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Impact of warning labels on energy drink perceptions and purchase intentions among emerging adults in Uruguay

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Abstract

Background: The rapid expansion of energy drink markets over the past two decades has sparked growing policy debate surrounding their regulation, due to their potential adverse health effects, particularly among young people. In this context, mandatory warning labels have emerged as a promising public health intervention. The present work aims to explore the effect of warning labels on emerging adults' purchase intention and perceived healthfulness of energy drinks in Uruguay.

Methods: An online randomized controlled trial was implemented using a convenience sample of 340 emerging adults. Commercial energy drink cans, varying in brand (market-leading vs. lesser-known brand) and sugar content (regular vs. zero-added sugar variant), were used as stimuli. Participants were randomly assigned to either the control group (no warning label) or

one of the four intervention groups, each of which was exposed to a warning label condition (Insomnia-graphic, Insomnia-textual, Tachycardia-graphic, Tachycardia-textual). The questionnaire comprised six main sections: (i) purchase intention; (ii) perceived effects of energy drink consumption and perceived healthfulness; (iii) perception of warning labels; (iv) comparison of warning labels; (v) socio-demographic characteristics; and (vi) energy drink consumption habits and perceived risk.

Results: The graphic warning referring to tachycardia led to a significant reduction in purchase intention and perceived healthfulness compared with the control condition; no significant effect was observed for the remaining warning label conditions. In addition, warning labels were consistently associated with an increased attribution of the negative effects they highlighted, whereas no statistically significant effects on positive outcomes were observed. Results also provide emerging insights into the role of branding, consumption patterns and risk perception in shaping perceived healthfulness and purchase intention for energy drinks. Regarding participants' perception of warning labels, the graphic tachycardia warning emerged as the most effective condition.

Conclusions: Results support the use of warning labels as a public health strategy to increase awareness of the potential harms associated with energy drink consumption and suggest that their impact may extend even to products with strong market presence and high consumer recognition.

Keywords: caffeinated beverages; front-of-pack; health warnings; food policy; labelling.

Background

Energy drinks are a category of non-alcoholic beverages typically containing caffeine combined with other stimulants such as taurine, glucuronolactone, ginseng extract, and B vitamins, sweetened with sugars or non-sugar sweeteners [1]. Globally, consumption of these beverages has increased substantially over the past two decades, particularly among children, adolescents

and emerging adults [2–4], fueled by heavy marketing strategies positioning them as an alternative to enhance alertness and physical or cognitive performance [5, 6].

A growing body of evidence has documented potential adverse health effects associated with energy drink consumption [7–9]. Regular consumption of energy drinks has been linked to cardiovascular symptoms, including increased heart rate and blood pressure, arrhythmias, as well as sleep disturbances, anxiety, hyperactivity, and gastrointestinal problems [2, 9, 10]. In light of these health risks, there is increasing recognition of the need for public health policies to discourage energy drink consumption, particularly among young people [11, 12].

Within the proposed policy landscape, mandatory warning labels have emerged as a potentially effective and feasible strategy [12]. Warning labels aim to make the health risks of energy drink consumption more salient at the point of purchase and discourage their purchase and consumption [13, 14]. Evidence from other product categories, such as tobacco and sugar-sweetened beverages, suggests that warning labels can influence consumers' perceptions, reduce product appeal, and lower purchase intentions [15–17]. However, the evidence base regarding warning labels on energy drinks is still limited.

Experimental studies have examined the effect of different types of energy drink warning labels, including labels highlighting caffeine presence (e.g., 'Contains caffeine'), labels describing potential adverse health effects (e.g., 'High levels of caffeine intake can cause headache, nausea, anxiety, irregular heartbeat, vomiting, and, in extreme cases, death'), and messages advising against consumption by specific population groups (e.g., 'Not recommended for children, pregnant women or people sensitive to caffeine') [18–23]. While some studies have reported that warnings increase risk perception and reduce purchase or consumption intentions [19, 20, 22, 23], others have reported null or counterproductive effects [18, 21]. Variability in warning design, message framing, study samples, and outcome measures hinders direct comparison across studies and limits the ability to draw robust conclusions for policy

development. In addition, most existing evidence originates from high-income, developed countries, constraining the generalizability of findings to other regulatory and cultural contexts.

Objectives and context

Given the rapid growth of energy drink markets globally and the evolving policy debate surrounding their regulation, further research is needed to assess the potential role of warning labels as a public health intervention beyond developed countries. The existing evidence base is characterized by inconsistent findings, variability in warning designs and study populations, and an almost exclusive focus on high-income, developed-country contexts, leaving a notable gap in evidence from developing countries, including Latin America. The present study addresses this gap by examining the effect of warning labels on emerging adults' purchase intention and perceived healthfulness of energy drinks in Uruguay, contributing empirical evidence relevant to public health policy and regulation. Purchase intention and perceived healthfulness were selected as the primary outcomes because they represent two key pathways through which warning labels may influence consumer behavior: cognitive appraisal of product healthfulness and subsequent behavioral intent [14, 16, 17, 24, 25].

In recent years, Uruguay has experienced a dramatic rise in energy drink consumption. Between 2010 and 2024, sales increased by 1325%, reaching an estimated annual per capita volume of 1.7 L, and are expected to continue expanding at an annual rate of 8% between 2024 and 2029 [26]. Consumption is especially common among younger populations: 81.8% of high school students report having tried energy drinks at least once [27]. Despite this widespread uptake and growing concern regarding potential adverse health effects, no specific regulatory measures targeting energy drink consumption are currently in place in the country. However, the country has adopted mandatory front-of-package warning labels for packaged foods and beverages that exceed established thresholds for sugars, sodium, total fats, and/or saturated fats [28, 29]. As a result, many sugar-sweetened energy drinks carry a warning label for excess sugar, but the regulation does not require any warning or precautionary statement regarding

caffeine content. In this context, a previous study evaluated the potential impact of an octagonal "Contains caffeine" warning label and found that it increased purchase intention [21]. The warning labels assessed in the present study extend the current policy to health-effect warnings specific to energy drinks, for which no equivalent regulation currently exists.

The study focuses on emerging adulthood, a distinct developmental stage situated between adolescence and full adulthood, generally encompassing ages 18 to 30 [30]. This period is characterized by increasing autonomy, identity exploration, and instability across key life domains such as education, employment, and interpersonal relationships, which collectively heighten susceptibility to experimentation with health-related behaviors [31].

Methods

A randomized controlled trial was implemented to assess the effect of different types of warning labels on emerging adult's perceived healthfulness and purchasing intentions of energy drinks. The study was part of a larger project about strategies to discourage energy drink consumption among adolescents and emerging adults. The project was reviewed and approved by the Ethics Committee of the School of Chemistry of Universidad de la República (Uruguay).

Participants

The study relied on a convenience sample of emerging adults. The inclusion criteria were being between 18 and 30 years of age, residing in Uruguay, and consuming energy drinks at least occasionally. Participants were recruited through two complementary strategies. First, invitations were distributed via student mailing lists from four faculties of the Universidad de la República, the country's largest public university, including the Schools of Chemistry, Psychology, Architecture, and Nutrition. In addition, the association of students from the Northeast Regional University Center of Universidad de la República was contacted and posted the link of the study on their social media networks. The invitation included the following text: "A study is being conducted to understand how young adults (18 to 30 years old) perceive energy drinks in our country. If you fall within this age range and are interested in participating, please

click on the link below". Second, participants were also recruited through a paid advertisement on Facebook and Instagram targeting individuals aged 18–30 years residing in Uruguay. The advertisement featured an image of an energy drink can and the message: "If you are between 18 and 30 years old, click the link to participate in our study about energy drinks", accompanied by background imagery depicting either a blurred library setting with students or a social scene in which individuals were holding an energy drink can. Recruitment was conducted between October and December 2025.

