual risk behaviours and family characteristics (parental regulation, monitoring and caring).

Results Of the 16-year-old students surveyed in Europe, 33.9% reported AmED use in the past year. The global prevalence observed among male students (37.3%) was higher than among female students (30.6%). Prevalence ranged from 14.9% in Latvia to 53.7% in Slovenia. The multivariate analysis reported significantly higher odds of being AmED users in many of the considered risk behaviours, including daily tobacco smoking, illicit drugs use (cannabis, inhalants, cocaine/crack, NPS), heavy episodic drinking, going around with friends, going out in the evening, truancy at school, engaging in physical fights, damaged or lost objects or clothing, being involved in serious arguments, having trouble with police, practicing sexual intercourse without a condom and deliberately hurting themselves.

Conclusions Consistent with previous studies, European students engaged in risk-taking behaviour showed higher odds of being AmED consumers. Youth AmED prevalence across Europe does not seem to follow a well-defined spatial distribution, suggesting that cultural patterns may only partially explain prevalence differences.

Keywords Prevalence · Alcohol mixed with energy drinks · ESPAD school survey · Risk-taking behaviours · Substance use · European countries

Introduction

Energy drinks (EDs) are a group of caffeinated beverages used to enhancing endurance and attention, promote wakefulness and improve athletic performance. The main active ingredients of EDs include varying amounts of caffeine, glucose, B vitamins, herbs and stimulants such as ephedrine, taurine, ginseng, guarana, green tea, creatine, carnitine and yerba mate (Higgins et al. 2010). The prevalence of ED consumption among Italian high school students has grown substantially over the past 12 years (Scalese et al. 2021). With the growing popularity of these beverages between teenagers (Scalese et al. 2021; Vercammen et al. 2019) a new consumption trend has emerged represented by the mix of alcohol and energy drinks (AmED) (Marczinski 2011). AmED includes cocktails, such as vodka Red Bull, served at bars or self-mixed, premixed caffeinated alcoholic beverages, and alcohol and energy drinks consumed separately but on the same occasion (Howland and Rohsenow 2013). To date, the market has pushed towards the normalization of this type of consumption and AmEDs have taken hold in well-known forms, such as 'Red Bull vodka' and 'Jägerbomb', that are increasingly consumed (O'Brien et al. 2008). Some health organizations and researchers have expressed preoccupation regarding the potential health risks associated with mixing alcohol and

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energy drinks. The existing literature identifies several potential health risks: AmED would increase total alcohol consumption when compared to consuming alcohol exclusively (Verster et al. 2012); AmED would mask intoxication effects caused by alcohol since the stimulant effects of ED altered the perception of drunkenness and can favour longer drinking sessions (Peacock et al. 2013a); AmED would also result in increased risk-taking behaviours and experiencing negative alcohol-related consequences (e.g. drunk driving or unprotected sex) (Scalese et al. 2017, 2023). Furthermore, there are raising concerns around AmED use, including adverse health effects due to excessive caffeine and alcohol consumption, and other risk behaviours [Scalese et al. 2017; Scalese et al. 2023; Snipes and Benotsch 2013; Quigley et al. 2019; Marczinski et al. 2018; Marczinski et al. 2017; Marczinski et al. 2016; Housman et al. 2016; Peacock et al. 2012; Benson et al. 2020; Peacock et al. 2013b). The current study pursued to examine AmED use among 16-year-old students in Europe, as well as the associations with social and behavioural characteristics. We aim to estimate possible cross-national differences examining all these potential relationships, from a cross-country perspective. Data about frequency of AmED sessions were extracted from the largest cross-national research project on adolescent substance use in the world, the European School Survey Project on Alcohol and Other Drugs (ESPAD).

Materials and methods

Design

Data were drawn from the ESPAD cross-sectional survey that, since 1995, collects comparable data among 16-year-old students to monitor behavioural trends between and within countries. The sample ($n = 96,783$) consisted of 35 countries that participated in the 2019 data collection. The study methodology used national samples of randomly selected schools/classes in which the cohort of students born in 2003 completed the standardized ESPAD questionnaire. The questionnaire covers demographics, family environment, use of substances and engagement in a number of behaviours, such as internet use, gaming and gambling. Sampling and data collection methodology have been reported elsewhere (ESPAD Group 2020). Proportion of selected classes participating in the survey ranged from 21 to 100%, with an average of 85%. The percentage of students who responded in participating classes ranged from 86 to 100%, with an average of 96%. Individual country data and sampling design within each country are reported in Supporting information, Table S1.

