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THE TOBACCO CONTROL POLICY: PREDICTIONS FOR LATVIA USING COST-BENEFIT ANALYSIS

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The Tobacco Control Policy: Predictions for Latvia using Cost-Benefit Analysis

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Ksenija Ivanova Marija Iriscenko

Date

07.04.2024

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Abstract

The problem of smoking e-cigarettes is relatively new; however, this matter requires exceptional attention not only due to overall serious underlying health risks but also because this phenomenon involves a substantial percentage of young people. The Ministry of Health of the Republic of Latvia aims to mitigate an enormously high consumption level of flavored e-cigarettes and heated tobacco products: the government is aiming to implement the policy of banning flavored vapes and tobacco products. This thesis will investigate the effect of the ban on the Latvian economy by creating a cost-benefit analysis that will aim to assess the efficiency of this policy in both social and economic terms. For the cost-benefit analysis for Latvia, experience of countries that have already implemented this policy (Canada, the Netherlands, Estonia, etc.) will be taken into consideration to derive assumptions relevant for the forecast. The study will evaluate the potential outcomes of the policy by estimating the costs and benefits associated with the reduction in e-cigarette smoking. The findings present the superiority of imposing the e-liquid flavor ban in terms of the Total Net Benefit, while the case of increasing the excise tax rate demonstrates the absolute gain in the government revenue, and the potential to provide more favorable conditions for consumers.

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Introduction

According to data from the study conducted by the Centre for Disease Prevention and Control (CDPC) *(Slimību profilakses un kontroles Centrs SPKC)* in 2019, the percentage of young people aged 13-15 who had ever tried smoking was 49.2%, 51.3% of them had tried smoking e-cigarettes (SPKC, 2019). These statistics signal a very young age of the smoking phenomenon. What is even more concerning, 50.3% of 13-15 years old youngsters admit that they became addicted to nicotine (SPKC, 2019). These numbers lead us to believe that investigating the impact of the policy implemented by the government may have significant outcomes.

In 2020, the government of Latvia submitted the draft law which implies the limitation of the circulation of flavored tobacco products, herbal smoking products, electronic smoking devices and their liquids (Saeima.lv, n.d.). The very first step towards the ban was the prohibition of any flavored heated tobacco products such as *HEETS* also branded as *HeatSticks* produced by Philip Morris and commercialized under the *IQOS* brand (Philip Morris International, n.d.) came into force on October 23, 2023 (LVportals.lv, 2023).

Many countries have investigated the effect of smoking and vaping regulatory policies by conducting cost-benefit analysis. One of the research projects that will be particularly frequently utilized as the basis for the methodology of this thesis will be the research done by the Maastricht University together with National Institute of Public Health and the Environment, Centre for Nutrition, Prevention, and Healthcare and Trimbos Institute (Netherlands Institute of Mental Health and Addiction). They conduct the "Social Cost-Benefit Analysis of Tobacco Control Policy in the Netherlands" (Kinderen et al., 2016). The focus of this study is on Consumer surplus, which implies the analysis of the effect on the Healthcare industry, excise tax, and government, and private consumption. Several scenarios are presented and then analyzed: "an increase of the excise tax, the introduction of a policy package defined by the *World Health Organization* (*WHO*) (consisting of smoking bans, quit smoking aids, mass media campaigns, advertisements bans - MPOWER), including an annual "x" % excise tax increase, a scenario in which the Netherlands is smoke-free in 35 years, and a scenario in which nobody starts smoking from 2017 onwards" (Kinderen et al., 2016).

In 2007, vapes first came to the U.S. market (Kenkel et al., 2020). As stated in the paper of Pesko et al. (2020), e-cigarettes or *vapes* are considered to be less harmful than cigarettes;

however, they still contain such toxicants that can be associated with causing lung injuries. This is a concern that Pesko et al. (2020) believe the researchers should pay more attention to. It used to be believed that the primary lung cancer (LCa) cause was smoking cigarettes. Now, as the popularity of vaping rises, some specialists assume (Bracken-Clarke et al., 2021) that it may also be a causing mechanism of lung cancer disease. Another phenomenon to analyze is heated-tobacco products such as *IQOS*. Its mechanism is to heat tobacco directly and deliver it straight to the consumer. Even though it is supposed to be a safer version in terms of causing LCa, no proof of a lower risk has been provided. In contrast, smoking *IQOS* shows a similar effect on the respiratory system as smoking regular cigarettes (Bracken-Clarke et al., 2021). This once again reflects the relevance of our research.

Following the clinical evidence above, our work aims to analyze the policy on tobacco and e-cigarette control that is about to be introduced in Latvia. To achieve our goal, we conduct a cost-benefit analysis that includes such areas of analysis as: estimating costs as the smoking-associated healthcare costs represented by the government expenditure on lung cancer treatment reimbursement; and benefits from positive health outcomes of smoking cessation, consumers utility, and government revenue derived from excise tax. Finally, we formulate our main research question as follows: ***What are the costs and benefits of tightening tobacco control policy in Latvia?***

We build three main scenarios to be analyzed:

Scenario 0: tobacco control policy is not implemented, and we expect no drastic changes in smoking habits. Both flavored tobacco and nicotine products are available on the market for sale.

Scenario 1: the government of Latvia implements the tobacco control policy on flavored tobacco products and e-cigarettes (incl. liquids).

Scenario 2: the government of Latvia puts a higher excise tax rate on tobacco products and products containing nicotine (incl. liquids) without banning the sale of flavored tobacco products and e-cigarettes.

Based on these scenarios, we formulate our hypothesis the following way: **We believe that Scenario 2 will have more significant impact on both governmental sector and private,** i.e this scenario would generate the biggest Net Benefit - government will face an increase in the revenue from excise tax, expenditures on reimbursement of LCa-related manipulations will be decreased, and the society will be better off since this scenario implies an increase in prices on tobacco and nicotine products but still gives the freedom of choice for consumers.

For our cost-benefit analysis to be successful, we requested the data from National Health Service on all government reimbursed manipulations on the C33 (Trahejas ļaundabīgs audzējs; *tracheal tumor)* and C34 (Bronhu un plaušu ļaundabīgs audzējs; *bronchi and lung tumor*) diagnoses. That allows us to see the total amount spent by the government and calculate potential expenditure or *costs* (in monetary terms) based on the assumptions described further in the main part of the work. Publicly available information on the budget of Latvia and its distribution will be used to estimate the *costs* (in monetary terms) that the government can potentially lose from decrease in the revenue from the excise tax on nicotine-containing products. To gain an expert view on this topic, we conducted semi-structured expert interviews with specialists in the healthcare field, namely, Healthcare Professional (further "HCP"), thoracic surgeon at the Riga East Clinical University Hospital, Centre of Tuberculosis and Lung Diseases. This step is helpful for our research as we get an expert opinion not only on how impactful on one's health smoking is but also the prediction of tobacco control policy's effectiveness based on the huge professional experience. We believe it gives a better explanation of the essence of the policy and problem itself.

2. Literature review

In this section we will synthesize the literary works that were most relevant for the establishment of our research.

Firstly, the existing published studies on the issue of the uncertain consequences of smoking e-cigarettes will be overviewed. It is vital to consider the divergent views of the experts regarding the conceivable outcomes of the consumption of e-cigarettes to base the presumptions about feasible health benefits implied with the proposed regulations.

Secondly, the current state of the existing international regulations on the control of the consumption of e-cigarettes and nicotine products will be addressed to contemplate what are the options to regulate the persisting "vaping epidemic".

Thirdly, the overall composition principles of the Cost-Benefit Analysis (CBA) will be scrutinized to recognize how to organize the evaluation of the proposed policy.

Finally, the methodological approaches and results of academic publications on the CBA of the smoking and vaping regulatory policies will be summarized.

2.1. Harm of Electronic Nicotine Delivery Systems and other Traditional Cigarettes Alternatives

The ongoing debate on the level of negative implications of vaping is present in society. While the negative effects of smoking traditional cigarettes are widely studied and are indisputable, the conclusions about the health damage evoked by e-cigarettes, e-liquids, and other electronic nicotine delivery systems (ENDS) products vary across the medical professionals and academic researchers. Some determine alternatives to conventional cigarettes as far less harmful to the human body and perceive them as effective tools for facilitating smoking cessation, while others are more concerned about the potential serious health ramifications.

King et al. (2020) deliberate the risks that the acquired prominence of the usage of e-cigarettes among the younger generation might possess by bringing to the attention two related epidemics: the recent outbreak of lung injuries and the continued soar in usage of ENDS by young people. Particularly the health issue that is addressed by the the Centers for Disease Control and Prevention is the spread of e-cigarette, or vaping, product use–associated lung injury (EVALI) – with 2602 cases reported and 57 deaths confirmed, with a median patient age of 24 years. The authors consider the crucial forces for the surge of the usage of the products among

young people include advertisement of the e-cigarettes, alluring diversity of offered flavors, and the availability of high-level nicotine devices that are easy to conceal. The adverse impact of the high nicotine levels consumed by young individuals includes affliction of the brain development that continues through 20s.

Viscusi (2016) in his article demonstrates the evidence that the multitude is prone to overemphasizing the risk levels of consuming e-cigarettes compared to the factual risk levels that are proven to exist. In his empirical study on the nationally representative survey in the United States, the author obtains the results that the sample's risk beliefs about the lung cancer mortality and total smoking mortality are lower about the implications of smoking e-cigarettes than those of traditional cigarettes. Nevertheless, according to the findings of Viscusi, perceptions of the magnitude of health-related riskiness of e-cigarettes are still excessively overestimated.

Even though a major part of the literature regards e-cigarettes as less harmful than the traditional tobacco cigarettes, the effects of the e-cigarettes are still not explored to the full extent. Bracken-Clarke et al. (2021) in their paper review current data and presently available literature on the issue of the relationship between e-cigarettes and lung cancer, which remains the most common cause of cancer mortality worldwide. The authors claim that despite the definitive data lacking, with the information that is attainable nowadays, an essential linkage between e-liquids and an elevated danger of getting diagnosed with Lung Cancer can be observed even though this association might not be apparent in the short-term considering the reviewed lag period between carcinogen exposure and invasive malignancy. Furthermore, findings show authors' apprehension about the evidence on the carcinogenic potential of heavy metals contained also in nicotine-free e-liquids. Another point that the authors make is that the accessible information demonstrates modest support for e-cigarettes' contribution to quitting smoking, while there is clear data that proves consuming e-cigarettes facilitates nicotine addiction. The authors do not find a transparent argument for vaped nicotine to be less harmful than that derived from the traditional tobacco services, that might be opposing to the view of, for example, British Healthcare Service, who state that considering vaping equally harmful or more harmful than smoking to be the inaccurate risk perception (2022).

2.2. Regulation of E-cigarettes

Fairchild, and Bayer (2015) convey the proposal that there are two approaches for regulating the e-cigarettes usage: (1) Harm reduction - staying open to the use of e-cigarettes aiming to limit the morbidity and mortality appertaining to smoking traditional cigarettes, and (2) Harm precaution – regulations directed towards the abatement of such a harmful habit like vaping being the preliminary goal.

Klein et al. (2020) formulate three categories of the international regulation of e-cigarettes: (1) Upholding consumer product standards by controlling standards of production, manufacturing and retail, with the primary goal of influencing public's beliefs about the product without initially intending to decrease sales volumes; (2) Restricting accessibility or appeal of e-cigarettes' consumption among young people and non-smokers; (3) Promoting e-cigarette intake as a tool for adults to cease smoking traditional tobacco products. The ban of flavored e-cigarettes according to this classification would fit in the second type of the regulation by reducing youths' and non-smokers' willingness to consume e-cigarettes. The authors underline that the World Health Organization endorses governments to efficiently mitigate possible negative impacts of ENDS by adopting discouraging measures such as introducing bans on the advertisement of the products, restricting available flavoring options, and forcing producers to create unappealing presentations of the products.

