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Tax on sugary drinks and trends in daily soda consumption by family affluence: an international repeated cross-sectional survey among European adolescents

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The authors declare no conflicts of interest.

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Short running head
Soda tax and socioeconomic position in adolescents

Abstract

Background

The World Health Organization calls for soda taxes to reduce sugar consumption, but the effect across socioeconomic groups is unclear.

Objective

We assessed 16-year trends in daily soda consumption among adolescents in 4 European countries with a soda tax and 5 comparison countries, by family affluence.

Methods

Five rounds of the international 'Health Behaviour in School-aged Children' (HBSC) school-based survey were used (school years 2001/02 to 2017/18, repeated cross-sectional design). Finland, France, Belgium, and Portugal introduced or updated a soda tax during this period. For comparison, we selected 5 neighboring countries without such a tax. Nationally-representative samples of adolescents aged 13 and 15 years (n=165,521; 51.2% girls) completed a standardized questionnaire, including a question on soda consumption frequency. Using the Family Affluence Scale (FAS), we categorized adolescents into lower-, middle- or higher-affluent groups. Changes in daily soda consumption were assessed in each country independently.

Results

Before taxation, daily soda consumption was more likely among lower-affluent adolescents in France and Belgium (P<0.001, socioeconomic inequalities) and was similar across FAS groups in Finland and Portugal (no inequalities). After the tax, daily soda consumption was reduced across all FAS groups in Finland, Belgium, and Portugal ($P_{interactions}$≥0.33). In France, post-tax decrease was observed only among lower-affluent adolescents (OR_{lower}0.76, 95%CI: 0.60, 0.96, reduced inequalities). During the same periods, socioeconomic patterns remained stable in 3 comparison countries ($P_{interactions}$≥0.38), and larger reductions in daily soda consumption were observed among middle- or higher-affluent adolescents compared to lower-affluent adolescents in the 2 remaining comparison countries ($P_{interactions}$≤0.08, increased inequalities).

Conclusions

Socioeconomic patterns did not change after the tax implementation in 3/4 countries and socioeconomic inequalities were reduced in France. Taxing sodas might be an effective measure to attenuate, or at least not exacerbate, socioeconomic inequalities in adolescent daily soda consumption.

Keywords

Tax on sugary drinks, soda tax, sugar-sweetened beverages, sodas, adolescents, social inequalities in diet, Health Behaviour in School-aged Children study

Introduction

Adolescents are large consumers of sugar-sweetened beverages (SSBs) (1, 2). Several types of SSBs exist (2, 3), but sodas (sugary soft drinks) are the most commonly consumed (2, 4). A socioeconomic gradient in SSB consumption has been reported in several Western European countries (5-9). Adolescents with a lower socioeconomic position (SEP) are more likely to consume more, and more often, SSBs (sodas especially) than those with a higher SEP (6, 8, 9). This may in part contribute to the observed socioeconomic inequalities in obesity (10, 11).

The World Health Organization (WHO) recommends taxing SSBs as a cost-effective measure to reduce sugar consumption (12). Worldwide, over 45 jurisdictions (country, region, or city) have introduced such a tax (13, 14). A meta-analysis estimated that a soda tax increasing SSB price by 10% would cut consumption by 10.0% (95%CI: −14.7%, −5.0%) (15). In Western Europe, positive findings were also reported (16-20). Most of the evidence came from econometrics studies relying on sales or purchase data aggregated at the household level, which prevents assessing the differential effects of taxes across household members, including adolescents. Recently, we showed that European countries with a soda tax did not experience larger beneficial changes in post-tax soda consumption among adolescents than their comparison countries (21). However, this null result at the overall population level might hide different effects of taxes on soda consumption by SEP.

Understanding the effects of soda taxes by SEP is essential to assess whether structural public health measures, such as taxes, may or may not reduce socioeconomic inequalities in adolescent soda consumption. So far, evidence has been inconsistent regarding the differential effects of taxes on SSB consumption by SEP in Western countries (among adults and children). Some studies reported similar effects across SEP groups (22-29), whereas others did find larger reductions in SSB consumption among lower SEP groups (30-35) or among higher SEP groups (36). Most studies using ‘real world’ data were conducted in the U.S. (27, 28, 35) and/or relied on sales or purchase data, aggregated at the store (35, 36) or household (29) levels, which limits the understanding of how the tax might impact European adolescents.

Adolescent consumption of SSBs and sodas has been on the decline since 2000-2010s in Western Europe (37). Therefore, when comparing pre-tax to post-tax soda consumption, having a comparison group, namely a population with similar socioeconomic conditions and living in a near geographical zone but not exposed to the tax, is needed. Thus, we investigated post-tax changes in daily soda consumption among adolescents by family

affluence using 16-year trends in four European countries that have implemented a soda tax, and five comparison countries (without such a tax).

Subjects and Methods

Study design and datasets

We used repeated cross-sectional data from the 'Health Behaviour in School-aged Children' (HBSC) study (38). HBSC is a large international school-based survey (http://www.hbsc.org/). Every four years, adolescents are surveyed in schools regarding their health behaviors and wellbeing via a standardized self-reported anonymous questionnaire. Each country uses cluster sampling to select a nationally-representative sample of adolescents aged 11, 13, and 15 years. The primary sampling unit is the school, with all adolescents in the selected class(es) being invited to complete the questionnaire (38). Details regarding the HBSC protocol can be found elsewhere (38).

Selection of countries with a soda tax

We selected HBSC countries (i) located in Western Europe to have countries with similar socioeconomic backgrounds; (ii) with data available for school years 2001/02, 2005/06, 2009/10, 2013/14, and 2017/18; and (iii) having introduced or updated a national soda tax between 2003 and 2017. For the last point, we reviewed literature (13, 14, 16) and had personal contacts with national experts. Hence, Finland, France, Belgium, and Portugal were included. Table 1 describes soda taxes by country according to the chronological order of tax implementation (13, 14, 16). Taxes were introduced or updated at different times depending on the country (e.g., between 2011 and 2014 in Finland with a 3-step tax increase) and had two different designs: volumetric-based in France and Belgium, and sugar-content-based in Finland and Portugal (Table 1). Tax sizes were heterogeneous across countries (€0.07/L in France to €0.22/L in Finland). In France and Finland, the average price increase due to the tax was estimated at 7-10% (15) and 20% (16), respectively. Of note, we did not find literature estimating price increase following the implementation of the Belgian nor the Portuguese taxes.

Selection of comparison countries

To compare how socioeconomic patterns evolved in countries without soda taxes, we selected one or two neighboring countries that (i) did not implement a tax between 2003 and 2017, and (ii) had similar demographic, economic, and nutritional characteristics. Thus, Sweden served as the comparison country for Finland, Germany and Italy for France, the Netherlands for Belgium, and Spain for Portugal. Supplementary Table 1 shows a relative similarity between the pairs of countries, based on 12 indicators (e.g., Gini index measuring

equity in income distribution). Survey response rates at the school level (and pupil level for 2017/18) were also similar, except that it was lower in Germany than in France (Supplementary Table 2).

Soda consumption

Adolescents completed a validated short food frequency questionnaire (sFFQ) (39, 40). The question was: '*How many times a week do you usually eat or drink Coke® or other soft drinks that contain sugar?*' and possible consumption frequency was (i) 'every day, more than once'; (ii) 'once a day, every day'; (iii) '5-6 days a week'; (iv) '2-4 days a week'; (v) 'once a week'; (vi) 'less than once a week'; or (vii) 'never' (38). Daily consumers were defined as those who ticked the first two answers (≥1x/day).

Family affluence

The Family Affluence Scale (FAS) is a brief assets-based measure of family wealth (41, 42). The FAS was based on 4 (survey rounds 2001/02 to 2009/10) to 6 (2013/14-2017/8) items: (i) having one's own bedroom; (ii) number of cars; (iii) computers/laptops/tablets in the family; (iv) number of vacation trips in the last year; and since 2013/14: (v) number of bathrooms in the house; and (vi) having a dishwasher at home. We ridit-transformed total FAS scores (2001/02−2009/10: 0−9; 2013/14−2017/18: 0−13) to estimate the relative family affluence of adolescents (38, 43). Ridit-based scores are based on cumulative probabilities within each country, survey round, sex, and age group. The ridit of the category *i* is the sum of the proportions (**π**) of individuals in each category below the category *i* plus half the proportion of individuals in the category *i* itself (43): $\mathrm{Ridit}_i = \sum_{0 \le k < i} \pi_k + \frac{\pi_i}{2}$. The ridit-score was then divided into quintiles to obtain three groups: the first 20% (lower affluence), the next 60% (middle affluence), and the last 20% (higher affluence). This procedure is recommended by the HBSC protocol (38) to better highlight the extremes and disregard cross-national and temporal differences in absolute poverty and material standards of living.

Covariates

SSBs are more likely to be consumed by male and older adolescents (44), and when the outside temperature is warmer (45-47). All HBSC participants included in the international database had complete data on sex (females or males) and age. Our analyses included only 13- and 15-year-olds. Adolescents aged 11 years were excluded (i) to have only secondary school students, who are more homogeneous in terms of school food environment as well as age-related food choice autonomy and SEP), and (ii) to limit the frequency of missing data for FAS (more common among younger adolescents). We recorded the mean monthly

temperature during the month participants completed their questionnaire using world climatic data (https://www.ncei.noaa.gov/). We selected the land-based station located close to the capital city with data available from 2001 to 2018. Supplementary Table 3 details the mean temperature of the months when data were collected, by survey round. Overall, temperatures were similar across paired countries.