Selected sample

Optionally, in 17 countries, students were also asked on how many occasions in the past 12 months they had used alcohol mixed with energy drinks, with the following response categories: '0', '1–2', '3–5', '6–9', '10–19', '20–39', '40 or more'. Thus, all the analyses were run only for the sub-sample of participants who responded to the relevant questions on AmED consumption ($n = 47,678$) (Table 1).
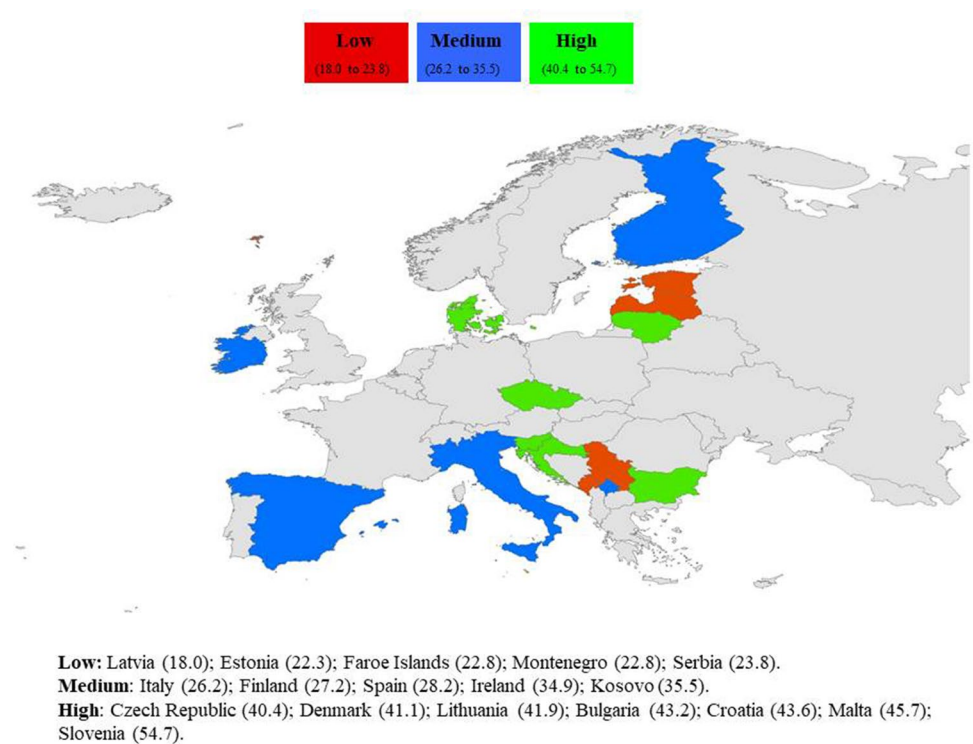
Measures

The dependent variable was the use of alcohol mixed with energy drinks in the past 12 months, coded dichotomously as no use (0 occasions) or use (1 or more occasions). The independent variables were social and behavioural characteristics described below. Family habitat characteristics were evaluated by measures connected to the parental monitoring of evening and Saturday night activities, the feeling of being emotionally supported by parents and friends, parental rule-setting at home and outside, easiness to obtain money from parents, parents' educational level and family structure/income. Individual behavioural characteristics were assessed by measures related to self-reported truancy at school, aggressive and antisocial behaviour, sexual practices, driving behaviour and engagement in leisure time activities (going around with friends just for fun; going out in the evening; participating actively in sports; reading books for enjoyment; hobbies such as playing an instrument, singing, drawing, writing). Substance use was measured by investigating daily cigarette smoking in the past month, heavy episodic drinking (HED) in the past month and past year; past year use of cannabis, inhalants, amphetamines, methamphetamines, cocaine, crack, ecstasy, heroin and NPS (new substances that imitate the effects of illicit drugs). The variables were coded dichotomously or in classes, a detailed list of the considered variables is presented in Supporting information, Table S2.

Prevalence of AmED groups

Apart from the Code of Practice relating to the marketing and labelling of energy drinks developed by Energy Drinks Europe (EDE), no specific regulations are currently in force at the European level to regulate energy drinks, resulting in a lack of cross-country variability. Thus, we used lifetime prevalence of AmED consumption to split countries into three homogenous groups with low, medium and high consumption prevalence (Fig. 1).

