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HEPAHEALTH II

Preventing liver disease with policy measures to tackle obesity and alcohol consumption

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The European Association for the Study of the Liver (EASL)

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Introduction

Europe has the largest burden of diagnosed liver disease globally [1] with almost 30 million people in the European Union alone estimated to be living with a chronic liver condition [2]. Modifiable risk factors such as obesity and alcohol consumption play a major role in the development of liver diseases [3]. Understanding how these risk factors are expected to change into the future is important for estimating the future burden of liver diseases, and the impact of different mitigation policies to reduce the burden.

Statistical modelling is a powerful methodology for quantifying the future burden of liver disease by taking account of combined risk factors such as obesity and excessive alcohol consumption. Such modelling also allows for different intervention scenarios to be compared which can predict the effect of health policies on the future burden of liver diseases, thus providing a quantitative evidence-base to help inform decision-making for policymakers.

This report extends previous work on the burden of chronic liver disease (CLD) in France, the Netherlands, and Romania by quantifying the future impact of a range of upstream policy scenarios to reduce obesity and alcohol consumption and the subsequent burden of CLD in these countries.
The specific aims of this study are:

- to project the impact of an 'inaction' scenario where no change in policy is implemented up to 2030 on the future burden of liver disease (CLD and liver cancer) in France, the Netherlands, and Romania.
- to contrast the impact of the inaction scenario with the impacts of different policy scenarios that tackle obesity or alcohol consumption, or both.

Methods

The same modelling framework is used as described in previous work and published elsewhere [4-6] and is summarized in Figure 1.

Using microsimulation methods, dynamic, representative virtual populations of France, Netherlands, and Romania were generated based on United Nations population data. Epidemiological and cost data for liver diseases were extracted from published sources and databases [6] and applied to this virtual population. Seven different policy scenarios were modelled and compared with an 'inaction' scenario where no policies are place into the future. The policies modelled are described in the table below.

Alcohol scenarios (N=3)	Obesity scenarios (N=2)	Combined scenarios (N=2)
1. Minimum unit pricing €0.5	4. Sugar sweetened beverage tax	6. Sugar sweetened beverage tax plus minimum unit pricing €0.5
2. Minimum unit pricing €0.7	5. Food marketing restrictions	7. Sugar sweetened beverage tax, plus minimum unit pricing €0.5 and, volumetric tax
3. Volumetric excise tax		

Results

All policies had a significant impact on the number of new CLD and liver cancer cases projected to 2030. In all three countries, for both CLD and liver cancer, implementing a 0.70€ MUP saw the greatest reduction in expected cases of disease by 2030 across all countries.

With a 0.70€ MUP, France, the Netherlands, and Romania saw an absolute reduction in new CLD cases between 2022-2030 of 7,632 (±731), 1,459 (±163) and 2,459 (±220) respectively.

For liver cancer the same policy resulted in an absolute reduction in cases between 2022-2030 of 5,705 (±698), 452 (±111) and 1,764 (±223) in France, The Netherlands, and Romania respectively. The policy package of a 0.50€ MUP, an SSB tax, and a volumetric tax saw the next largest reduction in new cases by 2030.

The 0.70€ MUP option suggests a significant reduction in healthcare costs. For example, a 0.70€ MUP would see France avoiding €612.49M (±€63.43M) costs for liver cancer and the Netherlands avoiding €9.10M (±€1.28M) costs for CLD by 2030. The combined scenarios add to the evidence base supporting the implementation of multiple, complementary policies to address the commercial drivers of CLDs, as well as NCDs at large. No economic data was available for Romania.

Other outputs reported are the number of premature deaths, disease specific deaths, and disability adjusted life years (DALYs) averted as a result of each policy scenario relative to 'inaction'.

Discussion

The results of this modelling study show the importance of targeting multiple drivers of obesity and alcohol consumption simultaneously via harmonized fiscal and marketing policy frameworks [7].

- All of the policy scenarios modelled decreased the disease incidence and mortality across both diseases in the three countries, taking into account differing context within each country.
- CLD and liver cancer can be addressed by mitigating primary risk factors through these public health policy scenarios intended to shift the consumer environment.
- Ambitious single policies such as a 0.70€ MUP were able to have the highest impact on population health over time by shifting the consumer environment and impacted the heaviest consumers most at risk for the diseases, or those that already have the diseases.
- Implementation of these policies would reduce CLD linked healthcare costs, deaths, and DALYs.

Introduction

Europe has the largest burden of diagnosed liver disease globally [1] [1] with almost 30 million people in the European Union alone estimated to be living with a chronic liver condition [2]. Liver cirrhosis accounts for 1.8% of all deaths reported in Europe (170,000 deaths annually) [2] with a 100% increase in cirrhosis deaths observed across the Eastern European region from 1990 to 2017 [8]. Liver disease is now the second leading cause of years of working life lost in Europe, after ischaemic heart disease [9].

Differences in liver disease epidemiology occur in part because of differences in the prevalence of risk factors such as alcohol consumption, obesity, and viral hepatitis [3]. Fatty liver disease will probably become the most prevalent type of chronic liver disease (CLD) [10, 11], largely driven by the increase of non-viral causes and the decline in viral hepatitis in most countries [12-14]. Tackling risk factors for CLDs, such as obesity, diabetes, and excessive alcohol consumption, is vital in reducing incidence and slowing the progression of liver diseases in Europe.

Statistical modelling provides a method to quantify the future burden of liver disease and can take account of combined risk factors such as obesity and excessive alcohol consumption. Such modelling also allows for different intervention scenarios to be compared which can predict the effect of health policies on the future burden of liver diseases, thus providing an informative decision-support tool for policymakers.

This report extends previous work on the burden of CLD in France, the Netherlands, and Romania by quantifying the future impact of a range of policy scenarios to reduce obesity and alcohol consumption and the subsequent burden of CLD in these countries.

The specific aims of this study are:

- to project the impact of an 'inaction' scenario where no change in policy is implemented up to 2030 on the future burden of liver disease (CLD and liver cancer) in France, the Netherlands, and Romania.
- to contrast the impact of the inaction scenario with the impacts of different policy scenarios that tackle obesity or alcohol consumption, or both.

There are several policy scenarios available to address the excessive consumption of foods high in fat, salt, or sugar (HFSS) or excessive alcohol consumption. The mechanisms for these policy scenarios are designed to address an element of wider determinants of health (e.g. heavy alcohol consumption; sugar sweetened beverage (SSB) consumption) and work most effectively as part of a package of measures intended to foster healthier and more equitable environments across the population [15].

The policy scenarios modelled in this study were:

1. for alcohol,

a. volumetric excise duties, which are a commonly used policy [16] and are a tax on the sale of specific goods, in this context a duty on alcohol content per volume of the product, rather than other considerations such as cost of product manufacturing or value added tax (VAT)

b. minimum unit pricing (MUP) i.e., when a government sets a minimum price per unit – most often based on volume – at which alcohol is allowed to be sold [17].

1 CLD is defined here according to global burden of disease ICD-10 code categorization [6]: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4. Liver cancer is defined by ICD-10 code C22, as per Ferlay et al. [7]

2. for obesity,

a. an SSB tax [18] is a well-used policy mechanism to address the over consumption of SSBs across populations

b. marketing restrictions on HFSS foods on mainstream television [19].

3. the effects of a combination of different obesity and alcohol policy scenarios were modelled to promote a package of policy measures. This approach is supported by the World Health Organization's (WHO) 'Best Buys' for the prevention of non-communicable diseases (NCDs), including the lowering of body mass index (BMI) and reduction of alcohol consumption across populations [20].

See Appendices

Appendix 1 - Policy scenarios for further information on the policy scenarios chosen.

This report focuses specifically on three countries in Europe with varying epidemiological and policy contexts: France, the Netherlands, and Romania (Table 1). These countries were chosen specifically based on their data availability and differing amounts of alcohol consumed per week. It was not feasible to model all European countries and many countries lacked sufficient data required to produce robust modelled estimates. See Appendix 2 – European policy context for further details.

Table 1: Overview of existing alcohol and obesity policies across each of the three countries

Policy - Alcohol	France	Netherlands	Romania
Written national policy or action plan	Yes	Yes	No
EU excise tax on beer, wine and spirits	Yes	Yes	Yes
Minimum pricing / below cost selling	No	No	No
Policy - Obesity	**France**	**Netherlands**	**Romania**
Operational policy or action plan to reduce unhealthy diet rel. to NCDs	Yes	No	No
Sugar-sweetened beverage tax (SSB)	Yes	No	No
Marketing restrictions of food and beverages high in saturated fats, trans-fatty acids, free sugars or salt	Yes	Yes	Yes

Methods

The same modelling framework is used as described in previous work and published elsewhere [4-6] and is summarized in Figure 1.

Using microsimulation methods, dynamic, representative virtual populations of France, Netherlands, and Romania were generated based on United Nations population data. Epidemiological and cost data for liver diseases were extracted from published sources and databases [6] and applied to this virtual population. Each year an individual had a probability of developing and then dying from or surviving a liver disease based on these epidemiological data (i.e. overweight status, alcohol consumption, current liver disease burden).

For each of the three countries (France, Netherlands, and Romania), there is an 'inaction' scenario where no future policy scenarios occur to impact BMI or alcohol consumption throughout the simulation period (2022-2030). Future projections in related liver diseases are then modelled based on baseline trends for these risk factors.

Policy scenarios are modelled as coming into effect from the beginning of 2022 and staying in place through 2030. Their effect is to reduce either alcohol consumption or BMI within the population. Results are compared between policy and inaction scenarios to determine the annual effectiveness of a policy scenario (at the end of each year from 2022 to 2030).

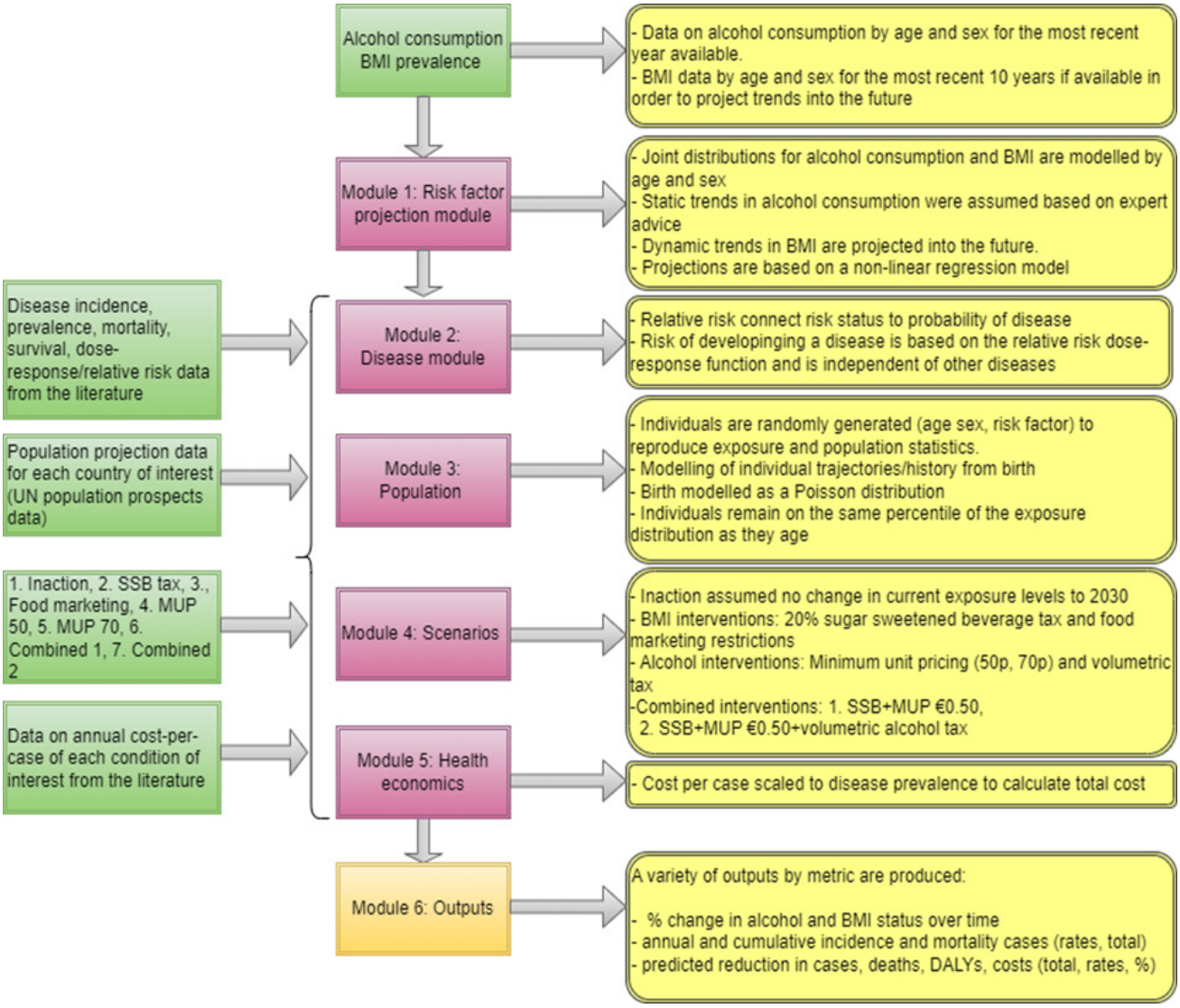

Figure 1. Summary of microsimulation modelling process

Risk Factor Data

BMI was categorised according to WHO cut-offs [21, 22]:

- Healthy weight: <25 kg/m2
- Pre-obesity: 25-29.99 kg/m2
- Obesity: ≥30 kg/m2

Pre-obesity is often termed 'overweight' but for the purposes of this report, standardised WHO labelling of 'pre-obesity' is used to define BMI 25-29.99 kg/m2. This avoids confusion with the WHO definition of overweight as BMI ≥25 kg/m2.

Alcohol consumption was categorised into the following groups:

Alcohol consumption category	Definition	
	Men units* per day (units per week)	Women units* per day (units per week)
"Non-harmful" or "low risk" alcohol consumption	≤1.75 (≤12.25)	≤1.75 (≤12.25)
"Hazardous" or "moderate risk" alcohol consumption	> 1.75 (<12.25) to ≤7.5 (≤52.5)	> 1.75 (<12.25) to ≤5 (≤35)
"Harmful" or "high risk" alcohol consumption	>7.5 (>52.5)	>5 (>35)

* where 1 unit equals 8 grams (g) of alcohol [23]

Disease inputs

CLD incidence, prevalence, survival, relative risk and mortality data were collected from the literature for each country and are presented in the data appendix 3 and previous work [4-6].
CLD is defined here according to global burden of disease ICD-10 code categorization [10]: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.
Liver cancer is defined under ICD-10 code C22, as per Ferlay et al [11].

Policy scenarios

Seven policy scenarios were run (as summarised in Table 2). Three for alcohol: MUP €0.5 and MUP €0.7 and a volumetric tax; two for BMI: an SSB tax and a food marketing restriction, plus two combined policy scenarios: 1. SSB tax and €0.5 MUP; 2. SSB tax, €0.5 MUP and volumetric tax (Table 2).

These policy scenarios were compared to an 'inaction' scenario where no new policies are implemented from 2022 to 2030. A summary of the current context in each country is provided in the Appendix 1 – Policy Scenarios. The next sections present each individual scenario as well as the combined set of policy scenarios.

Table 2: Summary of scenarios included in the model

Alcohol scenarios (N=3)	Obesity scenarios (N=2)	Combined scenarios (N=2)
4. Minimum unit pricing €0.5	4. Sugar sweetened beverage tax	6. Sugar sweetened beverage tax plus minimum unit pricing €0.5
5. Minimum unit pricing €0.7	5. Food marketing restrictions	7. Sugar sweetened beverage tax, plus minimum unit pricing €0.5 and, volumetric tax
6. Volumetric excise tax		

Assumed effects of different policy scenarios

Minimum unit pricing

Data from the Welsh adaptation of the Sheffield alcohol policy model were used [24]. This provides the percentage point drop in the prevalence of high, moderate, and low alcohol consumption in Wales resulting from the introduction of 0.5 GBP or 0.7 GBP MUP policies (Table 3).

The currency used in the Sheffield model was in GBP, so this was converted to equivalent country currency values using purchasing power parity (PPP) conversion values from [25] for each of the three countries (Table 3). PPPs are the rates of currency conversion that calibrate the purchasing power of different currencies by eliminating the differences in price levels between countries.

Table 3: Annual percentage drop in alcohol consumption by risk group taken from [24] for the first year of the simulation.

MUP per unit	Low Risk	Medium/Moderate Risk	High Risk
0.5 GBP	2.2%	2.0%	7.2%
0.7 GBP	7.9%	7.9%	20.0%

*Table 4: The purchasing power parity (PPP) conversion values used for each of the three countries**

Country	Year*	PPP
France	2021	0.725
Netherlands	2021	0.770
Romania	2021	1.746
UK (literature reference)	2021	0.693

**Note: it is assumed that these values hold for 2022. Accessed 11/07/2022. PPP values taken from OECD data [25]*

The MUP values presented in Table 3 and the PPP values presented in Table 4 are then used in Eq.1 to convert the MUP GBP to euros which are provided in Table 5.

Eq. 1 $$MUP\ in\ new\ currency\ 2022 = \frac{\text{UK,2022 values (table 3)x PPP,UK 2022(table 4)}}{\text{PPP,new country,2022 (table 4)}}$$

Table 5: Precise MUP values for each of the three countries

Country	0.5 GBP MUP	0.7 GBP MUP	PPP conversion per 1 GBP
France	0.478 Euros	0.669 Euros	0.956 Euros
Netherlands	0.450 Euros	0.630 Euros	0.900 Euros
Romania	0.198 Leu	0.278 Leu	0.397 Leu

Alcohol volumetric tax

For alcohol volumetric tax, data were taken from Meier et al. [26], which provides the percentage drop in alcohol units consumed for low, moderate, and high risk drinking groups for individuals in England for a 22 pence (€0.25) per 8g ethanol volumetric tax.

Table 6: Weekly alcohol consumption thresholds for the different risk groups [26]

Drinking level group	% drop in alcohol units consumed
Low risk	1.4
Moderate risk	1.5
High Risk	2.8

Sugar sweetened beverage tax

The assumptions for modelling SSB tax have been described elsewhere, see HepaHealth II phase 1 report. In summary, these assumptions translate into a 20% SSB tax which equates to a BMI drop of 1.26% for males and 0.85% for females applied to each population [27].

Food marketing and advertising restrictions

Food marketing restrictions are designed to reduce children's exposure to HFSS products, by shifting their preferences and the purchasing patterns of their caregivers and thus reducing the regular consumption of HFSS foods [28, 29]. Real world data on the effect of restricting television advertising were extracted from Brown et al, - a cost-effectiveness modelling study that projected the impacts of legislation to restrict HFSS food TV advertising before 21:30 in a cohort of children [30]. The policy predicted a mean average BMI decrease of 0.354 kg/m2 once the exposed children reached adulthood.

Figure 2 illustrates the assumptions related to this policy intervention.
For all policy scenarios, the policy starts in 2022 and is immediate and maintained until the end of the simulation (2030).

Given these data are based on impacts in adulthood due to a retrospective policy that took place when they were children, we applied the impact (a mean BMI drop of 0.354 kg/m2) to adults in the start year of the simulation. This change in BMI was maintained in these adults throughout the simulation.

No impacts of this policy were applied beyond 2022 because no data were available on subsequent cohorts of children. Therefore, a conservative assumption was used.

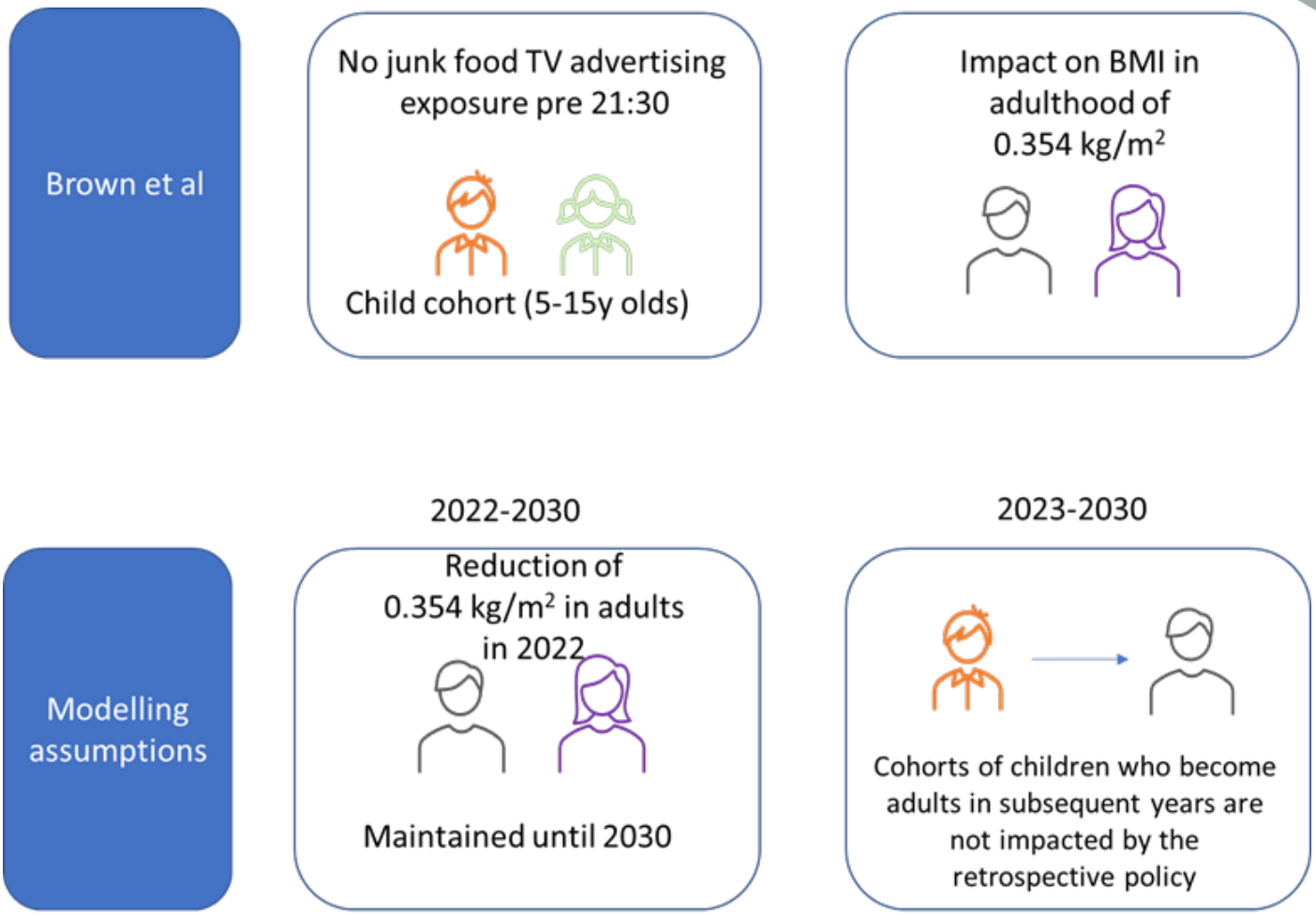

Figure 2. Schematic of food marketing study and assumptions used for the model in this study.

Combined policy scenarios

The two combined policy scenarios considered here are:
1) an MUP of €0.50 and a 20% SSB tax
2) 20% SSB tax, an MUP of €0.50, and a volumetric alcohol tax.

For the percentage drops in alcohol used in combined policy number 2, an assumption was made that the two percentage drops presented in Table 3 and Table 6 are summed (Table 7). For SSB tax, a BMI drop of 1.26% for males and 0.85% for females was applied to each population as described previously [27].

Table 7: Reductions in alcohol consumption from the combined policy scenario 2

Drinking level group	% drop in alcohol units consumed
Low risk	3.6
Moderate risk	3.5
High risk	10.0

Outputs generated

The following outputs were generated for each country.

- Risk factor outputs

The effects of each policy scenario on obesity prevalence and alcohol consumption are reported. Note that Monte-Carlo errors around the means are presented reflecting the accuracy of the microsimulation.

- Epidemiological outputs

* Annual and cumulative incidence of liver diseases

  Annual incidence refers to the number of new cases of CLD and liver cancer each year in a given country of interest. Cumulative incidence refers to the number of new cases of CLD and liver cancer over the specified time period. Note that Monte-Carlo errors around the means are presented reflecting the accuracy of the microsimulation.

* Predicted reduction in cumulative incidence of liver diseases

  The total reduction in new liver disease cases due to a policy scenario relative to the inaction scenario since the beginning of the policy scenario. It is computed as the cumulative incidence under the inaction scenario minus the cumulative incidence under the policy scenario. Thus, a positive value means that cases are reduced as a result of the intervention. Note that Monte-Carlo errors around the means are presented reflecting the accuracy of the microsimulation.

* Premature all-cause mortality events
  The total number of premature deaths from any cause by scenario are estimated. Premature deaths are defined as those that occur before the age of 75 [31]. Premature mortality is calculated from total all-cause mortality in a given country. Therefore, the specific cause of premature death is not available.

* Predicted reduction in premature all-cause mortality cases
  The total reduction in premature mortality cases due to a policy scenario relative to the inaction scenario. It is computed as the premature mortality burden under the inaction scenario minus the premature mortality burden under the policy scenario. A positive value means that premature all-cause mortality is reduced.

* Predicted reduction in CLD and liver cancer mortality cases

  The total reduction in CLD and liver cancer mortality cases due to a policy scenario relative to the inaction scenario. It is computed as the CLD and liver cancer mortality cases in the inaction scenario minus the CLD and liver cancer mortality cases in the policy scenario. A positive value means that mortality from CLD and liver cancer is reduced.

- Economic outputs

* Predicted reduction in Disability Adjusted Life Years (DALYs) as a result of the policy scenarios relative to baseline

  DALYs are a way of weighting a disease based on its impact on morbidity and mortality. One DALY represents 1 life-year of full health lost, and is the sum of years of life lost due to premature death (YLL) and years of life lived with disability (YLD) [32]. DALYs lost to CLD and liver cancer are

presented relative to baseline.

* Predicted reduction in costs as a result of the policy scenarios relative to the inaction scenario Implementing policy scenarios that reduce the morbidity and mortality of liver diseases will have an important impact on related healthcare utilisation. Therefore, the predicted reduction in healthcare costs as a result of these policy scenarios relative to inaction are output. No cost data was available for Romania so no analysis of costs is provided for Romania.

Validation

Detailed model validation is provided in Appendix 4.

Results

Table 8 to Table 13 provide a summary of the results by country and intervention. Percentage prevalence, cases per 100,000, and absolute figures in the total population are provided. Description of the outputs are provided in the subsequent sections by country.

Table 8. Percentage prevalence of moderate or high-risk alcohol consumption groups in 2030 by scenario in the total population of France, the Netherlands, and Romania

Country	Prediction Scenario	Moderate risk alcohol consumers (%(in 2030	High risk alcohol consumers (%) in 2030	Predicted reduction in high + moderate risk groups in 2030, 3elative to incaction (%)
France	Inaction	27.43	16.14	-
	0.50€ MUP	27.78	15.35	0.44
	0.70€ MUP	28.04	13.92	1.61
	Volumetric tax	27.46	15.83	0.28
	Combined (0.50€ MUP & SSB tax)	27.78	15.35	0.44
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	27.81	15.04	0.72
Netherlands	Inaction	26.50	11.07	-
	0.50€ MUP	26.69	10.41	0.47
	0.70€ MUP	26.58	9.25	1.74
	Volumetric tax	25.46	10.81	0.30
	Combined (0.50€ MUP & SSB tax)	26.69	10.41	0.47
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	26.64	10.15	0.78
Romania	Inaction	27.14	12.59	-
	0.50€ MUP	27.40	11.86	0.47
	0.70€ MUP	27.41	10.58	1.74
	Volumetric tax	27.13	12.31	0.29
	Combined (0.50€ MUP & SSB tax)	27.40	11.86	0.47
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	27.37	11.58	0.78

Note: each intervention occurs once at the beginning of year 2022. Previous work [4, 6, 33, 34] provides further detail about how these values were calculated (see technical appendix); predicted reduction values were calculated based on 'inaction' minus 'scenario' outputs. Population sizes by age and sex, and year for France, Netherlands, and Romania are provided in Appendix 3, Table 17 and Table 18 and these data have been extracted from UN population prospects 2019. Estimates for 2030 are as follows: France: 66,695,705, Netherlands: 17,450,317, Romania: 18,306,092.

Table 9: Summary of the impact of each policy scenario on obesity trends in the total population in France, the Netherlands and Romania from 2022-2030

		Pre-Obesity		Obesity	
Country	Prediction scenario	Pre-obese prevalence (%) in 2030	Predicted increase in pre-obese prevalence 2022-2030 (%)	Obesity prevalence (%) in 2030	Predicted increase in obese prevalence 2022-2030 (%)
France	Inaction	24.84	0.02	18.74	3.40
	SSB tax	25.12	0.96	17.48	2.75
	Food Marketing	24.86	1.06	17.32	2.64
	Combined (0.50€ MUP & SSB tax)	25.12	0.96	17.48	2.75
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	25.12	0.96	17.48	2.75
Nether-lands	Inaction	29.75	0.56	15.30	2.44
	SSB tax	30.20	1.84	13.83	1.60
	Food Marketing	29.93	1.98	13.68	1.49
	Combined (0.50€ MUP & SSB tax)	30.20	1.84	13.83	1.60
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	30.20	1.84	13.83	1.60
Romania	Inaction	41.48	3.29	6.62	-0.29
	SSB tax	41.81	4.76	5.46	-0.77
	Food Marketing	41.53	5.06	5.33	-0.87
	Combined (0.50€ MUP & SSB tax)	41.81	4.76	5.46	-0.77
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	41.81	4.76	5.46	-0.77

Note: each intervention occurs once at the beginning of year 2022. Population sizes by age and sex, by year for France, Netherlands, and Romania are provided in Appendix 3, Table 17 and Table 18 and these data have been extracted from UN population prospects 2019. Predicted reduction values were calculated based on 'inaction' minus 'scenario' outputs. Estimates for 2030 are as follows: France: 66,695,705, Netherlands: 17,450,317, Romania: 18,306,092.

