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Alcohol taxation, alcohol consumption and cancers in Lithuania: A case study

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Abstract

Aims: The aim of this contribution was to estimate the impact of the last significant alcohol taxation increase in Lithuania in 2017 on alcohol consumption, incident cancer cases, and cancer mortality, as well as the number of cancer outcomes that could have potentially been averted in 2018 had larger increases in alcohol excise taxation been applied. **Design:** Statistical modelling was used to estimate the change in alcohol per capita consumption following the tax increase, and alcohol-attributable fraction methodology was then used to estimate the associated cancer incidence and mortality. Potential increases of current excise duties were modelled in two steps. First, beverage-specific price elasticities of demand were used to predict the associated decreases in

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consumption and cancer outcomes, and second, the outcomes arising from the actual numbers and the modelled numbers were compared. **Method:** Data were taken from the following sources: alcohol consumption data from Statistics Lithuania and the WHO, cancer data from the International Agency of Research on Cancer, and risk relations and elasticities of demand from published meta-analyses. **Results:** A total of 15,857 new cancer cases (8,031 in women and 7,826 in men) and 8,534 cancer deaths (3,757 in women and 4,777 in men) were recorded in Lithuania in 2018. Using the attributable fraction methodology, we estimate that 4.8% of 761 of these new cancer cases were attributable to alcohol use (284 in women; 477 in men), as well as 5.5% or 466 cancer deaths (115 in women; 351 in men). With the taxation increase of 2017, 45 new cases and 24 deaths will be averted over the next 10 years. Further taxation increases of 100% could double the number of new cancer cases averted or saved. **Conclusion:** In a high-consumption European country like Lithuania, alcohol use is an important and avoidable risk factor for cancer. Taxation is an important measure to reduce the alcohol-attributable cancer burden.

Keywords
alcohol, cancer, incidence, Lithuania, taxation

In 2020, the European Union (EU) issued a European plan to fight cancer (European Commission, 2020) which stressed prevention as one of its four pillars. This plan provided a perfect complement to the World Health Organization's (WHO) efforts to reduce premature deaths from major non-communicable diseases (NCDs) as a global public health priority (World Health Organization, 2013), as it explicitly defined goals to strengthen prevention efforts through the reduction of major risk factors. The WHO Regional Office for Europe adopted its action plan for NCDs in 2016 with prevention and health promotion as one of its four priority areas (World Health Organization Regional Office for Europe, 2016), tailored specifically to the needs and resources of the region.

Alcohol use is one of the major modifiable risk factors causing cancer (Rehm, Shield, & Weiderpass, 2020b, Shield et al., 2020). The association between alcohol and cancer has long been known (Lamy, 1910; Newsholme, 1903), and was confirmed at the International Agency for Research on Cancer monograph meetings and by other major international cancer reviews (International Agency for Research on Cancer, 2010, 2012; World Cancer Research Fund International, 2018), which not only took into consideration epidemiological studies on cancer in humans, but also incorporated evidence from animal experiments, and mechanistic and other data (International Agency for Research on Cancer, 2015). The following cancer types have been classified as causally impacted by alcohol with the highest level of evidence by the International Agency for Research on Cancer (International Agency for Research on Cancer, 2012): lip and oral cavity cancer (ICD-10 codes: C00-06), oropharyngeal cancers (C09, C10), oesophagus cancer (C15), colon and rectum cancers (C18–20), liver cancer (C22), larynx cancer (C32), and female breast cancer (C50). Evidence from major prospective studies, such as the European Prospective Investigation into Cancer and Nutrition (Bergmann et al., 2013), corroborated this classification, and recent results suggest that the above-mentioned list may be conservative.