Kenkel et al. (2020) consider that the negative effects of vaping are overestimated, with their empirical model they demonstrate consumer optimization errors that lead to losing the opportunity to decrease number of conventional cigarettes smokers, and conclude that the current ban on e-cigarette flavors other than menthol would not entail significant changes on the consumer choices or welfare, while potential future state tax or subsidy policies could help to solve prevailing optimization errors to help consumers choosing e-cigarette products instead of combustible cigarettes.

Yang et al., (2020) sought to address a key challenge of regulating cigarette flavors effectively with the preliminary goal of minimizing public health losses associated with tobacco use initiation and fostering smoking cessation with the help of replacing it with vaping habit. The results achieved by the authors illustrate that with the ban of flavors entering into force

motivated e-cigarette users to replace it with other products and increasing overall smoking cessation rates. The authors also pointed to the concerning issues of some participants selected to purchase flavored products online, hoarding right before the ban, acquiring prohibited flavored products from outside the city, and making illegal purchases to proceed vaping even after the regulation was implemented. This study highlights the risks of driving the shadow economy activity that might be provoked by the ban.

Buckell et al. (2018) conducted a best discrete choice experiment based on a survey of current smokers and lately quitted ex-smokers, to reveal their priorities and demands for flavors and nicotine levels contained in traditional tobacco cigarettes and e-cigarettes, sensitivity to price changes of nicotine containing products, and importance of negative effects on health. The authors, who estimated logit choice models, arrived at the conclusion that in case of not limiting accessibility of menthol flavor in combustible cigarettes and imposing flavor ban on e-liquids, the preferences of the surveyed sample would lean towards the considerable growth of traditional cigarettes consumption and decrease in the e-cigarettes' consumption volumes. These conclusions go in line with another study of Pesko et al. (2020), who examined the outcomes of nicotine products' increased taxes on the consumption of combustible cigarettes and e-cigarettes in the U.S. Using a two-way fixed effects model, the authors determined that an increase in the price of e-cigarettes caused by the tax increase leads to the rise of demand on the traditional cigarettes, which possess caution in regulating e-cigarettes. Nevertheless, the case of banning non-tobacco flavors in e-cigarettes and traditional cigarettes would incite the opting-out option the most, while a large number of smokers would still prefer traditional cigarettes over e-cigarettes.

2.3. Cost-Benefit Analysis: Framework

Mishan, and Quah (2020) in their book provide an extensive overview of the nature of the Cost-Benefit Analysis (CBA). CBA is the orderly analytical approach that serves to answer whether the project or program or a set of them should be undertaken, assessing all the costs and benefits experienced by the individuals residing within the area of research. The CBA strives to give attention to the effects to the "economy as a whole" or "society as a whole" by discerning the excess social benefit over cost measure, also referred to as social net benefit that might be

recognized to be a potential Pareto improvement. In CBA the project in question that is analyzed would be acknowledged to be economic improvement in case when the enforcement of a project will produce social net benefits, where the positive sum of net valuations for each of the persons affected by the project will indicate a realization of the potential Pareto improvement, otherwise denoted as Kaldor-Hicks rule, that justifies reallocation decisions as long as they raise net social benefit that sometimes can happen at the expense of someone becoming worse off. Occasionally it might be vital for politicians to require additional political interventions such as exceeding a certain figure of benefit-cost ratio. Mishan & Quah define seven questions that the CBA conductors should answer to base their assessment: (1) While the reference target group must always be a society at large, which society is targeted by the regulation? (2) What are the benefits and costs, all the effects and impacts of a proposed project? (3) What are the measures of benefits and costs? (4) What should be the discount rate to account for the time value of monetary value of a proposed project? (5) Are there any equity considerations to adjust for different individuals' valuation of money? Is there a motivation for the use of weights when 1 EUR may not be the same for a rich and a poor person? (6) What is the approach for dealing with uncertainties? Are there adjustments necessary for the estimation of costs and benefits in the future? (7) What should be the investment decision criteria to use (Net Present Value, Internal Rate of Return, benefit-cost ratio, net terminal value)?

Guerriero (2020) provides the division of CBA into 3 types:

The first type that the author highlights is Financial CBA: that is an individual evaluation irrespective of the issue under analysis with the aim to achieve the maximization of profit and financial efficacy. The second type formulated by Guerriero is Economic CBA: this type represents public assessment that can differentiate depending on the topic investigated with the aim of reaching maximization of societal well-being and economic efficiency. The third kind is Societal CBA, which includes public assessment yet takes into account also financial efficiency of the subject analyzed and effects on the distribution of income. Societal CBA is the most inclusive yet the most sophisticated type of CBA. It is essential to recognize that the CBA analyst is not obliged to make decisions for the government but rather provide an independent evaluation of the project in focus, as there might be different holistic considerations beyond CBA.

Nas in his book (2016) recognizes four main stages in which the conduct of a Cost-benefit analysis might be divided into*:* (1) identification of relevant costs and benefits, (2) measurement of costs and benefits, (3) costs and benefits streams comparison that arise during the lifetime of a project, and (4) project selection. He argues that the main measure of welfare changes in the analysis that should be considered and thoroughly studied should be captured on a consumer surplus, which displays a person's maximum amount he is willing to pay. In these settings the consumer gain is indicated as paying below this determined maximum price, while loss is paying above this price. Any investment with the object of reducing the cost of a product or service, referred to as a cost-saving is perceived as a benefit provided for the community.

2.4. Cost-Benefit Analysis: Regulation of Smoking Products

There is a considerable amount of literature existing that studies the effects of implementing regulating policies directed at restricting smoking habitats of the society with the help of CBA framework. The authors looked at the CBA that was estimating the effects of different smoking and vaping cessation incentives.

Sung et al. (2018) looked at the economic impact of incentives to help smokers, provided with the health coverage from the Medicaid, United States federal and state program, in California by conducting the CBA implying the experimental design. In their case the CBA is confined to the costs and benefits of the program providers and the recipients of their services. The benefit of smoking prevention is future healthcare savings that arise when smoking population decreases and the costs are any expenses that incur when implementing the program. The major measures of the results of this analysis are net savings that are reflected in the difference between the incremental benefits and the incremental costs, and the ratio of incremental benefits over the incremental costs for different types of therapies.

MacMonegle et al. (2018) studied the cost-efficiency of media campaigns focused on smoking cessation. The key measures defined by the authors when implementing CBA to formulate the return on investment of public health expenditures by such measures as: costs incurred per quality-adjusted life year (QALY) saved, derived by approximating campaign costs; number of smokers averted between 2014 and 2016 because of the campaign; and the number of QALYs saved per prevented smoker. QALYs present a combination of number of Life Years

lost and quality-of-life losses measures coming from smoking-associated diseases. For LYs and QALYs saved predictions, and consequently the cost-savings per smoker estimation, the authors used the results formed in the previous research by Wang et al. (2001). For the calculation of the present value of the incurred expenses, the authors exploited the estimates from Sloan et al. (2006) and further discounted values to the average age of prevented smokers by a 3% discount rate. To update the monetary values to 2016 dollars the authors applied the Consumer Price Index (CPI) for healthcare costs and the CPI less medical care for remaining cost categories. The conclusions drawn from this CBA pointed to the effect of the mass media interventions aimed to negatively influence the tobacco usage to be cost savings of more than $31 billion.

The great part of the literature on the CBA of e-cigarettes regulation strategies regards it as an alternative to tobacco smoking that is arguably more harmful. Warner, and Mendez (2018) juxtapose the effects of vaping-induced initiation to the tobacco smoking cessation for the period from 2020 to 2070, concluding that in all the described simulations, life-years saving driven by additional vaping-induced smoking cessation exceeded life-years lost by vaping-induced smoking initiation. This means that benefits to the public's health from e-cigarettes' facilitation in quitting traditional smoking will exceed the possible costs of new smokers induced due to vaping.

The credible point that Kenkel et al. (2020) underline in their work is the importance of considering the relationship among the increased activity in the e-cigarette market, imposed restrictions on sale or advertising of nicotine products and the consumer welfare - which is different from other researchers who have conducted similar studies of evaluating the proposed regulations reviewing the implications on the public health only.

Kinderen et al., (2016) conducted a Social Cost Benefit Analysis of the effects of several smoking-related policies with a time horizon of 35 years and a discount rate of 3%. The authors reviewed the scenarios in which tax increase, mass media campaigns, quit smoking aids, and advertisements bans are introduced that are compared to the reference scenario that is the current situation. For the analysis of the potential policies net value, overview of debtor and creditor, plus the distributional effect are taken into account. For the measuring of healthcare costs (including smoking-related healthcare costs) and quality-adjusted life-years (QALYs) the authors

employ the Chronic Disease Model and the SimSmoke model, as well as the specially designed model in the Excel Software accounting for the societal costs, such as productivity losses.

The costs and benefits were presented by the authors in the form of the following measures: the monetary value of QALY health gains, healthcare expenditures that were reviewed in different divisions: those that directly relate to smoking (e.g. therapy expenses on respiratory diseases), as well as indirectly dependent on smoking healthcare costs (treatment of Alzheimer's disease, eye diseases, etc.); valuation of the consumer excess, and governmental tax revenue. Other less obvious but crucial factors that Kinderen et al. (2016) pointed out included environmental contamination and fire damage spendings, direct and indirect productivity losses and transfers associated with workers who smoke. The influence of the analyzed policies on the labor market and the review of the effects on the producer surplus were omitted entirely in their research. The exclusion of producer surplus is explained by the fact that no policy directly intervenes within the market. Their conclusion affirms that the effects of the addressed policies are positive for each scenario with respect to government income and decrease of smoking prevalence, while the effect on the consumer surplus is negative, resulting in a positive net benefit in both short-term and long-term.

3. Methodology

For the conduct of the CBA the implications of 3 scenarios will be observed. **Scenario 0** will be the reference point that will evaluate the forecasts for the situation when no smoking control policy is implemented, in **Scenario 1** predictions for the outcomes of when the government of Latvia implements the tobacco control policy on flavored e-cigarettes and e-liquids, and the **Scenario 2** will provide the review of the alternative scenario that the government of Latvia could implement that is setting higher excise tax rates on products containing nicotine.

According to the steps defined by Mishan, and Quah (2020) essential for creating the Cost-Benefit Analysis the commencement of the potential policy outcomes assessment should be addressing seven main components:

1. Defining the reference target group

In our case the reference target group is the population of Latvia. The policy will influence not only the e-cigarette smokers, but the net benefit (or loss) will be experienced by the whole population, the reference target group will be the population of Latvia.

2. Benefits and Costs: all effects of the proposed project

After the analysis of the existing literature on the related topics, we derived the following potential outcomes of regulating policy that should be considered.

We consider the potential **benefits** to be an increase in quality-adjusted life years saved per prevented smoker, consumer surplus gain associated with the consumption of nicotine products, government revenue derived from excise tax, and a negative effect on the contamination of the environment. From the abovementioned beneficial outcomes, it would be quite difficult to quantify the environmental effect, moreover in most CBA the environmental effect was ignored due to the interconnection of the e-cigarettes' consumption being still poorly quantifiable, so this benefit will be ignored in our analysis but provide the incentive for further analysis on the topic.