Ethics

Authorizations from the institutional ethics committees or the relevant boards were obtained at the country level before proceeding with data collection. Supplementary Table 4 details institutions in charge of ethical approval (or exemption) for each country. The surveyed schools, adolescents, and their parents or caregivers received detailed information about the study and were assured of their anonymity and the possibility to withdraw their participation. Pupils voluntarily filled out the anonymous questionnaire at school. No direct identifiable information about study participants was collected in the questionnaire.

Statistics

For all analyses, we used Stata® version 15 and applied multilevel logistic models with random intercepts. Level 1 was set for the pupil and level 2 for the class (median cluster size: 15 pupils/class). All analyses were conducted for each country independently, the prevalence of daily soda consumption being the dependent variable. All models were adjusted for survey round, sex, age group, and temperature at the time of data collection. Statistical significance was set at $P \leq 0.05$.

Firstly, we investigated whether the prevalence of daily soda consumption varied across the three FAS groups (independent variable, reference group = lower-affluent adolescents) at the last pre-tax and first post-tax survey rounds.

Secondly, we focused on *short-term* post-tax changes and tested whether there was a reduction in daily soda consumption between the last survey round before and the first survey round after the tax was implemented, in the whole sample (population level) and for each FAS group (stratified models). Data from all survey rounds were included and the pre-tax survey round was the reference survey round. Then, we determined whether results differed by socioeconomic groups, adding an interaction term between survey rounds and FAS groups (interaction models). The difference between groups was tested using a Wald test. Then, we computed and plotted the prevalence (95% CIs) of daily soda consumption by FAS for each county.

Thirdly, we investigated *long-term* post-tax changes in Finland and France, where two survey rounds were available after the tax implementation. For that, we modeled pre-and post-tax time trends (slopes) in daily soda consumption overall and by FAS groups (stratified trend models), applying two-piecewise linear spline multilevel logistic models (48) and setting the survey round (2001/02 to 2017/18) as a continuous time variable (1–5). We defined one knot at the survey time 3, creating two periods of analysis: the pre-tax (2001/02–2009/10) and the post-tax (2009/10–2017/18) trends. To determine whether pre-and post-tax trends in daily soda consumption differed by FAS, we added two interaction terms: (i) between pre-tax time and FAS groups, and (ii) between post-tax time and FAS groups (interaction trend models). Finally, the prevalence (95% CIs) of daily soda consumption was predicted and plotted at times 1 (2001/02), 3 (2009/10), and 5 (2017/18).

Results

Study participants

We excluded adolescents with missing data on soda consumption and FAS, respectively 0.6% and 5.1% of the sample (Supplementary Figure 1). Of note, about a third of missing FAS data came from Spain and the survey round 2013/14, because only a random subsample was surveyed about FAS that school year (Supplementary Table 4). In total, 165,521 HBSC participants had complete data: 51.2% of girls, and 50.9% aged 13-years old (Table 2). Samples were similar across paired countries in terms of age and sex. Supplementary Table 5 presents sample characteristics plus the unadjusted prevalence of daily soda consumption, by survey round.

Pre-tax socioeconomic inequalities in soda consumption

Pre-tax prevalence of daily soda consumption was similar among the three FAS groups in Finland (P≥0.38) and Portugal (P≥0.19, Supplementary Table 6). By contrast, middle- and higher-affluent adolescents were less likely to consume sodas daily than lower-affluent adolescents in France (Supplementary Table 6, OR≤0.63, 95%CI: ≥0.46, ≤0.75, P<0.001) and Belgium (OR≤0.73, 95%CI: ≥0.43, ≤0.84, P<0.001). Thus, France and Belgium experienced pre-tax socioeconomic inequalities in daily soda consumption with a clear socioeconomic gradient.

Short-term changes in daily soda consumption by FAS

Finland (comparison country: Sweden, Figure 1A): Between 2009/10 and 2013/14, Finland experienced a decline in daily soda consumption, especially among middle-affluent adolescents (Supplementary Table 7, OR 0.54; 95%CI: 0.36, 0.82). However, interaction models indicated that post-tax reductions among middle- and higher-affluent adolescents

were not different than those among lower-affluent pairs (Table 3, $P_{interactions}$≥0.44). Thus, no post-tax change in socioeconomic patterns was observed. Sweden also experienced a similar decline in daily soda consumption across FAS groups ($P_{interactions}$≥0.38).

France (comparison countries: Germany and Italy, Figure 1B): Prevalence of daily soda consumption was reduced only among lower-affluent adolescents in France between 2009/10 and 2013/14 (Supplementary Table 7, OR 0.76; 95%CI: 0.60, 0.96). Therefore, socioeconomic inequalities between lower- and middle-affluent adolescents were reduced after the tax introduction (Table 3, $P_{interaction\ middle\ vs.\ lower\ FAS}$=0.02; $P_{interaction\ higher\ vs.\ lower\ FAS}$=0.20). As for both comparison countries, between 2009/10 and 2013/14, probabilities of daily soda consumption were not reduced in any FAS groups (Supplementary Table 7, P≥0.18) and differences between FAS groups remained constant (Table 3, $P_{interactions}$≥0.63).

Belgium (comparison country: Netherlands, Figure 1C): Belgium experienced a reduction in the prevalence of daily soda consumption among all FAS groups between 2013/14 and 2017/18 (Supplementary Table 7, OR≤0.75, 95%CI: ≥0.54, ≤0.92, P≤0.01), without any differences between groups (Table 3, $P_{interactions}$≥0.79). Thus, pre-tax socioeconomic inequalities remained stable after the tax implementation (Supplementary Table 6). On the contrary, the Netherlands had during the same period a larger decline in daily soda consumption among higher-affluent than lower-affluent adolescents ($P_{interaction}$=0.002). This led to socioeconomic inequalities in 2017/18, while no differences between FAS groups were documented in 2013/14 (Supplementary Table 6).

Portugal (comparison country: Spain, Figure 1D): Between 2013/14 and 2017/18, daily soda consumption in Portugal was reduced at the population level, especially among lower-affluent adolescents (Supplementary Table 7, OR 0.71; 95%CI: 0.52, 0.95). However, the extent of reduction was not significantly larger than that observed among middle- and higher-affluent adolescents (Table 3, $P_{interactions}$≥0.33). As for Spain, a reduction in daily soda consumption was observed among higher-and middle-affluent adolescents, but not among lower-affluent ones (Supplementary Table 7, towards more inequalities, as also shown in Supplementary Table 6). The reduction tended to be larger in the middle-affluent group than in the lower-affluent one (Table 3, $P_{interaction}$=0.08).

Long-term changes in Finland and France

Between 2009/10 and 2017/18 (post-tax trend), Finland did not experience declines in daily consumers of sodas in any FAS groups (Supplementary Table 8, 0.82≤OR≤1.03, 95%CI: ≥0.55, ≤1.61, P≥0.34), and no difference was observed across FAS groups (Figure 2A,

$P_{interactions}$≥0.75). This indicates no long-term post-tax changes in socioeconomic patterns. During the same period in Sweden, lower-affluent adolescents tended to reduce their probability of consuming sodas daily (Supplementary Table 8, OR 0.81; 95%CI: 0.66, 1.00). This reduction was, however, not larger than those observed among middle- nor higher-affluent FAS groups (Figure 2A, $P_{interactions}$≥0.45), meaning no change in socioeconomic patterns.

In France, daily soda consumption declined among lower- and middle-affluent adolescents between 2009/10 and 2017/18, respectively (Supplementary Table 8, OR 0.78; 95%CI: 0.70, 0.87; OR 0.89; 95%CI: 0.83, 0.96). The reduction among the lower FAS group was larger than in the middle and higher FAS groups (Figure 2B, $P_{interactions}$≤0.03), indicating a long-term reduction in socioeconomic inequalities. As for trends in Italy and Germany, long-term reductions in daily soda consumption were observed among all FAS groups in both comparison countries (Supplementary Table 8, OR≤0.85, 95%CI: ≥0.48, ≤0.98, P≤0.03), without significant differences between FAS groups (Figure 2B, Germany: $P_{interactions}$≥0.38; Italy: $P_{interactions}$≥0.46).

Discussion

Analyses of daily soda consumption according to SEP groups showed two different patterns. First, in Finland and Portugal (no pre-tax socioeconomic inequalities) as well as in Belgium (pre-tax inequalities), all SEP groups reduced their probability of consuming soda daily in a similar way. During the same periods, their three corresponding comparison countries experienced no change in socioeconomic patterns (Sweden) or increased their socioeconomic inequalities (Netherlands, and, to a lesser extent, Spain). Second, in France, post-tax reductions were mostly observed among lower-affluent adolescents, also in the long term (6 years after the tax), whereas no change in socioeconomic patterns was observed in the two comparison countries over the same period.

Population-level changes in SSB consumption

This study showed an overall post-tax reduction in daily soda consumption among adolescents living in Finland, Belgium, and Portugal, but not in France. Although not directly comparable to our results, econometrics studies also revealed reductions in SSB sales/purchases in Finland (16, 17), Portugal (18), and also a slight decrease in France (19, 20) (no studies were found for Belgium). Why France did not experience a post-tax decline in daily soda consumption at the adolescent population level, as shown by our study, is unclear. This could be explained by a low tax rate (7-10%) (15), which might be insufficient to discourage soda purchase among

adolescents. Previous literature suggested that low tax rates (<5%) were unlikely to affect childhood SSB consumption at the population level (15, 49).

