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Title page

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Recent Time Trends in Energy Drinks Consumption Among Adolescents in Norway.

Background: In Norway, sales of energy drinks (EDs) increased with >50% from 2017 to 2019. EDs are caffeinated beverages marketed as performance boosters and have been linked to various potential adverse effects. This study describes the extent and trends in ED consumption among Norwegian adolescents in 2017, 2018 and 2019.

Methods: National data from annual youth surveys with 278,891 respondents in lower and upper secondary school was analyzed identifying time trends and determinants for ED consumption.

Results: Over the three-year period, 88,373 (66.4%) of the males and 57,816 (41.8%) of the females had consumed ED once a week or more. Of the ED consumers, 10.8% of the males and 4.2% of the females were high consumers. The proportion of female high consumers increased from 3.3% to 4.9% from 2017-2019; for males, the increase was from 9.8% to 11.5%. This corresponds to 23% and 6% average annual increase among girls and boys, respectively. Any consumption as well as high ED consumption were independently associated with school level, rural residency, low socioeconomic status, physical inactivity and high leisure screen time.

Conclusion: We observed an increase in high consumers among both boys and girls from 2017-2019. ED consumption adds to an already unhealthy behavior in certain adolescents.

Article summary

Strengths and limitations of this study:

- This study demonstrates recent time trends in the frequency at which energy drinks are consumed among adolescents in Norway.
- Data are derived from a large, annual, national survey in Norway with close to 300,000 adolescents participating in the study.
- The study relies on self-reported energy drink consumption which can be susceptible to both recall bias and social desirability bias.

Being marketed as a booster of mental and physical capacity, energy drinks (EDs) have gained worldwide popularity. In Norway, ED sales increased by more than 50% from 2017 to 2019 (1). EDs are defined as non-alcoholic beverages that contain at least 150 mg caffeine per liter, in addition to sugar combined with one or more substances known to have stimulant properties (2-4). Moreover, vitamins, minerals, and amino acids are often added to EDs (4). ED marketing is often targeted toward sports and the adolescent population. Moreover, increased odds of ED consumption have been found among viewers of channels targeted by ED advertisers (5-7). Zucconi et.al found that 41% of European adolescents consumed EDs for physical activity purposes (2).

ED consumption among children and adolescents has been linked to potential negative effects such as increased sleep disturbance resulting in tiredness, inattention, reduced school performance, and increased mental distress (8-10). It is mainly the high caffeine content in EDs combined with the sugar content and sweet flavor, and high content of stimulating substances which is giving rise to concern (11). It has been argued that this combination of ingredients may cause faster uptake of caffeine into the blood compared to regular coffee (11). Moreover, studies have indicated that adding caffeine to sugar-sweetened beverages (SSB) leads to increased use of SSBs, which in turn results in increased energy intakes (12, 13). Increased energy intake may eventually result in overweight and obesity, next to dental caries due to the high sugar and citric acid content of ED and SSBs (14).

In 2013, the European Food Safety Authority (EFSA) published a report on ED use, indicating that children and adolescents aged 10-18 years had the highest reported consumption (68%), compared with adults above 18 years (30%) and children below 10 years (18%) (3).

The potential negative short and long-term effects of ED in children and adolescents have gained attention of government authorities in several countries, of which some have issued restrictions on the caffeine content in EDs (15). The Norwegian Food Safety Authority (NFSA) has stated that the daily intake of caffeine for children and adolescents should not exceed 2.5 mg/kg. This was decided based on a review of current knowledge by the Norwegian Scientific Committee for Food and Environment (VKM) (4).

According to the findings of the VKM review, a child or youth would have a risk of sleep disturbance with an intake of 1.4 mg/kg bodyweight/day of caffeine (4). Furthermore, the risk of negative health effects affecting the heart and central nervous system would be present at an intake of 3 mg/kg bodyweight/day of caffeine. This would mean that a 13-15 years old adolescent with an average weight of 50 kg would be at risk of sleep disturbance when drinking more than 70 mg/day of caffeine and at risk of adverse cardiac and central neurologic effects at a daily consumption of 150 mg/day. These values are in line with recommendations by EFSA and correspond to an intake of one to two large cans (500ml) of ED for an adolescent described above (4).

ED consumption varies according to age and gender. Several studies have found that male adolescents are more likely to consume EDs than their female counterparts. Moreover, young (male) adolescents have a higher ED consumption rate than older adolescents at high school level (3, 16, 17). Furthermore, Degirmenci et al. found that high consumption (> 4 times a week) of ED was independently associated with male gender, physical inactivity, high leisure screen time, low socioeconomic status and rural residency (18).

Of special concern for potential adverse effects are children and adolescents who have lower body weight, and are less adapted to ED stimulants, including caffeine. According to the

American Academy of Pediatric; “Caffeine and other stimulants contained in energy drinks have no place in the diet of children and adolescents”(19). Given the aforementioned increased sales of ED in Norway, it is still unclear to which extent the consumption of ED among children and adolescents parallels this development (15). The objective of the current study is therefore to describe the extent and trends in ED consumption among Norwegian adolescents in 2017, 2018 and 2019, according to age, gender, socio-economic status (SES), residency, physical activity, and leisure screen-time.

METHODS

Study design and participants

Data for the study was collected through the Ungdata survey, a national representative survey, mapping the health and well-being of lower and upper secondary school students in Norway. The study was predefined according to the Norwegian Centre for Research data. Detailed information regarding the survey can be found on www.ungdata.no (20). All data collection is conducted anonymously and web-based during school hours with the teacher present in the classroom. Data from the surveys carried out in 2017, 2018 and 2019 were used for the present study. The study was approved by the Norwegian Centre for Research Data.

All municipalities in Norway are invited to participate in the Ungdata survey. Participation is free of charge and on a volunteer basis. The municipalities are encouraged to perform the survey every third year to ensure that all adolescents get to participate once both during lower (8^{th} to 10^{th} grade) and upper (11^{th} to 13^{th} grade) secondary school. The three-year interval is not a strict rule, which means that some municipalities participated twice and some all three years (2017-2019). In the present study, information from all municipalities were included regardless of how many years they participated. It is therefore possible that some adolescents responded twice or thrice. In total, we have data from 454 municipalities, 333 participated only once, 59 twice, and one municipality participated all three years.

In Norway, children start school the year they turn six years old (grade 1) and stay in school until the age of 15-16 years (grade 10). Attending school is obligatory by law until the completion of grade 10 whereas attending subsequent grades is voluntary. National

statistics show that the majority of 16-18 year olds (93.4% in 2019) go on to attend upper secondary schools (21).

A total of 297,102 adolescents from both lower and upper secondary school participated in the Ungdata surveys from 2017, 2018 and 2019. Of these, 278,891 answered the questions on ED consumption (93.9%) and were included the analyses. The overall participation from the total number of eligible students to those who answered the ED question was 74.4% over the three-year period. See figure 1 for more details.

The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). It does not have its own ID as data collection was done anonymous and does not contain sensitive information. The study was funded by Innlandet Hospital Trust (project number: 150377).

Measures

The Ungdata survey is an electronic questionnaire with a fixed section and an elective section. In 2017, 2018 and 2019, the fixed section consisted of 159 questions for lower secondary students and 168 questions for the upper secondary students (22). For the purpose of this article, selected questions from the fixed section were used.

The following variables were selected for the analyses in the present study: ED consumption, grade, gender, year, residency, SES, frequency of physical activity and leisure screen time. All variables were self-reported.

ED consumption was assessed with the question “How often do you usually drink energy drinks (Red Bull, Battery etc.)?” The participants could respond with one of seven incremental options, ranging from “never” to “several times a day”. The response to this

question was used to categorize adolescents into the following two groups subsequently used as outcome variables: ED consumers (ED ≥ once a month) and high ED consumers (ED ≥ 4 times a week). The ED consumers were compared to non-ED consumers, and the high ED consumers were compared to the rest (all other frequency of ED consumption including non-ED).

Leisure screen time was assessed using the question "Outside school, how much time do you normally spend on activities that involve looking at a screen (TV, computer, tablet, mobile phone) each day?" with options on a seven-point incremental scale ranging from "no time" to "more than six hours". The three lower options of the variable leisure screen-time were merged into one response of "less than two hours" due to the relatively low number of respondents in these categories.

Physical activity was assessed by the question "How often do you perform physical activity which gets you out of breath or makes you sweaty?" with options on a six-point incremental scale ranging from "never" to "at least five times a week".

SES was assessed according to a five-point scale which again was based on a compound score from three different dimensions (22, 23). These dimensions were: parental education, "culture capital" at home based on the question "how many books do you think there are in your home?", and the third dimension used four questions from the Family Affluence Scale (FAS II). FAS II contains questions regarding the number of cars in the family, whether the participant has her/his own bedroom, whether the participant has been on vacation and the number of computers/tablets in the house. The answers were assigned different points that were subsequently used to calculate a total score distributed into five equally sized groups. Group 1 refers to the lowest SES-score and group 5 to the highest.

For the purpose of this study, we used the official Norwegian centrality index to define residency. According to Statistics Norway, centrality is a term used to describe an index that is divided into 6 groups. Group 1 contains the most central municipalities (highest index) and group 6 the least central (lowest index) (24). The calculation of the index is based on travel time to workplaces and service functions from all populated basic units. Residency for each individual is based on where the adolescent attends school.

Statistical analyses

The association between the various exposure variables were generated using multiple regression models. We used a binomial distribution family and log and identity link functions to generate relative risk and risk differences, respectively. Thus, associations were estimated both on an additional and multiplicative scale. When the binomial models did not converge, we used multiple Poisson regression models to estimate risk ratios (25-27). In these analyses, the sandwich estimation method was used when creating the robust standard errors (25). We also included interaction terms between year and gender to estimate the extent to which these variables modified each other's association with the outcomes. In other words, we assessed if the association between gender and energy drinks differed by year and the extent to which the association between year and the consumption of ED differed by gender. The independent variables in the statistical models were decided *a priori* and consisted of: gender, year, grade, residency, SES, frequency of physical activity and leisure screen time. The dependent variables were 1) any consumption of ED and 2) high ED consumers. Values are given as relative risk (RR) with 95% confidence intervals (CI).

The interactions were also estimated on an additive scale using the relative excess risk due to interaction (RERI) to calculate the risk difference, and in generalized linear models with the binomial distribution family and identity link function (28). We used the likelihood ratio test to test the significances of the interaction terms. STATA version 15.1 (College Station, Texas) was used for all statistical analysis (29).

RESULTS

In total, 278,891 adolescents who participated in Ungdata answered the question about ED use and were included for further analyses. Most of the adolescents attended lower secondary school (Table 1). Grade thirteen was the least represented grade in the sample, which is in line with previous findings from the Ungdata survey (22).

In 2017, missing values for gender was 6.4% compared to less than 1% in 2018 and 2019. This is likely due to the order of questions in the electronic questionnaire, which led to overlooking of the question regarding gender in the 2017 survey. This ordering of questions was changed in 2018 and 2019 (personal correspondence with staff from Ungdata).

Most of the participants lived in municipalities with the centrality index two and three. The distribution seen in Table 1 is comparable to the overall distribution of the centrality index in Norway (30). The lesser percentage in level six was expected, as there are fewer people living in these areas.

Between 20-30% of the participants reported performing some kind of physical activity where they get sweaty either 1-2, 3-4, or more than 5 times a week, while less than 10% reported 1-2 times a month or less. In addition, almost 30% of the participants spent 3-4 hours daily looking at a screen outside school time, a little more than 20% 4-6 hours daily, while more than 10% spent 6 hours or more daily on this activity.

Overall, 25% of the participants had been drinking ED less than once a week. Around 10% had been drinking ED either once or 2-3 times a week. Almost 5% of the participants reported drinking ED 4-6 times a week, while 1.5% answered that they consumed ED every day or several times a day.

Energy drink consumption among boys and girls

Over the three years, there was a small decrease in the percentage of boys consuming ED from 67.3% (2017) to 65.7% (2019). Among girls, a small increase was found from 40.8% (2017) to 43.6% (2019) (Table 2a). However, high consumers of ED increased among both boys and girls (Table 2b). In 2017, 9.8% of the boys and 3.3% of the girls reported ED consumption in the range of high consumers, while these percentages increased to 11.5% in boys and 4.9% in girls in 2019.

Proportion of energy drink consumption

The Poisson regression models (Table 3) revealed several possible risk factors for being a high ED consumer. The proportion of female high ED consumers increased by an average of 23% per year. There was also an increase in the proportion of high consumers of ED in boys, however, this increase was lower at 10% per year. On a multiplicative scale, the interaction between gender and year was statistically significant (Table 3). In other words, the increase among girls in the high ED consumption group was larger relative to the increase among boys in the same group. On an additive scale, however, there was no interaction as the difference in percentage points were almost identical (1.7 in boys and 1.6 in girls).

The largest proportion of high ED consumers was found in participants living in centrality index 6. Furthermore, we found a larger proportion of high ED consumers with decreasing SES. The same association was found when looking at the any ED consumption group, however, differences were less pronounced.

Compared with the participants who reported never being physically active, the proportion of high ED consumers was 50% lower for the participants who were physically active 1-2 times a week.

The proportion of high ED consumers that spent more than 6 hours looking at a screen outside school hours was three times higher than the high ED consumers that spent less than 2 hours looking at a screen. Regarding the participants who consumed any ED, the proportion increased with increasing leisure screen time.

DISCUSSION

We found an increase in the percentage of both boys and girls being high ED consumers and a change in ED consumption according to time. We found that in total, over the three-year period, 4.2% of the girls and 10.8% of the boys were high ED consumers. There was also an annual increase in the proportion of high consumers that was most pronounced for girls increasing from 3.3% in 2017 to 4.9% in 2019. Moreover, we found that more than half of the adolescents participating in the study had consumed any ED during these three years.

In line with our expectation, we observed that the typical high ED consumer was male, had a lower SES, lived less central, spent more than 6 hours daily watching a screen, and was either not physically active or very physically active. The combination of either low or high physical activity and high leisure screen-time as predictors for ED consumption was also found in other studies from Saudi Arabia, Canada, and the U.S (3, 16, 31-33). Al-Hazza et. al proposed that the reason for why both low and high physical activity and high leisure screen-time was observed, is due to how EDs are being marketed (31). As mentioned before, this may, be due to the fact, that EDs are often marketed as boosters of an active lifestyle and higher performance. Our results also suggest that adolescents who spend much of their free time watching screens are those who consume most EDs.

Regarding the gender difference in high ED consumption, one could hypothesize that because of the marketing trends of ED focusing on masculinity and risk-taking behavior, boys are more likely to be influenced by this marketing strategy (7). However, as time passes, girls follow and adapt the same behavioral pattern, which has also been observed in other studies regarding risk taking behavior (34). This observation highlights that despite boys still being the highest consumers of ED, the increase in the proportion of female high-consumers

was larger, on a multiplicative scale but not an additive scale, compared to males over the three-year period. The increase was 1.7 percentage points for boys and 1.6 for girls from 2017 until 2019.

Limitations and strengths

A limitation of the study is that we were not able to take the regional differences in participation of schools each year into account, which might have confounded the observed time trend seen over the three-year period. However, there seems to be a quite even distribution of smaller and larger municipalities spread out across Norway participating in the Ungdata study in 2017, 2018 and 2019. Moreover, the participants are not randomly selected as only municipalities who wanted to participate in the Ungdata survey were included in the study. In addition, the participating schools within these municipalities were not selected at random. The lower secondary schools are run by the municipalities while the upper secondary schools are organized according to regional districts. This might have led to biases regarding representability of the study.

Other limitations common to such surveys, are that the study relies on self-reported ED consumption which can be susceptible to both recall bias and social desirability bias (35). Moreover, only children who attended school on the day of the survey answered the questionnaire. Adolescents who were absent or had dropped out were therefore not included in the study, which might have affected the results.

The major strength of this study is the representative and large sample included. One can argue that the sample is representative because most municipalities in Norway from all levels of centrality participated in the study over the three-year period. In addition, with

close to 300,000 adolescents answering the questionnaire, we had a response from 74.4% of the total eligible students in this time-period.

This study examined the extent and trends in ED consumption among Norwegian adolescents in 2017, 2018 and 2019 according to age, gender, SES, residency, physical activity and leisure screen-time. The main finding of an increasing proportion of female high ED consumers is of special interest as it highlights the fact that despite male high ED consumers still being the gender consuming most ED, females high ED consumers are catching up. This is an important finding to considerate in future research, which should focus on the possible effects of long-term ED consumption among adolescents.

Conclusion

The gender gap in high ED consumption is closing in. ED consumption is increasing among female adolescents, especially high ED consumption. It is important to find out how ED consumption among adolescents is related to consuming habits, body composition, cognitive, and socioemotional development. In other words, the typical ED consumers add to their health burden of risk taking behavior and future research should focus on the consequences of this.