The **costs** of the policy that the policymakers should consider are the LCa manipulation reimbursement expenditures, rising activity in the shadow economy, the negative consequences on the e-cigarettes and e-liquids retailers exiting the market, and the dissatisfaction of the smokers. In our study only the LCa healthcare costs will be included in the analysis due to the data unavailability on the other potential costs; nevertheless, one should keep in mind that smoking causes additional health, societal, economical, and environmental issues.

In literature on the CBA of smoking regulatory policies the effect on the producer's surplus of traditional cigarettes and tobacco products was usually ignored due to the high, quite inelastic demand for the traditional cigarettes. The situation with unflavored e-cigarettes is different – it is not that obvious what would be the effect on the e-cigarettes and e-liquids retailers, whose operations depend heavily on the available flavors' diversity. In case the flavors are banned, there might be an uncertain effect on the retailing shops – part of them would probably close, but due to data unavailability on the turnover of these shops, these costs will not be studied in this analysis as well. Moreover, the dissatisfaction of the smokers that could be

potentially examined by the survey data, will not be accounted for in the analysis due to the high probability of the snowball effect in conducting the surveys, which will greatly reduce reliability of the obtained data.

3. Measurement of Benefits and Costs

All the selected costs and benefits will be measured in monetary values.

For the QALY measure 50 000 EUR per QALY saved will be used, which is in line with the approach of Kinderen et al. (2016), who motivated such a value by the Dutch manual for CBA recommendations, it also lies within a range of the values in the guidelines described by CORDIS (2019), and the threshold per QALY value estimated in the recent research of Koukao et al. (2023) published in the European Journal of Health economics. Decrease in reimbursement expenditures related to lung cancer diseases will be measured in the present value of euros saved if the percentage of lung cancer cases decreases due to fewer people consuming e-cigarettes. Projections of the decreased lung cancer treatment expenditures will be estimated after interviewing experts in the field. For the estimates of the e-cigarette smokers prevalence the available data on the distribution of Estonian e-cigarette smokers summarized by Reile, and Veideman (2021) before the introduced ban in 2020, as well as to create forecasts the percentage estimates from Yang et al. (2020), findings of Buckel et al. (2019), key findings of the Tholos Foundation survey (2020) on the outcomes for Estonia after the flavor ban was introduced will be taken into account with respect to smoking and vaping quitters, those returning to traditional cigarettes, those continuing vaping only available flavors, and those buying flavored e-cigarettes and e-liquids illegally.

As concerns measuring the costs, the decrease in the government revenue derived from Excise Tax will primarily rely on the government statistical data available. The costs of rising activity in the shadow economy have been also considered by investigating the existing research of the shadow economy in Latvia (Pluta et al., 2020; KPMG, 2023), though was not included in the calculation of the total Net Benefit due to the difficulty of monetizing the results.

4. Weights use to adjust for income inequality

There will be no weights used to adjust for income inequality.

5. Discount rate

The next step integral for conducting CBA is defining the time frame and the discount rate to take into consideration the present monetary value of the proposed project.

We chose to establish the forecast for the time horizon of 30 years. This time horizon is set based on the previous CBA work conducted in the similar field (Ekpu, & Brown, 2015; Kinderen et al., 2016), as well as on the academic opinions regarding the choice of time horizon for the CBA (Rowell, 2014; Kim et al., 2017)

Taking into account recommendations about the fixed rate to be chosen for the analysis outlined in guidelines by Millenium Challenge Corporation (2021), suggested social discount rate in Canadian Cost-Benefit Analysis Guide for Regulatory Proposals (Government of Canada, n.d), by European Commission (2014, 2022a) as well as based on the previous practice in CBA executed for the related policies (Chen et al., 2011; Ekpu, & Brown, 2015; Connolly et al., 2018) the discount rate of 4% was chosen.

6. Dealing with uncertainties

Due to the limitations of data access, and ambiguity surrounding the effects of the topic, it is crucial to realize that our forecasts depend on the proposed assumptions. To increase the credibility of the projections, our assumptions are based either on those described in the existing literature, or derived from the statistics, or depend on the standard for creating CBA, or will be discussed with the field experts.

7. Investment decision criteria

The project investment decision criteria estimated in the work will be the total Net Benefit (Net Present Value of the introduced project).

After the formulation of the initial description of the Cost-Benefit Analysis, with the general characteristics of its constituents, it becomes clear that we will provide Economic Cost Benefit Analysis due to the primary objective to maximize the social well-being following criteria of economic efficiency.

3.1. Data

To begin with, we would like to explain the reasoning behind choosing to focus on LCa-related statistics. Firstly, it is a well-known fact that smoking is the biggest risk and a main reason for LCa- on average more than 70% of cases are closely linked to smoking worldwide (NHS, n.d.). And when tobacco smoking is an obvious risk factor, not so much attention is paid to e-cigarette or vape smoking. However, there has been some research that explains that even though e-cigarettes are considered to be less harmful than regular tobacco products, the composition of those products raises concerns. As Bein & Leikauf (2011) state, e-cigarettes contain a very dangerous toxic aldehyde called *acrolein*. This component is proven to be as hazardous to our lung health as regular tobacco. That is why we collected the database from the National Health Service of Latvia called "*Ambulatorā veselības aprūpē diagnozēm C33 un C34 gadījumu skaits un vidējās izmaksas. Periods 2022.gads*" (*Number of cases and average costs for diagnoses C33 and C34 in ambulatory and inpatient health care. Period 2022*" containing information on number of cases and average costs by types of manipulations (in the stage of active treatment). In addition, comes demographic data, namely, information is divided into 5-year age sub-groups as of year 2022. Year 2022 is the latest possible year of available data before any policies have been introduced, that is why 2022 was chosen for further analysis. This year perfectly reflects the latest trends in society, people's habits and preferences. As well as this, by choosing 2022, we include and analyze the latest statistics in the healthcare field. In total, the database contains 4624 unique values on 20 specific age groups and one with an undefined age group. Manipulations include such therapies as: Computed tomography (CT), Radiography, Chemotherapy, Hematology, Surgical interventions, and others. The average cost per each manipulation is indicated in a separate column of the database *("*Gadījumu skaits. 2022.gads*" Number of cases. Year 2022)*. As the data shows, the total amount of therapies served in 2022 is 30 310 and total average expenditures account for 2 159 933 EUR. This was calculated by multiplying the average cost of each manipulation type by the number of such therapies.

The next step in collecting relevant data for our analysis was to conduct semi-structured expert interviews with the main HCP in the specialty of pulmonology-member of Latvian and European Thoracic surgeon association, Dr. Maris Apsvalks. Main questions that were asked: 1) What does the situation of lung cancer diagnosed people look like in Latvia at the moment?, 2) What is the approximate lung and bronchus cancer reimbursement rate in Latvia?, 3) What is the

professional opinion on how to fight the tobacco and nicotine addiction in society?, 4) Taking into account the uncertainty about the harm of e-cigarettes, what is the professional view on the impact of smoking e-cigarettes on lung health? Moreover, to accord with a conversation, some field-related questions were asked in order to prove the statistical data, e.g. government reimbursement rate on LCa, % of population diagnosed with C33 or C34, the main causes for this type of cancer among patients etc.

Additional data used in our paper is primarily collected from publicly available sources. Valsts Ieņēmumu Dienests (VID), *State Revenue Service*, provides comprehensive report on excise tax regulations, process and tariffs as of 2021. It helps calculate potential government revenue or loss from policies depending on the scenario chosen. Slimību profilakses un kontroles centrs (SPKC), *Centre of Disease Prevention and Control*, presents statistical data on the smoking part of population gathered from research made in 2019. News portals that publish statistical data and the results of public experiments that were arranged by organizations including *KPMG* and *neatkarīgs pētījumu centrs SKDS (Independent Research Center)* on availability of illegally sold tobacco and nicotine products. Publicly available report created by *Stockholm School of Economics in Riga* in cooperation with *BICEPS (Baltic International Centre of Economic Policy Studies)* and *ISM University of Management and Economics* on excise tax policy in the Baltic countries is an extremely valuable source of information to be used for a thorough investigation of policies' effectiveness (Pluta et al., 2020). Finally, statistical evidence on smoking-related topics is retrieved from the World Health Organization's electronic database.

4. Analysis of Results

First of all, to better understand the essence of the topic, we met with one of the leading surgeons of the Centre of Tuberculosis and Lung Diseases in Riga - Dr. Maris Apsavlks. Due to the time constraint, we only asked the questions that, in our opinion, are directly related to our research topic, as well as serving as advice on the methods used later in calculations.

Dr. Apsvalks explained in simple words that lung cancer is the most common cancer type among all diagnoses. From that we can assume that healthcare expenditures related to cancer treatment for lung cancer are one of the highest among all cancer types. Lung cancer occurs when the soft tissue of lungs is damaged. One of the most popular reasons for damage is smoking. The carcinogens that (e)cigarettes consist of are weakening the immune system and create the ionizing radiation that destroys the cells.

We asked Dr. Apsvalks about the statistics, namely, what is the percentage of smokers out of all patients diagnosed with lung cancer, and the number is terrifying - at least 90% of diagnosed people are smokers. Since we are mostly interested in e-cigarette presence, we asked about the prevalence of people smoking e-cigarettes, however, the physician highlighted that there is not much research done, especially in Latvia, that would provide any specific numbers. We presented our estimate for calculating the e-cigarette smoking rate - in 2019 the prevalence of e-cigarette smokers was approximately 3% out of all the population of Latvia. Answering the question if that assumption might be applicable, HCP justified that due to lack of data, this estimate can be used. The physician also pointed out the fact that lung cancer is becoming *younger*, meaning that the average age of lung cancer is not 60-70 years anymore. This must be taken into account when evaluating the necessity of tobacco control policy - with an increasing presence of electronic cigarettes on the market, people will start smoking at a younger age and therefore, increase the number of lung cancer cases.

Secondly, we define the costs and benefits used in our analysis for calculating the net benefit of each policy. We will see that the main focus of our study is on the number of Quality Adjusted Life Years (QALY) per population of e-cigarette smokers in monetary terms 50,000 EUR/QALY (will be explained later), Consumer Surplus, smoking related healthcare costs, and government revenue. The following formula represents the Net Benefits:

Net Benefit= Benefits - Costs

of each respective policy we analyze. In our study, the **cost** category includes smoking-related **healthcare costs**/expenditure. **Benefit** category incorporates: **Consumer Surplus** that we consider as the "range of opportunities" the smokers have (e.g. what they are willing to consume vs. what they are able/allowed to consume), **number of QALYs** per e-cigarette smoking population since it depends on the health condition which, in turn, is negatively affected by smoking, **government revenue** that reflects the revenue from excise tax on tobacco products. *Table 1* provides an explanation for each classification.

Assumption	Explanation
Benefits:	
1. Total monetary value of QALYs	Represents the positive health outcome of smoking quitting
2. Consumer Surplus	Tobacco control policies imply the limitations of consumers opportunities, namely, consumers utility and contentment
3. Government revenue from excise tax	We investigate the effectiveness of the policies by evaluating both societal and governmental sides; revenue from taxes is a primary source of income for the government of Latvia; we believe that the benefits from earned income offset the costs associated with consumers paying the taxes
4. Producer surplus	Financial wealth gained from the sale of e-cigarettes. Is not included in the analysis since the data on financial performance is not available.
Costs:	
1. Smoking-associated healthcare costs	Directly caused by smoking
2. Other smoking-related costs: smoking-related diseases, shadow economy, environmental contamination	Not included in the analysis

Table 1 created by the authors. Classification of the costs and benefits.