Table 10: Summary of the impact of each policy scenario on annual and cumulative incidence of CLD (absolute population estimates and rate per 100,000 individuals) in France, the Netherlands, and Romania from 2022-2030

Chronic Liver Disease*								
Country	Prediction scenario	Absolute estimates			Estimates per 100,000 individuals			
		2030 annual incidence (absolute estimate of number of cases (±SD))	2030 cumulative incidence (absolute estimate of number of cases since 2022 (±SD))	Predicted absolute reduction in number of cases between 2022-2030 (±SD)	2030 Annual incidence (per 100,000 individuals) (±SD)	2030 Cumulative incidence cases since 2022 (per 100,000 individuals) (±SD)	Predicted reduction in cases between 2022–2030 (per 100,000 individuals) (±SD)	Reduced cases as % of cases under inaction scenario**
France	Inaction	11,941 (±175)	107,660 (±526)	-	17.90 (±0.26)	163 (±0.80)	-	-
	0.50€ MUP	11,693 (±173)	105,296 (±520)	2,364 (±740)	17.53 (±0.26)	159 (±0.79)	3.57 (±1.12)	2.20
	0.70€ MUP	11,177 (±170)	100,028 (±507)	7,632 (±731)	16.76 (±0.25)	151 (±0.77)	11.54 (±1.10)	7.09
	Volumetric tax	11,832 (±174)	106,573 (±524)	1,087 (±742)	17.74 (±0.26)	161 (±0.79)	1.64 (±1.12)	1.01
	SSB tax	11,765 (±174)	106,160 (±523)	1,500 (±742)	17.64 (±0.26)	160 (±0.79)	2.27 (±1.12)	1.39
	Food Marketing	11,744 (±174)	105,954 (±522)	1,706 (±741)	17.61 (±0.26)	160 (±0.79)	2.58 (±1.12)	1.58
	Combined (0.50€ MUP & SSB tax)	11,520 (±172)	103,809 (±517)	3,851 (±738)	17.27 (±0.26)	157 (±0.78)	5.82 (±1.11)	3.58
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	11,410 (±171)	102,738 (±514)	4,922 (±736)	17.11 (±0.26)	155 (±0.78)	7.44 (±1.11)	4.57
Netherlands	Inaction	2,276 (±39)	20,499 (±117)	-	13.04 (±0.22)	118 (±0.68)	-	-
	0.50€ MUP	2,230 (±39)	20,050 (±116)	449 (±165)	12.78 (±0.22)	116 (±0.67)	2.59 (±0.95)	2.12
	0.70€ MUP	2,132 (±38)	19,040 (±113)	1,459 (±163)	12.21 (±0.22)	110 (±0.65)	8.42 (±0.94)	7.12
	Volumetric tax	2,252 (±39)	20,292 (±117)	207 (±166)	12.91 (±0.22)	117 (±0.67)	1.20 (±0.96)	1.01
	SSB tax	2,242 (±39)	20,210 (±117)	289 (±165)	12.85 (±0.22)	117 (±0.67)	1.66 (±0.95)	1.41
	Food Marketing	2,236 (±39)	20,157 (±116)	342 (±165)	12.81 (±0.22)	116 (±0.67)	1.97 (±0.95)	1.67
	Combined (0.50€ MUP & SSB tax)	2,196 (±38)	19,769 (±115)	730 (±165)	12.59 (±0.22)	114 (±0.66)	4.21 (±0.95)	3.56
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	2,177 (±38)	19,553 (±115)	946 (±164)	12.47 (±0.22)	113 (±0.66)	5.45 (±0.95)	4.61

Chronic Liver Disease*								
Country	Prediction scenario	Absolute estimates			Estimates per 100,000 individuals			
		2030 annual incidence (absolute estimate of number of cases (±SD))	2030 cumulative incidence (absolute estimate of number of cases since 2022 (±SD))	Predicted absolute reduction in number of cases between 2022-2030 (±SD)	2030 Annual incidence (per 100,000 individuals) (±SD)	2030 Cumulative incidence cases since 2022 (per 100,000 individuals) (±SD)	Predicted reduction in cases between 2022–2030 (per 100,000 individuals) (±SD)	Reduced cases as % of cases under inaction scenario**
Romania	Inaction	3,573 (±51)	33,782 (±158)	-	19.52 (±0.28)	181 (±0.85)	-	-
	0.50€ MUP	3,500 (±51)	33,044 (±157)	737 (±223)	19.12 (±0.28)	177 (±0.84)	3.94 (±1.19)	2.18
	0.70€ MUP	3,347 (±50)	31,323 (±153)	2,459 (±220)	18.28 (±0.27)	168 (±0.82)	13.15 (±1.18)	7.28
	Volumetric tax	3,537 (±51)	33,418 (±158)	364 (±223)	19.32 (±0.28)	179 (±0.84)	1.95 (±1.20)	1.08
	SSB tax	3,539 (±51)	33,421 (±158)	361 (±223)	19.33 (±0.28)	179 (±0.84)	1.93 (±1.20)	1.07
	Food Marketing	3,532 (±51)	33,355 (±157)	427 (±223)	19.29 (±0.28)	179 (±0.84)	2.28 (±1.20)	1.26
	Combined (0.50€ MUP & SSB tax)	3,467 (±51)	32,690 (±156)	1,091 (±222)	18.94 (±0.28)	175 (±0.83)	5.84 (±1.19)	3.23
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	3,432 (±50)	32,333 (±155)	1,449 (±222)	18.75 (±0.28)	173 (±0.83)	7.75 (±1.19)	4.29

*Notes: *CLD is defined here according to global burden of disease ICD-10 code categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4. (±) refer to uncertainty values around the estimates. Each intervention occurs once at the beginning of year 2022. Predicted reduction values were calculated based on 'inaction' minus 'scenario' outputs. Population sizes by age and sex, by year for France, Netherlands, and Romania are provided in Appendix 3, Table 17 and Table 18 and these data have been extracted from UN population prospects 2019. Estimates for 2030 are as follows: France: 66,695,705, Netherlands: 17,450,317, Romania: 18,306,092. **This percentage is calculated by dividing the difference in cases between inaction and policy, then dividing this difference by the inaction cases and multiplying by 100.*

Table 11: Summary of the impact of each policy scenario on annual and cumulative incidence of liver cancer (absolute population estimates and rate per 100,000 individuals) in France, the Netherlands and Romania from 2022-2030

Liver Cancer*								
Country	Prediction scenario	Absolute estimates			Estimates per 100,000 individuals			
		2030 annual incidence (absolute estimate of number of cases (±SD))	2030 cumulative incidence (absolute estimate of number of cases since 2022 (±SD))	Predicted absolute reduction in number of cases between 2022-2030 (±SD)	2030 Annual incidence (per 100,000 individuals) (±SD)	2030 Cumulative incidence cases since 2022 (per 100,000 individuals) (±SD)	Predicted reduction in cases between 2022–2030 (per 100,000 individuals) (±SD)	Reduced cases as % of cases under inaction scenario**
France	Inaction	11,562 (±172)	97,785 (±501)	-	17.34 (±0.26)	148 (±0.76)	-	-
	0.50€ MUP	11,341 (±171)	95,900 (±496)	1,885 (±705)	17.00 (±0.26)	145 (±0.75)	2.85 (±1.07)	1.93
	0.70€ MUP	10,879 (±167)	92,080 (±486)	5,705 (±698)	16.31 (±0.25)	139 (±0.73)	8.62 (±1.06)	5.83
	Volumetric tax	11,459 (±171)	96,955 (±499)	830 (±707)	17.18 (±0.26)	147 (±0.75)	1.25 (±1.07)	0.85
	SSB tax	11,418 (±171)	96,578 (±498)	1,207 (±707)	17.12 (±0.26)	146 (±0.75)	1.82 (±1.07)	1.23
	Food Marketing	11,411 (±171)	96,521 (±498)	1,264 (±707)	17.11 (±0.26)	146 (±0.75)	1.91 (±1.07)	1.29
	Combined (0.50€ MUP & SSB tax)	11,201 (±170)	94,728 (±493)	3,057 (±703)	16.80 (±0.25)	143 (±0.75)	4.62 (±1.06)	3.13
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	11,110 (±169)	93,919 (±491)	3,866 (±702)	16.66 (±0.25)	142 (±0.74)	5.84 (±1.06)	3.95
Netherlands	Inaction	1,107 (±27)	9,401 (±80)	-	6.35 (±0.16)	54.20 (±0.46)	-	-
	0.50€ MUP	1,087 (±27)	9,251 (±79)	149 (±112)	6.23 (±0.16)	53.33 (±0.46)	0.86 (±0.65)	1.58
	0.70€ MUP	1,048 (±27)	8,949 (±78)	452 (±111)	6.01 (±0.15)	51.59 (±0.45)	2.60 (±0.64)	4.81
	Volumetric tax	1,097 (±27)	9,329 (±79)	72 (±113)	6.29 (±0.16)	53.78 (±0.46)	0.41 (±0.65)	0.77
	SSB tax	1,089 (±27)	9,283 (±79)	117 (±112)	6.24 (±0.16)	53.52 (±0.46)	0.68 (±0.65)	1.24
	Food Marketing	1,088 (±27)	9,277 (±79)	124 (±112)	6.24 (±0.16)	53.48 (±0.46)	0.71 (±0.65)	1.32
	Combined (0.50€ MUP & SSB tax)	1,068 (±27)	9,137 (±79)	264 (±112)	6.12 (±0.15)	52.67 (±0.45)	1.52 (±0.65)	2.81
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	1,059 (±27)	9,069 (±78)	332 (±112)	6.07 (±0.15)	52.28 (±0.45)	1.91 (±0.64)	3.53

Liver Cancer*								
Country	Prediction scenario	Absolute estimates			Estimates per 100,000 individuals			
		2030 annual incidence (absolute estimate of number of cases (±SD))	2030 cumulative incidence (absolute estimate of number of cases since 2022 (±SD))	Predicted absolute reduction in number of cases between 2022-2030 (±SD)	2030 Annual incidence (per 100,000 individuals) (±SD)	2030 Cumulative incidence cases since 2022 (per 100,000 individuals) (±SD)	Predicted reduction in cases between 2022–2030 (per 100,000 individuals) (±SD)	Reduced cases as % of cases under inaction scenario**
Romania	Inaction	3,938 (±54)	34,294 (±160)	-	21.51 (±0.30)	184 (±0.85)	-	-
	0.50€ MUP	3,871 (±54)	33,701 (±158)	594 (±225)	21.15 (±0.29)	181 (±0.84)	3.18 (±1.20)	1.73
	0.70€ MUP	3,730 (±53)	32,530 (±156)	1,764 (±223)	20.38 (±0.29)	174 (±0.82)	9.45 (±1.19)	5.14
	Volumetric tax	3,912 (±54)	34,033 (±159)	261 (±226)	21.37 (±0.29)	182 (±0.84)	1.40 (±1.21)	0.76
	SSB tax	3,890 (±54)	33,959 (±159)	335 (±226)	21.25 (±0.29)	182 (±0.84)	1.80 (±1.20)	0.98
	Food Marketing	3,886 (±54)	33,932 (±159)	362 (±226)	21.23 (±0.29)	182 (±0.84)	1.94 (±1.20)	1.06
	Combined (0.50€ MUP & SSB tax)	3,824 (±53)	33,374 (±158)	920 (±225)	20.89 (±0.29)	179 (±0.83)	4.93 (±1.20)	2.68
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	3,793 (±53)	33,103 (±157)	1,191 (±224)	20.72 (±0.29)	177 (±0.83)	6.38 (±1.20)	3.47

Note: (±) refer to uncertainty values around the estimates. Each intervention occurs once at the beginning of year 2022. Population sizes by age and sex, by year for France, Netherlands, and Romania are provided in Appendix 3, Table 17 and Table 18 and have been extracted from UN population prospects 2019. Estimates for 2030 are as follows: France: 66,695,705, Netherlands: 17,450,317, Romania: 18,306,092. The predicted reductions are calculated based on 'cases in inaction scenario' minus 'cases in intervention scenario' for a given year.

Table 12: Summary of the effects of each policy scenario on DALYs and DALYS lost to CLD and liver cancer, premature mortality, CLD mortality, and liver cancer mortality in France, the Netherlands and Romania from 2022-2030

Countries	Prediction scenario	2030 DALY absolute estimate	Reduction in DALYs between 2022-2030	Reduction in DALYs as a % of the inaction scenario in 2030	Reduction in premature all-cause mortality between 2022-2030	2030 CLD mortality absolute estimate	Cumulative CLD mortality absolute estimate 2022-2030	Reduction in CLD mortality between 2022 -2030	Reduction in CLD mortality as % of inaction scenario 2022-2030	Reduction in CLD mortality per 100,000 population between 2022-2030	2030 liver cancer mortality absolute estimate	Cumulative liver cancer mortality absolute estimate 2022-2030	Reduction in liver cancer mortality between 2022-2030	Reduction in liver cancer mortality as a % of inaction scenario between 2022-2030	Reduction in liver cancer mortality per 100,000 population between 2022-2030
France	Inaction	2,002,016	-	-	-	6,702	58,908	-	-	-	5,909	49,118	-	-	-
	50 MUP	2,000,369	10,229	0.51	232	6,683	58,839	69	0.12	0.10	5,846	48,725	393	0.80	0.59
	70 MUP	1,996,844	30,460	1.52	840	6,642	58,609	300	0.51	0.45	5,665	47,865	1,253	2.55	1.89
	Volumetric tax	2,001,574	4,602	0.23	121	6,696	58,878	31	0.05	0.05	5,881	48,947	172	0.35	0.26
	SSB tax	2,000,306	7,129	0.36	204	6,687	58,855	54	0.09	0.08	5,846	48,868	250	0.51	0.38
	Food Marketing	2,000,228	7,384	0.37	216	6,686	58,849	60	0.10	0.09	5,845	48,853	266	0.54	0.40
	Combined (0.50€ MUP & SSB tax)	1,998,730	17,436	0.87	445	6,666	58,787	121	0.21	0.18	5,784	48,485	633	1.29	0.95
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	1,998,108	22,064	1.10	616	6,658	58,726	182	0.31	0.27	5,755	48,303	815	1.66	1.23
Netherlands	Inaction	417,658	-	-	-	1,275	11,108	-	-	-	529	4,480	-	-	-
	0.50€ MUP	417,548	1,465	0.35	44	1,272	11,090	18	0.16	0.11	524	4,450	30	0.67	0.17
	0.70€ MUP	417,038	3,565	0.85	102	1,264	11,052	57	0.51	0.33	511	4,384	96	2.14	0.55
	Volumetric tax	417,589	666	0.16	11	1,273	11,100	8	0.07	0.05	527	4,467	13	0.29	0.07
	SSB tax	417,493	533	0.13	10	1,274	11,100	8	0.07	0.05	526	4,459	21	0.47	0.12
	Food Marketing	417,445	678	0.16	11	1,273	11,099	9	0.08	0.05	526	4,457	23	0.51	0.13
	Combined (0.50€ MUP & SSB tax)	417,369	1,982	0.47	51	1,272	11,083	26	0.23	0.15	521	4,430	50	1.12	0.29
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	417,263	2,381	0.57	60	1,270	11,074	35	0.32	0.20	518	4,416	64	1.43	0.37

Romania	Inaction	1,088,897	-	-	-	1,863	16,864	-	-	-	1,805	15,463	-	-	-
	0.50€ MUP	1,088,363	2,659	0.24	69	1,856	16,837	27	0.16	0.15	1,785	15,370	93	0.60	0.50
	0.70€ MUP	1,087,376	8,856	0.81	266	1,840	16,768	96	0.57	0.52	1,744	15,154	309	2.00	1.66
	Volumetric tax	1,088,637	1,496	0.14	42	1,860	16,850	14	0.08	0.08	1,795	15,418	45	0.29	0.24
	SSB tax	1,088,528	1,684	0.15	64	1,863	16,851	13	0.08	0.07	1,790	15,395	68	0.44	0.37
	Food Marketing	1,088,474	1,852	0.17	63	1,862	16,850	14	0.08	0.08	1,789	15,390	73	0.47	0.40
	Combined (0.50€ MUP & SSB tax)	1,087,977	4,331	0.40	128	1,855	16,824	40	0.24	0.22	1,770	15,303	160	1.03	0.86
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	1,087,566	6,184	0.57	211	1,850	16,808	56	0.33	0.31	1,762	15,257	206	1.33	1.11

Note: population sizes by age and sex, by year for France, Netherlands, and Romania are provided in Appendix 3, Table 17 and Table 18 and these data have been extracted from UN population prospects 2019. Estimates for 2030 are as follows: France: 66,695,705, Netherlands: 17,450,317, Romania: 18,306,092. Premature mortality is based on all-cause mortality data so specific cause of death is not provided. Predicted reductions are calculated based on 'cases in inaction scenario' minus 'cases in intervention scenario' for a given year.

Table 13: Summary of the effects of each policy scenario on CLD and liver cancer healthcare costs in France, the Netherlands and Romania between 2022-2030

Countries	Prediction scenario	Reduction in CLD* healthcare costs between 2022-2030	Reduction in liver cancer healthcare costs between 2022-2030
France	Inaction	-	-
	0.50€ MUP	-	€203.09M (±€63.79M)
	0.70€ MUP	-	€612.49M (±€63.43M)
	Volumetric Tax	-	€89.61M (±€63.89M)
	SSB Tax	-	€122.38M (±€63.86M)
	Food Marketing	-	€127.08M (±€63.85M)
	Combined (0.50€ MUP & SSB tax)	-	€322.05M (±€63.68M)
Netherlands	Combined (0.50€ MUP, SSB tax & Volumetric tax)	-	€409.47M (±€63.61M)
	Inaction	-	-
	0.50€ MUP	€2.87M (±€1.28M)	€2.66M (±€1.69M)
	0.70€ MUP	€9.10M (±€1.28M)	€8.18M (±€1.69M)
	Volumetric Tax	€1.35M (±€1.28M)	€1.31M (±€1.70M)
	SSB Tax	€1.77M (±€1.28M)	€1.86M (±€1.70M)
	Food Marketing	€2.09M (±€1.28M)	€2.01M (±€1.70M)
Romania	Combined (0.50€ MUP & SSB tax)	€4.60M (±€1.28M)	€4.49M (±€1.69M)
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	€5.94M (±€1.28M)	€5.72M (±€1.69M)
	Inaction		
	0.50€ MUP	-	-
	0.70€ MUP	-	-
	Volumetric Tax	-	-
	SSB Tax	-	-
	Food Marketing	-	-
	Combined (0.50€ MUP & SSB tax)	-	-
	Combined (0.50€ MUP, SSB tax & Volumetric tax)	-	-

** CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.*
*** No cumulative costs for CLD could be estimated for France or Romania due to a lack of suitable cost data inputs*
Note: Predicted reductions are calculated based on 'cases in inaction scenario' minus 'cases in intervention scenario' for a given year.

France

Risk factor results: policy scenario relative to inaction scenario by country (absolute estimates)

The following sections report the prevalence of alcohol consumption and obesity projected to 2030. Percentage prevalence figures are provided alongside Monte-Carlo errors around the means are presented reflecting the accuracy of the microsimulation.

Alcohol (Table 8)

For the inaction scenario, the prevalence of alcohol consumption remained stable and high, with 16.3% [±5.15e-5] and 16.1% [±5.07e-5] of the population in the high-risk group in 2022 and 2030 respectively. There was no change in the low-risk group which remained at 56.4% from 2022 to 2030; and the moderate group remained stable and high at 27.3% [±6.22e-5] and 27.4% [±6.16e-5] in 2022 and 2030 respectively. Both the SSB tax and food marketing policy scenarios showed the same baseline static trends in alcohol consumption as the inaction scenario.

For the 0.50€ MUP policy scenario, the prevalence of alcohol consumption decreased in the high-risk group by 0.8% (from 16.1% [±5.07e-5] to 15.3% [±4.96e-5]) in 2030 compared to the inaction scenario; the low-risk group and moderate risk group remained stable (at 57.0% and 27.8% in 2030, respectively).

For the 0.70€ MUP policy scenario, the prevalence of alcohol consumption decreased in the high-risk group by 2.2% (from 16.1% [±5.07e-5] to 13.9% [±4.75e -5]) in 2030 compared to the inaction scenario. Similar trends for the other categories were observed.

For the volumetric tax policy scenario, the prevalence of alcohol consumption decreased in the high-risk group by 0.3% (from 16.1% [±5.07e-5] with inaction to 15.8% [±5.03e-5] with the volumetric tax) in 2030. Similar trends for the other categories were observed.

Finally, for combined policy scenario 1 (0.50€ MUP and SSB tax) the exact same trend in alcohol consumption was observed as the 0.50€ MUP scenario since SSB tax does not impact alcohol consumption. For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax), the prevalence of alcohol consumption decreased in the high-risk group by 1.1% (from 16.1% [±5.07e-5] to 15.0% [±4.96e-5]) in 2030 compared to the inaction scenario. Similar trends for the other categories were observed.

Obesity (Table 9)

For the inaction scenario, the healthy weight population decreased from 59.8% [±6.03e-5] to 56.4% [±6.01e-5] between 2022 and 2030; the pre-obese population remained stable at around 24.8%; and the obese population increased from 15.3% [±4.86e-5] to 18.7% [±5.15e-5] from 2022 to 2030. No changes in these scenarios were observed with either MUP or volumetric tax policy scenarios.

For the SSB tax policy scenario, the obese population decreased by 1.2% (from 18.7% [±5.15e-5] to 17.5% [±5.03e-5]) in 2030 compared to the inaction scenario; and the healthy weight population increased by 1.1% (from 56.4% [±6.01e-5] to 57.5% [±6.02e-5]) with the pre-obese population remaining stable at around 25%. Both the combined policy scenario 1 (0.50€ MUP and SSB tax) and combined policy scenario 2 (0.50€ MUP, an SSB tax, and a volumetric tax) showed the exact same trend in obesity as the SSB tax policy scenario individually across the period.

For the food marketing policy scenario, the proportion of the population considered obese decreased by 1.4% (from 18.7% [±5.15e-5] to 17.3% [±5.01e-5]) in 2030 compared to the inaction scenario. The pre-obese population increased by 0.1% in 2030 compared to the inaction scenario (from 24.8% [±5.69e-5] to 24.9% [±5.69e-5]).

Disease Results (absolute estimates)

Annual incidence and predicted reduction in incidence (Table 10 and Table 11)

Figure 3 and Figure 4 present the annual total population incidence by inaction or intervention scenario for CLD and liver cancer respectively in France in 2022, 2026 and 2030. Sub-plots show a sub-section of the larger plot so that differences can be read more clearly. Figure 5 and Figure 6 present the predicted reduction in annual absolute CLD incidence following interventions relative to the inaction scenario in France.

For the inaction scenario, the annual incidence of CLD in France was estimated to be stable between 2022 and 2030 (from 11,993 [±176] in 2022 to 11,941 [±175] in 2030). However, the annual incidence of liver cancer was estimated to increase by 1,324 cases (from 10,238 [±162] in 2022 to 11,562 [±172] in 2030) over this same period. All policy scenarios resulted in a reduction in disease incidence relative to the inaction scenario.

For the 0.50€ MUP policy scenario, the annual incidence of CLD in 2030 was projected to decrease by 248 cases (from 11,941 [±175] to 11,693 [±173]) and liver cancer was projected to decrease by 221 cases (from 11,562 [±172] to 11,341 [±171]) relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the annual incidence of CLD in 2030 was projected to decrease by 764 cases (from 11,941 [±175] to 11,177 [±170]) and liver cancer was projected to decrease by 683 cases (from 11,562 [±172] to 10,879 [±167]) relative to the inaction scenario.

For the volumetric tax policy scenario, the annual incidence of CLD was not projected to change significantly in 2030 relative to the inaction scenario (11,941 [±175] relative to 11,832 (±174)) . Similarly, the annual incidence of liver cancer was not expected to change significantly in 2030 relative to the inaction scenario (11,562 [±172] relative to 11,459 [±171]).

For the SSB tax policy scenario, the annual incidence of CLD in 2030 was projected to decrease by 176 cases (from 11,941 [±175] to 11,765 [±174]) relative to the inaction scenario. However, the annual incidence of liver cancer in 2030 was not projected to change significantly compared to the inaction scenario (11,562 [±172] relative to 11,418 [±171]).

For the food marketing policy scenario, the annual incidence of CLD was projected to decrease by 197 cases (from 11,941 [±175] to 11,744 [±174]) in 2030 relative to the inaction scenario. However, the annual incidence of liver cancer in 2030 was not projected to change significantly compared to the inaction scenario (11,562 [±172] relative to 11,411 [±171]).

For the combined policy scenario consisting of a 0.50€ MUP and an SSB tax, the annual incidence of CLD was projected to decrease by 421 cases (from 11,941 [±175] to 11,520 [±172]) and liver cancer was projected to decrease by 361 cases (from 11,562 [±172] to 11,201 [±170]) in 2030 relative to the inaction scenario.

For the combined policy scenario consisting of a 0.50€ MUP, an SSB tax and a volumetric tax, the annual incidence of CLD was projected to decrease by 531 cases (from 11,941 [±175] to 11,410 [±171]) and liver cancer was projected to decrease by 452 cases (from 11,562 [±172] to 11,110 [±169]) in 2030 relative to the inaction scenario.

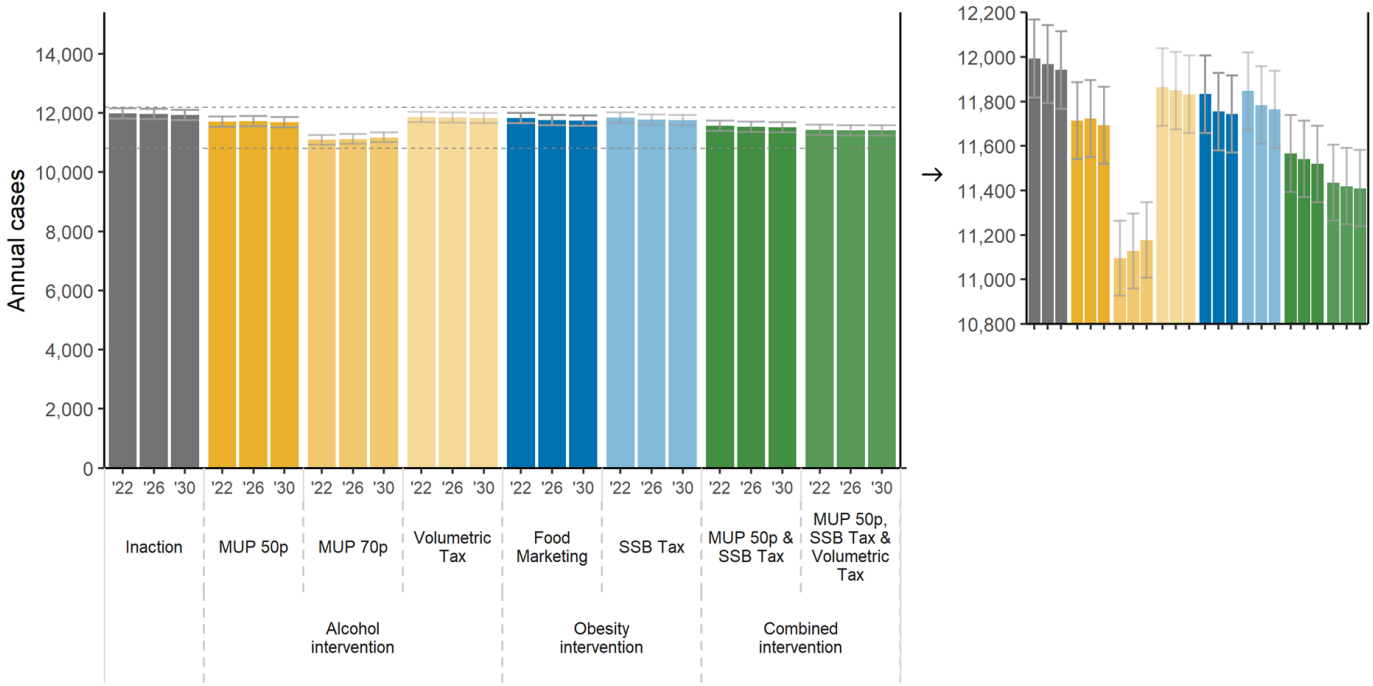

Figure 3: Annual total population incidence (number of new cases per year) by inaction or intervention scenario for CLD in France in 2022, 2026 and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

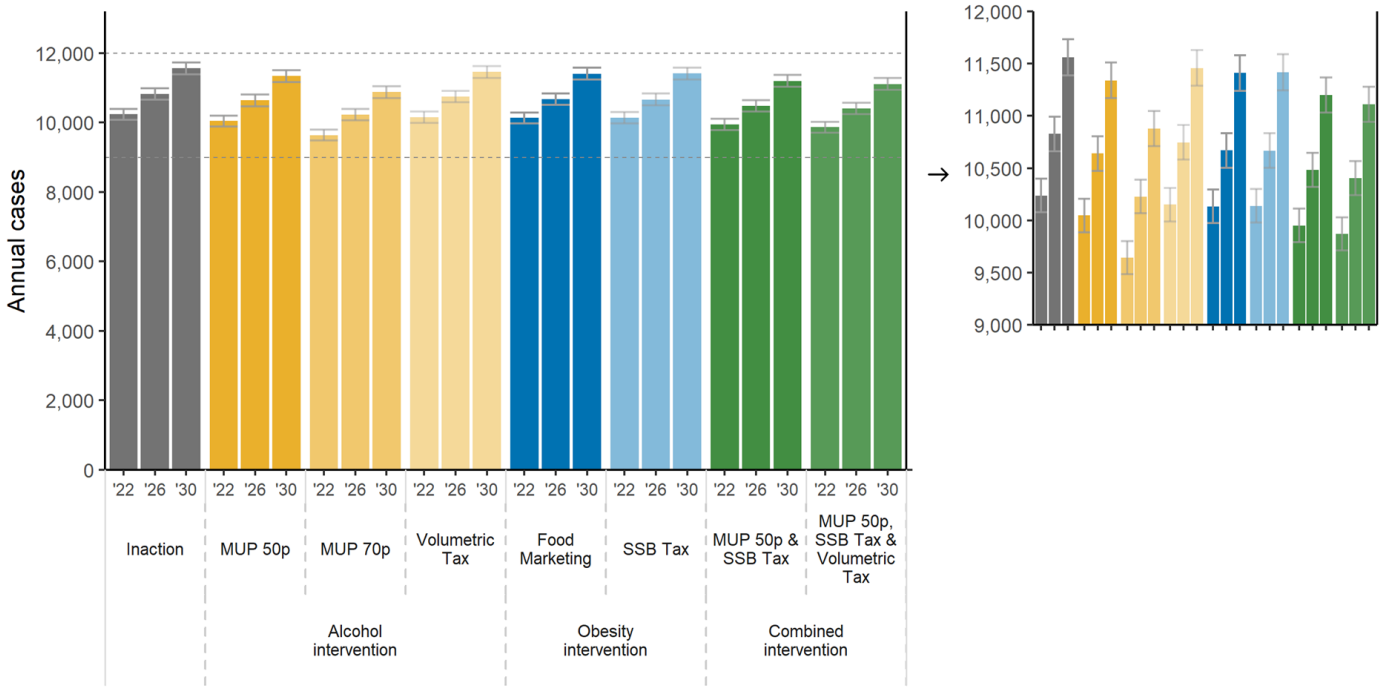

Figure 4: Annual total population incidence (number of new cases per year) by inaction or intervention scenario for liver cancer in France in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

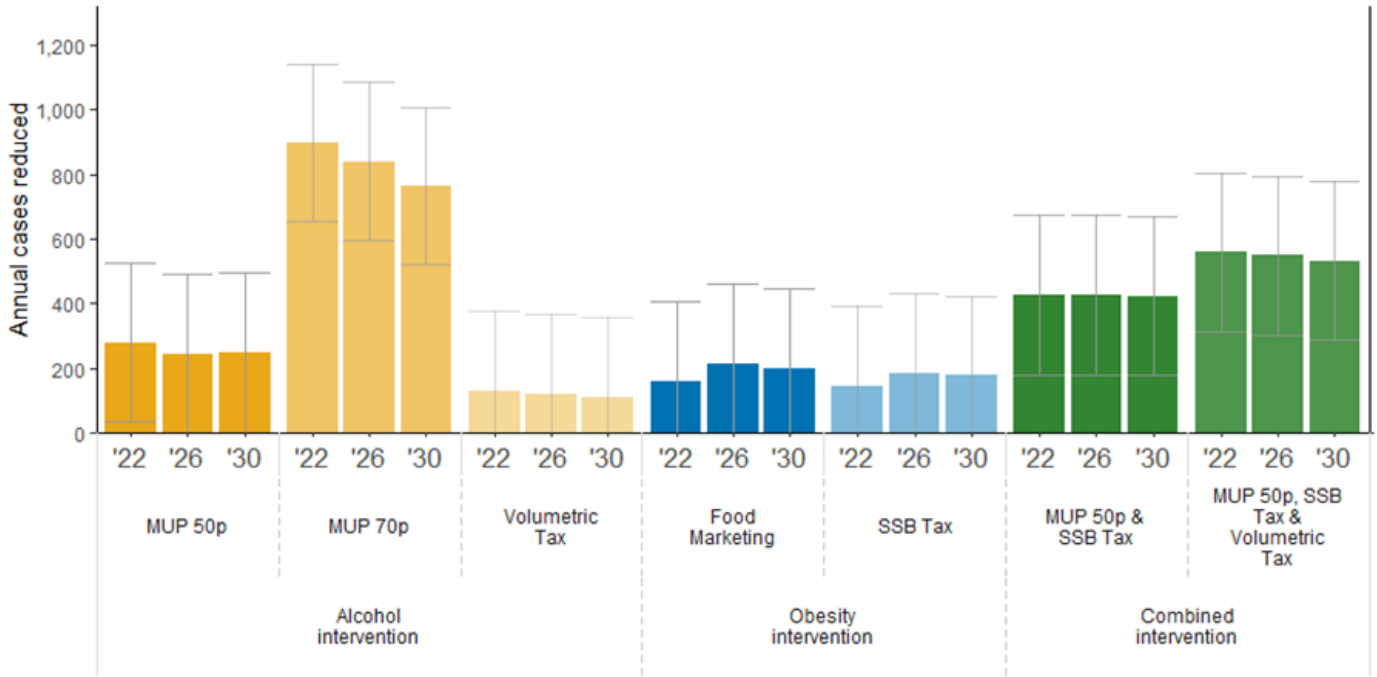

Figure 5: Predicted reduction in annual absolute CLD incidence following interventions relative to the inaction scenario in France in 2022, 2026, and 2030.

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

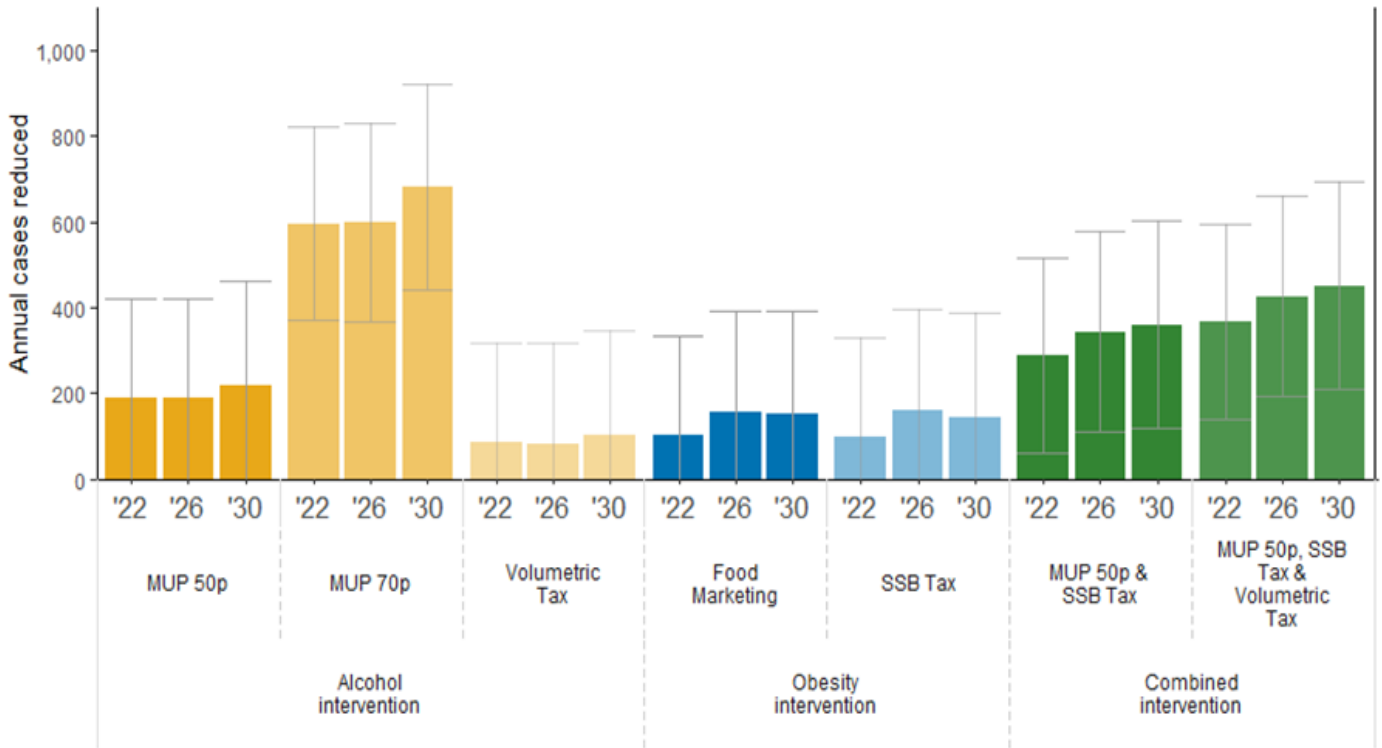

Figure 6: Predicted reduction in annual absolute liver cancer incidence following interventions relative to the inaction scenario in France in 2022, 2026, and 2030 .
MUP, minimum unit pricing; SSB, sugar sweetened beverage tax.
Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Cumulative incidence/ predicted reduction in incidence (Table 10 and Table 11)

Figure 7 and Figure 8 present the cumulative absolute incidence by inaction or interventions for CLD and liver cancer respectively in 2022, 2026, and 2030. Figure 9 and Figure 10 present the predicted cumulative reduction in absolute incidence for CLD and liver cancer respectively following interventions compared to the inaction scenario in France.

In the inaction scenario, the cumulative incidence of CLD between 2022 and 2030 was estimated to be 107,660 [±526] in the total population. The cumulative incidence of liver cancer during the same period was estimated to be 97,785 [±501].

