



Research article

Determinants of pupils' energy drink consumption – Findings from a Hungarian primary school

János Girán^{a,*}, Kyra Anna Girán^b, Dalma Ormándlaky^c, Éva Pozsgai^{a,d}, István Kiss^e, Zsófia Kollányi^f

^a University of Pécs, Medical School, Department of Public Health Medicine, Szigeti út 12, Pécs 7624, Hungary

^b Eötvös Loránd University, Faculty of Education and Psychology, Psychology BA Program, Kazinczy u. 23-27, Budapest 1075, Hungary

^c Kodály Zoltán Catholic Primary School and Kindergarten for Singing and Music in Komló, Templom tér 2, Komló 7300, Hungary

^d University of Pécs, Medical School, Department of Primary Health Care, Szigeti út 12, Pécs 7624, Hungary

^e University of Pécs, Medical School, Department of Public Health Medicine, Szigeti út 12, Pécs 7624, Hungary

^f Eötvös Loránd University, Faculty of Social Sciences, Institute of Economics, Pázmány P. stry. 1/A, Budapest 1117, Hungary



ARTICLE INFO

Keywords:

Pupils
Soft drink
Public health
Causal loop diagram
World café method

ABSTRACT

Consumption of energy drinks is harmful in childhood and adolescence, and its increasing popularity makes it a public health threat in this age group. Our study aimed to assess energy drink (ED) consumption and identify the context and determinants of its consumption at a Hungarian primary school. A mixed-method approach was used for the research, including a survey filled in by 157 10-15-year-old pupils and World Café workshops (WCWs) involving pupils, home-room teachers, and Parental Council representatives (N = 39). The Jamovi 2.2.5. The software was used to perform descriptive statistics and logistic regression, and a causal loop diagram was created based on the results of the WCWs. The survey results revealed that almost one-third of the pupils consumed EDs regularly, and most daily consumers drank high amounts (500ml). Most students considered ED consumption unhealthy, yet every fifth drank them. Buying breakfast on the way to school increased the odds of ED consumption almost threefold. According to the WCWs' findings, the determinants of ED consumption were embedded in two critical contextual sets; one was the need for energy and concentration boost and the Perception of high social acceptance of ED consumption. Our results suggest that interventions to reduce students' ED consumption need to include increased parents' involvement in controlling their children's screen time and encouraging them to provide breakfast at home for their children. There is also an urgent need to restrict the marketing of EDs and strictly regulate access to EDs for under-18s.

1. Introduction

Energy drinks (EDs) are non-alcoholic beverages that – mainly due to their high caffeine (>150mg per litre) and various amino acid and vitamin content – increase physical performance and stimulate brain function, thus enhancing alertness [1,2]. A recent study conducted by EFSA¹ and involving 16 EU countries showed that 68% of 10–18-year-olds had consumed energy drinks at least once a year before the survey [3]. Among the Hungarian youth, this proportion was 78%, indicating the second-highest consumption rate

* Corresponding

E-mail address: author.janos.giran@aok.pte.hu (J. Girán).

¹ European Food Safety Authority <https://www.efsa.europa.eu/en> (accessed: 26/03/2023).

<https://doi.org/10.1016/j.heliyon.2023.e15954>

Received 31 October 2022; Received in revised form 19 April 2023; Accepted 27 April 2023

Available online 3 May 2023

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among the studied countries (see Table 1).

A recent systematic review found that more frequent consumers of EDs were significantly more likely to report headaches (22.2% vs 16.8%), sleep disturbances (13.6% vs 8.5%) and a stomach upset (31.2% vs 23.1%) compared to children who drank EDs less than once a week [4]. In addition, drinking EDs was found to be associated with hyperactivity, elevated stress levels, inattention and anxiety or depression [5]. Due to their acid content, EDs can also cause erosion of teeth [6]. Moreover, since childhood and adolescence are periods of rapid growth and brain development, habitual caffeine consumption is more harmful for adolescents than for adults [7–9].