An a priori sample size calculation was conducted to determine the minimum number of participants required to detect differences between experimental conditions. Assuming a linear model comparing five groups, a significance level of 0.05, and a statistical power of 0.80, the analysis was based on a small-to-moderate effect size (Cohen's f = 0.20). Under these assumptions, a total sample size of approximately 305 participants (about 61 per group) was required. It should be noted that this power calculation assumed a simple between-subjects comparison without covariates, which does not fully reflect the covariate-adjusted regression models ultimately used in the main analyses.

Interventions

The intervention comprised four warning labels designed to highlight potential adverse effects of energy drink consumption. Labels were developed using a 2×2 experimental design that varied by health effect and presentation format. Two health outcomes, tachycardia and insomnia, were selected based on available evidence regarding commonly reported adverse effects of energy drink intake [2, 9, 10]. These two effects were specifically prioritized over other commonly reported negative health outcomes for three reasons: (i) they were frequently mentioned by emerging adults in a previous online survey assessing consumption experiences and negative health effects of energy drinks [32]; (ii) both are concrete, personally relatable outcomes that can be depicted graphically in a warning label format, and (iii) they were expected to differ in perceived severity: tachycardia (a cardiovascular symptom) was expected to be perceived as

more severe than insomnia (a sleep disturbance), enabling comparison of warning effectiveness across levels of perceived risk. Informed by research on the effectiveness of tobacco warning labels [16, 33, 34], both textual and graphic formats were tested.

Text-only warnings presented a brief description of the health effect ("Energy drink consumption can cause [health effect]"), whereas graphic warnings combined the same text with an illustrative image generated using OpenAI. Images were generated using ChatGPT's image-generation capabilities based on textual prompts describing each health effect (tachycardia and insomnia) and incorporating drawings developed by adolescents during co-creation workshops aimed at designing graphic materials to discourage energy drink consumption (unpublished data). Multiple candidate images were produced for each health outcome, and the final images were selected by consensus among the research team, considering their clarity and visual impact. The selected images were subsequently tested with adolescents in workshops conducted within the broader project in which this study was situated. All labels prominently displayed the word "Warning" ("Advertencia" in Spanish) and a black triangle containing an exclamation mark, visual elements commonly associated with warning messages [35].

The four warning labels evaluated in the study are presented in Figure 1. Five experimental groups were created, comprising one control group and four intervention groups corresponding to each warning label. Participants assigned to the intervention groups viewed energy drink cans displaying warning labels, whereas participants in the control group viewed the same cans without warning labels.

Stimuli

Commercial energy drink cans were used as stimuli. To introduce variability and reduce brand-specific effects, each participant evaluated four cans representing two brands and two product variants. The market-leading brand (Monster) and a lesser-known brand (Baly) were selected based on sales data [26]. For each brand, both a regular and a zero–added sugar variant were

included. The can images were digitally modified to incorporate the assigned experimental condition, resulting in five image variants (control or one of the four warning labels) for each commercial energy drink can. Figure 2 presents examples of the stimuli used for each type of can in the intervention conditions, along with an example of one of the cans shown to participants in the control group.

Questionnaire

A questionnaire was developed by the research team based on previously published studies examining the effects of warning labels on perceptions and purchase intentions of energy drinks [18–23]. The questionnaire comprised six main sections: (i) purchase intention; (ii) perceived effects of energy drink consumption and perceived healthfulness; (iii) perception of warning labels; (iv) comparison of warning labels; (v) socio-demographic characteristics; and (vi) energy drink consumption habits and perceived risk. An English language version of the questionnaire is provided as an additional file (Additional File 1).

In the first section, participants were shown the four energy drink cans corresponding to one of the experimental groups. The cans were presented individually in a balanced order following a Williams' Latin square design, implemented by the Compusense Cloud software. For each can, participants rated their purchase intention using a five-point scale in response to the question: "Would you purchase this drink?" (1 = definitely not; 3 = maybe yes/maybe not; 5 = definitely yes). This single-item measure was adapted from prior studies on front-of-package labelling, and is consistent with standard practice in this literature [36], as well as in sensory and consumer science [37]. While the use of a single item limits the assessment of measurement reliability, it reduces respondent burden in within-subject designs.

In the second section, the same cans were presented again, one by one. Participants first completed a check-all-that-apply (CATA) question [38] regarding the perceived effects of consuming each beverage ("What effects could consuming this beverage have on you?"). Nine response options were included, based on findings from an open-ended question included in a

previous survey with Uruguayan emerging adults [32]: increased concentration, fatigue reduction, increased energy, improvement in athletic performance, improvement in academic performance, tachycardia, insomnia, anxiety, and no effect. The presentation order of the response options was balanced across participants. Subsequently, participants rated the perceived healthfulness of each drink on a five-point scale ("How would you rate the health effects of this drink?"; 1 = very bad for health; 2 = bad for health; 3 = neither bad nor good for health; 4 = good for health; 5 = very good for health).

The third section focused on participants' perceptions of the warning labels and was therefore administered only to participants in the intervention groups. Participants were shown the warning label corresponding to their experimental condition and asked two closed-ended questions assessing warning recall and use (i.e., "Do you remember having seen this message on the cans you evaluated?" and, for those who answered affirmatively, "Did you take it into account when answering the questions?"). They were then asked to respond to an open-ended question regarding their opinion of the message ("What do you think about the message?").

In the fourth section, participants were presented with the four warning labels and asked to select the one they considered most effective in discouraging energy drink consumption ("Which of the following messages do you think would be most effective in discouraging the consumption of energy drinks?"). Participants were also asked to justify their choice in an open-ended question ("Why?").

The fifth section collected socio-demographic information, including gender, age, education level, student status, working status, and region of residence. The final section assessed energy drink consumption habits, including consumption frequency, usual brand, and perceived risk of energy drink consumption ("How risky do you think consuming energy drinks is?"; 1 = not at all risky; 2 = a little risky; 3 = moderately risky; 4 = very risky; 5 = extremely risky).

The questionnaire was pilot tested with 10 participants who met the inclusion criteria, and no issues related to comprehension or interpretation were identified.

Data collection and randomization

The questionnaire was administered using Compusense Cloud software (Compusense Inc., Guelph, Canada). Participants who accessed the survey link (n=747) were first presented with an information sheet and asked to provide informed consent through an online form. Those who consented to participate (n=490) were automatically randomized by the software to either the control group (no warning label) or one of four intervention groups exposed to different warning label variants: Insomnia–graphic, Insomnia–textual, Tachycardia–graphic, and Tachycardia–textual. Following randomization, participants proceeded to complete the questionnaire. Upon completion, they were thanked for their participation and provided with a link to a website of the National Drug Secretariat containing information about energy drinks.

Data analyses

The first step of the data analysis involved data cleaning and quality checks. Participants who were randomized but failed to complete the questionnaire (n = 130) and those who completed the questionnaire but did not meet the inclusion criteria (n = 20) were excluded from the analysis.. Excluded participants were equally distributed across the experimental groups (χ^2_4=0.45, p=0.978), indicating that post-randomization exclusion did not affect group comparability. No duplicate responses were identified based on the information provided in the informed consent form. To ensure data quality, completion time and responses to the open-ended questions were used to identify potential automated or non-genuine responses [39]. This procedure did not result in any exclusions, as all respondents spent more than four minutes completing the survey and provided coherent responses to the open-ended items. All analyses were conducted using R software [40], using packages ordinal [41], multgee [42], and lme4 [43]. Analyses were organized according to a predefined hierarchy. The primary outcomes were purchase intention and perceived healthfulness of energy drinks. Secondary outcomes included

participants' perceptions of the effects of energy drink consumption, assessed through the CATA question. Analyses of warning-label recall and use, preference for warning labels, and responses to open-ended questions were considered exploratory.