Table 1 Percentage of AmED use occasions stratified by country, ESPAD 2019

	Occasions of AmED use in the past 12 months						
	0	1–2	3–5	6–9	10–19	20–39	40 or more
Bulgaria	58.8	15.7	7.4	6.5	5.4	2.6	3.6
Croatia	60.1	15.7	9.1	6.0	4.5	2.2	2.3
Czechia	63.7	19.2	7.9	4.1	2.8	1.2	1.1
Denmark	59.3	17.7	9.8	5.4	4.0	2.5	1.2
Estonia	76.3	13.8	4.7	2.6	1.7	0.6	0.3
Faroes	70.5	16.0	5.8	4.0	1.5	1.2	0.9
Finland	67.0	21.0	5.4	3.1	1.8	0.9	0.7
Ireland	62.2	19.6	7.3	4.0	3.3	1.7	1.9
Italy	73.3	11.5	5.8	3.0	2.9	1.8	1.7
Latvia	85.1	10.3	2.3	1.1	.9	0.2	0.1
Lithuania	62.9	13.8	6.9	6.2	5.1	2.6	2.6
Malta	52.6	18.9	11.2	6.4	5.5	3.5	1.9
Montenegro	76.3	8.5	4.5	3.0	3.1	1.7	2.9
Serbia	76.4	10.4	4.5	3.0	2.5	1.2	2.0
Slovenia	46.3	23.9	11.4	7.2	5.8	3.2	2.3
Spain	70.2	16.3	5.9	4.1	1.8	1.0	0.7
Kosovo	50.0	17.5	7.7	4.8	9.0	3.7	7.4
Total	**66.1**	**15.7**	**6.9**	**4.3**	**3.4**	**1.8**	**1.8**

Fig. 1 Lifetime consumption prevalence of AmED stratified by country groups

Low: Latvia (18.0); Estonia (22.3); Faroe Islands (22.8); Montenegro (22.8); Serbia (23.8).
Medium: Italy (26.2); Finland (27.2); Spain (28.2); Ireland (34.9); Kosovo (35.5).
High: Czech Republic (40.4); Denmark (41.1); Lithuania (41.9); Bulgaria (43.2); Croatia (43.6); Malta (45.7); Slovenia (54.7).

Statistical analysis

AmED prevalence was summarized within country by using percentages. Univariate analysis was performed using multi-level mixed-effects logistic regression to assess relationships between the outcome and each of the adolescents' characteristics across countries. Multivariate multi-level mixed-effects logistic regression was performed including all variables to determine the independent association of the potential predictors' characteristics. The backward step-wise selection method was used to keep only the significant variables in the final model. In the country groups analysis,

each model was fitted separately within the group. All the models were performed modelling different countries and different schools as random effects. The relation between predictor and outcome (slope) was assumed to be the same throughout schools. The multi-level model allows many levels of nested clusters of random effects. For example, in a three-level model, it is possible to specify random effects for country and then random effects for school nested within country. In this model, the observations (students) comprise the first level, the country comprises the second level, and the schools comprise the third one. The multi-level model avoids bias due to correlation between students within the same school of the same country. The collected data have a hierarchical structure where students' characteristics (level 1) are nested in the school (level 2) that are nested in the country (level 3), with the likelihood that students' activity is correlated with belonging to the country they live in and the school they attend. Results are reported as odds ratio (OR) with a 95% confidence interval. All the statistical tests were two-sided, and a *p* value ≤ 0.05 was considered to be statistically significant. Blank spaces in Tables 2 and 3 relate to no significant variables in the final model. All statistical analyses were carried out with Stata version 13 (Stata Corporation, College Station, TX, USA).

Results

Of the 49,143 students from 17 countries that included the AmED questions in the 2019 ESPAD questionnaire, 48.9% were male students and 33.9% reported AmED use in the past year. The global prevalence observed among male students (37.3%) was higher than among female students (30.6%). Prevalence ranged from 14.9% of Latvia to 53.7% of Slovenia (Table 1).

Among consumers, most of the students reported having consumed AmED only on 1–2 occasions during the past year (46%), 20% in 3–5 occasions, 13% in 6–9 occasions, 10% in 10–19 occasions, 5% in 20–39 occasions and 5% in 40 or more occasions.