In Hungary, the National Public Health Centre has collected data on ED consumption from various public bodies, such as the Ambulance Services, Emergency departments, paediatricians, general practitioners, midwives, and primary and secondary schools since 2011. Between 2011 and 2020, 445 cases of excessive ED consumption were reported where medical assistance was required. An alarmingly high proportion, 42.7% of the 445 patients, were aged 15 or younger.²

Local surveys³ and several teachers' personal experiences also urge the initiation to curtail the consumption of EDs among primary school pupils. However, comparatively little data about the social and behavioural determinants of ED consumption patterns among primary school children is available. Furthermore, it would be essential to learn more about the parents' attitudes toward their children's ED consumption.

Our study was motivated by a Hungarian primary school's initiative, where the leadership voiced concerns over the rising ED consumption of EDs among its pupils. Thus, our research group designed an investigation to assess the characteristics of ED consumption in this school. We aimed to identify the factors that may influence the motives of primary school pupils to consume EDs. Moreover, this pilot study contributes to developing a broad national research program targeting the investigation of the consumption of EDs among adolescents aged below 18.

2. Materials and methods

Our data collection and analysis were performed based on a mixed-method approach. First, a specially designed survey exploring the ED consumption habits of pupils was completed by participants from grades 3 to 8 (9-15-year-olds).⁴ Next, World Café workshops (WCWs) were conducted to reveal the possible causal factors, motives and contexts of pupils' ED consumption. The representatives of school pupils, members of the Parental Council, and home-room teachers were invited to the WCWs separately.

2.1. Setting

The study was carried out at the Kodály Zoltán Catholic Primary School and Kindergarten for Singing and Music in Komló, Hungary. This primary school is one of the five primary schools in the city. The socio-cultural characteristics of the school's pupils align with the city's socio-cultural parameters as a whole. The city of Komló has about twenty-five thousand dwellers. Its population composition and socio-economic characteristics are similar to most of Hungary's small towns.

2.1.1. Sample

Pupils participated voluntarily and anonymously in the survey and with prior parental consent in the WCW part of the data collection.

In the WCWs, 18 pupils from grades 3 to 8 participated. Each class delegated two representatives to the workshops. Eight persons from the Parental Council and all the home-room teachers (13) from each grade (1–8) participated. The participation of home-room teachers and parent council members was also voluntary.

The qualitative and quantitative data collection were carried out between December 2021 and February 2022. The venue of the data collection was the school building.

Table 1

Total number of pupils and survey respondents by grades.

	Number of pupils in the class (person)	Number of respondents (person)	Proportion of respondents (%)
Grade 3	20	16	80.0
Grade 4	32	31	97.0
Grade 5	24	21	88.0
Grade 6	26	20	77.0
Grade 7	39	37	95.0
Grade 8	35	32	91.0
Total	176	157	89.2

² Source of data: the National Public Health Centre of Hungary provided data in 2021 based on a specific request of the authors.

³ c.f. Győr Megyei Jogú Város Egészségképe, 2021 (City Health Profile of the City of Győr, Hungary, 2021) <https://gyor.hu/easy-docs/61e98f3a824a6> (last access 12/05/2022).

⁴ Children start primary school at 6 in the Hungarian education system.

2.2. Quantitative data collection and analysis

The survey gathered information on the following topics: personal preferences for energy drink consumption, frequency of consumption, main motives of consumption and knowledge about the risks of consumption. The entire questionnaire included 26 questions, but 13 were related to ED consumption. Half of the questions were close-ended, and the other half were open-ended. The participants from grades 3 to 4 filled out a paper-based survey, and those from grades 5 to 8 filled out an online version. Based on the EFSA study's questionnaire [3], the research team developed the questionnaire on pupils' ED consumption habits with the help of teachers in the school under study. Four pupils in grades 3–4 and six in grades 5–8 completed the questionnaire before its use. These respondents were asked to rate the clarity of the questions and whether they felt they had sufficient knowledge and information to answer them. Students were then asked to interpret the questions in their own words to double-check the clarity of the questions. The answers to the questionnaire and the answers to the teacher's questions related to the questionnaire confirmed that the students understood the questions and were able to answer them.