Purchase intention and perceived healthfulness

Because each participant evaluated four energy drink cans, observations were nested within participants. To account for the resulting within-participant correlation, purchase intention and perceived healthfulness were analyzed using separate cumulative link mixed models (CLMMs) with a cumulative logit link and a participant-specific random intercept. Fixed effects included experimental group as the main independent variable, with adjustment for energy drink brand (well-known vs. lesser-known), energy drink variety (regular vs. zero-calorie), and individual-level covariates (gender, age group, education level, student status, employment status, region of residence, frequency of energy drink consumption, and perceived risk of energy drink consumption). Results are reported as odds ratios (ORs) with 95% confidence intervals (CIs). The contribution of the random intercept was confirmed via likelihood-ratio test against the corresponding fixed-effects-only model, and the proportional-odds assumption was tested for the experimental group variable.

As a sensitivity analysis, the same models were re-estimated using generalized estimating equations (GEE) for ordinal outcomes with an exchangeable correlation structure, providing a population-average alternative to the subject-specific CLMM estimates. Results did not differ materially in terms of the direction, magnitude, or statistical significance of the experimental group effects.

Perceived effects of energy drink consumption

Each perceived effect included in the check-all-that-apply question was analyzed as a separate binary outcome (selected = 1, not selected = 0). For each effect, a mixed-effects logistic regression model was fitted with experimental condition as the main independent variable, using the control group as the reference category. To account for the repeated evaluation of four

energy drink cans by each participant, models included a participant-specific random intercept. Fixed effects included the same energy drink characteristics (brand and product variant) and individual-level covariates (gender, age, education level, student status, employment status, region of residence, frequency of energy drink consumption, and perceived risk associated with energy drink consumption) considered in the primary analyses. Results are reported as ORs with 95% CIs. Because the nine perceived effects represented conceptually distinct outcomes rather than multiple indicators of a single underlying construct, no formal adjustment for multiple comparisons was applied.

Warning label perception

The percentage of participants who reported recalling the labels and using them to answer the questions was calculated for each experimental condition. Logistic regression models were estimated to assess differences among warnings. Experimental group was considered as the main independent variable and individual-level variables as covariates (gender, age group, education level, student status, employment status, region of residence, frequency of energy drink consumption, and perceived risk of energy drink consumption).

Responses to the multiple-choice question comparing the warnings in terms of effectiveness were analyzed using descriptive statistics. The percentage of participants who selected each warning as the most effective was calculated.

Responses to the open-ended questions regarding the warning labels were analyzed using qualitative content analysis based on an inductive coding approach [44]. Initially, one author developed the coding framework inductively from the data, without imposing predefined categories. The resulting framework was subsequently reviewed by a second researcher. Inter-coder discrepancies were identified in approximately 1% of the coded units and were resolved through discussion and consensus, resulting in minor refinements to category definitions. Once agreement on the final coding scheme had been reached, the entire dataset was coded and the resulting codes were subsequently grouped into higher-order categories that captured

conceptually related responses. To provide a descriptive overview of the qualitative findings and facilitate comparisons across experimental conditions, the proportion of participants who mentioned at least one response within each category was calculated.

Results

Participant characterization

A total of 340 participants completed the questionnaire and met the inclusion criteria. As shown in Table 1, most participants were female, aged 18–24 years, had incomplete university education, were both working and studying, resided in the capital city, and reported occasional consumption of energy drinks.

The number of participants per experimental group ranged from 59 to 80 (Table 1). No statistically significant differences in socio-demographic characteristics were observed across experimental groups, supporting the adequacy of the randomization procedure.

Primary outcomes: Energy drink perception

Purchase intention

The mean purchase intention across experimental conditions was 2.6, indicating a low-to-moderate level of intention and falling slightly below the midpoint of the scale (3 = maybe yes/maybe not). Table 2 shows results of the cumulative link mixed-effects models assessing the effect of the experimental warning label conditions on purchase intention, using the control group as the reference. Relative to the control condition, exposure to the tachycardia graphic warning label was associated with 44% lower odds of higher purchase intention, accounting for the within-participant correlation across the four evaluated cans and controlling for individual characteristics. The remaining warning label conditions (insomnia graphic, insomnia textual, and tachycardia textual) did not differ significantly from the control group.

Regarding control variables, brand emerged as a strong positive predictor of purchase intention, with well-known brands being associated with 520% higher odds of higher purchase intention scores compared to the less well-known brand. Sociodemographic characteristics

were not significantly associated with purchase intention. Energy drink consumption frequency was also significantly associated with purchase intention, such that participants with lower consumption frequency had lower odds of assigning higher purchase intention scores. Additionally, perceived risk of energy drink consumption was negatively associated with purchase intention, with 34% lower odds of reporting higher purchase intention for each one-point increase in perceived risk.

Perceived healthfulness

The mean perceived healthfulness score was 2.0, indicating that energy drinks were, on average, evaluated negatively, corresponding to “bad for health” on the scale. Results of the cumulative link mixed-effects models examining perceived healthfulness are shown in Table 2. Compared with the control group, only exposure to the graphic warning label depicting tachycardia was associated with significantly lower perceived healthfulness. Participants exposed to this warning had 70% lower odds of assigning a higher healthfulness rating than those in the control group, after accounting for the within-participant correlation arising from the evaluation of four cans and adjusting for individual characteristics. No significant differences in perceived healthfulness were observed for the insomnia graphic, insomnia textual, or tachycardia textual warning labels relative to the control condition.

Several control variables were significantly associated with perceived healthfulness. The well-known brand was associated with twice the odds of receiving a higher healthfulness rating compared with the less familiar brand. Similarly, the zero-calorie variety had 86% higher odds of being perceived as more healthful than its regular counterpart. Sociodemographic characteristics were not significantly associated with perceived healthfulness ratings. In contrast, participants who consumed energy drinks less than once a month had 95% lower odds of assigning higher healthfulness ratings than those who consumed energy drinks at least once a week. Finally, greater perceived risk associated with energy drink consumption was linked to

lower odds of providing higher healthfulness ratings, suggesting consistency between participants' pre-existing risk perceptions and their evaluations of the products.

Secondary outcome: Expected effects of energy drink consumption

Figure 3 presents the percentage of participants who selected each perceived effect of energy drink consumption included in the CATA question across experimental groups. Negative effects involving tachycardia, insomnia, and anxiety were frequently selected, with selection rates ranging from 52.6% to 63.3%. In contrast, increased energy and fatigue reduction were the most commonly endorsed positive effects, selected by 49.6% and 43.5% of participants, respectively. Only 9.9% of participants indicated that consuming the energy drink would have no effect on them.

The likelihood of selecting specific perceived effects of energy drink consumption was assessed using mixed-effect logistic regression models (Table 3). Compared with the control condition, none of the warning label conditions were significantly associated with the likelihood of selecting positive effects of energy drink consumption, including increased concentration, fatigue reduction, increased energy, and improved athletic or academic performance. In contrast, warning labels were consistently associated with a higher likelihood of selecting the negative health effects they highlighted. Compared with the control condition, exposure to the tachycardia graphic and tachycardia textual warning labels was associated with significantly higher odds of selecting tachycardia as an effect of energy drink consumption. In a similar vein, the insomnia graphic and insomnia textual warning labels were associated with an increased likelihood of selecting insomnia, relative to the control group.

Several covariates were significantly associated with the selection of both positive and negative effects (Table 3). Energy drinks from the familiar brand were more likely to be described as increasing concentration, reducing fatigue, and improving both athletic and academic performance, indicating more favorable evaluations of the well-known brand.

In terms of participant characteristics, those with lower frequencies of energy drink consumption had lower odds of selecting increased concentration and increased energy, suggesting that more frequent consumers were more likely to attribute functional benefits to these beverages. The zero-calorie variety and most sociodemographic characteristics were not significantly associated with the selection of positive effects. Notable exceptions included a higher likelihood of selecting improved athletic performance among males compared with females, and a higher likelihood of selecting fatigue reduction and increased energy among participants living in Montevideo compared with those residing elsewhere in the country.

