The potential health effects of taxing sugary drinks in Estonia

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Background

Sugary drinks are widely consumed in Estonia and around the world, and have been associated with overweight and obesity and a wide range of chronic diseases. The World Health Organization recommends that adults and children restrict free sugars to less than 10% (and preferably less than 5%) of total daily energy intake but a large proportion of the population consumes more than that, much of which is consumed as sugary drinks. Taxing sugary drinks has been proposed as an effective measure to reduce sugar consumption, improve health and raise revenue.

Methods

This study investigates the potential impact of taxation on soft drinks on the health of Estonians, and on government revenue. Using established modelling methods and Estonian data supplemented with international data, the following scenarios were assessed:

Scenario 1: Flat rate tax of €0.20 per litre on all soft drinks (including those with artificial sweeteners).

Scenario 2: Two-tiered tax with soft drinks with sugar content 5-7.9 g per 100 ml and products with sweeteners taxed €0.20 per litre, and soft drinks with sugar content over 8 g per 100 ml, and products that contain both sugar and sweeteners, taxed €0.40 per litre.

Scenario 3: Combination tax with soft drinks with artificial sweeteners but no added sugars taxed €0.20 per litre, soft drinks with added sugar with sugar content 5-7.9 g per 100 ml taxed €0.30 per litre, and soft drinks with artificial sweetener and sugar, and those with sugar content over 8g per 100 ml, taxed €0.50 per litre.

Scenario 4 (added later to the analysis and therefore not all of the details are published in this report): Two-tiered tax with low tax rates for soft drinks with sugar content 5-7.9 g per 100 ml and products with sweeteners taxed €0.10 per litre, and soft drinks with sugar content over 8 g per 100 ml, and products that contain both sugar and sweeteners, taxed €0.30 per litre.

Results

All four variants of the soft drinks tax lead to net health benefits that accrue over the lifetime of the population. A flat tax of €0.20 per litre (scenario 1) is expected to prevent approximately 1026 cases of obesity in men and 546 in women, mostly within the first year. Over the first 25 years, this tax could prevent 1228 cases of diabetes, 161 cases of heart disease, and 77 cases of stroke, for an overall benefit of 2,787 health-adjusted life years (HALYs) over the lifetime of the current population of Estonia. Tax revenue is estimated at €17 million per year. The effect of the two-tiered tax (scenario 2) is about 75% greater than that of the flat tax, the combination tax (scenario 3) has twice that impact, and two-tiered tax with low tax rates (scenario 4) is about 33% greater than that of the flat tax.

Conclusion

Taxing a broad range of soft drinks can lead to substantial health benefits, as part of a broader package of interventions to reduce the burden attributable to excess sugar consumption and obesity.

Background

This project aims to inform decision makers on the potential impact of a tax on sugary drinks in Estonia. The work is commissioned and supervised by the WHO Country Office in Estonia under the Biannual Collaborative Agreement for 2016-2017, and carried out by the Cancer Council NSW with the support from the Ministry of Social Affairs, the National Institute for Health Development, the Estonian Health Insurance Fund and WHO Regional Office for Europe.

Mathematical models (1) were adapted to the Estonian context, using epidemiological, demographic, nutritional and sales data on (and from) Estonia where those data were available.

The health impact of soft drinks

Obesity is an increasing health problem globally (2). Estonia is no exception (3-5). The consumption of sugary drinks has risen over time and contributes to weight gain. It has been linked to the occurrence of a wide range of health problems, including diabetes, heart disease, stroke, and cancer, and dental decay, in children and adults (6).

Several terms are used to describe different categories of drinks and the sugars they contain. *Soft drinks* are beverages with added sugar or other sweeteners. This includes soda, diet sodas, fruit drinks (typically with less than 90% fruit content), lemonade and other "-ades", sweetened powdered drinks, and sports and energy drinks (7). *Sugar-sweetened beverages (SSBs)* are the subset of soft drinks that contain added sugar. *Sugary drinks* form a broader category of drinks that contain free sugars, whether added or naturally occurring (6). This includes SSBs and 100% juice.

The World Health Organization recommends that adults and children restrict free sugars to less than 10% of total daily energy intake, with a conditional recommendation for restriction to less than 5% (8). In many countries, Estonia included, a large part of the population consumes more than this (9).

Countries around the world have implemented or announced taxes on SSBs to improve population health and/or generate revenue, including Mexico, Chile, France, Hungary, Norway, Belgium, Latvia and Finland (10). This report explores the potential impact of taxing various categories of soft drinks in Estonia.

The health impact of artificial sweeteners

Various types of artificial sweeteners (AS) are increasingly used to replace sugar in soft drinks. Concerns have been raised about the safety of these substances (aspartame, acesulfame-K, saccharin, sucralose, neaotame and advantame) but to date, no specific adverse effect on health has been conclusively proven (11).

Some studies that follow up consumers of AS drinks have found an association with weight gain (12, 13) and type 2 diabetes (14). This may be due to people who want to lose wait switching to AS drinks, rather than those drinks causing weight gain ('reverse causation'). A RCT study in normal, healthy children proved that replacing sugar with AS in drinks reduces weight gain and fat accumulation (15). Another RCT revealed that sugar-sweetened and AS produced the same satiety (16). A recent review found that compared to sugared drinks, AS drinks lead to lower energy intake, reduced body weight, and lower risk of type 2 diabetes and CVD (17).

Observational studies have linked maternal consumption of AS during pregnancy with higher infant BMI (18) and an increased risk of preterm delivery (19, 20). Again, this is possibly due to reverse causation.

A recent review concluded that heavy consumption of AS may increase the risk of certain cancers, but that overall the data remain inconclusive on the relationship between AS and cancer (21).

Consumption of large amounts of aspartame, one of the types of AS, may be related to some neurobehavioral effects on consumers such as more irritable mood, depressive symptoms, and worse performance on special orientation tests (22). Others call for more evidence on the association between AS and gastrointestinal symptoms (23).

The impact of AS on children's taste developments, food preferences and dietary patterns have not been fully elucidated (24).

Animal studies show associations between AS and increased body weigh in mice (25) or with negative effect on gut microbiome and glucose intolerance in mice (26). The usage of aspartame has an influence on brain antioxidant defence status in rats (27). The study on aspartame and saccharin suggested a link with liver damage in rats (28).

Overall, there is no conclusive evidence of any negative health impact of AS, but uncertainty remains. In the taxation scenarios included in this report, AS-containing beverages are included. In the absence of proven health impacts, no such impacts were included in the analyses.

Fiscal measures can improve health behaviours

The impact of the health-related food taxes, such as SSB taxes, has been assessed in a number of jurisdictions. There is evidence of an increase in retail prices (29) and a reduction in consumption (30-33) which may increase over time (34).

The scenarios explored in this report

The following **scenarios** were assessed for their potential health impacts:

Scenario 1: Flat rate tax

- All soft drinks (including soft drinks containing artificial sweeteners) are taxed €0.20 per litre

Scenario 2: Two-tiered tax

- Soft drinks with sugar content 5-7.9 g per 100 ml or artificial sweeteners taxed €0.20 per litre
- Soft drinks with sugar content ≥ 8 g per 100 ml, and soft drinks that contain both sugar and artificial sweeteners, irrespective of the amount of sugar, taxed €0.40 per litre.

Scenario 3: Combination

- Soft drinks with artificial sweeteners and without any added sugars, taxed €0.20 per litre

- Soft drinks with sugar content 5-7.9g per 100 ml, taxed €0.30 per litre
- Soft drinks with artificial sweetener and sugar, and those with sugar content ≥ 8g per 100 ml, taxed €0.50 per litre

Scenario 4: Two-tiered tax with low tax rates

- Soft drinks with artificial sweeteners and without any added sugars, taxed €0.10 per litre
- Soft drinks with sugar content 5-7.9g per 100 ml, taxed €0.10 per litre
- Soft drinks with artificial sweetener and sugar, and those with sugar content ≥ 8g per 100 ml, taxed €0.30 per litre

Data and Methods

Model overview

Epidemiological models were used to simulate the Estonian population in terms of drinks consumption, body mass and the burden of three obesity-related diseases (diabetes mellitus, ischemic heart disease, and stroke). The population was modelled in 5-year age groups by sex, over their remaining lifetime, comparing a scenario with tax to one without tax.

Most of the effect of SSB consumption on health was modelled via changes in body mass. An effect of sugary drink consumption on the number of new cases of diabetes, over and above the effect via body mass, was also included (35).

Figure 1 schematically presents the logic framework of the analysis.

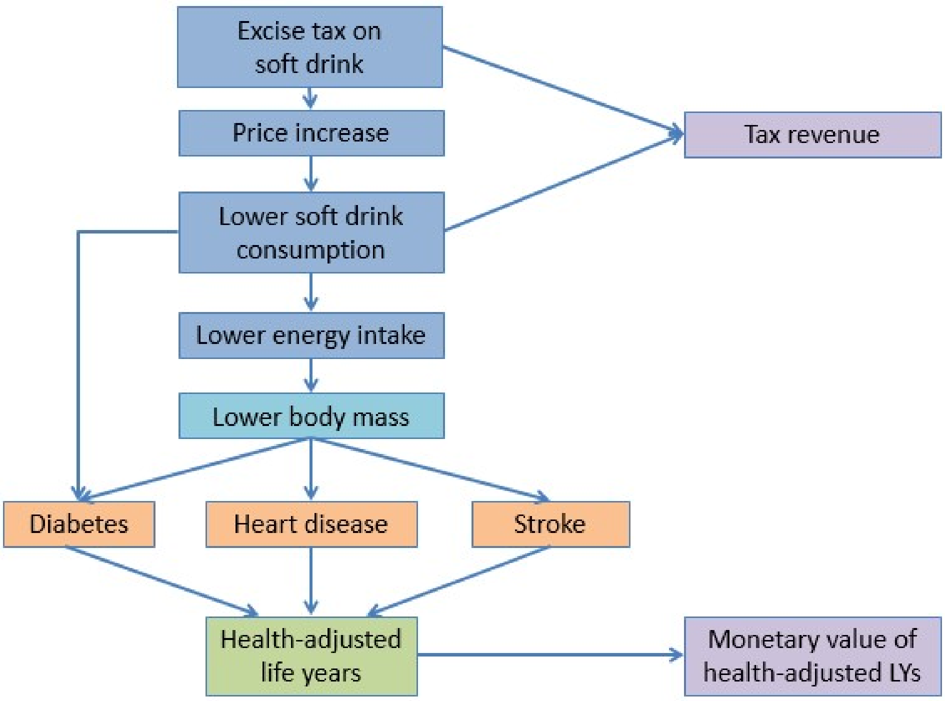


Figure 1: Schematic overview of model structure

Tax revenue is estimated, taking into account any reductions in consumption that may result from the increase in price.