Statistical analyses were performed using the Jamovi 2.2.5. Software. Descriptive statistics and binary logistic regression were carried out. Associations were tested using the chi-square test ($p \leq 0.05$).

2.3. Qualitative data collection and analysis

Qualitative data were collected by the "World Café" method. The WCWs were designed and implemented following the methodological principles of this method [10]. Each WCW focused on the following questions: what is the motivation for a primary school student to consume EDs; where and when do pupils typically consume EDs; why might a pupil feel the need to be "boosted" by EDs; how big of a problem is ED drinking perceived; what measures could be taken to stop students from drinking EDs; who should act to prevent pupils from consuming EDs.

Responses were recorded by audio recording. In addition, two observing researchers took notes on the focal points of the workflow and recorded the characteristics of the group dynamics. To avoid the flawed analytical practice that considers a problem's components in isolation, a Causal Loop Diagram (CLD) was developed. The CLD is based on the information gathered at the WCWs. It was created using the Vensim DSS Causal Tracing™ software.

Ethical approval

The study received ethical approval from the Hungarian Medical Research Council (ref. IV/6933-1/2021/EKU).

3. Results

3.1. Survey's results

More than one-fourth (28.02%) of all respondents consume ED regularly. Among them, 22.7% consume EDs daily, 15.9% drink them more than once a week, and 61.4% less than once a week (Fig. 1). ED consumption is already present in the third grade, and as age increases, the proportion of weekly and daily users of EDs increases in parallel. In the oldest age group, in grades 7–8, the ratio of those who consume EDs every day exceeds 10%. In addition to daily consumers, the proportion of those in this age group who consume EDs several times a week is close to 10%, while those who consume less than once a week account for a quarter of respondents (24.6%).

The amount of EDs consumed per day showed a significant difference depending on the frequency of consumption: the majority (60%) of those who consume EDs daily consume 500 ml daily. Almost half (42.9%) of those who consume EDs several times a week consume 250 ml daily. Most (80.0%) of those who drink EDs less than once a week also consume 250 ml daily.

There was also a significant difference ($p = 0.029$) in ED consumption depending on sex: 38.2% of the boys, while just 22.0% of the girls consume EDs.

The causes of ED consumption were also assessed. A relevant part of consumers (34.1%) drink EDs because they find them delicious. 13.6% of consumers do so because they find them delicious and their energy-boosting effects. One out of ten consumers (11.4%) drinks it mainly for its energy-boosting effects. Nearly two in ten consumers (6.8%) consume EDs because they collect cans containing EDs. The remaining respondents (25.0%) gave divergent answers that could not be categorized because of their specificity. However, 9.1% of the consumers did not answer this question.

Regarding consumption habits, students were also asked to rate how healthy they thought ED consumption was. The responses showed that most students (89.3%) thought ED consumption was very unhealthy or unhealthy (Fig. 2).

Of those who think that EDs are very unhealthy or unhealthy ($N = 130$), 3.1% consume them daily, 4.6% consume them several times a week, and 16.9% consume them less frequently than a month.

Of all the pupils, 15.1% buy breakfast on their way to school. According to the logistic regression analysis results, among these pupils, the odds of consuming EDs with any regularity are almost threefold compared to those who bring their breakfast from home ($OR = 2.87$ [CI 1.37–7.26]).

3.2. Personal and social determinants of ED consumption

The CLD based on the WCWs' results illustrates the causal associations among nodes that the WCWs' participants considered