Regarding negative effects, perceived risk of energy drink consumption was positively associated with the likelihood of selecting all negative effects (i.e., tachycardia, insomnia, and anxiety). In addition, participants with complete University or postgraduate studies were significantly more likely to select negative effects associated with energy drink consumption, including tachycardia, insomnia and anxiety, compared to those with complete secondary education or less. However, other sociodemographic variables showed no systematic patterns of association across negative outcomes. The only exception was gender, with males being less likely to indicate that energy drink consumption would cause anxiety compared to females.

Regarding energy drink characteristics, brand was not significantly associated with the likelihood of selecting negative health effects. However, the zero-sugar variety was associated with a lower likelihood of being linked to tachycardia and a higher likelihood of being associated with no effects of energy drink consumption.

Exploratory outcomes: Perception of warning labels

Self-reported warning recall and use

Among participants exposed to the warning labels, 63.3% reported recalling the labels, and of these, 72.0% indicated that they had taken them into account when answering the questions. No statistically significant differences in self-reported recall or use were observed across

warning label conditions. Additionally, individual-level variables were not significantly associated with either warning recall or use (Supplementary Material Table 1).

Opinions about the warning labels

As shown in Table 4, across all conditions, a substantial proportion of participants expressed positive evaluations of the warnings, highlighting their appropriateness and awareness-raising function, and in some cases their potential effectiveness in discouraging energy drink consumption. Participants also expressed support for mandatory implementation, viewing the warnings as a legitimate source of information to support informed consumer choice. Several respondents emphasized the accuracy of the messages, noting that they already known risks associated with energy drink consumption, while others drew comparisons with warning labels on cigarette packages and packaged foods and beverages, situating energy drink warnings within a broader regulatory context. With respect to format, participants frequently highlighted the impact of images in graphic warnings.

Despite these generally favorable perceptions, some participants described the warnings as ineffective or irrelevant, and in some cases argued that the messages were incomplete, as they failed to capture other relevant health risks. Others perceived the information as redundant, stating that the health effects were already widely known, while a subset regarded the warnings as exaggerated. In the case of insomnia-related warnings, some participants emphasized the low perceived severity of the health effect, and others framed insomnia as a potentially intended outcome of energy drink consumption, which undermined the perceived relevance of the warning.

Comparative perceived effectiveness

Warnings referring to tachycardia were most frequently selected as the most effective. The graphic tachycardia warning was chosen by 42.9% of participants, while the text-based tachycardia warning was selected by 31.2%. In contrast, insomnia-related warnings were

selected less often: 21.5% of participants chose the graphic insomnia warning, and only 4.4% selected the text-based insomnia warning.

As shown in Table 5, participants' justifications for selecting a warning as the most effective revealed clear differences according to both the type of health effect and the warning format. Overall, perceived effectiveness was strongly associated with the warning's capacity to increase risk perception, capture attention, and evoke emotional and cognitive responses.

Participants most commonly justified their selection of tachycardia warnings by referring to the perceived severity of the health effect, as well as the warnings' ability to raise awareness and attract attention. Tachycardia warnings were consistently framed as more effective because they were associated with a higher perceived health risk and greater potential severity, making them more compelling and persuasive. By contrast, insomnia-related warnings were often dismissed through references to the normalization of insomnia, with participants describing it as a common or manageable condition, or even as a desirable outcome of energy drink consumption. Nevertheless, participants who selected insomnia warnings as the most effective emphasized the importance of raising awareness about sleep-related harms.

Regarding label format, image-based warnings were primarily selected due to their visual salience and emotional impact, regardless of the health effect depicted. Participants frequently described these warnings as more noticeable and harder to ignore, highlighting their capacity to shock or generate strong reactions. In the specific case of the graphic tachycardia warning, participants underscored the value of depicting a real person experiencing health consequences, which was perceived as enhancing emotional engagement and awareness.

In contrast, text-based warnings were more often selected for their clarity and informational value. Participants who preferred text emphasized that these messages were less intrusive than images while still communicating the health risk.

Discussion

This study examined the effects of different types of warning labels on emerging adults' evaluations of energy drinks, focusing on purchase intention, perceived healthfulness, and the attribution of perceived effects of consumption. Overall, the findings showed that warning labels, particularly graphic tachycardia warnings, were effective in reducing perceived healthfulness and increasing the salience of adverse effects, while also decreasing purchase intention. These results are consistent with, and extend, existing evidence on the role of warning labels as public health tools [17, 24, 33, 34, 45–47].

Results showed that both the content of the health message and its format play a critical role in shaping consumers' interpretations and potential reactions to warning labels. The graphic tachycardia warning emerged as the only condition that differed significantly from the control, in line with participants' responses in the comparative evaluation task. Qualitative insights indicate that this result can be explained by two main factors: the perceived severity of the health effect and the graphic format, which heightened attention and emotional impact. These findings are consistent with evidence from tobacco control, alcohol, and sugary drink labeling, which shows that graphic warnings depicting salient physiological harms tend to exert stronger effects on intentions than text-only messages [24, 33, 34, 45, 47]. Moreover, the greater perceived effectiveness of cardiovascular-related warnings aligns with recent studies conducted among young adults in Australia, where warnings about heart-related risks were regarded as more impactful than those highlighting obesity [22, 23]. In terms of design, participants described graphic warnings as more attention-grabbing, intuitive, and difficult to ignore, echoing findings from eye-tracking research in the tobacco field [48].

The fact that the graphic tachycardia warning had a statistically significant effect on perceived healthfulness is consistent with previous studies examining the effects of caffeine warnings on perceptions of the safety of energy drinks [19, 20]. The findings also align with evidence from research on front-of-package nutrition labeling and health warnings on packaged foods and beverages, which indicates that warning labels are particularly effective in shifting

cognitive evaluations of product healthfulness, as well as purchase intentions [45, 46, 49]. Importantly, this result represents an improvement over the effects of octagonal warnings displaying the message “Contains caffeine,” which were previously found to increase purchase intention among Uruguayan adults [21].

Interestingly, the effects of the graphic tachycardia warning label observed in the present study emerged despite the use of well-established commercial brands. Previous research suggests that warning labels tend to be less effective when applied to familiar products, as brand familiarity can attenuate risk perception and reinforce positive associations built through repeated exposure and marketing [50]. In this context, the observed effects indicate that well-designed warnings, particularly those that are graphic and reference severe and personally relevant health risks, may partially counteract the protective influence of brand familiarity. This finding underscores the potential of warning labels and suggests that their impact may extend even to products with strong market presence and high consumer recognition.

The results from the logistic regression models performed on participants’ responses to the attribution of perceived effects of energy drinks consumption provided further insight into how warning labels influence consumers’ interpretations of energy drink effects. Warning labels were consistently associated with increased attribution of the negative effects they highlighted. This pattern is consistent with evidence from tobacco, alcohol, sugary drink warning labels, as well as nutritional warning labels on packaged foods, which suggests that warnings primarily operate by making the composition and health harms of products more salient on consumers’ mind [24, 45, 47, 51]. However, the effects of the warnings were highly specific: participants were more likely to endorse the particular health consequence featured in the warning, but not other negative effects. In addition, exposure to the warnings did not reduce the endorsement of positive effects, such as increased concentration or reduced fatigue. This pattern is consistent with prior studies on alcohol warning labels, which have found that warnings tend to increase

awareness of the risks they communicate without substantially weakening positive beliefs about the product [46, 47].

Although all warnings led to a significant increased likelihood of attribution of negative effects, only the graphic tachycardia warning led to significant reductions in perceived healthfulness and purchase intention compared to the control condition. Similar effects of warning labels have been reported in previous studies examining caffeine warnings [19, 20]. These findings are also consistent with broader evidence showing that warning labels tend to have stronger effects on cognitive evaluations than on behavioral intentions, although warnings that depict concrete, severe, and personally relevant health risks are more likely to influence consumption-related intentions [17, 24, 45–47]. The dissociation observed in the present study between attribution of negative effects and purchase intention reinforces prior evidence suggesting that changes in risk perception often precede, but do not guarantee, behavioral change, particularly for habitually consumed products.