4.1 Reference Scenario 0: no tobacco control policy

4.1.1 Smoking prevalence

According to *Slimību profilakses un Kontroles Centrs* (*Centre for Disease Prevention and Control, n.d.)* statistical database, in 2022, 29.3% of the population aged 15-74 were daily smokers. From 2016 to 2018, smoking rate decreased by 8.6%, from 2018-2020 it decreased by 1.8%, and for 2020-2022 it increased again by 6.7%. For predicting future smoking rate prevalence, we calculate the average of existing change in the smoking rates and apply it for the years from 2025 to 2050 (*Table 2*), assuming that the trend of decrease in smoking rate continues even if the tobacco control policy does not take place.

		Daily smoking prevalence (%)	
Year	**Sex**	**Age: 15-74**	**Change, %**
2016	both	33.0	
2018	both	24.4	-8.6
2020	both	22.6	-1.8
2022	both	29.3	6.7
2025	both	27.5	-0.6
2030	both	24.5	-1.2
2040	both	18.5	-1.2
2050	both	12.5	-1.2
		Average change in %	**-1.2**

Table 2 created by the authors using data from the Health statistics database (2023).

Unluckily, the research and statistical evidence on e-cigarette smoking prevalence in Latvia is limited. Therefore, we use the data from Organization for Economic Cooperation and Development (OECD, 2019) for the year 2019 only. It states that 3% of the whole population aged 15 and above smoke e-cigarettes. We assume that this rate remains at least the same (if not increases). First, we calculate the number of people that smoke e-cigarettes out of the whole population. Then, we calculate the number of people who generally smoke out of the whole population of Latvia.

Finally, we calculate the prevalence of e-cigarettes smokers out of the total smoking population of Latvia. Calculated numbers are reflected in *Table 3*: this rate will be used in the

further calculation of total expenditures related to e-cigarettes smokers.

Year	Annual population predicted by WHO	E-cigarette smokers out of all population (3%)	Total smokers out of all population (%)	Total number of smokers out of all population	Prevalence of smoking e-cigarettes from total number of smokers (%)
2022	1,848,834	55,465	29.3	541,708	10.2%
2025	1,790,805	53,724	27.5	492,471	10.9%
2030	1,701,345	51,040	24.5	416,830	12.2%
2040	1,554,135	46,624	18.5	287,515	16.2%
2050	1,433,740	43,012	12.5	179,218	24.0%

Table 3 created by the authors using data from the WHO (2021) and data from OECD (2019). Prevalence of e-cigarette smokers in the total smoking population of Latvia.

4.1.2 Lung cancer prevalence in Latvia

Here, we used the predictions made by International Agency for Research on Cancer by World Health Organization (WHO) for the change in number of patients diagnosed with C34 and combined it with the dataset from Health Statistics Database of Latvia on the number of patients diagnosed with C34 (lung cancer) for the year 2021. We then calculated the estimated number of patients for future years. WHO estimates 0% change for 2022, 3.8% increase for 2025, 5.5% increase for 2030, 6.2% increase for 2040, and 4.7% increase for 2050. This is reflected in *Table 4*.

Year	Diagnosis	Total number	Change predicted by WHO, %
2021	**C34 (Bronchi and lungs)**	2398	-
2022	**C34 (Bronchi and lungs)**	2398	0
2025	**C34 (Bronchi and lungs)**	2489	3.8
2030	**C34 (Bronchi and lungs)**	2530	5.5
2040	**C34 (Bronchi and lungs)**	2547	6.2
2050	**C34 (Bronchi and lungs)**	2511	4.7

Table 4 created by the authors using data from the Health Statistics Database (2023) and International Agency for Research on Cancer by the WHO (2021). Estimated number of patients diagnosed with C34 using the prediction of the WHO.

Table 5 reflects the prevalence of C34 diagnosis (lung cancer) in the population of Latvia in the recent years as well as the predicted prevalence rate over the next years:

Year	Diagnosis	Total number of patients	Annual population predicted by WHO	Prevalence, %
2021	**C34 (Bronchi and lungs)**	2398		
2022	**C34 (Bronchi and lungs)**	2398	1,848,834	0.13%
2025	**C34 (Bronchi and lungs)**	2489	1,790,805	0.14%
2030	**C34 (Bronchi and lungs)**	2530	1,701,345	0.15%
2040	**C34 (Bronchi and lungs)**	2547	1,554,135	0.16%
2050	**C34 (Bronchi and lungs)**	2511	1,433,740	0.18%

Table 5 created by the authors using data from the Health Statistics Database (2023) and International Agency for Research on Cancer by the WHO (2021). Prevalence of C34 diagnosis in the population of Latvia as a percentage rate.

4.1.3 Healthcare costs associated with smoking

To calculate healthcare costs associated with smoking we are using the data of the National Health Service of Latvia as of 2022 where we have taken total average C34 diagnosis (lung cancer) related costs (see *Table 6*).

Age group	Sum of Total Expenditures for 2022, EUR
16-20	277
21-25	16
25-30	2,181
31-35	3,397
36-40	13,865
41-45	20,908
46-50	37,538
51-55	160,602
56-60	271,837
61-65	430,220
66-70	499,679
71-75	403,815
76-80	203,986
81-85	88,258
86-90	7,295
91-95	2,606
96-100	4,300
Grand Total	**2,150,779**

Table 6 created by the authors using data from the National Health Service (2023). Sum of total expenditures on C34 related diagnosis by age group.

To calculate the average expenditures per patient in 2022, we divided the total average healthcare expenditures of C34 diagnosis as of 2022 provided by the National Health Service of Latvia by the number of patients: 2,150,779 EUR: 2398 = 896.91 EUR/patient on average.

Finally, having all necessary measures, we predicted total healthcare costs for C34 diagnosis by multiplying average expenditures per patient by the estimated number of patients for respective years and discounted at the discount rate (see *Table 7*).

Year	Diagnosis	Total number	Change predicted by WHO, %	Total costs per year	Discounted Total costs per year, EUR
2021	C34 (Bronchi and lungs)	2398	-	-	-
2022	C34 (Bronchi and lungs)	2398	0	2,150,779	2,150,779
2025	C34 (Bronchi and lungs)	2489	3.8	2,232,744	1,984,901
2030	C34 (Bronchi and lungs)	2530	5.5	2,269,311	1,658,164
2040	C34 (Bronchi and lungs)	2547	6.2	2,284,368	1,127,628
2050	C34 (Bronchi and lungs)	2511	4.7	2,252,103	751,026

Table 7 created by the authors using data from the National Health Service (2023). Discounted total costs per year associated with smoking.

To estimate the total expenditures related to e-cigarettes smoking, as mentioned before, we assume that costs are close to be split proportionally to the prevalence of smoking in general. Total healthcare costs related to e-cigarettes are as follows (see *Table 8*).

Year	Discounted Total costs per year, EUR	Prevalence of e-cigarette smoking, %	Discounted Total costs associated with e-cigarette smoking
2021	-	-	-
2022	2,150,779	10.2%	219,379.5
2025	1,984,901	10.9%	216,354.3
2030	1,658,164	12.2%	202,296.0
2040	1,127,628	16.2%	182,675.8
2050	751,026	24.0%	180,246.2

Table 8 created by the authors using data from the National Health Service (2023), Health Statistics Database (2023), and International Agency for Research on Cancer by the WHO (2021). Discounted Total costs associated with e-cigarette smoking.

4.1.4 Other smoking associated costs/diseases

This section covers the theoretical part since no numerical data for other diseases associated with smoking is used in our work. What must be taken into account when calculating

losses for the healthcare sector is the list of diseases that may occur due to regular smoking. As suggested in Lopez et al. (2022), e-cigarettes smoking affects our health in 4 major categories: pulmonary, neurological, cardiovascular, and oral/dental pathologies. Even though the research on e-cigarettes' impact on respiratory health is limited, it is clear that smoking is considered to be a cause of lung injuries (mainly cancer) and asthma, as well as worsening the existing symptoms of respiratory diseases. The link between e-cigarette usage and neurological disorders has been drawn. The experiment covering 123 users of e-cigarettes reported such new symptoms as tremors, seizures and syncopes. Cardiovascular diseases such as myocardial infarctions and strokes, are also one of the most frequent causes of smoking-related deaths. The data showed that about 20% of heart disease deaths were caused by smoking. Last but not least, e-cigarette components like benzene and nicotine have a very negative impact on the tongue, soft tissues and lips (Lopez et al., 2022). Approximate estimates of costs expressed in monetary values of respective disorders can be calculated by having data on healthcare expenditures on respective diseases.

4.1.5 Consumer Surplus

Consumer Surplus is a measure expressed in monetary terms that evaluates the maximum gain obtained from a product by an individual (Nas, 2016). This can also be defined as a difference between what the consumer is willing to pay for the product and the actual price for that.

Consumer Surplus for consumption is a hypothetical estimate based on our assumptions and methods used in the Dutch work of Kinderen et al. (2016). We primarily rely on statistical data from scientific papers. First, we calculate the consumer surplus for consumption of e-cigarettes. To do so, we take the price elasticity of disposable e-cigarettes which is believed to be -0.37, when price increases by 1% (Tingting, 2020). From that follows that by increasing the price of a disposable e-cigarette by 10%, we decrease the sales/consumption by 3.7%. To calculate the average price of a disposable e-cigarette, we looked at the prices of one of the most popular e-cigarette manufacturers *Salt Switch* (https://www.salt-switch.com/shop/) where prices deviate from 6.00 to 8.00 EUR. Based on that, we assume the average price of an e-cigarette is 7.00 EUR. Now, we can estimate the price at which everyone stops consuming disposable e-cigarettes based on a linear correlation. For a 50% price increase, which results in the price of

10.50 EUR per e-cigarette, 18.5% of the population stops buying e-cigarettes. For the whole population to quit smoking, the price must increase from 7.00 EUR to 25.92 EUR. The maximum consumer surplus here results in 18.92 EUR (price increase of 270.27%) with a mean of 9.46 EUR per e-cigarette. Weimer et al. (2009) suggests that "*...only between 60 and 70% of the consumer surplus in the cigarette market should be counted as actual value for consumers*" (p.182). Following this statement, we take a 70% correction factor and calculate the Consumer Surplus as 0.70*9.46=**6.62 EUR** per disposable e-cigarette.

On average, one disposable e-cigarette on Latvian market consists of 600 puffs, and we assume that an average person smokes 1 disposable e-cigarette per day. From that, having the total number of e-cigarette smokers in Latvia as of 2022 (541,708 people). The total consumer surplus in 2022 of the e-cigarette smoking population in this scenario can be calculated as follows:

6.62 EUR* 541,708= 3,586,109 EUR. Discounted Total Consumer Surplus per smoking population in EUR for future years are presented in *Table 9*.

Year	Total number of smokers out of all population	Maximum consumer surplus per disposable e-cigarette, EUR	Total consumer surplus per population, EUR	Discounted Total consumer surplus per population, EUR
2022	541,708	6.62	3,586,109	3,586,109
2025	492,471	6.62	3,260,161	2,898,271
2030	416,830	6.62	2,759,411	2,016,275
2040	287,515	6.62	1,903,349	939,547
2050	179,218	6.62	1,186,420	395,644

Table 9 created by the authors using data from the WHO (2021) and data from OECD (2019). Discounted total Consumer Surplus per smoking population.

4.1.6 Quality Adjusted Life Years (QALYs) assessment

For this part of assessment, we reference the paper of Jia, and Lubetkin (2016), where authors study the population with an average age of 73.7 years. We believe that our population fits the criteria, since the biggest expenditures in 2022 were associated with the age group of 66-70 years. Authors divide population into categories: smoking status, number of cigarettes per day, etc. The first two are the most important for our calculations. To understand how we can categorize a person who smokes on average 1 disposable e-cigarette per day, we refer to the

Guardian (June 23, 2023) where it is believed that one 20mg/ml e-cigarette equals 1-2 packs containing 20 cigarettes each.