Footnote page

Abbreviations

ED = Energy Drink

EFSA = European Food Safety Authority

FAS II = Family Affluence Scale II

NFSA = Norwegian Ministry of Health, the Norwegian Food Safety Authority

RR = Relative Risk

RERI = Relative Excess Risk due to Interaction

SES = Socio-Economic Status

VKM = Norwegian Scientific Committee for Food and Environment

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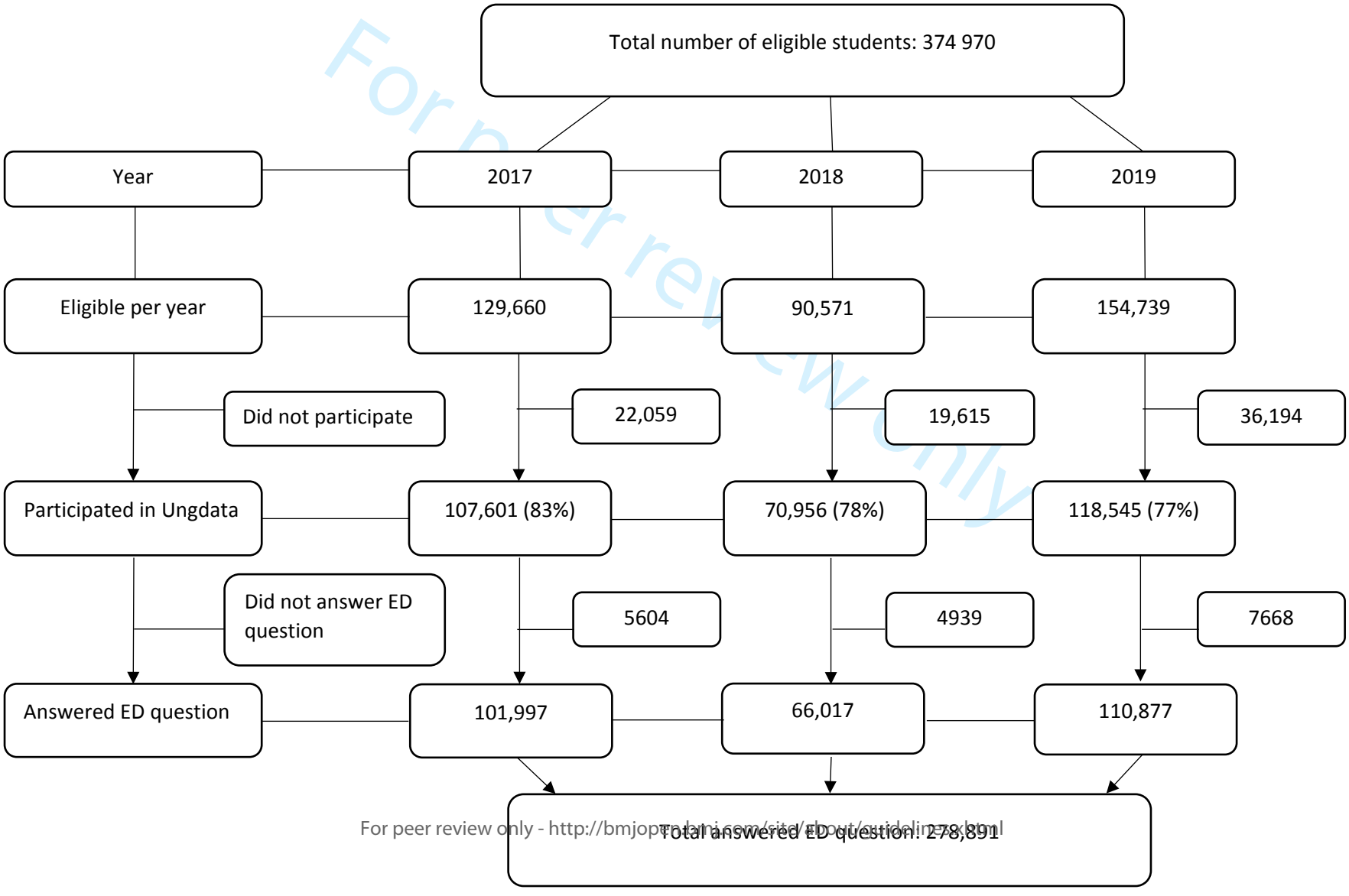

Table 1. Baseline Characteristics of Adolescents in 2017, 2018 and 2019.

VARIABLE	TOTAL (%)	2017 (%)	2018 (%)	2019 (%)
N	278,891	101,997	66,017	110,877
SCHOOL LEVEL				
LOWER SECONDARY	160,352 (57.5)	61,768 (60.6)	38,256 (57.9)	60,328 (54.4)
UPPER SECONDARY	118,539 (42.5)	40,229 (39.4)	27,761 (42.1)	50,549 (45.6)
GRADE				
8	52,984 (19.0)	20,381 (20.0)	12,695 (19.2)	19,908 (18.0)
9	51,393 (18.4)	19,514 (19.1)	12,558 (19.0)	19,321 (17.4)
10	50,547 (18.1)	19,632 (19.2)	11,687 (17.7)	19,228 (17.3)
11	50,972 (18.3)	18,580 (18.2)	11,190 (16.9)	21,202 (19.1)
12	40,391 (14.5)	12,824 (12.6)	9360 (14.2)	18,207 (16.4)
13	26,351 (9.5)	8632 (8.5)	7091 (10.7)	10,628 (9.6)
MISSING	6253 (2.2)	2434 (2.4)	1436 (2.2)	2383 (2.2)
GENDER				
FEMALE	138,218 (49.6)	47,218 (46.3)	31,802 (48.2)	54,020 (48.7)
MALE	133,040 (47.7)	48,254 (47.3)	33,908 (51.4)	56,056 (50.6)
MISSING	7633 (2.7)	6525 (6.4)	307 (0.5)	801 (0.7)
RESIDENCY				
CENTRALITY				
1	56,012 (20.2)	14,909 (14.7)	22,358 (34.0)	18,745 (16.9)
2	63,413 (22.8)	30,793 (30.5)	5601 (8.5)	27,019 (24.4)
3	74,853 (26.9)	23,190 (22.9)	16,117 (25.5)	35,546 (32.1)
4	46,826 (16.9)	16,688 (16.5)	11,286 (17.1)	18,852 (17.0)
5	27,900 (10.0)	12,358 (12.2)	7609 (11.6)	7933 (7.1)
6	8847 (3.2)	3195 (3.2)	2870 (4.4)	2782 (2.5)
FREQUENCY OF PHYSICAL ACTIVITY				
NEVER	4518 (1.6)	1374 (1.3)	1218 (1.8)	1926 (1.7)
SELDOM	19,642 (7.0)	6314 (6.2)	4997 (7.6)	8331 (7.5)
1-2 TIMES A MONTH	18,007 (6.5)	6105 (6.0)	4709 (7.1)	7193 (6.5)

1-2 TIMES A WEEK	75,687 (27.1)	26,901 (26.4)	18,484 (28.0)	30,302 (27.3)
3-4 TIMES A WEEK	89,537 (32.1)	33,164 (32.5)	20,458 (31.0)	35,915 (32.4)
≥ 5 TIMES A WEEK	65,897 (23.6)	25,472 (25.0)	14,402 (21.8)	26,023 (23.5)
MISSING	5603 (2.0)	2667 (2.6)	1749 (2.7)	1187 (1.1)
LEISURE SCREEN TIME				
≤ 2 HOURS DAILY	43,234 (15.5)	17,734 (17.4)	10,355 (15.7)	15,145 (13.7)
2-3 HOURS DAILY	60,567 (21.7)	22,786 (22.3)	14,284 (21.6)	23,497 (21.2)
3-4 HOURS DAILY	75,781 (27.2)	27,296 (26.8)	17,654 (26.7)	30,831 (27.8)
4-6 HOURS DAILY	59,250 (21.2)	20,379 (20.0)	13,878 (21.0)	24,993 (22.5)
≥ 6 HOURS DAILY	36,168 (13.0)	12,563 (12.3)	8873 (13.4)	14,732 (13.3)
MISSING	3891 (1.4)	1239 (1.2)	973 (1.5)	1679 (1.5)
ENERGY DRINKS CONSUMPTION				
NEVER	128,365 (46.0)	46,782 (45.9)	31,055 (47.0)	50,528 (45.6)
< ONCE A WEEK	71,200 (25.5)	27,530 (27.0)	16,594 (25.1)	27,076 (24.4)
ONCE A WEEK	29,653 (10.6)	10,936 (10.7)	6784 (10.3)	11,933 (10.8)
2-3 TIMES A WEEK	28,974 (10.4)	10,065 (9.9)	6595 (10.0)	12,314 (11.1)
4-6 TIMES A WEEK	12,310 (4.4)	4038 (4.0)	2843 (4.3)	5429 (4.9)
EVERY DAY	4080 (1.5)	1250 (1.2)	1005 (1.5)	1825 (1.6)
SEVERAL TIMES A DAY	4309 (1.5)	1396 (1.4)	1141 (1.7)	1772 (1.6)

Table 2a. ED Consumption per Year and Gender.

	TOTAL (%)		2017 (%)		2018 (%)		2019 (%)	
	Male	Female	Male	Female	Male	Female	Male	Female
ED CONSUMPTION	133,040	138,218	47,218	48,254	31,802	33,908	54,020	56,056
NEVER	44,667 (33.6)	80,402 (58.2)	15,433 (32.7)	28,554 (59.2)	10,705 (33.7)	20,206 (59.6)	18,529 (34.3)	31,642 (56.4)
ANY ED	88,373 (66.4)	57,816 (41.8)	31,785 (67.3)	19,700 (40.8)	21,097 (66.3)	13,702 (40.4)	35,491 (65.7)	24,414 (43.6)

ED; Energy drink

Table 2b. ED Consumption per Year and Gender.

	TOTAL (%)		2017 (%)		2018 (%)		2019 (%)	
	Male	Female	Male	Female	Male	Female	Male	Female
ED CONSUMPTION	133,040	138,218	47,218	48,254	31,802	33,908	54,020	56,056
NEVER/ANY	118,676 (89.2)	132,478 (95.8)	42,598 (90.2)	46,683 (96.7)	28,248 (88.8)	32,498 (95.8)	47,830 (88.5)	53,297 (95.1)
HIGH	14,364 (10.8)	5740 (4.2)	4620 (9.8)	1571 (3.3)	3554 (11.2)	1410 (4.2)	6190 (11.5)	2759 (4.9)

ED; Energy drink

Table 3. Modified Poisson Regression With Interaction Term According to ED Consumers and High ED Consumers.

VARIABLE	TOTAL SAMPLE	ED CONSUMERS			HIGH ED CONSUMERS		
	n	n	RR	95% CI	n	RR	95% CI
INTERACTION TERMS			1			1	
INTERACTION GENDER AND YEAR - 2018			0.99	0.96, 1.02		0.89	0.81, 0.97
INTERACTION GENDER AND YEAR - 2019			0.91	0.89, 0.94		0.77	0.71,0.83
SUBGROUPS							
YEAR							
2017 FEMALE	48,254	19,700	1		1571	1	
2018 FEMALE	33,908	13,702	0.98	0.96, 1.01	1410	1.24	1.15, 1.34
2019 FEMALE	56,056	24,414	1.05	1.03, 1.07	2759	1.46	1.37, 1.55
2017 MALE	47,218	31,785	1		4620	1	
2018 MALE	31,802	21,097	0.98	0.96, 1.00	3554	1.10	1.05, 1.16
2019 MALE	54,020	35,491	0.96	0.95, 0.98	6190	1.12	1.07, 1.16
GENDER							
FEMALE	138,218	57,816	1		5740	1	

MALE 2017	47,218	31,785	1.63	1.61, 1.66	4620	2.79	2.63, 2.97
MALE 2018	31,802	21,097	1.62	1.59, 1.66	3554	2.48	2.33, 2.65
MALE 2019	54,020	35,491	1.49	1.47, 1.52	6190	2.14	2.04, 2.24
GRADE							
8	52,984	22,741	1		2533	1	
9	51,393	26,914	1.20	1.18, 1.22	3224	1.25	1.18, 1.32
10	50,547	28,215	1.26	1.24, 1.29	3654	1.39	1.32, 1.47
11	50,972	30,154	1.34	1.32, 1.36	4756	1.78	1.70, 1.88
12	40,391	23,925	1.34	1.32, 1.37	3886	1.84	1.75, 1.94
13	26,351	14,864	1.32	1.29, 1.35	2154	1.73	1.63, 1.82
RESIDENCY							
1	56,012	26,965	1		3254	1	
2	63,413	32,609	1.06	1.04, 1.08	4355	1.20	1.14, 1.26
3	74,853	40,723	1.11	1.09, 1.13	5738	1.27	1.22, 1-33
4	46,826	27,433	1.20	1.18, 1.22	4077	1.46	1.39, 1.53
5	27,900	16,895	1.25	1.22, 1.28	2467	1.54	1.46, 1.63
6	8847	5329	1.24	1.19, 1.28	750	1.58	1.43, 1.75
SOCIOECONOMIC STATUS							
5 HIGHEST	56,418	28,084	1		3133	1	

4	55,641	29,692	1.03	1.02, 1.05	3665	1.11	1.05, 1.16
3	55,935	30,532	1.05	1.04, 1.07	4199	1.21	1.15, 1.27
2	55,947	31,269	1.07	1.05, 1.08	4542	1.28	1.22, 1.35
1 LOWEST	54,950	30,949	1.08	1.06, 1.09	5160	1.43	1.36, 1.50
PHYSICAL ACTIVITY							
NEVER	4518	2481	1		782	1	
SELDOM	19,642	11,086	1.05	1.00, 1.09	2002	0.65	0.59, 0.70
1-2 TIMES A MONTH	18,007	9903	1.04	1.00, 1.09	1357	0.53	0.48, 0.58
1-2 TIMES A WEEK	75,687	40,581	1.02	0.97, 1.06	5058	0.50	0.46, 0.54
3-4 TIMES A WEEK	89,537	47,874	1.03	0.99, 1.07	5614	0.52	0.48, 0.58
≥ 5 TIMES A WEEK	65,897	35,312	1.00	0.96, 1.04	5173	0.62	0.57, 0.67
LEISURE SCREEN TIME							
≤ 2 HOURS DAILY	43,234	18,797	1		1978	1	
2-3 HOURS DAILY	60,567	28,922	1.10	0.96, 1.04	2659	1.0	0.94, 1.07
3-4 HOURS DAILY	75,781	40,778	1.22	1.20, 1.24	4514	1.33	1.25, 1-40
4-6 HOURS DAILY	59,250	35,462	1.32	1.30, 1.34	4950	1.79	1.69, 1.89
≥ 6 HOURS DAILY	36,168	24,214	1.42	1.39, 1.45	6026	3.16	2.99, 3.33

ED: Energy drink; RR: Relative Risk; CI: Confidence Interval; [a] Modified Poisson regression with robust variance estimation; [b]Estimates are statistically significant if their CIs do not include 1.0.

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Title page

Title: Recent Development in Energy Drink Consumption among Adolescents in Norway: a cross-sectional study

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Recent Development in Energy Drink Consumption among Adolescents in Norway: a cross-sectional study

Objectives: To describe the social determinants and development in energy drink consumption among Norwegian adolescents in 2017, 2018 and 2019.

Design: Cross-sectional, online, annual, nationwide surveys (Ungdata).

Setting: Responses collected online from January 2017 to December 2019.

Participants: Lower- and upper secondary school students (n=278,891) aged 12-19 years who responded in 2017, 2018, and 2019.

Main outcome measures: Frequency of energy drink consumption.

Results: Over the three-year period, 66.4% of the males and 41.8% of the females had consumed energy drink once a week or more. The proportion of female high consumers (consuming energy drink more than 4 times a week) increased from 3.3% to 4.9% between 2017 and 2019; for males, the increase was from 9.8% to 11.5%. In females the proportion of high consumers increased with 24% (relative risk (RR); CI) (1.24; 1.15, 1.34) from 2017 to 2018, and 46% (1.46; 1.37, 1.55) from 2017 to 2019. The corresponding increases in males were 10% (1.10; 1.05, 1.16) from 2017 to 2018, and 12% (1.12; 1.07, 1.16) from 2017 to 2019. Any energy drink consumption as well as high energy drink consumption were independently associated with school level, less central residency, low socioeconomic status, physical inactivity, and high leisure screen time.

Conclusion: We found an increase in high consumers among both boys and girls between 2017 and 2019. The observed increase in energy drink consumption among adolescents can explain some of the increased sales of energy drink in Norway.

Article summary

Strengths and limitations of this study:

- This study identifies recent development in the frequency of energy drink consumption among adolescents in Norway.
- Data are derived from a large, annual, national survey in Norway including nearly 300,000 adolescents over three years from 2017 to 2019.
- The study relies on self-reported energy drink consumption, which can be susceptible to both recall bias and social desirability bias.

INTRODUCTION

Being marketed as a booster of mental and physical capacity, energy drinks (ED) have gained worldwide popularity. In Norway, ED sales increased by more than 50% from 2017 to 2019.(1) ED are defined as non-alcoholic beverages that contain at least 150 mg caffeine per liter, in addition to sugar combined with one or more substances known to have stimulant properties.(2-4) Moreover, vitamins, minerals, and amino acids are often added to ED.(4) ED marketing is often targeted toward athletes and the adolescent population. Moreover, viewers of TV-channels with greater ED advertising have increased odds of ED consumption.(5-7)

ED consumption among children and adolescents has been linked to potential negative effects such as increased cardiovascular symptoms with increased cardiac output, but also elevated systolic and diastolic blood pressure.(8) Moreover, sleep disturbance, nervousness, and headache have been reported.(9-12) These potential adverse effects can result in tiredness, inattention, reduced school performance, and increased mental distress. The main cause for concern is the high level of caffeine in ED combined with added sugar and sweet flavor, next to the high content of stimulating substances.(13) According to Iversen et. al, this combination of ingredients may cause faster uptake of caffeine into the circulation compared to regular coffee.(13) Moreover, studies have indicated that adding caffeine to sugar-sweetened beverages (SSB) leads to increased use of SSB, which in turn results in increased energy intake.(14, 15) The high energy intake may contribute to overweight and obesity, as well as dental caries due to the high sugar and citric acid content of ED and SSB.(16)

In 2013, the European Food Safety Authority (EFSA) published a report on ED use, indicating that children and adolescents aged 10-18 years had the highest reported consumption (68%), compared with adults above 18 years (30%) and children below 10 years (18%).(3) The potential negative effects of ED in children and adolescents have gained the attention of government authorities in several countries, of which some have issued restrictions on the caffeine content in ED.(17) The Norwegian Food Safety Authority (NFSA) has stated that the daily intake of caffeine for children and adolescents should not exceed 2.5 mg/kg. This was decided based on a review of current knowledge by the Norwegian Scientific Committee for Food and Environment (VKM).(4)

According to the findings of the VKM review, a child or youth would have a risk of sleep disturbance with an intake of 1.4 mg/kg body weight/day of caffeine.(4) Furthermore, the risk of negative health effects on the heart and central nervous system would be present at an intake of 3 mg/kg body weight/day of caffeine. This would mean that a 13-15 years old adolescent with an average weight of 50 kg would be at risk of sleep disturbance when drinking more than 70 mg/day of caffeine and at risk of adverse cardiac and central neurologic effects at daily consumption of 150 mg/day. These values are in line with recommendations by EFSA and correspond to an intake of one to two large cans (500ml) of ED for an adolescent described above.(4)

ED consumption varies according to age and gender. Several studies have found that male adolescents are more likely to consume ED than their female counterparts. Moreover, young (male) adolescents at middle school level have a higher ED consumption compared to older adolescents at high school level.(3, 18, 19) Furthermore, Degirmenci et al. found that high consumption (> 4 times a week) of ED was independently associated with male gender,

physical inactivity, high leisure screen time, low socioeconomic status, and rural residency.(20)

Of special concern for potential adverse effects are children and adolescents who have lower body weight, and are more sensitive to ED stimulants, including caffeine. According to the American Academy of Pediatrics; “Caffeine and other stimulants contained in energy drinks have no place in the diet of children and adolescents”.(21) Despite the aforementioned increased sales of ED in Norway, the extent to which the consumption of ED among children and adolescents followed this development remains unclear.(17) The objective of the current study is to describe the social determinants and development in energy drink consumption among Norwegian adolescents in 2017, 2018, and 2019. Potential social determinants include age, gender, socio-economic status (SES), residency, physical activity, and leisure screen time.