Another noteworthy finding of the present study concerns participants' support for the implementation of warning labels on energy drinks, which mirrors previous research documenting substantial public support for warning labels on different product categories [52–54]. Public support has been identified as a key factor facilitating the adoption and sustainability of regulatory policies [55, 56]. The favorable attitudes expressed by participants suggest that such measures may be socially acceptable among emerging adults, a group that represents a key target population for energy drink consumption.

The results also provide emerging insights into the role of branding and consumption patterns in shaping perceived healthfulness and purchase intention for energy drinks. Consistent with prior research [57, 58], brand familiarity emerged as a strong determinant of consumer evaluations, with well-known brands associated with higher purchase intention, greater perceived healthfulness, and a lower likelihood of endorsing negative health effects. Similarly, frequency of energy drink consumption was positively associated with the

endorsement of both positive and no perceived effects. This pattern aligns with previous evidence indicating that energy drink consumption is positively associated with perceived benefits and inversely related to perceived risk [32]. Taken together, these findings underscore the importance of interventions aimed at increasing risk perception and attenuating the perceived benefits associated with energy drink consumption.

In closing, several limitations should be acknowledged. First, the study relied on a convenience sample of participants who took part without financial compensation, which may have resulted in an overrepresentation of individuals with a greater interest in health-related issues. In addition, the sample was largely composed of infrequent energy drink consumers, and the reliance on university mailing lists and social media platforms likely skewed the sample toward highly educated individuals. These characteristics may limit the representativeness of the sample and constrain the generalizability of findings, particularly to more frequent energy drink consumers and less educated populations. Findings should therefore be interpreted with caution in relation to these groups. Second, although the overall sample size was sufficient to detect differences in the main outcomes, the relatively small number of participants within each experimental condition limited statistical power for some of the regression analyses. This is reflected in the wide confidence intervals observed for several odds ratio estimates in the analysis of responses to the CATA questions, particularly for less frequently selected effects. Consequently, some associations may have been estimated imprecisely, and the absence of statistically significant effects for certain outcomes should be interpreted with caution. Third, study outcomes were based on self-reported perceptions and intentions rather than observed purchasing or consumption behaviors. Although measures were taken to minimize response bias, such as assessing purchase intention prior to health-related questions across all stimuli, responses may still be subject to social desirability bias. Fourth, the experimental design captured short-term responses and did not account for potential habituation or desensitization to warning labels over time. Fifth, perceived risk associated with energy drink consumption was

measured in the final section of the questionnaire. Consequently, participants' responses may have been influenced by prior exposure to the warning labels in the experimental groups. However, it is important to note that including perceived risk as a covariate in the statistical models did not alter the conclusions regarding the effects of the intervention. Models excluding perceived risk yielded the same results. Finally, the results did not demonstrate the statistical superiority of the graphic tachycardia warning labels over the other warning formats in terms of changes in perceived healthfulness and purchase intention. Further research is needed to better understand differences in the effectiveness of different warning types. In the present study, the warnings differed not only in the presence of an image but also in visual complexity, layout, and salience, making it difficult to attribute the observed effects specifically to the inclusion of the image. Despite these limitations, the study provides robust evidence that warning labels can shape health-related perceptions and, to a more limited extent, purchase intentions related to energy drink consumption.

Conclusions

In line with evidence from other regulated product categories, this study supports the use of warning labels as a public health strategy to increase awareness of the potential harms associated with energy drink consumption. While their influence on purchase intention may be limited, graphic warning labels highlighting the association between energy drink consumption and tachycardia may contribute to reduce perceived healthfulness and increasing recognition of negative health effects, outcomes that are essential for informed consumer decision-making.

The present study makes several novel contributions to the evidence base on energy drink warning labels. First, it provides experimental evidence from a Latin American context, a setting that has been largely underrepresented in the energy drink warning-label literature, demonstrating that the effects of these labels are not confined to high-income countries. Notably, the findings show that graphic warnings depicting severe cardiovascular harm can influence perceptions and purchase intentions even when applied to familiar, commercially

successful products. Second, the study provides insight into the mechanisms underlying the effects of warning labels on perceived healthfulness and purchase intentions. The results highlight the central role of perceived health-effect severity in shaping warning effectiveness, suggesting that warnings communicating more severe consequences may be more successful in influencing consumer responses. These findings have important implications for the design and prioritization of warning content. Taken together, the results provide actionable evidence for policymakers in Uruguay and other countries considering the implementation of mandatory health warnings on energy drinks, supporting the use of warning labels as a strategy to improve consumer awareness of potential health risks and promote more informed beverage choices.

Declarations

Ethics approval and consent to participate

The study was conducted according to the guidelines laid down in the Declaration of Helsinki. The full study protocol was approved by the Ethics Committee of the School of Chemistry of Universidad de la República, Uruguay (Protocol 101900-000041-24). Written informed consent was obtained through an online form.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare no competing interests.

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Authors' contributions

All authors were involved in the conception and design of the study, as well as in the interpretation of the results. GA, LA, MG, SG, JV, LV and LM participated in the acquisition of the data. LA, MG, SG, JV, and GA were responsible for data analysis. LA and GA drafted an initial version of the manuscript, to which all other authors made relevant contributions. All authors read and approved the final manuscript.

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Tables

Table 1. Socio-demographic characteristics of the participants, overall and separate by experimental group.

Characteristic	All participants (n=340)	Experimental group					χ^2 (p-value)
		Control (n=65)	Insomnia graphic (n=72)	Insomnia textual (n=59)	Tachycardia graphic (n=80)	Tachycardia textual (n=64)	
Gender							4.05
Female	225	44	54	36	52	39	(0.399
Male	115	21	18	23	28	25	)
Age							4.63
18-24 years	212	38	40	41	55	38	(0.328
25-30 years	128	27	32	18	25	26	)
Education level							5.75
Complete secondary school or less	91	13	19	13	25	21	(0.218
Incomplete University	195	39	37	37	45	37	)
Complete University or postgraduate studies	54	13	16	9	10	6	
Student status							4.81
Currently studying	214	47	42	38	45	42	(0.307
Not currently studying	126	18	30	21	35	22	)
Working status							3.36
Currently working	201	44	43	31	45	38	(0.500
Not currently working	139	21	29	28	35	26	)
Region of residence							5.63
Montevideo (capital city)	207	45	48	35	46	33	(0.229
Rest of the country	133	20	24	24	34	31	)
Frequency of energy drink consumption							7.87
Once a week or more	45	6	6	7	12	14	(0.446
1 to 3 times a month	68	13	13	14	18	10	)
Less than once a month	227	46	53	38	50	40	

Table 2. Effects of warning-label condition and control variables on purchase intention and perceived healthfulness of energy drinks, expressed as odds ratios (ORs) and 95% confidence intervals from cumulative link mixed-effects models.