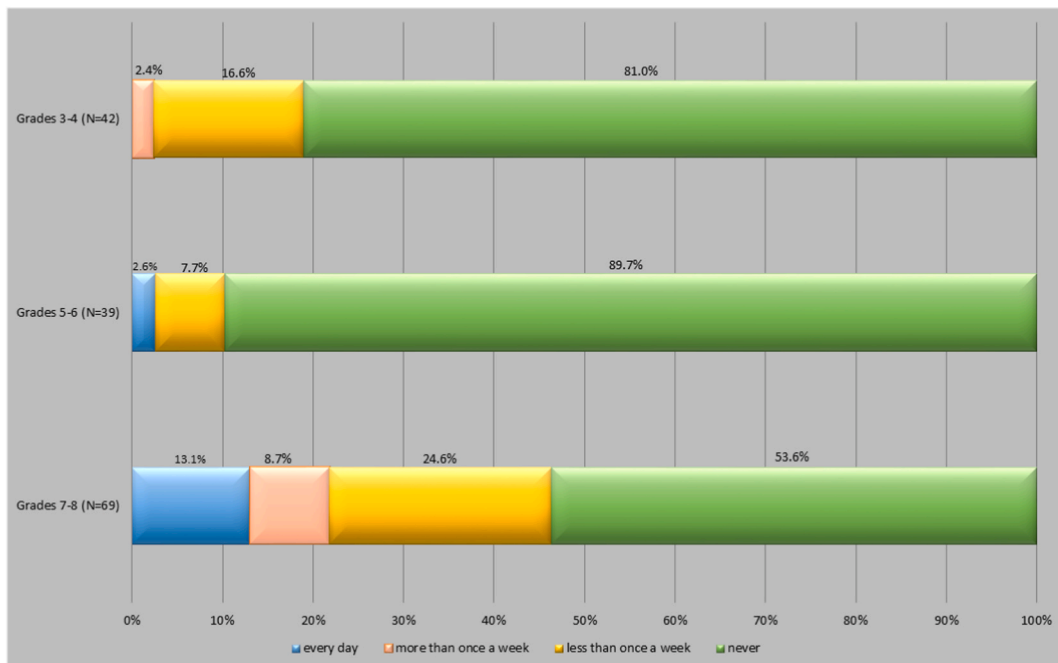


Fig. 1. Frequency of ED consumption among primary school pupils (N = 157).

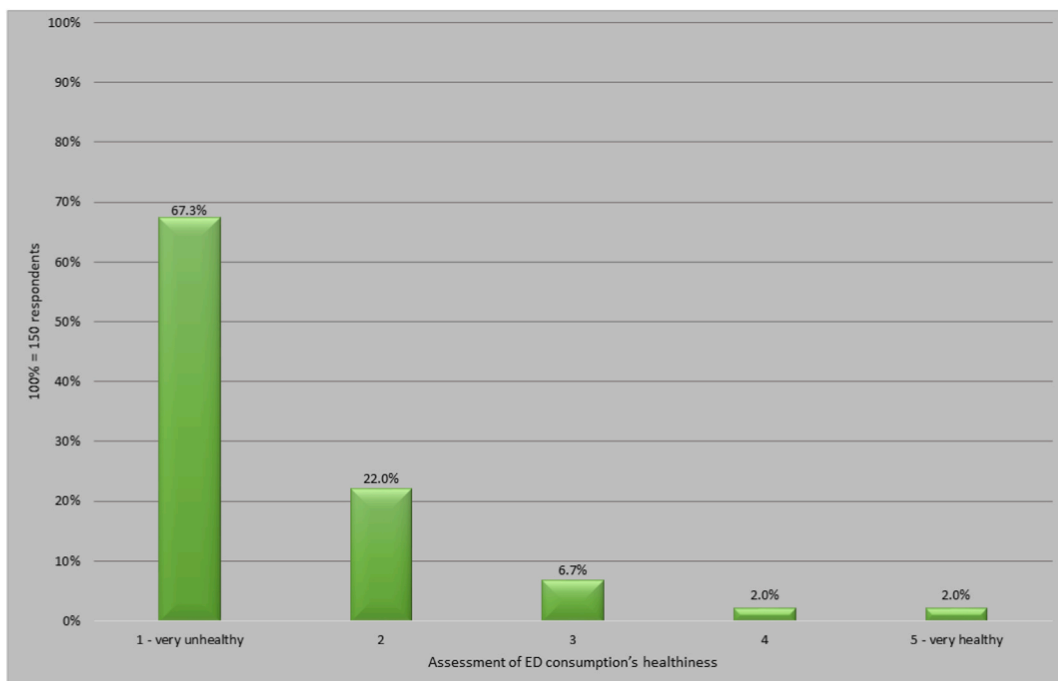


Fig. 2. Perceived degree of the healthiness of ED by pupils (N = 150).