In the WHO European Region (WHO EUR), the impact of alcohol use on cancer is

particularly high (Shield et al., 2020), which is not surprising given that it is the region with the highest level of drinking worldwide (Manthey et al., 2019; World Health Organization, 2018). To give an illustration: in a comprehensive study comparing the impacts of different modifiable risk factors on the incidence of cancer, alcohol use was found to be the second-leading cause of cancer in France after smoking (Soerjomataram et al., 2018). Consequently, the WHO Regional Office for Europe issued a factsheet specifically about alcohol use and the prevention of cancer for the region (World Health Organization Regional Office for Europe, 2020).

Lithuania is a Baltic country in the northeast corner of the EU, whose mean alcohol consumption in 2018 was 14.14 litres per year (95% CI: 11.02–18.23). This makes Lithuania one of countries with the highest levels of alcohol consumption in Europe, given that the mean consumption across the 28 European Union Countries for the same year was 11.32 litres per year (95% CI: 10.19–12.12) (Manthey et al., 2019). Lithuania, therefore, has a very high alcohol-attributable burden of disease (World Health Organization Regional Office for Europe, 2019b). However, this burden is expected to decrease due to the exemplary efforts made by Lithuania since 2017 to implement evidence-based alcohol control policies (Miščikienė et al., 2020; Rehm, Manthey et al., 2020; Rehm et al., 2021). For this reason, we selected Lithuania to demonstrate the potential for using increased alcohol taxation to reduce alcohol-attributable harm in a high-income country with a high alcohol-attributable disease burden.

The objectives of this contribution were to estimate the impact of the last significant alcohol tax increase in Lithuania in 2017 on alcohol consumption, incident cancer cases and cancer mortality, as well as the number of cancer outcomes that could have potentially been averted in 2018 if further increases in alcohol excise tax had been applied. Modelling the impact of taxation was chosen since taxation is one of the "best buys" recommended by the WHO to reduce alcohol-attributable harm (World Health Organization, 2017); "best buys" have not only been shown to be highly effective, but they are also highly cost-effective (Chisholm et al., 2018; Chisholm et al., 2004) and need relatively few resources to implement.

Materials and methods

Figure 1 gives an overview of the conceptual relations modelled.

In short, the impact of tax increases on alcohol was modelled as follows: the impact of the tax increase in 2017 on alcohol consumption was measured as the net decrease of adult per capita consumption after removing secular trends. In four scenarios, we modelled potential increases in alcohol taxation in Lithuania based on the level of current taxation and its impact on price, which then impacted on consumption via price elasticities (for a more detailed description of the mechanism, see Sornpaisarn et al., 2017; for a demonstration, see Rovira et al., 2020). The link between the level of consumption and alcohol-attributable harm was modelled via alcohol-attributable fractions from comparative risk analyses (see below; for risk relations, see Shield et al., 2020).

The year 2018 was used as the basis year for all potential taxation scenarios. As a first step, we needed estimates of alcohol-attributable cancer incidence and mortality in Lithuania for this year which we had estimated for the WHO European Region overview (World Health Organization Regional Office for Europe, 2020).

Building different taxation scenarios and estimating the impact of taxation on consumption

In this study, the following scenarios were modelled:

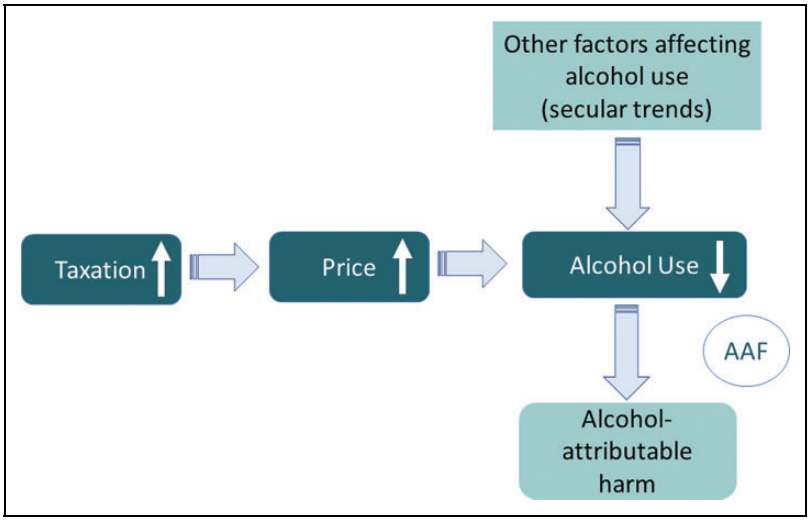

Figure 1. Conceptual relations modelled.