Table 2 in the paper of Jia, and Lubetkin (2016) mentions QALYs of 16.1 for people who never smoke and 6.6 QALYs for people smoking more than 20 cigarettes per day. Another thing to consider is the value of 1 QALY. As described in the methodology part of our work, we use EUR 50,000 per 1 QALY. We estimate the total number of QALYs in the e-cigarette smoking population in the respective year by multiplying 6.6 QALYs by the number of people. *Table 10* summarizes the total number of QALYs for 2022 and future years:

Year	E-cigarette smokers out of all population (3%)	Total e-cigarette smoking population QALYs	Total monetary value of population QALYs (50,000 EUR)	Discounted Total monetary value of population QALYs (50,000 EUR)
2022	55,465	366,069	18,303,456,600	18,303,456,600
2025	53,724	354,579	17,728,969,500	15,760,989,328
2030	51,040	336,866	16,843,315,500	12,307,245,656
2040	46,624	307,719	15,385,936,500	7,594,930,924
2050	43,012	283,881	14,194,026,000	4,733,387,898

Table 10 created by the authors using data from Jia, and Lubetkin (2016), and the WHO (2021). Discounted Total monetary value of population QALYs (50,000 EUR value)

4.1.7 Government

According to Eurostat (2024), governmental revenue from taxes in 2022 was 11,958.4 million Euros. Valsts Ieņēmumu Dienests (*the State Revenue Service*) reported the revenue of 1,131 million Euros from all excise taxes in 2022 and revenue from tobacco excise taxes accounted for 23% of all excise tax revenues, which equals 260.13 thousand Euros. In a similar manner as described in the Dutch work, despite the decrease in the smoking rate in Latvia, government revenues from taxes were increasing. This happens due to an increasing excise tax rate even in the **Reference Scenario 0**.

The government tax revenue for the future years is estimated via the predictions of the change in the prevalence of e-cigarette smokers in Latvia in the future. We acknowledge the limitations associated with the fact that the revenue from tobacco excise tax includes also regular cigarettes, however, we assume that this is the closest estimate given the (un)availability of data.

Since we estimate that the prevalence of e-cigarette smokers in the total population of smokers will continue growing with no tobacco control policy implemented, government revenues from excise tax on tobacco products are expected to grow proportionally (see *Table 11*).

Year	Prevalence of smoking e-cigarettes from total number of smokers (%)	Prevalence increase/decrease, %	Government revenue from excise tax on tobacco products, EUR	Discounted revenue from excise tax on tobacco products, EUR
2022	10.2%	-	260,130	260,130
2025	10.9%	0.7%	261,951	232,873
2030	12.2%	1.3%	265,356	193,893
2040	16.2%	4.0%	275,971	136,227
2050	24.0%	7.8%	297,496	99,208

Table 11 created by the authors using data from Eurostat (2024), and the Latvian State Revenue Service (2022). Discounted revenue from excise tax on tobacco products in EUR.

4.1.8 Producer Surplus

In our case, the Producer Surplus could have been estimated through market prices on e-cigarettes and sales volume. However, we do not have access to data on sales volumes of e-cigarettes in Latvia. This is the reason why we exclude Producer Surplus from our Social Cost-Benefit Analysis.

4.1.9 Summary overview

Table 12 provides an overview of all calculated costs and benefits of **Scenario 0** in monetary values. Those are divided into 4 main categories: consumer-related benefits; the healthcare sector costs; taxes collected by the government. The Total Net Benefit in the year 2050 equals **EUR 4,733,702,504**.

Year	2022	2025	2030	2040	2050
Value of total QALYs (50,000 EUR)	18,303,456,600	15,760,989,328	12,307,245,656	7,594,930,924	4,733,387,898
Value of consumer surplus	3,586,109	2,898,271	2,016,275	939,547	395,644
E-cigarette smoking related healthcare costs	219,379	216,354	202,296	182,676	180,246
Government revenue	260,130	232,873	193,893	136,227	99,208

Table 12 created by the authors. Costs and benefits of Scenario 0 in monetary terms per year in EUR

4.2 Scenario 1: the government of Latvia implements the smoking control policy on e-cigarettes and e-liquids

At the moment of writing this thesis there is no final decision from the Latvian Government on adopting the restriction on the sale of flavored e-cigarettes, and e-liquids, while the restriction on the sale of flavored heated tobacco products has come into force as of October 2023. The restriction imposed on the heated tobacco products does not completely prohibit the flavoring added in heated tobacco but limits the addition of additives to the extent when they do not create the characteristic aroma of products with the reference on the European Commission delegated directive for the EU (European Commission, 29 June 2022).

Taking into consideration the recommendations of the WHO (2020, p.2) claiming that: "Flavors should be banned to reduce the appeal of e-cigarettes to children and adolescents", and that the Latvia's neighboring Baltic countries, Lithuania and Estonia have already adopted the ban on flavored ENDS (Lithuania prohibits any e-liquids other than tobacco flavored from July, (Lithuanian Parliament, 2022) ; Estonia prohibits any e-liquids other than tobacco or menthol flavored from May, 2020 (Estonian Parliament, 2023)) it would become valuable to consider the scenario in which Latvian Parliament decides to implement the similar regulation. In this scenario we would predict the costs and benefits of prohibiting all e-liquid flavors except the tobacco flavored ones.

4.2.1 Smoking prevalence

In the research conducted by Buckel et al. (2019) the effect of flavor ban in cigarettes and e-cigarettes on the consumption of those was examined in the best-discrete choice experiment for a sample of 2031 regular smokers. The authors state their findings to have sizable policy implications for smoking products' flavor bans in the US. The results Buckel et al. obtain for the case of banning all e-liquid flavors except for tobacco flavor would be as follows:

- 2.7% increase in the use of combustible cigarettes
- 7.9% decrease in the use of e-cigarettes
- 5.2% increase of combustible cigarettes and e-cigarettes quitters

This study provides the most recent predictions of the smoker's preferences changes and will be utilized in deriving calculations for the vaping prevalence for Latvia in the absence of predictive research existing for Latvia or Europe.

Adjusting the values previously used in the reference scenario we estimate that:

- For 2025 the proportion of smokers would be by 5.2% less than in the Reference Scenario due to the initial effect on the smoking quitters, after that we assume that the proportion of smoking quitters will return to the historical yearly decline of 3% per year.
- The number of e-cigarette smokers in case of flavor ban would decline yearly by 7.9%.

Year	Annual population predicted by WHO	E-cigarette smokers out of all population, 3%	E-cigarette smokers in case of flavour ban	Total number of smokers out of all population, %	Total number of smokers out of all population	Prevalence of e-cigarettes smokers out of all smoking population, %
2022	1,848,834	55,465	55,465	29.3	541,708	**10.2%**
2025	1,790,805	53,724	51,083	22.3	399,350	**12.8%**
2030	1,701,345	51,040	47,048	19.3	328,360	**14.3%**
2040	1,554,135	46,624	39,908	13.3	206,700	**19.3%**
2050	1,433,740	43,012	33,851	7.3	104,663	**32.3%**

Table 13 created by the authors using data from the WHO (2021), and Buckel et al. (2019). Prevalence of e-cigarette smokers in the total smoking population of Latvia in case of e-cigarette flavor ban.

4.2.2 Lung cancer prevalence in Latvia

According to Cataldo et al. (2010) smoking cessation has an apparent association with more effective treatment and better prognosis for the survival rates at an early stage, moreover, Cadham et al. in their recent study assert that smoking cessation also decreases new lung cancer cases. Considering that around 90% of lung cancer cases risks are explained by smoking worldwide (American Lung Association, 2024) we calculate the decrease in the number of new lung cancer cases compared to the **Reference Scenario** numbers predicted by the WHO. Even though smoking cessation in real life will have the eventual accumulative effect on the prevention of lung cancer, for rough estimates we would assume that changes will be noticeable already in 2 years after the regulation takes place.

Year	Diagnosis	Total no of patients	From those non-smokers	From those smokers	From those smokers if flavored ban imposed	Total no of patients if e-cigarette flavor ban is imposed	Annual population predicted by WHO	Prevalence
2022	C34 (Bronchi and lungs)	2398	240	2158	2158	2398	1,848,834	0.13%
2025	C34 (Bronchi and lungs)	2489	249	2240	1817	2066	1,790,805	0.12%
2030	C34 (Bronchi and lungs)	2530	253	2277	1794	2047	1,701,345	0.12%
2040	C34 (Bronchi and lungs)	2547	255	2292	1648	1902	1,554,135	0.12%
2050	C34 (Bronchi and lungs)	2511	251	2260	1320	1571	1,433,740	0.11%

Table 14 created by the authors using data from Health Statistics Database (2023), and the WHO (2021). Estimated number of patients diagnosed with C34 using the prediction of WHO adjusting for smoking quitters.

Table 14 reflects the prevalence of C34 diagnosis (lung cancer) in the population of Latvia in the recent years as well as the predicted prevalence rate over the next years:
For the calculation of number of smokers after flavor ban is imposed the following steps were undertaken:

(1) After estimating smoking prevalence in section 4.2.1. the percentage decrease compared to the reference scenario smoking prevalence has been calculated according to the formula: **delta Total smokers $_{1,t}$ = (Total Smokers $_{1,t}$ - Total Smokers $_{0,t}$)/Total Smokers $_{0,t}$**

- where **Total Smokers $_{1,t}$** is the number of the smokers out of all population at a given year for scenario 1: implementation of flavor ban on e-cigarettes and **Total Smokers $_{0,t}$** is the number of smokers in case of scenario 0: reference scenario

(2) Taking an estimate of 90% of lung cancer patients being smokers (without clarification combustible cigarette or electronic cigarette smokers) we estimate the number of patients who are smokers in case of scenario 0, and then adjust numbers as: **Patients Smokers $_{1,t}$ = Patients Smokers $_{0,t}$*(1-delta Total Smokers $_{1,t}$)**

(3) Total number of Patients if e-cigarette flavor ban is imposed is then calculated as the Number of Non-Smoking Patients plus the Smoking patients after the ban on flavors is imposed **=10%*Total no Patients $_{0,t}$+Patients Smokers $_{1,t}$**

4.2.3 Healthcare costs associated with ban of flavored e-liquids

To estimate the total healthcare expenditures, we have recalculated the average government expenditure per patient with lung cancer in 2022 that is 896.91 EUR/patient by the total predicted number of patients with lung cancer in case of scenario 1 and discounting the total expenditures at the 4% discount rate.

For the total expenditures related to e-cigarettes smoking calculation, we assume that costs are close to be split proportionally to the prevalence of smoking in general. Total healthcare costs related to e-cigarettes are as follows:

Year	Diagnosis	Total no of patients if e-cigarette flavor ban is imposed	Total costs per year, EUR	Discounted Total costs per year, EUR
2022	C34 (Bronchi and lungs)	2398	2,150,790	2,150,790
2025	C34 (Bronchi and lungs)	2066	1,852,586	1,646,942
2030	C34 (Bronchi and lungs)	2047	1,835,642	1,341,286
2040	C34 (Bronchi and lungs)	1902	1,706,314	842,284
2050	C34 (Bronchi and lungs)	1571	1,408,774	469,795

Table 15 created by the authors using data from the National Health Service (2023), and Health Statistics Database (2023). Discounted total costs for bronchus & lungs cancer treatment per year in case of scenario 1

Year	Diagnosis	Discounted Total costs per year, EUR	Prevalence of e-cigarette smoking, %	Discounted Total costs associated with e-cigarette smoking, EUR
2022	C34 (Bronchi and lungs)	2,150,790	10.2%	220,217.4
2025	C34 (Bronchi and lungs)	1,646,942	12.8%	210,670.6
2030	C34 (Bronchi and lungs)	1,341,286	14.3%	192,180.8
2040	C34 (Bronchi and lungs)	842,284	19.3%	162,620.8
2050	C34 (Bronchi and lungs)	469,795	32.3%	151,946.8

Table 16 created by the authors using data from the National Health Service (2023), and Health Statistics Database (2023). Discounted Total costs of bronchi and lung cancer treatment per year in case of scenario 1 associated with e-cigarette smoking.