Univariate analyses showed that AmED consumers go more often around with friends just for fun and out in the evening to disco, cafe, party, etc. (respectively 70.4% and 53.6% versus 56.4% and 32.0% of non-AmED), while non-AmED users reported less frequently that they had skipped school (5.0% missed 3 or more days of school versus 11.9% AmED) and played on slot machines (2.5 vs 6.5%), and more frequently a higher parental monitoring, both in the evening and on Saturday night. AmED users reported higher family economic status and they more often belong to families other than traditional. Students reporting AmED consumption also showed a higher prevalence of tobacco and psychoactive substance use: 22.1% smoked tobacco daily in

the past 30 days (vs 6.1%), 59.4% were intoxicated from drinking alcoholic beverages in the past year (vs 19.7%) and 63.5% reported episodes of binge drinking (vs 24.0%); 30.1% smoked cannabis in the past year (vs 7.9%) and 22.1% reported having tried other illegal substances in the past year (vs 6.1%). Moreover, a lower proportion of students who consumed AmED in the past year reported reading books for enjoyment (13.5 versus 21.8% non-AmED) and having other hobbies (40.5 versus 49.5% non-AmED). Finally, a higher percentage of AmED consumers engaged in physical fights, accident or injury, serious arguments, trouble with police, sexual intercourse without a condom, accident while driving themselves, reported damaged or lost objects or clothing, were hospitalized or admitted to an emergency room, deliberately hurt themselves, were a victim of robbery or unwanted sexual advances (Table 2).

Results from the univariate analysis showed that the use of AmED was significantly associated with almost all the explored characteristics; however, some results were significant due to the very high sample size. For example, prevalence of Internet use for leisure activities were very similar in the two groups (97.2% in AmED and 96.4% in non-AmED); therefore, the odds ratio, even if significant, was not relevant in our discussion. Among those variables that showed a significant association only in the univariate analysis, we principally found family environment characteristics and students risk behaviours. In particular, we found association only in the first step analysis for: family structure other than traditional, low perception of emotional support, lack of parental monitoring of evening activities (where/with whom did they go), spending money on slot machines, experiencing accidents or injuries, being victimized by robbery or theft, being hospitalized or admitted to an emergency room, being a victim of unwanted sexual advances and being involved in an accident while driving themselves (Table 2).

The multivariate analysis reported significantly higher odds of being AmED users in many of the considered risk behaviours, including tobacco daily smoking, illicit drugs use (cannabis, inhalants, cocaine/crack, NPS), heavy episodic drinking, going around with friends, going out in the evening, truancy at school, engaging in physical fights, damaged or lost objects or clothing, being involved in serious arguments, having trouble with police, practicing sexual intercourse without a condom and deliberately hurting themselves. On the contrary, lower odds were found for reading books for enjoyment, having other hobbies, parents schooling college or university, low or medium family economic status and parental monitoring of Saturday night activities (Table 2).

Table 3 shows the results of the multivariate analyses for the respective country groups. Interestingly, parents schooling college or university, being involved in serious arguments and being involved in an accident while driving

Table 2 Distribution of socioeconomic factors and main behaviours adopted by students that use AmED; OR conducted separately on each variable (univariate) and multivariate analysis (aOR). ESPAD, 2019