- the impact of the 2017 taxation increase (Miščikienė et al., 2020; Rehm et al., 2019);
- three different scenarios to determine the effects after excise taxes for each of the three main alcoholic beverage types are increased by 20%, 50%, and 100% (for similar analyses, see Chisholm et al., 2018; Rovira et al., 2020);
- a shift to the Finnish level of excise taxation, which is the highest in the EU (European Commission Directorate-General Taxation and Customs Union, 2020).

The increases in excise taxes in 2017 amounted to more than 100% for beer and wine, and 23% for spirits (for details, see Appendix Table A1 in the online supplementary material), increasing the retail price on average by 15.5% for local and imported beer, 20.7% for wines, and 7.6% for local and imported vodka (data were based on the two beer, two vodka and four wine subcategories in the Lithuanian official classification system; Lithuanian Department of Statistics, 2020b). These numbers were based on information on taxation policies in Lithuania separate by alcohol beverage type from the EU and Lithuanian government (European Commission Directorate-General Taxation and Customs Union, 2020; State Tax Inspectorate, 2020); the data on the mean price were obtained from the Statista webpage (Statista, 2020). An overview of all data and procedures can be found in the Appendix Table A2 online.

As mentioned, alcoholic beverages were mainly categorised into the three major groups: beer, wine, and spirits. In order to evaluate the mean proportion of the alcohol tax for each type of alcoholic beverage, the mean percentage of pure alcohol for each beverage was assumed to be 5%, 12.5%, and 40% for beer, wine and spirits, respectively (the same assumptions as those made in World Health Organization, 2018).

Since the adult alcohol per capita consumption decreased from 2011 to 2017 prior to the tax increase, this secular trend was taken into account in our modelling, i.e., the average decrease since the peak in consumption in 2011 (for the data and statistical model, see Appendix Table A3 in the online supplementary material). In other words, we defined the effect of taxation as the decrease over and above the secular trend.

For the other taxation scenarios, the impact on average level of consumption was modelled indirectly via price elasticity (Formula 1; see Sornpaisarn et al., 2017 for a definition), which is an economic measure of the change in the quantity demanded or purchased of a product in relation to its price change, which is mathematically described in Formula 1.

$$E = \frac{\Delta Q}{\Delta P} \qquad \text{(Formula 1)}$$

Where E = elasticity, Q = quantity of demanded or purchased; and P = price. This formula expresses the proportion of consumption change given a price change. Thus, a value of –0.6 indicates that for a proportional increase of price of 10%, consumption will decrease by 6%. We have obtained the values for price elasticity, which tend to vary based on beverage type, from previous meta-analyses (Fogarty, 2010; Ornstein & Levy, 1983).

Prior meta-analyses have shown that price elasticities tend to be similar (Fogarty, 2010; Sornpaisarn et al., 2013; Wagenaar et al., 2009). As indicated above, however, they appear to differ by preferred beverage type. The price elasticities assumed here are –1.2 (95% CI: –1.44, –0.96), –0.6 (95% CI –0.72, –0.48), and –0.36 (95% CI: –0.48, –0.24) from the least-preferred to the most-preferred beverage type, i.e., wine, beer, and spirits in Lithuania (for beverage preference in Lithuania, see Lithuanian Department of Statistics, 2020a, based on Fogarty, 2010; Ornstein & Levy, 1983). From economic theory, it is plausible that the most-preferred beverage is more inelastic than others; level of consumption should change to a lesser degree, evidenced by its values being closer to zero.