4.2.4 Other smoking associated costs/diseases

This costs and benefits channel is not included in calculations for **Scenario 1** consequences.

4.2.5 Consumer surplus

As in this scenario we assume no changes in the price on the e-cigarettes, we take the same average price of a disposable cigarette as in the **Scenario 0** and the Consumer Surplus per disposable e-cigarette remains the same - 6.62 EUR/e-cigarette, the changes in consumer surplus will appear due to the decrease in the total number of e-cigarette smokers. See *Table 17* for the

discounted Total consumer surplus per smoking population in EUR for future years.

Year	E-cigarette smokers in case of flavor ban	Max consumer surplus per disposable e-cigarette, EUR	Total consumer surplus	Discounted Total consumer surplus
2022	55,465	6.62	367,178	367,178
2025	51,083	6.62	338,171	300,633
2030	47,048	6.62	311,456	227,578
2040	39,908	6.62	264,190	130,411
2050	33,851	6.62	224,096	74,731

Table 17 created by the authors using data from using data from the WHO (2021) and data from OECD (2019). Discounted Total consumer surplus per smoking population for scenario 1.

4.2.6 Quality Adjusted Life Years (QALYs) assessment

For the QALY assessment in **Scenario 1** we will still rely on the results described by Jia & Lubetkin (2016) but in this case it is essential to attribute the QALY gained due to the ban of flavored e-liquids. The effect on QALY will then consist of the increased number of people who do not smoke and the remaining e-cigarette users. For the calculation of QALYs we take 16.1 QALY for the number of people who never smoke - in this case those who quit smoking, while for the number that continue smoking e-cigarettes QALY taken is 6.6.

Year	Number of e-cigarette smokers in case of flavor ban	No of smoking quitters	QALYs smoking quitters	Total monetary value QALYs smoking quitters	Discounted total monetary value QALYs smoking quitters	QALYs e-cigarette users	Total monetary value QALYs e-cigarette users	Discounted total monetary value QALYs e-cigarette users
2022	55,465	2,641	42,518	2,125,897,597	2,125,897,597	366,069	18,303,456,600	18,303,456,600
2025	51,083	2,641	42,518	2,125,897,597	1,889,915,223	337,150	16,857,483,529	14,986,241,473
2030	47,048	3,993	64,282	3,214,080,006	2,348,496,778	310,515	15,525,742,330	11,344,507,846
2040	39,908	6,716	108,132	5,406,588,081	2,668,843,916	263,391	13,169,571,200	6,500,870,686
2050	33,851	9,161	147,488	7,374,423,890	2,459,204,231	223,419	11,170,970,244	3,725,266,909

Table 18 created by the authors using data from Jia, and Lubetkin (2016), and the WHO (2021). Discounted Total monetary value of population QALYs (50,000 EUR) for Scenario 1.

4.2.7 Government

We estimate the change of the government revenue in case of flavor e-liquid ban to be driven by the decrease in the total number of smokers after the flavor ban comes into force. The government revenue from excise tax is then the following (see *Table 19*):

Year	Decrease in number of total smokers in case of flavor ban, %	Government revenue from excise tax on smoking products, EUR	Discounted revenue from excise tax on smoking products, EUR
2022	-	260,130	260,130
2025	18.9%	210,942	187,526
2030	21.2%	166,170	121,419
2040	28.1%	119,463	58,970
2050	41.6%	69,766	23,266

Table 19 created by the authors using data from Eurostat (2024), and the Latvian State Revenue Service (2022). Discounted revenue from excise tax on tobacco products in EUR for Scenario 1.

4.2.8 Producer Surplus

The Producer Surplus could have been estimated through market prices on e-cigarettes and sales volume. However, we do not have access to data on sales volumes of e-cigarettes in Latvia. This is the reason why we exclude Producer Surplus from our Social Cost-Benefit Analysis.

4.2.9 Summary overview

Table 20 provides an overview of all calculated costs and benefits of Scenario 1 in monetary values. Those are divided into 4 main categories: benefits corresponding to consumers; healthcare sector related costs; the taxes collected from the government.

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	2,125,897,597	1,889,915,223	2,348,496,778	2,668,843,916	2,459,204,231
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,986,241,473	11,344,507,846	6,500,870,686	3,725,266,909
Value of consumer surplus	367,178	300,633	227,578	130,411	74,731
E-cigarette smoking related healthcare costs	220,217	210,671	192,181	162,621	151,947
Government revenue	260,130	187,526	121,419	58,970	23,266

Table 20 created by the authors. Costs and benefits of Scenario 1 in monetary discounted terms per year in EUR.

The Total Net Benefit of Scenario 1 equals **6,184,417,189 EUR.**

4.2.10 Sensitivity analysis

When conducting cost-benefit analysis, it is crucial to include the sensitivity analysis to see how the output changes when we change one of the inputs. By looking at the output, we might understand which scenario is the most sensitive and therefore, which input is affecting the Total Net Benefit the most.

First, we test the LCa prevalence by changing the year when the ban of flavored e-cigarettes has an effect on it. Tables C.1, C.2, and C.3 (see Appendix C) show the Total Net Benefit if the LCa prevalence decreases in the year 2030, year 2040, and year 2050 respectively.

We see that Total Net Benefit decreases by EUR 372,265 if the LCa prevalence starts to decrease only in 2030, and as a result, LCa associated healthcare costs decrease. The same happens in 2040, decreasing the Total Net Benefit by EUR 435,540; and by EUR 471,205 if the effect only starts in 2050 compared to the initial Total Net Benefit in section 4.2.9.

4.3 Scenario 2: the government of Latvia puts a higher excise tax rate on products containing nicotine (incl. liquids) without banning the sale of flavored tobacco products and e-cigarettes

The yearly increase of the excise duty on the alcohol and smoking products has been an actively incorporated measure of the tobacco, nicotine, and alcohol consumption in Latvia.

According to the Saema's decision made on December 21st, 2023, the numbers on the increase of the excise duty on the traditional cigarettes, cigars, cigarillos, heated tobacco

products, ENDS products, e-liquids, and the ingredients used in vaping liquids were for the horizon of the next 3 years. The yearly excise duty rates in euros per 1 ml of liquid used in ENDS, or per 1 ml of the ingredients used in vaping liquids stated by the Latvian State Revenue Services (VID, 2024) will reach the 0.35 EUR per 1 ml of liquid (see Appendix A). The yearly increase for the next 3 years is around 21%.

With the provided numbers on the excise tax rates for 2022-2026 we can see that the average yearly excise tax increase was approximately 24%, we would use this estimate for the prediction of excise tax for the period till 2030, thus by 2030 the excise tax duty fee per 1 ml of e-liquid would be 0.83 EUR. With the above-mentioned excise duty fees numbers, we then estimate the price per disposable e-cigarette containing 2 ml of e-liquid (see Appendix B).

The average yearly price increase we observe from our estimations for the period 2023-2028 is 6.98%. Given that the yearly price increases of 7% all along the horizon of 30 years might result in overestimation of the effect, the price increase attributable to the excise tax rate increase then would be estimated by us to be the average of 7% over every 5 years starting from 2030. With such an estimate the yearly e-cigarette demand then would be associated with a similar decrease in the number of smoking quitters.

4.3.1 Smoking prevalence

Diaz et al. (2023) in their empirical study estimated the effect of the price and tax increases of the e-cigarettes on the young consumer's demand patterns using data for 2015-2019. According to their results a 10% increase in the standardized tax rate per 1 ml of e-liquid has led to the decrease of monthly e-cigarette sales demand in the range from 9.17% to 11.55%. Stoklosa et al. (2016) have investigated the linkage between the price and demand of e-cigarette in the EU scope, their data was for the period of 2011-2014 and included data for Latvian market, their results proposed that 10% increase in e-cigarette price was associated with 11.5% drop in e-cigarette sales.

Given that the Diaz et al. (2023) research provides the most recent insights, and that the study by Stoklosa (2016) has the representative sample data with the results being quite

comparable, we would use the 11.5% drop of e-cigarette sales associated with the 10% price increase for the following calculations.

The number of e-cigarette smokers (see *Table 21*) in case of excise tax increase would then be approximately 8% less than in the **Reference Scenario**.

Year	Annual population predicted by WHO	E-cigarette smokers out of all population (3%)	E-cigarette smokers in case of excise tax increase	Number of smoking quitters	Total number of smokers out of all population	Total number of smokers in case of e-cigarette excise tax increase	Prevalence of smoking e-cigarettes from total number of smokers (%)
2022	1,848,834	55,465	55,465	3,927	541,708	537,781	**10.3%**
2025	1,790,805	53,724	49,797	3,927	492,471	488,544	**10.2%**
2030	1,701,345	51,040	45,654	5,387	416,830	411,443	**11.1%**
2035	1,622,120	48,664	44,756	3,908	348,756	344,848	**13.0%**
2040	1,554,135	46,624	42,880	3,744	287,515	283,771	**15.1%**
2045	1,492,564	44,777	41,181	3,596	231,347	227,752	**18.1%**
2050	1,433,740	43,012	39,558	3,454	179,218	175,764	**22.5%**

Table 21 created by the authors using data from the WHO (2021), and Diaz et al. (2023). Prevalence of e-cigarette smokers in the total smoking population of Latvia in case of excise tax increase on e-cigarettes.

4.3.2 Lung Cancer Prevalence in Latvia

Table 22 represents the predicted prevalence of lung cancer diagnosis in the population of Latvia till 2050, the calculation is similar to that described in **section 4.2.2.**

Year	Diagnosis	Total no of patients	From those non-smokers	From those smokers	From those smokers in case of excise tax increase	Total no of patients if e-cigarette tax increase	Annual population predicted by WHO	Prevalence
2022	C34 (Bronchi & Lungs)	2398	240	2158	2158	2398	1,848,834	0.13%
2025	C34 (Bronchi & Lungs)	2489	249	2240	2222	2471	1,790,805	0.14%
2030	C34 (Bronchi & Lungs)	2530	253	2277	2247	2500	1,701,345	0.15%
2040	C34 (Bronchi & Lungs)	2547	255	2292	2262	2517	1,554,135	0.16%
2050	C34 (Bronchi & Lungs)	2511	251	2260	2216	2467	1,433,740	0.17%

Table 22 created by the authors using data from Health Statistics Database (2023), and the WHO (2021). Estimated number of patients diagnosed with C34 using the prediction of WHO adjusting for smoking quitters in case of e-liquids excise tax increase.

It is possible to observe that the prevalence of smokers has increased compared to **Scenario 1** and is almost the same as in the **Reference Scenario**.

4.3.3 Healthcare costs associated with increased excise tax on e-liquids

The description of the calculation process for the healthcare costs associated with the smoking quitters is described in detail in **section 4.2.3**. The total expenditures related to e-cigarette smokers when the excise tax is increasing are presented in *Table 23* and *Table 24.*

Year	Diagnosis	Total number of patients if e-cigarette tax increases	Discounted Total Costs per year, EUR
2022	C34 (Bronchi & Lungs)	2398	2,150,790
2025	C34 (Bronchi & Lungs)	2471	1,970,459
2030	C34 (Bronchi & Lungs)	2500	1,638,714
2035	C34 (Bronchi & Lungs)	2521	1,357,961
2040	C34 (Bronchi & Lungs)	2517	1,114,301
2045	C34 (Bronchi & Lungs)	2509	912,912
2050	C34 (Bronchi & Lungs)	2467	737,925

Table 23 created by the authors using data from the National Health Service (2023), and Health Statistics Database (2023). Discounted total costs for bronchus & lung cancer treatment per year in case of scenario 2.