Where possible, Estonian data have been used (Table 1). Unless otherwise stated, results for health-adjusted life years (HALYs), life years and tax revenues are discounted at 3% per annum. Disease-specific results and obesity prevalence numbers are undiscounted.

Table 1: Data sources

Model Inputs	Source
Price elasticities	Updated from (36)
a) Own price elasticities	Updated from (36)
b) Cross with milk and fruit juice	(36)
Soft drinks, milk[1], fruit juice[2] consumption	The Estonian National Dietary Survey (National Institute for Health Development)
Total sugar consumption from the fruit juice, milk	
…to be converted to kJ/person/day from sugar	(37), & (38), as cited in (39).
Baseline population	The Health Statistics (National Institute for Health Development)
BMI/overweight/obesity estimates/Height	The Estonian National Dietary Survey (National Institute for Health Development)
Trends in soft drinks consumption	Euromonitor Passport database
Prevalence, Incidence and Mortality of Diseases	The Health Statistics (National Institute for Health Development) and Estonian Health Insurance Fund Database, Estonia
Prices of drinks	Euromonitor Passport database
Amount of sugar included in drinks	Data provided by Estonian collaborators
YLDs and DWs estimates	The GBD estimates 2015

The current prevalence of obesity in Estonia

The trend of obesity in Estonia

Estonia is experiencing rising obesity rates, both in adults and in children. The prevalence of overweight (including obesity) among children aged 11, 13, and 15 years old was increasing by approximately 7.2% and 8.4% for girls and boys, respectively from 2002 to 2010 (40). In children from 2 to 9.9 years old, the percentage with overweight or obesity was about 13.8%

[1] Milk: fresh milk (cow's or goat's; skimmed, semi skimmed or whole) and unflavoured fermented milk drinks (soured milk, kefir, drinking yoghurt, buttermilk). Intake includes milk as a separate drink, milk added to coffee, coffee substitutes, tea, cocoa, breakfast cereals or desserts (e.g. bread pudding, semolina mousse). Not included is milk as a component of other foods (e.g. porridges, sauces, soups, omelettes, cakes and desserts, smoothies, milk or ice cream shakes)

[2] Juice: 100% fruit and vegetable juices (homemade or commercial; without added sugar, but may include fruit pulp, natural flavourings, preservatives, salt, etc.). Intake includes juice as drink, not included is juice as a component of other foods (e.g. salad dressings, jelly, cakes and desserts, smoothies, milk or ice cream shakes). Homemade drinks with juice that were also added sweeteners (e.g. diluted juice with sugar or honey, kissel) were classified as sugary drinks.

in boys and 15% in girls, based on data collected between 2007 and 2010 (3). The proportion of adults aged 16 to 64 years with overweight and obesity in Estonia was approximately 57.9% and 48.1% in males and females, respectively (4).

The current of body mass index (BMI) estimates were based on the data from the Estonian national dietary survey (41) (Figure 2). Body mass was modelled as lognormal distributions of body mass index, by age and sex.

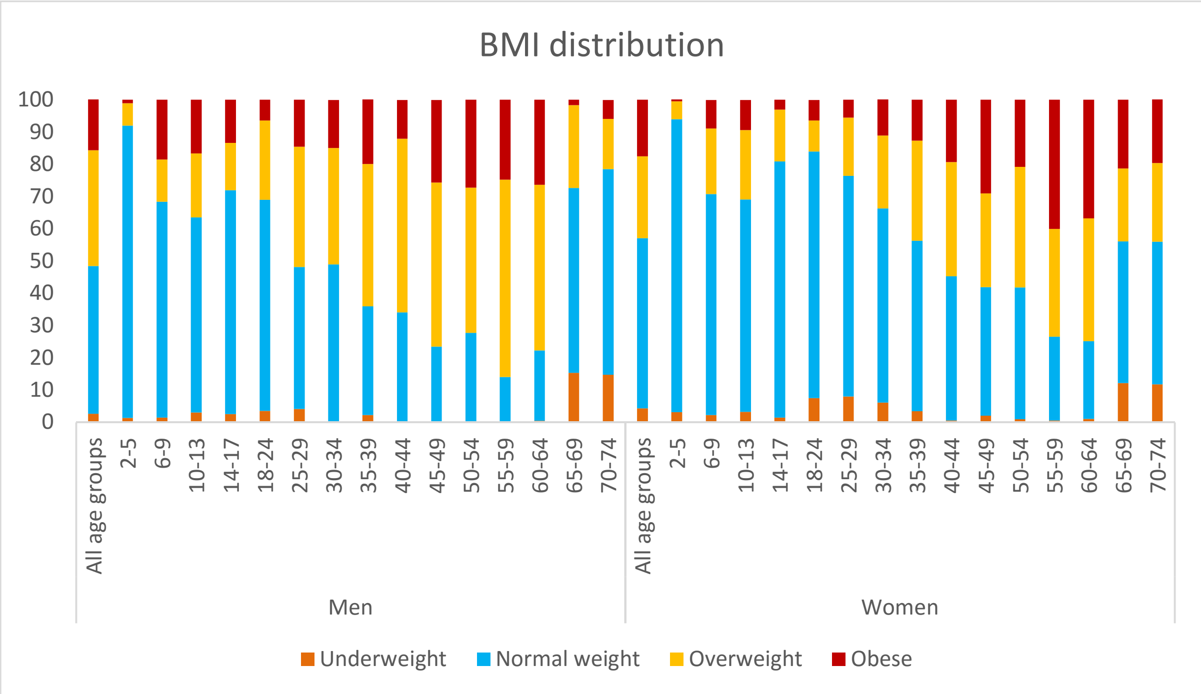


Figure 2: Prevalence of underweight, normal weight, overweight and obesity in Estonia 2014 (Source: The Estonian National Dietary Survey 2014).

The health impact of obesity

Obesity is associated with a wide range of diseases such as type-2 diabetes, cardiovascular disease and some types of cancer (42). These effects start from an early age. In Estonia, a study shows that overweight and obesity are associated with the risk of high blood pressure among 9 to 11-year old children (5). These diseases are translated to the loss of health-adjusted life years, which is defined by the number of healthy years lost as a result of mortality (number of life years lost) and morbidity (number of years lived with diseases, adjusted for severity).

The evidence for the causal link between SSB consumption and obesity

The strongest evidence that SSB consumption leads to weight gain is provided by a double-blind randomised controlled trial (RCTs) in 641 healthy, normal-weight Dutch children over 18 months (15). Compared to the group randomized to artificially sweetened beverages, children who received a similar sugar-sweetened beverage (SSBs) gained more weight, which shows that SSB consumption leads to overweight and obesity in children.

In Estonian children, among many multiple lifestyle-related health factors being examined in the study IDEFICS (Identification and prevention of Dietary-and lifestyle-induced health effects in children and infant), SSB consumption may be linked to fat accumulation and childhood obesity (43). The causal effect of SSBs and obesity in children was confirmed by the review of Libuda and Kersting (44), and a meta-analysis of trials and prospective studies shows a higher risk of being overweight or obese in those consuming more SSBs for both children and adults (45). In view of the collective body of evidence, experts have concluded that there is sufficient scientific evidence that decreasing sugar-sweetened beverage consumption will reduce the prevalence of obesity and obesity-related diseases (46).

Soft drinks in Estonia

Current soft drink sales

Sales data from 2002 to 2016 provided by the industry were extracted from Euromonitor Passport Database (47). The total volume of soft drinks sold in Estonia in 2016 was 104.75 million litres. Figure 3 shows that carbonated soft drinks accounted for the largest market share.

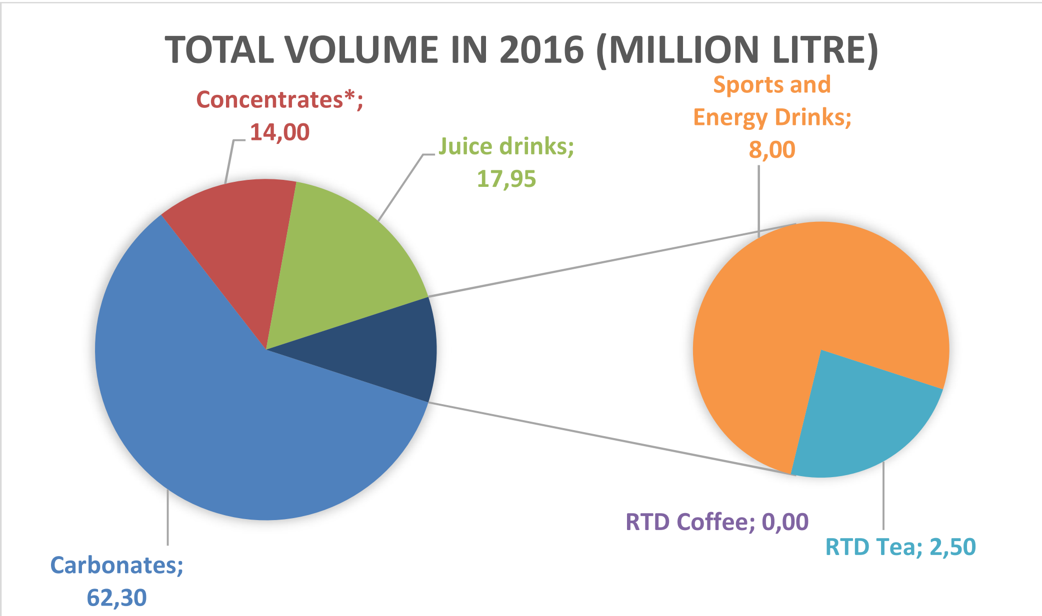


Figure 3: Soft drink consumption in 2016 by percentage of categories.
A dilution ratio 1:4 was applied to liquid and powder concentrates to calculate drinkable volume.