Our previous analyses also showed that reductions in daily soda consumption in Finland, Belgium, and Portugal were not larger than those observed in comparison countries (same comparison countries as this study) (21). Multiple reasons could explain this phenomenon, such as: (i) youth might be less sensitive to taxes than adults, as shown in two different U.S. cities, where tax rates were above 20% (27, 28), (ii) adolescents, who are not the main household shoppers, do not habitually face a price rise, and (iii) taxes have a limited health risk 'signaling effect' on adolescents (50). We expanded on these matters (21) and the possible reasons why there is an overall declining trend in soda consumption in Western Europe (37) in our previous papers.

Differential effects among SEP groups: comparison with other studies

This study shows that socioeconomic patterns in adolescent daily consumption of sodas did not change after the implementation of the tax, or socioeconomic inequalities were reduced. Modeling studies in the Western English-speaking countries also simulated that a tax rate of 10-20% would produce equal or greater reductions in SSB consumption among lower-SEP households compared to higher-SEP households (22-26, 30-34). Unfortunately, these studies are specific to a context, i.e., the jurisdiction under study, and none of the above studies were conducted in the jurisdictions we analyzed, hence limiting the comparison with our findings.

Beyond simulation modeling, our findings should be compared to those from studies assessing tax effects under 'real life' circumstances like ours. In Catalonia, a province of Spain (tax rate: ~15%), the reduction in SSB purchases was larger in stores located in higher-income regions, without significant changes in middle- and lower-income regions (36). By contrast, Bleich et al. showed in the U.S. city of Philadelphia that the decrease in SSB purchases was larger among customers shopping in lower-income neighborhoods and individuals with less education two years after the tax (tax rate >20%) (35). In the same city, Crawley et al. found similar reductions in the *purchase* of sodas among adults in poverty than other adults. However, *consumption* data did not show a reduced intake of sodas among adults in poverty (28). This may indicate that lower SEP individuals are more prone to cross-border shopping. This phenomenon was however not accounted for by Bleich and colleagues (35).

Comparing our results to those from national taxes, where cross-border is constrained, is of particular interest. In the U.K., a country with a large two-tiered sugar-content-based tax, total sugar purchased per household from taxed beverages has declined across all SEP groups one year post tax (−33% to −39%, five occupational groups based on the main wage earner) (29). To the best of our knowledge, this is the only Western country with published data on tax effects by SEP (29). Given those literature gaps, more research is needed to evaluate the effect of soda taxes by SEP.

Public health implications

Taxation might be a valuable tool to complement educational programs (e.g., mass-media campaigns on healthy eating, promotion of water consumption) which tend to increase socioeconomic inequalities in diet (51). If taxes on SSBs produce equal or greater reductions in SSB consumption among lower-SEP than higher-SEP groups (22-26, 29-35), they could be viewed as a progressive tool for reducing socioeconomic inequalities in SSB consumption, and potentially, in SSB-related diseases, such as obesity. However, soda taxes are financially regressive, i.e., the economic burden of the tax falls more heavily on lower-income families, especially those who consume sodas regularly (52). Thus, mitigating the tax burden on lower-income households is essential (52). This can be done with the redistribution of a fraction of the tax revenue via subsidies for healthy foods (e.g., fruit and vegetables) (53) or public health measures for the most disadvantaged communities (e.g., free healthy school meals).

Strengths and limitations

Our study has several strengths. The protocol was standardized across survey rounds and countries. Our study involved large school-based samples, taken to be nationally representative. We included four European countries to better understand tax effects where pre-tax inequalities in daily soda consumption existed or did not.

The main limitation of this study is that public health measures other than soda taxes and socioeconomic events impacting soda consumption may have occurred during the periods under scrutiny, especially while investigating long-term changes. Socioeconomic characteristics of lower- and higher-affluent adolescents might also have changed over time. In addition, Finland and Sweden had a low prevalence of daily soda consumption (increased risk of type II error, low power). However, when we assessed post-tax short-term changes using a consumption cut-off at ≥5x/week instead of ≥1x/day (raw prevalence presented in Supplementary Table 5), we also found equal post-tax reductions in all FAS groups (data not shown). Another limitation is the restricted information collected via the sFFQ (no information

on soda sugar contents, nor portion sizes). No data on other types of consumed beverages were collected either, limiting the analysis of potential substitutions towards other beverages or the calculation of sugar intake, especially relevant for sugar-content-based taxes (Finland and Portugal). Underreporting of food intake is common with sFFQ (54). Underreporting of soda consumption might have increased over time due to rising awareness of their negative consequences on health. As higher-SEP adolescents tend to be more health-educated, they could have been more subject to desirability bias over time (leading to increased inequalities). Furthermore, FAS reflects only one dimension of SEP and may not well distinguish adolescents from heterogeneous contexts (e.g., urban vs. rural, small vs large countries). We may suppose that socioeconomic inequalities would have been more pronounced if we used parental education or occupation (not assessed every survey round) (5). Finally, FAS score construction also changed between 2010 and 2014 to take societal changes into account (two additional items), which increased the likelihood of missing values and might have reduced the consistency in the definition of family affluence.

Conclusions

Taxing SSBs might be an effective measure to attenuate, or at least not exacerbate, persisting socioeconomic inequalities in SSB consumption found in several Western countries (44, 55). More research is needed to evaluate the effect of such taxes, possibly with and without subsidies for healthy foods, and using complementary SEP indicators. Such an issue is especially important if public health actors want to promote taxes on SSBs (and potentially also on other unhealthy foods) to simultaneously reduce consumption and related socioeconomic inequalities.

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Authors' Contributions

AC and KC designed the manuscript. AC analyzed the data. AC wrote the manuscript and KC, MR, CK, ASF, CP, and LD reviewed and edited it. AC and KC had primary responsibility for final content. All authors read and approved the final manuscript.

Data sharing

Data described in the manuscript and analytic code will be made available upon request. All HBSC protocols, questionnaires, and data can be accessed via a request to the HBSC Data Management Centre (dmc@hbsc.org). For further information, see http://www.uib.no/en/hbscdata.

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Table 1 European countries with a soda tax introduced/updated between 2003 and 2017 and description of the tax during the study period [1] (in chronological order of tax introduction or update).

Countries	**Dates of tax introduction or update**	**Types of tax** [2]	**Tax sizes** (euros [3] per liter)	**Tax rates** (% price increase)
Finland	Introduction: before 2001/02	Volumetric, excise tax on non-alcoholic drinks with added sugar	Before 2011: €0.05	-
	Update: 1 Jan 2011	Idem	€0.08	Unknown
	Update: 1 Jan 2012	Idem	€0.11	Unknown
	Update: 1 Jan 2014	Sugar content-based, excise tax on non-alcoholic drinks with added sugar	€0.22 (>5g of sugar/100mL) and €0.11 (<5g/100mL)	20% from Dec 2010
France	Introduction: 1 Jan 2012	Volumetric, excise tax on non-alcoholic drinks with added sugar (also with artificial sweeteners)	€0.07	7-10%
Belgium	Introduction: Unknown	Volumetric, excise tax on non-alcoholic drinks with added sugar, other sweeteners, or flavors	Before 2016: €0.03	Unknown
	Update: 1 Jan 2016	Idem	€0.07	Unknown
	Update: 1 Jan 2018	Idem	€0.12	Unknown
Portugal	Introduction: 1 Jan 2017	Sugar content-based, excise tax on non-alcoholic drinks with added sugar, other sweeteners, or flavors	€0.16 (>8g of sugar/100mL) and €0.08 (<8g/100mL)	Unknown

[1] Some taxes (e.g., in France) have been updated after the 2017/18 HBSC data collection, i.e., after the period we studied.

[2] An excise tax is a duty levied on a particular product at the point of manufacture (i.e., soda producers), as opposed to a sales tax that is applied to end consumers at the point of purchase.

[3] 1 Euro ≈ 1 US dollar (in 2022).

Table 2 Description of survey participants (total sample and % of the total sample), by country (in black = country with a tax; in grey = comparison country), Health Behaviour in School-aged Children study, 2001/02–2017/08 (five survey rounds)

	Total sample (n)	**Females** (%)	**Males** (%)	**13 y/o** (%)	**15 y/o** (%)	**Lower FAS** (%)	**Middle FAS** (%)	**Higher FAS** (%)	**2001-2002** (%)	**2005-2006** (%)	**2009-2010** (%)	**2013-2014** (%)	**2017-2018** (%)
Finland	16 647	51.6	48.4	49.9	50.1	22.0	59.7	18.3	20.3	19.9	24.8	22.4	12.5
Sweden	16 965	51.0	49.0	47.7	52.3	21.1	61.3	17.6	13.9	16.5	24.6	28.1	17.0
France	23 095	51.0	49.0	54.8	45.2	22.6	59.1	18.3	23.2	19.6	16.4	16.0	24.9
Germany	18 386	51.3	48.7	49.1	50.9	22.4	58.8	18.7	18.8	26.5	17.4	21.9	15.5
Italy	13 826	51.4	48.6	53.1	46.9	22.1	59.6	18.3	20.1	19.0	22.8	18.8	19.4
Belgium	27 344	50.2	49.8	48.9	51.1	21.7	60.4	17.9	24.6	19.6	17.1	22.9	15.8
Netherlands	14 201	50.6	49.4	52.2	47.8	22.5	58.1	19.3	19.3	19.8	20.2	18.8	22.0
Portugal	13 681	53.4	46.6	53.8	46.2	21.7	60.5	17.8	12.7	19.1	20.2	22.0	26.0
Spain	21 376	51.6	48.4	50.2	49.8	21.5	60.5	18.0	17.2	27.2	17.1	24.0	14.4
All	165 521	51.2	48.8	50.9	49.1	21.9	59.8	18.2	19.4	21.0	19.6	21.7	18.3