For the 0.50€ MUP policy scenario, the cumulative incidence of CLD was projected to decrease by 2,364 cases (from 107,660 [±526] to 105,296 [±520]) and liver cancer was projected to decrease by 1,885 cases (from 97,785 [±501] to 95,900 [±496]) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative incidence of CLD was projected to decrease by 7,632 cases (from 107,660 [±526] to 100,028 [±507]) and liver cancer was projected to decrease by 5,705 cases (from 97,785 [±501] to 92,080 [±486]) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the cumulative incidence of CLD was projected to decrease by 1,087 cases (from 107,660 [±526] to 106,573 [±524]) and liver cancer was projected to decrease by 830 cases (from 97,785 [±501] to 96,955 [±499]) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the cumulative incidence of CLD was projected to decrease by 1,500 cases (from 107,660 [±526] to 106,160 [±523]) and liver cancer was projected to decrease by 1,207 cases (from 97,785 [±501] to 96,578 [±498]) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the cumulative incidence of CLD was projected to decrease by 1,706 cases (from 107,660 [±526] to 105,954 [±522]) and liver cancer was projected to decrease by 1,264 cases (from 97,785 [±501] to 96,521 [±498]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario consisting of a 0.50€ MUP and an SSB tax, the cumulative incidence of CLD was projected to decrease by 3,851 cases (from 107,660 [±526] to 103,809 [±517]) and liver cancer was projected to decrease by 3,057 cases (from 97,785 [±501] to 94,728 [±493]) between 2022 and 2030 relative to the inaction scenario.
For the combined policy scenario consisting of a 0.50€ MUP, an SSB tax and a volumetric tax, the cumulative incidence of CLD was projected to decrease by 4,922 cases (from 107,660 [±526] to 102,738 [±514]) and liver cancer was projected to decrease by 3,866 cases (from 97,785 [±501] to 93,919 [±491]) between 2022 and 2030 relative to the inaction scenario.

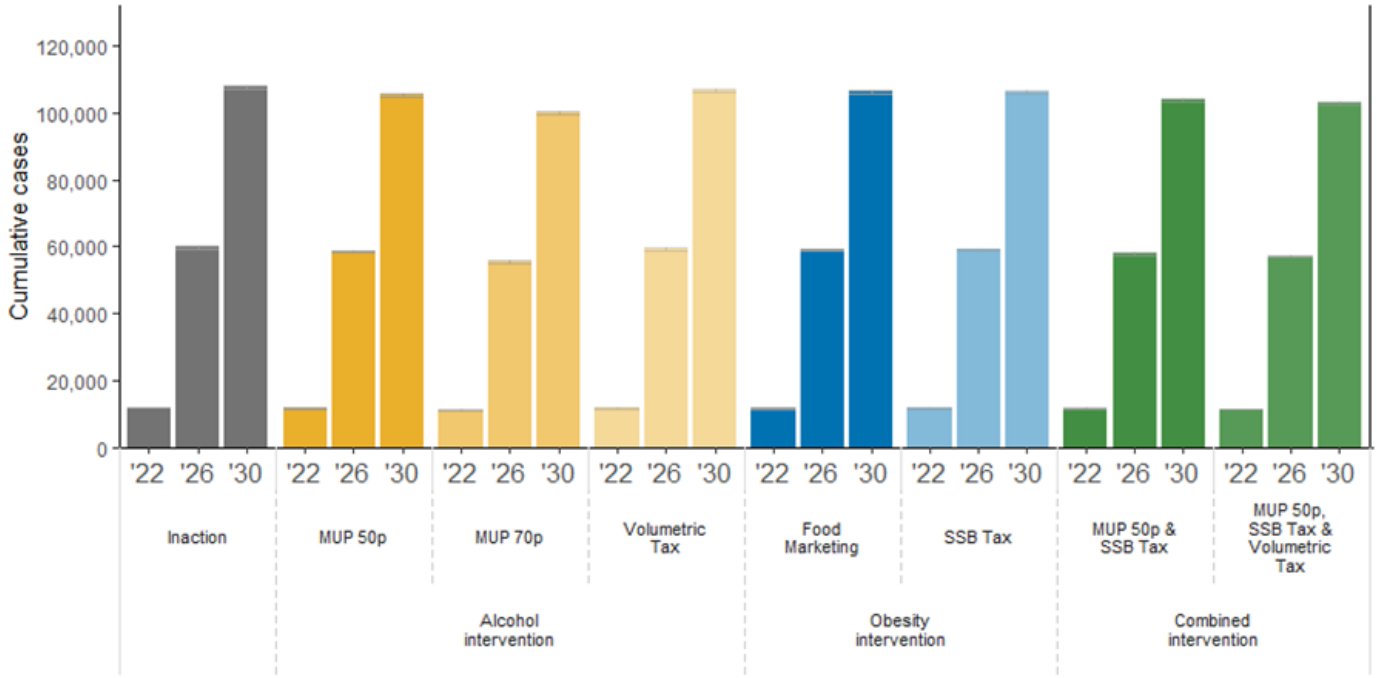

Figure 7: Cumulative absolute incidence by inaction or intervention scenario for CLD in France in 2022, 2026, and 2030
MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

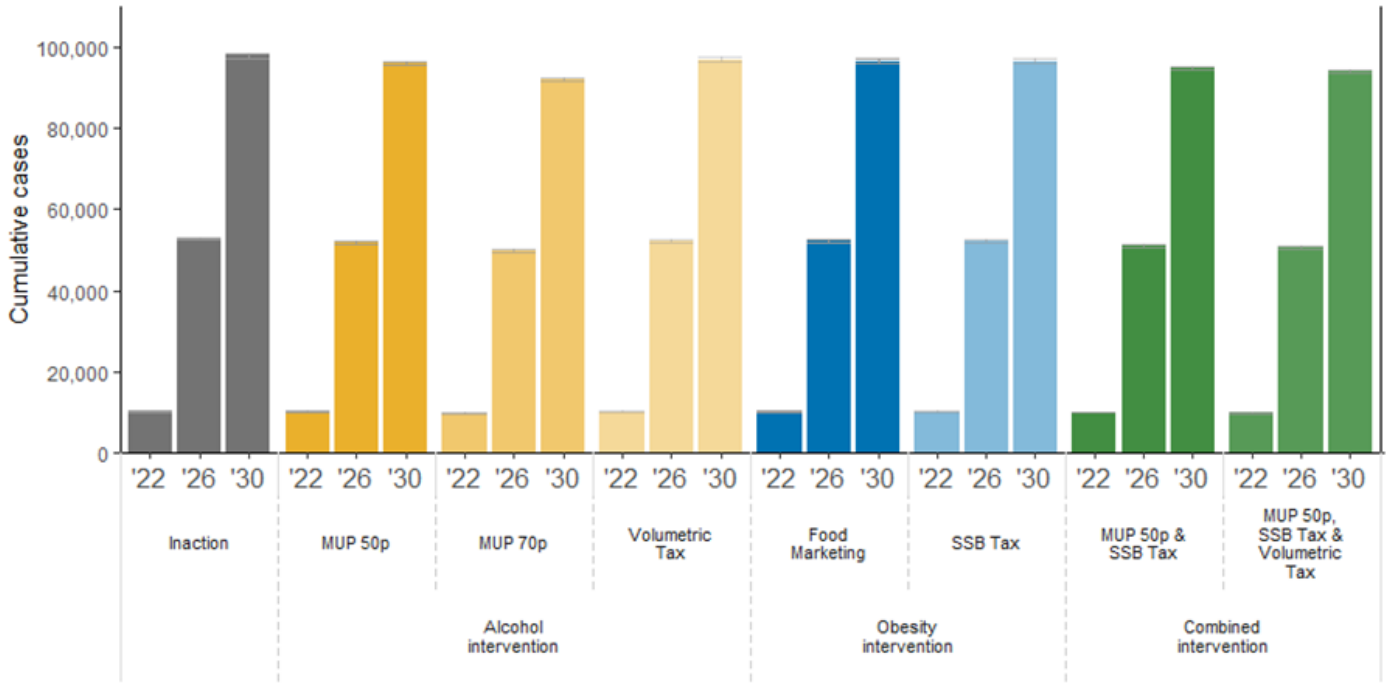

Figure 8: Cumulative absolute incidence by inaction or intervention scenario for liver cancer in France in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

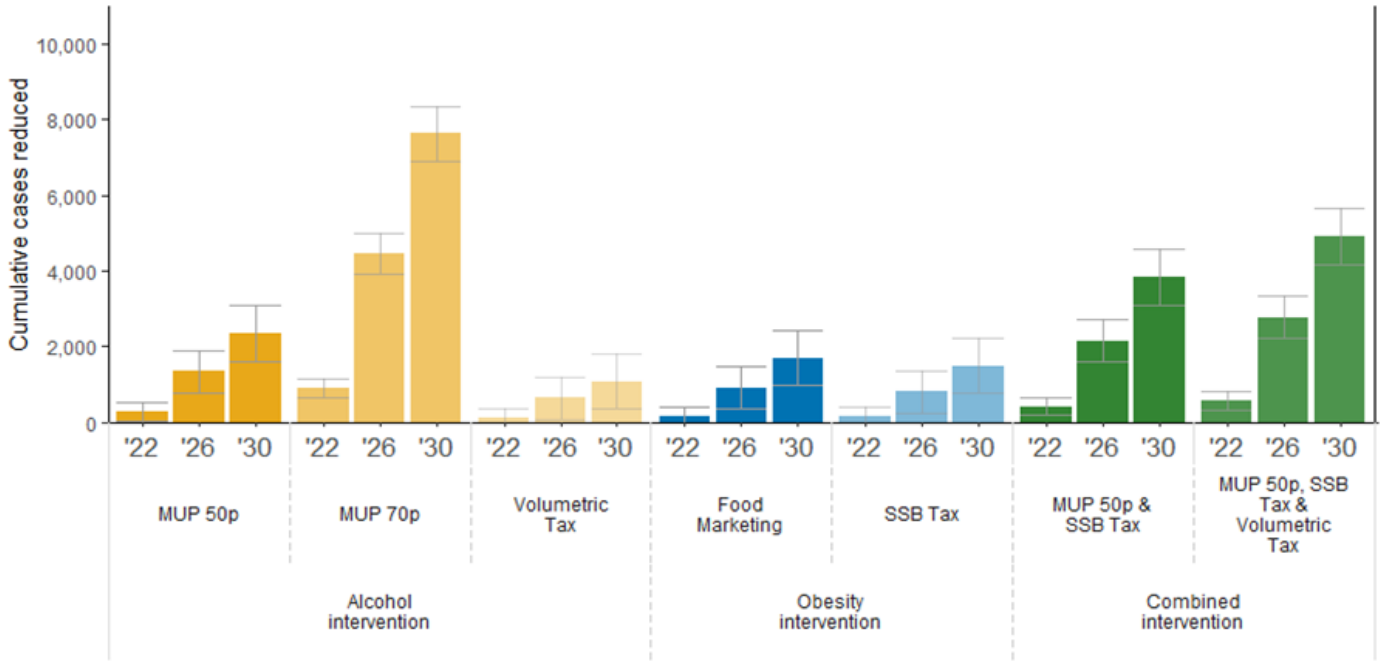

Figure 9: Predicted cumulative reduction in absolute incidence for CLD following interventions compared to the inaction scenario in France in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

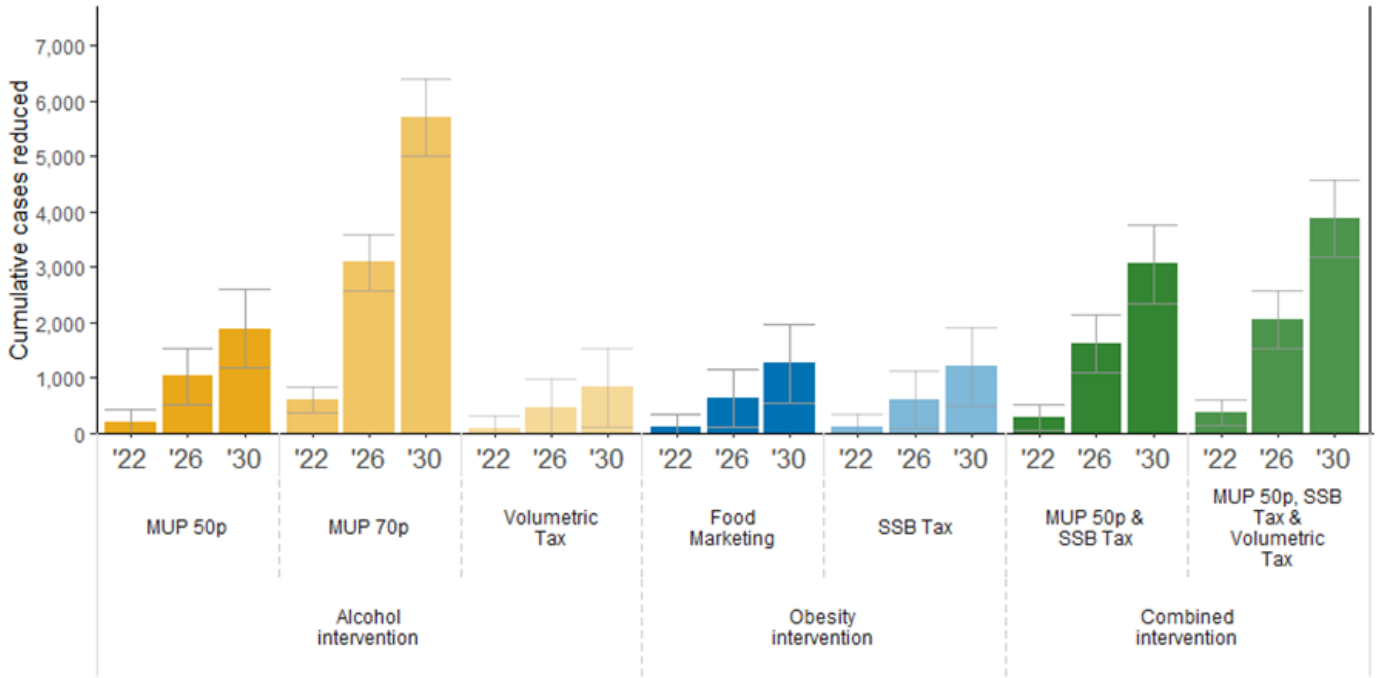

Figure 10: Predicted cumulative reduction in absolute incidence for liver cancer following interventions compared to the inaction scenario in France in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and end of the last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4. MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Premature and specific mortality results (absolute estimates)

Premature mortality/ predicted reduction in premature mortality relative to the inaction scenario between 2022 and 2030 (Table 14)

For the inaction scenario, the cumulative premature mortality between 2022 and 2030 was estimated to be 1,212,781.

For the 0.50€ MUP policy scenario, the cumulative premature mortality was projected to decrease by 232 cases (from 1,212,781 to 1,212,549) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, cumulative premature mortality was projected to decrease by 840 cases (from 1,212,781 to 1,211,941) relative to the inaction scenario between 2022 and 2030.

For the volumetric tax policy scenario, cumulative premature mortality was projected to decrease by 121 cases (from 1,212,781 to 1,212,660) between 2022 and 2030 relative to the inaction scenario.
For the SSB tax policy scenario, cumulative premature mortality was projected to decrease by 204 cases (from 1,212,781 to 1,212,577) between 2022 and 2030 relative to the inaction scenario.
For the food marketing policy scenario, cumulative premature mortality was projected to decrease by 216 cases (from 1,212,781 to 1,212,565) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and an SSB tax), cumulative premature mortality was projected to decrease by 445 cases (from 1,212,781 to 1,212,336) relative to the inaction scenario and for the combined policy scenario consisting of a 0.50€ MUP, an SSB tax and a volumetric tax, cu-

mulative premature mortality was projected to decrease by 616 cases (from 1,212,781 to 1,212,165) between 2022 and 2030 relative to the inaction scenario.

Table 14: Cumulative predicted reduction in premature mortality for France compared to the inaction scenario (absolute estimates) from 2022-2030

Scenario	Estimated reduction in cumulative premature mortality by 2030
MUP 0.50€	232
MUP 0.70€	840
Volumetric Tax	121
SSB Tax	204
Food Marketing	216
MUP 0.50€ and SSB Tax	445

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Specific cumulative mortality estimates (CLD and liver cancer absolute estimates) (Table 12)

For the inaction scenario, the total cumulative number of CLD and liver cancer deaths was estimated to be 58,908 and 49,118 respectively between 2022 and 2030.

For the 0.50€ MUP policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 69 and 393 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 300 and 1,253 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 31 and 172 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 54 and 250 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 60 and 266 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the 0.50€ MUP and an SSB tax combined policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 121 and 633 cases respectively between 2022 and 2030 relative to the inaction scenario. Finally, for the 0.50€ MUP, an SSB tax and a volumetric tax combined policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 182 and 815 cases respectively between 2022 and 2030 relative to the inaction scenario.

Disability Adjusted Life Years (absolute estimates)

Predicted reduction in cumulative DALYs (Table 12)

Figure 11 presents the total predicted cumulative reduction in DALYs between 2022 and 2030 following different policy interventions compared to the inaction scenario in France. There is a large amount of error around the projections so interpretation is made with caution. However, the analyses suggest that policies reduce DALYs over time.

For the inaction scenario, the number of DALYs lost to CLD and liver cancer was estimated to be 18,164,075 between 2022 and 2030.

For the 0.50€ MUP policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 10,229 (from 18,164,075 to 18,153,846) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 30,459 (from 18,164,075 to 18,133,615) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 4,602 (from 18,164,075 to 18,159,473) between 2022 and 2030 relative to the inaction scenario.
For the SSB tax policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 7,129 (from 18,164,075 to 18,156,946) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 7,384 (from 18,164,075 to 18,156,691) between 2022 and 2030 relative to the inaction scenario.

For the 0.50€ MUP and SSB tax combined policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 17,435 (from 18,164,075 to 18,146,639) between 2022 and 2030 relative to the inaction scenario.

Finally, for the 0.50€ MUP, SSB tax, and a volumetric tax combined policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 22,063 (from 18,164,075 to 18,142,011) between 2022 and 2030 relative to the inaction scenario.

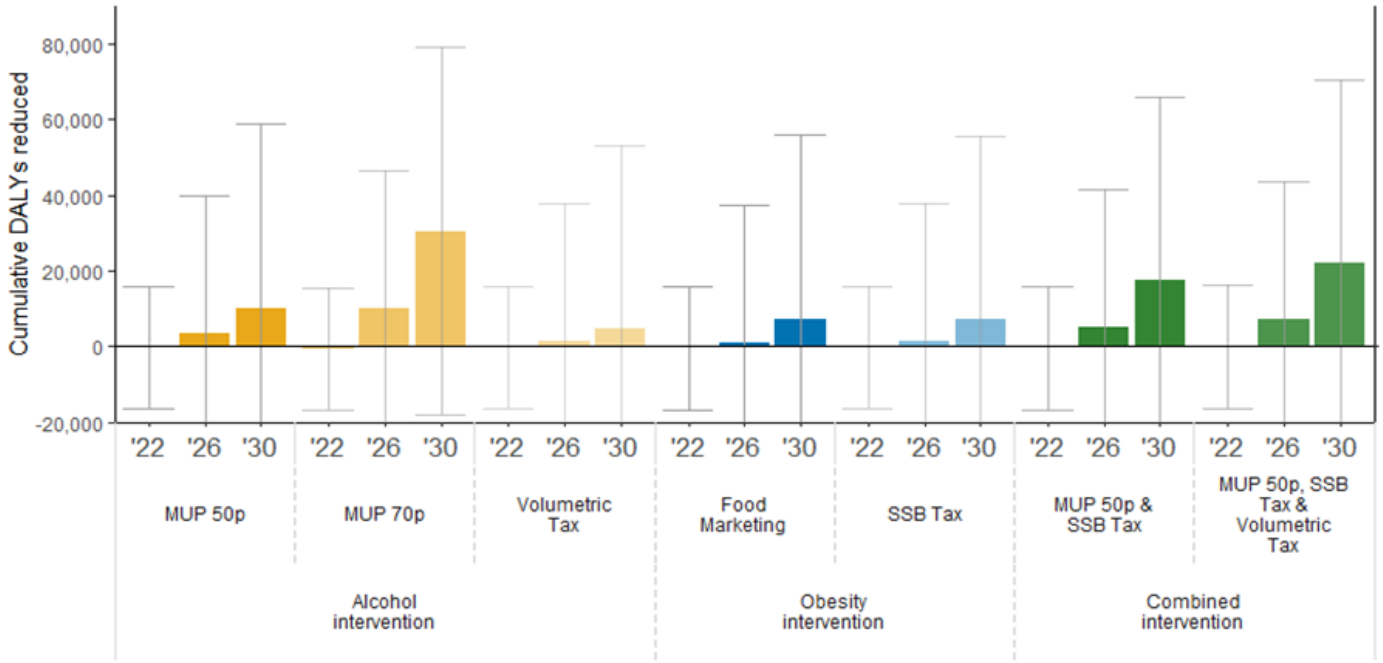

Figure 11: Predicted cumulative reduction in DALYs by 2022, 2026, and 2030 following different policy interventions compared to the inaction scenario in France

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Note: Each intervention occurs once at the beginning of year 2022, while the outputs presented in this figure show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and end of the last year (2030).

Cumulative direct cost (Table 13)

Figure 12 presents the predicted reduction in the cumulative direct healthcare cost for liver cancer in France between 2022 and 2030 as a result of the policy scenarios relative to the inaction scenario (absolute estimates). For the inaction scenario, it is estimated that the cumulative direct cost for liver cancer will be €22.61B [±€0.05B] between 2022 and 2030. There was no cost estimate for CLD in France.

For the 0.50€ MUP policy scenario, the cumulative direct cost for liver cancer was projected to decrease by €203.09M (from €22.61B [±€0.05B] to €22.41B [±€0.04B]) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative direct cost for liver cancer was projected to decrease by €612.49M (from €22.61B [±€0.05B] to €22.00B [±€0.04B]) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the cumulative direct cost for liver cancer was projected to decrease by €89.61M (from €22.61B [±€0.05B] to €22.52B [±€0.05B]) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the cumulative direct cost for liver cancer was projected to decrease by €122.38M (from €22.61B [±€0.05B] to €22.49B [±€0.05B]) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the cumulative direct cost for liver cancer was projected to decrease by €127.08M (from €22.61B [±€0.05B] to €22.49B [±€0.05B]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and an SSB tax), the cumulative direct cost for liver

cancer was projected to decrease by €322.05M (from €22.61B [±€0.05B] to €22.29B [±€0.04B]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 2 (0.50€ MUP, an SSB tax, and a volumetric tax), the cumulative direct cost for liver cancer was projected to decrease by €409.47M (from €22.61B [±€0.05B] to €22.20B [±€0.04B]) between 2022 and 2030 relative to the inaction scenario.

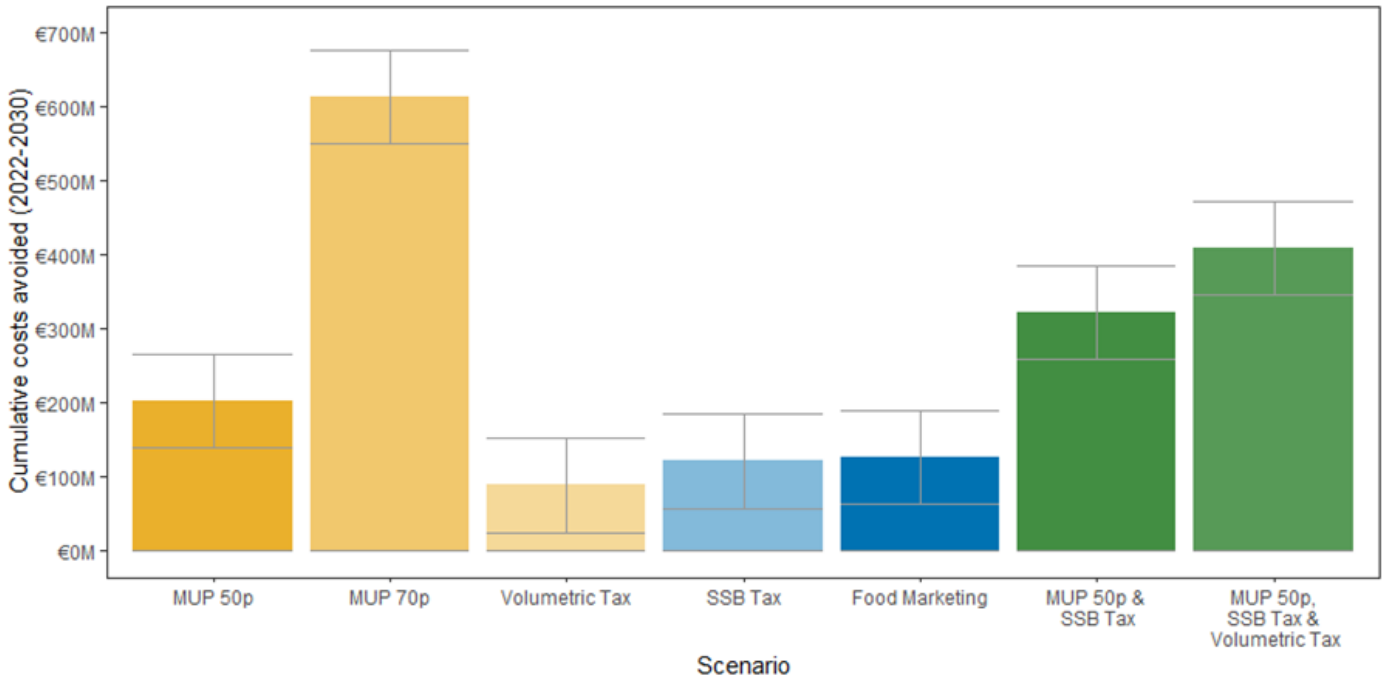

Figure 12: Predicted reduction in the cumulative direct healthcare costs for liver cancer in France between 2022 and 2030 as a result of the policy scenarios relative to the inaction scenario

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Note: CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Netherlands

Risk factor results

Alcohol (Table 8)

For the inaction scenario, the prevalence of alcohol consumption remained stable and high for the high-risk group: 11.2% [±4.38e -5] and 11.1% [±4.33e -5] in 2022 and 2030 respectively. Similarly, the moderate group remained stable and high at 26.4% [±6.14e -5] and 26.5% [±6.11e -5] in 2022 and 2030 respectively. There was no change in the low-risk group which remained at 62.4% from 2022 to 2030; Both the SSB tax and food marketing policy scenarios showed the same baseline static trends in alcohol consumption as the inaction scenario. All other policy scenarios resulted in a reduction in alcohol consumption relative to the inaction scenario.

For the 0.50€ MUP policy scenario, the prevalence of alcohol consumption decreased in the high-risk group by 0.7% (from 11.1% [±4.33e-5] to 10.4% [±4.24e-5]) in 2030 relative to the inaction scenario; the low-risk group and moderate risk group remained stable (at 62.9% and 26.7% in 2030, respectively).

For the 0.70€ MUP policy scenario, the prevalence of alcohol consumption decreased in the high-risk group by 1.8% (from 11.1% [±4.33e-5] to 9.3% [±3.98e -5]) in 2030 compared to the inaction scenario. Similar trends for the other categories were observed.

For the volumetric tax policy scenario, the prevalence of alcohol consumption decreased in the high-risk group by 0.3% (from 11.1% [±4.33e-5] to 10.8% [±4.29e-5]) in 2030 compared to the inaction scenario. Similar trends for the other categories were observed.

Finally, for the combined policy scenario 1 (0.50€ MUP and SSB tax), the exact same trend in alcohol consumption was seen as the 0.50€ MUP scenario individually across the period. For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax), the prevalence of alcohol consumption decreased in the high-risk group by 0.9% (from 11.1% [±4.33e-5] to 10.2% [±4.18e-5]) in 2030. Similar trends for the other categories were observed.

Obesity (Table 9)

For the inaction scenario, the healthy weight population decreased from to 57.9% [±6.20e-5] to 54.9% [±6.20e-5] between 2022 and 2030; the pre-obese population increased from 29.2% [±6.01e-5] to 29.7% [±6.03e-5]; and the obese population increased from 12.9% [±4.57e-5] to 15.3% [±4.86e-5] from 2022 to 2030. The 0.50€ MUP, 0.70€ MUP, and volumetric tax policy scenarios all showed the exact same trends in obesity as the inaction scenario across the simulation period since these policies were not impacting BMI.

For the SSB tax policy scenario, the obese population decreased by 1.5% (from 15.3% [±4.86e-5] to 13.8% [±4.68e-5]) in 2030 compared to the inaction scenario; the healthy weight population increased by 1.1% (from 54.9% [±6.20e-5] to 56.0% [±6.22e-5]) and the pre-obese population increased by 0.5% (from 29.7% [±6.03e-5] to 30.2% [±4.68e-5]). Both combined policy scenario 1 (0.50€ MUP and SSB tax) and combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax) showed the exact same trend in obesity as the SSB tax policy scenario individually across the period.

For the food marketing policy scenario, the proportion of the population considered obese decreased by 1.6% (from 15.3% [±4.86e-5] to 13.7% [±4.66e-5]) in 2030 compared to the inaction scenario; similar trends were observed for the other categories.

Disease results

Annual incidence/ predicted reduction in incidence (Table 10 and Table 11)

Figure 13 and Figure 14 presents the annual total population incidence (number of new cases per year) by inaction or intervention scenario for CLD and liver cancer respectively in 2022, 2026, and 2030. Figure 15 and Figure 16 presents the predicted reduction in annual absolute CLD and liver cancer incidence respectively following interventions relative to the inaction scenario in 2022, 2026, and 2030.

For the inaction scenario, the annual incidence of CLD in the Netherlands was estimated to be stable between 2022 to 2030 (from 2,302 [±39] to 2,276 [±39]). However, the annual incidence of liver cancer was estimated to increase by 114 cases (from 994 [±26] to 1,107 [±27]) over this same period.

Both combined intervention scenarios and the 0.70€ MUP scenario showed a significant reduction in the annual incidence of CLD and liver cancer compared to the inaction scenario. Little change was observed for the other policy scenarios.

For the 0.50€ MUP policy scenario, the annual incidence of CLD in 2030 was projected to decrease by 46 cases (from 2,276 [±39] to 2,230 [±39]) relative to the inaction scenario. However, the annual incidence of liver cancer in 2030 was not projected to change significantly (from 1,107 [±27] to 1,087 [±27]) relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the annual incidence of CLD in 2030 was projected to decrease by 144 cases (from 2,276 [±39] to 2,132 [±38]) and the annual incidence of liver cancer was projected to decrease by 59 cases (from 1,107 [±27] to 1,048 [±27]) relative to the inaction scenario.

For the volumetric tax policy scenario, both the annual incidence of CLD (from 2,276 [±39] to 2,252 [±39]) and liver cancer (from 1,107 [±27] to 1,097 [±27]) were not projected to change significantly in 2030 relative to the inaction scenario.

For the SSB tax policy scenario, both the annual incidence of CLD (from 2,276 [±39] to 2,242 [±39]) and liver cancer (from 1,107 [±27] to 1,089 [±27]) were not projected to change significantly in 2030 relative to the inaction scenario.

For the food marketing policy scenario, both the annual incidence of CLD (from 2,276 [±39] to 2,236 [±39]) and liver cancer (from 1,107 [±27] to 1,088 [±27]) were not projected to change significantly in 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and SSB tax), the annual incidence of CLD was projected to decrease by 80 cases (from 2,276 [±39] to 2,196 [±38]) and liver cancer was projected to decrease by 39 cases (from 1,107 [±27] to 1,068 [±27]) in 2030 relative to the inaction scenario.

For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax), the annual incidence of CLD was projected to decrease by 99 cases (from 2,276 [±39] to 2,177 [±38]) and liver cancer was projected to decrease by 48 cases (from 1,107 [±27] to 1,059 [±27]) in 2030 relative to the inaction scenario.