Projected soft drink sales

Per capita consumption of soft drinks has increased over recent years (Figure 4). In this study, the trend in sales for the last 4 years (data extracted from the Euromonitor Passport database over 2012-2016) is used to extrapolate to the year 2025 based on the assumption of a constant annual growth rate. Consumption of soft drinks was assumed to be stable after 2025. These sales volumes were used in the calculation of tax revenues, while the relative growth rates were used to forecast consumption patterns.

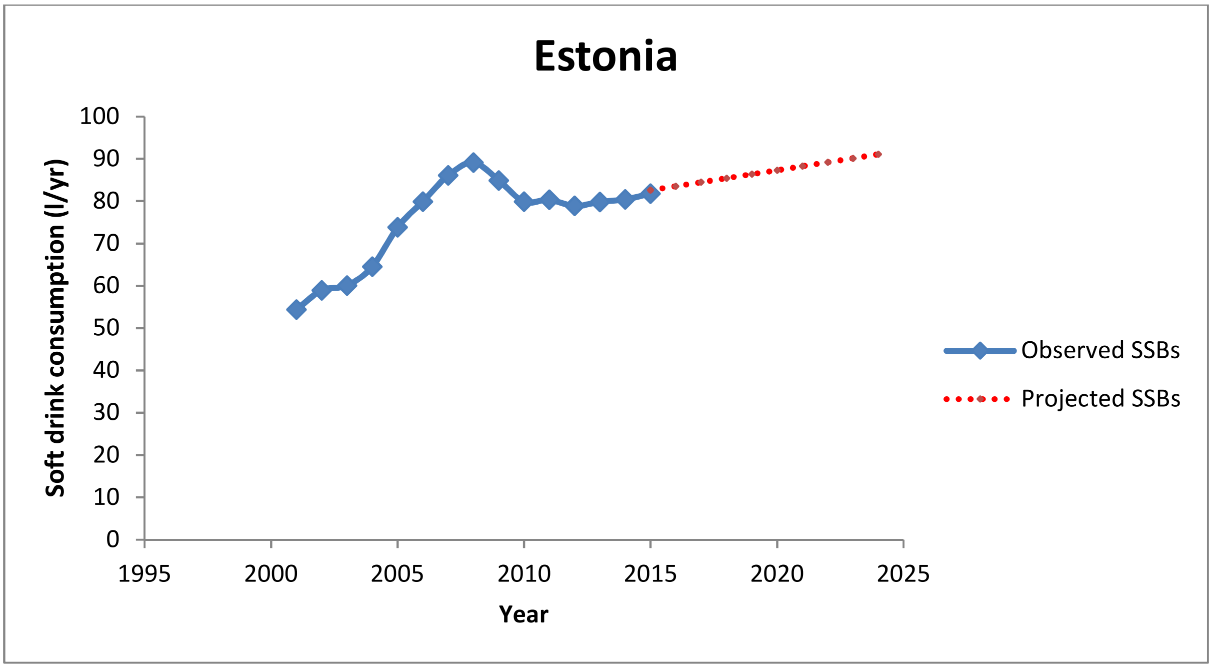


Figure 4: Observed and projected per capita sales of sugar-sweetened beverages in Estonia (2011-2025).
Source: Euromonitor Passport Database

Retail pricing of soft drinks

The weighted average of the main brands accounting for the largest market share in each category (four brands for carbonates and three for other categories) was used to compute the average retail price prior sales tax (Table 2).

The prices of main brands are extracted from Euromonitor Database where prices of a specific product of any specific brand vary based on the size of the bottle and selling place. The smaller the size of the bottle, the higher the price tends to be. Considering the 'conservative approach', we took the price of the smallest size bottle, as this would result in the smallest relative price increase, and thus the smallest deterrent effect. In the sensitivity analysis, we use the average retail price of soft drink based on the largest size bottle. Prices also depend on where a product is sold. We used supermarket/hypermarket prices, as this is where the greatest volumes of soft drinks are sold. (See supp. material Tables S5 and S6 for calculations.)

Table 2: The calculation of average retail price for sugary drinks

Product	Total market share (%) of the main brands	Weighted average pre-tax price per litre	Total sale of SSBs in 2016 (million litre)	Weighted average price
Carbonates	42.50	1.59	62.30	
Concentrates	56.60	0.40	14.00	
Juice	94.42	1.53	17.95	
RTD coffee	70.30	3.01	0.00	1.57
RTD tea	98.70	1.52	2.50	
Energy drink	39.70	3.52	8.00	

* Concentrates were assumed to have 4 parts water added per part.

Soft drink consumption estimates

Data were extracted from the Estonian national dietary survey 2013-2014 to estimate soft drinks, fruit juice and milk consumption in the population, including children and adults. The sample for the survey was selected by stratified random sampling from Estonian residents based on age, gender, nationality and place of residence. The Estonian national dietary survey obtained the data on food intake by computer assisted personal interview for 11 to 74-year-old participants. For younger participants, a food diary was filled out by their parents. Food intake was generally assessed on two non-consecutive days; for 112 out of 4018 participants, information was available only for a single day. Mean intakes per sex and age group are based on participants' average daily intakes. Results were weighed by sex, age, nationality and region.

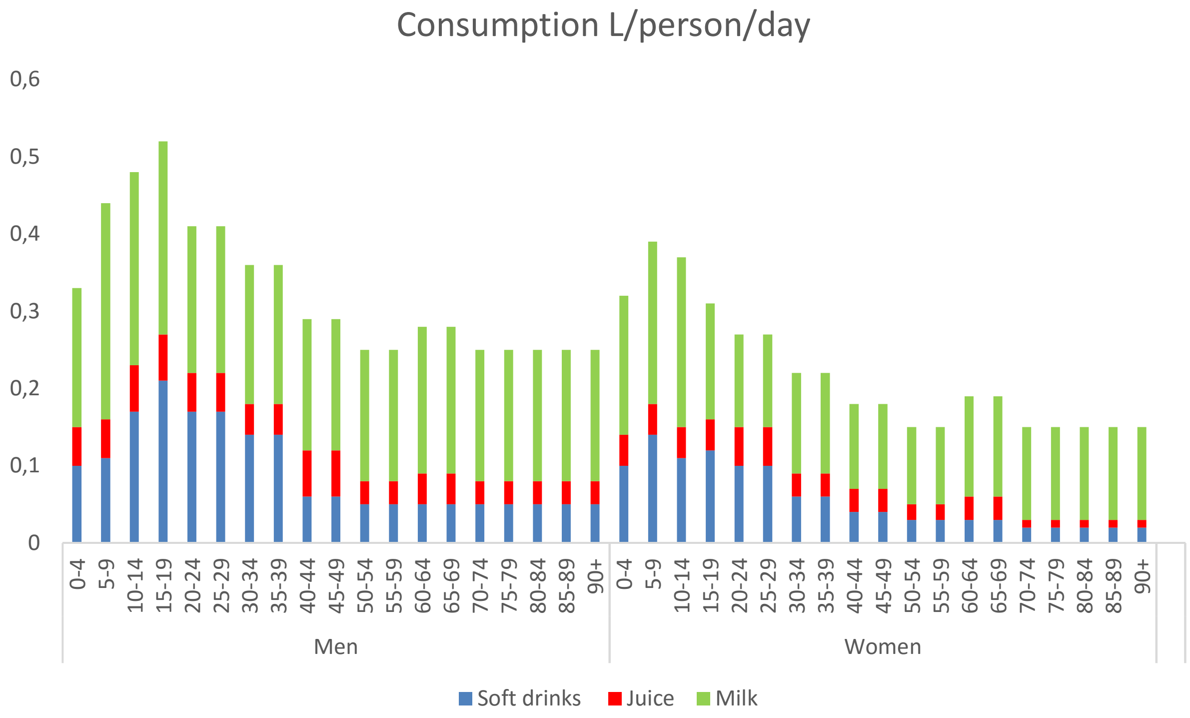


Figure 5: Consumption of soft drinks, 100% juice and milk per person per day by age and sex

The per capita sales data of soft drink from Euromonitor were 2.5 times the estimated per capita consumption of soft drinks reported by participants in the Estonian national dietary survey. The difference between the numbers could be due to various reasons, including ‘social desirability bias’, which also results in under-reporting of weight in self-report surveys. If the actual consumption of soft drinks is higher than that reported in the survey, the health impact of a soft drink tax may be considerably larger than that estimated in this report. We explore this in the sensitivity analysis.

Taxation proposal

Type of soft drink tax

To reduce soft drink consumption, excise taxes are generally recommended (48)(50). Excise taxes generally apply to products sold in a jurisdiction. There are some sub-categories of excise tax; for example, *ad valorem* tax is levied proportionally to the value of a beverage (e.g. 20% of the pre-tax price) while *volumetric* tax is placed on the volume (e.g. €0.20 per litre). Nutrient-based taxation, another type of excise tax, is based on sugar content (e.g. €0.03 per gram of sugar). Volumetric or content-based taxes are generally regarded as more effective in reducing consumption, as they lead to higher relative price rises in cheaper goods, which discourages consumers from choosing a less costly but equally unhealthy variety of a product (48).