Price elasticity for regular heavier drinkers – including but not limited to people with alcohol use disorders (Rehm et al., 2013) – has also been shown to be lower (Wagenaar et al., 2009). Inability to reduce level of drinking is a defining characteristic of alcohol use disorders (Carvalho et al., 2019). For all heavy drinkers, defined here as men drinking > 60 g pure alcohol/day; and women > 40 g/day, based on WHO and European Medicines Agency categories (European Medicines Agency, 2010), we applied the same lower price elasticity irrespective of beverage, preference: –0.28 (95% CI: –0.37, –0.19; based on a meta-analysis by Wagenaar et al., 2009).

Producers were assumed to pass the cost of the tax increase directly on to the consumer by increasing their alcoholic beverage prices by exactly that amount (Nelson & Moran, 2019). The price change (ΔP) will therefore increase by Ti*0.2, Ti*0.5 and Ti*1, respectively, where Ti is the current tax rate.

To estimate the number of cancers that could have been averted in 2018 via an increase in excise duties on alcohol applied in 2017, we modelled the proportional change on exposure 10 years ago, assuming a lag time between exposure and cancer incidence of 10 years (Grundy et al., 2016). Alcohol exposure data were taken from Statistics Lithuania (Lithuanian Department of Statistics, 2020a) and from Manthey and colleagues (2019).

In order to distinguish the heavy drinkers from other drinkers, we have simulated the distribution of level of drinking in each country with the gamma distribution (Kehoe et al., 2012; Rehm et al., 2010). In simulating this distribution, we can determine the percentage of alcohol consumed by heavy drinkers. Based on the drinking distribution, the distribution of beverage preference, and price elasticities, the decrease in total adult alcohol per capita consumption (APC) following increases in excise duty can be calculated.

For non-heavy drinkers, the decrease in consumption can be calculated as shown in Formula 2.

$$APC - APC * \%B * \%Qb - APC * \%W * \%Qw - APC * \%S * \%Qs = APC(1 - \%B\,\%Qb - \%W\,\%Qw - \%S\,\%Qs) \qquad \text{(Formula 2)}$$

Where %B, %W and %S are the percentages of consumption of beer, wine, and spirits, respectively. The %Qb, %Qw and %Qs are the

changes in percentages for beer, wine, and spirits consumption due to the increase of prices, respectively. For heavy drinkers, the formula is less complicated since there are no differences in elasticities by beverage type (see Formula 3):

$$APC - APC * \%Qa = APC(1 - \%Qa) \quad \text{(Formula 3)}$$

Where %Qa is the difference in consumption for all drinks considering the price increase due to the tax increase.

The overall results of applying the price elasticities on indicators of consumption can be seen in the online supplementary material Appendix Table A2.

Deriving alcohol-attributable fractions and applying them to cancer incidence

To estimate the cancer outcomes due to alcohol consumption we evaluated the alcohol-attributable fractions. Alcohol-attributable fractions denote the proportion of cancers that are a consequence of drinking alcohol; in other words, these cancer cases and mortality would not appear in the absence of alcohol use. Formula 4 below gives details, where "abs" is the abbreviation for abstainers, "form" is for former drinkers, and "CD" is for current drinkers, P_i is the prevalence of each drinking status and RR_i is its risk function and differs for different cancer types.

$$AAF = \frac{P_{abs}RR_{abs} + P_{form}RR_{form} + \int_0^{150} P_{CD}(x)RR_{CD}(x)dx - 1}{P_{abs}RR_{abs} + P_{form}RR_{form}\,\mathrm{q} + \int_0^{150} P_{CD}(x)RR_{CD}(x)dx} \quad \text{(Formula 4)}$$