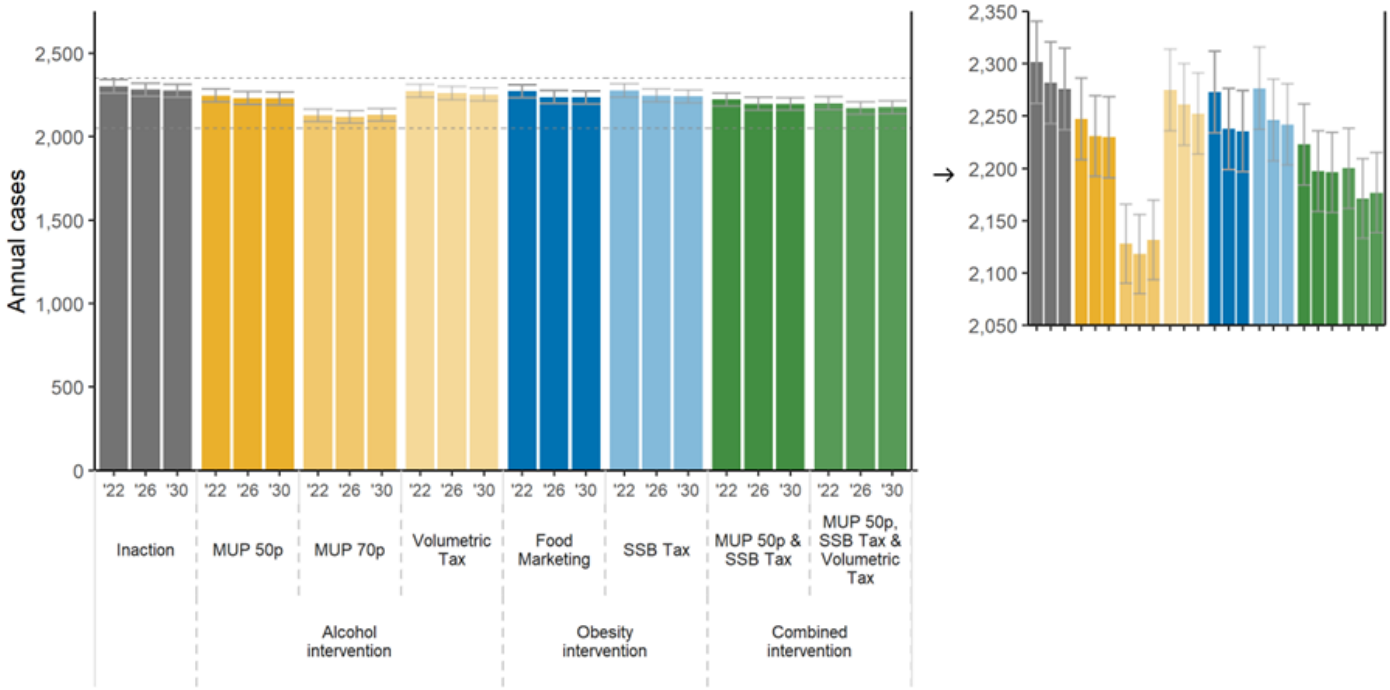

Figure 13: Annual total population incidence (number of new cases per year) by inaction or intervention scenario for CLD in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

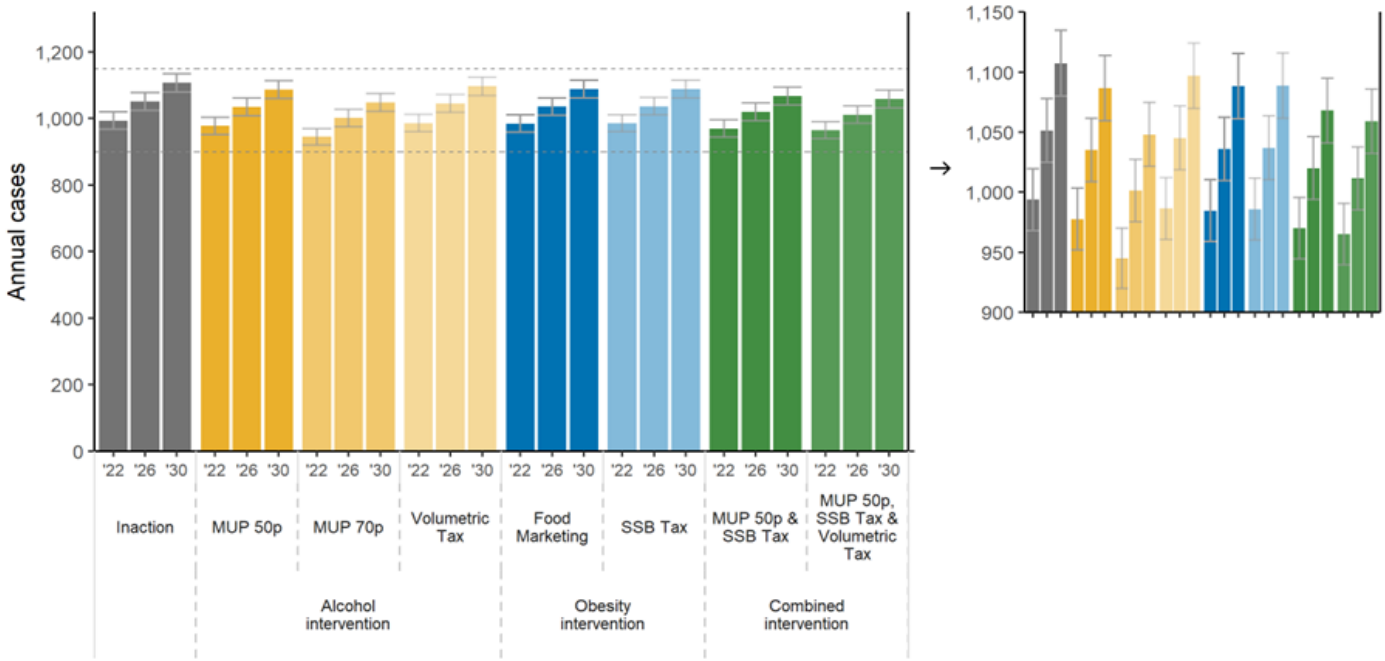

Figure 14: Annual total population incidence (number of new cases per year) by inaction or intervention scenario for liver cancer in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

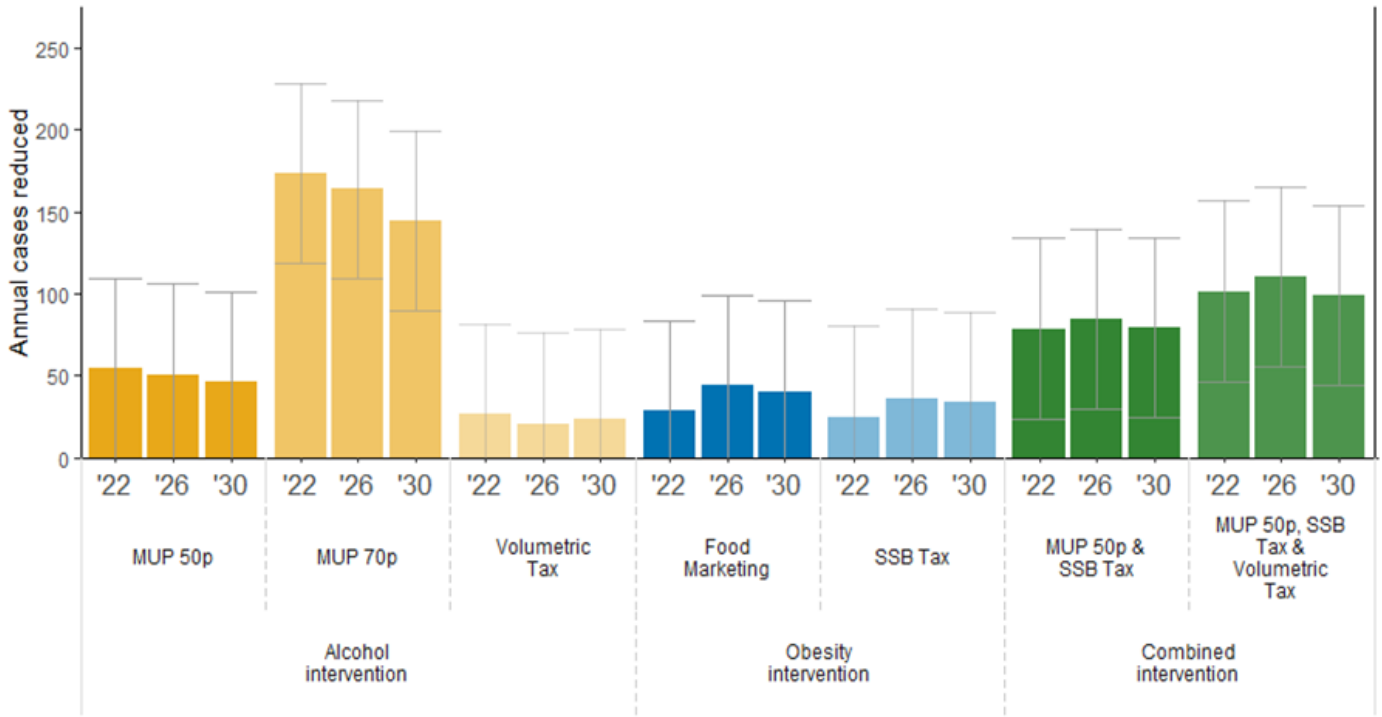

Figure 15: Predicted reduction in annual absolute CLD incidence following interventions relative to the inaction scenario in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

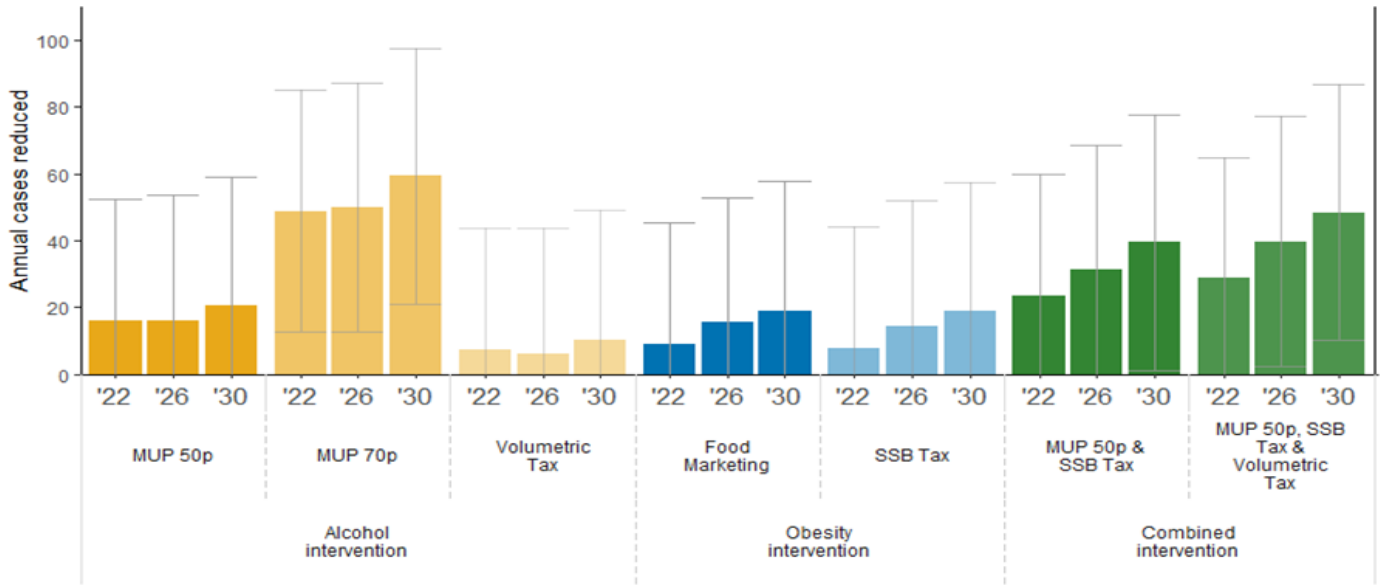

Figure 16: Predicted reduction in annual absolute liver cancer incidence following interventions relative to the inaction scenario in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Cumulative incidence/ predicted reduction in incidence (Table 10 and Table 11)

Figure 17 and Figure 18 present the cumulative absolute incidence by inaction or interventions for CLD and liver cancer in 2022, 2026, and 2030 respectively. Figure 19 and Figure 20 present the predicted reduction in cumulative absolute incidence for CLD and liver cancer respectively following interventions compared to the inaction scenario.

In the inaction scenario, the cumulative incidence of CLD in the Netherlands was estimated to reach 20,499 [±117] between 2022 and 2030 in the total population. The cumulative incidence of liver cancer was estimated to reach 9,401 [±80] cases over the same period. The policy scenarios all result in a reduction in disease incidence relative to the inaction scenario.

For the 0.50€ MUP policy scenario, the cumulative incidence of CLD was projected to decrease by 449 cases (from 20,499 [±117] to 20,050 [±116]) and liver cancer was projected to decrease by 149 cases (from 9,401 [±80] to 9,251 [±79]) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative incidence of CLD was projected to decrease by 1,459 cases (from 20,499 [±117] to 19,040 [±113]) and liver cancer was projected to decrease by 452 cases (from 9,401 [±80] to 8,949 [±78]) between 2022 and 2030 relative to the inaction scenario.
For the volumetric tax policy scenario, the cumulative incidence of CLD was projected to decrease by 207 cases (from 20,499 [±117] to 20,292 [±117]) and liver cancer was projected to decrease by 72 cases (from 9,401 [±80] to 9,329 [±79]) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the cumulative incidence of CLD was projected to decrease by 289 cases (from 20,499 [±117] to 20,210 [±117]) and liver cancer was projected to decrease by 118 cases (from 9,401 [±80] to 9,283 [±79]) between 2022 and 2030 relative to the inaction scenario.
For the food marketing policy scenario, the cumulative incidence of CLD was projected to decrease by 342 cases (from 20,499 [±117] to 20,157 [±116]) and liver cancer was projected to decrease by 124 cases (from 9,401 [±80] to 9,277 [±79]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and an SSB tax), the cumulative incidence of CLD was projected to decrease by 730 cases (from 20,499 [±117] to 19,769 [±115]) and liver cancer was projected to decrease by 264 cases (from 9,401 [±80] to 9,137 [±79]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax), the cumulative incidence of CLD was projected to decrease by 964 cases (from 20,499 [±117] to 19,553 [±115]) and liver cancer was projected to decrease by 332 cases (from 9,401 [±80] to 9,069 [±78]) between 2022 and 2030 relative to the inaction scenario.

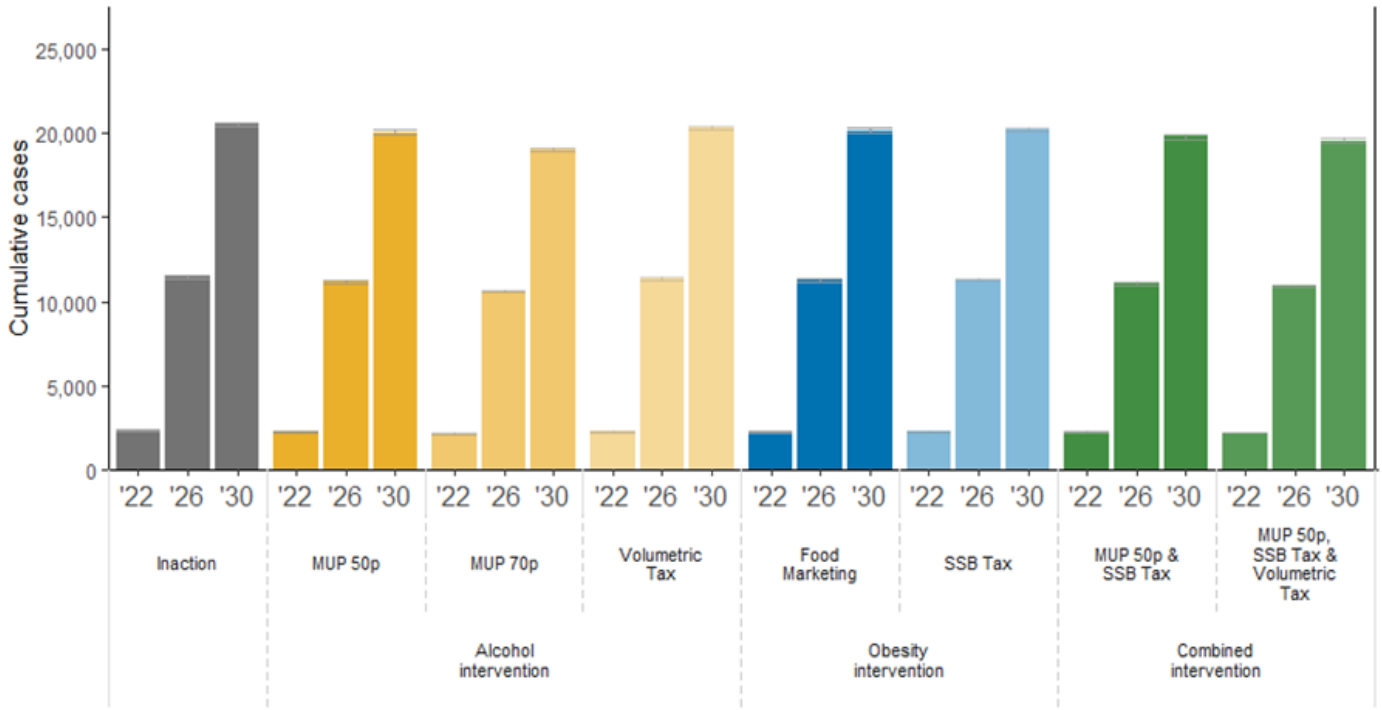

Figure 17: Cumulative absolute incidence by inaction or intervention scenarios for CLD in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

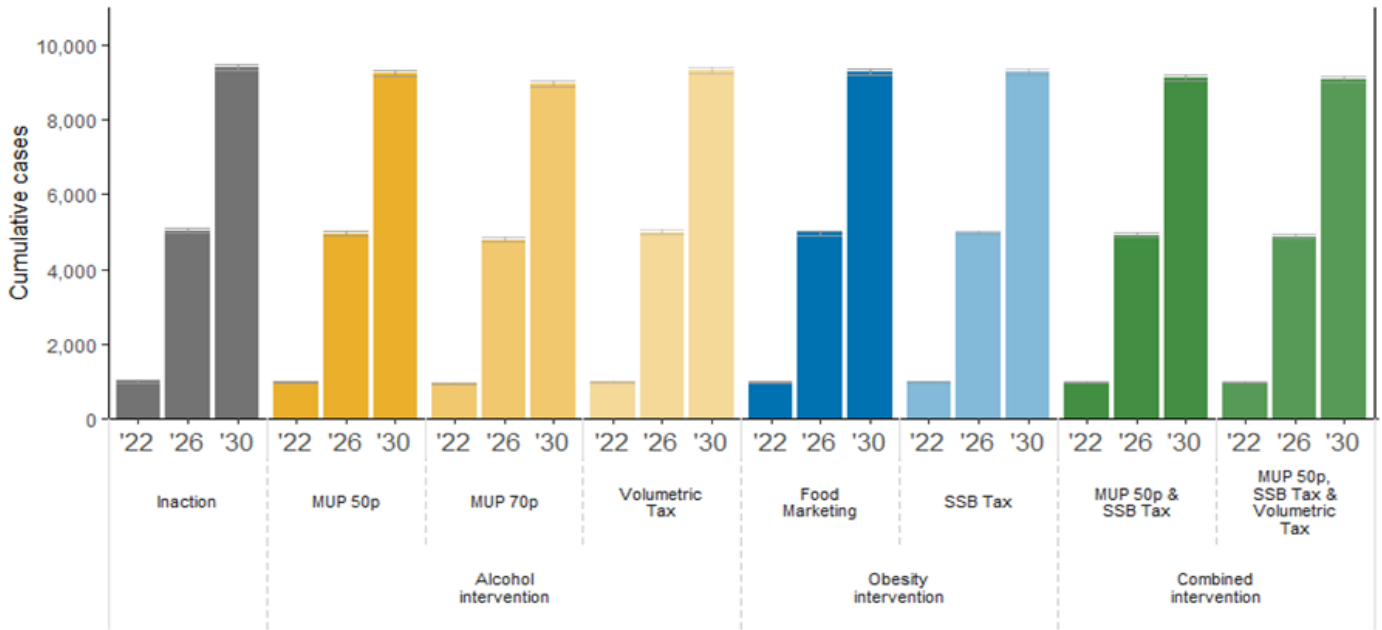

Figure 18: Cumulative absolute incidence by inaction or intervention scenarios for liver cancer in France in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

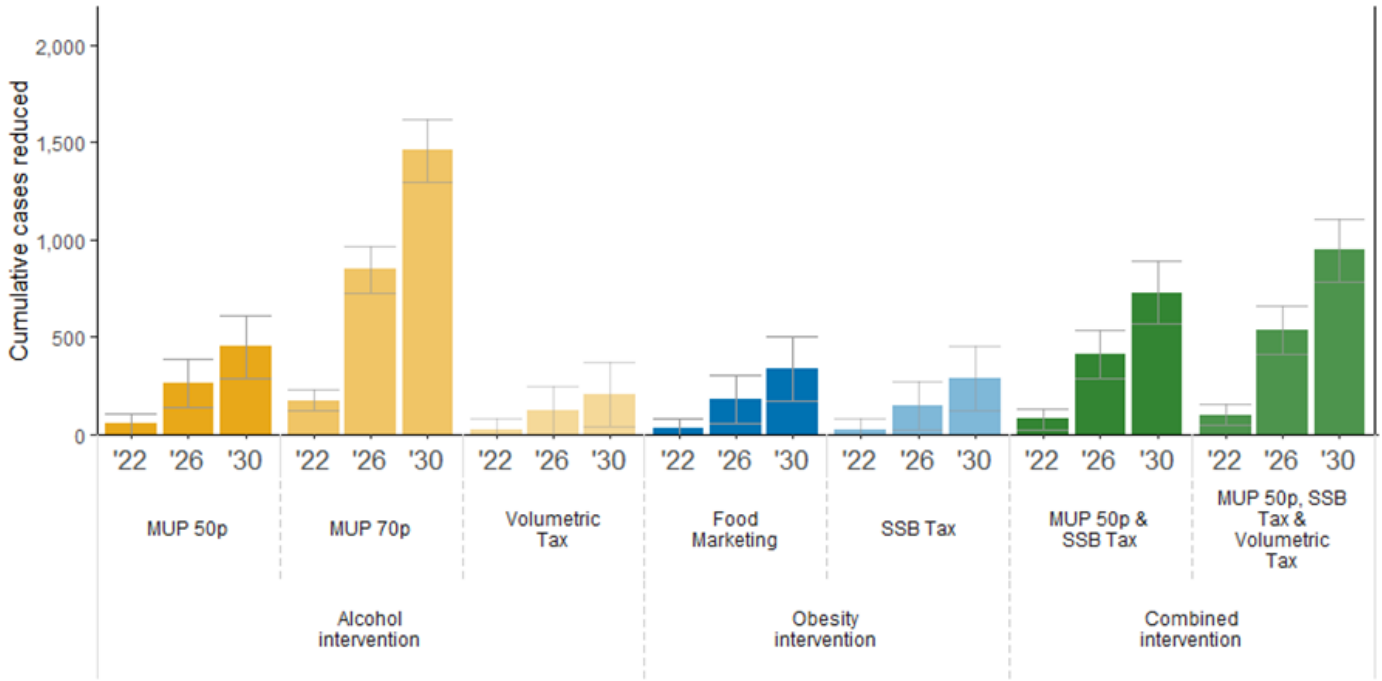

Figure 19: Predicted cumulative reduction in absolute incidence for CLD following interventions compared to the inaction scenario in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

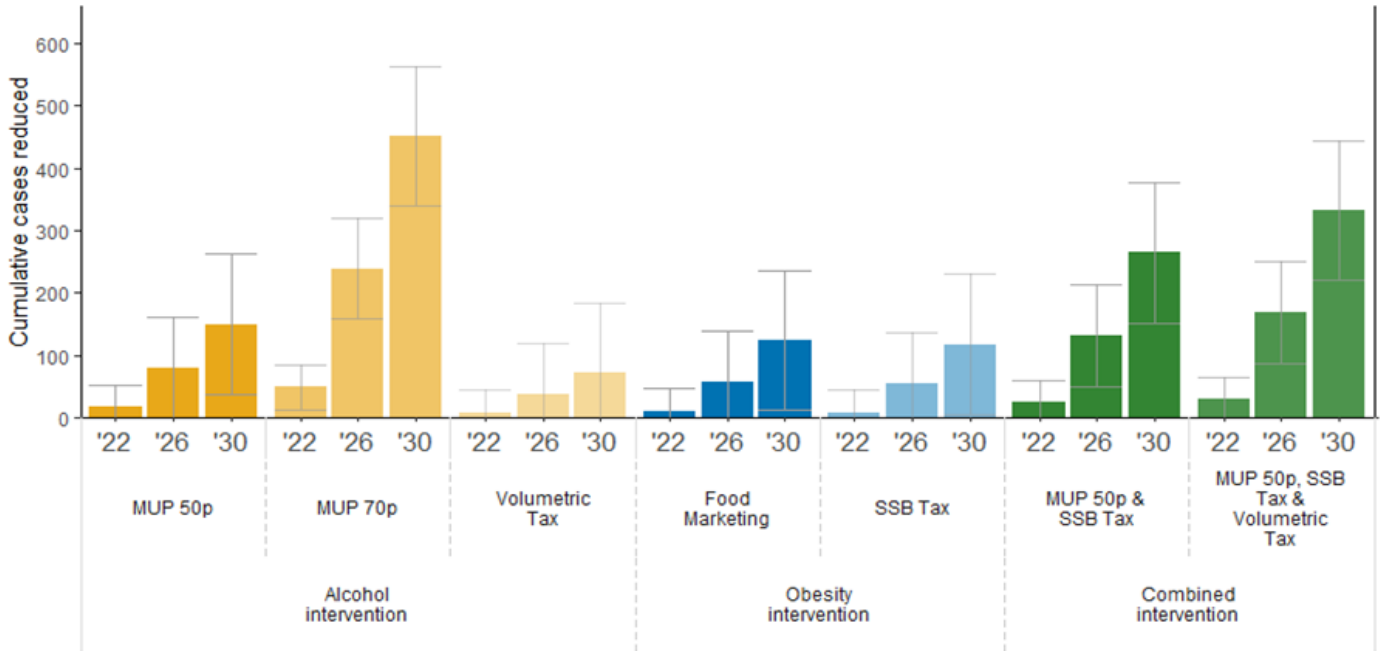

Figure 20: Predicted cumulative reduction in absolute incidence for liver cancer following interventions compared to the inaction scenario in the Netherlands in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Premature and specific mortality results (absolute estimates)

Premature mortality/ predicted reduction in premature mortality (Table 15)

For the inaction scenario, the premature mortality defined by deaths before age 75 years was estimated to reach 302,960 cases between 2022 and 2030.

Given the short time horizon of the study, the impact from the interventions on premature mortality is relatively small (Table 15).

For the 0.50€ MUP policy scenario, the cumulative premature mortality was projected to decrease by 44 cases (from 302,960 to 302,915) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative premature mortality was projected to decrease by 102 cases (from 302,960 to 302,857) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the cumulative premature mortality was projected to decrease by 11 cases (from 302,960 to 302,949) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the cumulative premature mortality was projected to decrease by 10 cases (from 302,960 to 302,950) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the cumulative premature mortality was projected to decrease by 11 cases (from 302,960 to 302,948) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and SSB tax), the cumulative premature mortality was projected to decrease by 51 cases (from 302,960 to 302,908) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax), the cumulative premature mortality was projected to decrease by 60 cases (from 302,960 to 302,900) between 2022 and 2030 relative to the inaction scenario.

Table 15: Cumulative predicted reduction in premature mortality for the Netherlands compared to the inaction scenario (absolute estimates) from 2022-2030

Scenario	Cumulative mortality reduced
MUP 0.50€	44
MUP 0.70€	102
Volumetric Tax	11
SSB Tax	10
Food Marketing	11
MUP 0.50€ and SSB Tax	51
MUP 0.50€, SSB Tax, and Volumetric Tax	60

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Specific mortality estimates (CLD and liver cancer absolute estimates) (Table 12)

For the inaction scenario, the total number of CLD and liver cancer deaths was estimated to be 11,108 and 4,480 respectively between 2022 and 2030.

For the 0.50€ MUP policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 18 cases and by 30 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 57 and 96 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 8 and 13 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 8 and 21 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 9 and 23 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the 0.50€ MUP and an SSB tax combined policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 26 and 50 cases respectively between 2022 and 2030 relative to the inaction scenario.

Finally, for the 0.50€ MUP, an SSB tax and a volumetric tax combined policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 35 and 64 cases respectively between 2022 and 2030 relative to the inaction scenario.

Disability Adjusted Life Years (absolute estimates)

Figure 21 presents the predicted reduction in DALYs following interventions relative to the inaction scenario (absolute estimates) between 2022 and 2030. There is a large amount of error around the projections so interpretation is made with caution. However, there is a positive trend suggesting the policies reduce DALYs over time.

For the inaction scenario, the total number of DALYs lost to CLD and liver cancer in the Netherlands was estimated to reach 3,820,246 by 2030.

For the 0.50€ MUP policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 1,466 (from 3,820,246 to 3,818,780) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 3,565 (from 3,820,246 to 3,816,681) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 666 (from 3,820,246 to 3,819,580) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 533 (from 3,820,246 to 3,819,713) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 678 (from 3,820,246 to 3,819,568) between 2022 and 2030 relative to the inaction scenario.

For the 0.50€ MUP and an SSB tax combined policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 1,982 (from 3,820,246 to 3,818,263) between 2022 and 2030 relative to the inaction scenario.

Finally, for the 0.50€ MUP, SSB tax and volumetric tax combined policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 2,381 (from 3,820,246 to 3,817,864) between 2022 and 2030 relative to the inaction scenario.

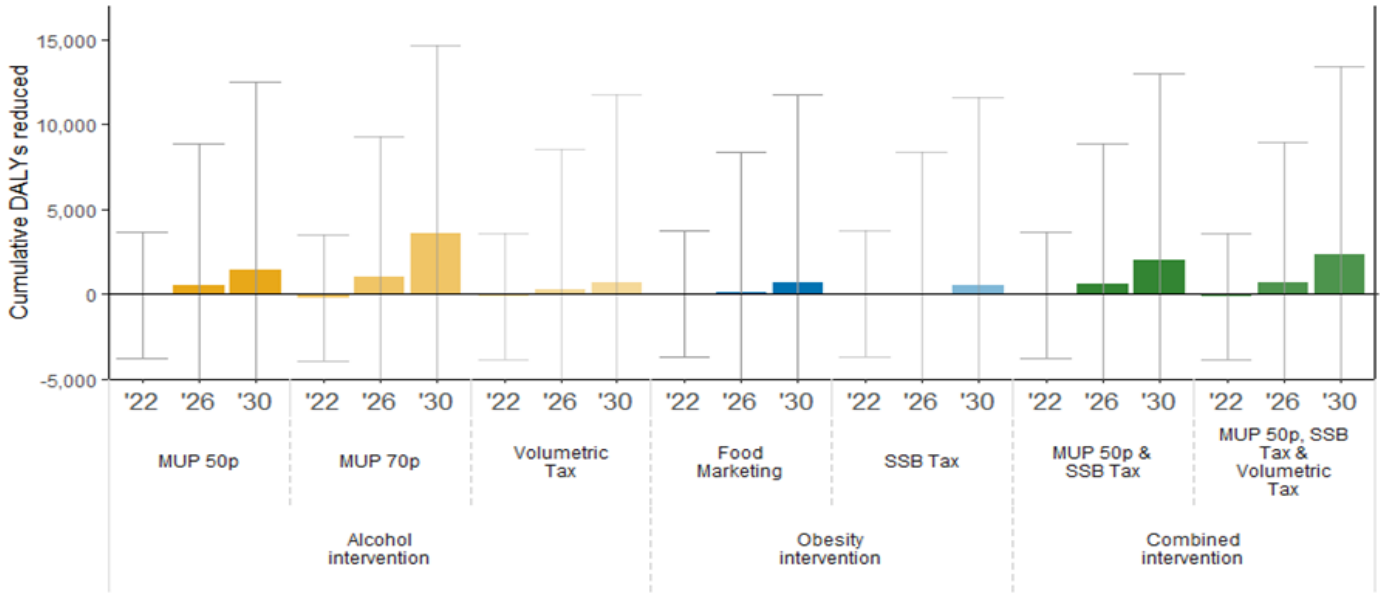

Figure 21: Predicted cumulative reduction in DALYs by 2022, 2026, and 2030 following different policy interventions relative to the inaction scenario in the Netherlands
MUP, minimum unit pricing; SSB, sugar sweetened beverage tax
Note: Each intervention occurs once at the beginning of year 2022, while the outputs presented in this figure show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and end of the last year (2030).

Cost results (absolute estimates) (Table 13)

Figure 22 presents the predicted reduction in the cumulative (2022-2030) direct healthcare cost for the Netherlands relative to the inaction scenario (absolute estimates).

For the inaction scenario, it is estimated that the cumulative direct cost for CLD in the Netherlands will be €891.67M [±€0.91M] between 2022 and 2030. The cumulative direct cost for liver cancer is estimated to reach €348.09M [±€1.20M] between 2022 and 2030. Under each policy scenario, costs are projected to be lower than the inaction scenario.

For the 0.50€ MUP policy scenario, the cumulative direct cost of CLD was projected to decrease by €2.87M (from €891.67M [±€0.91M] to €888.80M [±€0.91M]) and liver cancer was projected to decrease by €2.66M (from €348.09M [±€1.20M] to €345.43M [±€1.20M]) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative direct cost of CLD was projected to decrease by €9.10M (from €891.67M [±€0.91M] to €882.57M [±€0.90M]) and liver cancer was projected to decrease by €8.18M (from €348.09M [±€1.20M] to €339.91M [±€1.18M]) between 2022 and 2030 rela-

tive to the inaction scenario.

For the volumetric tax policy scenario, the cumulative direct cost of CLD was projected to decrease by €1.35M (from €891.67M [±€0.91M] to €890.31M [±€0.91M]) and liver cancer was projected to decrease by €1.31M (from €348.09M [±€1.20M] to €346.78M [±€1.20M]) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the cumulative direct cost of CLD was projected to decrease by €1.77M (from €891.67M [±€0.91M] to €889.90M [±€0.91M]) and liver cancer was projected to decrease by €1.86M (from €348.09M [±€1.20M] to €346.23M [±€1.20M]) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the cumulative direct cost of CLD was projected to decrease by €2.09M (from €891.67M [±€0.91M] to €889.58M [±€0.91M]) and liver cancer was projected to decrease by €2.01M (from €348.09M [±€1.20M] to €346.08M [±€1.20M]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and SSB tax) policy scenario, the cumulative direct cost of CLD was projected to decrease by €4.60M (from €891.67M [±€0.91M] to €887.07M [±€0.90M]) and liver cancer was projected to decrease by €4.49M (from €348.09M [±€1.20M] to €343.60M [±€1.19M]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax) policy scenario, the cumulative direct cost of CLD was projected to decrease by €5.94M (from €891.67M [±€0.91M] to €885.73M [±€0.90M]) and liver cancer was projected to decrease by €5.72M (from €348.09M [±€1.20M] to €342.37M [±€1.19M]) between 2022 and 2030 relative to the inaction scenario.

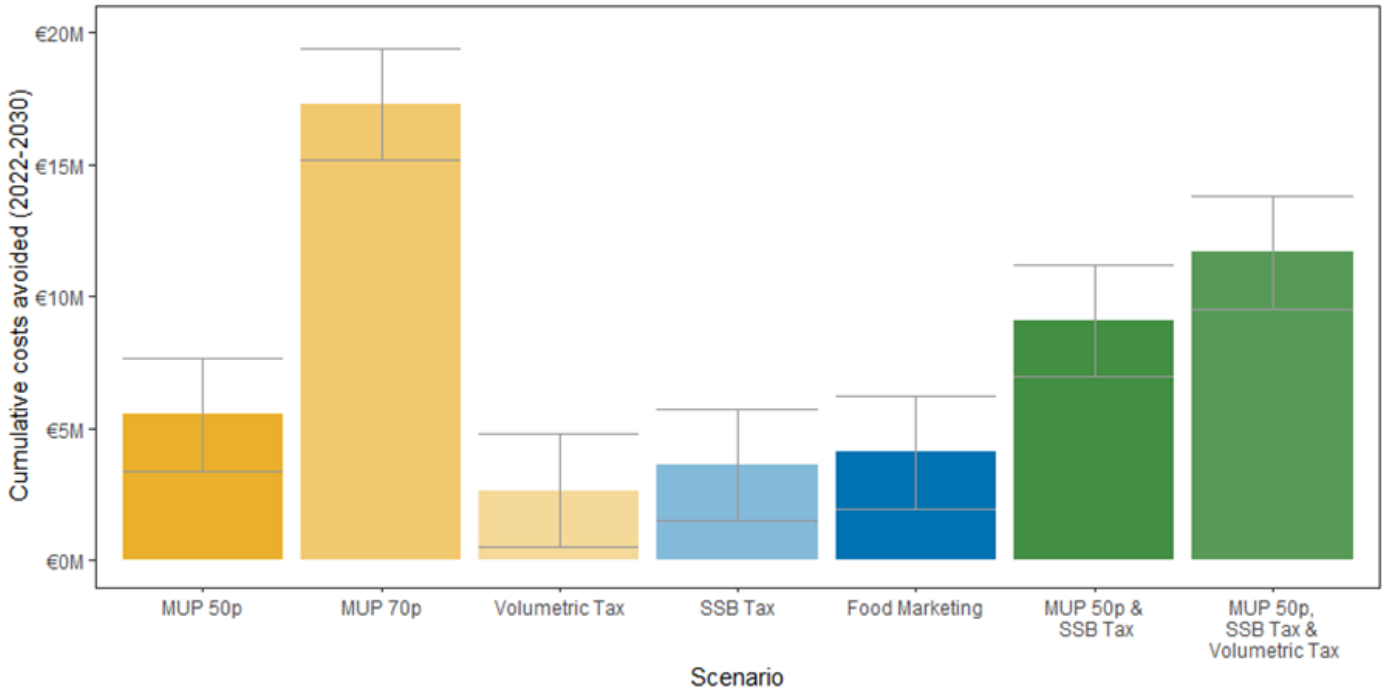

Figure 22 Predicted reduction in the cumulative direct healthcare costs (CLD + Liver cancer) for the Netherlands between 2022 and 2030 following different policy interventions relative to the inaction scenario

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Romania

Risk factor results

Alcohol (Table 8)

For the inaction scenario, the prevalence of alcohol consumption remained stable for the high-risk group: 12.8% [±4.64e-5] and 12.6% [±4.70e-5] from 2022 to 2030, respectively; there was no change in the low-risk group which remained at 60.2% [±6.97e-5] from 2022 to 2030 and the moderate group remained stable and high at 27.0% [±6.18e-5] and 27.1% [±6.32e-5] in 2022 and 2030, respectively. Both the SSB tax and food marketing policy scenarios showed the same baseline static trends in alcohol consumption as the inaction scenario. All other policy scenarios resulted in a reduction in alcohol consumption relative to the inaction scenario.