METHODS

Study design and participants

Data for the study was collected through the Ungdata survey, a national, annual, survey, mapping the health and well-being of lower and upper secondary school students in Norway. The study was approved by the Norwegian Centre for Research Data. Detailed information regarding the survey can be found on www.ungdata.no.(22) All data collection is conducted anonymously and web-based during school hours with the teacher present in the classroom. Data from the surveys carried out in 2017, 2018, and 2019 were used for the present study.

All 422 municipalities in Norway (2019) are invited to participate in the Ungdata survey. Participation is free of charge and on a volunteer basis. The municipalities are encouraged to perform the survey every three years in the schools of the municipalities. This is to ensure that all adolescents get to participate once both during lower (8^{th} to 10^{th} grade) and upper (11^{th} to 13^{th} grade) secondary school. The three-year interval is not a strict rule, which means that some municipalities participated twice and some all three years (2017-2019). In the present study, information from all municipalities was included regardless of how many years they participated. It is therefore possible that some adolescents responded twice or thrice. In total, we have data from 422 municipalities, 333 participated only once, 59 twice, and one municipality participated all three years. Fewer municipalities participated in the Ungdata survey in 2018, compared to 2017 and 2019 (Figure 1).

In Norway, children start school the year they turn six years old (grade 1) and stay in school until the age of 15-16 years (grade 10). Attending school is obligatory by law until the completion of grade 10 whereas attending subsequent grades is voluntary. National

statistics show that the majority of 16- to 18-year-old (93.4% in 2019) go on to attend upper secondary schools.(23)

A total of 297,102 adolescents from both lower and upper secondary schools participated in the Ungdata surveys in 2017, 2018, and 2019. Of the participating adolescents, 278,891 answered the questions on ED consumption (response rate of 93.9%) and were included in the analyses (Figure 1).

In 2017, missing values for gender were 6.4% compared to less than 1% in 2018 and 2019. This is likely due to the order of questions in the electronic questionnaire, which led to overlooking of the question regarding gender in the 2017 survey. This ordering of questions was changed in 2018 and 2019 (personal correspondence with staff from Ungdata).

The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). Participants do not have unique identification numbers as data collection is done anonymously and does not contain sensitive information. Therefore, no ethical approval was needed. The study was funded by Innlandet Hospital Trust (project number: 150377).

Measures

ED consumption was assessed with the question “How often do you usually drink energy drinks (Red Bull, Battery, etc.)?” The participants could respond with one of seven incremental options, ranging from “never” to “several times a day”. The response to this question was used to categorize adolescents into the following two groups subsequently used as outcome variables: ED consumers (ED ≥ once a week) and high ED consumers (ED ≥ 4 times a week). The ED consumers were compared to never ED consumers, and the high ED consumers were compared to the rest (all other frequency of ED consumption including non-ED).

Leisure screen time was assessed using the question “Outside school, how much time do you normally spend on activities that involve looking at a screen (TV, computer, tablet, mobile phone) each day?” with options on a seven-point incremental scale ranging from “no time” to “more than six hours”. The first three options of the variable leisure screen-time were merged into one response of “less than two hours” due to the relatively low number of respondents in these categories.

Physical activity was assessed by the question “How often do you perform physical activity which gets you out of breath or makes you sweaty?” with options on a six-point incremental scale ranging from “never” to “at least five times a week”.

SES was assessed according to a five-point scale which again was based on a compound score from three different dimensions.(24, 25) These dimensions were: parental education, “culture capital” at home based on the question “how many books do you think there are in your home?”, and the third dimension used four questions from the Family Affluence Scale (FAS II). FAS II contains questions regarding the number of cars in the family, whether the participant has her/his own bedroom, whether the participant has been on vacation, and the number of computers or tablets in the house. The answers were assigned different points that were subsequently used to calculate a total score distributed into five equally sized groups. Group 1 refers to the lowest SES-score and group 5 to the highest.

For this study, we used the official Norwegian centrality index to define residency. According to Statistics Norway, centrality is a term used to describe an index that is divided into 6 groups. Group 1 contains the most central municipalities (highest index) and group 6 the least central (lowest index).(26) The calculation of the index is based on travel time to workplaces and service functions from all populated basic units. Residency for each

individual is based on where the adolescent attends school and is not per se the place of living.

Further details on variables and answer options are given in Table 1.

Statistical analyses

The association between the outcome variables (any and high ED consumption) and the independent variables were estimated in multivariable Poisson regression models. These models allowed us to estimate the risk ratios (RR) between the categories of the independent variables.(27-29) We used the sandwich estimation method to generate robust standard errors.(27) We also included interaction terms between year and gender to estimate the extent to which these variables modified each other's association with the outcomes. In other words, we assessed if the association between gender and energy drinks differed by year and the extent to which the association between year and the consumption of ED differed by gender. The independent variables in the statistical models were decided *a priori* and consisted of: gender, year, grade, residency, SES, frequency of physical activity and leisure screen time. The analyses were performed with and without adjusting the standard errors for clustering within municipalities.

The interactions terms between gender and year were estimated both on an additive and a multiplicative scale using generalized linear models with identity and log link, respectively.(30) In these models we estimated the significance of the interaction terms using likelihood ratio tests. STATA version 15.1 (College Station, Texas) was used for all statistical analysis.(31)

Patient and public involvement

There were no patients involved in the study.

RESULTS

In total, 278,891 adolescents who participated in Ungdata answered the question about ED use and were included for further analyses. Most of the adolescents (57.5%) attended lower secondary school (Table 1). Grade thirteen was the least represented grade in the sample, which is in line with previous findings from the Ungdata survey.(24)

Most of the participants lived in municipalities with the centrality index two and three. The distribution seen in Table 1 is comparable to the overall distribution of the centrality index in Norway.(32) A lesser percentage in level six was expected, as fewer people are living in these areas.

Table 1. Baseline Characteristics of Adolescents participating in the Ungdata surveys in 2017, 2018 and 2019.

VARIABLE	TOTAL (%)	2017 (%)	2018 (%)	2019 (%)
N	278,891	101,997	66,017	110,877
SCHOOL LEVEL				
LOWER SECONDARY	160,352 (57.5)	61,768 (60.6)	38,256 (57.9)	60,328 (54.4)
UPPER SECONDARY	118,539 (42.5)	40,229 (39.4)	27,761 (42.1)	50,549 (45.6)
GRADE				
8	52,984 (19.0)	20,381 (20.0)	12,695 (19.2)	19,908 (18.0)
9	51,393 (18.4)	19,514 (19.1)	12,558 (19.0)	19,321 (17.4)
10	50,547 (18.1)	19,632 (19.2)	11,687 (17.7)	19,228 (17.3)
11	50,972 (18.3)	18,580 (18.2)	11,190 (16.9)	21,202 (19.1)
12	40,391 (14.5)	12,824 (12.6)	9360 (14.2)	18,207 (16.4)
13	26,351 (9.5)	8632 (8.5)	7091 (10.7)	10,628 (9.6)
MISSING	6253 (2.2)	2434 (2.4)	1436 (2.2)	2383 (2.2)
GENDER				
FEMALE	138,218 (49.6)	47,218 (46.3)	31,802 (48.2)	54,020 (48.7)
MALE	133,040 (47.7)	48,254 (47.3)	33,908 (51.4)	56,056 (50.6)

MISSING	7633 (2.7)	6525 (6.4)	307 (0.5)	801 (0.7)
RESIDENCY				
1	56,012 (20.2)	14,909 (14.7)	22,358 (34.0)	18,745 (16.9)
2	63,413 (22.8)	30,793 (30.5)	5601 (8.5)	27,019 (24.4)
3	74,853 (26.9)	23,190 (22.9)	16,117 (25.5)	35,546 (32.1)
4	46,826 (16.9)	16,688 (16.5)	11,286 (17.1)	18,852 (17.0)
5	27,900 (10.0)	12,358 (12.2)	7609 (11.6)	7933 (7.1)
6	8847 (3.2)	3195 (3.2)	2870 (4.4)	2782 (2.5)
FREQUENCY OF PHYSICAL ACTIVITY				
NEVER	4518 (1.6)	1374 (1.3)	1218 (1.8)	1926 (1.7)
SELDOM	19,642 (7.0)	6314 (6.2)	4997 (7.6)	8331 (7.5)
1-2 TIMES A MONTH	18,007 (6.5)	6105 (6.0)	4709 (7.1)	7193 (6.5)
1-2 TIMES A WEEK	75,687 (27.1)	26,901 (26.4)	18,484 (28.0)	30,302 (27.3)
3-4 TIMES A WEEK	89,537 (32.1)	33,164 (32.5)	20,458 (31.0)	35,915 (32.4)
≥ 5 TIMES A WEEK	65,897 (23.6)	25,472 (25.0)	14,402 (21.8)	26,023 (23.5)
MISSING	5603 (2.0)	2667 (2.6)	1749 (2.7)	1187 (1.1)
LEISURE SCREEN TIME				
≤ 2 HOURS DAILY	43,234 (15.5)	17,734 (17.4)	10,355 (15.7)	15,145 (13.7)
2-3 HOURS DAILY	60,567 (21.7)	22,786 (22.3)	14,284 (21.6)	23,497 (21.2)
3-4 HOURS DAILY	75,781 (27.2)	27,296 (26.8)	17,654 (26.7)	30,831 (27.8)
4-6 HOURS DAILY	59,250 (21.2)	20,379 (20.0)	13,878 (21.0)	24,993 (22.5)
≥ 6 HOURS DAILY	36,168 (13.0)	12,563 (12.3)	8873 (13.4)	14,732 (13.3)
MISSING	3891 (1.4)	1239 (1.2)	973 (1.5)	1679 (1.5)
ENERGY DRINKS CONSUMPTION				
NEVER	128,365 (46.0)	46,782 (45.9)	31,055 (47.0)	50,528 (45.6)
< ONCE A WEEK	71,200 (25.5)	27,530 (27.0)	16,594 (25.1)	27,076 (24.4)
ONCE A WEEK	29,653 (10.6)	10,936 (10.7)	6784 (10.3)	11,933 (10.8)
2-3 TIMES A WEEK	28,974 (10.4)	10,065 (9.9)	6595 (10.0)	12,314 (11.1)
4-6 TIMES A WEEK	12,310 (4.4)	4038 (4.0)	2843 (4.3)	5429 (4.9)

EVERY DAY	4080 (1.5)	1250 (1.2)	1005 (1.5)	1825 (1.6)
SEVERAL TIMES A DAY	4309 (1.5)	1396 (1.4)	1141 (1.7)	1772 (1.6)

Between 20-30% of the participants reported performing some kind of physical activity where they get sweaty either 1-2, 3-4, or more than 5 times a week, while less than 10% reported 1-2 times a month or less. In addition, more than 10% spent 6 hours or more looking at a screen. Overall, 46% of the participants had never consumed ED and 7.4% had consumed ED more than 4 times a week.

Over the three years, there was a small decrease in the percentage of boys consuming ED from 67.3% (CI: 66.9-67.7) in 2017 to 65.7% (CI: 65.3-66-1) in 2019. Among girls, a small increase was found from 40.8% (CI: 40.4-41.3) in 2017 to 43.6% (CI: 43.1-44.0) in 2019 (Figure 2). However, high ED consumers increased among both boys and girls (Figure 3). In 2017, 9.8% (CI: 9.5-10.0) of the boys and 3.3% (CI: 3.1-3.4) of the girls reported ED consumption in the range of high consumers, while these percentages increased to 11.5% (CI: 11.2-11.7) in boys and 4.9% (CI: 4.7-5.1) in girls in 2019.

Table 2 shows the annual increase in high ED consumption among both boys and girls. The proportion of female high ED consumers increased by an average of 23% per year. That is, the proportion of female high consumers increased by 24% (RR; CI) (1.24; 1.15, 1.34) from 2017 to 2018, and by 46% (1.46; 1.37, 1.55) from 2017 to 2019. There was also an increase in the proportion of high consumers of ED in boys, however, this increase was lower at 12% from 2017 to 2019. On a multiplicative scale, the interaction terms between gender and year was statistically significant (Table 2). However, on an additive scale there was no interaction found according to the generalized linear models as the difference in percentage points was almost identical (1.7 in boys and 1.6 in girls). Adjusting for clustering of municipalities only

showed marginal alteration of the standard errors and CIs. Table 2 demonstrates the results from the Poisson regression models.

Table 2. Determinants for being energy drink consumers (any ED or high ED) in Norwegian adolescents.

VARIABLE	TOTAL SAMPLE			ED CONSUMERS		HIGH ED CONSUMERS			
	n	n	%	RR	95% CI	n	%	RR	95% CI
INTERACTION TERMS				1				1	
INTERACTION GENDER AND YEAR - 2018				0.99	0.96, 1.02			0.89	0.81, 0.97
INTERACTION GENDER AND YEAR - 2019				0.91	0.89, 0.94			0.77	0.71,0.83
SUBGROUPS									
YEAR									
2017 FEMALE	48,254	19,700	40.8	1		1571	3.3	1	
2018 FEMALE	33,908	13,702	40.4	0.98	0.96, 1.01	1410	4.2	1.24	1.15, 1.34
2019 FEMALE	56,056	24,414	43.5	1.05	1.03, 1.07	2759	4.9	1.46	1.37, 1.55
2017 MALE	47,218	31,785	67.3	1		4620	9.8	1	
2018 MALE	31,802	21,097	66.3	0.98	0.96, 1.00	3554	11.2	1.10	1.05, 1.16
2019 MALE	54,020	35,491	65.7	0.96	0.95, 0.98	6190	11.5	1.12	1.07, 1.16
ASSOCIATION BETWEEN GENDER AND ED PER YEAR (FEMALES IN REFERANCE GROUP)									

MALE 2017				1.63	1.61, 1.66			2.79	2.63, 2.97
MALE 2018				1.62	1.59, 1.66			2.48	2.33, 2.65
MALE 2019				1.49	1.47, 1.52			2.14	2.04, 2.24
GRADE									
8	52,984	22,741	42.9	1		2533	4.8	1	
9	51,393	26,914	52.4	1.20	1.18, 1.22	3224	6.3	1.25	1.18, 1.32
10	50,547	28,215	55.8	1.26	1.24, 1.29	3654	7.2	1.39	1.32, 1.47
11	50,972	30,154	59.2	1.34	1.32, 1.36	4756	9.3	1.78	1.70, 1.88
12	40,391	23,925	59.2	1.34	1.32, 1.37	3886	9.6	1.84	1.75, 1.94
13	26,351	14,864	56.4	1.32	1.29, 1.35	2154	8.2	1.73	1.63, 1.82
RESIDENCY									
1	56,012	26,965	48.1	1		3254	5.8	1	
2	63,413	32,609	51.4	1.06	1.04, 1.08	4355	6.9	1.20	1.14, 1.26
3	74,853	40,723	54.4	1.11	1.09, 1.13	5738	7.7	1.27	1.22, 1.33
4	46,826	27,433	58.6	1.20	1.18, 1.22	4077	8.7	1.46	1.39, 1.53
5	27,900	16,895	60.6	1.25	1.22, 1.28	2467	8.8	1.54	1.46, 1.63
6	8847	5329	60.2	1.24	1.19, 1.28	750	8.5	1.58	1.43, 1.75
SOCIOECONOMIC STATUS									
5 HIGHEST	56,418	28,084	49.8	1		3133	5.6	1	

4	55,641	29,692	53.4	1.03	1.02, 1.05	3665	6.6	1.11	1.05, 1.16
3	55,935	30,532	54.6	1.05	1.04, 1.07	4199	7.5	1.21	1.15, 1.27
2	55,947	31,269	55.9	1.07	1.05, 1.08	4542	8.1	1.28	1.22, 1.35
1 LOWEST	54,950	30,949	56.3	1.08	1.06, 1.09	5160	9.4	1.43	1.36, 1.50
PHYSICAL ACTIVITY									
NEVER	4518	2481	54.9	1		782	17.3	1	
SELDOM	19,642	11,086	56.4	1.05	1.00, 1.09	2002	10.2	0.65	0.59, 0.70
1-2 TIMES A MONTH	18,007	9903	55.0	1.04	1.00, 1.09	1357	7.5	0.53	0.48, 0.58
1-2 TIMES A WEEK	75,687	40,581	53.6	1.02	0.97, 1.06	5058	6.7	0.50	0.46, 0.54
3-4 TIMES A WEEK	89,537	47,874	53.5	1.03	0.99, 1.07	5614	6.3	0.52	0.48, 0.58
≥ 5 TIMES A WEEK	65,897	35,312	53.6	1.00	0.96, 1.04	5173	7.9	0.62	0.57, 0.67
LEISURE SCREEN TIME									
≤ 2 HOURS DAILY	43,234	18,797	43.5	1		1978	4.6	1	
2-3 HOURS DAILY	60,567	28,922	47.8	1.10	0.96, 1.04	2659	4.4	1.0	0.94, 1.07
3-4 HOURS DAILY	75,781	40,778	53.8	1.22	1.20, 1.24	4514	6.0	1.33	1.25, 1-40
4-6 HOURS DAILY	59,250	35,462	59.9	1.32	1.30, 1.34	4950	8.4	1.79	1.69, 1.89
≥ 6 HOURS DAILY	36,168	24,214	66.9	1.42	1.39, 1.45	6026	16.7	3.16	2.99, 3.33

ED: Energy drink; RR: Relative Risk; CI: Confidence Interval; [a] Modified Poisson regression with robust variance estimation; [b]Estimates are statistically significant if their CIs do not include 1.0. Walds test shows statistically significant p-values at $p<0.05$. Loglikelihood ratio test of complete interaction term was significant at $p<0.01$.