Effect	Coefficient (p-value)	
	Purchase intention	**Perceived healthfulness**
Experimental group		
Insomnia – Graphic	0.69 [0.69-1.05]	0.42 [0.11-1.47]
Insomnia – Textual	0.75 [0.40-1.41]	0.35 [0.09-1.38]
Tachycardia - Graphic	0.56 [0.31-0.99]*	0.30 [0.10-1.00]*
Tachycardia – Textual	0.63 [0.35-1.12]	0.42 [0.12-1.40]
Energy drink brand		
Well-known brand	6.2 [4.9-7.9]*	2.00 [1.48-2.72]*
Energy drink variety		
Zero	0.85 [0.69-1.05]	1.86 [1.37-2.52]*
Gender		
Male	0.83 [0.54-1.27]	1.02 [0.41-2.49]
Age		
25-30 years	0.85 [0.54-1.27]	1.33 [0.488-3.67]
Education level		
Incomplete University	1.10 [0.65-1.84]	0.49 [0.17-1.49]
Complete University or postgraduate studies	1.33 [0.67-2.64]	0.62 [0.14-2.78]
Student status		
Currently studying	1.38 [0.84-2.27]	1.02 [0.35-3.00]
Working status		
Currently working	1.40 [0.91-2.16]	1.24 [0.49-3.15]
Region of residence		
Montevideo (capital city)	0.92 [0.61-1.36]	1.38 [0.59-1.36]
Frequency of energy drink consumption		
1 to 3 times a month	0.40 [0.20-0.80]*	0.26 [0.06-1.10]
Less than once a month	0.08 [0.04-0.15]*	0.05 [0.01-0.20]*
Perceived risk of energy drink consumption	0.66 [0.51-0.85]*	0.05 [0.03-0.10]*

Notes: Models included participant-specific random intercepts to account for repeated evaluations of four energy drink cans by each participant. The reference level in the models were: Experimental group (control), Energy drink brand (lesser-known brand), Energy drink variety (regular), Gender (female), Age (18-24 years), Education level (Secondary school or less), Student status (not currently studying), Working status (not currently working), Region of residence (Rest of the country), Frequency of energy drink consumption (Once a week or more). Perceived risk of energy drink consumption was measured as a continuous variable on a 5-point scale. ORs significantly different from 1 at a significance level of 0.05 are highlighted with *.

Table 3. Results of the mixed-effect logistic regression models assessing the association between warning label conditions and likelihood of selection of perceived effects of energy drink consumption in a check-all-that-apply question, adjusted for product characteristics and individual covariates.

Effect	Odds-ratio [95% confidence interval]								
	Increased concentration	Fatigue reduction	Increased energy	Improvement in athletic performance	Improvement in academic performance	Tachycardia	Insomnia	Anxiety	No effect
Experimental group									
Insomnia – Graphic	0.95 [0.13-7.09]	1.04 [0.22-4.85]	2.93 [0.72-11.84]	0.82 [0.05–13.29]	0.61 [0.03–14.84]	2.29 [0.11-44.13]	17.45 [1.13–269.06]*	4.35 [0.40-47.63]	0.64 [0.05–7.54]
Insomnia – Textual	0.93 [0.11-8.09]	2.04 [0.40-10.42]	2.52 [0.58-10.81]	2.31 [0.16–34.28]	0.44 [0.01–13.59]	18.53 [0.90-383.98]	88.02 [5.63–1375.61]*	7.14 [0.57-88.86]	0.47 [0.03–7.29]
Tachycardia - Graphic	0.81 [0.12-5.33]	0.75 [0.18-3.09]	1.61 [0.44-5.85]	0.60 [0.05–8.00]	0.29 [0.01–5.95]	224.42 [13.83-3640.79]*	8.48 [0.78–91.82]	7.25 [0.85-61.93]	0.14 [0.01–2.56]
Tachycardia – Textual	1.76 [0.25-12.33]	0.77 [0.18-3.31]	2.43 [0.641-9.18]	1.04 [0.07–14.75]	2.54 [0.14–47.00]	88.13 [5.51-1408.97]*	1.80 [0.16–20.62]	2.99 [0.33-27.01]	0.10 [0.00–2.41]
Energy drink brand									
Well-known brand	3.83 [2.17-6.78]*	2.14 [1.48-3.10]*	2.07 [1.46-2.94]	3.16 [1.61–6.18]*	10.96 [4.25–28.24]*	0.92 [0.58-1.46]	0.86 [0.56–1.32]	0.98 [0.65-1.48]	0.52 [0.25–1.07]
Energy drink variety									
Zero	1.11 [0.65-1.88]	0.89 [0.62-1.28]	0.75 [0.53-1.06]	0.70 [0.37–1.32]	2.06 [0.91–4.70]	0.57 [0.36-0.91]*	0.50 [0.32–0.77]	0.59 [0.39-0.90]	2.78 [1.33–5.81]*
Gender									
Male	2.04 [0.49-8.57]	2.11 [0.72-6.24]	0.89 [0.34-2.31]	6.96 [1.09–44.65]*	2.72 [0.35–21.46]	0.82 [0.12-5.80]	1.87 [0.35–10.05]	0.05 [0.01-0.37]*	0.56 [0.07–4.45]
Age									
25-30 years	0.51 [0.10-2.76]	1.76 [0.53-5.84]	0.35 [0.12-1.04]	0.26 [0.02–2.69]	0.47 [0.04–6.32]	0.13 [0.01-1.19]	1.20 [0.18–8.11]	0.29 [0.04-1.89]	1.14 [0.14–9.64]
Education level									
Incomplete University	1.65 [0.26-10.37]	0.90 [0.24-3.39]	1.72 [0.53-5.65]	0.60 [0.06–5.74]	0.55 [0.04–7.33]	4.30 [0.39-47.28]	3.35 [0.39–29.10]	3.59 [0.45-28.90]	0.60 [0.05–7.22]
Complete University or postgraduate studies	6.31 [0.51-78.12]	2.32 [0.38-14.00]	1.62 [0.33-7.89]	3.53 [0.10–121.73]	2.41 [0.06–93.33]	168.19 [5.64-5014.73]*	40.89 [2.41–695.03]*	27.34 [1.72-433.62]*	0.31 [0.01–7.42]
Student status									
Currently studying	1.91 [0.33-11.06]	2.18 [0.60-7.94]	1.00 [0.32-3.14]	2.38 [0.24–23.79]	1.90 [0.15–24.56]	0.29 [0.03-2.93]	0.73 [0.10–5.45]	0.49 [0.07-3.54]	0.30 [0.03–3.21]
Working status									
Currently working	0.70 [0.16-3.08]	1.54 [0.51-7.94]	0.92 [0.34-2.51]	0.17 [0.02–1.43]	0.49 [0.05–5.14]	0.71 [0.10-4.92]	0.16 [0.02–1.00]	1.15 [0.20-6.50]	0.92 [0.11–7.43]
Region of residence									
Montevideo (capital city)	1.93 [0.48-7.76]	2.91 [1.04-8.13]*	4.15 [1.77-11.24]*	1.63 [0.26–10.22]	0.96 [0.11–8.18]	1.55 [0.27-8.99]	0.57 [0.12–2.77]	1.55 [0.33-7.24]	1.67 [0.24–11.71]
Frequency of energy drink consumption									
1 to 3 times a month	0.02 [0.00-0.29]*	0.35 [0.06-2.01]	0.71 [0.15-3.32]	0.07 [0.00–1.53]	0.26 [0.01–4.56]	0.17 [0.00-6.82]	0.23 [0.01–3.89]	1.31 [0.09-18.13]	0.29 [0.01–5.96]
Less than once a month	0.01 [0.00-0.09]*	0.20 [0.04-1.02]	0.22 [0.05-0.92]*	0.01 [0.00–0.31]	0.05 [0.00–0.74]	6.22 [0.30-130.53]	1.65 [0.14–20.08]	4.15 [0.36-47.89]	0.34 [0.03–4.57]
Perceived risk of energy drink consumption	0.72 [0.30-1.73]	0.38 [0.20-0.75]*	0.86 [0.47-1.55]	0.75 [0.23–2.41]	0.56 [0.14–2.23]	6.86 [1.86-25.29]*	4.09 [1.38–12.13]*	4.26 [1.51-12.00]*	0.72 [0.21–2.49]

Notes: Models included participant-specific random intercepts to account for repeated evaluations of four energy drink cans by each participant. The reference level in the models were: Experimental group (control), Energy drink brand (lesser-known brand), Energy drink variety (regular), Gender (female), Age

(18-24 years), Education level (Secondary school or less), Student status (not currently studying), Working status (not currently working), Region of residence (Rest of the country), Frequency of energy drink consumption (Once a week or more). Perceived risk of energy drink consumption was measured as a continuous variable on a 5-point scale. ORs significantly different from 1 at a significance level of 0.05 are highlighted with *.

Table 4. Percentage of participants who mentioned responses corresponding to the categories identified in the content analysis when expressing their opinion about the warning label they were assigned.