For the 0.50€ MUP policy scenario, the proportion of individuals in the high-risk group decreased by 0.7% (from 12.6% [±4.70e-5] to 11.9% [±4.57e-5]) in 2030 relative to the inaction scenario; the low-risk group and moderate risk group remained both high and stable (around 60.7% and 27.4% in 2030, respectively).

For the 0.70€ MUP policy scenario, the proportion of individuals in the high-risk group decreased by 2.0% (from 12.6% [±4.70e-5] to 10.6% [±4.34e-5]) in 2030 relative to the inaction scenario. Similar trends for the other categories were observed.

For the volumetric tax policy scenario, the proportion of individuals in the high-risk group remained relatively stable (from 12.6% [±4.70e-5] to 12.3% [±4.65e-5]) in 2030 relative to the inaction scenario. Similar trends for the other categories were observed.

Finally, for the combined policy scenario 1 (0.50€ MUP and SSB tax), the exact same trend in alcohol consumption was seen as the 0.50€ MUP scenario individually across the period. For the 0.50€ MUP, an SSB tax and a volumetric tax combined policy scenario, the proportion of individuals in the high-risk group decreased by 1.0% (from 12.6% [±4.70e-5] to approximately 11.6% [±4.52e-5]) in 2030 relative to the inaction scenario. Similar trends for the other categories were observed.

Obesity (Table 9)

For the inaction scenario, the healthy weight population decreased from 54.9% [±5.35e-5] to 51.9% [±5.14e-5] between 2022 and 2030; the pre-obese population increased from 38.2% [±5.66e-5] to 41.5% [±5.59e-5]; and the obese population decreased from 6.9% [±3.46e-5] to 6.6% [±3.45e-5] from 2022 to 2030. The 0.50€ MUP, 0.70€ MUP and volumetric tax policy scenarios all showed the exact same trends in obesity as the inaction scenario. All other policy scenarios resulted in a reduction in obesity relative to the inaction scenario.

For the SSB tax policy scenario, the obese population decreased by around 1.1% (from 6.6% [±3.45e-5] to 5.5% [±3.17e-5]) in 2030; the healthy weight population and pre-obese populations both remained high and stable compared to the inaction scenario (around 52.7% and 41.8%, respectively). Both combined policy scenario 1 (0.50€ MUP and SSB tax) and combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax) showed the exact same trend in obesity as the SSB tax policy scenario individually across the period.

For the food marketing policy scenario, the proportion of the population considered obese decreased by 1.3% (from 6.6% [±3.45e-5] to 5.3% [±3.14e-5]) in 2030 relative to the inaction scenario. Similar trends were observed for the other categories.

Disease Results (absolute estimates)

Annual incidence/ predicted reduction in incidence (Table 10 and Table 11)

Figure 23 and Figure 24 present the annual total population incidence (number of new cases per year) by inaction or intervention scenario for CLD and liver cancer respectively. Figure 25 and Figure 26 present the predicted reduction in annual absolute CLD incidence (reduction in number of cases per year) in Romania relative to the inaction scenario in 2022, 2026, and 2030.

For the inaction scenario, the annual incidence of CLD in Romania was estimated to decrease by 391 cases between 2022 and 2030 (from 3,964 [±54] to 3,573 [±51]). However, the annual incidence of liver cancer was projected to increase by 303 cases (from 3,635 [±52] to 3,938 [±54] over this same period.

For the 0.50€ MUP policy scenario, the annual incidence of CLD was projected to decrease by 73 cases (from 3,573 [±51] to 3,500 [±51]) and liver cancer was projected to decrease by 67 cases (from 3,938 [±54] to 3,871 [±54]) in 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the annual incidence of CLD was projected to decrease by 226 cases (from 3,573 [±51] to 3,347 [±50]) and liver cancer was projected to decrease by 208 cases (from 3,938 [±54] to 3,730 [±53]) in 2030 relative to the inaction scenario.

For the volumetric tax policy, SSB tax policy, and food marketing policy, no significant difference between inaction and scenario was observed.

For the combined policy scenario 1 (0.50€ MUP and SSB tax), the annual incidence of CLD was projected to decrease by 106 cases (from 3,573 [±51] to 3,467 [±51]) and liver cancer was projected to decrease by 113 cases (from 3,938 [±54] to 3,824 [±53]) in 2030 relative to the inaction scenario.
For the combined policy scenario 2 (0.50€ MUP, SSB tax, and a volumetric tax), the annual incidence of CLD was projected to decrease by 141 cases (from 3,573 [±51] to 3,432 [±50]) and liver cancer was projected to decrease by 145 cases (from 3,938 [±54] to 3,793 [±53]) in 2030 relative to the inaction scenario.

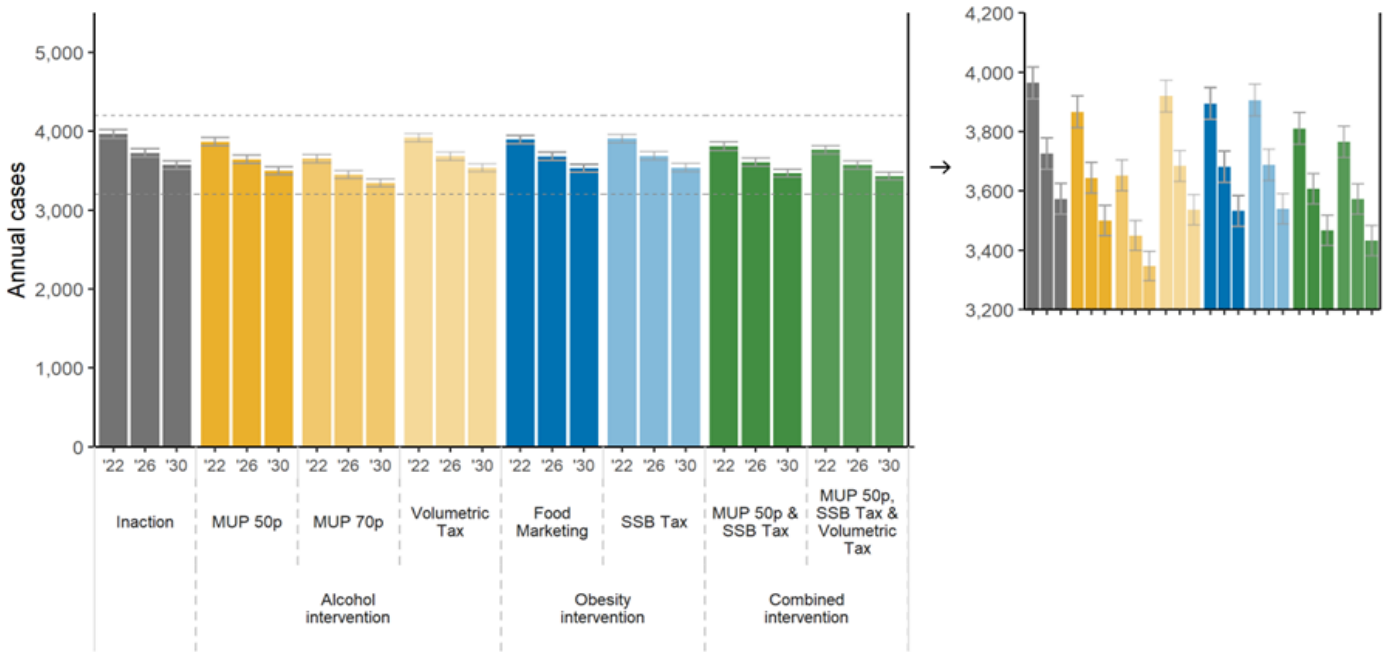

Figure 23: Annual total population incidence (number of new cases per year) by inaction or intervention scenario for CLD in Romania in 2022, 2026, and 2030
MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

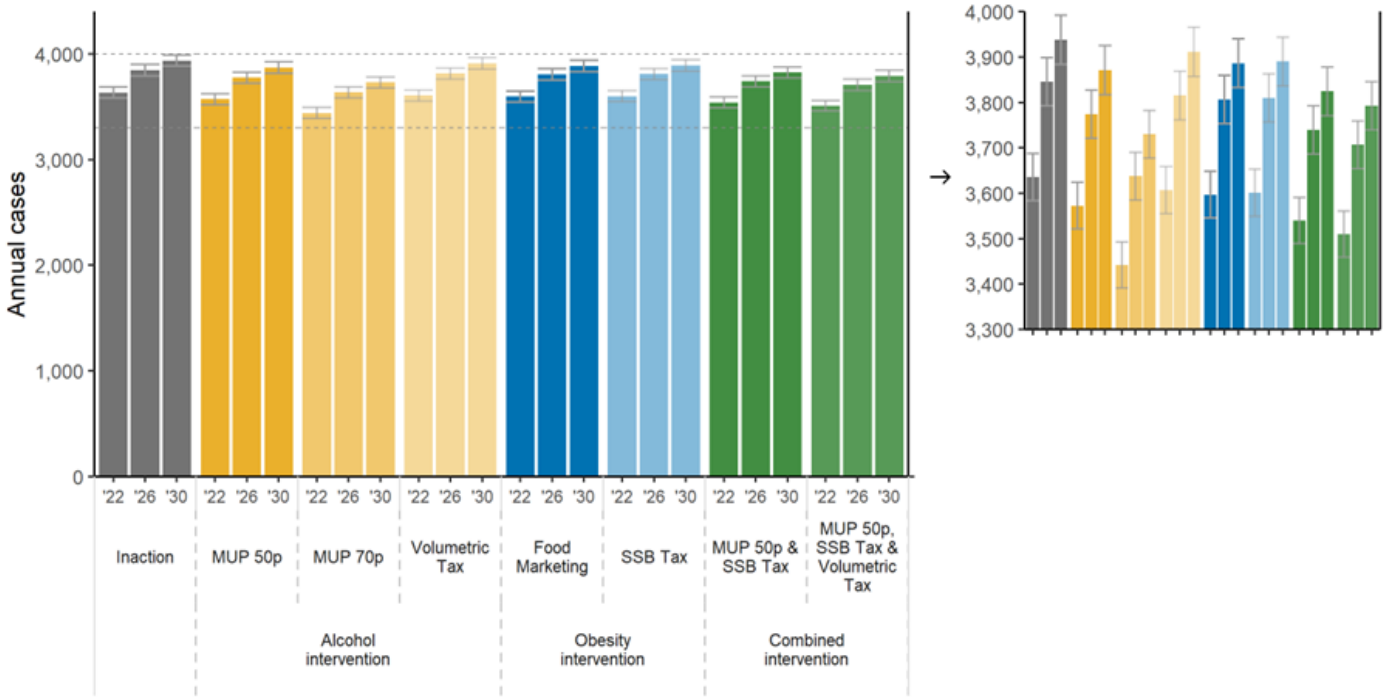

Figure 24: Annual total population incidence (number of new cases per year) by inaction or intervention scenario for liver cancer in Romania in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and end of the last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

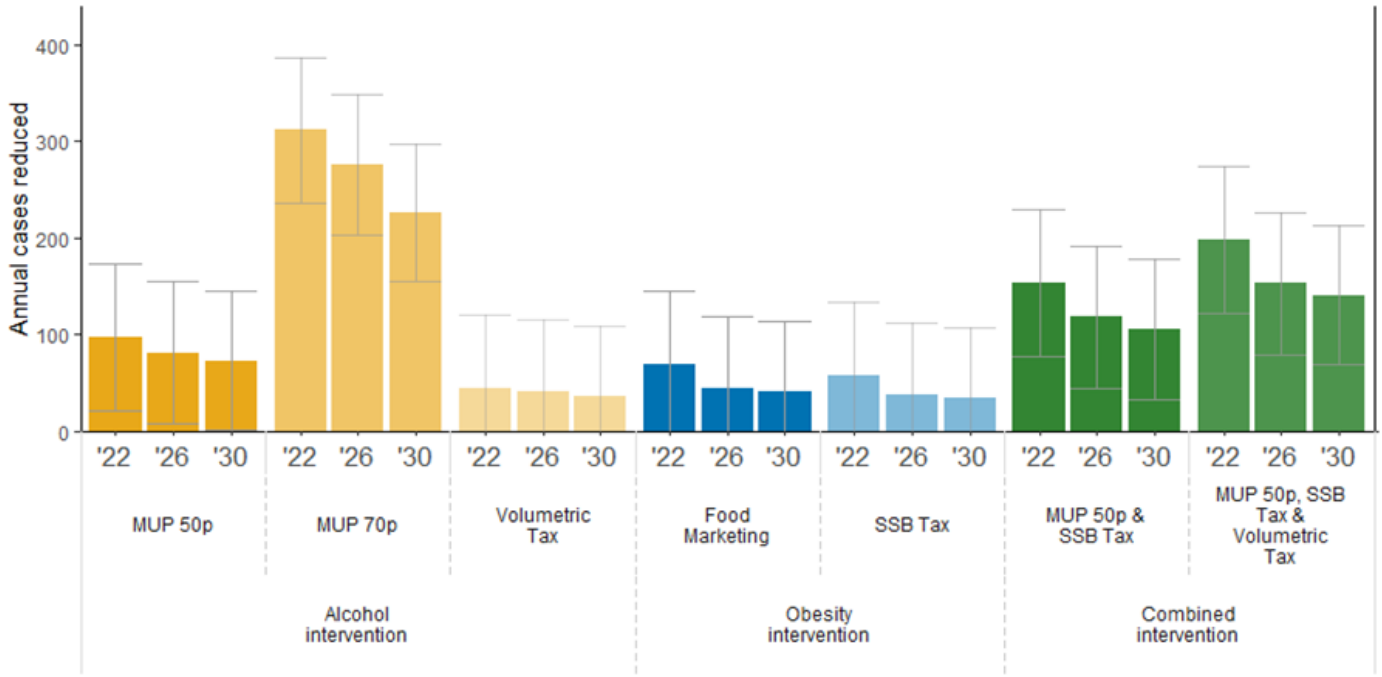

Figure 25: Predicted reduction in annual absolute CLD incidence in Romania relative to the inaction scenario in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

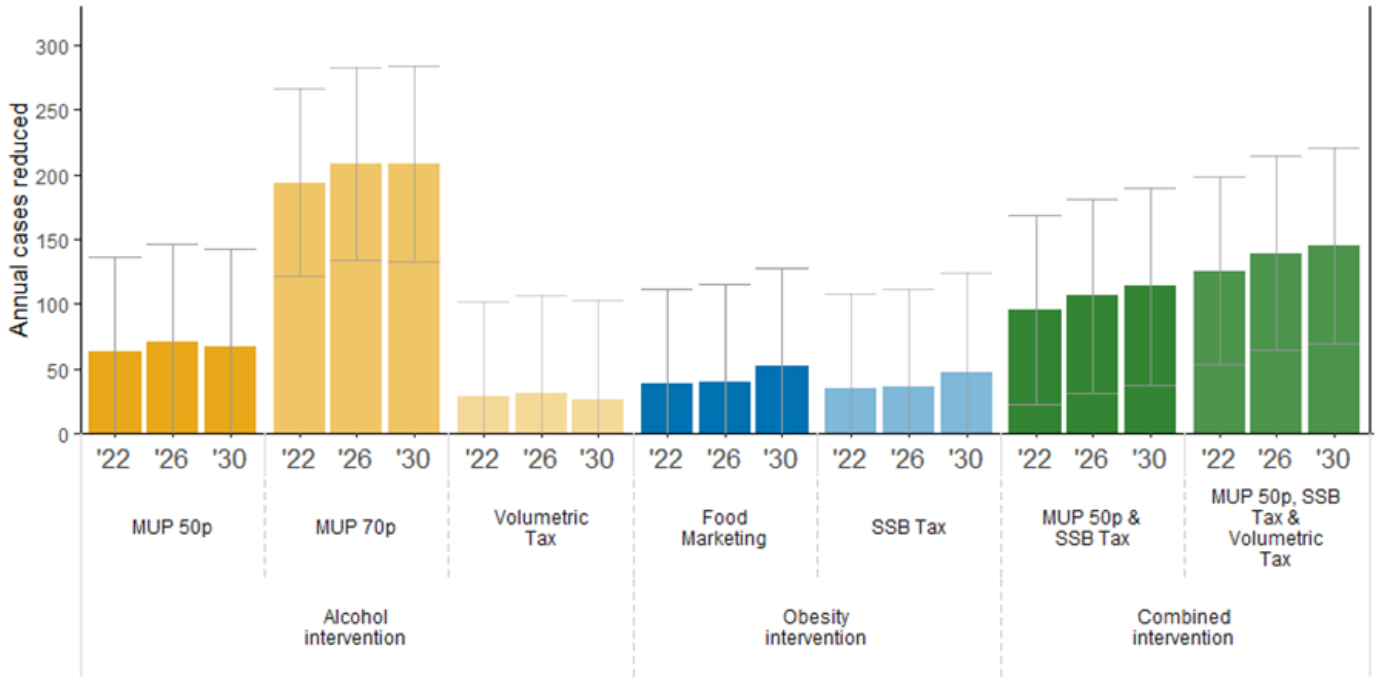

Figure 26: Predicted reduction in annual absolute liver cancer incidence in Romania relative to the inaction scenario in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and end of the last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Cumulative incidence/ predicted reduction in incidence (Table 10 and Table 11)

Figure 27 and Figure 28 present the cumulative absolute incidence by inaction or interventions for CLD by 2022, 2026, and 2030. Figure 29 presents the predicted reduction in cumulative absolute incidence for CLD following interventions compared to the inaction scenario by 2022, 2026, and 2030.

In the inaction scenario, the cumulative incidence of CLD in Romania was projected to reach 33,782 [±158] between 2022 and 2030 in the whole population. The cumulative incidence of liver cancer was projected to be 34,294 [±159] over the same period.

For the 0.50€ MUP policy scenario, the cumulative incidence of CLD was projected to decrease by 737 cases (from 33,782 [±158] to 33,044 [±157]) and liver cancer was projected to decrease by 594 cases (from 34,294 [±159] to 33,701 [±160]) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative incidence of CLD was projected to decrease by 2,459 cases (from 33,782 [±158] to 31,323 [±153]) and liver cancer was projected to decrease by 1,764 cases (from 34,294 [±159] to 32,530 [±155]) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the cumulative incidence of CLD was projected to decrease by 364 cases (from 33,782 [±158] to 33,418 [±158]) liver cancer was projected to decrease by 261 cases (from 34,294 [±159] to 34,033 [±159]) between 2022 and 2030 relative to the inaction scenario.
For the SSB tax policy scenario, the cumulative incidence of CLD was projected to decrease by 361 cases (from 33,782 [±158] to 33,421 [±158]) and liver cancer was projected to decrease by 335 cases (from 34,294 [±159] to 33,959 [±159]) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the cumulative incidence of CLD was projected to decrease by 427 cases (from 33,782 [±158] to 33,355 [±157]) and liver cancer was projected to decrease by 362 cases (from 34,294 [±159] to 33,932 [±159]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 1 (0.50€ MUP and SSB tax), the cumulative incidence of CLD was projected to decrease by 1,091 cases (from 33,782 [±158] to 32,690 [±156]) and liver cancer was projected to decrease by 920 cases (from 34,294 [±159] to 33,374 [±157]) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario 2 (0.50€ MUP, SSB tax, and volumetric tax), the cumulative incidence of CLD was projected to decrease by 1,449 cases (from 33,782 [±158] to 32,333 [±155]) and liver cancer was projected to decrease by 1,191 cases (from 34,294 [±159] to 33,103 [±157]) between 2022 and 2030 relative to the inaction scenario.

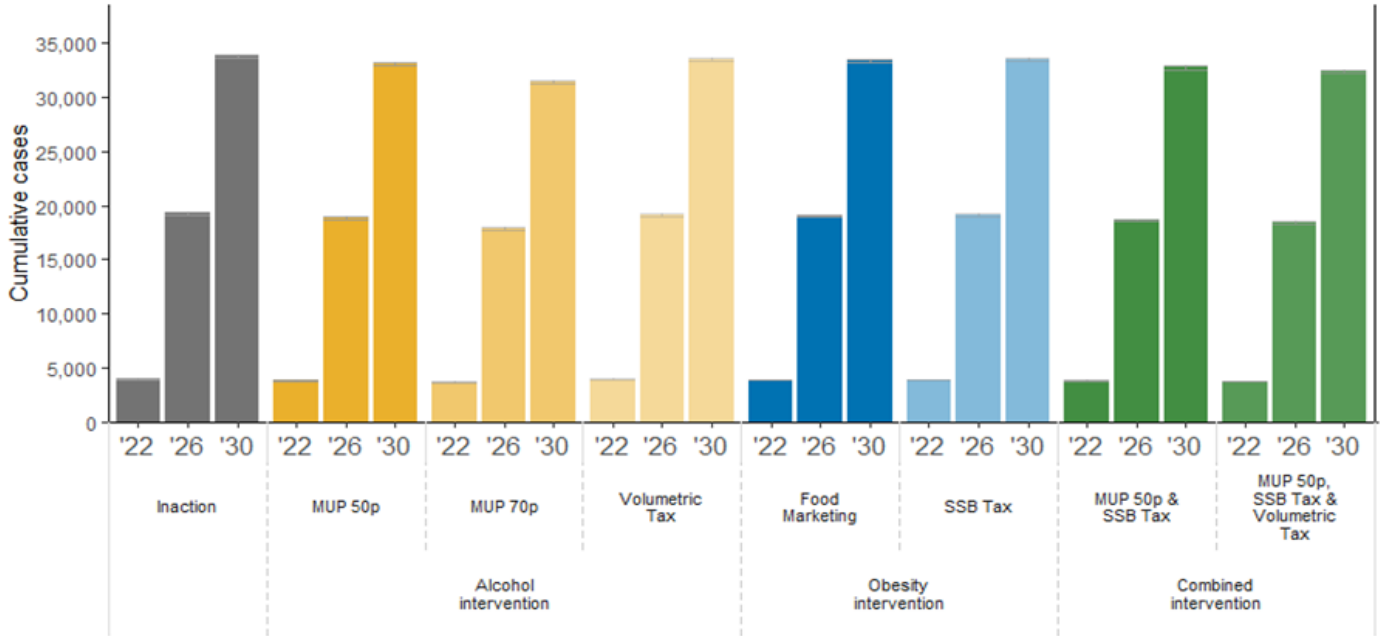

Figure 27: Cumulative absolute incidence by inaction or intervention scenarios for CLD in Romania in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

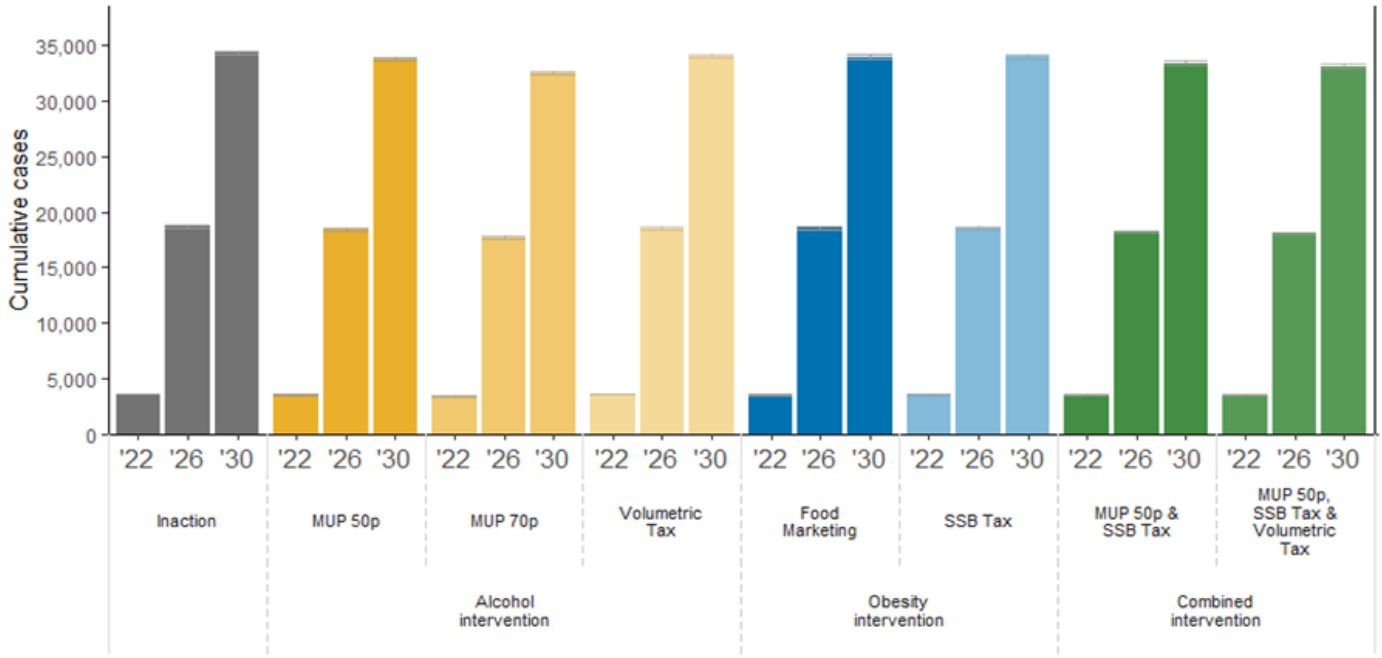

Figure 28: Cumulative absolute incidence by inaction or intervention for liver cancer in Romania in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year and end of the last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4

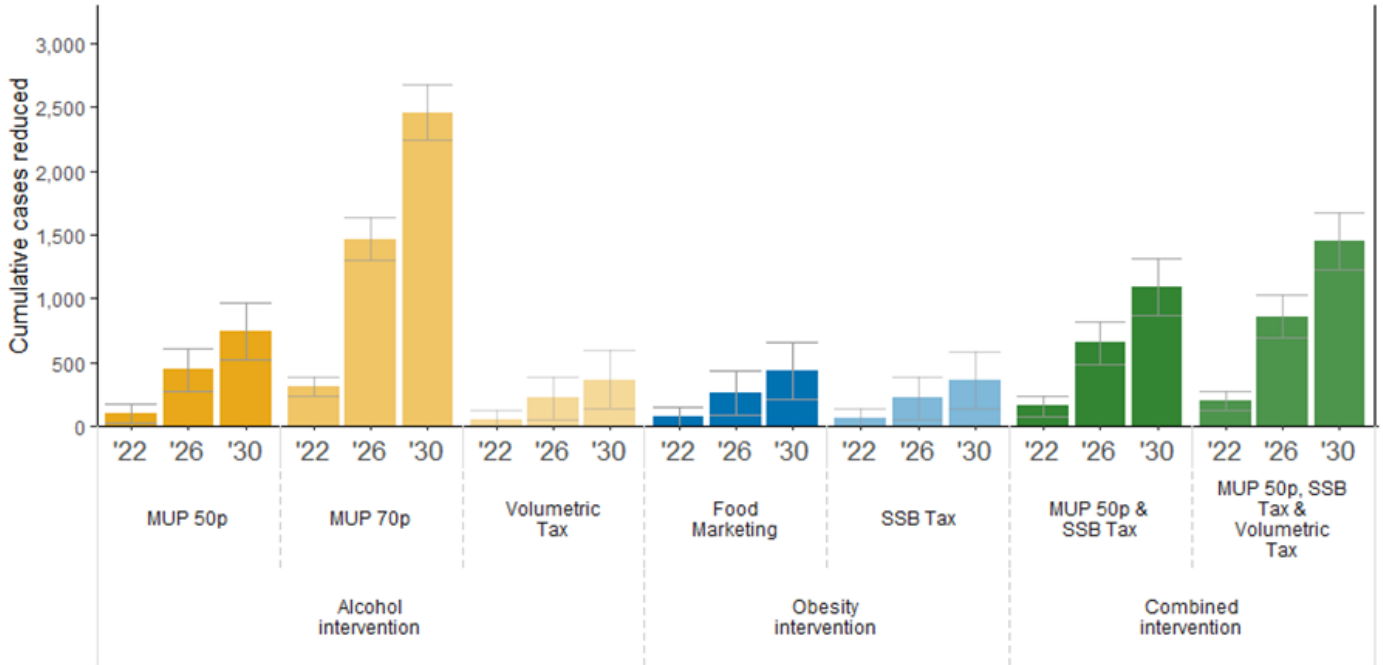

Figure 29: Predicted cumulative reduction in absolute incidence for CLD following interventions compared to the inaction scenario in Romania in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax; CLD, Chronic Liver Disease

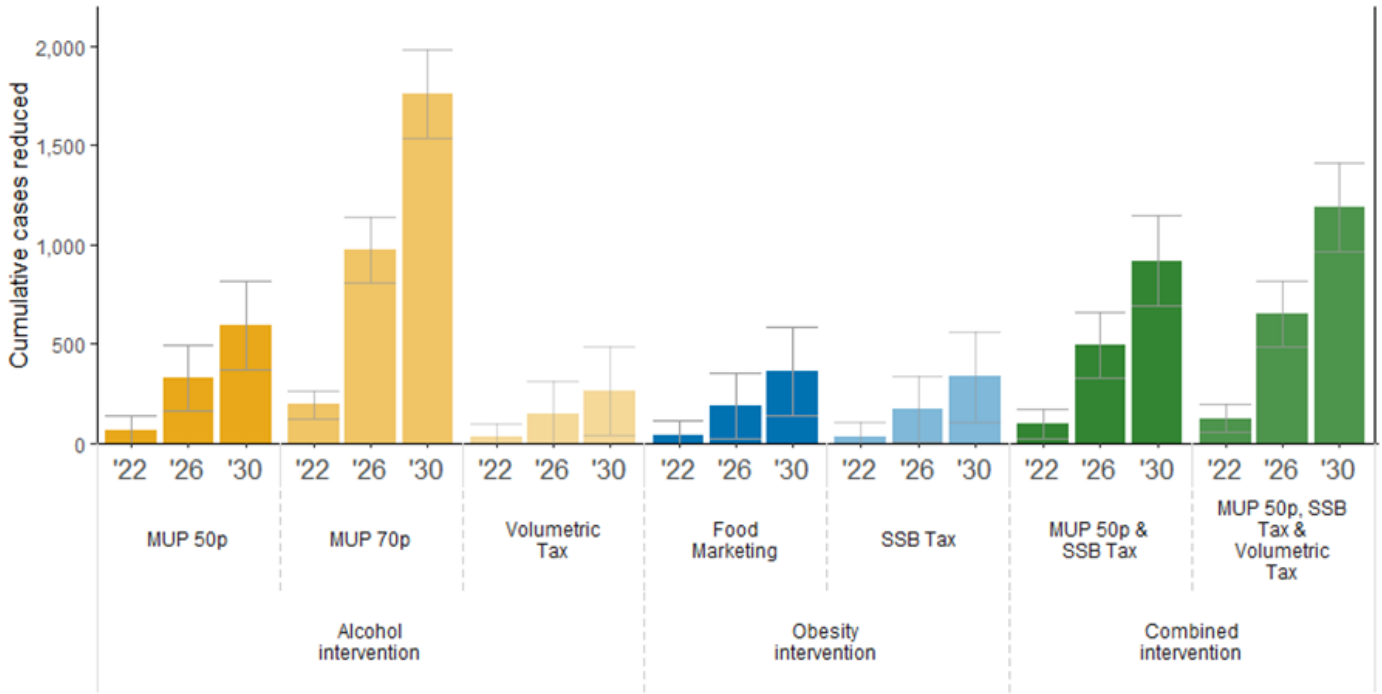

Figure 30: Predicted cumulative reduction in absolute incidence for liver cancer following interventions compared to the inaction scenario in Romania in 2022, 2026, and 2030

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Notes: Each intervention occurs once at the beginning of year 2022, while the outputs presented in these figures show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026) and end of the last year (2030). CLD is defined here according to global burden of disease ICD-10 codes categorisation: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4.

Premature and specific mortality results (absolute estimates)

Premature mortality/ predicted reduction in premature mortality (Table 16)

For the inaction scenario, the premature mortality defined by deaths before age 75 years was estimated be 710,900 between 2022 and 2030. This may underestimate premature mortality since life expectancy in Romania is 74 years in 2020 (and has dropped from 76 years in 2019 largely a result of the COVID-19 pandemic) [35]. For the inaction scenario, the premature mortality defined by deaths before age 75 years was estimated to be 710,900 between 2022 and 2030.

For the 0.50€ MUP policy scenario, the cumulative premature mortality was projected to decrease by 70 (from 710,900 to 710,830) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the cumulative premature mortality was projected to decrease by 266 (from 710,900 to 710,634) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the cumulative premature mortality was projected to decrease by 42 (from 710,900 to 710,858) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the cumulative premature mortality was projected to decrease by 64 (from 710,900 to 710,836) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the cumulative premature mortality was projected to decrease by 63 (from 710,900 to 710,837) between 2022 and 2030 relative to the inaction scenario.
For the combined policy scenario consisting of a 0.50€ MUP and an SSB tax, the cumulative prema-

ture mortality was projected to decrease by 128 (from 710,900 to 710,772) between 2022 and 2030 relative to the inaction scenario.