The association between ED consumption and social determinants (Table 2) showed that the largest proportion of high ED consumers was found in participants living in centrality index 6 (least central residency). Furthermore, we found a larger proportion of high ED consumers with decreasing SES. The same association was found when looking at the any ED consumption group, although differences were less pronounced. There was a non-linear relation between high ED consumption and physically active. However, this was not observed for the any ED consumption group. Regarding both the participants who consumed any ED as well as the high consumers, the proportions increased with increasing leisure screen time. The proportion of high ED consumers that spent more than 6 hours looking at a screen outside school hours was three times higher than the high ED consumers that spent less than 2 hours looking at a screen.

DISCUSSION

We have described social determinants and development in energy drink consumption among Norwegian adolescents between 2017 and 2019. We found an increase in the percentage of both boys and girls being high ED consumers and a change in ED consumption according to time. We found that in total, over the three years, 4.2% of the girls and 10.8% of the boys were high ED consumers. There was also an annual increase in the proportion of high consumers that was most pronounced for girls increasing from 3.3% in 2017 to 4.9% in 2019. Moreover, we found that more than half of the adolescents participating in the study had consumed any ED during these three years. The increase in high ED consumption was expected as sales in ED in Norway have increased. However, adolescents are most likely not the only group consuming increasing amounts of ED. It is plausible that other groups in the population follow the same trend in ED consumption.

High ED consumption was positively associated with the male gender, lower SES, rural living, excessive screen watching, physical inactivity, and being very physically active. The combination of either low or high physical activity and high leisure screen-time as predictors for ED consumption was also found in other studies from Saudi Arabia, Canada, and the U.S.(3, 18, 33-35) Al-Hazza et. al proposed that the reason why both low and high physical activity and high leisure screen-time was observed, is due to how ED are being marketed.(33)

As mentioned above, ED are often marketed as boosters of an active lifestyle and higher levels of performance. Regarding the gender difference in high ED consumption, one could hypothesize that because of the marketing trends of ED focusing on masculinity boys are more likely influenced by this marketing strategy.(7) According to the study by Emond et. al

on ED advertisement, ED was primarily advertised on channels with adolescents as their base audience.(5) Based on this, one could imagine that increased screen time and thereby increased exposure to ED advertising would lead to higher ED consumption rates. In addition, Hammond et. al. found that TV was the main common source of marketing of ED to adolescents next to marketing in grocery stores.(36) Our results also suggest that adolescents who spend much of their spare time watching screens are those who consume most ED.

Our results show that even though boys still are the highest consumers of ED, the increase in the proportion of female high consumers was larger, on a multiplicative scale but not an additive scale, compared to males over the three years. The increase was 1.7 percentage points for boys (9.8-11.5%) and 1.6 for girls (3.3-4.9%) from 2017 until 2019. Based on this finding it could be speculated that girls are becoming more exposed and perhaps more susceptible to ED marketing than before.

Limitations and strengths

A limitation of the study is that we were not able to take the regional differences in participation of schools each year into account. This might have affected the observed development of ED consumption seen over the three years. However, the breadth of the municipalities participating in the Ungdata study in 2017, 2018 and 2019 with an even distribution of smaller and larger communities spread out across Norway makes the sample sufficiently large and wide-reaching. Moreover, the participants are not completely selected at random as only municipalities who wanted to participate in the Ungdata survey were included in the study. In addition, the participating schools within these municipalities were not selected completely at random. The lower secondary schools are run by the

municipalities while the upper secondary schools are organized according to regional districts, therefore the schools have different catchment areas when it comes to children attending the schools.

Other limitations common to such surveys are that the study relies on self-reported ED consumption which can be susceptible to both recall bias and social desirability bias.(37) Moreover, only children who attended school on the day of the survey answered the questionnaire. Adolescents who were absent or had dropped out were therefore not included in the study, which might have affected the results. Finally, some adolescents might have participated more than once, yet no adjustment for lack of independence between these observations was possible.

The major strength of this study is the large sample included, with close to 300,000 adolescents answering the questionnaire and a response from 74.4% of the total eligible students in this time period.

This study examined development and social determinants in ED consumption among Norwegian adolescents in 2017, 2018 and 2019 according to age, gender, SES, residency, physical activity, and leisure screen-time. The main finding of an increasing proportion of female high ED consumers is of special interest as it highlights the fact that despite male high ED consumers still being the gender consuming most ED, females high ED consumers are catching up. This is an important finding to consider in future research which could focus on possible differences between the consumers of the specific types of ED, but also possible the reasons why they drink ED. In addition, it is important to investigate the potential long-term effects of ED consumption among adolescents.

CONCLUSION

The increase in ED sales in Norway is alarming. ED consumption is increasing among female adolescents, especially high ED consumption. Yet, the mechanism or reason behind this increase remains unclear. As a result, future research should consider gender-related differences when studying various aspects of ED consumption. In addition, adolescents are most likely not the only group contributing to the large increase in ED sales in Norway.

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Footnote page

Abbreviations

ED = Energy Drinks

EFSA = European Food Safety Authority

FAS II = Family Affluence Scale II

NFSA = Norwegian Ministry of Health, the Norwegian Food Safety Authority

RR = Relative Risk

SES = Socio-Economic Status

VKM = Norwegian Scientific Committee for Food and Environment

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Ethical approval: The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). Participants do not have unique identification numbers as data collection is done anonymously and does not contain sensitive information. Therefore, no ethical approval was needed.

Patient and public involvement: There was no patient or public involvement in study.

Data availability statement: The data supporting our study is available from the Norwegian Centre for Research Data (NSD) and were used under license for the current study. The Ungdata survey is funded by The Norwegian Directorate of Health. Anonymous data has been made available for the authors by NOVA through NSD – the Norwegian Center for Research Data. Neither NOVA, The Norwegian Directorate of Health or NSD are responsible for the analyses or interpretation of the presented data.

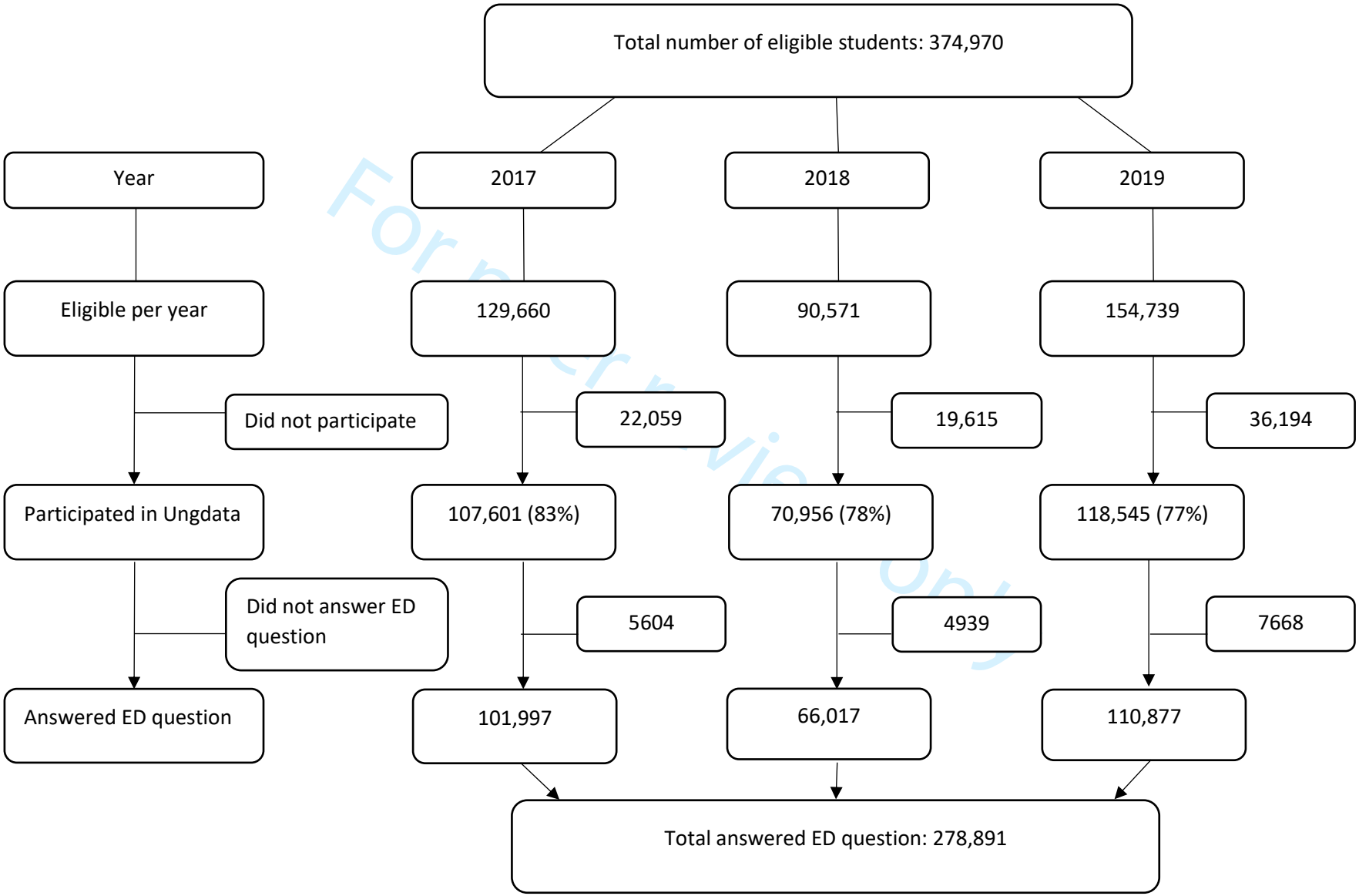
Competing interest: None declared

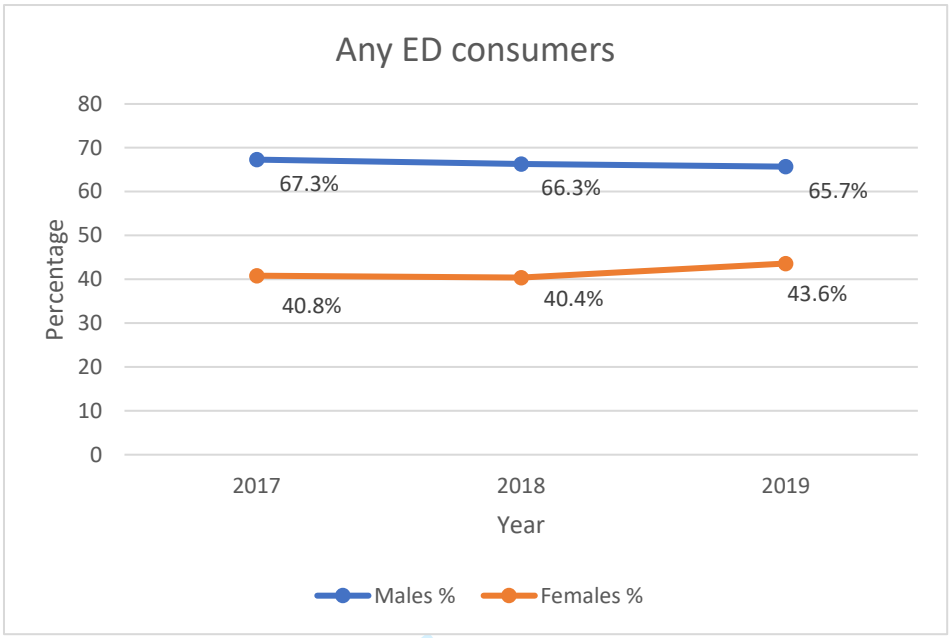
Figures

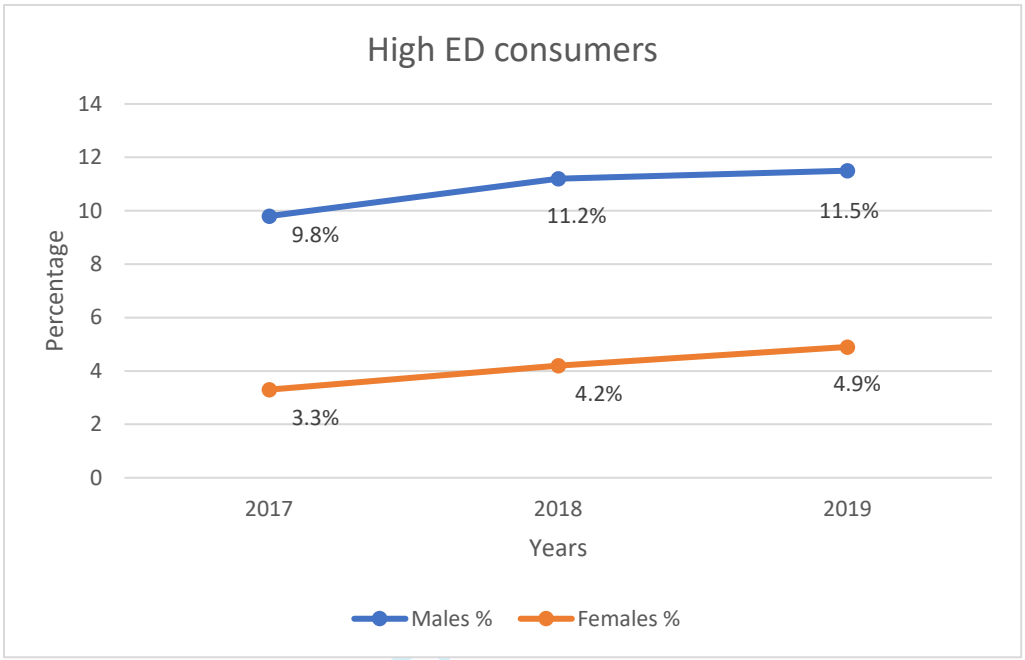
Figure 1: Overview of the Study Participants.

Figure 2: Any ED Consumers per Year and Gender.

Figure 3: High ED Consumers per Year and Gender.







STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	0
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	0
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1-3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	0+4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	0+4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-15

		(*b*) Report category boundaries when continuous variables were categorized	10-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	18-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4-5

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Social Determinants and Changes in Energy Drink Consumption among Adolescents in Norway, 2017-2019: A Cross-sectional Study

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Title page

Title: Social Determinants and Changes in Energy Drink Consumption among Adolescents in Norway, 2017-2019: A Cross-sectional Study

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Social Determinants and Changes in Energy Drink Consumption among Adolescents in Norway, 2017-2019: A Cross-sectional Study

Objectives: To describe the social determinants and development in energy drink consumption among Norwegian adolescents in 2017, 2018 and 2019.

Design: Cross-sectional, online, annual, nationwide surveys (Ungdata).

Setting: Responses collected online from January 2017 to December 2019.

Participants: Lower- and upper secondary school students (n=297,102) aged 12-19 years who responded in 2017, 2018, and 2019.

Main outcome measures: Frequency of energy drink consumption.

Results: Over the three-year period, 66.4% of the males and 41.8% of the females had consumed energy drink once a week or more. The proportion of female high consumers (consuming energy drink more than 4 times a week) increased from 3.3% to 4.9% between 2017 and 2019; for males, the increase was from 9.8% to 11.5%. In females the proportion of high consumers increased with 24% (relative risk (RR); CI) (1.24; 1.09, 1.41) from 2017 to 2018, and 46% (1.46; 1.31, 1.62) from 2017 to 2019. The corresponding increases in males were 10% (1.10; 1.01, 1.20) from 2017 to 2018, and 12% (1.12; 1.05, 1.19) from 2017to 2019. Any energy drink consumption as well as high energy drink consumption were independently associated with school level, less central residency, low socioeconomic status, physical inactivity, and high leisure screen time.

Conclusion: We found an increase in high consumers among both boys and girls between 2017 and 2019. The observed increase in energy drink consumption among adolescents can explain some of the increased sales of energy drink in Norway.

Article summary

Strengths and limitations of this study:

- This study identifies recent development in the frequency of energy drink consumption among adolescents in Norway.
- Data are derived from a large, annual, national survey in Norway including nearly 300,000 adolescents over three years from 2017 to 2019.
- The study relies on self-reported energy drink consumption, which can be susceptible to both recall bias and social desirability bias.