Based on the reduced alcohol use, we determined alcohol-attributable fractions for each cancer type and compared them to the alcohol-attributable fractions in the baseline scenario. These comparisons were separated by sex and age for all four different scenarios (taxation increases of 20%, 50%, 100%; assuming the taxation level in Finland), for all cancer types which are causally related to alcohol. The latter were based on the classification system devised by the International Agency for Research on Cancer, and included only the cancer types with sufficient evidence for having a causal impact of alcohol (International Agency for Research on Cancer, 2010, 2012); for a listing of cancer types, please see above). The risk functions used for the calculation of the alcohol-attributable fractions were extracted from the World Cancer Research Fund (WCRF) Continuous Update Project Expert Report (World Cancer Research Fund/American Institute for Cancer Research, 2018) and Shield et al. (2020) and the data for the total number of incident cancers came from the GLOBOCAN 2018 database in the Global Cancer Observatory (Ferlay et al., 2018).

Results

Alcohol and cancer and Lithuania

Overall, for the year 2018, we estimate 15,857 new cancer cases (8,031 in women and 7,826 in men; International Agency for Research on Cancer, 2020) and 8,534 cancer deaths (3,757 in women and 4,777 in men). Using the alcohol-attributable fraction methodology as described above, we estimate that 4.8% of these new cancer cases or a total number of 761 cases (284 in women; 477 in men), and 5.5% or 466 cancer deaths (115 in women; 351 in men) are attributable to alcohol. In other words, if there had been no alcohol consumption in the years prior to 2018 in Lithuania, none of these cancer cases

or cancer deaths would have occurred in 2018 (for the full interpretation, see Rehm et al., 2006). For the year 2018, Lithuania ranked as the third and eighth highest of the EU countries for alcohol-attributable cancer mortality and incidence, respectively (World Health Organization Regional Office for Europe, 2020).

The distribution of the new cancer cases by site can be seen in Figure 2 (see Appendix Figure A1 in the online supplementary material for alcohol-attributable deaths by site and sex).

Impact of the last taxation increase

The increases in excise taxation of 2017 were estimated to decrease the APC by 10.3% (see Appendix Table A3 online), resulting in 45 new cases being averted (6.0%; 95% CI: 5.6–6.4%), and of 24 deaths averted (5.1%; 95% CI: 4.7–5.7%). Note that these estimates assume immediate consequences, whereas for biological reasons the real effects can only be seen a decade later. In reality, we expect that cancer incidence and cancer mortality by the year 2027 will be respectively 6.0% and 5.0% lower than they would have been without the increase in excise taxation of 2017.

Impact of different taxation scenarios

The impacts of different increases in excise duties for alcohol are summarised in Table 1. These new cancer cases could be avoided by increases in current taxation (based on the 2018 cancer incidence as a conservative estimate for the number of cancer cases in 2028).

Discussion

Prevention of cancer has been identified as a major public health priority for Europe and alcohol use is a leading risk factor for various types of cancer (Rehm, Shield, & Weiderpass, 2020). As our results show, both the taxation increases in 2017 and the modelled alcohol taxation increases were associated with decreases in alcohol consumption, which translate into substantial decreases in cancer incidence and cancer mortality. For example, the increases in excise taxation of 2017 were estimated to decrease APC by 10.3%, resulting in 45 new cases being averted (6.0%; 95% CI: 5.6–6.4%), and of 24 deaths averted (5.1%; 95% CI: 4.7–5.7%) over the next 10 years. Similar effects could be achieved if current excise duties were increased by 100%.

Alcohol taxation increases are thus an effective and cost-effective policy option to reduce overall alcohol consumption and consequently the cancer burden (Babor et al., 2010). However, out of all available alcohol control measures, pricing policies, including alcohol taxation measures, are the least implemented measures in the EU (World Health Organization Regional Office for Europe, 2019a). Unlike the majority of EU Member States (see Estonia for another exception; Pärna, 2020), Lithuania introduced a number of effective alcohol control measures, including higher alcohol tax rates (Rehm et al., 2021). As a result, the overall level of consumption has decreased markedly, associated with decreases in alcohol-attributable mortality and increases in life expectancy (OECD/European Observatory on Health Systems and Policies, 2019; Štelemėkas et al., 2021; Stumbrys et al., 2020). This would suggest that such alcohol control policies should be much more widely implemented across Europe (Berdzuli et al., 2020).