	AmED past year		Univariate		Multivariate	
	No (%)	Yes (%)	OR (95% CI)	p	aOR (95% CI)	p
Gender (female)	52.9	45.6	0.75 (0.72–0.78)	<0.001	0.76 (0.71–0.82)	<0.001
Leisure time activities (at least one a week)						
Play computer games	43.6	46.7	1.09 (1.05–1.14)	<0.001		
Actively participate in sports, athletics or exercising	79.9	79.3	1.00 (0.95–1.06)	0.861		
Read books for enjoyment (do not count schoolbooks)	21.8	13.5	0.55 (0.52–0.59)	<0.001	0.81 (0.74–0.89)	<0.001
Go out in the evening (to a disco, cafe, party, etc.)	32.0	53.6	2.96 (2.83–3.11)	<0.001	1.41 (1.31–1.52)	<0.001
Other hobbies (play an instrument, sing, draw, write)	49.5	40.5	0.69 (0.66–0.72)	<0.001	0.82 (0.77–0.88)	<0.001
Go around with friends to shopping centres, streets, parks, etc., just for fun	56.4	70.4	2.22 (2.11–2.33)	<0.001	1.23 (1.14–1.32)	<0.001
Use the Internet for leisure activities (chats, music, games, social networks, videos, etc.)	96.4	97.2	1.34 (1.18–1.53)	<0.001		
Play on slot machines (the kind in which you may win money)	2.5	6.5	3.59 (3.22–4.00)	<0.001		
Parents rules (seldom, almost never)						
Parents define rules at home	34.2	34.2	0.98 (0.94–1.03)	0.479		
Parents define rules outside	34.6	37.4	1.09 (1.04–1.14)	<0.001		
Parental monitoring of evening activities (with who)	7.0	11.8	1.81 (1.68–1.94)	<0.001		
Parental monitoring of evening activities (where)	6.3	11.5	2.08 (1.93–2.24)	<0.001		
Scholars can easily borrow money from parents	14.4	16.2	1.06 (0.99–1.12)	0.063		
Scholars can easily get money as a gift from parents	18.6	19.6	0.97 (0.92–1.02)	0.282		
Risk behaviour						
Physical fight	17.9	34.5	2.77 (2.62–2.93)	<0.001	1.34 (1.24–1.46)	<0.001
Accident or injury	35.3	44.9	1.60 (1.52–1.68)	<0.001		
Damaged or lost objects or clothing	39.4	50.4	1.73 (1.65–1.82)	<0.001	1.10 (1.03–1.18)	0.008
Serious arguments	36.4	47.6	1.90 (1.81–2.00)	<0.001	1.14 (1.06–1.23)	<0.001
Victimized by robbery or theft	4.6	9.1	2.18 (1.99–2.40)	<0.001		
Trouble with police	6.2	17.7	3.68 (3.41–3.98)	<0.001	1.21 (1.08–1.36)	0.001
Hospitalised or admitted to an emergency room because of severe intoxication	1.8	4.6	2.91 (2.54–3.34)	<0.001		
Hospitalised or admitted to an emergency room because of accident or injury	12.2	17.3	1.57 (1.47–1.68)	<0.001		
Engaged in sexual intercourse without a condom	6.0	20.0	4.07 (3.78–4.38)	<0.001	1.56 (1.40–1.73)	<0.001
Being a victim of unwanted sexual advance	4.0	9.6	2.78 (2.52–3.05)	<0.001		
Deliberately hurt yourself	9.7	17.1	2.15 (2.01–2.30)	<0.001	1.20 (1.08–1.33)	0.001
Being involved in an accident while driving yourself	2.1	5.3	3.11 (2.74–3.53)	<0.001		
3 or more days of school lessons skipped or 'cut'	5.0	11.9	3.07 (2.83–3.33)	<0.001	1.16 (1.05–1.29)	0.004
Parents sometimes/usually don't know about Saturday night activities	7.5	17.5	2.99 (2.81–3.20)	<0.001	1.26 (1.10–1.44)	0.001
Father schooling not college or university	53.1	58.0	1.14 (1.09–1.21)	<0.001	1.09 (1.01–1.17)	0.028
Mother schooling not college or university	46.3	50.9	1.21 (1.15–1.26)	<0.001	1.16 (1.08–1.26)	<0.001
Economic status: high	39.8	43.5	Reference		Reference	
Medium	51.0	47.0	0.82 (0.78–0.85)	<0.001	0.93 (0.86–0.99)	0.032
Low	9.3	9.5	0.92 (0.85–1.01)	0.055	0.93 (0.82–1.06)	0.287
Family structure: Tradition family	74.5	69.3	Reference			
Single parents	15.0	16.6	1.24 (1.17–1.31)	<0.001		
Stepfamily	6.4	8.4	1.52 (1.41–1.65)	<0.001		
Other	4.0	5.7	1.51 (1.37–1.66)	<0.001		
Substance use						
Tobacco every day in the past month	6.1	22.1	5.03 (4.71–5.38)	<0.001	1.38 (1.25–1.54)	<0.001

Table 2 (continued)

	AmED past year		Univariate		Multivariate	
	No (%)	Yes (%)	OR (95% CI)	p	aOR (95% CI)	p
Intoxicated from drinking alcoholic beverages in the past year	19.7	59.4	5.68 (5.42–5.95)	< 0.001	2.66 (2.47–2.87)	< 0.001
Binge drinking (HED) in the past month	24.0	63.5	6.79 (6.46–7.14)	< 0.001	2.27 (2.11–2.44)	< 0.001
Cannabis use in the past year	7.9	30.1	5.87 (5.52–6.24)	< 0.001	1.63 (1.48–1.79)	< 0.001
Inhalants use in the past year	2.3	6.7	3.43 (3.09–3.80)	< 0.001	1.33 (1.12–1.59)	0.001
Ecstasy use in the past year	0.8	4.7	8.19 (7.01–9.58)	< 0.001		
Amphetamine use in the past year	0.5	3.2	7.88 (6.53–9.52)	< 0.001		
Methamphetamine use in the past year	0.3	2.5	8.03 (6.46–9.98)	< 0.001		
Cocaine/crack use in the past year	0.7	4.7	8.69 (7.37–10.25)	< 0.001	1.50 (1.14–1.97)	0.004
Heroin use in the past year	0.3	1.8	8.06 (6.25–10.39)	< 0.001		
NPS use in the past year	4.2	15.4	6.84 (6.00–7.80)	< 0.001	1.43 (1.17–1.75)	0.001
Illegal substances use (no cannabis) in the past year	6.1	22.1	5.09 (4.71–5.51)	< 0.001		
Scholar's feeling of emotional support (Likert scale from 1 (very strongly disagree) to 7 (very strongly agree))	mean	mean				
My family really tries to help me	6.1	5.8	0.93 (0.92–0.94)	< 0.001		
I get the emotional help and support I need from my family	5.7	5.3	0.93 (0.92–0.94)	< 0.001		
I can talk about my problems with my family	5.4	5.0	0.92 (0.91–0.93)	< 0.001		
My family is willing to help me make decisions	5.9	5.6	0.93 (0.92–0.94)	< 0.001		
My friends really try to help me	5.4	5.3	0.99 (0.98–1.01)	0.244		
I can count on my friends when things go wrong	5.3	5.3	1.02 (1.01–1.03)	0.004		
I have friends with whom I can share my joys and sorrows	5.6	5.7	1.01 (1.00–1.02)	0.026		
I can talk about my problems with my friends	5.4	5.5	1.03 (1.02–1.04)	< 0.001		