INTRODUCTION

Marketed as a booster of mental and physical capacity, energy drinks (ED) have gained worldwide popularity. In Norway, ED sales increased by more than 50% from 2017 to 2019.(1) ED are defined as non-alcoholic beverages that contain at least 150 mg caffeine per litre, in addition to sugar combined with one or more substances known to have stimulant properties.(2-4) Moreover, vitamins, minerals, and amino acids are frequently added to ED.(4) ED marketing is often targeted toward athletes and the adolescent population, and recent studies have shown that viewers of TV-channels with greater ED advertising have increased odds of ED consumption.(5-7)

ED consumption among children and adolescents has been linked to potential negative effects such as increased cardiovascular symptoms with increased cardiac output, but also elevated systolic and diastolic blood pressure.(8) Moreover, sleep disturbance, nervousness, and headache have been reported.(9-12) These potential adverse effects can result in tiredness, inattention, reduced school performance, and increased mental distress. The main cause for concern is the high level of caffeine in ED combined with added sugar and sweet flavour, next to the high content of stimulating substances.(13) According to Iversen et. al, this combination of ingredients may cause faster uptake of caffeine into the circulation compared to regular coffee.(13) Moreover, studies have indicated that adding caffeine to sugar-sweetened beverages (SSB) leads to increased use of SSB, which in turn results in increased energy intake.(14, 15) The high energy intake may contribute to overweight and obesity, as well as dental caries due to the high sugar and citric acid content of ED and SSB.(16)

In 2013, the European Food Safety Authority (EFSA) published a report on ED use, indicating that children and adolescents aged 10-18 years had the highest reported consumption (68%), compared with adults above 18 years (30%) and children below 10 years (18%).(3) The potential negative effects of ED in children and adolescents have gained the attention of government authorities in several countries, of which some have issued restrictions on the caffeine content in ED.(17) The Norwegian Food Safety Authority (NFSA) has stated that the daily intake of caffeine for children and adolescents should not exceed 2.5 mg/kg. This was decided based on a review of current knowledge by the Norwegian Scientific Committee for Food and Environment (VKM).(4)

According to the findings of the VKM review, a child or youth would be at risk of sleep disturbance with an intake of 1.4 mg/kg body weight/day of caffeine.(4) Furthermore, the risk of negative health effects on the heart and central nervous system would be present at an intake of 3 mg/kg body weight/day of caffeine. This would mean that a 13-15 years old adolescent with an average weight of 50 kg would be at risk of sleep disturbance when drinking more than 70 mg/day of caffeine and at risk of adverse cardiac and central neurologic effects at daily consumption of 150 mg/day. These values are in line with recommendations by EFSA and correspond to an intake of one to two large cans (500ml) of ED for an adolescent described above.(4)

ED consumption varies according to age and gender. Several studies have found that male adolescents are more likely to consume ED than their female counterparts. Moreover, young (male) adolescents at middle school level have a higher ED consumption compared to older adolescents at high school level.(3, 18, 19) Furthermore, Degirmenci et al. found that high consumption (> 4 times a week) of ED was independently associated with male gender,

physical inactivity, high leisure screen time, low socioeconomic status, and rural residency.(20)

Of special concern for potential adverse effects are children and adolescents who have lower body weight, and are more sensitive to ED stimulants, including caffeine. According to the American Academy of Pediatrics, “Caffeine and other stimulants contained in energy drinks have no place in the diet of children and adolescents”.(21) Despite the aforementioned increased sales of ED in Norway, the extent to which the consumption of ED among children and adolescents followed this development remains unclear.(17) The objective of the current study is to describe the social determinants and changes in energy drink consumption among Norwegian adolescents in 2017, 2018, and 2019. Potential social determinants include age, gender, socio-economic status (SES), residency, physical activity, and leisure screen time.

METHODS

Study design and participants

Data for the study was collected through the Ungdata survey, a national, annual, survey, mapping the health and well-being of lower and upper secondary school students in Norway. The study was approved by the Norwegian Centre for Research Data. Detailed information regarding the survey can be found on www.ungdata.no.(22) All data collection is conducted anonymously and web-based during school hours with the teacher present in the classroom. Data from the surveys carried out in 2017, 2018, and 2019 were used for the present study.

All 422 municipalities in Norway (2019) are invited to participate in the Ungdata survey. Participation is free of charge and on a volunteer basis. The municipalities are encouraged to perform the survey every three years in the schools of the municipalities. This is to ensure that all adolescents get to participate once both during lower (8^{th} to 10^{th} grade) and upper (11^{th} to 13^{th} grade) secondary school. The three-year interval is not a strict rule, which means that some municipalities participated twice and some all three years (2017-2019). In the present study, information from all municipalities was included regardless of how many years they participated. It is therefore possible that some adolescents responded twice or thrice. In total, we have data from 422 municipalities, 333 participated only once, 59 twice, and one municipality participated all three years. Fewer municipalities participated in the Ungdata survey in 2018, compared to 2017 and 2019 (Figure 1).

In Norway, children start school the year they turn six years old (grade 1) and stay in school until the age of 15-16 years (grade 10). Attending school is obligatory by law until the completion of grade 10 whereas attending subsequent grades is voluntary. National

statistics show that the majority of 16- to 18-year-old (93.4% in 2019) go on to attend upper secondary schools.(23)

A total of 297,102 adolescents from both lower and upper secondary schools participated in the Ungdata surveys in 2017, 2018, and 2019. Of the participating adolescents, 278,891 answered the questions on ED consumption (response rate of 93.9%) and were included in the analyses (Figure 1).

In 2017, missing values for gender were 6.4% compared to less than 1% in 2018 and 2019. This is likely due to the order of questions in the electronic questionnaire, which led to overlooking of the question regarding gender in the 2017 survey. This ordering of questions was changed in 2018 and 2019 (personal correspondence with staff from Ungdata).

The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). Participants do not have unique identification numbers as data collection is done anonymously and does not contain sensitive information. Therefore, no ethical approval was needed. The study was funded by Innlandet Hospital Trust (project number: 150377).

Measures

ED consumption was assessed with the question “How often do you usually drink energy drinks (Red Bull, Battery, etc.)?” The participants could respond with one of seven incremental options, ranging from “never” to “several times a day”. The response to this question was used to categorize adolescents into the following two groups subsequently used as outcome variables: ED consumers (ED < once a week or more) and high ED consumers (ED ≥ 4 times a week). The definition of high ED consumers was based on previous studies.(2, 20) The ED consumers were compared to never ED consumers, and the

high ED consumers were compared to the rest (all other frequency of ED consumption including non-ED).

Leisure screen time was assessed using the question “Outside school, how much time do you normally spend on activities that involve looking at a screen (TV, computer, tablet, mobile phone) each day?” with options on a seven-point incremental scale ranging from “no time” to “≥ 6 hours”. The first three options of the variable leisure screen-time were merged into one response of “≤ 2 hours” due to the relatively low number of respondents in these categories.

Physical activity was assessed by the question “How often do you perform physical activity which gets you out of breath or makes you sweaty?” with options on a six-point incremental scale ranging from “never” to “at least five times a week”.

SES was assessed according to a five-point scale which again was based on a compound score from three different dimensions.(24, 25) These dimensions were: parental education, “culture capital” at home based on the question “how many books do you think there are in your home?”, and the third dimension used four questions from the Family Affluence Scale (FAS II). FAS II contains questions regarding the number of cars in the family, whether the participant has her/his own bedroom, whether the participant has been on vacation, and the number of computers or tablets in the house. The answers were assigned different points that were subsequently used to calculate a total score distributed into five equally sized groups. Group 1 refers to the lowest SES-score and group 5 to the highest.

For this study, we used the official Norwegian centrality index to define residency. According to Statistics Norway, centrality refers to an index of travel time to workplaces and service functions from all populated basic units. Groups 1 contains the most central municipalities

(highest index) and group 6 the least central (lowest index).(26) Residency for each individual is based on where the adolescent attends school and is not per se the place of living.

Further details on variables and answer options are given in Table 1.

Statistical analyses

The association between the outcome variables (any and high ED consumption) and the independent variables were estimated in multivariable Poisson regression models. These models allowed us to estimate the risk ratios (RR) between the categories of the independent variables.(27-29) We used the sandwich estimation method to generate robust standard errors.(27) We also included interaction terms between year and gender to estimate the extent to which these variables modified each other's association with the outcomes. In other words, we assessed if the association between gender and energy drinks differed by year and the extent to which the association between year and the consumption of ED differed by gender. The independent variables in the statistical models were decided *a priori* and consisted of: gender, year, grade, residency, SES, frequency of physical activity and leisure screen time. We adjusted the standard errors for clustering within the municipalities.

The interactions terms between gender and year were estimated both on an additive and a multiplicative scale using generalized linear models with identity and log link, respectively.(30) In these models we estimated the significance of the interaction terms using likelihood ratio tests. STATA version 15.1 (College Station, Texas) was used for all statistical analysis.(31)

Patient and public involvement

There were no patients involved in the study.

RESULTS

In total, 278,891 adolescents who participated in Ungdata answered the question about ED use and were included for further analyses. Most of the adolescents (57.5%) attended lower secondary school (Table 1). Grade thirteen was the least represented grade in the sample, which is in line with previous findings from the Ungdata survey.(24)

Most of the participants attended schools in municipalities with the centrality index two and three. The distribution seen in Table 1 is comparable to the overall distribution of the centrality index in Norway.(32) A lesser percentage in level six was expected, as fewer people are living in these areas.

Table 1. Baseline Characteristics of Adolescents participating in the Ungdata surveys in 2017, 2018 and 2019.

VARIABLE	TOTAL (%)	2017 (%)	2018 (%)	2019 (%)
N	278,891	101,997	66,017	110,877
SCHOOL LEVEL				
LOWER SECONDARY	160,352 (57.5)	61,768 (60.6)	38,256 (57.9)	60,328 (54.4)
UPPER SECONDARY	118,539 (42.5)	40,229 (39.4)	27,761 (42.1)	50,549 (45.6)
GRADE				
8	52,984 (19.0)	20,381 (20.0)	12,695 (19.2)	19,908 (18.0)
9	51,393 (18.4)	19,514 (19.1)	12,558 (19.0)	19,321 (17.4)
10	50,547 (18.1)	19,632 (19.2)	11,687 (17.7)	19,228 (17.3)
11	50,972 (18.3)	18,580 (18.2)	11,190 (16.9)	21,202 (19.1)
12	40,391 (14.5)	12,824 (12.6)	9360 (14.2)	18,207 (16.4)
13	26,351 (9.5)	8632 (8.5)	7091 (10.7)	10,628 (9.6)
MISSING	6253 (2.2)	2434 (2.4)	1436 (2.2)	2383 (2.2)
GENDER				
FEMALE	138,218 (49.6)	47,218 (46.3)	31,802 (48.2)	54,020 (48.7)
MALE	133,040 (47.7)	48,254 (47.3)	33,908 (51.4)	56,056 (50.6)

MISSING	7633 (2.7)	6525 (6.4)	307 (0.5)	801 (0.7)
RESIDENCY				
1	56,012 (20.2)	14,909 (14.7)	22,358 (34.0)	18,745 (16.9)
2	63,413 (22.8)	30,793 (30.5)	5601 (8.5)	27,019 (24.4)
3	74,853 (26.9)	23,190 (22.9)	16,117 (25.5)	35,546 (32.1)
4	46,826 (16.9)	16,688 (16.5)	11,286 (17.1)	18,852 (17.0)
5	27,900 (10.0)	12,358 (12.2)	7609 (11.6)	7933 (7.1)
6	8847 (3.2)	3195 (3.2)	2870 (4.4)	2782 (2.5)
FREQUENCY OF PHYSICAL ACTIVITY				
NEVER	4518 (1.6)	1374 (1.3)	1218 (1.8)	1926 (1.7)
SELDOM	19,642 (7.0)	6314 (6.2)	4997 (7.6)	8331 (7.5)
1-2 TIMES A MONTH	18,007 (6.5)	6105 (6.0)	4709 (7.1)	7193 (6.5)
1-2 TIMES A WEEK	75,687 (27.1)	26,901 (26.4)	18,484 (28.0)	30,302 (27.3)
3-4 TIMES A WEEK	89,537 (32.1)	33,164 (32.5)	20,458 (31.0)	35,915 (32.4)
≥ 5 TIMES A WEEK	65,897 (23.6)	25,472 (25.0)	14,402 (21.8)	26,023 (23.5)
MISSING	5603 (2.0)	2667 (2.6)	1749 (2.7)	1187 (1.1)
LEISURE SCREEN TIME				
≤ 2 HOURS DAILY	43,234 (15.5)	17,734 (17.4)	10,355 (15.7)	15,145 (13.7)
2-3 HOURS DAILY	60,567 (21.7)	22,786 (22.3)	14,284 (21.6)	23,497 (21.2)
3-4 HOURS DAILY	75,781 (27.2)	27,296 (26.8)	17,654 (26.7)	30,831 (27.8)
4-6 HOURS DAILY	59,250 (21.2)	20,379 (20.0)	13,878 (21.0)	24,993 (22.5)
≥ 6 HOURS DAILY	36,168 (13.0)	12,563 (12.3)	8873 (13.4)	14,732 (13.3)
MISSING	3891 (1.4)	1239 (1.2)	973 (1.5)	1679 (1.5)
ENERGY DRINKS CONSUMPTION				
NEVER	128,365 (46.0)	46,782 (45.9)	31,055 (47.0)	50,528 (45.6)
< ONCE A WEEK	71,200 (25.5)	27,530 (27.0)	16,594 (25.1)	27,076 (24.4)
ONCE A WEEK	29,653 (10.6)	10,936 (10.7)	6784 (10.3)	11,933 (10.8)
2-3 TIMES A WEEK	28,974 (10.4)	10,065 (9.9)	6595 (10.0)	12,314 (11.1)
4-6 TIMES A WEEK	12,310 (4.4)	4038 (4.0)	2843 (4.3)	5429 (4.9)

EVERY DAY	4080 (1.5)	1250 (1.2)	1005 (1.5)	1825 (1.6)
SEVERAL TIMES A DAY	4309 (1.5)	1396 (1.4)	1141 (1.7)	1772 (1.6)

Between 20-30% of the participants reported performing some kind of physical activity where they get sweaty either 1-2, 3-4, or more than 5 times a week, while less than 10% reported 1-2 times a month or less. In addition, more than 10% spent 6 hours or more looking at a screen. Overall, 46% of the participants had never consumed ED and 7.4% had consumed ED more than 4 times a week.

Over the three years, there was a small decrease in the percentage of boys consuming ED from 67.3% (CI: 66.9-67.7) in 2017 to 65.7% (CI: 65.3-66-1) in 2019. Among girls, a small increase was found from 40.8% (CI: 40.4-41.3) in 2017 to 43.6% (CI: 43.1-44.0) in 2019 (Figure 2). However, high ED consumers increased among both boys and girls (Figure 3). In 2017, 9.8% (CI: 9.5-10.0) of the boys and 3.3% (CI: 3.1-3.4) of the girls reported ED consumption in the range of high consumers, while these percentages increased to 11.5% (CI: 11.2-11.7) in boys and 4.9% (CI: 4.7-5.1) in girls in 2019.

Table 2 shows the annual increase in high ED consumption among both boys and girls. The proportion of female high ED consumers increased by 46% over the period. That is, the proportion of female high consumers increased by 24% (RR; CI) (1.24; 1.09, 1.41) from 2017 to 2018, and by 46% (1.46; 1.31, 1.62) from 2017 to 2019. There was also an increase in the proportion of high consumers of ED in boys, however, this increase was lower at 12% (1.12; 1.05, 1.19) from 2017 to 2019. On a multiplicative scale, the interaction terms between gender and year were statistically significant for 2019 (Table 2). However, on an additive scale there was no interaction found according to the generalized linear models as the difference in percentage points was almost identical (1.7 in boys and 1.6 in girls). Table 2

demonstrates the results from the Poisson regression models adjusted for clustering of municipalities. As no substantial differences between the crude and adjusted estimates from the Poisson regression models were found, only adjusted results are shown.

Table 2. Determinants for being energy drink consumers (any ED or high ED) in Norwegian adolescents.

VARIABLE	TOTAL SAMPLE			ED CONSUMERS		HIGH ED CONSUMERS			
	n	n	%	RR	95% CI	n	%	RR	95% CI
INTERACTION TERMS				1				1	
INTERACTION GENDER AND YEAR - 2018				0.99	0.90, 1.10			0.89	0.78, 1.01
INTERACTION GENDER AND YEAR - 2019				0.91	0.89, 0.94			0.77	0.69, 0.84
SUBGROUPS									
YEAR									
2017 FEMALE	48,254	19,700	40.8	1		1571	3.3	1	
2018 FEMALE	33,908	13,702	40.4	0.98	0.91, 1.06	1410	4.2	1.24	1.09, 1.41
2019 FEMALE	56,056	24,414	43.5	1.05	1.02, 1.09	2759	4.9	1.46	1.31, 1.62
2017 MALE	47,218	31,785	67.3	1		4620	9.8	1	
2018 MALE	31,802	21,097	66.3	0.98	0.94, 1.01	3554	11.2	1.10	1.01, 1.20
2019 MALE	54,020	35,491	65.7	0.96	0.95, 0.98	6190	11.5	1.12	1.05, 1.19
ASSOCIATION BETWEEN GENDER AND ED PER YEAR (FEMALES IN REFERANCE GROUP)									

MALE 2017				1.64	1.57, 1.71			2.79	2.58, 3.03
MALE 2018				1.62	1.48, 1.78			2.48	2.24, 2.75
MALE 2019				1.49	1.43, 1.56			2.14	2.01, 2.29
GRADE									
8	52,984	22,741	42.9	1		2533	4.8	1	
9	51,393	26,914	52.4	1.20	1.18, 1.22	3224	6.3	1.25	1.17, 1.33
10	50,547	28,215	55.8	1.26	1.24, 1.29	3654	7.2	1.39	1.30, 1.49
11	50,972	30,154	59.2	1.34	1.30, 1.38	4756	9.3	1.79	1.64, 1.95
12	40,391	23,925	59.2	1.34	1.30, 1.39	3886	9.6	1.85	1.67, 2.04
13	26,351	14,864	56.4	1.32	1.27, 1.38	2154	8.2	1.74	1.56, 1.94
RESIDENCY									
1	56,012	26,965	48.1	1		3254	5.8	1	
2	63,413	32,609	51.4	1.06	1.03, 1.10	4355	6.9	1.20	1.04, 1.37
3	74,853	40,723	54.4	1.11	1.09, 1.13	5738	7.7	1.27	1.11, 1.46
4	46,826	27,433	58.6	1.20	1.16, 1.23	4077	8.7	1.46	1.28, 1.66
5	27,900	16,895	60.6	1.25	1.21, 1.29	2467	8.8	1.54	1.34, 1.77
6	8847	5329	60.2	1.24	1.17, 1.30	750	8.5	1.58	1.34, 1.86
SOCIOECONOMIC STATUS									
5 HIGHEST	56,418	28,084	49.8	1		3133	5.6	1	

4	55,641	29,692	53.4	1.04	1.03, 1.05	3665	6.6	1.09	1.05, 1.14
3	55,935	30,532	54.6	1.06	1.05, 1.07	4199	7.5	1.22	1.17, 1.28
2	55,947	31,269	55.9	1.07	1.06, 1.08	4542	8.1	1.28	1.22, 1.35
1 LOWEST	54,950	30,949	56.3	1.08	1.07, 1.10	5160	9.4	1.46	1.39, 1.53
PHYSICAL ACTIVITY									
NEVER	4518	2481	54.9	1		782	17.3	1	
SELDOM	19,642	11,086	56.4	1.05	1.01, 1.08	2002	10.2	0.65	0.58, 0.72
1-2 TIMES A MONTH	18,007	9903	55.0	1.04	1.01, 1.07	1357	7.5	0.53	0.48, 0.58
1-2 TIMES A WEEK	75,687	40,581	53.6	1.02	0.98, 1.05	5058	6.7	0.50	0.45, 0.55
3-4 TIMES A WEEK	89,537	47,874	53.5	1.03	1.00, 1.06	5614	6.3	0.52	0.47, 0.57
≥ 5 TIMES A WEEK	65,897	35,312	53.6	1.01	0.98, 1.05	5173	7.9	0.62	0.57, 0.68
LEISURE SCREEN TIME									
≤ 2 HOURS DAILY	43,234	18,797	43.5	1		1978	4.6	1	
2-3 HOURS DAILY	60,567	28,922	47.8	1.10	1.09, 1.11	2659	4.4	1.00	0.95, 1.06
3-4 HOURS DAILY	75,781	40,778	53.8	1.22	1.20, 1.24	4514	6.0	1.33	1.26, 1.40
4-6 HOURS DAILY	59,250	35,462	59.9	1.32	1.30, 1.34	4950	8.4	1.79	1.70, 1.88
≥ 6 HOURS DAILY	36,168	24,214	66.9	1.42	1.40, 1.45	6026	16.7	3.15	3.00, 3.32

ED: Energy drink; RR: Relative Risk; CI: Confidence Interval; [a] Modified Poisson regression with robust variance estimation; [b]Estimates are statistically significant if their CIs do not include 1.0. Total sample n= 256,801. Walds test shows statistically significant p-values at $p<0.05$. Loglikelihood ratio test of complete interaction term was significant at $p<0.01$.