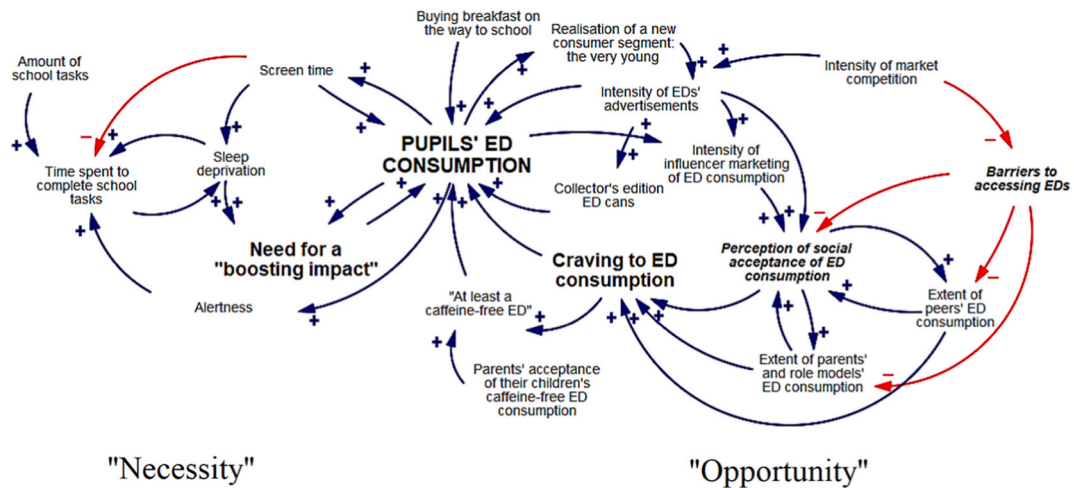


Fig. 3. Personal and social determinants of ED consumption among primary school pupils.

critical personal or social determinants of students' ED consumption. Fig. 3 shows that the determinants of pupils' ED consumption constitute a complex system.⁵ The core node of this system is the pupils' ED consumption. There are two feedback structures (FS) that feed this core node: the "Necessity" and the "Opportunity" for ED consumption.

The "Necessity" FS is fed by two feedback loops (FL). In this case, the *Screen time* and *Time spent to complete school tasks* are the out-degree nodes.⁶ The further FS of the diagram is the "Opportunity" for ED consumption. In this FS, two out-degree nodes were identified: the variable *Perception of social acceptance of ED consumption (PSA)* and the variable *Barriers of ED access (BoEDa)*. Thus, the "Necessity" and the "Opportunity" FSs are the critical contexts that determine and motivate the pupils' ED consumption.

4. Discussion

This study investigated the main determinants and possible motivating factors of primary school pupils' energy drink consumption habits. We found that the prevalence of ED consumption among primary school pupils is considerably high: one in four pupils consumes EDs with some regularity. At first glance, this data may compare favourably with the results of the EU study mentioned earlier, where 55% of 10–14-year-olds had consumed EDs at least once the year preceding the survey [3]. However, while that study found the proportion of daily and more often than weekly ED consumers to be around 5% and 6%, our study showed that 13.1% of 7–8 graders consumed EDs daily, and 8.7% consumed EDs more than once a week. Our results align with other recent studies: among 1006 randomly selected Saudi Arabian male children, 60% were regular ED consumers [11]. In Germany, 8.9% of 12–17-year students stated that they had consumed energy drinks over the last four weeks before the data collection [12]. Among Belgian adolescents, 14.0% of boys and 7.6% of girls consume energy drinks more than once a week [13]. These data indicate a tendency, showing an increase in adolescents' regular consumption over the past few years. The situation calls for action far beyond current measures to reduce ED consumption among primary school pupils.