themselves were statistically significant only for the high prevalence group of countries. The lack of parental monitoring of Saturday night activities, deliberately hurting themselves and having trouble with police were associated with AmED use only in the medium prevalence group. Only in the low prevalence group, playing computer games, playing on slot machines, reading books for enjoyment and tobacco use every day did not seemed to affect AmED use. On the other hand, only in this group being a victim of unwanted sexual advances was positively associated with AmED use. Going out in the evening, around with friends just for fun, having other hobbies, engaging in sexual intercourse without a condom, in binge drinking, in intoxication from drinking alcoholic beverages and cannabis use in the past year, remained significant for all the prevalence groups.

Discussion

Our results reported that a third of adolescents in Europe (33.9%) consumed alcohol mixed with energy drinks during the past year. This prevalence is similar to that found in the USA (Schulenberg et al. 2020). Students engaging in risk-taking behaviours showed higher odds of being AmED consumers (daily tobacco smoking, illicit drug use, heavy episodic drinking, truancy at school, engaging in physical fights, etc.). On the contrary, lower odds were found for reading books for enjoyment, having other hobbies, higher parental educational level, low or medium family economic status and parental monitoring of Saturday night activities.

Similar to other studies examining the relationship between drugs, nonmedical prescription stimulant use and AmED use (Snipes and Benotsch 2013; Woolsey et al. 2015; Housman and Williams 2018), we found significant relationships between illegal substances use and AmED. The multivariate logistic regression analysis indicated that students who used inhalants, cocaine/crack, NPS and cannabis were more likely to use AmED. Energy drink use and subsequent drugs use during adolescence seem to be related, despite that the causal mechanisms remain unknown (Arria et al. 2017). This represents a particularly fragile population of high-risk adolescents who should be noted by health professionals and substance use and misuse prevention specialists.

In line with previous studies providing laboratory evidence (double-blind, within-subjects, placebo-controlled study design) that AmED beverages lead to a greater desire to drink alcohol versus the same amount of alcohol consumed alone (Marczinski et al. 2016), our results show that students engaged in heavy episodic drinking (binge drinking and intoxication) were more than twice as likely to use AmED.

Table 3 Distribution of main behaviours adopted by students that use AmED, stratified by country groups, adjusted odds ratios (aOR), multivariate analysis. ESPAD, 2019