FAS, Family Affluence Scale

Table 3 Country-level short-term changes (interaction models) in the proportion of daily soda consumption between the last pre-tax survey round (reference) and the first post-tax survey round in countries with a soda tax (in black) and comparison countries (in grey), by family affluence (FAS)

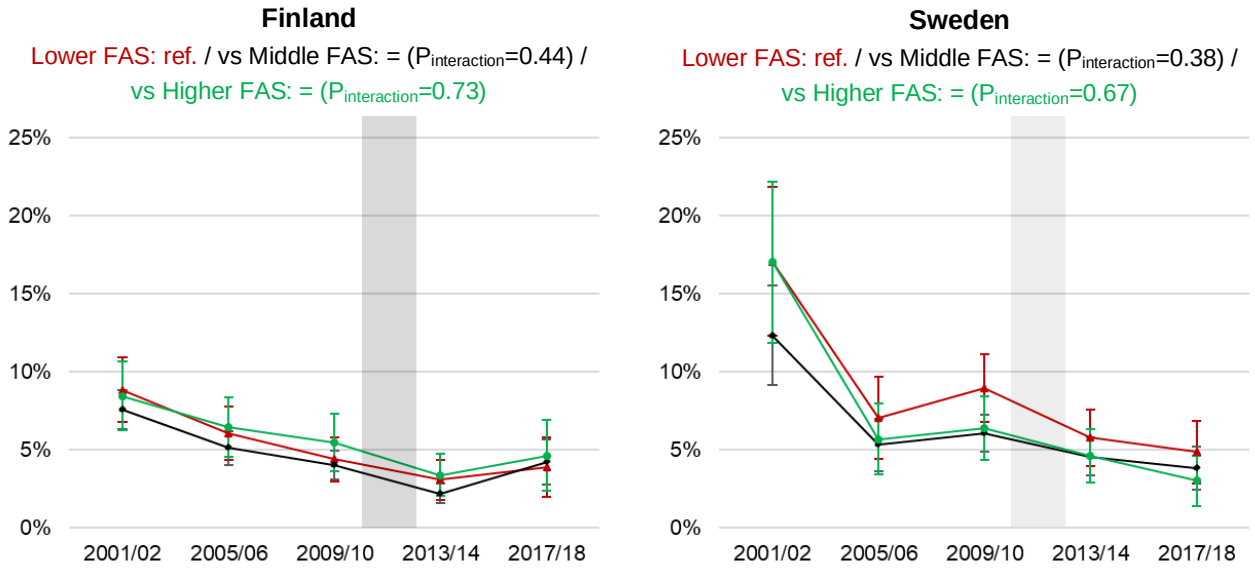
	Middle vs. lower FAS [1]			Higher vs. lower FAS [1]		
	OR	**(95% CI)**	**P-Val.**	**OR**	**(95% CI)**	**P-Val.**
Finland	0.79	(0.43, 1.45)	0.44	0.88	(0.42, 1.83)	0.73
Sweden	1.20	(0.79, 1.83)	0.38	1.13	(0.64, 2.00)	0.67
France	**1.34**	**(1.04, 1.73)**	**0.02**	1.25	(0.89, 1.75)	0.20
Germany	1.01	(0.76, 1.34)	0.95	1.09	(0.75, 1.59)	0.64
Italy	1.01	(0.71, 1.43)	0.97	0.89	(0.56, 1.42)	0.63
Belgium	0.98	(0.79, 1.21)	0.83	0.96	(0.71, 1.29)	0.79
Netherlands	0.89	(0.66, 1.21)	0.46	**0.52**	**(0.35, 0.79)**	**0.002**
Portugal	1.18	(0.85,1.64)	0.33	1.23	(0.81, 1.89)	0.34
Spain	0.77	(0.57, 1.04)	0.08	0.76	(0.51, 1.14)	0.19

[1] OR > 1 indicates that middle/higher-affluent adolescents reduced their consumption to a lesser extent than lower-affluent adolescents (decreased inequalities); OR < 1 indicates that middle/higher-affluent adolescents reduced their consumption to a larger extent than lower-affluent adolescents (increased inequalities); ORs represent the interaction between FAS (reference = lower FAS) and survey round (reference = pre-tax survey round) and were modeled using multilevel logistic models (dependent variable = daily soda consumption), adjusted for FAS, survey round, sex, age group, and temperature at the time of data collection (P≤0.05 in bold, all survey rounds included, total n=165,521; numbers of participants by country and survey round are detailed in Supplementary Table 5).