For the combined policy scenario consisting of a 0.50€ MUP, an SSB tax and a volumetric tax, the cumulative premature mortality was projected to decrease by 211 (from 710,900 to 710,689) between 2022 and 2030 relative to the inaction scenario.

Table 16: Cumulative predicted reduction in premature mortality for Romania compared to the inaction scenario (absolute estimates) from 2022-2030

Scenario	Cumulative mortality reduced
MUP 0.50€	70
MUP 0.70€	266
Volumetric Tax	42
SSB Tax	64
Food Marketing	63
MUP 0.50€ and SSB Tax	128
MUP 0.50€, SSB Tax, and Volumetric Tax	211

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Specific mortality estimates (CLD and liver cancer absolute estimates) (Table 12)

For the inaction scenario, the total number of CLD and liver cancer deaths was estimated to be 16,864 and 15,463 cases respectively between 2022 and 2030.

For the 0.50€ MUP policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 27 cases and by 93 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 97 and 309 cases respectively between 2022 and 2030 relative to the inaction scenario.
For the volumetric tax policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 15 and 45 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 13 and 68 cases respectively between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 15 and 73 cases respectively between 2022 and 2030 relative to the inaction scenario.
For the 0.50€ MUP and an SSB tax combined policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 41 and 160 cases respectively between 2022 and 2030 relative to the inaction scenario.

Finally, for the 0.50€ MUP, an SSB tax and a volumetric tax combined policy scenario, the number of CLD and liver cancer deaths was projected to decrease by 57 and 206 cases respectively between 2022 and 2030 relative to the inaction scenario.

Cumulative DALYs/ predicted reduction in DALYs (absolute estimates) (Table 12)

Figure 31 presents the predicted reduction in DALYs following interventions relative to the inaction scenario between 2022 and 2030. There is a large amount of error around the projections so interpretation is made with caution. However, there is a positive trend suggesting the policies reduce DALYs over time.

For the inaction scenario, the total number of DALYs lost to CLD and liver cancer in Romania was estimated to reach 9,826,529 by 2030.

For the 0.50€ MUP policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 2,659 (from 9,826,529 to 9,823,870) between 2022 and 2030 relative to the inaction scenario.

For the 0.70€ MUP policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 8,856 (from 9,826,529 to 9,817,673) between 2022 and 2030 relative to the inaction scenario.

For the volumetric tax policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 1,496 (from 9,826,529 to 9,825,032) between 2022 and 2030 relative to the inaction scenario.

For the SSB tax policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 1,684 (from 9,826,529 to 9,824,845) between 2022 and 2030 relative to the inaction scenario.

For the food marketing policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 1,852 (from 9,826,529 to 9,824,676) between 2022 and 2030 relative to the inaction scenario.

For the 0.50€ MUP and an SSB tax combined policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 4,331 (from 9,826,529 to 9,822,197) between 2022 and 2030 relative to the inaction scenario.

Finally, for the 0.50€ MUP, an SSB tax and a volumetric tax combined policy scenario, the number of DALYs lost to CLD and liver cancer was projected to decrease by 6,184 (from 9,826,529 to 9,820,345) between 2022 and 2030 relative to the inaction scenario.

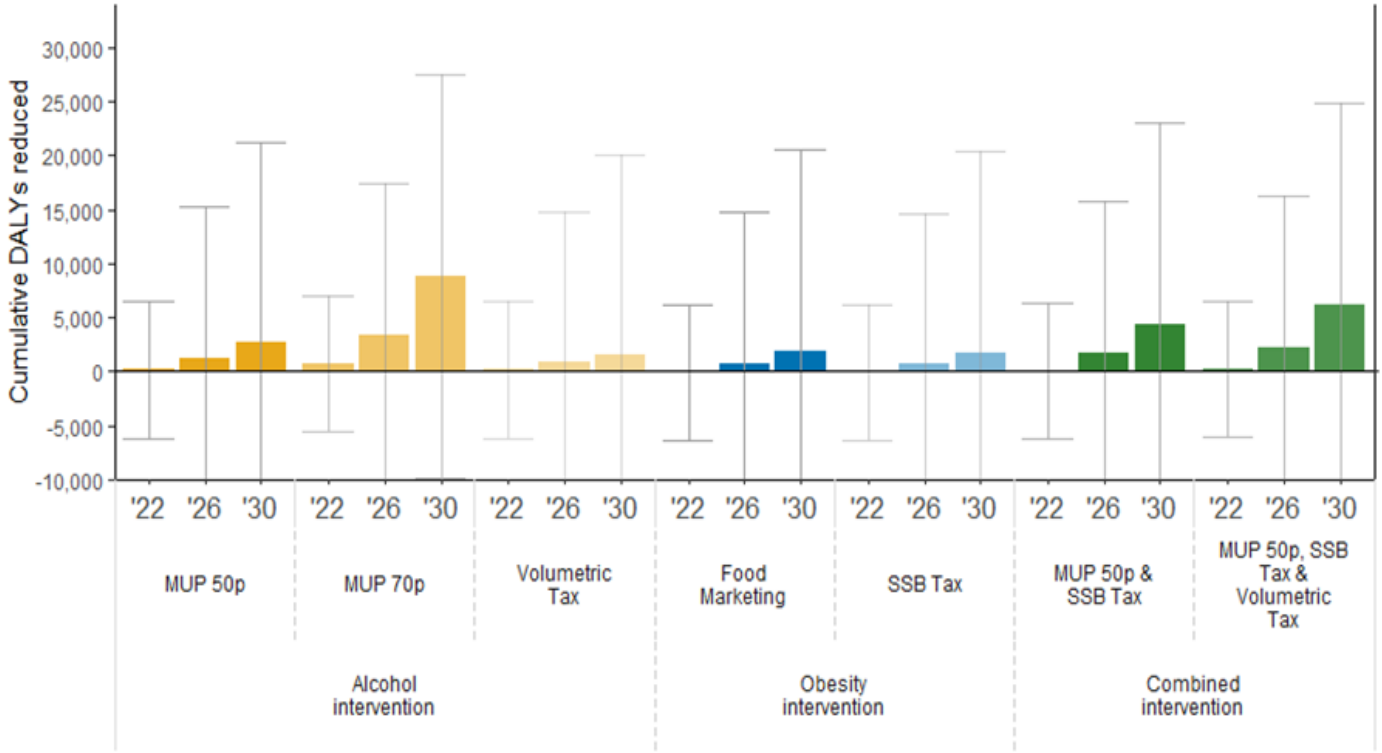

Figure 31: Predicted cumulative reduction in DALYs by 2022, 2026, and 2030 following different policy interventions relative to the inaction scenario in Romania

MUP, minimum unit pricing; SSB, sugar sweetened beverage tax

Note: Each intervention occurs once at the beginning of year 2022, while the outputs presented in this figure show the impact of the inaction scenario and policy scenarios at the end of the first year (2022), middle year (2026), and end of the last year (2030).

Cost results (absolute estimates)

No cost data were available for Romania.

Discussion

This study shows that CLD and liver cancer can be prevented by mitigating the primary risk factors through public health policies intended to shift the consumer environment to one that is healthier.

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This study shows that CLD and liver cancer can be prevented by mitigating the primary risk factors through public health policies intended to shift the consumer environment to one that is healthier.

Key findings

Our results suggest that with no change to current policy environments (inaction scenario), obesity prevalence is expected to increase in France and the Netherlands by 2030, which is in line with other published findings that predict an increase in obesity prevalence in Europe [36]. In contrast, a slight decrease in obesity is expected in Romania, in line with current trends [37]. Importantly, without any policy change there would be almost 108,000 new cases of CLD and 98,000 cases of liver cancer between 2022 and 2030 in France, 20,000 new cases of CLD and 9,400 cases of liver cancer in the Netherlands, and approximately 34,000 new cases for both CLD and liver cancer in Romania by 2030.

All policy scenarios decreased disease incidence in each of the three countries, although for some policies these changes were not always statistically significant. The 0.70€ MUP policy scenario had the most significant impact impact: if implemented from the beginning of 2022, it would have resulted in a reduction in 11.5, 8.4, and 13.2 cases per 100,000 individuals for France, the Netherlands, and Romania respectively by the end of 2030; and a reduction in liver cancer of 8.6, 2.6, and 9.5 cases per 100,000 individuals for France, the Netherlands, and Romania respectively by the end of 2030. This intervention also showed the largest reduction in mortality with a decrease of 2.4, 0.9, and 2.2 deaths caused by CLD or liver cancer per 100,000 individuals in France, Netherlands, and Romania relative to inaction. Interestingly, the reduction in alcohol consumption was mostly in the high-risk alcohol consumers, thus resulting in a decrease in the prevalence of alcohol-related disease.

Following the impacts from a €0.70 MUP, disease incidence, premature mortality, specific disease mortality, and DALYs are all lower with the combined scenarios compared with individual SSB, alcohol tax, or the €0.500.50€ MUP scenarios alone0.70€. Smaller reductions were observed for mortality given the relatively short time horizon with which the policies would take effect. Nevertheless, important reductions were observed. With regards to premature mortality linked to alcohol consumption and obesity, for the combined policy scenario '20% SSB tax, an MUP of 0.50€, and a volumetric alcohol tax', it is expected that 0.9, 0.3 and 1.1 cases of premature mortality would be avoided per 100,000 individuals by 2030 in France, the Netherlands, and Romania respectively. Combining policy scenarios into a package of complementary measures may lead to countries experiencing a 'compression of morbidity', when higher rates of morbidity occur later in life therefore in a more compressed section of the population [20, 38, 39]. This could result from the population living longer if diseases such as CLD and liver cancer are prevented. Importantly, upstream policy measures such as MUP and SSB taxes are wide-reaching, resulting in the reduction of other alcohol- and obesity-related NCDs such as cardiovascular disease, as presented in our earlier work [5]. Thus, implementation of upstream policy interventions will have wide-reaching impacts beyond liver diseases warranting a joined up cross-disease approach to tackling NCDs.

Overall, our results demonstrate the value of policies that reduce alcohol consumption across the population, and especially among those who are considered high risk drinkers. For example, an MUP of 0.70€ demonstrated a decrease in the prevalence of alcohol consumption among these groups by around 2% in each of the study countries (impacting around 2 million people in France, Netherlands, and Romania). We have shown that these policy scenarios have important impacts on burden of disease, quality of life, as well as associated healthcare cost across the population. These findings agree with recent studies which highlight that policy scenarios need to be targeted towards the heaviest drinkers - those most at risk of liver disease - through both downstream targeted measures as well as population level measures such as MUP [17, 24, 40]. MUP is applied to everyone, but has the great-

est impact on the heavier drinkers, which is important given that these people are disproportionately suffering from alcohol health harms [24, 41]. The direct impact of 0.70€ MUP is higher for HCC as compared to CLD-related mortality. One explanation for this could be that the policy would have a more pronounced effect over time on moderate risk consumers than on heavier consumers who may continue to drink large amounts regardless of price and die prematurely. HCC usually develops later in the progression of CLD.

Some of the policy scenarios that are more likely to be implemented on their own in the short-term, such as the lower level of MUP and food marketing restrictions on television, did not show the greatest effects among the scenarios modelled. This highlights the need for ambitious and combined interventions that have the biggest impact. However, we may be underestimating some effects because the alcohol policies did not impact obesity in the model. Further work might explore the impact that reducing alcohol consumption has on overall calories consumed which would impact BMI.

These results emphasise the impact of price on reducing risk factors and resultant disease burden but also the importance of applying a package of policy scenarios to have maximum impact. However, a range of different interventions may also be applied - such as screening and treatment. Regarding liver cancer, it is important to note that screening programmes will impact the diagnosis of disease and liver cancer outcomes as will access to, and allocation of, therapeutic and curative procedures in a country. Interestingly, there was a near 1:1 incidence rate of CLD:liver cancer in France and Romania, but approximately a 2:1 rate in the Netherlands. This is driven by the observed input data such that liver cancer incidence is much lower in the Netherlands than in France and Romania [11].

The results of this modelling study show the importance of targeting multiple drivers of obesity and alcohol consumption simultaneously via harmonized fiscal policy frameworks [7]. Furthermore, as with many upstream fiscal policies which aim to shift consumption environments and patterns, a high level of MUP could also impact population prevalence of other NCDs such as coronary heart disease [42].

Comparison with other results

In comparing the HealthLumen microsimulation model and the Sheffield Alcohol Policy Model (SAPM) there are several key points to consider. Both models consider the impact of policy interventions on populations, however the two models are not like-for-like in their methodology or outputs. The primary difference which prohibits direct comparison is that the SAPM reports total alcohol consumption by risk group whereas the HepaHealth II model reports the percentage of people in each alcohol consumption risk group. Furthermore, the SAPM model reports on UK all-cause mortality, hospital admissions, and total costs as opposed to the HepaHealth II model which reports premature mortality, disease specific mortality, prevalence, and disease-specific costs respectively in France, the Netherlands, Romania projected to 2030 [1].

Nevertheless, the two models are aligned with regards to their outputs supporting alcohol policy interventions, in particular the impact of MUP; it is a policy that can have an impact on alcohol consumption and linked health harms. For example, with a 0.50€ MUP SAPM shows a reduction in alcohol consumption by 4% across the population in Wales in the study period and this study found a smaller reduction of 0.44% in moderate and high-risk consumers in France in the study period [1]. For all-cause mortality, SAPM estimated a reduction of 53 deaths annually in Wales, while the present study showed a reduction of 232 premature mortality cases, 393 liver cancer deaths, and 69 CLD deaths between 2023-30 with a 0.50€ MUP in France. The higher rate of liver cancer deaths reflects that these deaths occur mostly after age 75 beyond the premature mortality cut-off. Regardless of the output metric, both models provide evidence of the impact of population level alcohol policies in the same direction, however the results are not directly comparable. Further comparison is presented in Appendix 4.

Strengths and limitations

This study has strengths and limitations. The use of a microsimulation model is a key strength of this study since it models many millions of individuals over time (rather than groups/cohorts using weighted averages, as in many studies) and records this history to determine an individual's future risk of NCDs over the long term. However, the strength of the model is only as good as the data input and there were some data limitations, such as the lack of cost data for CLD in Romania and limited incidence data on CLD for each country.

This study has some limitations to consider when advocating for policy change. For example, the OECD definition of premature mortality was used for consistency across the countries, however, in the case of Romania, age 75 may be too high a value relative to life expectancy – 72 for men, for example - thus we may be underestimating the true effect of these policies on premature death in Romania [43]. Further, it may be that additional parameters within country-specific settings will impact premature mortality including healthcare systems, which should be considered when exploring interventions. Also, it is not certain within this timeframe, until 2030, if there will be a significant change in the defined age for premature mortality.

A further limitation of the model is that it does not incorporate the effect of uncertainty of parameters, such as the distribution of standard errors. However, this is due to a lack of reporting of uncertainty on input data as only dose-response uncertainties were available in the literature. Some of the data upon which assumptions around the policy scenarios were made were limited. For example, the food marketing scenario was based on a single modelling study [30] that predicted reduction in BMI in adults not being exposed to food marketing as children. Given the limited data available, we assumed this reduction in the start year of the model only, so impacts of that intervention may be underestimated in our modelling with perhaps even stronger effects expected following real-world implementation. It is important to note that only restrictions on television food marketing were modelled here, however advertising on other medias is increasingly targeting children e.g. advergames, social media, pay-per-view. Policies which limit these other types of advertising would be an important area of future work for modelling and advocacy. Nevertheless, the present study highlights that even with a conservative assumption focussed on mainstream television advertising, there are important impacts on disease outcomes.

A final limitation of note is that alcohol is modelled in this study as units per week, not accounting for modes of drinking such as binge drinking which may impact disease differently [44], or for types of alcohol consumed e.g. wine vs spirits [45]. Future work, data allowing, could consider this additional level of granularity with regards to alcohol-related diseases.

Policy conclusions

As outlined at the start of this report, the three countries in this study have unique population and policy landscapes. While Romania and the Netherlands have very different contexts with regards to obesity and alcohol consumption, the implementation of the policies modelled would result in similarly notable changes to their current efforts. Conversely, France has a form of SSB tax and, therefore, our data show that further gains could be made by implementing MUP, and potentially adjusting their current excise tax on alcohol and SSB regulations. As previously noted, all three countries have the EU-regulated excise taxes on alcohol. There will also be regional and generational variations in the forms of excess alcohol consumption (binge vs chronic drinking, for example) which would further influence the impact of upstream measures such as the policies modelled in this report.

Although an MUP of 0.70€ may show the greatest impact in reducing the effects of liver disease, it could be hard to advocate for its implementation in the current political and economic environments. It could be politically difficult to push for high levels of MUP [46]. Data from Scotland have shown that

MUP of 0.50€ has resulted in a notable rise in the price of alcohol, a reduction in alcohol sales, and a reduction in ALD-linked hospital discharges since it was introduced in 2018 [17, 47, 48], which may be a more realistic approach to begin with in many countries. The combined policy scenarios modelled here, with a lower MUP for example, may also be more palatable to policy makers in countries aiming to balance public health considerations with economic concerns.

In general, raising taxes and duties is not always politically acceptable. Taxes are inherently economically regressive in that lower income households pay a larger proportion of their income with any additional tax added, such as an SSB tax, than higher income households [18]. The food and alcohol industries often use this as an argument against the implementation of such policies. They claim that these taxes will negatively impact poorer portions of a population and are therefore unfair [18]. The counter argument to this, however, is that alcohol- and diet-related ill-health are also regressive and disproportionately affect lower-income populations. These populations are generally more likely to suffer from CLDs and therefore would be positively impacted by such taxation mechanisms over the long-term [49]. Some civil society organisations may also be cautious of supporting policies seen to cause short-term economic strain for households, however this further strengthens the argument for policies which aim to improve the food and drink environment for everyone. In addition to the arguments on the regressive nature of taxation, some countries in Europe are significant wine, beer and spirits producers and may view these measures as an economic risk. However, this study adds to the evidence to support the implementation of fiscal measures, including taxation, at the population level to shift consumer environments overtime allowing countries to adjust in other areas.

In addition to contributing to the evidence that single policies such as 0.70€ MUP are able to have a significant impact on population health over time, this study supports and adds to the evidence which demonstrates that a combination of complementary policies are important to address upstream determinants across a population [19, 50]. In most countries these policy decisions would be coordinated across ministries and departments, not just health, requiring a joined-up approach across governments to make the case. Given the linked nature of NCDs and shared risk factors for obesity, diabetes, various cancers, and hypertension, coordinated policy scenarios have a greater impact across the population with regards to shifting consumption patterns and therefore reducing morbidity and mortality over time.

Appendices

Appendix 1 - Policy scenarios

As described in the introduction, there are several policy scenarios available to address excess alcohol consumption and the high consumption of high in fat salt, or sugar (HFSS) foods. The mechanisms for these policy scenarios are designed to address an element of wider determinants of health (i.e. heavy alcohol consumption; sugar sweetened beverage (SSB) consumption; etc) and work best as part of a package of measures intended to foster healthier and more equitable environments across the population [19, 50].

Alcohol

Evidence, including modelling, supports the use of economic measures applied to the whole population as a policy scenario option to impact the purchase and consumption of alcohol. These types of policies include excise duties and setting a minimum unit price (MUP) for alcohol.
Alcohol taxation is another commonly used policy scenario [16], of which the most common mechanism is volumetric excise duties. Excise duties are indirect taxes applied to the sale or use of goods such as alcohol. In the European Union (EU), regulations stipulate the minimum excise tax rates to be applied, however each country can set their tax rates higher if they choose. The tax payable is usually based on volume or quantity such as per kilogram (kg), hectolitre (hl) or degree of alcohol [51]. Some countries use a tax escalator, which increases the rate of tax on alcoholic products over time. Aims of these taxes, of which the most common mechanism is volumetric excise duties, include deterring the initiation into drinking as well as the recognition that among current drinkers it is the volume of alcohol consumed on both single occasions and then over time that increases health risks [52].

MUP of alcohol is an evidence-supported pricing policy designed to shift consumer purchasing and consumption patterns. MUP is when a government sets a minimum price per unit – most often based on volume – at which alcohol is allowed to be sold. For example, in Scotland there is an MUP of 50 pence GBP per unit of alcohol sold [17]. Evidence supports MUP as a policy scenario to address all consumers across the population, with the greatest impact on heavy consumers and especially those in the lowest income categories which have a disproportionately higher rate of alcohol-related liver diseases (and overall poor health) and often spend a disproportionate amount of their income on alcohol [40].

Scotland and Wales provide the best real-world evidence for the effectiveness of MUP having implemented the policy in 2018 and 2020, respectively. Between 2018 and 2020, following the introduction of MUP there was a marked reduction in the overall sale of alcohol in both countries [17]. This change is equivalent to a reduction in purchases of 328 grams (g) (41 UK units) per adult per household per year [40]. Furthermore, based on modelling that adjusted for household income and on-trade sales, and controlled for alcohol sales in England and Wales, there was an estimated net reduction in per-adult off-trade sales in Scotland of 3.5% one year after implementation [53].

There is little impact on moderate drinkers – across all income levels – from MUP [17, 40, 54]. Additionally, evidence supports MUP as a policy measure to address health inequalities and the disproportionate effects of excessive alcohol consumption [40].

Food

There are several policy scenarios for the reduction of HFSS across populations to reduce levels of pre-obese and obesity that are evidence-based. These policies include fiscal measures (i.e., SSB taxes), product reformulation (voluntarily or via direct or indirect legislation), and marketing restrictions [18, 19]. SSB taxes and levies are a well-used policy mechanism to address the over consumption of SSBs across populations. The mechanism by which SSB taxes are intended to work is four-fold. One, a tax on a product forces or encourages companies to reformulate their products so that there is less added sugar. Two, the rise in price that is passed on to consumers leads to a drop in purchasing and in turn a drop in the rate of consumption of these products. Three, these policies raise public awareness about the amount of sugar in the diet and its effect on health. Four, the revenue from sugary beverage taxes can be earmarked to serve as a revenue-raising mechanism for governments – often identified to help pay for other health promotion measures [18]. Furthermore, revenue from these taxes may be used to off-set the cost to health systems from diet-linked NCDs. Modelling has been used to both predict the impact of a proposed SSB tax and to evaluate the impact of a tax after it has been implemented. [18].

Finally, marketing restrictions on HFSS foods, across media, is a further population level policy scenario designed to impact consumption levels. Evidence suggests that legislation to restrict HFSS TV advertising, for example, would decrease the amount of calories consumed [30, 55, 56]. HFSS TV advertising restrictions – particularly for children – are suggested to reduce exposure to HFSS products and therefore lead to a reduction in the purchase and consumption of these products [56].

Restrictions on specific platforms or sectors, such as those which already exist in some countries in Europe, have shown an impact on calorie intake. For example, the implementation of HFSS advertising restrictions on London's transportation network was associated with a reduction in average weekly household energy purchased from HFSS products of 1,001.0 kcal or 6.7% [55]. Furthermore, strict marketing restrictions may also be a further lever to lead to product reformulation by producers [19]. These policy scenarios are all good examples of the inter-connected nature of policies and their ability to work together within a wider food and alcohol environment.

Appendix 2 – European policy context

The report focuses specifically on three countries in Europe with varying epidemiological and policy contexts: France, the Netherlands, and Romania. These countries were chosen specifically based on their differing prevalence of alcohol consumption and data availability.
This appendix provides an overview of the policy scenarios and strategies to lower levels of obesity and reduce alcohol consumption, that are already in place for each country in this study. This overview provides some of the background for which policy scenarios were selected for this study based on what countries do and do not already have in place. Most policy scenarios, policies, and strategies already in place across the three countries and presented here focus on both prevention and mitigation of risk factors for alcoholic liver disease and pre-obese and obesity (BMI). Many of the policy scenarios in place across the three countries are those which are considered to have the strongest evidence base globally and are supported by international institutions such as the WHO. However, there is variation across the three countries with regards to which policy scenarios are in place.

France

France had an alcohol per capita consumption of 12.6 litres of pure alcohol in 2016, which is almost 3 litres higher than the average in the WHO European region [23]. Although France has among the lowest prevalence of obesity in the EU, with under 50% of the adult population pre-obese or obese, the OECD projects that obesity prevalence is estimated to increase from 15% to 21% within the next 10 years [37, 57]. France currently has excise taxes on alcohol in line with EU regulations, but no MUP [58]. Unlike the other countries in this study, France already has an SSB tax and levels of marketing restrictions on HFSS [59, 60]. The SSB tax, updated in 2018, consists of a sliding scale tax for drinks that contain 1g of sugar per 100ml. It will rise to the point where the most sugary drinks will be taxed at 20 euros a hectolitre for drinks that contain more than 11g of sugar per 100 millilitres (ml) [59]. With regards to marketing restrictions, TV advertising of food or drink of low nutritional value must be accompanied by a specific health education statement approved by the National Institute of Health Education [60]. In 2019 the European Parliament adopted regulations limiting and eliminating industrially-produced trans-fats; this applies in all three countries in this study [61].

The Netherlands

The Netherlands had an alcohol per capita consumption of 8.7 litres of pure alcohol in 2016, which is much lower than most other European countries, and has declined about 17% since 2010 [23]. Furthermore, the Netherlands has one of the lowest levels of obesity in Europe, with approximately 14% of adults considered obese in 2019 [62]. However, nearly 45% of adults are pre-obese [63]. The Netherlands has excise duties on alcohol in line with EU regulations [58] but no policies in place for MUP or an SSB tax; however since 2016 there have been economic regulations on the manufacturing of fat products [28]. There are marketing restrictions in place; a code which includes regulation on the advertisement of food to children, including a ban on advertising certain foods to children under the age of 13 years on television, and a ban on food advertising in schools [38].

Romania

Romania has a similar prevalence of alcohol consumption to France, with an alcohol per capita consumption of 12.6 litres per person of pure alcohol, but Romania has a higher proportion of high risk drinkers, with around 64% of drinkers experiencing heavy episodic drinking at least once a month [23]. Furthermore, almost 60% of adults in Romania are pre-obese or obese [37]. Obesity prevalence on its own is projected to rise to >40% of the total adult population by 2025 [14]. Romania has an excise tax for alcohol in line with EU regulations [58] but no MUP. Currently they do have some marketing restrictions in place for HFSS but not in the form of a SSB tax. The current marketing restrictions, updated in 2017, target children and young people and prohibit the use of children in food advertising [64].

Appendix 3 – Data Inputs

Population data

Table 17. Population projections by age, males, 2022-2030.

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
France	0	360,450	367,456	373,407	376,193	375,024	370,823	364,984	359,623	356,275
	1	361,888	363,933	365,854	366,572	373,521	363,880	361,445	359,197	357,700
	2	356,956	362,850	361,662	360,690	366,124	370,954	359,424	359,291	359,035
	3	363,945	358,281	360,400	358,091	361,752	365,780	368,414	359,883	360,331
	4	371,116	364,445	359,605	358,319	360,052	362,918	365,463	365,787	361,642
	5	378,277	371,217	364,944	360,919	360,668	362,116	364,111	365,060	363,019
	6	385,235	378,318	371,318	365,435	363,164	363,121	364,207	365,218	364,516
	7	392,007	385,466	378,359	371,410	367,102	365,514	365,601	366,214	366,185
	8	398,611	392,696	385,696	378,390	372,544	368,874	367,890	367,996	368,078
	9	403,804	400,043	393,384	385,917	379,306	373,785	370,673	370,182	370,248
	10	406,970	405,650	401,475	394,063	386,782	380,332	375,054	372,386	372,329
	11	408,549	408,606	407,497	402,895	394,647	387,758	381,385	376,235	373,955
	12	409,717	409,577	410,242	409,332	403,078	395,344	388,762	382,349	377,271
	13	410,391	410,287	410,604	411,867	409,063	403,375	396,070	389,675	383,166
	14	409,833	410,571	410,856	411,620	411,102	408,911	403,702	396,703	390,438
	15	407,846	409,576	410,750	411,414	410,352	410,455	408,788	403,935	397,184
	16	404,771	407,107	409,318	410,920	409,657	409,201	409,837	408,570	404,011
	17	401,341	403,544	406,368	409,049	408,674	408,017	408,079	409,123	408,194
	18	397,635	399,638	402,316	405,619	406,495	406,545	406,406	406,862	408,252
	19	393,356	395,458	397,936	401,078	403,025	404,056	404,444	404,699	405,488
	20	388,502	390,878	393,280	396,224	398,640	400,546	401,646	402,248	402,837
	21	383,389	385,986	388,401	391,093	393,950	396,316	398,095	399,141	399,898
	22	378,423	381,024	383,470	385,914	389,000	391,790	394,020	395,549	396,483
	23	373,629	376,218	378,660	380,944	384,125	387,018	389,656	391,630	392,853
	24	369,632	371,599	374,013	376,286	379,611	382,447	385,063	387,431	389,091

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	25	366,820	367,896	369,568	371,799	375,498	378,385	380,795	383,018	385,057
	26	365,084	365,524	366,160	367,528	371,563	374,817	377,187	379,053	380,825
	27	363,602	364,315	364,228	364,415	367,872	371,434	374,163	375,900	377,167
	28	362,154	363,368	363,545	362,922	365,222	368,321	371,332	373,421	374,468
	29	362,985	362,479	363,133	362,767	363,996	366,132	368,796	371,143	372,536
	30	367,007	363,755	362,803	362,889	363,969	365,175	367,070	369,186	370,811
	31	373,077	368,032	364,525	363,119	364,221	365,275	366,380	367,922	369,433
	32	379,045	374,219	369,056	365,286	364,569	365,658	366,608	367,499	368,632
	33	385,231	380,307	375,360	370,071	366,773	366,123	367,123	367,855	368,477
	34	390,572	386,601	381,569	376,492	371,500	368,365	367,705	368,501	368,961
	35	394,284	391,972	387,970	382,822	377,793	373,035	369,984	369,200	369,738
	36	396,737	395,625	393,372	389,329	383,968	379,203	374,598	371,517	370,554
	37	399,710	397,953	396,966	394,762	390,287	385,226	380,641	376,073	372,907
	38	403,598	400,774	399,169	398,296	395,542	391,357	386,511	381,990	377,403
	39	404,496	404,471	401,837	400,375	398,934	396,435	392,456	387,706	383,191
	40	400,879	405,196	405,344	402,889	400,893	399,687	397,357	393,464	388,752
	41	394,805	401,453	405,896	406,207	403,261	401,525	400,469	398,186	394,319
	42	389,020	395,279	402,027	406,585	406,412	403,748	402,187	401,157	398,862
	43	381,970	389,368	395,753	402,591	406,635	406,733	404,264	402,755	401,691
	44	380,881	382,178	389,716	396,217	402,506	406,801	407,084	404,686	403,168
	45	389,304	380,930	382,386	390,054	396,006	402,537	406,996	407,339	404,952
	46	403,474	389,169	380,979	382,584	389,709	395,909	402,596	407,096	407,438
	47	416,403	403,137	389,034	381,019	382,106	389,476	395,840	402,561	407,039
	48	429,882	415,860	402,799	388,889	380,368	381,738	389,271	395,679	402,371
	49	438,708	429,127	415,316	402,451	388,008	379,827	381,396	388,975	395,365
	50	439,713	437,739	428,372	414,762	401,302	387,238	379,313	380,966	388,529
	51	435,556	438,529	436,769	427,606	413,347	400,269	386,496	378,710	380,388

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	52	431,962	434,157	437,345	435,788	425,918	412,051	399,263	385,663	377,961
	53	427,665	430,344	432,758	436,150	433,846	424,352	410,784	398,164	384,682
	54	423,970	425,828	428,727	431,348	433,989	432,028	422,816	409,420	396,911
	55	422,063	421,912	423,991	427,099	428,990	431,952	430,241	421,181	407,899
	56	420,984	419,780	419,854	422,144	424,537	426,754	429,945	428,352	419,384
	57	418,851	418,477	417,498	417,785	419,376	422,096	424,549	427,837	426,299
	58	416,354	416,118	415,971	415,205	414,811	416,728	419,685	422,243	425,565
	59	412,012	413,387	413,386	413,455	412,024	411,955	414,108	417,175	419,776
	60	405,001	408,834	410,421	410,643	410,063	408,960	409,129	411,391	414,504
	61	396,305	401,649	405,657	407,444	407,036	406,789	405,924	406,205	408,517
	62	387,564	392,798	398,297	402,470	403,607	403,546	403,543	402,792	403,126
	63	378,246	383,888	389,292	394,936	398,423	399,886	400,083	400,202	399,506
	64	370,397	374,392	380,213	385,776	390,713	394,490	396,191	396,525	396,708
	65	365,133	366,346	370,538	376,529	381,388	386,601	390,583	392,403	392,816
	66	361,430	360,862	362,296	366,675	371,952	377,109	382,515	386,584	388,465
	67	356,477	356,912	356,591	358,237	361,888	367,480	372,856	378,339	382,437
	68	350,039	351,720	352,396	352,311	353,190	357,204	363,034	368,514	374,018
	69	344,859	345,072	346,964	347,870	346,934	348,244	352,544	358,501	364,031
	70	341,759	339,569	340,105	342,200	342,103	341,656	343,320	347,800	353,831
	71	339,084	335,980	334,281	335,130	336,054	336,434	336,400	338,315	342,923
	72	335,709	332,725	330,202	328,985	328,651	330,004	330,786	331,064	333,181
	73	333,490	328,780	326,366	324,416	321,999	322,265	323,975	325,060	325,602
	74	322,143	325,942	321,853	320,000	316,664	315,104	315,900	317,869	319,210
	75	296,957	314,210	318,395	314,918	311,347	309,002	308,230	309,459	311,642
	76	263,338	289,014	306,279	310,841	305,405	302,783	301,359	301,281	302,901
	77	230,779	255,608	281,071	298,341	300,430	295,979	294,237	293,643	294,218
	78	196,640	223,232	247,879	273,123	287,376	290,105	286,570	285,620	285,816