The association between ED consumption and social determinants (Table 2) showed that the largest proportion of high ED consumers was found in participants living in centrality index 6 (least central residency). Furthermore, we found a larger proportion of high ED consumers with decreasing SES. The same association was found when looking at the any ED consumption group, although differences were less pronounced. There was a relationship between high ED consumption and physical activity. Here, the lowest proportion was observed for those who were physically active 1-2 times a week compared to those who were never being physically active. However, this was not observed for the any ED consumption group. Regarding both the participants who consumed any ED as well as the high consumers, the proportions increased with increasing leisure screen time. The proportion of high ED consumers that spent more than 6 hours looking at a screen outside school hours was three times higher than the high ED consumers that spent less than 2 hours looking at a screen.

DISCUSSION

We have described social determinants and changes in ED consumption among Norwegian adolescents between 2017 and 2019. We found an increase in the percentage of both boys and girls being high ED consumers and a change in ED consumption according to time. The main finding was an increasing proportion of female high ED consumers, which is of special interest as it highlights the fact that despite male high ED consumers still being the gender consuming most ED, females high ED consumers are catching up.

We found that in total, over the three years, 4.2% of the girls and 10.8% of the boys were high ED consumers. There was an annual increase in the proportion of high consumers that was most pronounced for girls increasing from 3.3% in 2017 to 4.9% in 2019. Moreover, we found that more than half of the adolescents participating in the study had consumed any ED during these three years. The increase in high ED consumption was expected as sales in ED in Norway have increased. However, adolescents are most likely not the only group consuming increasing amounts of ED. It is plausible that other groups in the population follow the same trend in ED consumption.

High ED consumption was positively associated with the male gender, lower SES, rural living, excessive screen watching, physical inactivity, and being very physically active. The combination of either low or high physical activity and high leisure screen-time as predictors for ED consumption was also found in other studies from Saudi Arabia, Canada, and the U.S.(3, 18, 33-35) Al-Hazza et. al proposed that the reason why both low and high physical activity and high leisure screen-time was observed, is due to how ED are being marketed.(33)

According to the study by Emond et. al on ED advertisement, ED was primarily advertised on channels with adolescents as their base audience.(5) Based on this, one could imagine that increased screen time and thereby increased exposure to ED advertising would lead to higher ED consumption rates.(7) In addition, Hammond et. al. found that TV was the main common source of marketing of ED to adolescents next to marketing in grocery stores.(36) Our results also suggest that adolescents who spend much of their spare time watching screens are those who consume most ED. Regarding the gender difference in high ED consumption, one could hypothesize that the marketing of ED appeals more to boys as they are the ones consuming more ED.

Our results show that even though boys still are the highest consumers of ED, the increase in the proportion of female high consumers was larger, on a multiplicative scale but not an additive scale, compared to males over the three years. The increase was 1.7 percentage points for boys (9.8-11.5%) and 1.6 for girls (3.3-4.9%) from 2017 until 2019. Based on this finding it could be speculated that girls are becoming more exposed and perhaps more susceptible to ED marketing than before.

Limitations and strengths

A limitation of the study is that we were not able to take the regional differences in participation of schools each year into account. This might have affected the observed development of ED consumption seen over the three years. However, the breadth of the municipalities participating in the Ungdata study in 2017, 2018 and 2019 with an even distribution of smaller and larger communities spread out across Norway makes the sample sufficiently large and wide-reaching. Moreover, the participants are not completely selected at random as only municipalities who wanted to participate in the Ungdata survey were

included in the study. In addition, the participating schools within these municipalities were not selected completely at random. The lower secondary schools are run by the municipalities while the upper secondary schools are organized according to regional districts, therefore the schools have different catchment areas when it comes to children attending the schools.

Other limitations common to such surveys are that the study relies on self-reported ED consumption which can be susceptible to both recall bias and social desirability bias.(37) Moreover, only children who attended school on the day of the survey answered the questionnaire. Adolescents who were absent or had dropped out were therefore not included in the study, which might have affected the results. Finally, some adolescents might have participated more than once, yet no adjustment for lack of independence between these observations was possible.

The major strength of this study is the large sample included, with close to 300,000 adolescents answering the questionnaire and a response from 74.4% of the total eligible students in this time period.

CONCLUSION

ED consumption is increasing among female adolescents, especially high ED consumption. This is an important finding to consider in future research which could focus on possible gender-related differences when studying various aspects of ED consumption. In addition, with rising ED consumption it is increasingly important to investigate the potential long-term effects of ED use among adolescents.

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Footnote page

Abbreviations

ED = Energy Drinks

EFSA = European Food Safety Authority

FAS II = Family Affluence Scale II

NFSA = Norwegian Ministry of Health, the Norwegian Food Safety Authority

RR = Relative Risk

SES = Socio-Economic Status

VKM = Norwegian Scientific Committee for Food and Environment

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Ethical approval: The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). Participants do not have unique identification numbers as data collection is done anonymously and does not contain sensitive information. Therefore, no ethical approval was needed.

Patient and public involvement: There was no patient or public involvement in study.

Data availability statement: The data supporting our study is available from the Norwegian Centre for Research Data (NSD) and were used under license for the current study. The Ungdata survey is funded by The Norwegian Directorate of Health. Anonymous data has been made available for the authors by NOVA through NSD – the Norwegian Center for Research Data. Neither NOVA, The Norwegian Directorate of Health or NSD are responsible for the analyses or interpretation of the presented data.

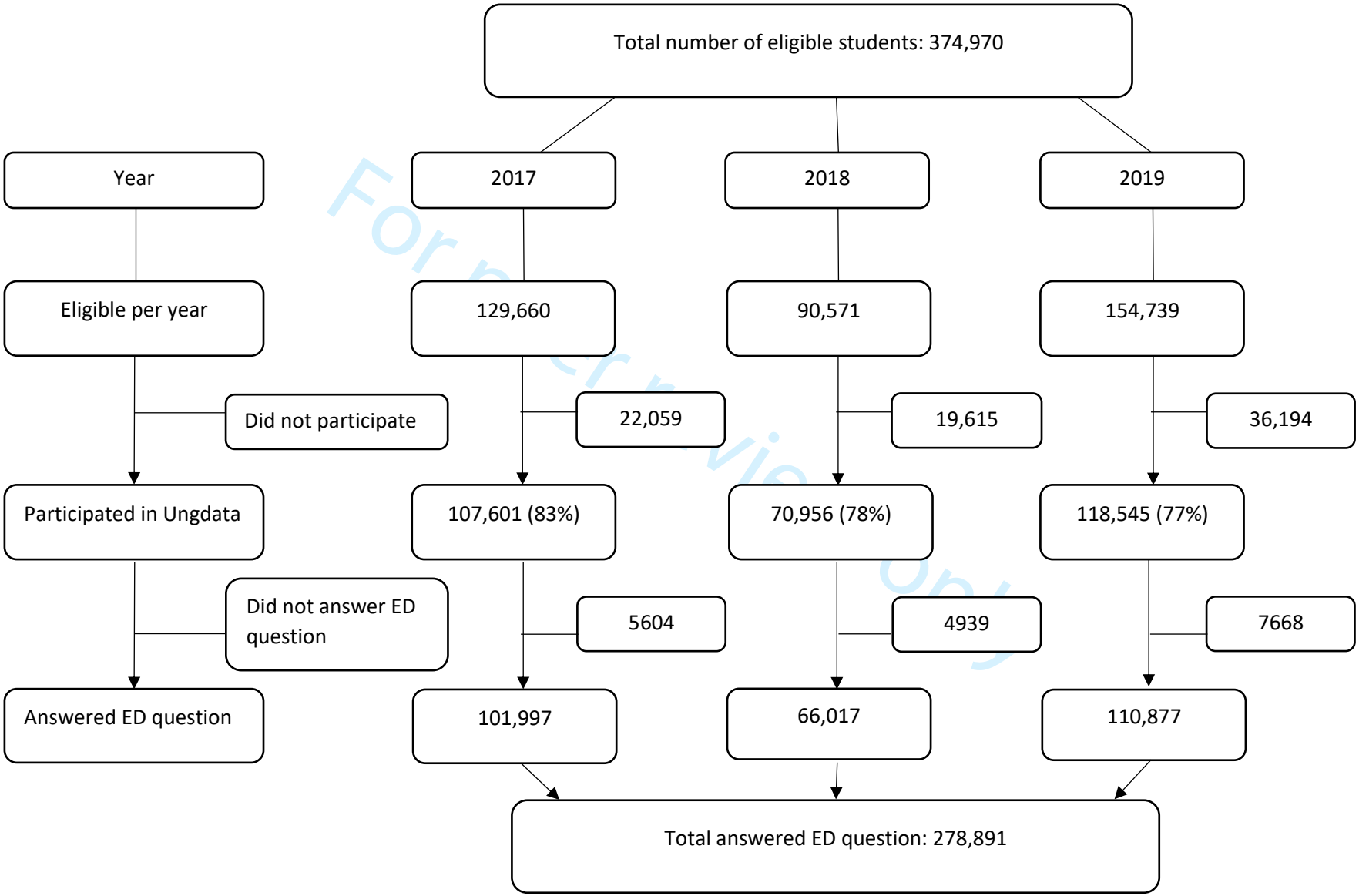
Competing interest: None declared

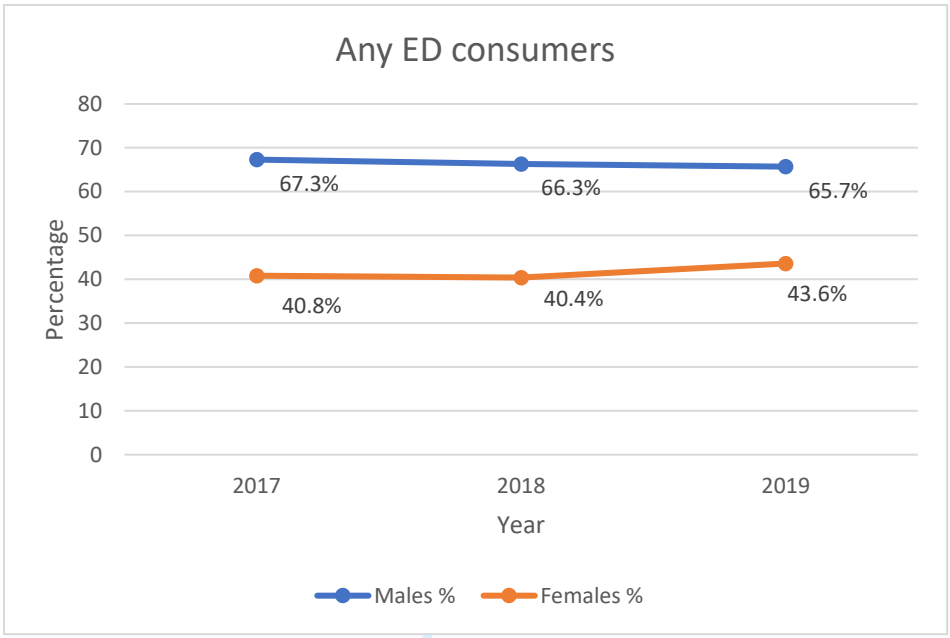
Figures

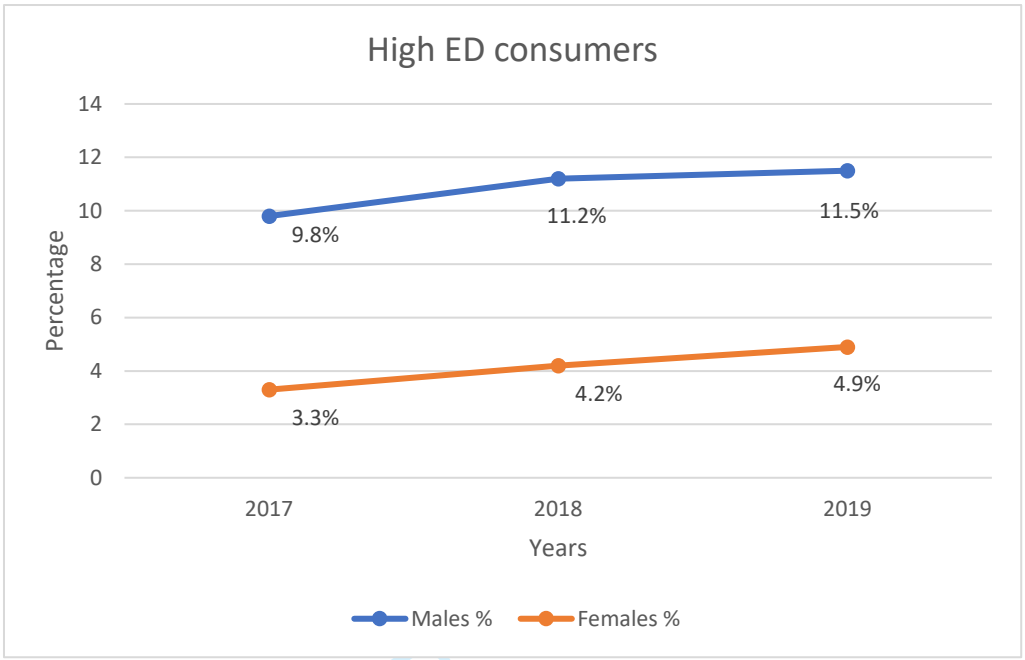
Figure 1: Overview of the Study Participants.

Figure 2: Any ED Consumers per Year and Gender.

Figure 3: High ED Consumers per Year and Gender.







STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	0
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	0
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1-3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	0+4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	0+4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-15

		(*b*) Report category boundaries when continuous variables were categorized	10-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	18-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4-5

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Social Determinants and Changes in Energy Drink Consumption among Adolescents in Norway, 2017-2019: A Cross-sectional Study

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Title page

Title: Social Determinants and Changes in Energy Drink Consumption among Adolescents in Norway, 2017-2019: A Cross-sectional Study

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Social Determinants and Changes in Energy Drink Consumption among Adolescents in Norway, 2017-2019: A Cross-sectional Study

Objectives: To describe the social determinants and development in energy drink consumption among Norwegian adolescents in 2017, 2018 and 2019.

Design: Cross-sectional, online, annual, nationwide surveys (Ungdata).

Setting: Responses collected online from January 2017 to December 2019.

Participants: Lower- and upper secondary school students (n=297,102) aged 12-19 years who responded in 2017, 2018, and 2019.

Main outcome measures: Frequency of energy drink consumption.

Results: Over the three-year period, 66.4% of the males and 41.8% of the females had consumed energy drink once a week or more. The proportion of female high consumers (consuming energy drink more than 4 times a week) increased from 3.3% to 4.9% between 2017 and 2019; for males, the increase was from 9.8% to 11.5%. In females the proportion of high consumers increased with 24% (relative risk (RR); CI) (1.24; 1.09, 1.41) from 2017 to 2018, and 46% (1.46; 1.31, 1.62) from 2017 to 2019. The corresponding increases in males were 10% (1.10; 1.01, 1.20) from 2017 to 2018, and 12% (1.12; 1.05, 1.19) from 2017to 2019. Any energy drink consumption as well as high energy drink consumption were independently associated with school level, less central residency, low socioeconomic status, physical inactivity, and high leisure screen time.

Conclusion: We found an increase in high consumers among both boys and girls between 2017 and 2019. The observed increase in energy drink consumption among adolescents can explain some of the increased sales of energy drink in Norway.

Article summary

Strengths and limitations of this study:

- This study identifies recent development in the frequency of energy drink consumption among adolescents in Norway.
- Data are derived from a large, annual, national survey in Norway including nearly 300,000 adolescents over three years from 2017 to 2019.
- The study relies on self-reported energy drink consumption, which can be susceptible to both recall bias and social desirability bias.