It is also worth highlighting that ED consumption is already present among very young pupils in grades 3–4. This phenomenon, in addition to the increasing direct health risks for this age group [14–16], also predicts that if current trends remain unchanged, by that time when current Grade 3 pupils will be in Grade 8, the proportion of consumers will exceed the current, already very high ratio. Considering the association between ED consumption and other substance use among middle schoolers [17], this prediction warns of additional risks.

The extent of consumption has also changed: while in the past, daily consumers typically drank 250 ml per day [3], the respondents in our study drank 500 ml per day. This may probably be due to an overall trend in ED consumption from an early age [11,12].

A new finding revealed by our study suggests that there is a novel element of EDs consumption that was ranked in third place among the main reasons for consumption: drinking EDs to obtain limited edition cans for collections. This reason has not previously been identified as a determinant of ED consumption [3,4,18,19]. ED manufacturers regularly release specially designed collector's editions of ED cans for a limited time. ED can collectors purchase these for their collection, but once the can is purchased, the contents are drunk. Thus, the desire to expand collections of ED cans also leads to increased ED consumption. If this factor were eliminated, consumption could be reduced by around 10%. This goal could be supported by mandating uniformized and designless packaging of

⁵ In Fig. 3, an arrow with a plus sign between two nodes indicates that the connected two nodes are moving in the same direction or positively correlated. If the determinant represented by the node at the arrow's tail increases (intensifies, etc.) or decreases, the determinant represented by the node at the head also increases or decreases. An arrow with a minus sign indicates that the two connected nodes are moving in opposite directions or are negatively correlated: if the node at the arrow's tail increases, the node at the head decreases, and in reverse.

⁶ The out-degree or influential nodes can influence many other nodes and determinants in the system.

EDs – similar to uniformized cigarette packaging.

Another new finding of our study was identifying “buying breakfast on the way to school” as a risk factor, which increased the odds of ED consumption almost threefold. It is one of the most crucial components of the challenges related to ED consumption. This finding characterizes an important “at-risk” group and identifies parents as critical actors in preventing ED consumption by their children. Based on these results, preventive strategies need to motivate and support parents by not giving their children money to buy breakfast but providing it in other ways.

Our study also found that despite being aware of the harmful impacts of EDs, students still consumed them. Earlier studies showed that knowledge about the adverse health impacts of ED consumption was limited, especially among children and adolescents [8,20,21]. In contrast, our study suggests that pupils are now aware of the risks and possible health consequences of ED consumption; however, this knowledge does not discourage them from drinking EDs. This finding indicates that conventional awareness-raising-type of prevention approaches might be less effective in the case of ED consumption because, in this case, social influences play crucial roles.

Sleep deprivation is also a crucial determinant of ED consumption. A recent study found that short sleep duration elevates the odds of ED consumption (OR = 1.60, 95% CI = 1.10–2.34) among adolescents [22]. Larson and her colleagues investigated a sample of 2793 6–12 grade students. They found that 1 h of additional video game time among boys elevated the odds of consuming EDs more than once a week twentyfold and ninefold among girls [23]. Another study suggested that for those adolescents who consumed EDs regularly, the odds of a late bedtime were almost eightfold higher compared to non-consumers [24]. This aspect is closely associated with the “Necessity” feedback structure (FS), which is, according to our results, one of the primary determinant contexts of ED consumption (Fig. 3). Two feedback loops (FL) feed the “Necessity” FS: *Screen time* and *Time spent to complete school tasks*. For both FLs, Time as a factor plays a decisive role: the relationship between screen time and sleep deprivation affects the need for a boosting impact: the increase in screen time decreases sleeping time, and thus the students’ need to consume some energy and concentration boosters in the morning or during the day increases significantly. This need raises the consumption of EDs. However, increasing ED consumption boosts alertness, decreasing the extent to which students feel the need to sleep, so screen time may also increase. Moreover, the more time they spend on electronic devices, the more likely pupils will consume EDs to maintain their alertness and extend their screen time. As the upper-grade pupils mentioned, this situation is often supported by targeted advertisements focusing primarily on online gamers.