In this study, a volumetric excise tax at a uniform rate is used in scenario 1 ('Flat tax €0.20'), while different levels of volumetric tax are applied to drinks with different sugar and AS content in scenarios 2, 3 and 4 (tiered taxes).

Consumer response to a soft drink tax

A tax levied on soft drinks leads to an increase in the price of these products. The response of consumers to a change in product price is generally expressed as own-price elasticity and cross price elasticity with other products.

Own-price elasticity refers to the change in the quantity of a good demanded when price of the same good increases by 1% (51). It has negative values, indicating that the purchase of a good will decrease in response to an increase in its price (Table 3).

Cross price elasticity is the change in the demand of a good in response to price changes of another good (51). When the price of SSBs increases, own-price elasticity predicts the consumption of SSBs will decrease. In response, the consumption of other drinks such as fruit juices and milk may also change, either upward ('substitution') or downward ('complementarity'). The cross-price elasticities of fruit juice and milk used in this study are positive, which means that consumers switch to these types of drink as the prices of SSBs rise.

In the absence of price elasticity estimates for Estonia, we used elasticity estimates from an updated version of the pooled estimates (Table 3) (36). This review included evidence on the reduction of SSBs consumption due to an increase in prices from both high- and middle-income countries.

Table 3: Price elasticities.

	SSB	Fruit juice	Milk
Price Elasticities	-1.20 (-1.06--1.34)	0.22 (0.14-0.29)	0.09 (0.03-0.14)

Price elasticities are updated from (36) based on (52),(53),(54)

Producer response to a soft drink tax

Excise taxes are paid by producers, who can respond by passing on the costs to consumers, or by reformulating the product so that less tax is due (55). Absorbing the costs is also an option, but this goes directly at the expense of profits (56).

Pass on rate

Soft drinks tax may be absorbed partly by the manufactures (under-shifting) or the prices can be increased more than that after sugary drinks excise tax (over-shifting). In larger jurisdictions like Mexico or France, where consumers cannot easily cross borders to buy products in neighbouring jurisdictions that do not apply the tax, taxes have been passed on in full (57, 58).

The modelled scenarios assumed that a tax in Estonia is passed on in full to consumers (100% pass on rate). The sensitivity analysis includes scenarios with 80% and 120% pass on rates.

Product reformulation

Product reformulation may serve to lower or even escape the newly-introduced soft drink tax. To minimize a volumetric sugar content tax, producers may lower the sugar content included in their product to below the threshold value (e.g. reformulating a product to have sugar content of 4.9 g if a tax is levied on the category having sugar content 5 g or more). We explore the potential impact of reformulation in the sensitivity analysis.

The health impact of a soft drink tax

Changes in energy intake and body mass

Based on the current levels of drinks consumption, the trend in the consumption of soft drinks, the characteristics of the tax, and the price elasticities, expected average energy consumption by age was calculated for each cohort across their remaining lifetime. For the different categories of soft drinks, Estonian data on brands, quantities sold from Euromonitor combined with data on sugar content from Estonian sources (59) were used to estimate the average sugar and energy content (1g of sugar = 170kJ). 100% Fruit juice was estimated to have an energy density of 1821kJ/litre, and milk was assumed to be of the full cream variety with a fat content of 2.5% (2660kJ/litre).

Table 6: Soft drink categories with volumes sold and sugar and energy content.

Category	% Sweeteners (sugar and bulk sweeteners)	Sugar (g) per 100 ml	Sugar kJ/L
Carbonates	6.20	8.63	1,467
Carbonates ex diet varieties		9.84	1,674
Concentrates	42.60*	6.46**	1,099**
Juice drinks	3.30	10.44	1,775
RTD Coffee	6.00	4.79	815
RTD Tea	3.10	4.79	815
Sports and Energy Drinks	9.60	10.59	1,800
Total soft drinks consumed		9.16	1,557
Total Ex. Diet carbonates		9.87	1,678

*Undiluted. **Diluted with 4 parts water added per part.

Changes in total energy consumption were translated to changes in body mass using well-established energy balance estimates. For adults, every 94.0kJ (88.2 – 99.8) reduction in daily energy intake results in a 1kg lower equilibrium weight (38). For children, higher kJ values per kg apply, depending on age (60). Most of the weight change is expected to materialize within a year (38).

Changes in weight are translated to changes in average body mass index (BMI) for each age group, and applied to lognormal distributions of BMI. The spread in BMI (standard deviation) was reduced commensurately, such that the impact of a reduction in BMI is largest at the higher end of the BMI distribution (61, 62).

Health impact

A shift in the BMI distribution means that the population is exposed to lower levels of risk for diabetes, ischaemic heart disease and ischaemic stroke. The association of BMI with diseases was based on estimates prepare for the Global Burden of Disease 2015 (63). Potential impact fraction calculations were used to quantify the risk reductions (64).

Disease epidemiology was based on estimates for Estonia from the 2015 Global Burden of Disease study. Upon a reduction in the number of new cases (incidence) of obesity related diseases, the number of existing cases goes down over time at higher ages, and finally the number of deaths follows. However, as people live longer, they are at risk of dying from other causes, and the life table structure takes this into account. The average quality of life at older ages improves when cases of obesity-related disease are prevented, which the model weighs using disability weights provided in the Global Burden of Disease study. The model compares outcomes for diseases and health-adjusted life years that can be expected under various tax scenarios with a 'business as usual' scenario in which no additional tax is applied.

Sensitivity Analyses

Sensitivity analyses are conducted to identify the key drivers and the sensitivity of the results to variations in variable values and assumptions. The following variables are examined: (1) discount rates of 0% (no discounting), 2% and 5%, (2) tax rates vary €0.10 higher or lower for all categories, (3) pass on rates of 80% and 120%, (4) average price of soft drinks based on prices of the largest size bottle, (5) no cross price elasticities applied (the assumption of consumers not switching to other calorie-containing products), (6) 10% increase in the average price of soft drinks, and (7) consumption across all ages increased by a factor 2.5 to match sales according to data from Euromonitor. To estimate the producer response to the tax by reformulating their product, we construct a scenario of reformulation corresponding to scenario 2 in which producers of soft drinks with sugar content 5-7.9g would reformulate their product to be having sugar less than 4.9g and producers of products with sugar higher than 8g become less than 7.9g. Producers with product containing both sugar and AS would exclude AS in their product while change sugar content fell in the range 5-7.9g. Two scenarios are assumed: one with no tax applied and one with 20 cent tax applied for the third category. Finally, to examine the total avoidable health burden resulting from soft drinks consumption, we tested a scenario in which all soft drinks are replaced by water.

Findings

Changes in energy intake by age and sex

The effect of taxing on all soft drinks (including those that contain artificial sweeteners but no sugar) would reduce the average energy intake to different levels in the three scenarios examined in this study. The change is substantial in children, especially in adolescence (Figure 6). A flat tax of €0.20 per litre (scenario 1) reduces the energy intake by approximately 20kJ in males and 11kJ in females in the age group 20-24-year-old. Scenarios 2 and 3 have a higher impact on the reduction in energy intake, being 36kJ and 40kJ in males and 20kJ and 23kJ in females, respectively. Furthermore, the change in energy intake would be considerably greater in men than in women, and among young adult people than among older generations, which relates to higher consumption of soft drinks reported among the young adults and men.

Figure 6: The reduction in energy intake by age and sex for 3 scenarios
Error bars represent 95% uncertainty interval

Changes in body mass

Reductions in energy intake would lead to changes in BMI, following the same pattern with the change in energy intake (Figure 7). For children, BMI cut-offs were sourced from an international study (65).