INTRODUCTION

Marketed as a booster of mental and physical capacity, energy drinks (ED) have gained worldwide popularity. In Norway, ED sales increased by more than 50% from 2017 to 2019.(1) ED are defined as non-alcoholic beverages that contain at least 150 mg caffeine per litre, in addition to sugar combined with one or more substances known to have stimulant properties.(2-4) Moreover, vitamins, minerals, and amino acids are frequently added to ED.(4) ED marketing is often targeted toward athletes and the adolescent population, and recent studies have shown that viewers of TV-channels with greater ED advertising have increased odds of ED consumption.(5-7)

ED consumption among children and adolescents has been linked to potential negative effects such as increased cardiovascular symptoms with increased cardiac output, but also elevated systolic and diastolic blood pressure.(8) Moreover, sleep disturbance, nervousness, and headache have been reported.(9-12) These potential adverse effects can result in tiredness, inattention, reduced school performance, and increased mental distress. The main cause for concern is the high level of caffeine in ED combined with added sugar and sweet flavour, next to the high content of stimulating substances.(13) According to Iversen et. al, this combination of ingredients may cause faster uptake of caffeine into the circulation compared to regular coffee.(13) Moreover, studies have indicated that adding caffeine to sugar-sweetened beverages (SSB) leads to increased use of SSB, which in turn results in increased energy intake.(14, 15) The high energy intake may contribute to overweight and obesity, as well as dental caries due to the high sugar and citric acid content of ED and SSB.(16)

In 2013, the European Food Safety Authority (EFSA) published a report on ED use, indicating that children and adolescents aged 10-18 years had the highest reported consumption (68%), compared with adults above 18 years (30%) and children below 10 years (18%).(3) The potential negative effects of ED in children and adolescents have gained the attention of government authorities in several countries, of which some have issued restrictions on the caffeine content in ED.(17) The Norwegian Food Safety Authority (NFSA) has stated that the daily intake of caffeine for children and adolescents should not exceed 2.5 mg/kg. This was decided based on a review of current knowledge by the Norwegian Scientific Committee for Food and Environment (VKM).(4)

According to the findings of the VKM review, a child or youth would be at risk of sleep disturbance with an intake of 1.4 mg/kg body weight/day of caffeine.(4) Furthermore, the risk of negative health effects on the heart and central nervous system would be present at an intake of 3 mg/kg body weight/day of caffeine. This would mean that a 13-15 years old adolescent with an average weight of 50 kg would be at risk of sleep disturbance when drinking more than 70 mg/day of caffeine and at risk of adverse cardiac and central neurologic effects at daily consumption of 150 mg/day. These values are in line with recommendations by EFSA and correspond to an intake of one to two large cans (500ml) of ED for an adolescent described above.(4)

ED consumption varies according to age and gender. Several studies have found that male adolescents are more likely to consume ED than their female counterparts. Moreover, young (male) adolescents at middle school level have a higher ED consumption compared to older adolescents at high school level.(3, 18, 19) Furthermore, Degirmenci et al. found that high consumption (> 4 times a week) of ED was independently associated with male gender,

physical inactivity, high leisure screen time, low socioeconomic status, and rural residency.(20)

Of special concern for potential adverse effects are children and adolescents who have lower body weight, and are more sensitive to ED stimulants, including caffeine. According to the American Academy of Pediatrics, “Caffeine and other stimulants contained in energy drinks have no place in the diet of children and adolescents”.(21) Despite the aforementioned increased sales of ED in Norway, the extent to which the consumption of ED among children and adolescents followed this development remains unclear.(17) The objective of the current study is to describe the social determinants and changes in energy drink consumption among Norwegian adolescents in 2017, 2018, and 2019. Potential social determinants include age, gender, socio-economic status (SES), residency, physical activity, and leisure screen time.

METHODS

Study design and participants

Data for the study was collected through the Ungdata survey, a national, annual, survey, mapping the health and well-being of lower and upper secondary school students in Norway. The study was approved by the Norwegian Centre for Research Data. Detailed information regarding the survey can be found on www.ungdata.no.(22) All data collection is conducted anonymously and web-based during school hours with the teacher present in the classroom. Data from the surveys carried out in 2017, 2018, and 2019 were used for the present study.

All 422 municipalities in Norway (2019) are invited to participate in the Ungdata survey. Participation is free of charge and on a volunteer basis. The municipalities are encouraged to perform the survey every three years in the schools of the municipalities. This is to ensure that all adolescents get to participate once both during lower (8^{th} to 10^{th} grade) and upper (11^{th} to 13^{th} grade) secondary school. The three-year interval is not a strict rule, which means that some municipalities participated twice and some all three years (2017-2019). In the present study, information from all municipalities was included regardless of how many years they participated. It is therefore possible that some adolescents responded twice or thrice. In total, we have data from 422 municipalities, 333 participated only once, 59 twice, and one municipality participated all three years. Fewer municipalities participated in the Ungdata survey in 2018, compared to 2017 and 2019 (Figure 1).

In Norway, children start school the year they turn six years old (grade 1) and stay in school until the age of 15-16 years (grade 10). Attending school is obligatory by law until the completion of grade 10 whereas attending subsequent grades is voluntary. National

statistics show that the majority of 16- to 18-year-old (93.4% in 2019) go on to attend upper secondary schools.(23)

A total of 297,102 adolescents from both lower and upper secondary schools participated in the Ungdata surveys in 2017, 2018, and 2019. Of the participating adolescents, 278,891 answered the questions on ED consumption (response rate of 93.9%) and were included in the analyses (Figure 1).

In 2017, missing values for gender were 6.4% compared to less than 1% in 2018 and 2019. This is likely due to the order of questions in the electronic questionnaire, which led to overlooking of the question regarding gender in the 2017 survey. This ordering of questions was changed in 2018 and 2019 (personal correspondence with staff from Ungdata).

The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). Participants do not have unique identification numbers as data collection is done anonymously and does not contain sensitive information. Therefore, no ethical approval was needed. The study was funded by Innlandet Hospital Trust (project number: 150377).

Measures

ED consumption was assessed with the question “How often do you usually drink energy drinks (Red Bull, Battery, etc.)?” The participants could respond with one of seven incremental options, ranging from “never” to “several times a day”. The response to this question was used to categorize adolescents into the following two groups subsequently used as outcome variables: ED consumers (ED < once a week or more) and high ED consumers (ED ≥ 4 times a week). The definition of high ED consumers was based on previous studies.(2, 20) The ED consumers were compared to never ED consumers, and the

high ED consumers were compared to the rest (all other frequency of ED consumption including non-ED).

Leisure screen time was assessed using the question “Outside school, how much time do you normally spend on activities that involve looking at a screen (TV, computer, tablet, mobile phone) each day?” with options on a seven-point incremental scale ranging from “no time” to “≥ 6 hours”. The first three options of the variable leisure screen-time were merged into one response of “≤ 2 hours” for the regression analysis due to the relatively low number of respondents in these categories.

Physical activity was assessed by the question “How often do you perform physical activity which gets you out of breath or makes you sweaty?” with options on a six-point incremental scale ranging from “never” to “at least five times a week”.

SES was assessed according to a five-point scale which again was based on a compound score from three different dimensions.(24, 25) These dimensions were: parental education, “culture capital” at home based on the question “how many books do you think there are in your home?”, and the third dimension used four questions from the Family Affluence Scale (FAS II). FAS II contains questions regarding the number of cars in the family, whether the participant has her/his own bedroom, whether the participant has been on vacation, and the number of computers or tablets in the house. The answers were assigned different points that were subsequently used to calculate a total score distributed into five equally sized groups. Group 1 refers to the lowest SES-score and group 5 to the highest.

For this study, we used the official Norwegian centrality index to define residency. According to Statistics Norway, centrality refers to an index of travel time to workplaces and service functions from all populated basic units. Groups 1 contains the most central municipalities

(highest index) and group 6 the least central (lowest index).(26) Residency for each individual is based on where the adolescent attends school and is not per se the place of living.

Further details on variables and answer options are given in Table 1.

Statistical analyses

The association between the outcome variables (any and high ED consumption) and the independent variables were estimated in multivariable Poisson regression models. These models allowed us to estimate the risk ratios (RR) between the categories of the independent variables.(27-29) We used the sandwich estimation method to generate robust standard errors.(27) We also included interaction terms between year and gender to estimate the extent to which these variables modified each other's association with the outcomes. In other words, we assessed if the association between gender and energy drinks differed by year and the extent to which the association between year and the consumption of ED differed by gender. The independent variables in the statistical models were decided *a priori* and consisted of: gender, year, grade, residency, SES, frequency of physical activity and leisure screen time. We adjusted the standard errors for clustering within the municipalities.

The interactions terms between gender and year were estimated both on an additive and a multiplicative scale using generalized linear models with identity and log link, respectively.(30) In these models we estimated the significance of the interaction terms using likelihood ratio tests. STATA version 15.1 (College Station, Texas) was used for all statistical analysis.(31)

Patient and public involvement

There were no patients involved in the study.

RESULTS

In total, 278,891 adolescents who participated in Ungdata answered the question about ED use and were included for further analyses. Most of the adolescents (57.5%) attended lower secondary school (Table 1). Grade thirteen was the least represented grade in the sample, which is in line with previous findings from the Ungdata survey.(24)

Most of the participants attended schools in municipalities with the centrality index two and three. The distribution seen in Table 1 is comparable to the overall distribution of the centrality index in Norway.(32) A lesser percentage in level six was expected, as there are fewer schools in these areas.

Table 1. Baseline Characteristics of Adolescents participating in the Ungdata surveys in 2017, 2018 and 2019.

VARIABLE	TOTAL (%)	2017 (%)	2018 (%)	2019 (%)
N	278,891	101,997	66,017	110,877
SCHOOL LEVEL				
LOWER SECONDARY	160,352 (57.5)	61,768 (60.6)	38,256 (57.9)	60,328 (54.4)
UPPER SECONDARY	118,539 (42.5)	40,229 (39.4)	27,761 (42.1)	50,549 (45.6)
GRADE				
8	52,984 (19.0)	20,381 (20.0)	12,695 (19.2)	19,908 (18.0)
9	51,393 (18.4)	19,514 (19.1)	12,558 (19.0)	19,321 (17.4)
10	50,547 (18.1)	19,632 (19.2)	11,687 (17.7)	19,228 (17.3)
11	50,972 (18.3)	18,580 (18.2)	11,190 (16.9)	21,202 (19.1)
12	40,391 (14.5)	12,824 (12.6)	9360 (14.2)	18,207 (16.4)
13	26,351 (9.5)	8632 (8.5)	7091 (10.7)	10,628 (9.6)
MISSING	6253 (2.2)	2434 (2.4)	1436 (2.2)	2383 (2.2)
GENDER				
FEMALE	138,218 (49.6)	47,218 (46.3)	31,802 (48.2)	54,020 (48.7)
MALE	133,040 (47.7)	48,254 (47.3)	33,908 (51.4)	56,056 (50.6)

MISSING	7633 (2.7)	6525 (6.4)	307 (0.5)	801 (0.7)
RESIDENCY				
1	56,012 (20.2)	14,909 (14.7)	22,358 (34.0)	18,745 (16.9)
2	63,413 (22.8)	30,793 (30.5)	5601 (8.5)	27,019 (24.4)
3	74,853 (26.9)	23,190 (22.9)	16,117 (25.5)	35,546 (32.1)
4	46,826 (16.9)	16,688 (16.5)	11,286 (17.1)	18,852 (17.0)
5	27,900 (10.0)	12,358 (12.2)	7609 (11.6)	7933 (7.1)
6	8847 (3.2)	3195 (3.2)	2870 (4.4)	2782 (2.5)
FREQUENCY OF PHYSICAL ACTIVITY				
NEVER	4518 (1.6)	1374 (1.3)	1218 (1.8)	1926 (1.7)
SELDOM	19,642 (7.0)	6314 (6.2)	4997 (7.6)	8331 (7.5)
1-2 TIMES A MONTH	18,007 (6.5)	6105 (6.0)	4709 (7.1)	7193 (6.5)
1-2 TIMES A WEEK	75,687 (27.1)	26,901 (26.4)	18,484 (28.0)	30,302 (27.3)
3-4 TIMES A WEEK	89,537 (32.1)	33,164 (32.5)	20,458 (31.0)	35,915 (32.4)
≥ 5 TIMES A WEEK	65,897 (23.6)	25,472 (25.0)	14,402 (21.8)	26,023 (23.5)
MISSING	5603 (2.0)	2667 (2.6)	1749 (2.7)	1187 (1.1)
LEISURE SCREEN TIME				
NO TIME	2489 (0.9)	1015 (1.0)	630 (1.0)	844 (0.8)
≤ 1 HOUR DAILY	8261 (3.0)	3499 (3.4)	2049 (3.1)	2713 (2.5)
1-2 2 HOURS DAILY	32,484 (11.6)	13,220 (13.0)	7676 (11.6)	11,588 (10.4)
2-3 HOURS DAILY	60,567 (21.7)	22,786 (22.3)	14,284 (21.6)	23,497 (21.2)
3-4 HOURS DAILY	75,781 (27.2)	27,296 (26.8)	17,654 (26.7)	30,831 (27.8)
4-6 HOURS DAILY	59,250 (21.2)	20,379 (20.0)	13,878 (21.0)	24,993 (22.5)
≥ 6 HOURS DAILY	36,168 (13.0)	12,563 (12.3)	8873 (13.4)	14,732 (13.3)
MISSING	3891 (1.4)	1239 (1.2)	973 (1.5)	1679 (1.5)
ENERGY DRINKS CONSUMPTION				
NEVER	128,365 (46.0)	46,782 (45.9)	31,055 (47.0)	50,528 (45.6)
< ONCE A WEEK	71,200 (25.5)	27,530 (27.0)	16,594 (25.1)	27,076 (24.4)
ONCE A WEEK	29,653 (10.6)	10,936 (10.7)	6784 (10.3)	11,933 (10.8)

2-3 TIMES A WEEK	28,974 (10.4)	10,065 (9.9)	6595 (10.0)	12,314 (11.1)
4-6 TIMES A WEEK	12,310 (4.4)	4038 (4.0)	2843 (4.3)	5429 (4.9)
EVERY DAY	4080 (1.5)	1250 (1.2)	1005 (1.5)	1825 (1.6)
SEVERAL TIMES A DAY	4309 (1.5)	1396 (1.4)	1141 (1.7)	1772 (1.6)

Between 20-30% of the participants reported performing some kind of physical activity where they get sweaty either 1-2, 3-4, or more than 5 times a week, while less than 10% reported 1-2 times a month or less. In addition, more than 10% spent 6 hours or more looking at a screen. Overall, 46% of the participants had never consumed ED and 7.4% had consumed ED more than 4 times a week.

Over the three years, there was a small decrease in the percentage of boys consuming ED from 67.3% (CI: 66.9-67.7) in 2017 to 65.7% (CI: 65.3-66-1) in 2019. Among girls, a small increase was found from 40.8% (CI: 40.4-41.3) in 2017 to 43.6% (CI: 43.1-44.0) in 2019 (Figure 2). However, high ED consumers increased among both boys and girls (Figure 3). In 2017, 9.8% (CI: 9.5-10.0) of the boys and 3.3% (CI: 3.1-3.4) of the girls reported ED consumption in the range of high consumers, while these percentages increased to 11.5% (CI: 11.2-11.7) in boys and 4.9% (CI: 4.7-5.1) in girls in 2019.

Table 2 shows the annual increase in high ED consumption among both boys and girls. The proportion of female high ED consumers increased by 46% over the period. That is, the proportion of female high consumers increased by 24% (RR; CI) (1.24; 1.09, 1.41) from 2017 to 2018, and by 46% (1.46; 1.31, 1.62) from 2017 to 2019. There was also an increase in the proportion of high consumers of ED in boys, however, this increase was lower at 12% (1.12; 1.05, 1.19) from 2017 to 2019. On a multiplicative scale, the interaction terms between gender and year were statistically significant for 2019 (Table 2). However, on an additive scale there was no interaction found according to the generalized linear models as the

difference in percentage points was almost identical (1.7 in boys and 1.6 in girls). Table 2 demonstrates the results from the Poisson regression models adjusted for clustering of municipalities. As no substantial differences between the crude and adjusted estimates from the Poisson regression models were found, only adjusted results are shown.

Table 2. Determinants for being energy drink consumers (any ED or high ED) in Norwegian adolescents.