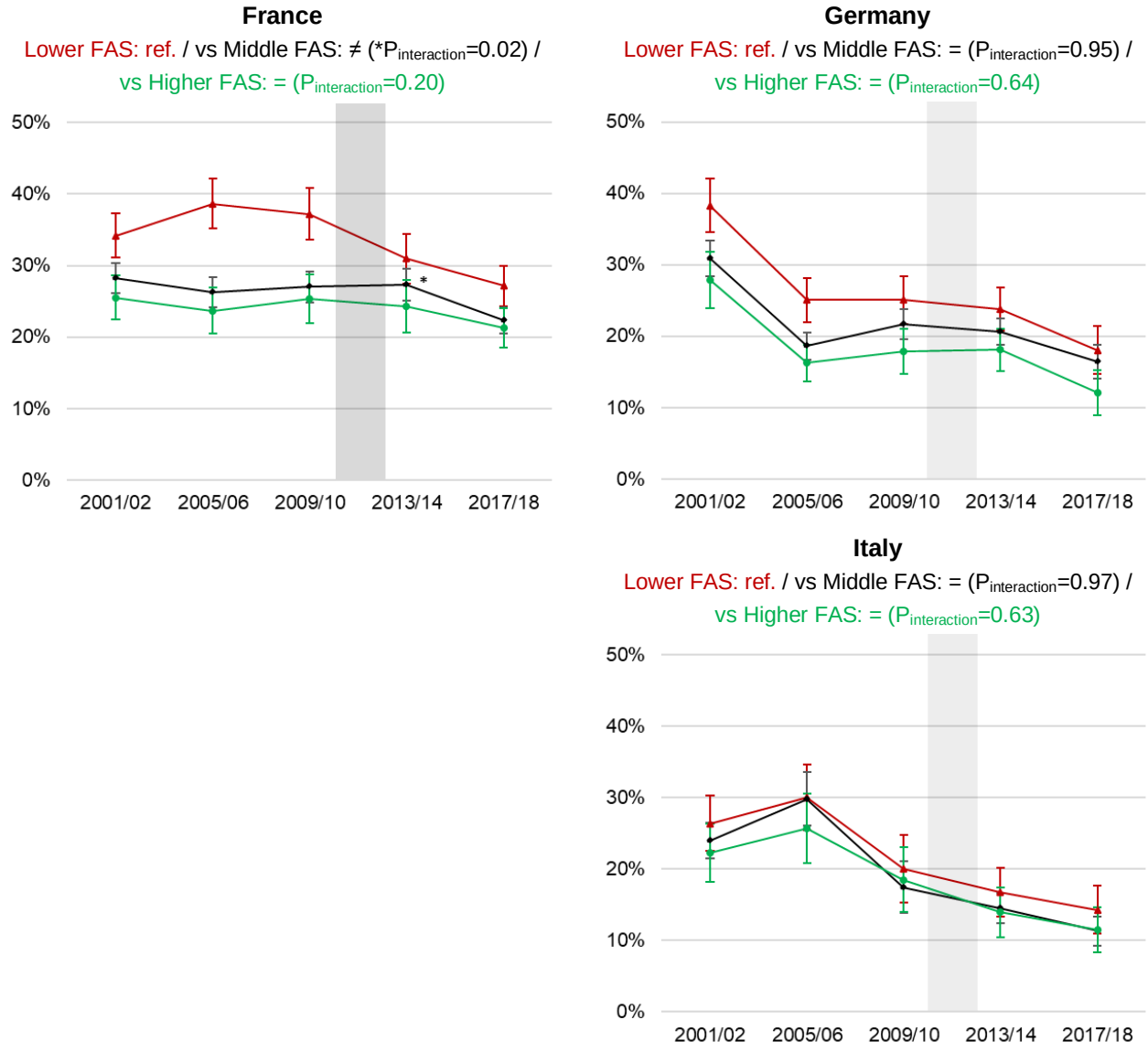
List of figures

Figure 1

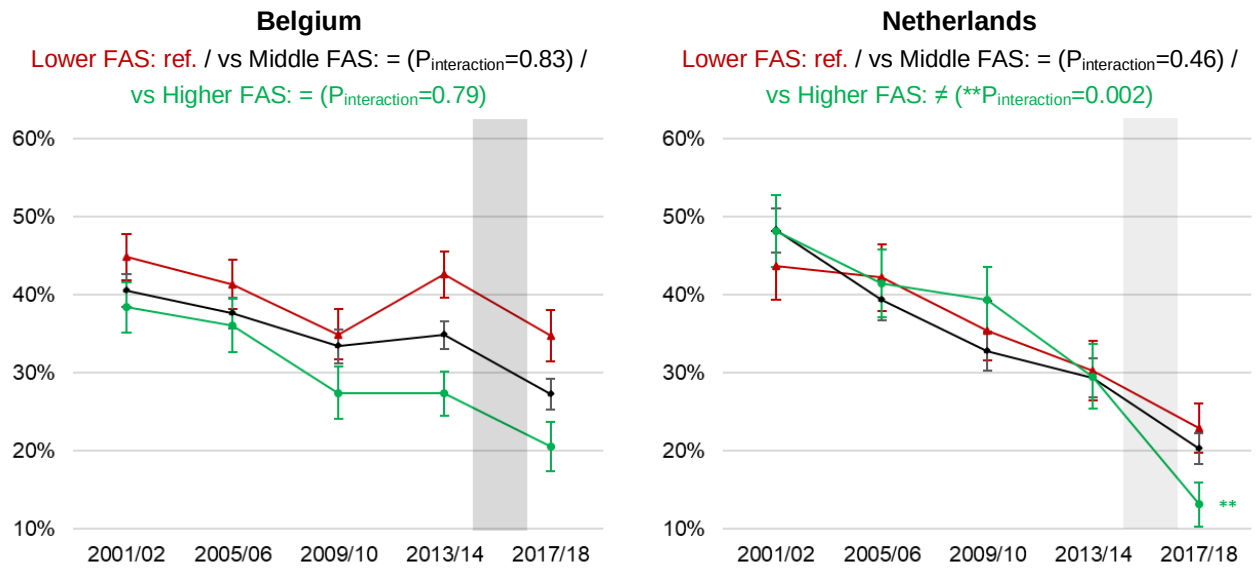
A


Finland
Lower FAS: ref. / vs Middle FAS: = (P interaction=0.44) /
vs Higher FAS: = (P interaction=0.73)
25%
20%
15%
10%
5%
0%
2001/02
2005/06
2009/10
2013/14
2017/18
Sweden
Lower FAS: ref. / vs Middle FAS: = (P interaction=0.38) /
vs Higher FAS: = (P interaction=0.67)
25%
20%
15%
10%
5%
0%
2001/02
2005/06
2009/10
2013/14
2017/18

B


France
Lower FAS: ref. / vs Middle FAS: ≠ (*P interaction=0.02) /
vs Higher FAS: = (P interaction=0.20)
50%
40%
30%
20%
10%
0%
*
2001/02
2005/06
2009/10
2013/14
2017/18
Germany
Lower FAS: ref. / vs Middle FAS: = (P interaction=0.95) /
vs Higher FAS: = (P interaction=0.64)
50%
40%
30%
20%
10%
0%
2001/02
2005/06
2009/10
2013/14
2017/18
Italy
Lower FAS: ref. / vs Middle FAS: = (P interaction=0.97) /
vs Higher FAS: = (P interaction=0.63)
50%
40%
30%
20%
10%
0%
2001/02
2005/06
2009/10
2013/14
2017/18

C


Belgium
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.83) /
vs Higher FAS: = (Pinteraction=0.79)
60%
50%
40%
30%
20%
10%
2001/02
2005/06
2009/10
2013/14
2017/18
Netherlands
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.46) /
vs Higher FAS: ≠ (**Pinteraction=0.002)
60%
50%
40%
30%
20%
10%
**
2001/02
2005/06
2009/10
2013/14
2017/18

D

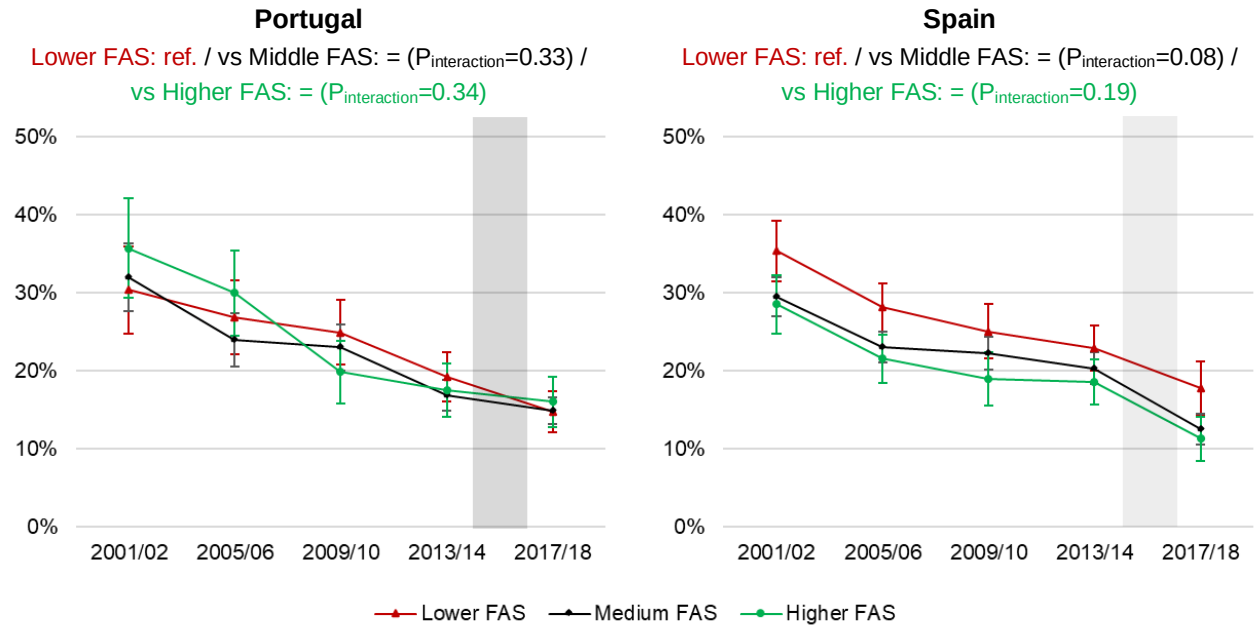
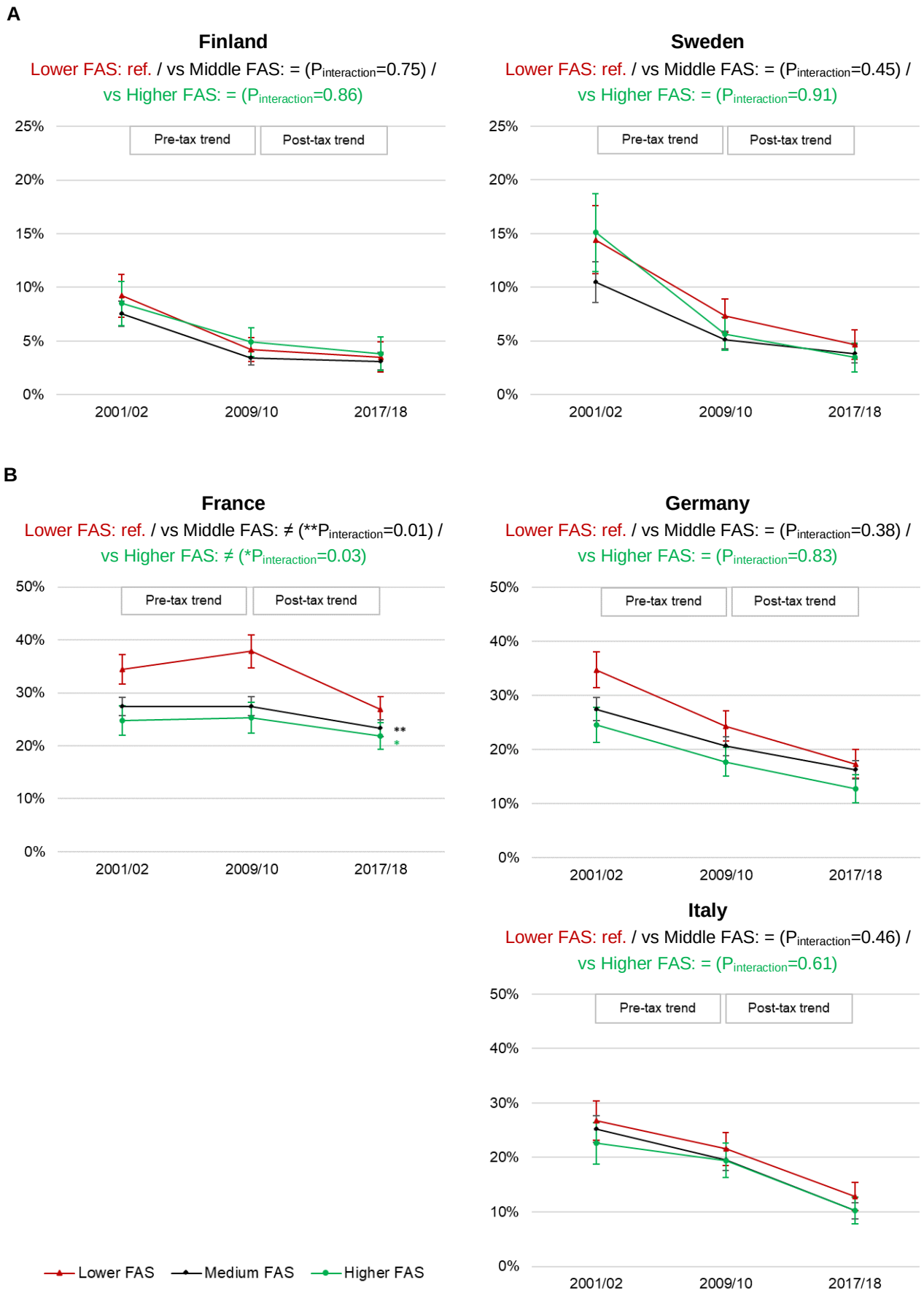