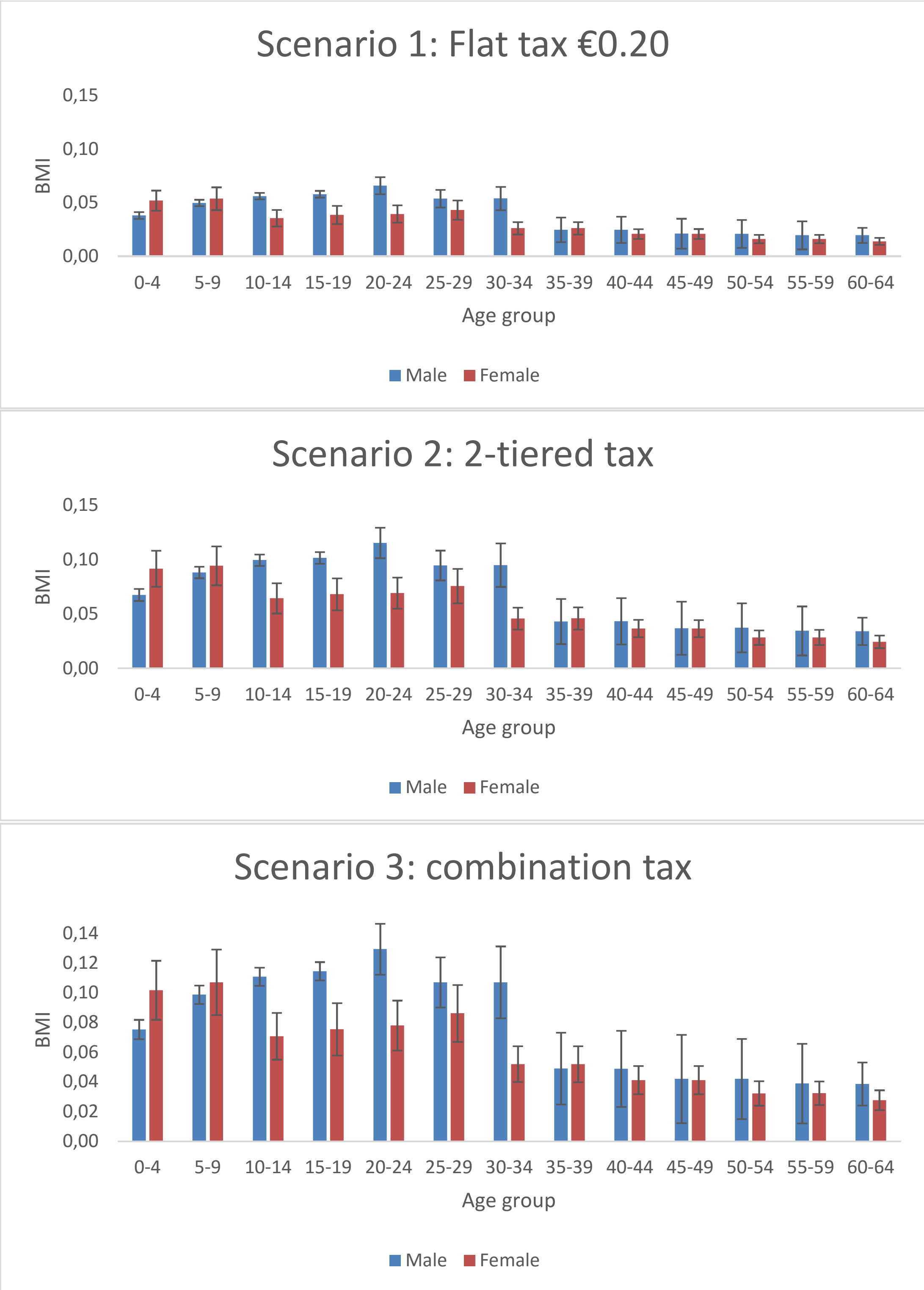


Figure 7: The reduction in BMI by age and sex for 3 scenarios
Error bars represent 95% uncertainty intervals.

Obesity prevalence

The reduction in energy intake and BMI would lead to the decrease in the prevalence of overweight and obesity within the first few years. Figure 8 illustrates the projected health impact of four scenarios of soft drink tax on the overweight and obesity in Estonia. In scenario 1, the reduction in obesity and overweight is expected to be approximately 1026 (666-1405) cases of obesity and 356 (226-496) cases of overweight in men while 546 (358-744) cases of obesity and 242 (156-331) cases of overweight in women. The reductions in obesity and overweight in scenarios 2, 3 and 4 are greater than that in scenario 1. (See Suppl. Material Table S7.)

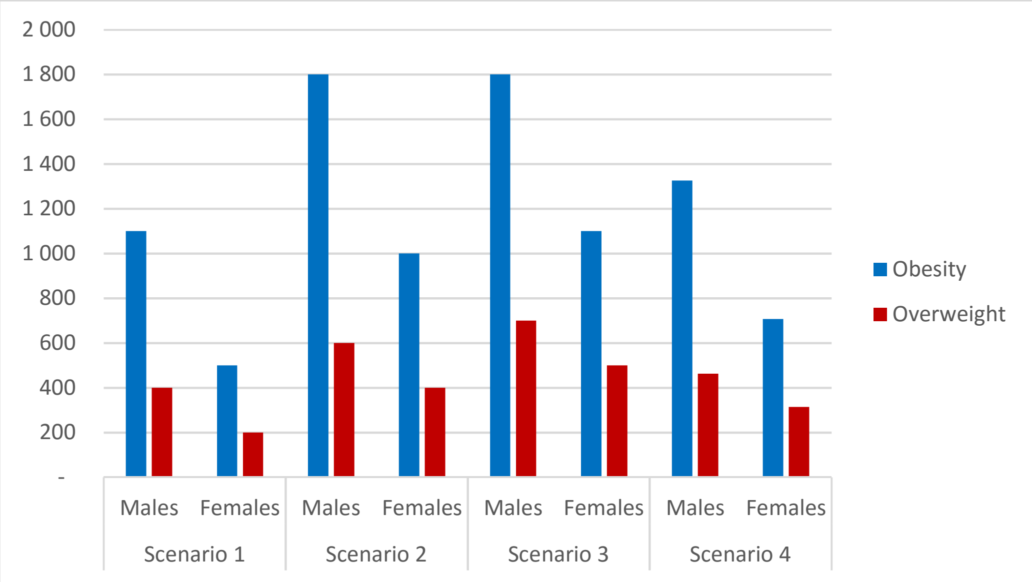


Figure 8: The reduction in number of cases of obesity and overweight for 4 scenarios.

In children, the numbers of obesity cases prevented are 246 and 210 for boys and girls, respectively. The reduction in obesity is more substantial in scenario 2, 3 and 4, being 433, 482 and 308 cases for boys and 366, 408 and 261 cases for girls, respectively.

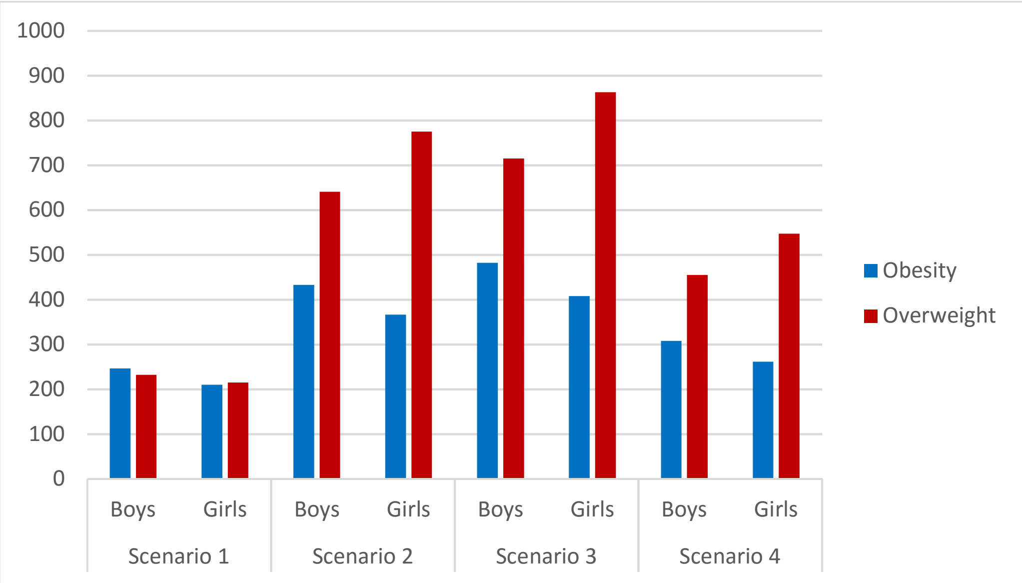
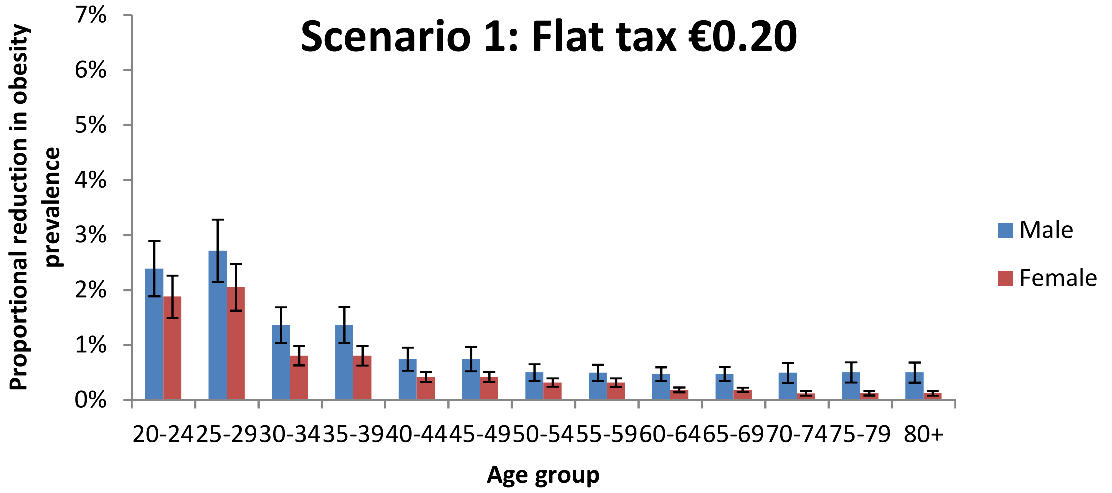
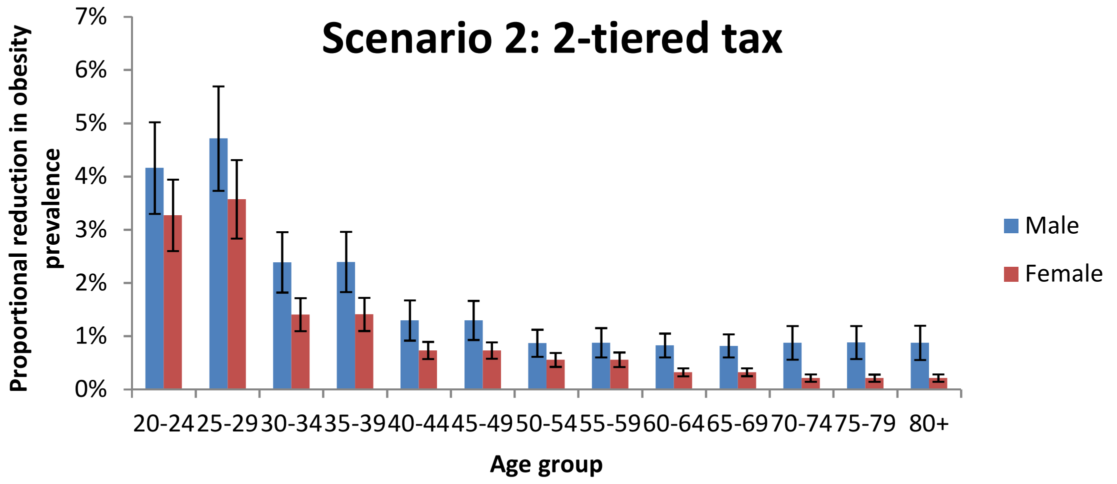


Figure 9: The reduction in number of cases of obesity and overweight for 4 scenarios among children.