Year	Discounted Total Costs per year, EUR	Prevalence of e-cigarette smoking, %	Discounted Total Costs associated with e-cigarette smoking, EUR
2022	2,150,790	10.3%	221,825
2025	1,970,459	10.2%	200,848
2030	1,638,714	11.1%	181,832
2035	1,357,961	13.0%	176,242
2040	1,114,301	15.1%	168,380
2045	912,912	18.1%	165,070
2050	737,925	22.5%	166,081

Table 24 created by the authors using data from the National Health Service (2023), and Health Statistics Database (2023). Discounted Total costs of bronchus & lung cancer treatment per year in case of Scenario 2 associated with e-cigarette smoking.

4.3.4 Other smoking associated costs/diseases

This costs and benefits channel is not included in calculations for **Scenario 2** consequences.

4.3.5 Consumer Surplus

Given the restrictions on the nicotine concentration in electronic cigarettes and volume of reservoirs and capsules imposed in the *Report from the Commission to the European Parliament and the Council* on the potential risks to public health associated with the use of refillable electronic cigarettes: "Nicotine concentration in electronic cigarettes in liquid must not exceed 20 mg/ml (Article 20 (3)(b)), and reservoirs and capsules should not exceed 2 ml volume, refill vials should not exceed 10 ml volume (Article 20 (3)(g), Article 20 (4)(a, b))" (European Commission, 2016), for the calculations we will apply the standard of 2 ml e-liquids contained in one disposable e-cigarette. Similarly to **Scenario 0**, the one disposable cigarette will be equivalent to 1-2 packs of 20 cigarettes each (Guardian, 2023).

The maximum consumer surplus of 6.62 EUR per e-cigarette has been described in **section 4.1.5** - the consumer is still willing to pay 6.62 EUR per e-cigarette. *Table 25* presents the estimated Total Consumer Surplus for the smoking population.

Max Consumer Surplus per disposable e-cigarette, EUR	Discounted Total Consumer Surplus
6.62	367,178
6.62	293,064
6.62	220,835
6.62	177,940
6.62	140,124
6.62	110,609
6.62	87,330

Table 25 created by the authors using data from using data from the WHO (2021) and data from OECD (2019). Discounted Total consumer surplus per smoking population for Scenario 2.

4.3.6 Quality Adjusted Life Years (QALYs) assessment

The methodology behind the calculation process of QALYs has been described in detail in **sections 4.1.6**, and **4.2.6**. The total monetary value of QALYs calculated for **Scenario 2** are reflected in *Table 26*.

Year	E-cigarette smokers in case of excise tax increase	No of smoking quitters	QALYs smoking quitters	Discounted total monetary value QALYs smoking quitters	QALYs e-cigarette users	Discounted total monetary value QALYs e-cigarette users
2022	55,465	3,927	63,224	3,161,176,048	366,069	18,303,456,600
2025	49,797	3,927	63,224	2,810,273,996	328,662	14,608,951,541
2030	45,654	5,387	86,725	3,168,469,023	301,314	11,008,370,156
2035	44,756	3,908	62,915	1,889,247,199	295,389	8,870,138,035
2040	42,880	3,744	60,278	1,487,742,784	283,009	6,985,048,789
2045	41,181	3,596	57,890	1,174,371,160	271,796	5,513,748,704
2050	39,558	3,454	55,608	927,205,759	261,085	4,353,291,127

Table 26 created by the authors using data from Jia, and Lubetkin (2016), and the WHO (2021). Discounted Total monetary value of population QALYs (50,000 EUR value) for Scenario 2

4.3.7 Government

The government revenue changes associated with the excise tax increase is driven both by the reduction of the excise taxpayers, e-cigarette smokers, and by the excise duty increase, the estimates for which have been described in the beginning of **section 4.3**.

Year	Decrease in number of total smokers, %	Increase in excise tax, %	Discounted revenue from excise tax, EUR
2022			260,130
2025	1%	81%	415,807
2030	1%	185%	962,571
2035	1%	-13%	678,749
2040	1%	30%	716,688
2045	2%	30%	754,816
2050	2%	30%	791,960

Table 27 created by the authors using data from the Latvian State Revenue Service (2022). Discounted revenue from excise tax on tobacco products in EUR for Scenario 2.

There is a noticeable rise in government revenue compared to both previously examined scenarios.

4.3.8 Producer Surplus

The Producer Surplus could have been estimated through market prices on e-cigarettes and sales volume. However, we do not have access to data on sales volumes of e-cigarettes in Latvia. This is the reason why we exclude Producer Surplus from our Social Cost-Benefit Analysis.

4.3.9 Summary overview

The overview of the estimated costs and benefits in discounted monetary values of Scenario 2 is presented in *Table 28*.

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	3,161,176,048	2,810,273,996	3,168,469,023	1,487,742,784	927,205,759
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,608,951,541	11,008,370,156	6,985,048,789	4,353,291,127
Value of consumer surplus	367,178	293,064	220,835	140,124	87,330
E-cigarette smoking related healthcare costs	221,825	200,848	181,832	168,380	166,081
Government revenue	260,130	415,807	962,571	716,688	791,960

Table 28 created by the authors. Costs and benefits of Scenario 2 in monetary discounted terms per year in EUR

The Total Net Benefit of **Scenario 2** equals 5,281,210,094 EUR.

4.4.0 Sensitivity Analysis

We conduct the sensitivity analysis for Scenario 2 the way we did with Scenario 1, keeping the alternative inputs the same. Assuming that the effect of flavor e-cigarette ban on LCa prevalence starts in the year 2030, we see that Total Net Benefit decreases by EUR 567, by EUR 1,227 if the effect starts in the year 2040, and by EUR 1,719 if the effect starts in the year 2050 (see Appendix D tables D.1, D.2, and D.3).

5.Sensitivity Analysis testing alternative discount rates

We conduct sensitivity analysis for all three Scenarios by testing the effect of alternative discount rates (3% and 5% vs. 4%) on the Total Net Benefit.

Scenario 0: Total Net Benefit in the initial analysis was EUR 4,733,702,504. *Table 29* presents the Total Net Benefit applying the discount rate of 3% instead of initially used 4%.

Year	2022	2025	2030	2040	2050
Value of total QALYs (50,000 EUR)	18,303,456,600	16,224,518,567	13,296,268,792	9,037,616,133	6,203,878,798
Value of consumer surplus	3,586,109	2,983,509	2,178,305	1,118,017	518,557
E-cigarette smoking related healthcare costs	219,379	222,717	218,553	217,376	236,242
Government revenue	260,130	239,722	209,475	162,104	130,029
					6,204,291,142

Table 29 created by the authors. Costs and benefits of Scenario 0 in monetary discounted terms per year in EUR using 3% discount rate.

By using a lower discount rate, we observe a significant increase in Total Net Benefit by EUR 1,470,588,638.

Table 30 presents the Total Net Benefit by applying a 5% discount rate, which is higher than our initial discount rate of 4% used in all calculations.

Year	2022	2025	2030	2040	2050
Value of total QALYs (50,000 EUR)	18,303,456,600	15,293,164,829	11,400,218,917	6,393,174,410	3,620,805,718
Value of consumer surplus	3,586,109	2,812,243	1,867,678	790,881	302,648
E-cigarette smoking related healthcare costs	219,379	209,932	187,387	153,771	137,879
Government revenue	260,130	225,961	179,604	114,671	75,889
					3,621,046,376

Table 30 created by the authors. Costs and benefits of Scenario 0 in monetary discounted terms per year in EUR using 5% discount rate.

According to our calculations, by applying a discount rate of 5%, we arrive at the Total Net Benefit of EUR 3,621,046,376 which is by EUR 1,112,656,128 lower than our initial one.

Scenario 1: we follow the same steps of applying alternative discount rates to data in order to see the effect on Scenario 1. *Table 31* presents the summary overview with an applied 3% discount rate.

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	2,125,897,597	1,945,497,454	2,537,224,437	3,175,800,685	3,223,189,250
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	15,426,985,449	12,256,164,365	7,735,735,107	4,882,571,404
Value of consumer surplus	367,178	309,475	245,866	155,184	97,947
E-cigarette smoking related healthcare costs	220,217	216,866	207,625	193,511	199,151
Government revenue	260,130	193,042	131,176	70,172	30,493
					8,105,689,944

Table 31 created by the authors. Costs and benefits of Scenario 1 in monetary discounted terms per year in EUR using 3% discount rate.

Table 32 presents the summary overview with applied 5% discount rate.

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	2,125,897,597	1,836,430,275	2,175,415,861	2,246,549,020	1,881,168,612
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,562,128,089	10,508,433,534	5,472,228,849	2,849,643,430
Value of consumer surplus	367,178	292,125	210,806	109,776	57,166
E-cigarette smoking related healthcare costs	220,217	204,709	178,017	136,889	116,232
Government revenue	260,130	182,219	112,471	49,639	17,797
					4,730,770,773

Table 32 created by the authors. Costs and benefits of Scenario 1 in monetary discounted terms per year in EUR using 5% discount rate.

Scenario 2: *Table 33* and *Table 34* present different outcomes by applying 3% and 5% discount rates, respectively.

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	3,161,176,048	2,892,923,894	3,423,090,508	1,770,345,027	1,215,254,755
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	15,038,599,455	11,893,014,298	8,311,884,632	5,705,699,831
Value of consumer surplus	367,178	301,683	238,581	166,741	114,460
E-cigarette smoking related healthcare costs	221,825	206,755	196,444	200,364	217,677
Government revenue	260,130	428,036	1,039,924	852,826	1,037,993
					6,921,889,361

Table 33 created by the authors. Costs and benefits of Scenario 2 in monetary discounted terms per year in EUR using 3% discount rate.

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	3,161,176,048	2,730,742,726	2,934,957,301	1,252,335,168	709,266,172
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,195,515,531	10,197,068,720	5,879,794,776	3,330,050,641
Value of consumer surplus	367,178	284,771	204,559	117,952	66,803
E-cigarette smoking related healthcare costs	221,825	195,164	168,431	141,737	127,044
Government revenue	260,130	404,039	891,631	603,286	605,810
					4,039,862,382

Table 34 created by the authors. Costs and benefits of Scenario 2 in monetary discounted terms per year in EUR using 5% discount rate.

6. Discussion

We aimed to study the effect of three scenarios with two different government policies whose goal is to reduce the prevalence of smoking in the society of Latvia. This section presents the main findings of our investigation, namely, comparing monetary values of social costs and benefits of smoking and its prevalence decrease and assess the effectiveness of policies mentioned above.

First of all, we have defined the rate at which smoking rate declines naturally, meaning, if no interventions from the government are present. The rate 1.2% was calculated taking into account historical data on smoking prevalence and its changes, and applying the average rate for future years estimation. We expect that by 2050, 43 thousand people will be still smoking (12 453 people decrease from the year 2022). Nevertheless, the government of Latvia may reach better results by imposing the ban on flavored e-cigarettes. This would show a more significant decline in the smoking rate - a 7.9% decrease year-by-year. Another potential policy could be an increase in the excise tax rate which we also estimated the numerical efficiency for as well, our calculations illustrate that by imposing excise tax the expected number of e-cigarette smokers will be 39.6 thousand people.