Category	Examples of responses	Insomnia – Graphic	Insomnia - Textual	Tachycardia - Graphic	Tachycardia - Textual
Perceived appropriateness	"It's good that it's there", "It's excellent", That way people can decide taking the information into account"	19.8	27.9	33.8	48.8
Risk awareness and informative function	"They warn about risks", "Inform about the effects", "Quite informative"	24.4	25.0	36.5	36.3
Clarity and brevity of the message	"Appropriate", "short and clear message", "Relevant"	25.6	22.1	17.6	7.5
Perceived ineffectiveness	"It doesn't generate an effect on consumption", "In most cases it's not taken into account", "consumers often don't pay the attention they should to these warning signs"	8.1	17.6	16.2	13.8
Perceived accuracy	"Correct", "The insomnia claim is real", "True", "A possibly common effect of energy drinks"	11.6	13.2	2.7	12.5
Conditional risk interpretation	"I don't consume these drinks frequently, only occasionally, and in my case I don't think it would cause major harm to my health", "The warning is appropriate for people prone to heart problems", "It doesn't always have that effect", "Insomnia depends more on other factors"	9.3	2.9	9.5	11.3
Perceived incompleteness of the message	"There are other effects (for example heart rate issues / tachycardia, anxiety, etc.), sleep disorders, cardiac risks", "It's incomplete"	8.1	14.7	4.1	0.0
Comparison with warnings on cigarettes	"It is similar to warnings on cigarettes", "It simulates what they put on cigarette packages"	7.0	5.9	6.8	3.8
Perceived effectiveness	"Effective", "It could influence some people's decision", "Useful to reduce consumption"	9.3	2.9	6.8	2.5
Suggestions to improve the warning	"It should be more sober", "It's very abrupt and not very serious", "I would use more colors so it draws more attention"	3.5	5.9	5.4	5.0
Lack of familiarity	"Cans in Uruguay don't have them", "I had never seen them before"	0.0	5.9	4.1	7.5
Reference to warning signs on packaged foods	"They are as important as in everyday foods", "I agree as with octagons"	0.0	11.8	0.0	5.0
Perceived redundancy of information	"Most people already know the effects", "It's obvious", "We all know it's harmful"	7.0	5.9	0.0	3.8
Lack of knowledge on health effects of energy drinks	"Many of us don't know everything it causes or we don't see its effects", There is a lot of misinformation circulating about these drinks"	1.2	4.4	2.7	6.3
Perceived exaggeration	"Excessive", "Exaggerated", "Extremist"	3.5	2.9	5.4	2.5
Perceived relevance for younger populations	"It would be important for all young people to read it", "There is a lack of discouragement of use among minors"	4.7	2.9	2.7	3.8
Low perceived severity of the health effect	"Insomnia is not that concerning", "I don't think it's an adverse effect", "I don't know if people consider it a problem"	4.7	8.8	0.0	0.0
Support for mandatory implementation	"It should be on all cans on the market", "It should be mandatory for all energy	2.3	1.5	4.1	5.0

	drinks to have it"				
Impact of graphic elements	"The image causes rejection", "it makes you think twice before buying it", "The image is impactful"	8.1	0.0	4.1	0.0
The warning depicts intended effects of energy drinks	"That's what I use it for", "Excessive use to avoid sleeping or to be more productive"	2.3	8.8	0.0	0.0
Perceived irrelevance	"Unnecessary", "Indifferent in my case", "Insignificant"	3.5	4.4	1.4	0.0
Others	"I drink energy drinks for their flavour", "Minors still can buy them"	12.8	2.9	1.4	3.8

Table 5. Percentage of participants who mentioned responses corresponding to the categories identified in the content analysis when justifying their choice of the most effective label.

Category	Examples of responses	Insomnia – Graphic (n=73, 21.5%)	Insomnia – Textual (n=15, 4.4%)	Tachychardia – Graphic (n=146, 42.9%)	Tachychardia – Textual (n=106, 31.2%)
Attentional capture and effectiveness of images	"Images catch attention", "People react to graphical images", "Images connect more with people"	81.0	0.0	45.2	0.0
Perceived severity of tachycardia	"The heart is more striking", "Heart problems carry more weight than insomnia"	3.8	0.0	40.8	34.2
Impact and shock value	"Shocking image", "The image has more impact", "The image is very striking"	49.4	0.0	15.9	3.5
Awareness raising	"I think that when people read 'tachycardia' they would be more alert", "It produces more awareness", "It generates more fear"	8.9	12.5	17.8	21.9
Attentional capture	"It draws more attention", "It seems more eye-catching"	13.9	0.0	14.0	18.4
Perceived effectiveness of the image of a person	"Maybe because there's an image of a person", "Seeing a person would generate more effect", "Real image"	27.8	0.0	12.1	0.0
Raises awareness about insomnia	"We need to pay more attention to insomnia", "The sleep cycle is a very important aspect of life"	7.6	25.0	0.0	0.0
Message clarity and brevity	"Clear message", "Important message", "It directly shows the problem it causes"	3.8	6.3	2.5	19.3
Perceived ineffectiveness of images	"Images have no effect", "People won't pay attention to images of people", "Photos take away seriousness"	0.0	6.3	0.0	25.4
Focus on the most relevant health effects	"It better informs about the most important dangers of energy drinks", "It warns about their real effect on health", "It's the most common case of consequences when consuming"	5.1	6.3	8.3	9.6
References to cigarette warnings	"It is impactful as warnings on cigarette packages", "Similar to the strategies from cigarette packaging"	8.9	6.3	5.1	7.0
Insomnia may be a desired effect	"Insomnia can be seen as an advantage", "Maybe staying awake is the desired effect"	2.5	0.0	7.6	14.9
Perceived intrusiveness of images	"An image seems more invasive than something written", "It's not invasive advertising, even if that is the goal"	0.0	18.8	0.0	5.3

Perceived ineffectiveness of the warnings	"Nobody pays attention to this type of signs", "None would work but I had to choose one"	8.9	6.3	2.5	2.6
Use of real person suffering the consequences	“Image with a person suffering consequences: the image makes it more tangible and personal”, “I think having a person in the warning creates a closer connection”, “Humans empathize more with other humans”	0.0	0.0	0.0	19.3
Normalization of Insomnia	"Insomnia is temporary", "Uruguayans tend to sleep few hours and go to bed very late, they’re not afraid of insomnia"	0.0	0.0	8.3	5.3
Perceived informational value of images	"You don’t need to read to know it’s bad", The use of visual images directly linked to the consequence of energy drink consumption facilitates understanding"	1.3	0.0	3.8	0.0
Suggested changes	"Please don’t use AI", "If children consume more, use images of children", "Warning symbol in red"	0.0	0.0	3.2	1.8
Perceived informational value of text and image	"Combining text and image", "It is understood more completely with the image"	1.3	0.0	2.5	0.0
Others	"It happened to me that I got tachycardia once", “These images could also be included on alcoholic beverages”	1.3	0.0	5.7	4.4
No response		1.3	0.0	3.2	3.5

Figures

Figure 1. Warning labels evaluated in the study: (a) graphic warning about insomnia, (b) text-only warning about insomnia, (c) graphic warning about tachycardia and (d) text-only warning about tachycardia. Both, textual and graphic formats, contain the text "WARNING Energy drink consumption can cause [health effect]".