The proportional reduction in obesity for each scenario is shown in Figure 8. The pattern of the obesity reduction is similar to that of energy intake and BMI reduction, which reflects the difference in soft drink consumption by age and sex.

The prevalence of obesity would decline by about 2-5% in young adults within a few years, while the proportion of obese older Estonians, especially among women, would barely change (Figure 10).





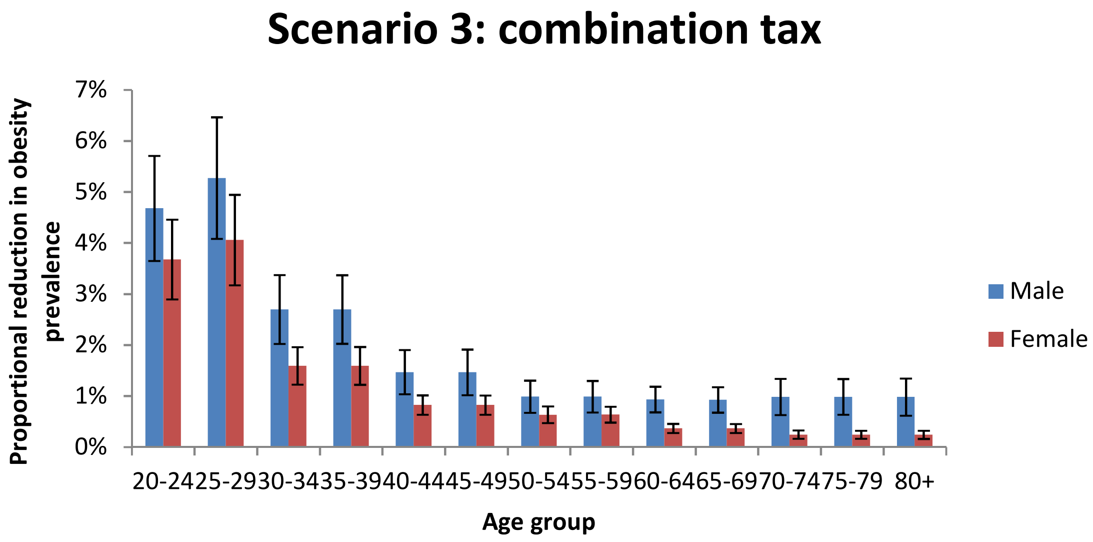


Figure 10: The relative reduction in the numbers of Estonian women and men with obesity
Error bars represent 95% uncertainty intervals.

Obesity-related diseases

The reduction in energy intake and BMI would prevent part of the new cases of obesity-associated diseases that would occur without the implementation of a soft drink tax.

The potential health benefits are substantial, with the largest effects on diabetes and a more modest impact on heart disease and stroke. Over the first 25 years of the tax, approximately 1,220 fewer new cases of diabetes are expected to occur, while 160 cases of heart disease and 80 cases of stroke would also be prevented. At least 330 fewer deaths would occur in that period (Figure 11). The impact of scenario 2 (two-tiered tax) is about 72% larger than that for the flat tax in scenario 1, with scenario 3 (combination tax) having twice the impact of scenario 1 and with scenario 4 (two-tiered tax with low tax rate) having about 29% larger than that for scenario 1 on the number of new cases of type 2 diabetes. (See Suppl. Material Table S8.)

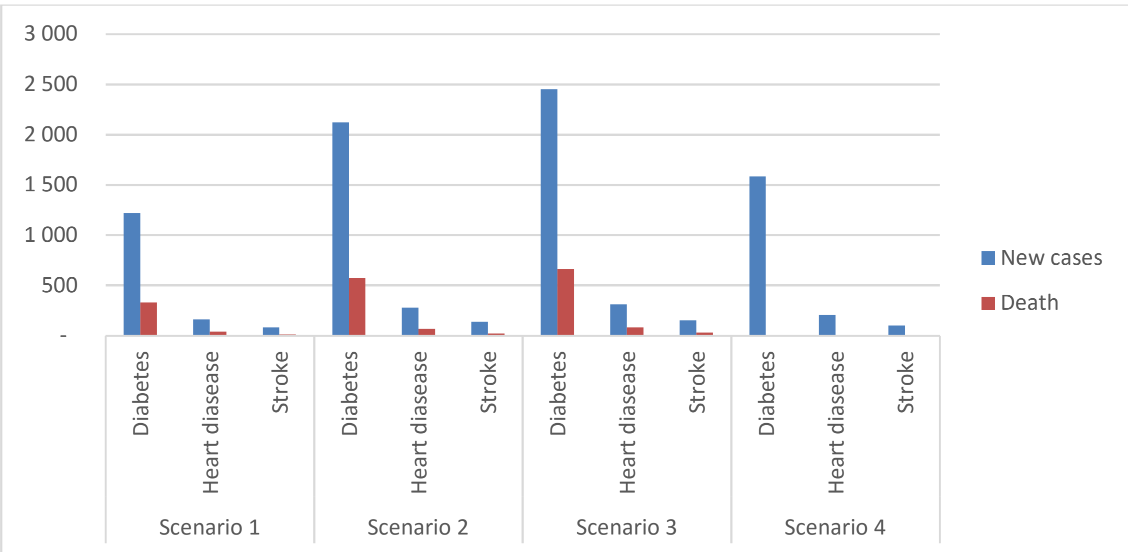


Figure 11: Number of new cases prevented and deaths in type 2 diabetes, heart disease and stroke for 4 scenarios over the first 25 years of the tax (for scenario 4 only new cases are shown).
The deaths attributable to diabetes are partly via cardiovascular disease and other complications of diabetes. The mortality numbers in this figure can therefore not be added.

Following the imposition of a tax, the health gains would grow over the years. Figure 12 shows that the reduction in the number of diabetes cases over the period of 25 years after the introduction of the €0.20 excise tax rises to 392 cases and 367 cases for men and women, respectively, in the 25th year.

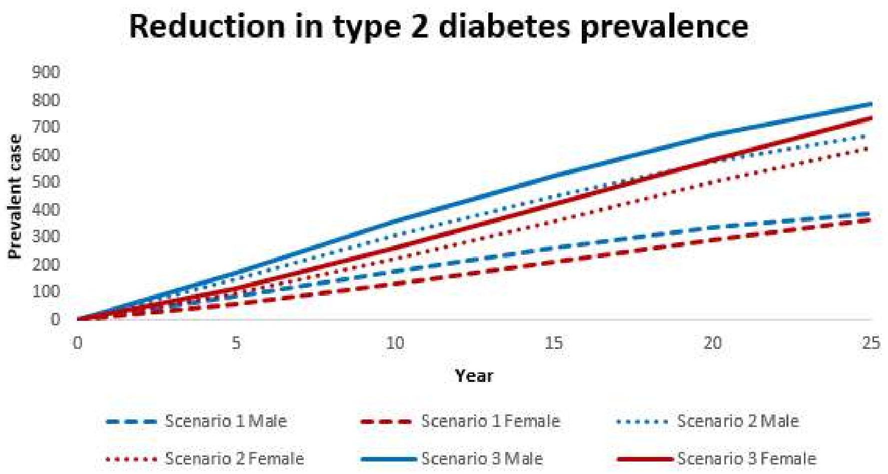


Figure 12: The reduction in type 2 diabetes prevalence over the first 25 years after the introduction of the €0.20 excise tax

Health-adjusted life years gained

Our modelling suggests that over the lifetime of the 2015 population of Estonia, taxing soft drinks (including those with artificial sweeteners) per scenario 1 could result in an additional 2,787 health-adjusted life years (HALYs; Figure 13) with men benefiting slightly more than women. Scenarios 2, 3 and 4 are expected to result in substantially more HALYs. (See Suppl. Material Table S10.)