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	79	170,142	189,334	215,686	240,144	262,142	276,493	279,796	277,092	276,895
	80	156,599	162,831	182,029	208,135	229,497	251,236	265,625	269,418	267,510
	81	151,438	148,872	155,522	174,721	197,820	218,915	240,344	254,692	258,940
	82	144,820	143,046	141,146	148,209	164,850	187,561	208,343	229,392	243,664
	83	138,774	135,865	134,655	133,418	138,579	155,026	177,312	197,720	218,355
	84	131,308	129,313	126,912	126,263	123,645	128,987	145,209	167,017	187,025
	85	120,461	121,420	119,852	117,956	116,141	113,906	119,401	135,355	156,662
	86	107,624	110,284	111,534	110,391	107,519	106,052	104,171	109,784	125,452
	87	95,871	97,293	100,109	101,647	100,194	97,111	95,966	94,409	100,128
	88	86,221	85,201	86,962	89,934	91,570	90,025	86,705	85,855	84,614
	89	76,675	75,767	74,532	76,632	80,113	81,518	79,858	76,277	75,714
	90	65,334	66,903	65,315	63,864	66,928	70,314	71,468	69,670	65,822
	91	52,612	55,980	57,132	54,864	55,089	57,242	60,516	61,398	59,459
	92	41,207	43,273	46,626	47,362	47,374	46,329	47,556	50,701	51,308
	93	33,688	33,046	33,936	37,273	40,712	39,897	37,568	37,856	40,870
	94	28,365	27,254	24,885	24,599	31,835	34,073	32,419	28,796	28,145
	95	21,697	22,751	20,822	16,726	20,745	26,406	27,434	24,932	20,016
	96	13,686	17,174	17,137	14,390	14,959	16,896	20,976	20,786	17,438
	97	10,546	10,525	12,651	11,525	12,004	12,553	13,048	15,540	14,133
	98	7,330	7,585	7,364	8,129	8,496	8,908	9,340	9,195	10,100
	99	3,536	3,760	3,979	4,204	4,436	4,672	4,906	5,131	5,340
	100	3,897	4,523	5,146	5,696	6,151	6,533	6,868	7,199	7,558
Netherlands	0	88,315	90,050	91,526	92,299	92,265	91,556	90,434	89,298	88,443
	1	88,379	89,344	90,215	90,764	92,075	90,855	90,517	90,098	89,708
	2	87,100	88,850	89,242	89,597	90,792	91,857	90,480	90,585	90,547
	3	87,665	87,417	88,583	88,770	89,777	90,827	91,634	90,808	91,021
	4	88,268	87,801	87,722	88,254	89,020	89,964	90,856	91,386	91,187

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	5	88,911	88,286	87,924	88,020	88,508	89,277	90,146	90,860	91,104
	6	89,593	88,862	88,290	88,042	88,215	88,770	89,528	90,303	90,831
	7	90,336	89,523	88,802	88,289	88,110	88,416	89,026	89,755	90,427
	8	91,158	90,286	89,440	88,735	88,271	88,185	88,611	89,258	89,949
	9	91,965	91,171	90,223	89,350	88,723	88,260	88,254	88,783	89,457
	10	92,721	92,028	91,172	90,155	89,402	88,719	88,243	88,300	88,922
	11	93,483	92,790	92,078	91,167	90,238	89,461	88,709	88,203	88,313
	12	94,254	93,534	92,846	92,122	91,266	90,328	89,515	88,674	88,130
	13	94,923	94,309	93,572	92,896	92,243	91,371	90,413	89,544	88,608
	14	96,051	94,992	94,350	93,603	93,048	92,370	91,471	90,473	89,540
	15	97,884	96,142	95,048	94,385	93,792	93,207	92,492	91,546	90,500
	16	100,104	98,005	96,220	95,098	94,610	93,988	93,360	92,589	91,588
	17	102,252	100,260	98,112	96,290	95,359	94,842	94,178	93,488	92,652
	18	104,543	102,443	100,402	98,213	96,582	95,627	95,068	94,342	93,582
	19	106,022	104,769	102,620	100,538	98,527	96,882	95,890	95,268	94,472
	20	106,208	106,279	104,980	102,789	100,868	98,849	97,175	96,126	95,434
	21	105,592	106,487	106,520	105,184	103,134	101,206	99,165	97,443	96,327
	22	105,063	105,887	106,750	106,754	105,542	103,487	101,537	99,455	97,674
	23	104,340	105,373	106,167	107,007	107,117	105,908	103,833	101,842	99,707
	24	104,272	104,664	105,668	106,439	107,366	107,489	106,268	104,151	102,109
	25	105,339	104,602	104,973	105,956	106,788	107,734	107,855	106,599	104,432
	26	107,077	105,664	104,918	105,275	106,291	107,145	108,096	108,191	106,890
	27	108,549	107,390	105,975	105,225	105,594	106,635	107,495	108,428	108,487
	28	109,947	108,848	107,688	106,278	105,527	105,922	106,971	107,816	108,720
	29	110,927	110,229	109,132	107,979	106,561	105,837	106,243	107,279	108,097
	30	111,227	111,191	110,495	109,408	108,244	106,853	106,140	106,535	107,548
	31	111,027	111,472	111,439	110,754	109,652	108,517	107,138	106,415	106,788

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	32	110,846	111,254	111,703	111,680	110,976	109,905	108,784	107,395	106,650
	33	110,670	111,053	111,466	111,925	111,880	111,207	110,151	109,021	107,612
	34	110,058	110,855	111,244	111,669	112,105	112,089	111,430	110,367	109,218
	35	108,871	110,221	111,024	111,427	111,831	112,294	112,291	111,624	110,543
	36	107,324	109,014	110,369	111,184	111,569	112,001	112,476	112,463	111,777
	37	105,871	107,450	109,143	110,508	111,306	111,719	112,164	112,628	112,593
	38	104,538	105,977	107,560	109,263	110,609	111,435	111,862	112,297	112,738
	39	103,213	104,623	106,069	107,663	109,345	110,718	111,557	111,975	112,388
	40	101,926	103,279	104,694	106,152	107,725	109,434	110,821	111,650	112,047
	41	100,820	101,973	103,330	104,757	106,194	107,795	109,517	110,893	111,701
	42	99,876	100,849	102,006	103,373	104,778	106,244	107,859	109,570	110,925
	43	98,941	99,885	100,863	102,031	103,372	104,806	106,288	107,893	109,583
	44	99,231	98,928	99,880	100,871	102,010	103,379	104,827	106,302	107,888
	45	101,299	99,194	98,902	99,867	100,828	101,996	103,379	104,821	106,278
	46	104,558	101,234	99,143	98,868	99,802	100,793	101,976	103,352	104,776
	47	107,746	104,461	101,155	99,085	98,777	99,743	100,752	101,928	103,286
	48	110,974	107,617	104,350	101,069	98,965	98,693	99,679	100,684	101,843
	49	114,276	110,809	107,472	104,232	100,915	98,852	98,603	99,587	100,578
	50	117,495	114,071	110,629	107,320	104,041	100,769	98,733	98,486	99,460
	51	120,538	117,245	113,850	110,440	107,088	103,858	100,617	98,587	98,334
	52	123,495	120,238	116,979	113,621	110,166	106,864	103,667	100,437	98,405
	53	126,381	123,144	119,922	116,704	113,297	109,900	106,634	103,449	100,221
	54	128,332	125,976	122,775	119,597	116,321	112,981	109,626	106,375	103,194
	55	128,936	127,870	125,552	122,397	119,149	115,947	112,658	109,323	106,077
	56	128,514	128,414	127,390	125,121	121,881	118,709	115,565	112,305	108,981
	57	127,892	127,930	127,874	126,901	124,533	121,374	118,262	115,152	111,910
	58	127,018	127,243	127,328	127,326	126,240	123,955	120,859	117,783	114,697

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	59	125,442	126,302	126,578	126,718	126,591	125,589	123,368	120,311	117,261
	60	123,059	124,660	125,568	125,903	125,909	125,867	124,929	122,749	119,720
	61	120,095	122,216	123,861	124,826	125,015	125,109	125,133	124,236	122,084
	62	116,937	119,194	121,357	123,054	123,854	124,136	124,301	124,366	123,498
	63	113,572	115,971	118,276	120,490	122,000	122,891	123,249	123,460	123,555
	64	110,227	112,533	114,988	117,351	119,360	120,955	121,920	122,329	122,574
	65	107,075	109,117	111,479	113,999	116,145	118,238	119,902	120,915	121,365
	66	104,092	105,897	107,992	110,418	112,710	114,948	117,108	118,816	119,867
	67	100,824	102,844	104,705	106,860	109,037	111,429	113,743	115,947	117,688
	68	97,057	99,504	101,583	103,506	105,383	107,665	110,141	112,507	114,743
	69	94,426	95,673	98,171	100,315	101,929	103,913	106,284	108,823	111,231
	70	93,601	92,932	94,277	96,832	98,628	100,358	102,436	104,875	107,466
	71	93,713	91,928	91,426	92,875	95,037	96,947	98,780	100,932	103,429
	72	93,507	91,819	90,242	89,915	90,987	93,249	95,260	97,175	99,391
	73	93,579	91,402	89,913	88,551	87,872	89,105	91,454	93,548	95,536
	74	91,276	91,256	89,285	88,002	86,258	85,834	87,217	89,634	91,801
	75	85,261	88,791	88,922	87,162	85,407	83,970	83,791	85,305	87,782
	76	76,905	82,702	86,294	86,583	84,286	82,818	81,676	81,724	83,363
	77	68,867	74,330	80,131	83,793	83,423	81,415	80,223	79,360	79,629
	78	60,557	66,276	71,745	77,557	80,438	80,269	78,537	77,605	77,016
	79	53,397	57,969	63,677	69,156	74,145	77,089	77,108	75,638	74,961
	80	48,342	50,792	55,373	61,075	65,783	70,738	73,733	73,926	72,713
	81	44,676	45,680	48,180	52,775	57,747	62,413	67,324	70,357	70,720
	82	40,735	41,938	43,012	45,568	49,518	54,421	59,038	63,893	66,958
	83	36,867	37,949	39,196	40,343	42,388	46,264	51,091	55,647	60,439
	84	33,063	34,049	35,158	36,453	37,227	39,211	43,006	47,747	52,238
	85	29,159	30,251	31,228	32,367	33,401	34,112	36,029	39,736	44,388

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	86	25,282	26,401	27,435	28,406	29,330	30,351	30,994	32,838	36,453
	87	21,585	22,622	23,642	24,619	25,547	26,293	27,297	27,867	29,637
	88	18,431	18,954	19,959	20,882	22,067	22,688	23,254	24,236	24,732
	89	15,713	15,967	16,321	17,296	18,527	19,515	19,826	20,208	21,168
	90	12,889	13,560	13,501	13,689	15,008	16,172	16,961	16,959	17,156
	91	9,994	10,936	11,407	11,035	11,733	12,720	13,816	14,402	14,087
	92	7,419	8,114	8,981	9,255	9,494	9,776	10,431	11,455	11,839
	93	5,743	5,866	6,233	7,028	7,933	7,953	7,818	8,138	9,092
	94	4,719	4,605	4,312	4,353	5,991	6,610	6,411	5,858	5,844
	95	3,506	3,756	3,466	2,760	3,669	4,954	5,287	4,868	3,897
	96	2,103	2,759	2,793	2,328	2,503	2,985	3,916	3,962	3,323
	97	1,514	1,613	2,012	1,830	1,970	2,128	2,300	2,878	2,637
	98	1,040	1,107	1,124	1,266	1,365	1,476	1,596	1,614	1,839
	99	505	545	587	634	686	742	803	865	929
	100	589	661	735	808	880	951	1,024	1,104	1,194
Romania	0	97,499	92,509	87,834	84,643	83,309	83,351	84,271	85,300	85,867
	1	94,540	92,077	89,742	87,939	85,216	86,191	85,898	85,717	85,471
	2	99,348	92,073	91,368	90,530	88,067	85,752	87,324	86,293	85,464
	3	96,815	97,920	92,753	92,513	90,384	88,156	86,259	87,009	85,797
	4	95,263	96,472	96,500	93,982	92,232	90,196	88,216	86,768	86,422
	5	94,585	95,601	96,139	95,032	93,679	91,909	89,978	88,277	87,291
	6	94,678	95,270	95,952	95,758	94,819	93,333	91,556	89,763	88,353
	7	95,306	95,441	95,968	96,256	95,748	94,563	92,956	91,204	89,562
	8	96,233	95,877	96,216	96,620	96,389	95,695	94,276	92,582	90,868
	9	98,014	96,343	96,461	96,946	96,749	96,478	95,610	93,991	92,222
	10	100,810	97,792	96,464	96,998	96,982	96,834	96,535	95,527	93,721
	11	104,120	100,582	97,580	96,539	96,997	96,974	96,887	96,594	95,460

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	12	107,539	104,082	100,366	97,321	96,529	96,952	96,933	96,942	96,669
	13	111,453	107,555	104,056	100,100	97,298	96,475	96,874	96,895	97,012
	14	113,303	111,456	107,584	103,979	100,060	97,230	96,388	96,799	96,873
	15	111,872	113,286	111,472	107,561	103,918	99,974	97,131	96,304	96,739
	16	108,396	111,824	113,282	111,434	107,480	103,810	99,854	97,033	96,236
	17	105,287	108,312	111,789	113,222	111,333	107,350	103,668	99,737	96,952
	18	102,014	105,167	108,240	111,700	113,103	111,181	107,184	103,528	99,637
	19	99,820	101,857	105,059	108,115	111,567	112,932	110,992	107,021	103,404
	20	99,553	99,632	101,712	104,899	107,971	111,383	112,724	110,805	106,876
	21	100,578	99,342	99,455	101,517	104,745	107,779	111,162	112,518	110,637
	22	101,568	100,351	99,142	99,229	101,352	104,543	107,550	110,943	112,330
	23	102,975	101,326	100,135	98,893	99,058	101,141	104,307	107,323	110,743
	24	104,075	102,717	101,094	99,870	98,722	98,842	100,897	104,072	107,115
	25	104,436	103,808	102,470	100,813	99,702	98,506	98,594	100,655	103,855
	26	104,604	104,171	103,554	102,174	100,648	99,488	98,257	98,347	100,430
	27	104,902	104,346	103,918	103,248	102,010	100,436	99,242	98,010	98,117
	28	104,481	104,651	104,100	103,613	103,088	101,800	100,192	98,997	97,780
	29	107,333	104,240	104,413	103,803	103,457	102,881	101,556	99,949	98,769
	30	115,222	107,100	104,010	104,124	103,652	103,255	102,639	101,314	99,723
	31	125,884	114,997	106,880	103,730	103,977	103,455	103,018	102,400	101,089
	32	136,176	125,665	114,785	106,607	103,588	103,784	103,223	102,784	102,178
	33	147,792	135,962	125,461	114,517	106,460	103,399	103,556	102,993	102,566
	34	153,183	147,580	135,763	125,195	114,350	106,264	103,176	103,330	102,781
	35	148,618	152,973	147,386	135,498	124,998	114,131	106,033	102,954	103,121
	36	138,065	148,406	152,779	147,119	135,270	124,745	113,874	105,805	102,750
	37	128,514	137,848	148,211	152,512	146,851	134,980	124,450	113,619	105,594
	38	117,714	128,288	137,647	147,944	152,214	146,516	134,645	124,158	113,384

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	39	113,004	117,477	128,078	137,379	147,635	151,848	146,133	134,312	123,886
	40	118,467	112,744	117,253	127,805	137,068	147,260	151,431	145,752	134,003
	41	130,197	118,171	112,498	116,972	127,481	136,694	146,835	151,017	145,396
	42	140,487	129,854	117,889	112,196	116,633	127,100	136,275	146,414	150,628
	43	151,217	140,091	129,526	117,549	111,820	116,241	126,677	135,859	146,017
	44	158,309	150,757	139,710	129,134	117,105	111,393	115,810	126,257	135,465
	45	159,066	157,789	150,315	139,261	128,600	116,608	110,929	115,382	125,857
	46	155,758	158,493	157,286	149,799	138,632	128,008	116,072	110,468	114,973
	47	152,946	155,133	157,938	156,707	149,067	137,939	127,372	115,539	110,025
	48	149,230	152,264	154,525	157,305	155,864	148,267	137,201	126,740	115,025
	49	147,341	148,499	151,599	153,841	156,346	154,950	147,417	136,466	126,129
	50	148,937	146,517	147,784	150,860	152,760	155,317	153,985	146,571	135,754
	51	152,238	147,955	145,709	146,996	149,659	151,610	154,235	153,024	145,750
	52	154,737	151,061	146,989	144,829	145,687	148,389	150,410	153,158	152,088
	53	158,056	153,365	149,899	145,949	143,374	144,311	147,071	149,213	152,106
	54	155,782	156,469	152,009	148,662	144,291	141,853	142,887	145,756	148,042
	55	144,832	154,057	154,896	150,576	146,773	142,566	140,285	141,467	144,466
	56	128,817	143,094	152,346	153,246	148,461	144,817	140,794	138,721	140,071
	57	113,681	127,142	141,371	150,558	150,879	146,277	142,813	139,026	137,181
	58	97,334	112,051	125,478	139,575	148,065	148,442	144,046	140,812	137,281
	59	87,800	95,762	110,431	123,751	137,156	145,505	145,956	141,818	138,836
	60	89,386	86,196	94,198	108,754	121,522	134,674	142,896	143,474	139,615
	61	97,967	87,601	84,598	92,586	106,693	119,238	132,147	140,291	141,017
	62	105,152	95,909	85,824	82,957	90,713	104,584	116,914	129,624	137,710
	63	112,669	102,843	93,859	84,001	81,140	88,798	102,440	114,594	127,123
	64	117,490	110,106	100,541	91,761	82,025	79,286	86,853	100,299	112,294
	65	117,277	114,708	107,552	98,187	89,487	80,011	77,405	84,912	98,175

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	66	113,657	114,339	111,934	104,941	95,644	87,171	77,971	75,527	82,985
	67	110,786	110,606	111,407	109,101	102,133	93,057	84,827	75,934	73,663
	68	108,068	107,621	107,562	108,417	106,037	99,278	90,439	82,486	73,909
	69	103,972	104,795	104,462	104,461	105,131	102,924	96,389	87,824	80,160
	70	98,225	100,614	101,527	101,246	100,980	101,794	99,778	93,505	85,225
	71	91,335	94,809	97,261	98,204	97,572	97,451	98,425	96,635	90,636
	72	84,216	87,887	91,399	93,855	94,342	93,851	93,890	95,059	93,508
	73	76,844	80,743	84,442	87,938	89,863	90,434	90,100	90,333	91,711
	74	69,575	73,346	77,272	80,951	83,899	85,829	86,498	86,352	86,792
	75	62,729	66,097	69,850	73,759	76,929	79,820	81,766	82,565	82,621
	76	56,314	59,333	62,620	66,314	69,766	72,871	75,715	77,707	78,647
	77	49,818	53,036	55,938	59,107	62,359	65,740	68,788	71,614	73,662
	78	43,108	46,667	49,758	52,510	55,255	58,375	61,692	64,710	67,525
	79	38,033	40,119	43,516	46,451	48,843	51,376	54,371	57,648	60,643
	80	35,391	35,106	37,128	40,338	43,021	45,152	47,480	50,371	53,614
	81	34,320	32,363	32,178	34,115	37,159	39,569	41,446	43,587	46,380
	82	33,258	31,101	29,334	29,229	31,222	33,960	36,104	37,743	39,703
	83	32,625	29,878	27,878	26,285	26,545	28,312	30,751	32,642	34,047
	84	31,111	29,082	26,496	24,637	23,681	23,848	25,394	27,545	29,186
	85	27,937	27,529	25,536	23,096	22,037	21,065	21,144	22,477	24,344
	86	23,775	24,515	23,943	21,971	20,559	19,426	18,443	18,441	19,566
	87	19,912	20,645	21,089	20,340	19,487	18,011	16,809	15,822	15,742
	88	16,416	16,982	17,511	17,647	17,922	16,993	15,458	14,193	13,205
	89	13,651	13,798	14,049	14,364	15,419	15,495	14,495	12,906	11,580
	90	11,218	11,498	11,176	11,104	12,355	13,183	13,064	11,997	10,357
	91	9,001	9,327	9,343	8,544	9,461	10,339	10,943	10,634	9,503
	92	6,921	7,206	7,434	7,179	7,329	7,813	8,321	8,704	8,206

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	93	5,494	5,449	5,409	5,533	6,140	6,110	6,162	6,303	6,468
	94	4,540	4,374	3,975	3,606	4,712	5,097	4,888	4,513	4,287
	95	3,388	3,594	3,253	2,496	3,046	3,888	4,052	3,668	2,865
	96	2,036	2,659	2,646	2,128	2,205	2,484	3,063	3,008	2,449
	97	1,460	1,570	1,929	1,695	1,759	1,813	1,921	2,238	1,965
	98	1,011	1,079	1,103	1,197	1,248	1,292	1,330	1,358	1,414
	99	501	548	593	635	673	706	736	765	796
	100	615	716	823	924	1,016	1,101	1,180	1,254	1,324

Table 18. Population projections by age, females, 2022-2030.

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
France	0	343,196	349,875	355,537	358,200	357,300	353,555	348,246	343,316	340,170
	1	345,538	347,318	348,958	349,488	355,881	347,129	344,968	342,955	341,577
	2	340,659	346,895	345,452	344,260	349,196	353,651	343,126	343,076	342,869
	3	348,038	342,234	344,624	342,090	345,333	348,991	351,435	343,662	344,105
	4	355,385	348,636	343,747	342,550	343,964	346,493	348,800	349,120	345,343
	5	362,542	355,468	349,171	345,216	344,759	345,925	347,668	348,513	346,642
	6	369,352	362,482	355,486	349,661	347,310	347,054	347,901	348,746	348,061
	7	375,874	369,431	362,355	355,459	351,210	349,492	349,365	349,781	349,659
	8	382,164	376,393	369,443	362,184	356,523	352,848	351,689	351,580	351,495
	9	386,992	383,441	376,843	369,410	363,078	357,677	354,501	353,789	353,627
	10	389,769	388,717	384,648	377,247	370,309	364,064	358,847	356,056	355,721
	11	390,985	391,330	390,372	385,806	377,946	371,302	365,065	359,917	357,442
	12	391,841	391,999	392,819	391,977	386,194	378,742	372,311	365,965	360,816
	13	392,253	392,478	392,942	394,258	392,061	386,679	379,553	373,216	366,692
	14	391,710	392,587	393,044	393,835	394,075	392,244	387,180	380,260	373,945
	15	390,132	391,750	392,850	393,560	393,425	393,992	392,443	387,574	380,786
	16	387,786	389,913	391,719	393,064	392,927	393,115	393,924	392,533	387,785
	17	385,196	387,348	389,624	391,639	392,203	392,394	392,821	393,748	392,438
	18	382,463	384,541	386,839	389,286	390,694	391,442	391,876	392,417	393,385
	19	379,426	381,587	383,817	386,283	388,464	389,848	390,697	391,249	391,828
	20	376,127	378,469	380,643	383,045	385,728	387,741	389,018	389,842	390,437
	21	372,825	375,290	377,444	379,652	382,757	385,271	387,033	388,079	388,804
	22	369,764	372,247	374,385	376,372	379,639	382,565	384,830	386,217	386,957
	23	366,927	369,444	371,601	373,434	376,674	379,721	382,389	384,281	385,219
	24	365,169	366,874	369,057	370,910	374,087	377,071	379,819	382,106	383,551
	25	364,952	365,422	366,754	368,625	371,927	374,834	377,484	379,811	381,643

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	26	366,011	365,544	365,608	366,589	370,005	373,037	375,598	377,792	379,624
	27	367,271	366,955	366,070	365,748	368,343	371,479	374,164	376,257	377,921
	28	368,527	368,566	367,832	366,550	367,761	370,191	372,969	375,187	376,738
	29	371,834	370,184	369,794	368,662	368,645	369,868	372,055	374,356	376,032
	30	377,973	373,740	371,773	370,975	370,715	370,834	371,991	373,816	375,564
	31	385,840	379,956	375,578	373,315	372,982	372,862	373,040	374,011	375,399
	32	393,492	387,777	381,868	377,367	375,257	375,083	375,026	375,142	375,853
	33	401,248	395,380	389,642	383,732	379,204	377,294	377,201	377,086	377,066
	34	407,676	403,068	397,195	391,458	385,429	381,137	379,347	379,215	378,966
	35	411,843	409,391	404,815	398,960	392,989	387,223	383,087	381,296	381,049
	36	414,274	413,420	411,031	406,510	400,303	394,619	389,034	384,931	383,063
	37	417,104	415,688	414,921	412,619	407,641	401,747	396,267	390,738	386,592
	38	420,722	418,333	417,026	416,369	413,565	408,876	403,209	397,805	392,256
	39	421,089	421,740	419,486	418,311	417,181	414,616	410,128	404,559	399,154
	40	416,672	421,927	422,682	420,586	419,021	418,098	415,684	411,267	405,717
	41	409,624	417,387	422,689	423,571	421,182	419,837	419,033	416,637	412,210
	42	402,840	410,252	418,027	423,398	424,050	421,886	420,671	419,852	417,393
	43	394,789	403,368	410,805	418,614	423,762	424,637	422,607	421,388	420,471
	44	392,772	395,215	403,822	411,306	418,865	424,234	425,241	423,210	421,905
	45	400,413	393,085	395,570	404,225	411,445	419,222	424,723	425,727	423,614
	46	413,975	400,588	393,325	395,875	404,255	411,688	419,597	425,095	426,012
	47	426,385	413,997	400,689	393,517	395,801	404,387	411,947	419,855	425,265
	48	439,408	426,261	413,944	400,741	393,328	395,826	404,535	412,093	419,914
	49	448,304	439,139	426,059	413,839	400,421	393,239	395,868	404,571	412,043
	50	450,114	447,898	438,790	425,805	413,378	400,201	393,166	395,800	404,416
	51	447,295	449,583	447,411	438,387	425,206	413,022	399,999	392,983	395,545
	52	445,149	446,649	448,971	446,868	437,646	424,714	412,682	399,685	392,615

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	53	442,479	444,387	445,922	448,304	446,004	437,016	424,239	412,228	399,182
	54	440,511	441,602	443,545	445,141	447,347	445,253	436,404	423,647	411,578
	55	440,342	439,525	440,644	442,649	444,108	446,502	444,520	435,670	422,854
	56	441,050	439,258	438,460	439,633	441,534	443,186	445,676	443,664	434,730
	57	440,859	439,875	438,095	437,341	438,434	440,530	442,283	444,726	442,597
	58	440,416	439,590	438,621	436,879	436,051	437,346	439,545	441,256	443,565
	59	438,233	439,047	438,242	437,313	435,482	434,870	436,276	438,437	440,022
	60	433,487	436,768	437,600	436,840	435,799	434,196	433,707	435,084	437,121
	61	427,129	431,929	435,224	436,099	435,199	434,394	432,926	432,423	433,687
	62	420,767	425,478	430,294	433,627	434,315	433,667	433,007	431,536	430,935
	63	413,876	419,009	423,750	428,607	431,704	432,640	432,153	431,499	429,943
	64	408,398	411,998	417,176	421,971	426,555	429,889	430,983	430,518	429,788
	65	405,399	406,385	410,045	415,293	419,787	424,610	428,092	429,206	428,680
	66	403,885	403,233	404,299	408,044	412,948	417,709	422,682	426,175	427,226
	67	400,995	401,547	400,995	402,164	405,507	410,706	415,647	420,636	424,057
	68	396,335	398,476	399,136	398,710	399,403	403,073	408,481	413,469	418,392
	69	393,328	393,640	395,885	396,679	395,685	396,742	400,653	406,141	411,096
	70	393,079	390,377	390,876	393,248	393,347	392,759	394,097	398,122	403,611
	71	393,508	389,751	387,355	388,065	389,595	390,114	389,849	391,341	395,404
	72	393,115	389,731	386,353	384,288	384,102	386,039	386,895	386,829	388,401
	73	394,217	388,872	385,885	382,909	379,865	380,237	382,498	383,568	383,627
	74	384,208	389,441	384,559	381,994	377,807	375,538	376,385	378,850	380,061
	75	357,308	379,055	384,597	380,203	376,082	372,798	371,224	372,427	375,024
	76	320,172	352,038	373,836	379,708	373,478	370,263	367,803	366,806	368,295
	77	284,337	314,923	346,706	368,575	372,104	366,846	364,458	362,704	362,216
	78	246,414	279,046	309,619	341,336	360,314	364,592	360,226	358,549	357,436
	79	218,509	241,085	273,705	304,281	332,786	352,143	357,092	353,505	352,473

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	80	207,468	212,888	235,713	268,335	295,660	324,319	343,982	349,490	346,619
	81	207,224	201,162	207,231	230,317	259,620	287,113	315,861	335,723	341,727
	82	204,817	199,973	194,823	201,552	221,596	250,969	278,573	307,313	327,310
	83	202,777	196,684	192,689	188,464	192,514	212,930	242,324	269,953	298,624
	84	198,535	193,825	188,518	185,386	178,592	183,522	204,269	233,609	261,210
	85	189,488	188,644	184,840	180,335	174,389	168,764	174,534	195,548	224,788
	86	177,287	178,502	178,722	175,840	168,653	163,435	158,937	165,495	186,739
	87	166,094	165,164	167,489	168,786	163,596	157,010	152,482	149,064	156,382
	88	157,637	152,710	153,017	156,462	155,620	151,392	145,369	141,483	139,124
	89	146,639	143,934	139,303	140,859	142,556	142,492	139,187	133,683	130,423
	90	130,955	132,734	130,211	125,888	125,994	128,682	129,362	126,941	121,940
	91	111,452	116,503	118,811	116,482	111,307	111,158	114,807	116,193	114,640
	92	94,306	95,818	102,036	104,884	102,728	96,751	96,319	100,896	102,975
	93	83,486	79,327	80,173	87,566	91,953	88,996	82,191	81,449	86,944
	94	73,153	70,290	64,341	64,529	76,162	79,043	75,261	67,605	66,548
	95	59,242	60,952	57,087	49,356	55,354	64,775	66,130	61,502	52,994
	96	41,755	48,604	48,745	43,886	44,513	46,192	53,385	53,194	47,720
	97	36,233	33,246	37,961	36,540	37,138	37,953	37,027	41,977	40,240
	98	26,483	26,781	24,735	27,321	27,899	28,606	29,364	27,849	30,555
	99	14,306	15,009	15,636	16,227	16,797	17,333	17,829	18,275	18,663
	100	20,800	23,897	26,902	29,401	31,274	32,643	33,659	34,569	35,555
Netherlands	0	84,109	85,796	87,220	87,951	87,910	87,207	86,100	84,983	84,143
	1	84,136	85,099	85,959	86,492	87,754	86,578	86,237	85,814	85,420
	2	82,874	84,597	85,009	85,370	86,533	87,561	86,238	86,326	86,272
	3	83,369	83,188	84,349	84,559	85,554	86,576	87,357	86,567	86,756
	4	83,896	83,509	83,487	84,035	84,808	85,740	86,611	87,125	86,931
	5	84,459	83,923	83,634	83,773	84,288	85,060	85,917	86,616	86,855

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	6	85,058	84,422	83,934	83,747	83,967	84,543	85,302	86,067	86,585
	7	85,714	84,999	84,369	83,932	83,822	84,165	84,789	85,517	86,178
	8	86,447	85,674	84,925	84,304	83,927	83,900	84,353	85,008	85,694
	9	87,171	86,468	85,619	84,838	84,307	83,924	83,968	84,514	85,189
	10	87,853	87,239	86,473	85,551	84,905	84,313	83,912	84,010	84,638
	11	88,548	87,930	87,292	86,465	85,652	84,974	84,310	83,872	84,014
	12	89,258	88,611	87,991	87,332	86,584	85,755	85,035	84,279	83,796
	13	89,880	89,329	88,659	88,039	87,476	86,705	85,849	85,068	84,211
	14	90,948	89,969	89,384	88,693	88,219	87,624	86,817	85,915	85,063
	15	92,694	91,063	90,042	89,426	88,915	88,403	87,762	86,901	85,943
	16	94,820	92,844	91,161	90,101	89,689	89,141	88,576	87,871	86,946
	17	96,889	95,011	92,977	91,245	90,406	89,955	89,356	88,721	87,942
	18	99,105	97,120	95,184	93,096	91,584	90,713	90,212	89,543	88,827
	19	100,575	99,376	97,334	95,344	93,459	91,926	91,011	90,439	89,690
	20	100,850	100,881	99,630	97,533	95,721	93,824	92,258	91,279	90,627
	21	100,391	101,180	101,169	99,869	97,925	96,102	94,180	92,560	91,507
	22	100,025	100,735	101,490	101,441	100,273	98,320	96,473	94,505	92,822
	23	99,488	100,382	101,061	101,786	101,849	100,681	98,704	96,812	94,789
	24	99,586	99,858	100,722	101,371	102,186	102,260	101,077	99,057	97,109
	25	100,772	99,960	100,210	101,047	101,756	102,591	102,661	101,441	99,365
	26	102,605	101,138	100,316	100,547	101,414	102,145	102,984	103,028	101,760
	27	104,192	102,956	101,485	100,656	100,895	101,786	102,523	103,343	103,349
	28	105,705	104,524	103,287	101,818	100,982	101,245	102,146	102,868	103,658
	29	106,852	106,016	104,837	103,603	102,123	101,311	101,585	102,474	103,167
	30	107,393	107,141	106,308	105,134	103,888	102,432	101,630	101,892	102,756
	31	107,480	107,661	107,411	106,584	105,397	104,177	102,730	101,916	102,155
	32	107,587	107,728	107,910	107,664	106,823	105,664	104,455	102,995	102,156

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	33	107,719	107,812	107,956	108,142	107,881	107,066	105,919	104,698	103,214
	34	107,356	107,919	108,018	108,168	108,338	108,101	107,298	106,140	104,896
	35	106,319	107,533	108,101	108,207	108,345	108,538	108,309	107,494	106,315
	36	104,867	106,477	107,692	108,265	108,364	108,525	108,725	108,483	107,643
	37	103,523	105,006	106,615	107,834	108,402	108,524	108,693	108,878	108,608
	38	102,287	103,643	105,127	106,738	107,951	108,543	108,673	108,826	108,982
	39	101,135	102,387	103,745	105,231	106,836	108,073	108,671	108,786	108,912
	40	100,141	101,216	102,469	103,830	105,312	106,939	108,182	108,765	108,852
	41	99,400	100,204	101,279	102,535	103,893	105,396	107,030	108,256	108,811
	42	98,790	99,445	100,249	101,326	102,579	103,958	105,469	107,086	108,283
	43	98,162	98,817	99,473	100,279	101,352	102,626	104,013	105,507	107,095
	44	98,752	98,170	98,826	99,486	100,287	101,381	102,662	104,033	105,499
	45	101,109	98,741	98,162	98,821	99,477	100,299	101,398	102,664	104,009
	46	104,628	101,075	98,712	98,138	98,795	99,472	100,299	101,383	102,622
	47	108,058	104,570	101,023	98,668	98,093	98,772	99,456	100,267	101,324
	48	111,530	107,975	104,493	100,956	98,603	98,051	98,738	99,407	100,192
	49	114,906	111,421	107,872	104,401	100,869	98,541	97,999	98,672	99,315
	50	117,953	114,770	111,292	107,754	104,290	100,786	98,468	97,914	98,563
	51	120,663	117,790	114,614	111,147	107,617	104,182	100,691	98,364	97,787
	52	123,310	120,470	117,605	114,441	110,984	107,485	104,063	100,563	98,216
	53	125,900	123,087	120,256	117,402	114,249	110,825	107,340	103,910	100,392
	54	127,545	125,645	122,842	120,023	117,178	114,061	110,654	107,161	103,712
	55	127,848	127,259	125,368	122,578	119,762	116,957	113,860	110,447	106,935
	56	127,157	127,531	126,950	125,073	122,280	119,506	116,723	113,622	110,191
	57	126,292	126,809	127,191	126,622	124,733	121,985	119,235	116,451	113,335
	58	125,177	125,911	126,439	126,832	126,242	124,398	121,677	118,927	116,128
	59	123,594	124,760	125,507	126,049	126,411	125,865	124,048	121,329	118,566