The further time-related FL represents the relationship between the time spent on homework, school or extracurricular activities, and sleeping time. As the *Time spent on school assignments* and other learning activities increases, sleep time decreases, increasing the need for a boosting impact. ED consumption boosts the alertness needed to complete school tasks. However, longer Time spent on school tasks reduces sleeping time, increasing the need for EDs.

The additional FL shows that the relationship between screen time and learning time may also affect the need for a boosting impact: some pupils “postpone” their school tasks to the evening and night hours because of the increased screen time during the day, which ultimately reduces sleeping time. Consequently, when developing interventions against pupils’ ED consumption, parental control over children’s late bedtime and the often associated uncontrolled screen time is crucial.

An additional possible area of prevention linked to the need for a boost is the time spent on school-related tasks. Research has shown evidence of ED consumption associated with increased learning tasks among secondary school and university students [18,25]. In the case of primary schoolers, the practice of ED consumption to complete learning tasks must be prevented. As a possible first step, parents and teachers should be encouraged to review the pupils’ family- and school-related expectations and reassess the school assignments and extracurricular activities that can be done without the risk of overloading children’s timetables.

Regarding the craving to consume EDs, a recent study suggests that a particular beverage’s sugar and caffeine can have an addictive impact on consumers [26]. Caffeine triggers pleasure circuits in the brain’s reward system resulting in a similar impact that leads to drug addiction [27]. The sugar content of EDs rises the risk of overweight and tooth decay in children, as well as the risk of preventable diseases such as obesity and type 2 diabetes [28,29]. But the sweet taste increases the craving to consume EDs. Additionally, if children consume artificially-sweetened EDs, due to their cardiometabolic impact elevates the risks of cardiovascular diseases [30]. Besides these ingredients, ED can contain various amino acids (eg. L-Carnitine, L-Citulline, L-Glutamine, L-Leucine, Taurin, others) too. A regular and extensive amino acid intake can impact the expression of amino acid transporters and the synthesis of toxic metabolites. Besides, there is a hazard that the uncontrolled combination of different amino acids or blends with other substances or medications can also elevate health risks. The abrupt withdrawal of the amino acid intake probably results in a damaging influence on metabolism as well [31]. In addition, a present study, based on a review of the 75 commercially available EDs’ ingredients, identified their most prevalent ingredients. The results suggest that the relative prevalence and average amounts of the top ingredients were as follows: caffeine (100%; 174.4 ± 81.1 mg), vitamin B6 (72%; 367 ± 648% daily value (%DV)), vitamin B3 (67%; 12.41 ± 69.9% DV), vitamin B12 (67%; 5245 ± 10,475% DV), vitamin B5 (37.3%; 113.6 ± 76.6% DV), and taurine (37.3%; amounts undisclosed). These results show that one can of EDs contain a high level of vitamins B3, B6, and B12. This amount is several times higher than an adult’s daily B vitamin requirements. The extensive consumption of B-complex vitamins may result in adverse events, particularly if a person has any renal or liver function impairment, as it could lead to a buildup of these vitamins. Common harmful occurrences of excess B-complex vitamin consumption include skin rashes, gastrointestinal distress, and insomnia [32]. In the case of children, this kind of vitamin overdose can lead to more severe health consequences than in adults.

A further issue of interest is the consumption of decaffeinated EDs. To our knowledge, decaffeinated EDs’ role in ED consumption has not been previously investigated and discussed in health promotion discourses. Our findings suggest (Fig. 3) that perceived social acceptance of ED consumption strengthens pupils’ craving to consume EDs. However, the majority of children are not allowed to consume caffeinated EDs. But, some soft drinks taste and smell and are packaged very similar to EDs but without caffeine and amino acids. These products usually contain a high dose of different vitamins (mainly various B vitamins) instead of caffeine and sweeteners instead of sugar, based on which attributes they are often advertised as “healthy”. Some parents allow their children to try these soft

drinks, and after a while, consuming these decaffeinated EDs becomes accepted within the family. As a result, decaffeinated ED consumption may help escalate ED consumption among elementary schoolers due to their potential gateway effect because consuming decaffeinated EDs does not reduce the craving for the “real stuff”, the caffeinated EDs. Thus, after the child feels mature enough, and the parents let them do so, the consumption of EDs, based on the routine of decaffeinated ED consumption, becomes accepted. Hence, tolerance of the decaffeinated EDs can smoothly lead to the approval of the caffeinated version – as it was articulated both at the pupils’ and teachers’ WCWs. As mentioned earlier, in children’s cases, the groundlessly high vitamin content of EDs can also cause adverse health effects, perhaps more severe than in adults.