Before we present conclusions, we would like to point out some potential limitations of our research. First, any statistical model is only as good as the underlying data and assumptions. The calculations presented depend on data retrieved from Statistics Lithuania, the International Agency for Research on Cancer, and on meta-analyses on the impact of taxation on consumption, as well as meta-analyses on the impact of alcohol on cancer. Overall, we believe the data have relatively small biases. However, there may be some impact of unrecorded consumption (Rehm et al., 2014) via cross-border shopping, as the Baltic countries

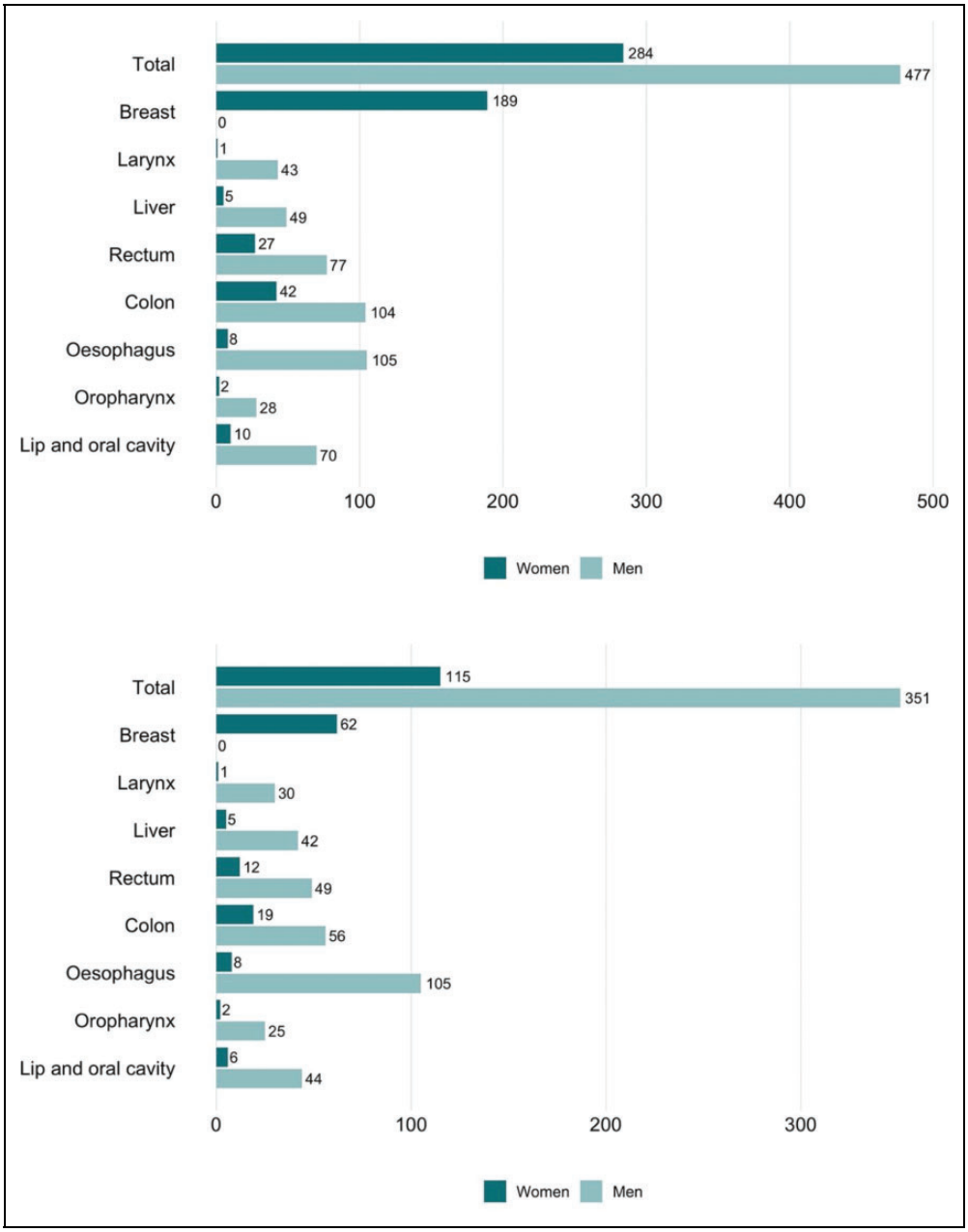

Figure 2. Alcohol-attributable new cancer cases (a) and mortality (b) in Lithuania 2018 by sex and site.
Sources: International Agency for Research on Cancer, 2020; World Health Organization Regional Office for Europe, 2020.

are small and price differentials are relatively large (Pärna, 2020). However, as a recent interrupted time-series analysis on all-cause mortality in Lithuania demonstrated, the increase in excise taxation in 2017 was associated with decreased all-cause mortality despite

Table 1. Potential impact of additional taxation increases on new cancer cases and cancer deaths in Lithuania (based on 2018 data).

Taxation increase scenarios	Number of new cancer cases prevented	% of all alcohol-attributable cancers prevented	Number of cancer deaths prevented	% of all alcohol-attributable cancers deaths prevented
Increasing current excise duties by 20%	8	1.09 (0.89–1.35)	4	0.92 (0.77–1.18)
Increasing current excise duties by 50%	21	2.76 (2.25–3.44)	11	2.34 (1.94–3.03)
Increasing current excise duties by 100%	43	5.66 (4.57–7.10)	22	4.82 (3.98–6.30)
Adopting the Finnish excise taxation (currently highest in European Union)	23	3.04 (2.34–3.76)	12	2.61 (1.95–3.23)

Note. 95% confidence intervals are presented in brackets.

potential increases in cross-border shopping (Štelemėkas et al., 2021).