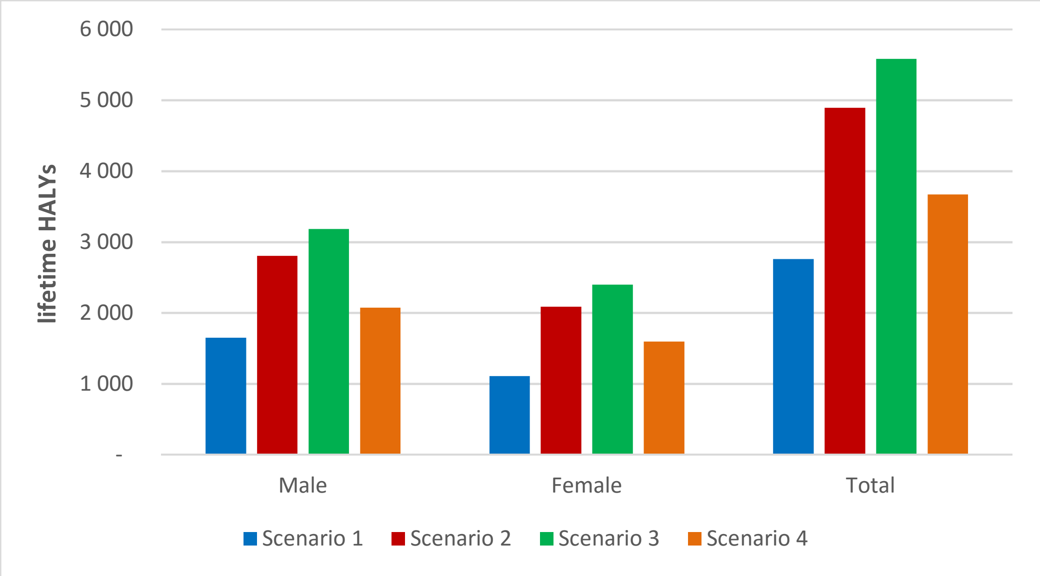
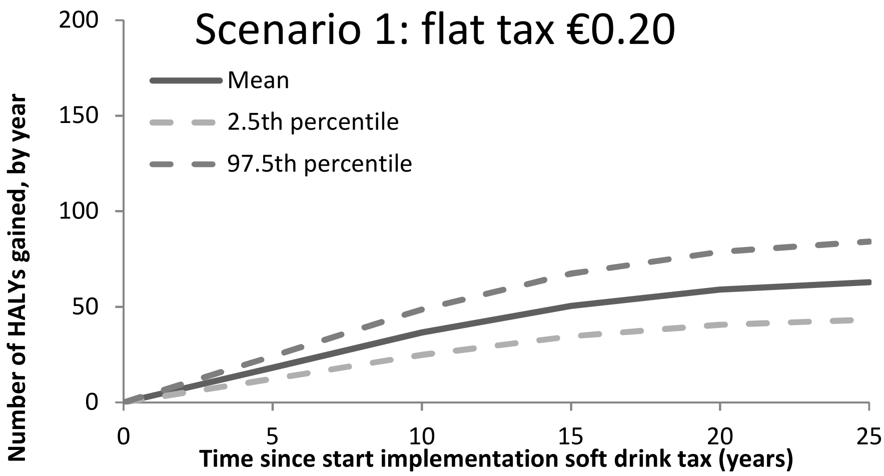
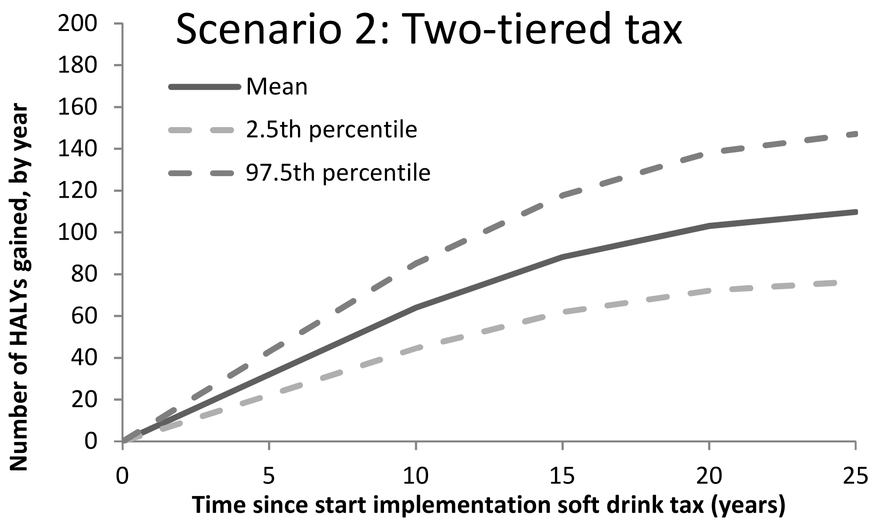


Figure 13: Number of lifetime HALYs gained for 4 scenarios.

In scenario 1, the figure shows that in the 5th year health gains equivalent to 18 years in full health are realised, rising to 63 in year 25 (Figure 14).





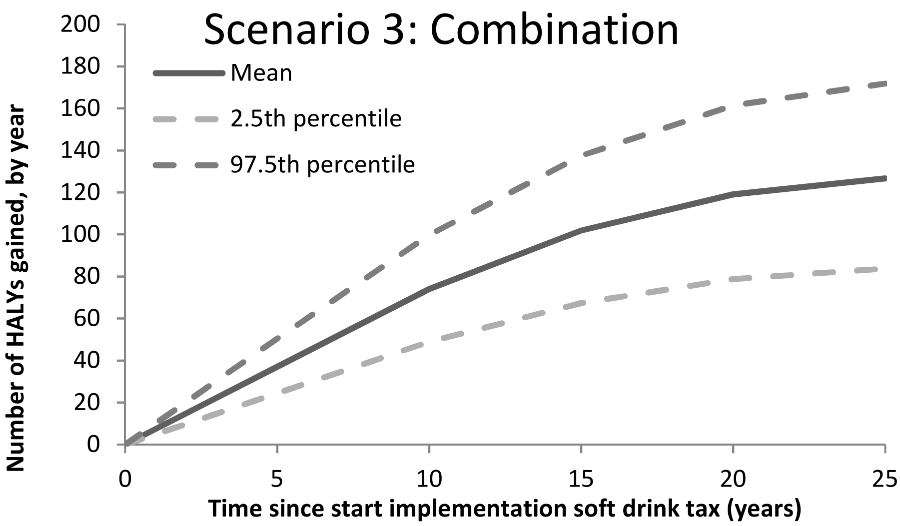


Figure 14: The number of health-adjusted life years gained over the first 25 years for different scenarios of soft drink tax in Estonia.

The gain in health-adjusted life years can be translated to the monetary terms, although this practice is controversial. The WHO / World Bank Commission on Macroeconomics and Health considered interventions that deliver health gains at a cost of up to one time per capita Gross Domestic Product (pcGDP) 'highly cost-effective', and those that do so at up to three times pcGDP 'cost-effective'. Figure 15 shows that if we value one year in full health at pcGDP, Estonia would save an amount of about €43.3 million over the life time of the 2015 population from the implementation of the excise tax at the flat €0.20 rate, again with scenarios 2, 3 and 4 delivering larger benefits (See Suppl. Material, Table S11).

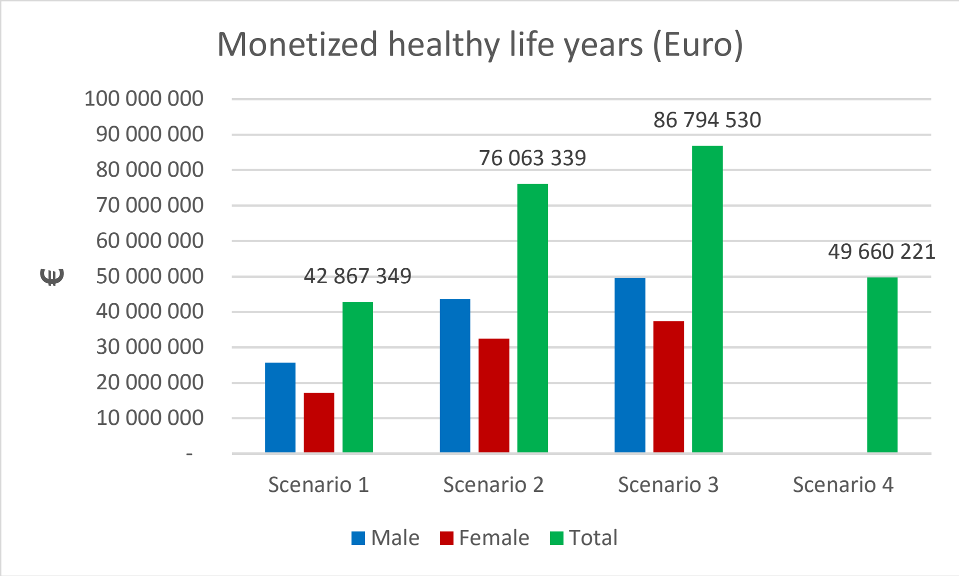


Figure 15: Monetized healthy life years gained for 4 scenarios
Notes: Health-adjusted life years are converted to the monetary terms by multiplying by per capita GDP (https://www.focus-economics.com/country-indicator/estonia/gdp-per-capita-EUR)

Tax revenue

Based on sales data from Euromonitor and after the reduction of sales caused by the tax, revenue over the first year of the sugary drink tax introduction is expected to be about €17 million in scenario 1 and rising to €25 million in scenario 3 (Figure 16).

Figure 17 presents the tax revenue over 25 years of the soft drink tax implementation, discounted at 3%, for the three scenarios. The tax revenue is projected to be approximately €4.33 million at the year 25th of the tax implementation in scenario 1 while being €5,37 million and €6.36 million in scenario 2 and 3, respectively. This does stress that to keep effectiveness and revenue stable, the tax will need to be indexed to keep pace with inflation and income growth.

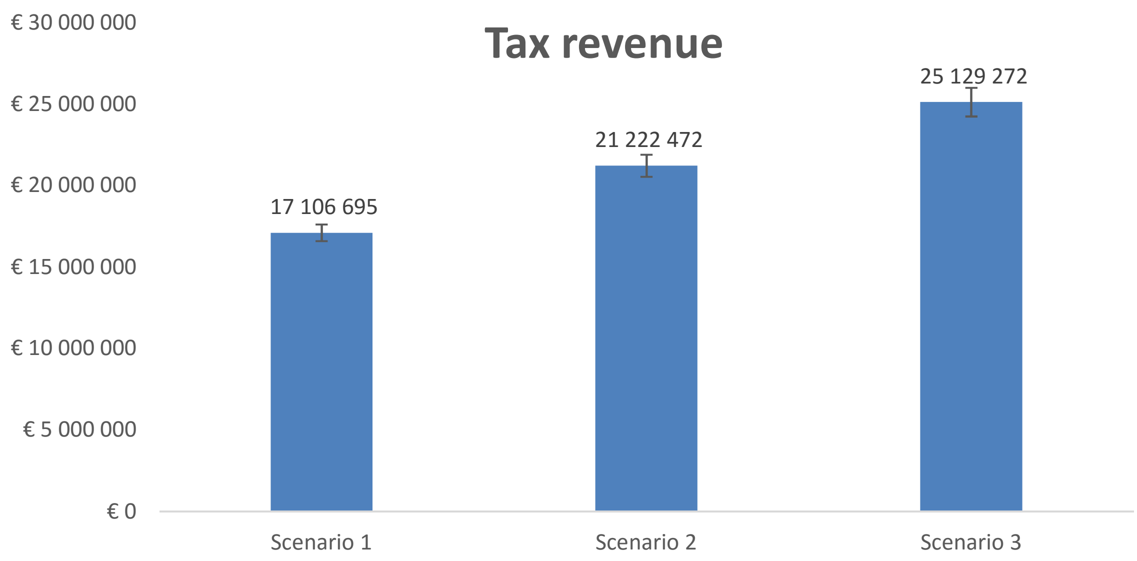


Figure 16: Tax revenue over the first year for 3 scenarios
Error bars represent 95% uncertainty intervals.