VARIABLE	TOTAL SAMPLE			ED CONSUMERS		HIGH ED CONSUMERS			
	n	n	%	RR	95% CI	n	%	RR	95% CI
INTERACTION TERMS				1				1	
INTERACTION GENDER AND YEAR - 2018				0.99	0.90, 1.10			0.89	0.78, 1.01
INTERACTION GENDER AND YEAR - 2019				0.91	0.89, 0.94			0.77	0.69, 0.84
SUBGROUPS									
YEAR									
2017 FEMALE	48,254	19,700	40.8	1		1571	3.3	1	
2018 FEMALE	33,908	13,702	40.4	0.98	0.91, 1.06	1410	4.2	1.24	1.09, 1.41
2019 FEMALE	56,056	24,414	43.5	1.05	1.02, 1.09	2759	4.9	1.46	1.31, 1.62
2017 MALE	47,218	31,785	67.3	1		4620	9.8	1	
2018 MALE	31,802	21,097	66.3	0.98	0.94, 1.01	3554	11.2	1.10	1.01, 1.20
2019 MALE	54,020	35,491	65.7	0.96	0.95, 0.98	6190	11.5	1.12	1.05, 1.19
ASSOCIATION BETWEEN GENDER AND ED PER YEAR (FEMALES IN REFERANCE GROUP)									

MALE 2017				1.64	1.57, 1.71			2.79	2.58, 3.03
MALE 2018				1.62	1.48, 1.78			2.48	2.24, 2.75
MALE 2019				1.49	1.43, 1.56			2.14	2.01, 2.29
GRADE									
8	52,984	22,741	42.9	1		2533	4.8	1	
9	51,393	26,914	52.4	1.20	1.18, 1.22	3224	6.3	1.25	1.17, 1.33
10	50,547	28,215	55.8	1.26	1.24, 1.29	3654	7.2	1.39	1.30, 1.49
11	50,972	30,154	59.2	1.34	1.30, 1.38	4756	9.3	1.79	1.64, 1.95
12	40,391	23,925	59.2	1.34	1.30, 1.39	3886	9.6	1.85	1.67, 2.04
13	26,351	14,864	56.4	1.32	1.27, 1.38	2154	8.2	1.74	1.56, 1.94
RESIDENCY									
1	56,012	26,965	48.1	1		3254	5.8	1	
2	63,413	32,609	51.4	1.06	1.03, 1.10	4355	6.9	1.20	1.04, 1.37
3	74,853	40,723	54.4	1.11	1.09, 1.13	5738	7.7	1.27	1.11, 1.46
4	46,826	27,433	58.6	1.20	1.16, 1.23	4077	8.7	1.46	1.28, 1.66
5	27,900	16,895	60.6	1.25	1.21, 1.29	2467	8.8	1.54	1.34, 1.77
6	8847	5329	60.2	1.24	1.17, 1.30	750	8.5	1.58	1.34, 1.86
SOCIOECONOMIC STATUS									
5 HIGHEST	56,418	28,084	49.8	1		3133	5.6	1	

4	55,641	29,692	53.4	1.04	1.03, 1.05	3665	6.6	1.09	1.05, 1.14
3	55,935	30,532	54.6	1.06	1.05, 1.07	4199	7.5	1.22	1.17, 1.28
2	55,947	31,269	55.9	1.07	1.06, 1.08	4542	8.1	1.28	1.22, 1.35
1 LOWEST	54,950	30,949	56.3	1.08	1.07, 1.10	5160	9.4	1.46	1.39, 1.53
PHYSICAL ACTIVITY									
NEVER	4518	2481	54.9	1		782	17.3	1	
SELDOM	19,642	11,086	56.4	1.05	1.01, 1.08	2002	10.2	0.65	0.58, 0.72
1-2 TIMES A MONTH	18,007	9903	55.0	1.04	1.01, 1.07	1357	7.5	0.53	0.48, 0.58
1-2 TIMES A WEEK	75,687	40,581	53.6	1.02	0.98, 1.05	5058	6.7	0.50	0.45, 0.55
3-4 TIMES A WEEK	89,537	47,874	53.5	1.03	1.00, 1.06	5614	6.3	0.52	0.47, 0.57
≥ 5 TIMES A WEEK	65,897	35,312	53.6	1.01	0.98, 1.05	5173	7.9	0.62	0.57, 0.68
LEISURE SCREEN TIME									
≤ 2 HOURS DAILY	43,234	18,797	43.5	1		1978	4.6	1	
2-3 HOURS DAILY	60,567	28,922	47.8	1.10	1.09, 1.11	2659	4.4	1.00	0.95, 1.06
3-4 HOURS DAILY	75,781	40,778	53.8	1.22	1.20, 1.24	4514	6.0	1.33	1.26, 1.40
4-6 HOURS DAILY	59,250	35,462	59.9	1.32	1.30, 1.34	4950	8.4	1.79	1.70, 1.88
≥ 6 HOURS DAILY	36,168	24,214	66.9	1.42	1.40, 1.45	6026	16.7	3.15	3.00, 3.32

ED: Energy drink; RR: Relative Risk; CI: Confidence Interval; [a] Modified Poisson regression with robust variance estimation; [b]Estimates are statistically significant if their CIs do not include 1.0. Total sample n= 256,801. Walds test shows statistically significant p-values at $p<0.05$. Loglikelihood ratio test of complete interaction term was significant at $p<0.01$.

The association between ED consumption and social determinants (Table 2) showed that the largest proportion of high ED consumers was found in participants living in centrality index 6 (least central residency). Furthermore, we found a larger proportion of high ED consumers with decreasing SES. The same association was found when looking at the any ED consumption group, although differences were less pronounced. There was a relationship between high ED consumption and physical activity. Here, the lowest proportion was observed for those who were physically active 1-2 times a week compared to those who were never being physically active. However, this was not observed for the any ED consumption group. Regarding both the participants who consumed any ED as well as the high consumers, the proportions increased with increasing leisure screen time. The proportion of high ED consumers that spent more than 6 hours looking at a screen outside school hours was three times higher than the high ED consumers that spent less than 2 hours looking at a screen.

DISCUSSION

We have described social determinants and changes in ED consumption among Norwegian adolescents between 2017 and 2019. We found an increase in the percentage of both boys and girls being high ED consumers and a change in ED consumption according to time. The main finding was an increasing proportion of female high ED consumers, which is of special interest as it highlights the fact that despite male high ED consumers still being the gender consuming most ED, females high ED consumers are catching up.

We found that in total, over the three years, 4.2% of the girls and 10.8% of the boys were high ED consumers. There was an annual increase in the proportion of high consumers that was most pronounced for girls increasing from 3.3% in 2017 to 4.9% in 2019. Moreover, we found that more than half of the adolescents participating in the study had consumed any ED during these three years. The increase in high ED consumption was expected as sales in ED in Norway have increased. However, adolescents are most likely not the only group consuming increasing amounts of ED. It is plausible that other groups in the population follow the same trend in ED consumption.

High ED consumption was positively associated with the male gender, lower SES, attending schools located in rural areas, excessive screen watching, but not with physical activity at any level. The combination of either low or high physical activity and high leisure screen-time as predictors for ED consumption was also found in other studies from Saudi Arabia, Canada, and the U.S.(3, 18, 33-35) Al-Hazza et. al proposed that the reason why both low and high physical activity and high leisure screen-time was observed, is due to how ED are being marketed.(33)

According to the study by Emond et. al on ED advertisement, ED was primarily advertised on channels with adolescents as their base audience.(5) Based on this, one could imagine that increased screen time and thereby increased exposure to ED advertising would lead to higher ED consumption rates.(7) In addition, Hammond et. al. found that TV was the main common source of marketing of ED to adolescents next to marketing in grocery stores.(36) Our results also suggest that adolescents who spend much of their spare time watching screens are those who consume most ED. Regarding the gender difference in high ED consumption, one could hypothesize that the marketing of ED appeals more to boys as they are the ones consuming more ED.

Our results show that even though boys still are the highest consumers of ED, the increase in the proportion of female high consumers was larger, on a multiplicative scale but not an additive scale, compared to males over the three years. The increase was 1.7 percentage points for boys (9.8-11.5%) and 1.6 for girls (3.3-4.9%) from 2017 until 2019. Based on this finding it could be speculated that girls are becoming more exposed and perhaps more susceptible to ED marketing than before.

Limitations and strengths

A limitation of the study is that we were not able to take the regional differences in participation of schools each year into account. This might have affected the observed development of ED consumption seen over the three years. However, the breadth of the municipalities participating in the Ungdata study in 2017, 2018 and 2019 with an even distribution of smaller and larger communities spread out across Norway makes the sample sufficiently large and wide-reaching. Moreover, the participants are not completely selected at random as only municipalities who wanted to participate in the Ungdata survey were

included in the study. In addition, the participating schools within these municipalities were not selected completely at random. The lower secondary schools are run by the municipalities while the upper secondary schools are organized according to regional districts, therefore the schools have different catchment areas when it comes to children attending the schools.

Other limitations common to such surveys are that the study relies on self-reported ED consumption which can be susceptible to both recall bias and social desirability bias.(37) Moreover, only children who attended school on the day of the survey answered the questionnaire. Adolescents who were absent or had dropped out were therefore not included in the study, which might have affected the results. Finally, some adolescents might have participated more than once, yet no adjustment for lack of independence between these observations was possible.

The major strength of this study is the large sample included, with close to 300,000 adolescents answering the questionnaire and a response from 74.4% of the total eligible students in this time period.

CONCLUSION

ED consumption is increasing among female adolescents, especially high ED consumption. This is an important finding to consider in future research which could focus on possible gender-related differences when studying various aspects of ED consumption. In addition, with rising ED consumption it is increasingly important to investigate the potential long-term effects of ED use among adolescents.

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Footnote page

Abbreviations

ED = Energy Drinks

EFSA = European Food Safety Authority

FAS II = Family Affluence Scale II

NFSA = Norwegian Ministry of Health, the Norwegian Food Safety Authority

RR = Relative Risk

SES = Socio-Economic Status

VKM = Norwegian Scientific Committee for Food and Environment

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Ethical approval: The annual Ungdata Survey is approved by the Norwegian Centre for Research Data (NSD). Participants do not have unique identification numbers as data collection is done anonymously and does not contain sensitive information. Therefore, no ethical approval was needed.

Patient and public involvement: There was no patient or public involvement in study.

Data availability statement: The data supporting our study is available from the Norwegian Centre for Research Data (NSD) and were used under license for the current study. The Ungdata survey is funded by The Norwegian Directorate of Health. Anonymous data has been made available for the authors by NOVA through NSD – the Norwegian Center for Research Data. Neither NOVA, The Norwegian Directorate of Health or NSD are responsible for the analyses or interpretation of the presented data.

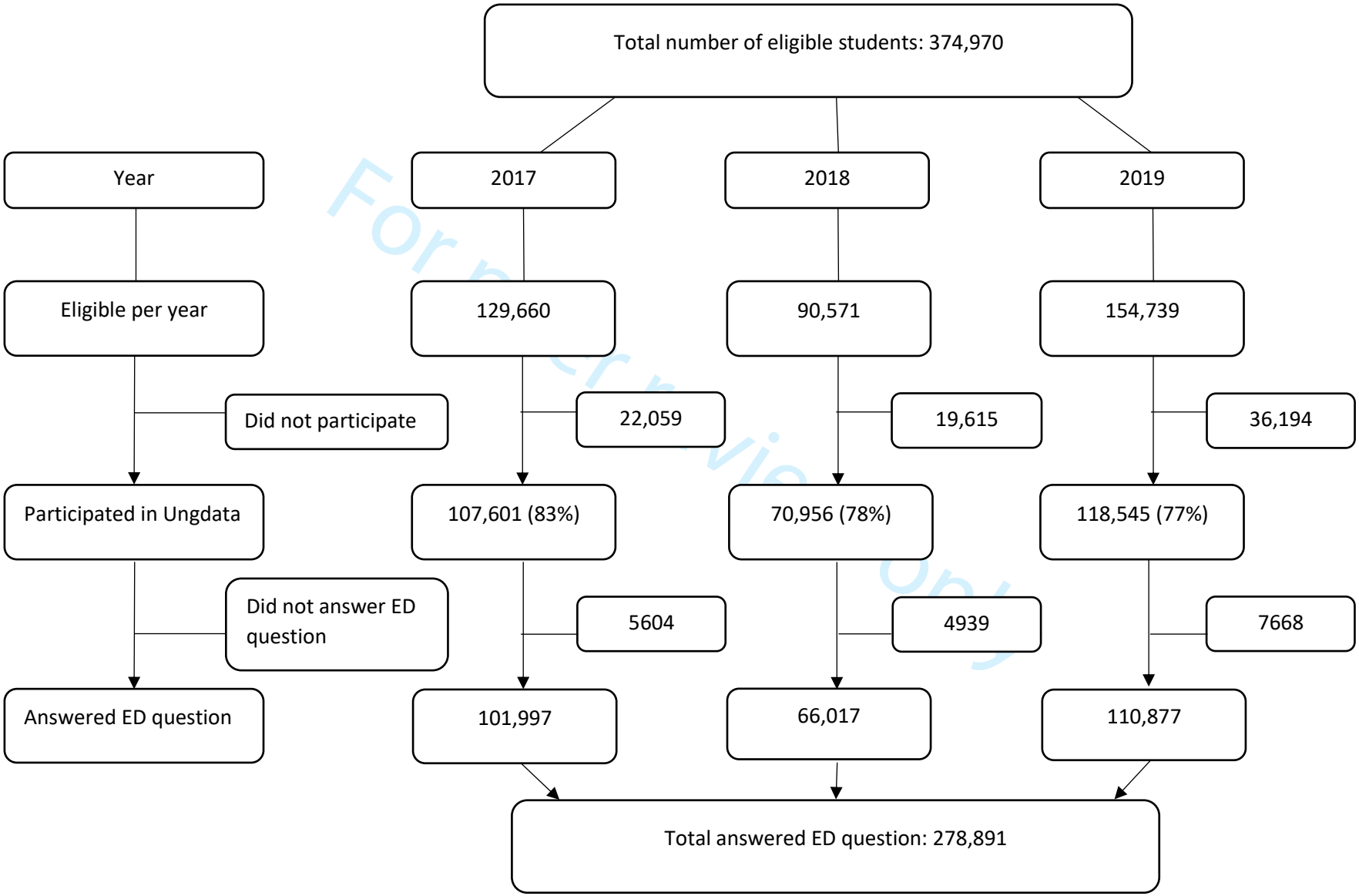
Competing interest: None declared

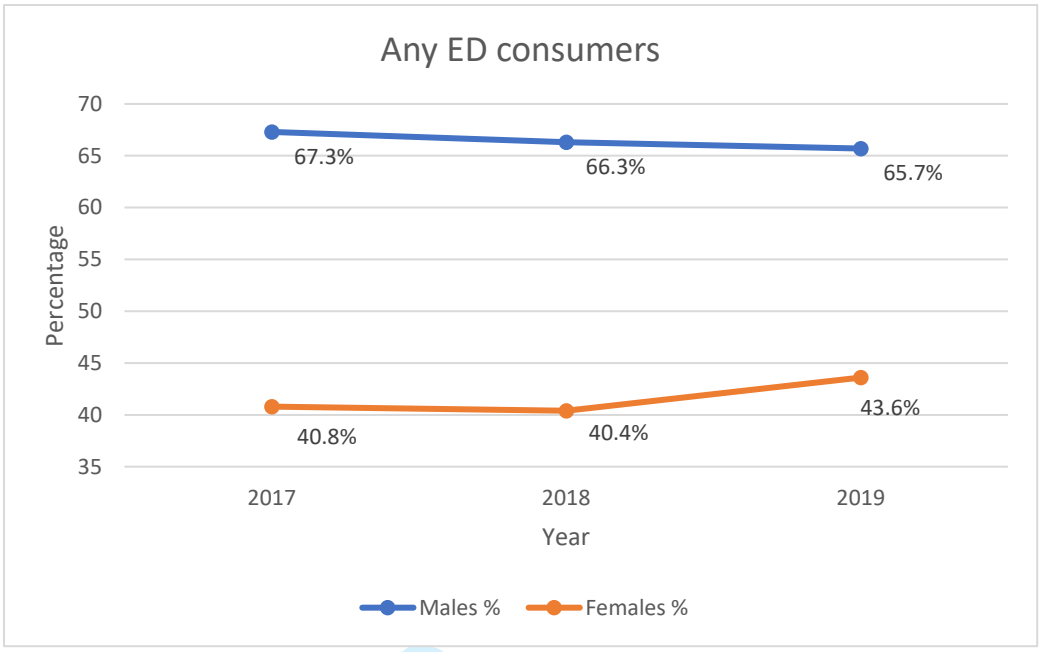
Figures

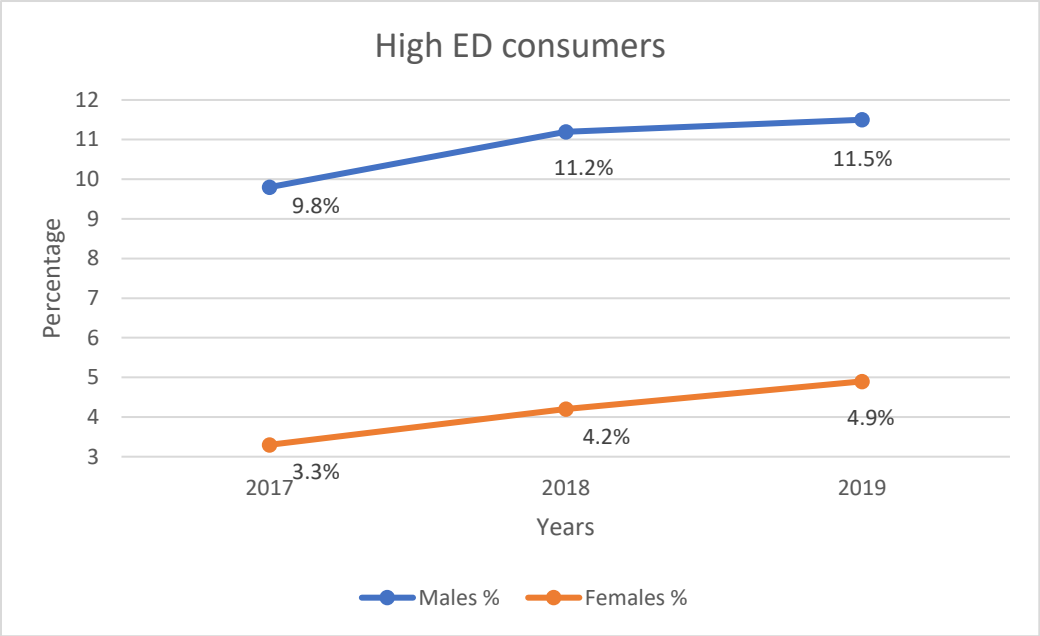
Figure 1: Overview of the Study Participants.

Figure 2: Any ED Consumers per Year and Gender.

Figure 3: High ED Consumers per Year and Gender.







STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	0
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	0
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1-3
Objectives	3	State specific objectives, including any prespecified hypotheses	3
Methods			
Study design	4	Present key elements of study design early in the paper	0+4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	0+4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	5-7
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	7
		(*c*) Explain how missing data were addressed	5
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	NA
		(*e*) Describe any sensitivity analyses	7
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	9
		(b) Give reasons for non-participation at each stage	5
		(c) Consider use of a flow diagram	5
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	9
		(b) Indicate number of participants with missing data for each variable of interest	9
Outcome data	15*	Report numbers of outcome events or summary measures	9-10
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-15

		(*b*) Report category boundaries when continuous variables were categorized	10-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	18-19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	17-19
Generalisability	21	Discuss the generalisability (external validity) of the study results	18-19
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	4-5

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.