The confidence intervals are usually larger for cancer incidence data than for cancer deaths, but both sets of data are relatively reliable as cancer is considered a life-threatening disease which requires the use of medical services and results in formal registration in Lithuania. The estimates of the meta-analyses of the effects of excise taxation on consumption seem to be conservative, given the estimated effect of the excise taxes of 2017. And since the meta-analyses of alcohol use and cancer converge between major meta-analyses (Bagnardi et al., 2015; GBD 2019 Risk Factors Collaborators, 2020), we do not expect a large bias to result from this factor. In sum, our estimates seem to be based on relatively reliable data.

Our analyses arrive at similar conclusions as recent work in other countries. Gredner et al. (2020) looked into the possibility of price-based policies on cancer incidence, and concluded that increases in the price of alcoholic beverages will result in substantial decreases in cancer incidence. Similarly, Rovira and colleagues modelled taxation increases in four countries in the WHO European Region, and found that taxation increases would result in decreases of cancer incidence and mortality, in line with the level of current taxation measured as a proportion of price (Rovira et al., 2020). Both studies used different statistical modelling techniques, as the usual interrupted time-series methodology to evaluate and predict changes in alcohol control policies cannot be applied due to the long and distributed time lags between intervention and cancer outcomes. For example, the Gorbachev Anti-Alcohol Campaign had strong effects on reducing consumption and mortality in all alcohol-attributable causes of death except for cancer (Leon et al., 1997).

Conclusion

Increasing the price of alcoholic beverages has been shown to be an effective measure to reduce the disease burden of cancer in Lithuania. Lithuania should continue with its current efforts to reduce alcohol use, and other countries should be encouraged to follow its example. As a final thought, it should be noted that reductions in alcohol consumption in Lithuania not only reduce cancer burden, but also lower mortality rates resulting from other disease and injury types, while also increasing overall life

expectancy (Rehm, Shield, & Weiderpass, 2020; Štelemėkas et al., 2021; Stumbrys et al., 2020).

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Supplemental material

Supplemental material for this article is available online.

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