Portugal
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.33) /
vs Higher FAS: = (Pinteraction=0.34)
50%
40%
30%
20%
10%
0%
2001/02
2005/06
2009/10
2013/14
2017/18
Spain
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.08) /
vs Higher FAS: = (Pinteraction=0.19)
50%
40%
30%
20%
10%
0%
2001/02
2005/06
2009/10
2013/14
2017/18
Lower FAS
Medium FAS
Higher FAS

Figure 2


A
Finland
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.75) /
vs Higher FAS: = (Pinteraction=0.86)
Sweden
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.45) /
vs Higher FAS: = (Pinteraction=0.91)
Pre-tax trend
Post-tax trend
25%
20%
15%
10%
5%
0%
2001/02
2009/10
2017/18
B
France
Lower FAS: ref. / vs Middle FAS: ≠ (**Pinteraction=0.01) /
vs Higher FAS: ≠ (*Pinteraction=0.03)
Germany
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.38) /
vs Higher FAS: = (Pinteraction=0.83)
Italy
Lower FAS: ref. / vs Middle FAS: = (Pinteraction=0.46) /
vs Higher FAS: = (Pinteraction=0.61)
50%
40%
30%
20%
10%
0%
**
*
Lower FAS
Medium FAS
Higher FAS

Online Supplementary Material

Tax on sugary drinks and trends in daily soda consumption by family affluence: an international repeated cross-sectional survey among European adolescents − *Chatelan et al.*

Supplementary Table 1. Key demographic, economic, and nutritional characteristics of studied countries

Countries	Location within Europe [1]	National languages [2]	Total population in 2019 (millions) [3]	Life expectancy at birth in 2018 (years) [4]	Gross national income per capita in 2002 (2017 PPP $) [5]	Gross national income per capita in 2018 (2017 PPP $) [5]	Mean FAS (2001/02, min.0, max. 9)	Mean FAS (2017/18, min. 0, max. 13)	Gini index (2003) [6]	Gini index (2018) [6]	Dietary risks in 2019 (death rates/100,000) [7]	Prevalence of adult obesity in 2013 (%) [8]
Finland	Northern	Finnish, Swedish	5.5	81.7	41,604	48,456	5.2	8.9	27.7	27.3	183	23
Sweden	Northern	Swedish	10.0	82.7	42,128	53,442	5.8	9.4	25.3	30.0	138	19
France	Western	French	65.1	82.5	40,939	46,491	5.3	8.6	31.4	32.4	100	18
Germany	Western	German	83.5	81.2	42,836	54,878	5.4	9.4	30.0	31.9 [10]	163	25
Italy	Southern	Italian	60.6	83.4	43,856	42,647	4.8	7.9	34.9	35.9 [11]	144	20
Belgium	Western	Dutch, French, German	11.5	81.5	44,814	51,776	5.1	9.0	28.1	27.2	112	22
Netherlands	Western	Dutch	17.1	82.1	47,981	56,880	5.7	9.0	29.8 [9]	28.1	97	19
Portugal	Southern	Portuguese	10.2	81.9	30,468	33,317	4.7	8.1	38.8	33.5	125	24
Spain	Southern	Spanish	46.7	83.4	36,044	40,515	4.9	8.5	31.8	34.7	93	27

[1] Reference: Publications Office of the European Union. EU Vocabularies. Access to the Thesaurus: https://op.europa.eu/en/web/eu-vocabularies/concept-scheme/-/resource?uri=http://eurovoc.europa.eu/100277.

[2] Reference: Wikipedia, the free encyclopedia (e.g., access for Latvia: https://en.wikipedia.org/wiki/Latvia).

[3] Reference: Human Development Report 2020 from the United Nations Development Programme. Access to Table 7: http://hdr.undp.org/en/content/download-data

[4] Reference: United Nations Development Programme. 2019. Human Development Report 2019. Beyond income, beyond averages, beyond today: Inequalities in human development in the 21st century. New York. Access to the report: http://hdr.undp.org/en/content/human-development-report-2019.

[5] Reference: World Bank. Access to 2002 and 2018 data: https://data.worldbank.org/indicator/NY.GNP.PCAP.PP.KD.

[6] Reference: World Bank. Access to data: https://data.worldbank.org/indicator/SI.POV.GINI/.

[7] Reference: Global Burden of Diseases. Access to data: https://vizhub.healthdata.org/gbd-compare/ (selected options: map, risk, any dietary risks, deaths, year 2019, all ages, both sexes, rate, rate of change: off, detail: 2).

[8] Reference: WHO Regional Office for Europe. Country profiles on nutrition, physical activity, and obesity. Access to monitoring and surveillance indicators: https://www.euro.who.int/en/health-topics/disease-prevention/nutrition/country-work (obesity = BMI≥30, both sexes, >15-25 years).

[9] Data for 2004 (no previous data found).

[10] Data for 2016 (no more recent data found).

[11] Data for 2017 (no more recent data found).

Supplementary Table 2. Response rates [1,2] at school and pupil levels (only for 2018), by country, and by survey round

Countries	2001/02 School level	2005/06 School level	2009/10 School level	2013/14 School level	2017/2018 School level	Pupil level [3]
Finland	NA	89%	74%	67%	47%	60%
Sweden	NA	90%	88%	77%	47%	NA
France	NA	80%	95%	89%	88%	87%
Germany	50%	46%	89%	25%	16%	54%
Italy	NA	95%	NA	93%	89%	96%
Belgium	Flemish: NA French: NA	Flemish: 50% French: NA	Flemish: 33% French: 60%	Flemish: 26% French: 21%	Flemish: 22% French: 25%	Flemish: 71% French: 82%
Netherlands	NA	50%	50%	49%	38%	94%
Portugal	NA	92%	86%	97%	51%	NA
Spain	NA	86%	79%	59%	69%	NA

NA = Not available

[1] Response rates apply to all age categories of HBSC study participants (11-, 13-, and 15-year-olds). Therefore, response rates of the 13- and 15-year-olds included in this study may vary slightly.

[2] Reference: HBSC International Coordinating Centre 2021. Health Behaviour in School-aged Children (HBSC). Publications: International Reports. Access to reports: http://www.hbsc.org/publications/international/

[3] Pupil response rates are based on (estimated) pupils enrolled at the participating schools.

Supplementary Table 3. Data collection months (% interviewed adolescents) and mean temperature during data collection month(s) [1], by country, and by survey round