Scenario 0 with no intervention from the government results in the Net Benefit of roughly 4.7 bn EUR in 2050. Such a huge “benefit” occurs due to a huge number of QALYs because of

the large number of smokers. This result seems feasible since we have no control over society's habits and behavior. As well as this, it is very important to pay attention to the Consumer Surplus. It might seem obvious that the Consumer Surplus should be smaller if we have a smoking population with more people smoking. However, here, we define consumer surplus as the reflection of population's willingness to smoke vs. actual ability and allowance to smoke; are smokers really able to get what they are willing to. When we impose the ban on flavored e-cigarettes, from consumers perspective, smokers are worse-off. This can also be explained via value stick: e-cigarette ban can be viewed as the enormous price increase, which consumers are not ready to pay, and this price exceeds the willingness to pay - that creates negative consumer surplus. This effect can be seen in Scenario 1 and 2, where we witness the limitation of the flavored e-cigarette availability on the market. The Consumer Surplus in Scenario 1 in 2050 is 74,731 EUR - it is a dramatic drop from 395,644 in Scenario 0 of the same year. Nevertheless, even with a decrease in Consumer Surplus, the Net Benefit of Scenario 1 equals 6.2 bn EUR in 2050. Already this number indicates that the policy of banning flavored e-cigarettes is resulting in a higher monetary value. This Net Benefit consists of higher QALY value per population of smokers and former smokers that quit after the ban has been imposed. QALYs per person who used to smoke but quit is more than 2x larger, which explains an increase in monetary value of the total number of QALYs. Another similarly important driver of a higher Net Benefit is a decrease in healthcare costs associated with smoking, which is obvious due to the decreased number of smokers. We also notice that a decrease in the government revenue from excise tax income is less than an increase in the QALY and decrease in the healthcare costs, which also supports the idea of a bigger efficiency of Scenario 1. Last but not least, we explain Scenario 2.

The outcome of the introduction of the increase in excise tax duty results in the Net Benefit of 5.3 bn EUR. This number represents a gain the Latvian public experiences when the excise tax increases - the Net Benefit of Scenario 2 is greater than that in the Reference Scenario 0; however, it is inferior to the Net Benefit of Scenario 1. The Consumer Surplus for Scenario 2 is estimated to be 87 thousand EUR - still a considerable reduction in comparison with the Reference Scenario but representing higher consumer gain than proposed by Scenario 1. Total QALY gain, which represents the health gain for the population from the proposed policy, is prominently being driven by the increased number of smoking quitters; nevertheless, the increase in QALYs is still less than it is in Scenario 1. The apparent advantage of Scenario 1 in

comparison with the alternative scenarios is the increase of the government revenue - with the excise tax raise being greater than the smoking quittance rate induced by the policy, the state revenue has been found to increase with a course of time. The moderate decrease in the LCa reimbursement expenditure is still present in case of tax increase due to the provoke of smoking cessation but the expenditures are still higher than that in Scenario 1.

Sensitivity analyses conducted by taking two different alternative inputs showed valuable outcomes. Firstly, when testing the LCa prevalence's different scenarios, we looked at how significant is the year when the effect of flavored e-cigarette ban decreases the number of patients diagnosed with LCa and as a result, affects the LCa associated healthcare costs. Our calculations show that Total Net Benefit is not sensitive to the year when the ban affects the number of patients diagnosed with LCa since the decreases in the monetary value of Total Net Benefit are not significant.

Secondly, we tested the sensitivity of our model to the changes in the discount rate, choosing 3% and 5% versus our initial rate of 4%. Our estimation highlights the importance of choosing the appropriate rate to discount at. Our model is highly sensitive to changes in the discount rate even by 1%. We show the highest increase in Total Net Benefit using a 3% discount rate- EUR 1,921,272,754. However, when comparing the volatility of changes in the Total Net Benefit monetary terms, Scenario 2 performs the lowest - EUR 399,331,555. This might signal about lesser sensitivity to variation in the alternative inputs.

6.1 Limitations

Unfortunately, our work might be more precise and provide more accurate insights. Due to some limitations, our study is far from being perfect. First, as we have explained earlier, Latvian research on this topic is extremely limited, almost not existing. This led us to using information not so applicable to our country's information - from the United States and the Netherlands. Our work is primarily based on assumptions that are built on other countries' statistics. Second, the public opinion has not been taken into account- our justification for that is our willingness to provide strictly numerical evidence and avoid the presence of biases. Third, we excluded such components of social cost-benefit analysis as producer surplus. Because of the lack of information on the producer's financial performance in Latvia, our analysis does not account for this factor. Lastly, our analysis does not include additional effects of smoking, for

example, labor productivity, some outer factors that may affect the consumption of e-cigarettes such as mass media (as it was done by Kinderen et al. (2016)). All this indicates that further research and analysis is needed to state which scenario completely surely is the best and the most optimal.

7. Conclusions

Our work proves the relevance and novelty of our research topic since we see the lack of clinical evidence and statistical data on the e-cigarette smoking prevalence and the harm it causes to people's health. Our work steps into this field, being one of the first to present the monetary value of governmental decisions and its potential outcomes. We believe this is a good starting point in this topic. We conducted the analysis that is sufficient for making predictions and measuring the effectiveness of the respective policies.

The purpose of this research was to answer the main question: *What are the costs and benefits of tightening tobacco control policy in Latvia?* To conclude, we get back to our Research Question and Hypothesis that stated that **Scenario 2** will be the most beneficial and efficient both for the public and private sector. Although the numerical evidence does not support the formulated hypothesis, and suggests that the most effective policy in terms of monetary gain, and Net Benefit, is that of **Scenario 1:** implementing the flavor ban on e-liquids, there are reasons to believe that the **Scenario 2** might be seen as the most optimal one as it reflects both higher Consumer Surplus compared to Scenario 1, and significantly higher Government revenue compared to both scenarios.

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When creating this document, authors used an Artificial Intelligence tool called ChatGPT only for the purpose of finding synonyms and definitions for a better understanding of the question. However, information provided by AI was not directly used in this document and was not quoted anywhere in this document.

Appendices

Appendix A. Table A.1 created by the authors using data from VID (2024). Excise duty rates on Liquids used in electronic smoking devices and their ingredients for the upcoming years

	2021	2022	2023	2024	2025	2026
EUR/ml	0.12	0.16	0.20	0.24	0.29	0.35

Appendix B. Table B.1 Table created by the authors using data from VID (2024), Diaz et al. (2023), and Stoklosa et al. (2016). Excise duty rates and price increase

	Historical data						Projections						
	2022	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2035**	**2040**	**2045**	**2050**
excise tax in EUR per 1ml	0.16	0.20	0.24	0.29	0.35	0.43	0.54	0.67	0.83	0.72	0.93	1.22	1.58
excise tax increase	0.33	0.25	0.20	0.21	0.21	0.24	0.24	0.24	0.24				
discounted excise tax		0.19	0.22	0.26	0.30	0.36	0.43	0.51	0.60	0.43	0.46	0.49	0.53
price	6.62	7.00	7.45	7.96	8.56	9.28	10.13	11.14	12.35	13.21	14.13	15.12	16.18
price increase, %		5.81%	6.34%	6.92%	7.51%	8.33%	9.17%	10.02%	10.85%	6.98%	6.98%	6.98%	6.98%
decrease in demand, %		6.68%	7.29%	7.96%	8.64%	9.58%	10.55%	11.52%	12.48%	8.03%	8.03%	8.03%	8.03%

Appendix C. Table C.1 Table created by the authors. Costs and benefits of Scenario 1 in monetary discounted terms per year in EUR if effect of flavored e-cigarettes ban on LCa prevalence appears only starting from 2030

Year	**2022**	**2025**	**2030**	**2040**	**2050**
Value of total QALYs for smoking quitters (50,000 EUR)	2,125,897,597	1,889,915,223	2,348,496,778	2,668,843,916	2,459,204,231
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,986,241,473	11,344,507,846	6,500,870,686	3,725,266,909
Value of consumer surplus	367,178	300,633	227,578	130,411	74,731
E-cigarette smoking related healthcare costs	2,150,790	1,984,702	1,375,836	882,084	524,212
Government revenue	260,130	187,526	121,419	58,970	23,266
					6,184,044,924

Appendix C. Table C.2 Table created by the authors. Costs and benefits of Scenario 1 in monetary discounted terms per year in EUR if effect of flavored e-cigarettes ban on LCa prevalence appears only starting from 2040

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	2,125,897,597	1,889,915,223	2,348,496,778	2,668,843,916	2,459,204,231
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,986,241,473	11,344,507,846	6,500,870,686	3,725,266,909
Value of consumer surplus	367,178	300,633	227,578	130,411	74,731
E-cigarette smoking related healthcare costs	2,150,790	1,984,702	1,657,997	935,633	587,488
Government revenue	260,130	187,526	121,419	58,970	23,266
					6,183,981,649

Appendix C. Table C.3 Table created by the authors. Costs and benefits of Scenario 1 in monetary discounted terms per year in EUR if effect of flavored e-cigarettes ban on LCa prevalence appears only starting from 2050

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	2,125,897,597	1,889,915,223	2,348,496,778	2,668,843,916	2,459,204,231
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,986,241,473	11,344,507,846	6,500,870,686	3,725,266,909
Value of consumer surplus	367,178	300,633	227,578	130,411	74,731
E-cigarette smoking related healthcare costs	2,150,790	1,984,702	1,657,997	1,127,515	623,152
Government revenue	260,130	187,526	121,419	58,970	23,266
					6,183,945,984

Appendix D. Table D.1 Table created by the authors. Costs and benefits of Scenario 2 in monetary discounted terms per year in EUR if effect of flavored e-cigarettes ban on LCa prevalence appears only starting from 2030

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	3,161,176,048	2,810,273,996	3,168,469,023	1,487,742,784	927,205,759
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,608,951,541	11,008,370,156	6,985,048,789	4,353,291,127
Value of consumer surplus	367,178	293,064	220,835	140,124	87,330
E-cigarette smoking related healthcare costs	221,825	202,300	182,651	168,659	166,649
Government revenue	260,130	415,807	962,571	716,688	791,960
					5,281,209,527

Appendix D. Table D.2 Table created by the authors. Costs and benefits of Scenario 2 in monetary discounted terms per year in EUR if effect of flavored e-cigarettes ban on LCa prevalence appears only starting from 2040

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	3,161,176,048	2,810,273,996	3,168,469,023	1,487,742,784	927,205,759
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,608,951,541	11,008,370,156	6,985,048,789	4,353,291,127
Value of consumer surplus	367,178	293,064	220,835	140,124	87,330
E-cigarette smoking related healthcare costs	221,825	202,300	183,971	169,154	167,308
Government revenue	260,130	415,807	962,571	716,688	791,960
					5,281,208,867

Appendix D. Table D.3 Table created by the authors. Costs and benefits of Scenario 2 in monetary discounted terms per year in EUR if effect of flavored e-cigarettes ban on LCa prevalence appears only starting from 2050

Year	2022	2025	2030	2040	2050
Value of total QALYs for smoking quitters (50,000 EUR)	3,161,176,048	2,810,273,996	3,168,469,023	1,487,742,784	927,205,759
Value of total QALYs for e-cigarette smokers (50,000 EUR)	18,303,456,600	14,608,951,541	11,008,370,156	6,985,048,789	4,353,291,127
Value of consumer surplus	367,178	293,064	220,835	140,124	87,330
E-cigarette smoking related healthcare costs	221,825	202,300	183,971	170,377	167,800
Government revenue	260,130	415,807	962,571	716,688	791,960
					5,281,208,375