	Low AmED prevalence		Medium AmED prevalence		High AmED prevalence	
	aOR (95% CI)	p	aOR (95% CI)	p	aOR (95% CI)	p
Gender			0.70 (0.63–0.78)	<0.001	0.79 (0.72–0.87)	<0.001
Leisure time activities (at least one a week)						
Play computer games						
Read books for enjoyment (do not count schoolbooks)			0.84 (0.73–0.96)	0.013	0.75 (0.66–0.85)	<0.001
Go out in the evening (to a disco, cafe, party, etc.)	1.52 (1.30–1.77)	<0.001	1.18 (1.05–1.33)	0.005	1.47 (1.33–1.63)	<0.001
Other hobbies (play an instrument, sing, draw, write)	0.79 (0.68–0.92)	0.002	0.88 (0.79–0.98)	0.016	0.81 (0.74–0.89)	<0.001
Go around with friends to shopping centres, streets, parks, etc., just for fun	1.25 (1.06–1.47)	0.008	1.44 (1.27–1.63)	<0.001	1.15 (1.04–1.27)	0.009
Play on slot machines (the kind in which you may win money)			1.38 (1.01–1.90)	0.049		
Risk behaviour						
Physical fight			1.33 (1.18–1.51)	<0.001	1.62 (1.44–1.82)	<0.001
Serious arguments					1.23 (1.11–1.36)	<0.001
Trouble with police			1.40 (1.17–1.68)	<0.001		
Engaged in sexual intercourse without a condom	1.73 (1.39–2.15)	<0.001	1.49 (1.28–1.74)	<0.001	1.57 (1.35–1.82)	<0.001
Being a victim of unwanted sexual advance	1.32 (1.01–1.72)	0.046				
Deliberately hurt yourself			1.37 (1.18–1.59)	<0.001		
Being involved in an accident while driving yourself					1.67 (1.17–2.38)	0.005
3 or more days of school lessons skipped or 'cut'	1.49 (1.18–1.89)	0.001	1.23 (1.02–1.49)	0.030	1.27 (1.03–1.57)	0.028
Parents sometimes/usually don't know about Saturday night activities			1.37 (1.18–1.59)	<0.001		
Father schooling not college or university					1.17 (1.05–1.30)	0.004
Mother schooling not college or university					1.18 (1.06–1.32)	0.002
Economic status: High					reference	
Medium					0.89 (0.81–0.98)	0.017
Low					0.84 (0.70–1.01)	0.068
Family structure: Tradition family			reference			
Single parents			1.08 (0.94–1.24)	0.266		
Stepfamily			1.28 (1.04–1.56)	0.017		
Other			1.02 (0.80–1.30)	0.903		
Substance use						
Tobacco every day in the past month			1.27 (1.07–1.50)	0.006	1.69 (1.45–1.96)	<0.001
Intoxicated from drinking alcoholic beverages in the past year	2.94 (2.50–3.46)	<0.001	2.32 (2.06–2.61)	<0.001	2.11 (1.91–2.33)	<0.001
Binge drinking (HED) in the past month	2.77 (2.36–3.25)	<0.001	2.73 (2.41–3.08)	<0.001	2.66 (2.4–2.95)	<0.001
Cannabis use in the past year	2.37 (1.95–2.88)	<0.001	1.56 (1.35–1.80)	<0.001	1.57 (1.39–1.79)	<0.001
Inhalants use in the past year			1.61 (1.18–2.19)	0.003	1.32 (1.04–1.69)	0.025
Cocaine/crack use in the past year					1.57 (1.04–2.37)	0.034
Illegal substances use (no cannabis) in the past year	1.67 (1.35–2.06)	<0.001				
Scholar's feeling of emotional support (Likert scale from 1 (very strongly disagree) to 7 (very strongly agree))						
My friends really try to help me			0.96 (0.92–0.99)	0.042		
I can talk about my problems with my friends			1.04 (1.01–1.09)	0.025		

Consistent with previous comparisons of driving behaviour among AmED consumers (Brache and Stockwell 2011), the odds of being AmED users was higher for the students involved in an accident while driving, even only at univariate analysis level. The differential development of acute tolerance may explain why many studies observe higher rates of impaired driving for AmED consumers (Marczinski et al. 2018). In a study testing subjective versus objective

measures of alcohol intoxication, young adults reported feeling that they had less impaired motor coordination when they consumed AmED compared to when they consumed only alcohol (Ferreira et al. 2006).

In the same way, a positive relationship was found between AmED use and experience of physical fights, serious arguments and truancy at school, as reported in other studies (Howland and Rohsenow 2013; Azagba et al. 2013). A survey on college students who consumed AmED highlighted that they were at increased risk of being injured or hurt (O'Brien et al. 2008); in addition, we found association with experience of deliberately hurting themselves. Hence, especially risk behaviours that are deliberately inflicted should be taken seriously by prevention specialists.

Hypotheses of association between risk-taking and AmED consumption were also supported for engagement in sexual intercourse without a condom and trouble with police: these behaviours increased the likelihood of AmED use after controlling for all the other variables. Also in previous studies, AmED consumption was associated with an increased likelihood of specific behaviours, including sexual behaviour and aggressive behaviours (Snipes and Benotsch 2013; Berger et al. 2013).

Our data show that students going out in the evening and around with friends are at greater odds for AmED consumption. Conversely, AmED use decreases when students read books for enjoyment and have other hobbies, such as playing an instrument, etc., thus supporting the evidence that organized and constructive leisure-time activities protect against common risky behaviours in adolescence (Badura et al. 2017). Tobacco use every day in the past month is also associated with AmED consumption. This is in line with previous studies indicating that AmED use could be a potential marker for smoking susceptibility among never-smoking adolescents (Azagba and Sharaf 2014).