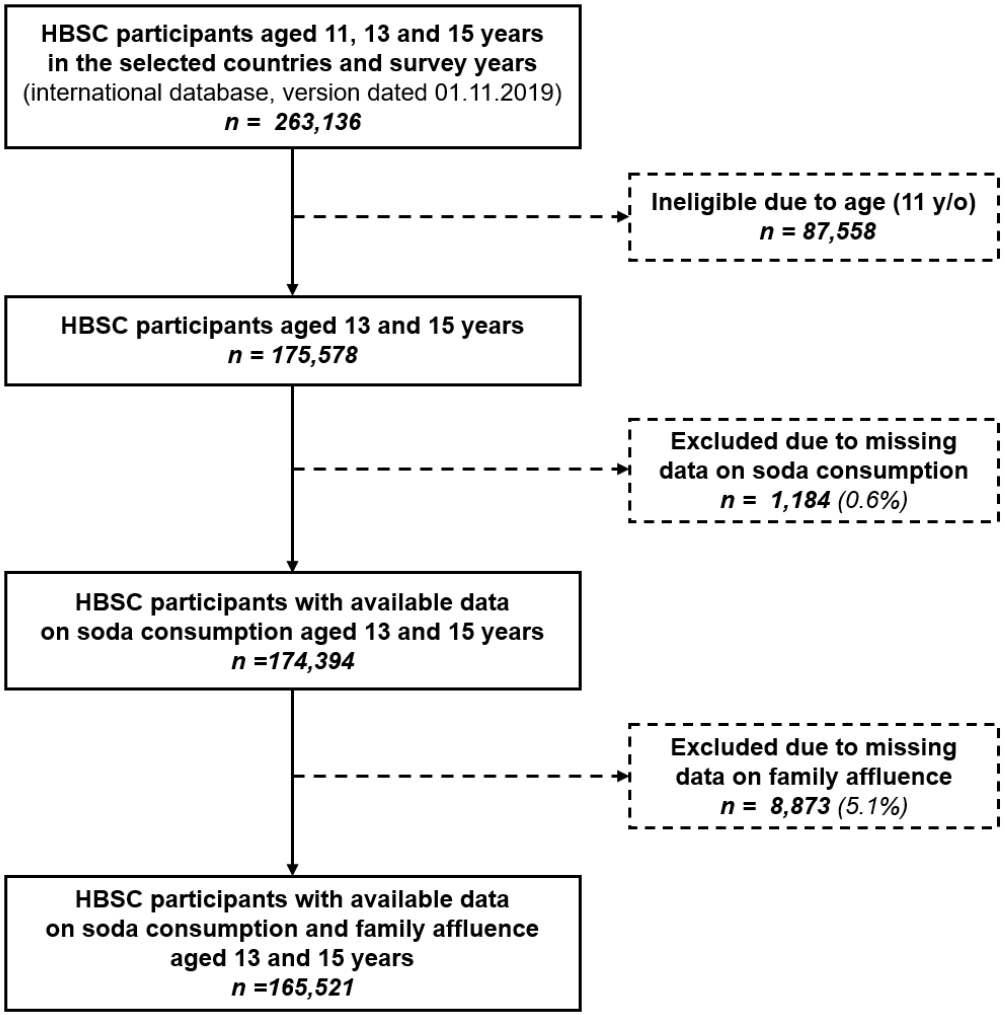
	Months of data collection					Mean temperature degree (in °C)				
Countries	**2001/02**	**2005/06**	**2009/10**	**2013/14**	**2017/2018**	**2001/02**	**2005/06**	**2009/10**	**2013/14**	**2017/2018**
Finland	Mar (40.0%) / Apr (59.1%) / May (0.9%)	Mar (30.7%) / Apr (63.6%) / May (4.5%) / Jun (1.2%)	Mar (98.0%) / Apr (1.6%) / May (0.4%)	Mar (0.4%) / Apr (89.2%) / May (10.5%)	Apr (16.9%) / May (83.1%)	1.3	-0.6	-4.5	4.3	11.9
Sweden	Dec (100.0%)	Nov (100.0%)	Dec (100.0%)	Jan (100.0%)	Oct (0.6%) / Nov (65.1%) / Dec (34.3%)	-3.5	4.1	-1.4	-3.0	4.5
France	Mar (38.0%) / Apr (38.6%) / May (21.8%) / Jun (1.6%)	Mar (8.2%) / Apr (67.5%) / May (19.7%) / Jun (4.5%)	Apr (4.5%) / May (83.7%) / Jun (11.9%)	Apr (26.9%) / May (51.8%) / Jun (21.4%)	Apr (18.3%) / May (72.0%) / Jun (9.8%)	11.1	11.4	13.6	14.3	16.1
Germany	Feb (12.0%) / Mar (2.5%) / Apr (2.7%) / May (61.5%) / Jun (21.3%)	Jan (13.3%) / Feb (23.8%) / Mar (42.5%) / Apr (13.7%) May (3.6%) / Jun (3.2%)	Feb (3.2%) / Mar (15.2%) / Apr (32.4%) / May (34.1%) / Jun (13.5%) / Jul (1.7%)	Oct (0.2%) / Nov (6.3%) / Dec (1.2%) Jan (3.3%) / Feb (9.0%) / Mar (19.3%) / Apr (18.4%) / May (16.5%) / Jun (11.3%) / Jul (13.2%) / Aug (1.4%)	Apr (7.2%) / May (8.4%) / Jun (33.5%) / Jul (38.7%) / Aug (2.8%) / Sep (9.4%)	14.6	2.6	10.8	12.1	19.9
Italy	Apr (52.5%) / May (47.5%)	May (100%)	Nov (31.5%) / Dec (64.7%) / Feb (0.9%) / Mar (2.9%)	Apr (10.1%) / May (84.9%) / Jun (5.0%)	May (99.0%) / Jun (1.0%)	15.0	17.9	8.6	16.1	17.6
Belgium	Mar (6.2%) / Apr (27.5%) / May (61.5%) / Jun (4.9%)	Mar (4.3%) / Apr (18.2%) / May (72.4%) / Jun (5.2%)	Mar (29.0%) / Apr (11.5%) / May (55.0%) / Jun (4.5%)	Feb (16.7%) / Mar (15.9%) / Apr (7.3%) / May (60.1%)	Feb (0.1%) / Mar (16.5%) / Apr (20.3%) / May (61.3%) / Jun (1.9%)	12.4	12.3	9.5	11.5	13.9
Netherlands	Sep (1.2%) / Oct (22.0%) / Nov (54.5%) / Dec (14.9%) / Jan (6.7%) / Feb (0.6%)	Oct (31.9%) / Nov (67.8%) / Dec (0.4%)	Oct (30.3%) / Nov (68.2%) / Dec (1.5%)	Oct (37.7%) / Nov (55.7%) / Dec (6.6%)	Oct (35.4%) / Nov (62.7%) / Dec (1.9%)	7.9	8.9	9.8	8.7	9.6
Portugal	Mar (100.0%)	Jan (100.0%)	Nov (64.4%) / Jan (35.6%)	Jan (4.8%) / Feb (91.1%) / Mar (4.2%)	Jan (100.0%)	14.9	10.2	14.3	12.1	12.1
Spain	May (100%)	May (100%)	Mar (6.5%) / Apr (30.9%) / May (59.1%) / Jun (3.5%)	Mar (1.1%) / Apr (8.9%) / May (25.8%) / Jun (21.1%) / Jul (0.1%) / Sep (0.1%) / Oct (10.6%) / Nov (25.1%) / Dec (7.2%)	Feb (33.6%) / Mar (28.8%) / Apr (17.9%) / May (19.8%)	14.8	19.7	14.8	16.2	10.1

[1] Reference: Monthly temperature during the month of data collection was extracted from U.S. National Centers for Environmental Information (former National Climatic Data Center), which published monthly climatic data for the world. One land-based station (if possible, close to the capital city) was selected as follows: Finland: Jyvaskyla, Sweden: Karlstad Flygplats, France: Paris-Orly, Germany: Berlin-Tempelhof, Italy: Pisa, Belgium: Uccle (Brussels), Netherlands: De Bilt, Portugal: Lisboa/Geof, Spain: Madrid/Barajas.

Supplementary Table 4. Relevant information regarding ethical issues, by country

Countries	Information regarding ethical issues
Finland	Ethical approval by the Finnish Teachers' Union and the Finnish National Board of Education
Sweden	Ethical clearance not needed (Privacy Act of The Swedish Data Protection Authority)
France	Ethical clearance not needed (French Control of electronic datasets with personal information)
Germany	Ethical approvals by the Committee of the General Medical Council Hamburg and the Federal State Ministries of Culture and Education
Italy	Ethical approvals by the Committee of the 'Istituto Superiore di Sanità' and the University of Torino
Belgium	Flemish: Ethical approval by the Committee of the University Hospital Ghent French: Ethical approval by the Committee of the Faculty of Psychology of the 'Université libre de Bruxelles'
Netherlands	Ethical approval by the Committee of the University of Utrecht
Portugal	Ethical approval by the Committee of the São João University Hospital and the National Commission for Individual Data Protection
Spain	Ethical approval by the Committee of the University of Seville

IMPORTANT NOTE: Information regarding ethical issues is often related to the most recent survey rounds. Information for older survey rounds may not be similar but this information is often absent in the international HBSC database. Of note, all data were collected with anonymous questionnaires.



Supplementary Figure 1. Flowchart showing causes of participants' exclusion for analyses, by survey round (HBSC, Health Behaviour School-aged Children).

Supplementary Table 5. Percentage of the sample excluded due to missing FAS [1] data, sample size (with complete data) and description, by country, and by survey round

Countries	2001/02						2005/06						2009/10					
	FAS [1] missing (%)	n	Females (%)	Mean age	Daily consumers (%)	Regular consumers (>5x/week) (%)	FAS [1] missing (%)	n	Females (%)	Mean age	Daily consumers (%)	Regular consumers (>5x/week) (%)	FAS [1] missing (%)	n	Females (%)	Mean age	Daily consumers (%)	Regular consumers (>5x/week) (%)
Finland	2.2	3 386	49.8	14.8	8.6	18.2	2.7	3 310	52.8	14.8	6.0	13.7	3.0	4 135	52.4	14.7	4.6	12.3
Sweden	1.9	2 355	49.6	14.5	14.8	27.4	1.7	2 794	51.4	14.6	7.7	15.6	3.4	4 170	50.8	14.4	7.6	16.5
France	1.5	5 353	50.8	14.1	29.5		2.2	4 516	51.3	14.6	28.8		3.8	3 796	51.0	14.4	29.4	
Germany	2.3	3 451	51.8	14.6	31.6		1.8	4 873	50.0	14.4	22.0		2.2	3 190	52.9	14.4	22.4	
Italy	1.5	2 774	53.4	14.7	24.8		1.5	2 626	50.6	14.8	28.9		2.0	3 154	50.5	14.4	20.5	
Belgium	4.1	6 720	52.8	14.5	41.4		10.9	5 356	48.9	14.5	38.3		13.2	4 669	50.4	14.4	33.0	
Netherlands	1.5	2 736	49.4	14.4	47.0		2.1	2 806	50.0	14.4	40.6		5.3	2 862	50.4	14.4	35.3	
Portugal	2.5	1 739	53.0	14.8	33.0		3.2	2 608	54.1	14.6	25.9		2.4	2 763	54.7	14.6	23.6	
Spain	1.1	3 670	51.6	14.5	31.7		1.1	5 823	50.1	14.5	25.5		2.9	3 665	51.7	14.5	23.6	

Countries	2013/14						2017/18					
	FAS [1] missing (%)	n	Females (%)	Mean age	Daily consumers (%)	Regular consumers (>5x/week) (%)	FAS [1] missing (%)	n	Females (%)	Mean age	Daily consumers (%)	Regular consumers (>5x/week) (%)
Finland	2.9	3 731	51.4	14.8	2.8	9.8	4.7	2 085	51.1	14.8	4.6	10.2
Sweden	4.7	4 770	51.1	14.7	5.4	12.6	3.0	2 876	51.7	14.5	5.6	11.8
France	5.2	3 687	50.6	14.4	28.2		3.3	5 743	51.2	14.2	24.4	
Germany	3.1	4 018	49.1	14.4	21.4		1.5	2 854	54.1	14.4	15.0	
Italy	2.6	2 596	49.8	14.6	15.6		2.4	2 676	52.8	14.6	12.2	
Belgium	7.7	6 266	48.5	14.6	35.4		2.3	4 333	50.1	14.5	28.3	
Netherlands	7.0	2 672	51.6	14.4	30.1		2.5	3 125	51.6	14.4	20.3	
Portugal	8.6	3 016	51.8	14.4	18.4		0.0	3 555	53.4	14.3	15.7	
Spain	35.5 [2]	5 130	53.0	14.4	21.7		1.2	3 088	51.8	14.4	14.3	

[1] FAS, Family Affluence Scale.