Finally, in the context of the craving to consume EDs, the ease of access to EDs is another determining factor of ED consumption. Although some European countries, like Lithuania, Latvia, Sweden, and Scotland, have officially regulated the age of purchase of EDs [33], and there are examples of shops voluntarily announcing an age restriction on EDs as part of their social responsibility [34]. Yet, in Hungary, there are no age restrictions on the sale of energy drinks.

Thus, easy access was identified by all respondent groups as one of the crucial points that has the most significant impact on ED consumption by primary school pupils. This point offers the fastest and most effective intervention possibility, as it can change crucial elements of social practice associated with ED consumption, like access to EDs and perceived social acceptance of consumption. Our qualitative data analysis suggests (Fig. 3) that in the case of the “Opportunity” FS, the *Perception of social acceptance of ED consumption* (PSA) and *Barriers of ED access* (BoEDa) out-degree nodes are considerable. The development of the out-degree node PSA is significantly influenced by ED-related marketing activities associated with the tight market competition in the segment: an expansion in ED supply makes the intensifying of ED advertising necessary for the producers, thus increasing the “visibility” of EDs, as well as the Perception of social acceptance of these products. Students may interpret the sensed social acceptance of ED consumption as a “permission” to consume: “everyone drinks it so I can drink it too”. This permission to satisfy their desire increases ED consumption; thus, the causal chain repeats itself repeatedly with escalating intensity.

Moreover, there is a strong interrelation between the PSA and the BoEDa: as the PSA increases, BoEDa will decrease. The easier it is to access EDs, the more peer group members, parents and role models consume EDs. When the elements of a social practice change, the social practice reconfigures itself [35], which can contribute to changing the social acceptability of ED consumption.

4.1. Limitations

Asking for and collecting data on a sensitive issue in a school setting, despite its anonymity, may result in the “sugar-coating” of real situations. It could lead to more positive responses than reality regarding the fact, frequency, and quantities of EDs consumed.

5. Conclusion

Using a novel, mixed-methods approach, our study not only captures the characteristics of drinking habits but also identifies some relevant access points for interventions. Our results suggest that knowledge of the adverse health effects of EDs wouldn’t reduce consumption while its social acceptance remained high. Consequently, preventive interventions, besides other health promotion goals, should aim to reduce the social acceptance of ED consumption.

Until legal restriction of EDs access, health promotion tools are primarily available to reduce this consumption. An initiative could be the installation of water dispensers and drinking fountains in elementary school corridors and announcing a water challenge that encourages students to consume water. Inviting local and national social media influencers and other role models to participate in the actions against ED consumption is also a way to support this goal. Furthermore, cooperation among the local community stakeholders (school, Parents’ Council, grocery store managers) can also help reduce EDs consumption: grocery stores operating in the vicinity of schools voluntarily follow a policy that EDs are not sold to young people under 18.

Some of these initiatives (water challenge, installation of water dispensers) have already started in the investigated school. The implementation of the other initiatives is under preparation. We plan to measure the results of the health promotion initiatives with an impact assessment, the results of which will be published.

Author contribution statement

János Girán, Zsófia Kollányi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper. Kyra Anna Girán: Performed the experiments; Analyzed and interpreted the data. Dalma Ormándlaky: Conceived and designed the experiments; Performed the experiments. Éva Pozsgai: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper. István Kiss: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Funding

The University of Pécs, Medical School, Dr. Szolcsányi János Research Fund, supported this work. The Fund had no role in study

design, data collection and analysis, the decision to publish, or the preparation of the manuscript.

Declaration of competing interest

The authors have declared that no competing interests exist.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e15954>.

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