Given this high variability, the countries were grouped to analyse the influence between positive and negative associations at personal- and family-level in countries presenting a low to high prevalence of AmED.

Our results clearly show that in Europe there is not a well-defined spatial distribution of youth AmED consumption prevalence. This may suggest that, in the case of AmED, differently from other risk behaviours (i.e. alcohol use) (Bendtsen et al. 2014), cultural factors depending on geographical proximity may play a very limited role or are outweighed by the influence of country socio-economic indicators or individual factors.

Regarding cross-country comparisons, parents schooling college or university, being involved in serious arguments and in an accident while driving were statistically significant only for the high group, suggesting that such behaviours could be related to widespread use of AmED. On the contrary, going out in the evening, around with friends just for fun, having other hobbies, engaging in sexual intercourse without a condom, in binge drinking, in intoxication drinking alcoholic beverages and using cannabis in the past year remained significant for all low, medium and high groups, indicating that the consumption of AmED is associated with serious consequences even when the prevalence of use is low.

The uneven results of the multivariate analysis stratified by country groups deserve further investigation, in future work the socioeconomic context of each country should also be considered. This might contribute considerably to a clearer explanation of the observed between-country variability.

Strengths

The most remarkable strength of the study is the use of a consistent methodology throughout 35 European countries, resulting in a very large sample of adolescents, although the question about AmED is adopted only in 17 countries. Furthermore, all samples had a national geographical coverage, except for Finland, where the Åland Islands were not covered by the sampling frame. The student representativeness was large in the majority of the participating countries, as well as the students' response rate (average 86%) (ESPAD Group 2020). The students were recruited and surveyed with homogeneous procedures in each country, in terms of inclusion and exclusion criteria and outcome measures. The questionnaire was adapted to the common language of each country through a strict translation and back-translation process. Furthermore, to the best of our knowledge, this study on young AmED users comprises the largest geographic area reported so far.

Limitations

With regard to limitations, our study does not account for quantity of consumption. Students were asked on how many occasions in the past 12 months they had used alcohol mixed with energy drinks, regardless of the intake amount. Comprehensive research that takes into consideration the role of alcohol intake in determining risk-taking behaviours is needed. Disinhibition as a consequence of acute alcohol intoxication is well-recognized, with a linear relationship between breath alcohol concentration and risk of negative behavioural outcomes (e.g. falls and injuries, motor vehicle accidents) (Taylor et al. 2010). Moreover, we do not know whether beverage consumption characteristics (i.e. ED and alcohol use) were associated with greater risk-taking during AmED sessions to determine whether they are preventable risk factors for AmED risk-taking.

Another limitation to be mentioned concerns the ESPAD methodology. All participants were 16-year-old

students. Future studies should include students of different ages. ESPAD is a survey conducted only among high school students: the findings of this study may therefore not be extendable to young people not involved in education pathways. In addition to common limitations of self-reporting data (e.g. memory recall biases and social desirability biases), since ESPAD is a cross-sectional study, it is clearly not possible to establish causal directionality of the revealed relationships.

Conclusions

Overall, our study revealed that the consumption of AmED has become a widespread behaviour among European youth. One-third of adolescents reported past-year use in 17 countries, emphasizing the importance of closely monitoring this phenomenon. Furthermore, in line with previous studies, students engaging in risk-taking behaviours showed higher odds of being AmED consumers. These findings pave the way for future and more sophisticated analyses, considering not only prevalence but also the amount of energy drink and alcohol intake during AmED sessions. While such analyses are required to provide additional insights for a clearer interpretation of some risk-taking outcomes identified in our work, our findings regarding prevalence and associated factors support the need for adopting specific prevention and policy-level actions. This ranges from AmED consumption practices in alcohol prevention efforts to creating ad hoc surveillance systems and implementing restrictions on the sale of energy drinks to adolescents.

While the average European AmED prevalence found is similar to that observed in the USA, national AmED prevalence across Europe does not seem to follow a well-defined spatial distribution. This suggests that cultural patterns may only partially, or to a limited extent, explain prevalence differences, and that other factors, such as advertising and marketing, play a relevant role. A future comprehensive analysis considering country-level market and socio-economic factors could, therefore, support an inclusive interpretation of the distribution patterns linking geographically distant countries. This would allow for the identification of country-level risk factors and facilitate the adoption of common policy strategies.

Declarations

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