[2] Only a random subsample of the 2013/2014 Spanish sample was asked the questions on family affluence, which explains the large proportion of missing data that survey round.

Supplementary Table 6. Odds ratios (95% CI) of the cross-sectional association between daily soda consumption and Family Affluence Scale (FAS) category (reference group = lower-affluent adolescents) at the last pre-tax survey round and at the first post-tax survey round, by country

	Pre-tax survey round						Post-tax survey round					
	Middle FAS			Higher FAS			Middle FAS			Higher FAS		
Countries	**OR [1]**	**(95% CI)**	**P-value**	**OR [1]**	**(95% CI)**	**P-value**	**OR [1]**	**(95% CI)**	**P-value**	**OR [1]**	**(95% CI)**	**P-value**
Finland	0.86	(0.60, 1.25)	0.47	1.23	(0.77, 1.94)	0.38	0.63	(0.38, 1.04)	0.07	0.96	(0.53, 1.74)	0.90
Sweden	0.64	(0.48, 0.85)	**0.002**	0.76	(0.51, 1.12)	0.16	0.76	(0.56, 1.04)	0.09	0.83	(0.55, 1.26)	0.38
France	0.63	(0.53, 0.75)	**<0.001**	0.58	(0.46, 0.73)	**<0.001**	0.84	(0.70, 1.01)	0.07	0.72	(0.56, 0.92)	**0.01**
Germany	0.87	(0.70, 1.08)	0.20	0.68	(0.51, 0.90)	**0.007**	0.86	(0.71, 1.05)	0.14	0.75	(0.58, 0.97)	**0.03**
Italy	0.83	(0.66, 1.04)	0.10	0.90	(0.67, 1.20)	0.46	0.84	(0.64, 1.11)	0.22	0.80	(0.56, 1.16)	0.25
Belgium	0.73	(0.64, 0.84)	**<0.001**	0.51	(0.43, 0.62)	**<0.001**	**0.73**	(0.61, 0.86)	**<0.001**	0.50	(0.39, 0.63)	**<0.001**
Netherlands	0.95	(0.77, 1.19)	0.67	0.99	(0.75, 1.31)	0.95	0.84	(0.68, 1.03))	0.09	0.51	(0.37, 0.69)	**<0.001**
Portugal	0.85	(0.68, 1.08)	0.19	0.88	(0.65, 1.18)	0.40	1.00	(0.79, 1.27)	0.99	1.09	(0.81, 1.48)	0.57
Spain	0.84	(0.71, 0.99)	**0.05**	0.78	(0.62, 0.98)	**0.03**	0.67	(0.53, 0.87)	**0.002**	0.58	(0.42, 0.82)	**0.002**

[1] Difference between FAS groups estimated by multilevel logistic models (dependent variable: daily soda consumption) adjusted for sex, age groups and mean temperature at month of data collection, FAS categories (odds ratios for FAS categories). OR<1 and P<0.05 (in bold) indicate that lower-affluent adolescents are more likely to consume sodas daily than middle- and high-affluent ones (conversely for OR>1: larger daily soda consumers = middle- and high-affluent adolescents). The numbers of participants by country and survey round are detailed in Supplementary Table 5.

Supplementary Table 7. Country-level short-term changes (OR (95% CI)) in the proportion of daily soda consumption between the last pre-tax survey round (reference) and the first post-tax survey round in countries with a soda tax (in black) and comparison countries (in grey), overall and by family affluence (FAS, stratified models)

	Population-level			Stratified models								
	All [1]			Lower FAS [1,2]			Middle FAS [1,2]			Higher FAS [1,2]		
	OR	(95% CI)	P-Val.	OR	(95% CI)	P-Val.	OR	(95% CI)	P-Val.	OR	(95% CI)	P-Val.
Finland	**0.59**	**(0.43, 0.80)**	**0.001**	0.63	(0.34, 1.17)	0.15	**0.54**	**(0.36, 0.82)**	**0.003**	0.71	(0.37, 1.37)	0.31
Sweden	**0.70**	**(0.55, 0.90)**	**0.005**	0.72	(0.49, 1.07)	0.10	**0.72**	**(0.53, 0.97)**	**0.03**	0.70	(0.41, 1.21)	0.20
France	0.93	(0.82, 1.07)	0.32	**0.76**	**(0.60, 0.96)**	**0.02**	1.01	(0.86, 1.18)	0.92	0.94	(0.71, 1.24)	0.65
Germany	0.95	(0.83, 1.10)	0.51	0.91	(0.72, 1.16)	0.45	0.94	(0.80, 1.12)	0.51	1.03	(0.74, 1.42)	0.88
Italy	0.79	(0.57, 1.09)	0.15	0.74	(0.43, 1.27)	0.28	0.82	(0.56, 1.21)	0.32	0.65	(0.34, 1.23)	0.18
Belgium	**0.71**	**(0.64, 0.79)**	**<0.001**	**0.75**	**(0.62, 0.90)**	**0.002**	**0.68**	**(0.60, 0.78)**	**<0.001**	**0.71**	**(0.54, 0.92)**	**0.01**
Netherlands	**0.58**	**(0.50, 0.66)**	**<0.001**	**0.67**	**(0.53, 0.86)**	**0.002**	**0.61**	**(0.51, 0.72)**	**<0.001**	**0.33**	**(0.23, 0.47)**	**<0.001**
Portugal	**0.83**	**(0.71, 0.97)**	**0.02**	**0.71**	**(0.52, 0.95)**	**0.02**	0.87	(0.72, 1.06)	0.16	0.89	(0.65, 1.21)	0.45
Spain	**0.60**	**(0.49, 0.72)**	**<0.001**	0.80	(0.57, 1.11)	0.18	**0.55**	**(0.43, 0.69)**	**<0.001**	**0.55**	**(0.38, 0.80)**	**0.002**

[1] OR < 1 indicates a post-tax reduction in daily consumption; OR > 1 indicates a post-tax increase in daily consumption. ORs were modeled using multilevel logistic models (dependent variable = daily soda consumption), adjusted for all survey rounds (reference = pre-tax survey round), sex, age group, and temperature at the time of data collection (P≤0.05 in bold). The numbers of participants by country and survey round are detailed in Supplementary Table 5.

[2] Models were stratified by FAS.

Supplementary Table 8. Country-level long-term trends (OR (95% CI) in the proportion of daily soda consumption in the pre-tax period (between 2001/02 and 2009/10) and the post-tax period between 2009/10 and 2017/18 in countries with a soda tax (in black) and comparison countries (in grey), overall and by family affluence (FAS, stratified models)

		Pre-tax trend (2001/02–2009/10)		Post-tax trend (2009/10–2017/18)	
		OR [1]	**(95% CI)**	**OR [1,2]**	**(95% CI)**
Finland	All	0.67	(0.60, 0.76) ***	0.94	(0.76, 1.16)
	Lower FAS [2]	0.69	(0.56, 0.86) ***	0.82	(0.55, 1.23)
	Middle FAS [2]	0.69	(0.56, 0.76) ***	0.97	(0.73, 1.28)
	Higher FAS [2]	0.71	(0.55, 0.91) **	1.03	(0.66, 1.61)
Sweden	All	0.67	(0.60, 0.75) ***	0.86	(0.75, 0.98) *
	Lower FAS [2]	0.71	(0.60, 0.85) ***	0.81	(0.66, 1.00) *
	Middle FAS [2]	0.69	(0.59, 0.79) ***	0.91	(0.77, 1.07)
	Higher FAS [2]	0.60	(0.47, 0.75) ***	0.81	(0.60, 1.07)
France	All	1.01	(0.95, 1.08)	0.86	(0.81, 0.92) ***
	Lower FAS	1.06	(0.95, 1.18)	0.78	(0.70, 0.87) ***
	Middle FAS	0.98	(0.91, 1.06)	0.89	(0.83, 0.96) **
	Higher FAS	1.03	(0.91,1.18)	0.88	(0.78, 1.00)
Germany	All	0.81	(0.76, 0.87) ***	0.84	(0.77, 0.91) ***
	Lower FAS [2]	0.79	(0.70, 0.88) ***	0.81	(0.69, 0.94) **
	Middle FAS [2]	0.83	(0.77, 0.91) ***	0.85	(0.76, 0.95) **
	Higher FAS [2]	0.81	(0.69, 0.95) **	0.79	(0.64, 0.98) *
Italy	All	0.94	(0.85, 1.04)	0.62	(0.55, 0.69) ***
	Lower FAS [2]	0.95	(0.81, 1.11)	0.64	(0.53, 0.78) ***
	Middle FAS [2]	0.96	(0.85, 1.08)	0.57	(0.50, 0.66) ***
	Higher FAS [2]	0.97	(0.79, 1.20)	0.61	(0.48, 0.78) ***

[1] OR < 1 indicates a decreasing trend in daily soda consumption; OR > 1 indicates an increasing trend in daily soda consumption. ORs were modeled using multilevel two-piecewise linear spline logistic models (dependent variable: daily soda consumption), adjusted for sex, age group, and temperature at the time of data collection (*P≤0.05, **P≤0.01, ***P≤0.001). The numbers of participants by country and survey round are detailed in Supplementary Table 5.

[2] Models were stratified by FAS.