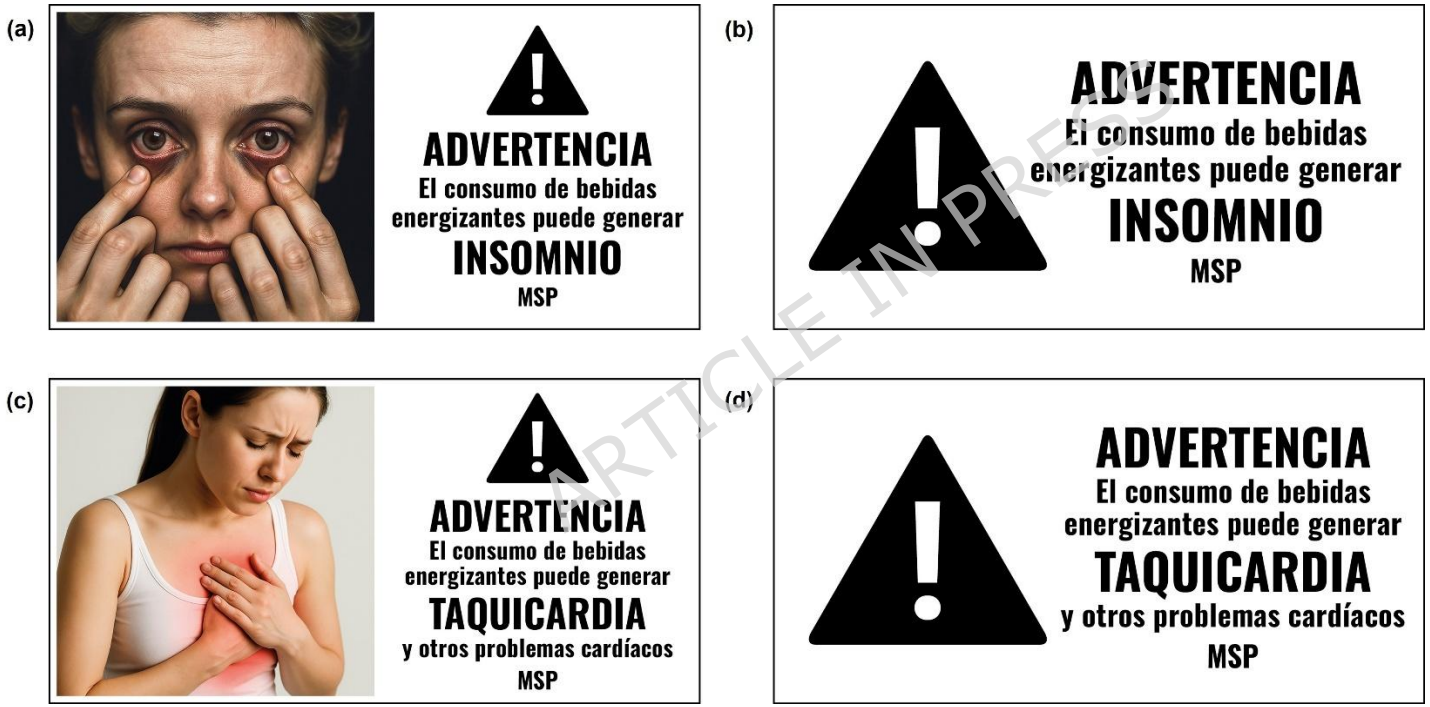
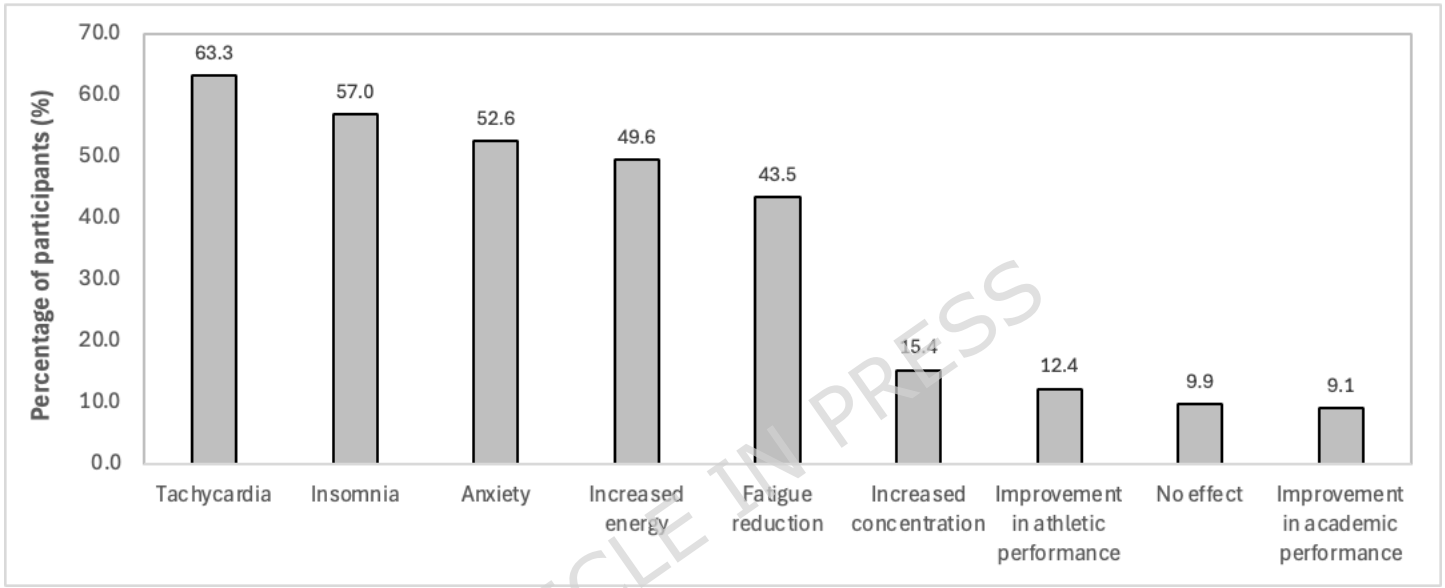


Figure 2. Example of the stimuli presented to one of the experimental groups (those assigned to the graphic warning about insomnia). Cans (a) and (b) corresponded to the market-leading brand (Monster) in its regular and zero-added sugar variant, respectively, while (c) and (d) corresponded to a lesser-known brand (Baly) in its regular and zero-added sugar variant, respectively. Panel (e) shows an example of one of the stimulus presented to the control group, in which no warning label was displayed.

(a) (b) (c) (d) (e)

Figure 3. Percentage of participants who selected each of the effects of energy drink consumption included in the check-all-that-apply question across experimental groups.



Supplementary Material

Table 1. Results of the logistic regression models assessing the association between experimental group and warning recall and use, adjusted for product characteristics and individual covariates.

Effect	Odds-ratio [95% confidence interval]	
	Warning recall	**Warning use**
Experimental group		
Insomnia – Textual	0.88 [0.74-1.04]	0.85 [0.70-1.04]
Tachycardia - Graphic	0.86 [0.72-1.01]	0.99 [0.81-1.21]
Tachycardia – Textual	0.92 [0.78-1.08]	0.92 [0.76-1.11]
Gender		
Male	1.04 [0.92-1.18]	0.96 [0.83-1.11]
Age		
25-30 years	1.05 [0.91-1.21]	0.92 [0.77-1.10]
Education level		
Incomplete University	0.83 [0.67-1.02]	1.20 [0.93-1.56]
Complete University or postgraduate studies	0.96 [0.82-1.13]	1.01 [0.84-1.21]
Currently studying		
Yes	0.97 [0.83-1.13]	1.00 [0.83-1.21]
Currently working		
Yes	0.90 [0.78-1.03]	0.95 [0.81-1.11]
Region of residence		
Montevideo (capital city)	1.02 [0.90-1.15]	0.96 [0.83-1.11]
Frequency of energy drink consumption		
1 to 3 times a month	1.11 [0.90-1.35]	0.79 [0.62-1.00]
Less than once a month	1.12 [0.93-1.34]	0.93 [0.76-1.17]
Perceived risk of energy drink consumption	0.93 [0.86-1.01]	1.00 [0.91-1.10]

Notes: The reference level in the models were: Experimental group (Insomnia - Graphic), Gender (female), Age (18-24 years), Education level (Secondary school or less), Student status (not currently studying), Working status (not currently working), Region of residence (Rest of the country), Frequency of energy drink consumption (Once a week or more). Perceived risk of energy drink consumption was measured as a continuous variable on a 5-point scale.