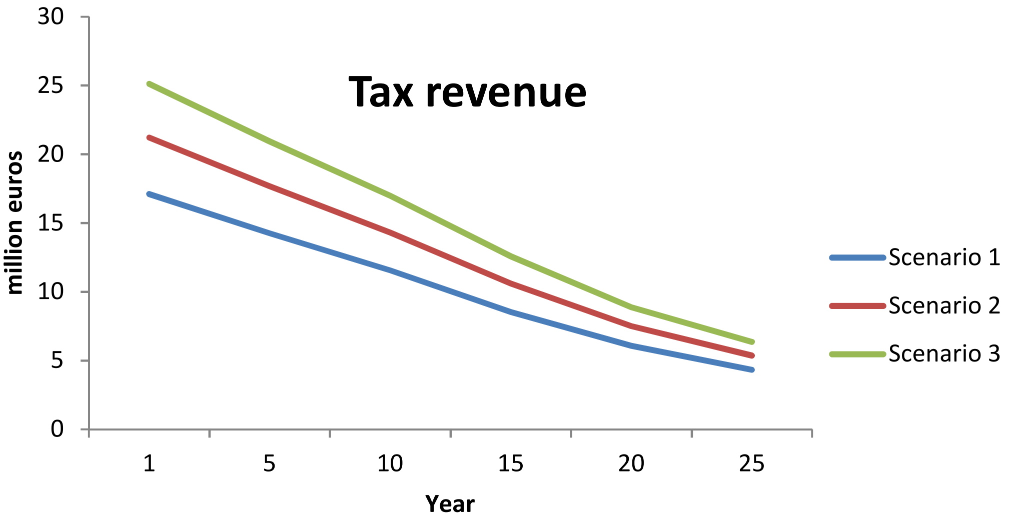


Figure 17: The projected tax revenue over 25 years of the tax implementation for 3 scenarios (discounted at 3%)

One-way sensitivity

Table 4 presents the results for one-way sensitivity analyses of a number of key parameters. The results are highly sensitive to the discount rate that is applied, with results trebling with no discounting. This is because many of the health gains, notably reductions in mortality due to chronic disease, take place up to decades in the future. Uniformly higher or lower taxes have most impact on scenarios with a low initial tax rate. Not surprisingly, halving the €0.20 tax modelled in scenario 1 would reduce the impact by about 50%, while increasing it to €0.30 would lead to 38% higher benefits. If the average retailing price of soft drinks were derived from the prices of the biggest size bottles, the health impact of the soft drink tax becomes roughly 68% larger. (Flat taxes have larger relative impacts with lower initial prices.) If consumers replace soft drinks with water, rather than other drinks that contain calories (mimicked here by not applying cross price elasticities for milk and juice), the health benefit gained would also be about 50% higher. The study's results are moderately sensitive to the variations of the tax pass-on rate and the 10% increase in the average price.

The scenarios using the sales data from Euromonitor demonstrate an approximately 236% higher health benefit gained. If the consumption of soft drinks was indeed underestimated to this extent in the nutrition survey, then the true health gains would be up to this much higher than the results in this report suggest.

We also examined a scenario that focused on the industry response. The 'reformulation' scenario in Table 4 is based on the two-tiered tax scenario (scenario 2), whereby consumption patterns do not change but instead the sugar content of the products in each category are reduced to just below the nearest cut-off (8 and 5 grams per 100ml). This would result in health gains that are 31% higher than under base case assumptions. If price elasticities are then also applied (at the rate associated with the new, lower sugar content) and consumers reduce their soft drinks consumption, the health impact is almost 70% larger than under base case assumptions. Clearly, the industry's response matters for the impact of soft drinks taxes.

The total burden of the modelled diseases associated with soft drinks is illustrated by the scenario in which all soft drinks are assumed to be replaced by water. The results show that the current level of soft drink consumption may cause the total loss of about 120,000 HALYs. Theoretically, this burden can be avoided if (sugary) soft drink consumption is reduced to zero. (See Supp. Material Table S12.)

Table 4: One-way sensitivity analysis

Sensitivity scenario	Scenario 1		Scenario 2		Scenario 3	
	HALYs gained	% base case	HALYs gained	% base case	HALYs gained	% base case
Base case	2,787		4,869		5,622	
No discounting	8,406	+202%	14,792	+204%	16,918	+201%
2% discounting	3,890	+40%	6,824	+40%	7,830	+39%
5% discounting	1,562	-44%	2,760	-43%	3,145	-44%
10 cents lower tax	1,484	-47%	3,862	-21%	4,810	-14%
10 cents higher tax	3,860	+38%	5,749	+18%	6,277	+12%
Tax pass-on 80%	2,299	-18%	4,134	-15%	4,819	-14%
Tax pass-on 120%	3,262	+17%	5,623	+15%	6,309	+12%
Average price from largest packs	4,695	+68%	7,519	+54%	8,175	+45%
No cross price elasticities applied	4,107	+47%	7,188	+48%	8,359	+49%
10% higher average price	2,561	-8%	4,540	-7%	5,285	-6%
Euromonitor sales data	9,459	+239%	16,355	+236%	18,909	+236%
Reformulation			6,423	+32%		
Reformulation + consumption change			8,334	+71%		
All soft drinks replaced with water	120,501	+4223%	121,889	+2403%	120,709	+2047%

Interpretation

Taxing soft drinks in Estonia would deliver health gains via reductions in the number of cases of type 2 diabetes, ischaemic heart disease and stroke. These health gains would materialize gradually over time. The greatest benefit in terms of obesity is seen in young adults and men. Depending on the characteristics of the tax, it could generate annual revenue in the order of 17 to 25 million Euros, which could be used to subsidize healthy foods or other health promotion interventions.

This study has several strengths. Firstly, an important part of the data used in the model are derived from Estonian source instead of other international source such as epidemiological data of diseases, sale data, soft drink, juice, and milk consumption. This supports the relevance of the study for the Estonian context. Secondly, various levels of health and economic outcome in this study, such as health-adjusted life years, monetized value of HALYs and tax revenue would be very helpful for policy-makers to make informed decisions. Thirdly, this study models examine four different scenarios of soft drink tax, which supports policy-makers in choosing a soft drink tax design that is optimal in terms of health and economic benefits.

This study has several limitations, in addition to the assumption that consumption patterns remain stable by age. Although the available international evidence consistently shows that higher prices are associated with lower levels of sales and consumption, predicting the response of Estonian consumers to changes in the price of soft drinks can be done with a limited degree of confidence. In the absence of information on the effect of past price changes in the Estonian context, we used price elasticity estimates from the international literature. For the uniform taxes in scenario 1, price elasticity estimates for the categories of drinks affected by the tax (soft drinks via own-price elasticities, juice and milk via cross-price elasticities). This was not the case for the more complex scenarios 2, 3 and 4, where ideally, a system of price elasticities would have been available that treats each of the different categories of soft drinks (with higher or lower content of sugar, with or without artificial sweetener). This would enable to model shifts from high-sugar, high tax varieties to lower-sugar, lower tax varieties. Here, we applied the price elasticity for SSBs and assume shifts are to other drinks only. More study, preferably using Estonian data, is needed to better characterize the response of consumers to price changes.

As older Estonians consume very little soft drinks, they are not much affected by a tax, while young consumers lose most weight and hence, gain most in health. In our model, consumption patterns are assumed stable by age, rather than cohort, which implies an expectation that the high-consuming generation now in their twenties will reduce their consumption drastically as they age. This has a large impact on the results since the risk of disease increases steeply with age. If, in reality, consumption patterns are stable by cohort, then the health impact of taxing soft drinks is likely to be much higher than our results suggest.

The comparatively high consumption of milk in Estonia mitigates the impact of soft drinks taxes (Figure 5, sensitivity analysis). In response to rises in the price of soft drinks, some consumers are expected to consume more juice and milk, which are also high in calories from sugar and fats, respectively. In this model, we assumed that this would be full-cream milk, which has an energy density that is higher than that of most sugared drinks. While this analysis cautiously took into account the resulting effect on body mass, the evidence suggests that milk consumption is not related to weight gain (66) and may protect against a range of chronic diseases (67) which reduced the impact of the taxes on soft drinks, it does not include any positive effect of the nutrients in milk (calcium, magnesium, vitamin B-12) and juice (vitamin C).

Another important limitation is that only three diseases were included in this analysis and although these are responsible for a large share of the obesity-related burden of disease, there are at least 16 other conditions that have convincingly been linked to obesity, including common conditions like low back pain, osteoarthritis, post-menopausal breast and colon cancer (42). This would suggest that the true health gains of a soft drink tax are likely to be substantially higher than the present results suggest.

This study did not examine the impact of the soft drink tax on different socioeconomic groups. Previous studies show that low-income groups tend to be more sensitive to price changes (68)(32)(69). This suggests that their health will benefit more than that of wealthier Estonians. Taxing soft drinks are likely to reduce socio-economic inequalities in health (70).

In our model, the consumption of soft drinks is related to a lower body mass at the same age, but does not influence the rate of weight gain over time. There are indications that soft drink consumption can contribute to a chronically positive energy balance, which can result in substantial weight gain over a lifetime (71).

Finally, if the industry responds to a tax by reformulating drinks to contain less sugar, or changes its marketing efforts from beverages high in sugar towards low-sugar alternatives, this could enhance the impact of a tax beyond what our analysis includes, as shown in the sensitivity analysis.

For these reasons, our estimates are very likely to underestimate the true impact that can be expected from taxing soft drinks.

Conclusion

Taxing a broad range of soft drinks can lead to substantial health benefits, as part of a broader package of interventions to reduce the burden attributable to excess sugar consumption and obesity. The tax would also raise revenue that could finance other elements of this health promotion package. Artificially sweetened beverages can be included in the soft drink tax as a matter of precaution.

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