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	60	121,545	123,142	124,321	125,085	125,587	125,994	125,474	123,659	120,928
	61	119,153	121,060	122,668	123,863	124,577	125,129	125,563	125,043	123,215
	62	116,576	118,634	120,553	122,176	123,304	124,073	124,657	125,091	124,557
	63	113,828	116,018	118,095	120,029	121,564	122,748	123,555	124,144	124,565
	64	111,138	113,225	115,440	117,538	119,366	120,957	122,179	122,997	123,577
	65	108,652	110,488	112,602	114,845	116,821	118,706	120,335	121,570	122,385
	66	106,337	107,955	109,818	111,962	114,064	116,107	118,034	119,675	120,908
	67	103,766	105,589	107,239	109,133	111,106	113,287	115,380	117,323	118,963
	68	100,729	102,963	104,823	106,507	108,195	110,253	112,496	114,616	116,561
	69	98,729	99,870	102,141	104,041	105,484	107,261	109,388	111,669	113,802
	70	98,378	97,783	98,995	101,305	102,921	104,463	106,315	108,487	110,794
	71	98,857	97,295	96,819	98,104	100,083	101,804	103,431	105,334	107,539
	72	99,029	97,606	96,194	95,841	96,787	98,864	100,675	102,365	104,308
	73	99,478	97,610	96,337	95,080	94,370	95,472	97,634	99,514	101,254
	74	97,524	97,880	96,173	95,055	93,369	92,901	94,146	96,372	98,309
	75	91,831	95,775	96,264	94,723	93,054	91,660	91,421	92,790	95,068
	76	83,783	89,982	94,009	94,635	92,441	91,054	89,940	89,911	91,393
	77	76,025	81,863	88,117	92,231	92,068	90,161	89,044	88,191	88,363
	78	67,940	74,029	79,929	86,240	89,432	89,501	87,870	87,004	86,404
	79	61,129	65,876	72,020	77,985	83,300	86,635	86,924	85,550	84,928
	80	56,626	58,963	63,801	70,002	74,966	80,362	83,827	84,319	83,194
	81	53,619	54,303	56,787	61,717	66,911	71,949	77,413	80,992	81,679
	82	50,259	51,107	51,971	54,605	58,579	63,821	68,922	74,439	78,124
	83	46,913	47,581	48,587	49,632	51,412	55,441	60,723	65,873	71,434
	84	43,516	44,089	44,895	46,061	46,360	48,220	52,295	57,604	62,797
	85	39,850	40,556	41,257	42,204	42,707	43,088	45,020	49,132	54,463
	86	36,057	36,768	37,589	38,421	38,731	39,352	39,810	41,806	45,951

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	87	32,412	32,877	33,680	34,619	35,026	35,258	35,992	36,518	38,576
	88	29,360	29,088	29,692	30,589	31,390	31,630	31,780	32,619	33,213
	89	26,312	26,075	25,760	26,504	27,427	28,161	28,228	28,291	29,235
	90	22,693	23,184	22,786	22,431	23,273	24,264	24,928	24,818	24,792
	91	18,629	19,637	20,053	19,495	19,461	20,041	21,097	21,686	21,399
	92	15,065	15,519	16,580	16,922	16,915	16,489	16,805	17,923	18,437
	93	12,729	12,252	12,407	13,521	14,612	14,335	13,515	13,564	14,744
	94	10,878	10,396	9,437	9,295	11,601	12,302	11,751	10,536	10,319
	95	8,566	8,802	8,062	6,623	7,880	9,679	9,990	9,164	7,555
	96	5,794	6,838	6,724	5,728	5,858	6,466	7,756	7,674	6,574
	97	4,527	4,505	5,109	4,647	4,755	4,896	5,049	5,830	5,357
	98	3,273	3,299	3,215	3,380	3,461	3,566	3,683	3,631	3,903
	99	1,803	1,843	1,883	1,926	1,978	2,035	2,095	2,155	2,213
	100	2,814	2,978	3,129	3,258	3,364	3,448	3,521	3,598	3,687
Romania	0	92,393	87,613	83,132	80,069	78,801	78,847	79,733	80,717	81,253
	1	89,546	87,193	84,954	83,223	80,625	81,572	81,298	81,125	80,882
	2	94,163	87,177	86,501	85,697	83,352	81,146	82,666	81,680	80,880
	3	91,699	92,776	87,813	87,583	85,561	83,444	81,639	82,365	81,200
	4	90,177	91,356	91,390	88,973	87,319	85,388	83,507	82,128	81,796
	5	89,497	90,492	91,017	89,960	88,688	87,016	85,185	83,566	82,622
	6	89,560	90,147	90,811	90,633	89,762	88,364	86,683	84,979	83,632
	7	90,139	90,285	90,800	91,087	90,632	89,525	88,009	86,346	84,778
	8	91,006	90,679	91,014	91,412	91,223	90,590	89,256	87,651	86,016
	9	92,697	91,103	91,223	91,700	91,544	91,318	90,516	88,984	87,299
	10	95,367	92,474	91,203	91,725	91,742	91,635	91,382	90,439	88,719
	11	98,533	95,138	92,254	91,260	91,732	91,744	91,695	91,442	90,369
	12	101,795	98,486	94,912	91,990	91,258	91,698	91,714	91,750	91,508

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	13	105,513	101,800	98,443	94,641	91,976	91,216	91,633	91,680	91,812
	14	107,283	105,505	101,808	98,352	94,613	91,922	91,142	91,563	91,653
	15	105,958	107,255	105,500	101,768	98,308	94,543	91,836	91,064	91,500
	16	102,691	105,900	107,231	105,446	101,708	98,220	94,441	91,746	90,992
	17	99,749	102,599	105,846	107,155	105,368	101,602	98,098	94,334	91,662
	18	96,633	99,623	102,510	105,742	107,063	105,244	101,461	97,972	94,234
	19	94,475	96,472	99,500	102,373	105,639	106,924	105,084	101,315	97,853
	20	94,053	94,285	96,314	99,330	102,261	105,490	106,748	104,919	101,177
	21	94,785	93,844	94,099	96,111	99,210	102,105	105,303	106,567	104,762
	22	95,476	94,564	93,638	93,868	95,984	99,047	101,913	105,113	106,394
	23	96,565	95,244	94,346	93,388	93,737	95,815	98,850	101,717	104,929
	24	97,267	96,322	95,015	94,084	93,258	93,564	95,612	98,648	101,528
	25	97,137	97,020	96,083	94,740	93,957	93,086	93,359	95,406	98,453
	26	96,748	96,893	96,776	95,797	94,618	93,789	92,882	93,151	95,206
	27	96,525	96,513	96,652	96,486	95,680	94,455	93,589	92,675	92,949
	28	95,672	96,299	96,280	96,365	96,374	95,521	94,258	93,384	92,474
	29	97,939	95,458	96,077	96,002	96,260	96,220	95,328	94,057	93,187
	30	105,007	97,738	95,247	95,808	95,903	96,112	96,032	95,131	93,863
	31	114,767	104,819	97,539	94,990	95,716	95,761	95,930	95,840	94,941
	32	124,243	114,594	104,635	97,294	94,903	95,580	95,586	95,745	95,656
	33	135,001	124,084	114,424	104,401	97,211	94,775	95,412	95,407	95,566
	34	140,198	134,857	123,929	114,200	104,316	97,086	94,614	95,239	95,235
	35	136,438	140,065	134,717	123,715	114,111	104,186	96,926	94,449	95,074
	36	127,334	136,311	139,937	134,513	123,620	113,971	104,019	96,762	94,290
	37	119,182	127,209	136,188	139,742	134,409	123,470	113,792	103,848	96,605
	38	109,865	119,057	127,088	136,001	139,631	134,246	123,277	113,607	103,684
	39	106,411	109,739	118,936	126,906	135,889	139,459	134,035	123,079	113,431

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	40	112,679	106,282	109,616	118,759	126,794	135,717	139,238	133,819	122,889
	41	124,907	112,544	106,155	109,442	118,644	126,626	135,497	139,011	133,613
	42	135,819	124,762	112,412	105,979	109,321	118,476	126,414	135,271	138,794
	43	147,287	135,663	124,622	112,226	105,844	109,152	118,267	126,196	135,056
	44	154,817	147,115	135,512	124,423	112,066	105,663	108,946	118,052	125,987
	45	155,575	154,629	146,949	135,296	124,227	111,856	105,446	108,734	117,847
	46	152,027	155,368	154,445	146,712	135,063	123,977	111,607	105,223	108,530
	47	149,027	151,800	155,166	154,188	146,437	134,770	123,683	111,354	105,009
	48	145,063	148,777	151,577	154,890	153,871	146,098	134,430	123,385	111,108
	49	143,404	144,793	148,532	151,283	154,533	153,486	145,708	134,085	123,095
	50	145,986	143,097	144,527	148,217	150,884	154,107	153,047	145,311	133,749
	51	150,769	145,622	142,795	144,192	147,776	150,419	153,628	152,602	144,925
	52	154,771	150,335	145,263	142,425	143,711	147,269	149,901	153,142	152,169
	53	159,789	154,264	149,905	144,834	141,889	143,167	146,712	149,377	152,667
	54	158,918	159,198	153,762	149,404	144,218	141,290	142,573	146,148	148,864
	55	148,808	158,273	158,610	153,186	148,695	143,538	140,642	141,973	145,595
	56	133,359	148,159	157,631	157,947	152,381	147,921	142,809	139,988	141,384
	57	118,975	132,734	147,514	156,915	157,031	151,509	147,095	142,073	139,345
	58	103,359	118,362	132,113	146,798	155,934	156,044	150,584	146,263	141,348
	59	95,299	102,758	117,753	131,428	145,833	154,885	155,003	149,653	145,442
	60	99,490	94,665	102,160	117,086	130,520	144,803	153,781	153,956	148,734
	61	111,391	98,754	94,034	101,513	116,216	129,554	143,722	152,671	152,920
	62	121,750	110,505	98,021	93,358	100,678	115,294	128,543	142,635	151,573
	63	132,406	120,716	109,622	97,240	92,492	99,797	114,333	127,527	141,560
	64	140,176	131,215	119,685	108,686	96,244	91,586	98,883	113,366	126,520
	65	142,542	138,831	130,028	118,596	107,488	95,205	90,647	97,964	112,408
	66	141,164	141,051	137,488	128,777	117,196	106,242	94,132	89,705	97,053

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	67	140,456	139,534	139,564	136,078	127,169	115,744	104,959	93,057	88,770
	68	139,815	138,678	137,907	138,008	134,231	125,503	114,251	103,672	91,988
	69	137,174	137,884	136,903	136,212	135,893	132,325	123,794	112,754	102,393
	70	132,036	135,088	135,955	135,060	133,807	133,716	130,372	122,081	111,267
	71	125,119	129,789	133,002	133,960	132,365	131,342	131,492	128,414	120,377
	72	117,889	122,710	127,543	130,851	130,976	129,609	128,831	129,264	126,467
	73	110,348	115,307	120,303	125,234	127,585	127,932	126,808	126,315	127,047
	74	102,418	107,568	112,725	117,835	121,698	124,260	124,844	124,004	123,810
	75	94,306	99,482	104,787	110,086	114,046	118,106	120,892	121,753	121,209
	76	86,285	91,282	96,544	101,953	106,051	110,205	114,472	117,521	118,671
	77	78,007	83,203	88,256	93,556	97,666	101,967	106,325	110,836	114,160
	78	69,047	74,873	80,119	85,184	89,105	93,333	97,847	102,443	107,209
	79	62,931	65,919	71,736	76,994	80,698	84,612	88,968	93,726	98,570
	80	61,221	59,605	62,788	68,562	72,554	76,173	80,090	84,602	89,612
	81	62,189	57,378	56,277	59,624	64,192	68,079	71,621	75,566	80,243
	82	62,831	57,653	53,531	52,917	55,393	59,791	63,581	67,069	71,050
	83	64,095	57,668	53,111	49,653	48,700	51,134	55,369	59,082	62,524
	84	62,714	58,300	52,498	48,538	45,233	44,459	46,858	50,947	54,589
	85	56,870	56,572	52,497	47,298	43,808	40,791	40,202	42,583	46,530
	86	48,258	50,828	50,421	46,662	42,389	39,055	36,334	35,946	38,312
	87	39,929	42,622	44,778	44,239	41,618	37,457	34,289	31,879	31,694
	88	32,160	34,456	36,979	38,700	39,139	36,552	32,513	29,524	27,427
	89	26,411	27,145	28,975	31,311	33,888	34,019	31,474	27,570	24,763
	90	21,592	22,363	22,123	23,474	26,879	29,058	28,887	26,397	22,631
	91	17,351	18,002	18,310	17,084	19,890	22,432	24,219	23,756	21,324
	92	13,307	13,827	14,406	14,242	14,606	16,294	17,977	19,380	18,629
	93	10,523	10,379	10,296	10,800	12,135	12,120	12,694	13,524	14,546

Country	Age	2022	2023	2024	2025	2026	2027	2028	2029	2030
	94	8,679	8,291	7,445	6,757	9,158	10,022	9,630	9,095	9,074
	95	6,433	6,791	6,055	4,505	5,672	7,510	7,905	7,141	5,498
	96	3,783	4,983	4,899	3,813	3,969	4,585	5,860	5,789	4,653
	97	2,623	2,867	3,531	3,003	3,125	3,238	3,495	4,211	3,675
	98	1,788	1,889	1,949	2,076	2,165	2,246	2,330	2,406	2,563
	99	836	903	968	1,030	1,087	1,139	1,190	1,248	1,318
	100	856	995	1,139	1,272	1,390	1,498	1,597	1,694	1,792

Risk factor data: BMI

BMI was categorised according to the World Health Organization (WHO) definitions:

Table 19: BMI data sources, by country and year

	BMI (kg/m2)
Healthy weight	< 25
Pre-obesity	25 - 29.99
Obesity	≥ 30

Risk factor data: alcohol

Alcohol consumption was categorised based on definitions used by the Organisation for Economic Co-Operation and Development's (OECD) strategic public health model for non-communicable diseases (NCD):

Table 20: Alcohol data sources by country

	Alcohol units per day	Alcohol units per week	Alcohol grams per week
Low risk	M: ≤ 1.75 F: ≤ 1.75	M: ≤ 12.25 F: ≤12.25	M: ≤ 98g F: ≤ 98g
Moderate risk	M: >1.75 – ≤7.5 F: >1.75 - ≤5	M: >12.25– ≤52.5 F: > 12.25 - ≤35	M: >98g – ≤420g F: > 98g – ≤280g
High risk	M: > 7.5 F: > 5	M: > 52.5 F: > 35	M: > 420g F: > 280g

*1 unit = 8g alcohol

Liver disease data

A literature review was conducted to identify data sources for epidemiological characteristics of CLD and liver cancer, to identify and extract incidence, prevalence, and mortality data for both diseases.

Proxy countries with a similar population distribution of mean alcohol consumption, mean BMI and age were identified and literature searches conducted for available data from all suitable proxy countries. If no suitable data were identified for any country, then proxy parameters were estimated by computation from other parameters for which data were available.

All epidemiological data sources included in the model are shown in Table 21-Table 24.

Table 21: Liver cancer incidence, prevalence and mortality statistics were taken from Ferlay et al. 2018 (Using ICD-10 code: C22) [11] [2]

		France (2018)		Netherlands (2018)		Romania (2018)	
		Male	Female	Male	Female	Male	Female
Incidence (per 100,000)	0-24	0.29	0.18	0.28	0.21	0.31	0.08
	25-39	0.68	0.36	0.44	0.26	0.94	0.78
	40-54	15.2	2.1	2.8	1.4	11.9	14.8
	55-69	62.9	11.1	12.7	5.9	61.6	36.5
	70+	94.5	25.4	34.4	19.6	98.6	46.8
Prevalence (per 100,000)	0-24	0.83	0.52	0.89	0.89	0.34	0.16
	25-39	0.88	0.65	0.57	0.45	1.2	0.98
	40-54	4	2.9	0.96	1.9	9.4	3.9
	55-69	49.1	9.8	10.2	5.4	44.3	17.6
	70+	58.8	13.9	21.7	11.1	56.6	25
Mortality (per 100,000)	0-24	0.08	0.04	0.04	0.04	0.19	0.08
	25-39	0.78	0.34	0.25	0.26	0.99	0.41
	40-54	19.2	1.9	5.2	1.4	8.8	10.8
	55-49	45.3	9.4	12.6	6.6	54.7	18.9
	70+	106.6	36.9	38.9	20.6	93.9	45.8

2 Liver cancer incidence, prevalence and mortality extracted from Ferlay et al.2018 which provides counts based on the appearance of ICD-10 code: C22

Table 22: Chronic liver disease incidence statistics for the three countries were taken from the GBD IHME 2019 [65] [3]

Incidence (per 100,000 individuals)	France		Netherlands		Romania (France proxy)	
	Male	Female	Male	Female	Male	Female
1-4	2.830914	3.930574302	2.772326	3.944123446	2.830914	3.930574302
5-9	1.801893	2.658654157	1.741736	2.626692831	1.801893	2.658654157
10-14	2.635208	4.005622526	2.53286	3.857202228	2.635208	4.005622526
15-19	4.853969	6.438638364	4.581821	6.137236065	4.853969	6.438638364
20-24	8.637271	9.589780878	7.803385	8.990176666	8.637271	9.589780878
25-29	15.16136	15.21588384	12.68802	13.66625317	15.16136	15.21588384
30-34	30.4319	25.68685056	21.37693	21.61559922	30.4319	25.68685056
35-39	63.18247	42.55129715	34.49666	31.95185113	63.18247	42.55129715
40-44	113.9212	59.64491398	50.97959	42.41038854	113.9212	59.64491398
45-49	120.1417	53.04460777	61.07324	44.50434515	120.1417	53.04460777
50-54	60.18469	24.03765677	47.13494	30.49839192	60.18469	24.03765677
55-59	4.014793	2.769119745	15.38179	11.0889896	4.014793	2.769119745
60-64	0	0.010749442	0.121178	0.753579448	0	0.010749442
65-69	0	0	0	0.008385031	0	0
70-74	0	0	0	0	0	0
75-79	0	0	0	0	0	0
80-84	0	0	0.014544	0.002109265	0	0
85-89	0.068887	0.00620315	2.328795	1.661646439	0.068887	0.00620315
90-94	4.643852	6.51151108	24.0378	32.46203363	4.643852	6.51151108

3 Chronic liver disease incidence extracted from the GBD IHME 2019 which classifies cases as those based on "cirrhosis and other chronic liver disease" and the appearance of at least one of the following ICD-10 codes: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4

Table 23: Chronic liver disease prevalence data inputs for the three countries were taken from the GBD IHME 2019 [65] [4]

Prevalence	France		Netherlands		Romania (France proxy)	
	Male	Female	Male	Female	Male	Female
1-4	215.7133033	199.8614666	141.8263732	147.7233719	657.4264377	764.8443362
5-9	449.8902741	405.6236842	325.4414018	346.2882105	1088.430034	1204.352984
10-14	895.3591195	751.944305	872.1964978	937.8561132	1284.902436	1383.092348
15-19	5343.439189	3345.248558	5599.348032	3660.065457	6617.673322	4665.595211
20-24	9857.614177	5683.905411	10550.08478	6403.669925	12112.45769	8111.266598
25-29	13862.63998	7596.240424	14602.15976	8471.231269	18295.39406	12757.29486
30-34	17113.72048	9113.193099	17422.79013	9755.679382	22035.38311	15619.29019
35-39	18782.77559	9920.275209	18736.66939	10255.66772	24721.06718	17780.83967
40-44	20196.0457	10781.27685	19815.17316	10832.74013	26589.51935	19357.21237
45-49	22784.22424	12638.80988	21876.16567	12581.06673	29588.34838	22416.77426
50-54	24466.79319	13889.4892	23192.13762	13801.74758	32016.29589	25413.76949
55-59	24957.63648	14057.43445	23756.31219	13886.4551	33371.01074	27513.90665
60-64	25401.83487	14562.35439	24362.50206	14513.08874	33854.51929	29449.54829
65-69	26827.56297	16294.40902	25970.00215	16713.57101	34334.57369	31990.97309
70-74	28212.95997	18553.34029	27551.66142	19363.87031	34485.40168	34197.80955
75-79	28126.26386	20107.51723	27758.75056	21227.56439	34236.86397	35121.58735
80-84	26735.90197	20386.39792	26641.92153	21597.19321	33486.27068	33558.46921
85-89	24111.62259	19318.94349	24018.81327	20365.45546	29874.56855	28298.61435
90-94	22437.39017	18516.96962	22394.40706	19469.04577	26733.26174	24721.17332

4 Chronic liver disease prevalence extracted from the GBD IHME 2019 which classifies cases as those based on "cirrhosis and other chronic liver disease" and the appearance of at least one of the following ICD-10 codes: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4

Table 24: Chronic liver disease mortality data for the three countries were taken from the GBD IHME 2019 [65]

Mortality (per 100,000 individuals)	France		Netherlands		Romania (France proxy)	
	Male	Female	Male	Female	Male	Female
1-4	0.049790657	0.042470122	0.03619135	0.021395966	0.049790657	0.042470122
5-9	0.02031519	0.01951163	0.021723016	0.014545005	0.02031519	0.01951163
10-14	0.019507245	0.021022033	0.026497325	0.021942033	0.019507245	0.021022033
15-19	0.061647935	0.047198957	0.048040127	0.036405651	0.061647935	0.047198957
20-24	0.16032819	0.120496819	0.102313063	0.080793898	0.16032819	0.120496819
25-29	0.554510418	0.271136656	0.387775383	0.208243847	0.554510418	0.271136656
30-34	1.606378632	0.740087445	0.921997148	0.344901783	1.606378632	0.740087445
35-39	4.297681343	1.604164515	1.482589162	0.818045638	4.297681343	1.604164515
40-44	10.37543893	3.401908832	3.337108868	1.598790849	10.37543893	3.401908832
45-49	19.7017754	6.792232771	6.746523323	2.858361882	19.7017754	6.792232771
50-54	31.1655738	11.51219746	11.67719559	5.296791825	31.1655738	11.51219746
55-59	42.95331318	15.03081795	17.37849712	7.706804352	42.95331318	15.03081795
60-64	53.82973833	17.68559739	22.24799342	10.35904739	53.82973833	17.68559739
65-69	56.78975713	20.09790006	25.08079957	12.9735447	56.78975713	20.09790006
70-74	55.95190565	21.81545138	28.54963567	16.88389172	55.95190565	21.81545138
75-79	59.98942059	26.90390282	37.8635334	24.25613004	59.98942059	26.90390282
80-84	66.499522	33.00437225	56.47342528	40.61958039	66.499522	33.00437225
85-89	87.15999134	44.94325421	97.16273486	76.36291624	87.15999134	44.94325421
90-94	123.6931699	71.55839203	164.5869481	154.116355	123.6931699	71.55839203

Relative risk data

A literature review was conducted to identify the relative risks for liver disease incidence from increases in BMI and alcohol consumption. The extracted risks are shown in Table 25 and Table 26.

Table 25: BMI liver disease risks

Liver disease relative risks				
Disease	Description	Risk values	Reference	Notes
Chronic Liver Disease	Hazard ratio by BMI category, adjusted for age and year of birth. Risk data identified only for males with anthropometric measurements at 17–19 years who were followed-up for average 28.5 years. Hazard ratio by BMI category, adjusted for alcohol consumption. Risk data identified only for females 50-74 years of age.	Male: 18.5-22.5: 1.00 (reference) 22.5-25.0: 1.12 25.0-30.0: 1.53 >30: 2.44 Female: 18.5-22.5: 1.00 (reference) 22.5-25.0: 1.00 25.0-30.0: 1.44 >30: 2.25	Hagstrom et al. 2018 [66] Trembling et al. 2017 [67]	Large sample at enrolment (n=1,220,261) in Sweden. No ICD-codes provided. Outcomes from ICD-10 codes: K70, K73, K76, I85, Z94.4, C22.0 and death certificate text. Large sample (n= 95,126).
Liver cancer	International Relative risk	Pre-obese compared with healthy weight: 1.19 (1.10-1.27) Obese compared with healthy weight: 1.87 (1.65-2.11)	Yang C et al. 2020 [68]	C22

Table 26: Alcohol liver disease risks

Liver disease relative risks				
Disease	Description	Risk values	Reference	Notes
Chronic Liver Disease	Hazard ratio by dose (grams per day). Male only, no references identified for overall population or female-only risks. Univariate and multivariate risks reported in reference- univariate risks extracted. Swedish	0: 1.00 (reference) 1-5: 1.56 6-10: 1.98 11-15.0: 2.01 16-20: 2.67 21-25: 3.66 26-30: 3.87 31-40: 5.02 41-50: 7.45 51-60: 11.68	Hagstrom et al. 2018 [69]	Large sample at enrolment (n=1,220,261) in Sweden. No ICD-codes provided. Outcomes from ICD-10 codes: K70, K73, K76, I85, Z94.4, C22.0 and death certificate text. Large sample (n= 95,126).
Liver cancer	Relative risk (as compared to no alcohol consumption, by grams consumed per day)	None: 1.00 (reference) 12g: 1.08 (1.04-1.11) 25g: 1.19 (1.12-1.27) 50g: 1.54 (1.36-1.74) 75g: 2.14 (1.74-2.62) 100g: 3.21 (2.34-4.40) 125g: 5.20 (3.25-8.29)	Chuang SC et al. 2015 [70]	C22

Disability weights data

The mean disability weight of 0.451 for liver cancer was used, as reported from Paik et al 2021 [71]. As the study does not estimate disability weights stratified by sex, we have chosen to use this value for both males and females.

For chronic liver disease, a mean disability weight of 0.178 for both males and females as reported from the Global Burden of Disease 2019 study was used [8, 65].

For the DALYs calculation, a life expectancy is needed. Using the WHO estimate, we assumed that premature death from liver related disease includes deaths of those below the age of 70 [72].

Table 27: Disability weights data inputs

Disability weights			
Disease	Criteria		Mean average disability weight
Liver cancer	Metastatic phase of liver cancer due to alcohol use Metastatic phase of liver cancer due to NASH Metastatic phase of hepatoblastoma Metastatic phase of liver cancer due to other causes	Cancer, metastatic	0.451 (0.307-0.600)
Chronic Liver Disease	Cirrhosis and other CLDs due to alcohol, decompensated, without anaemia. Cirrhosis and other CLDs due to other, decompensated, with no anaemia	Decompensated cirrhosis of the liver	0.178 (0.123-0.250)

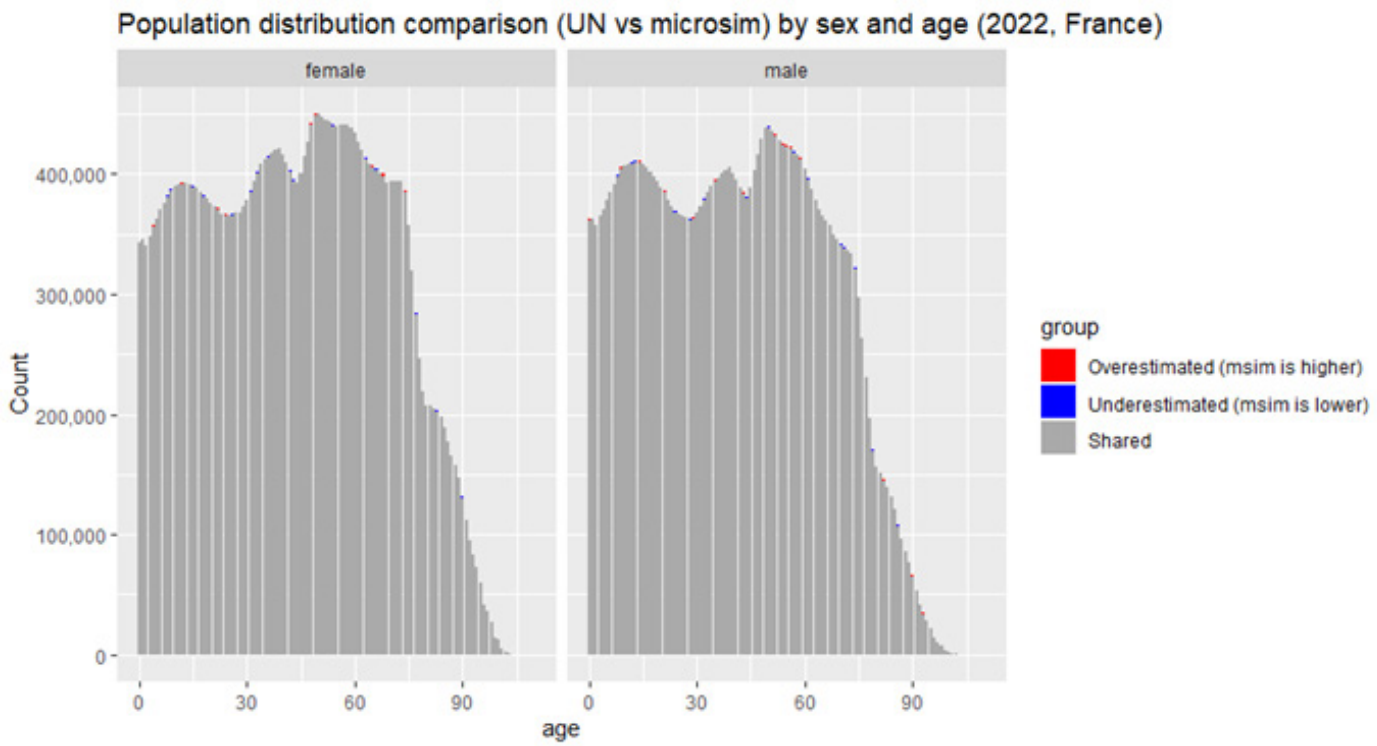
Appendix 4. Model validation

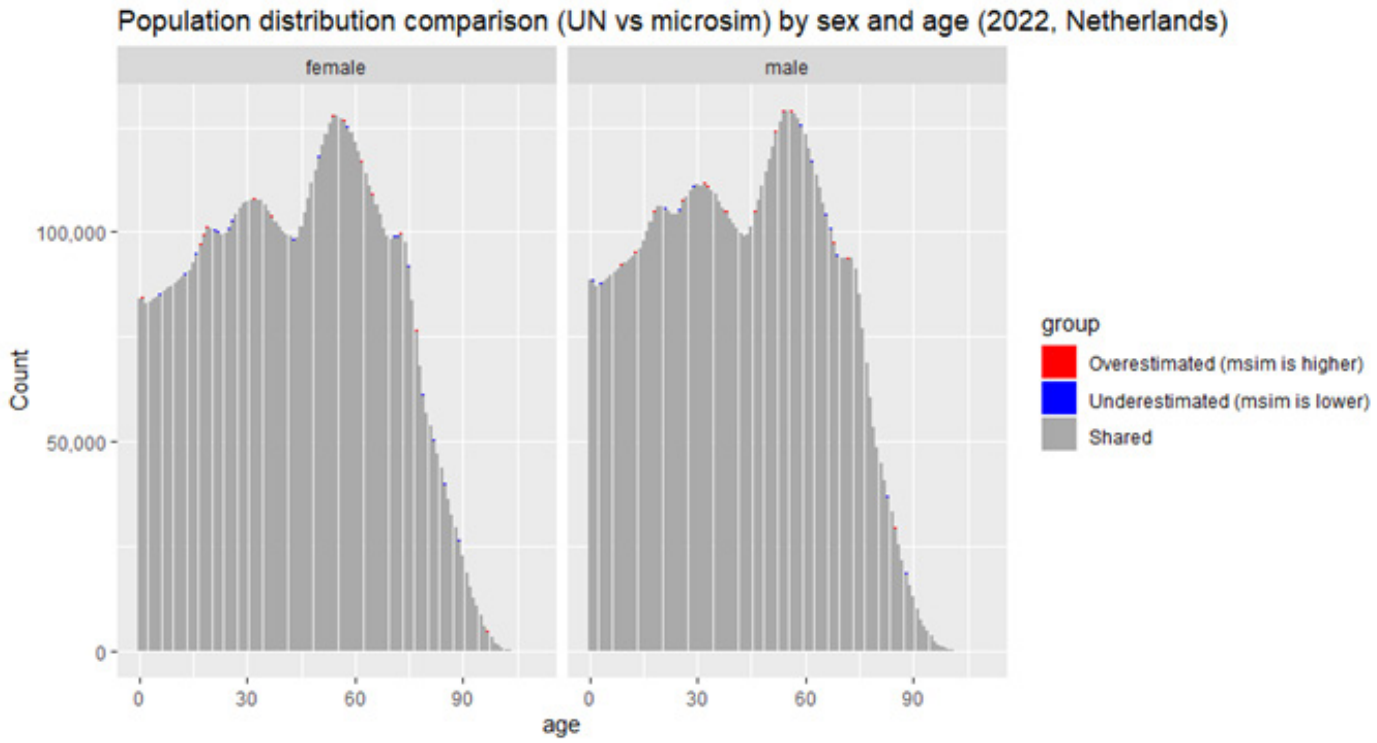
This appendix outlines internal, predictive, and cross-validation tests that have been carried out based on recommendations from Eddy et al. [73]:

- Internal validation
  * This aims to 'check' that the model can replicate the input data in the start year of the simulation across various parameters such as population and mortality data
  * The model showed strong internal validity
- Predictive validity
  * Back-validation of the BMI and alcohol projections are provided as an example of predictive validity of the model
  * The model showed robust predictive validity
- Cross and external validation
  * comparing results against two other policy models - the OECD and Sheffield models
  * difficult to compare given methodological differences
  * HepaHealth shows larger impacts on CLD incidence of policies but lower impacts on mortality, but comparability is challenging. See analysis below.
- Historical validation against the literature
  * Mortality trends are comparable to published literature

Internal validity

Figure 32 represents the virtual France, Netherlands, Romania populations recreated via the HepaHealth microsimulation for males and females by age. There is alignment between inputs (UN population prospects data) and outputs from the microsimulation.





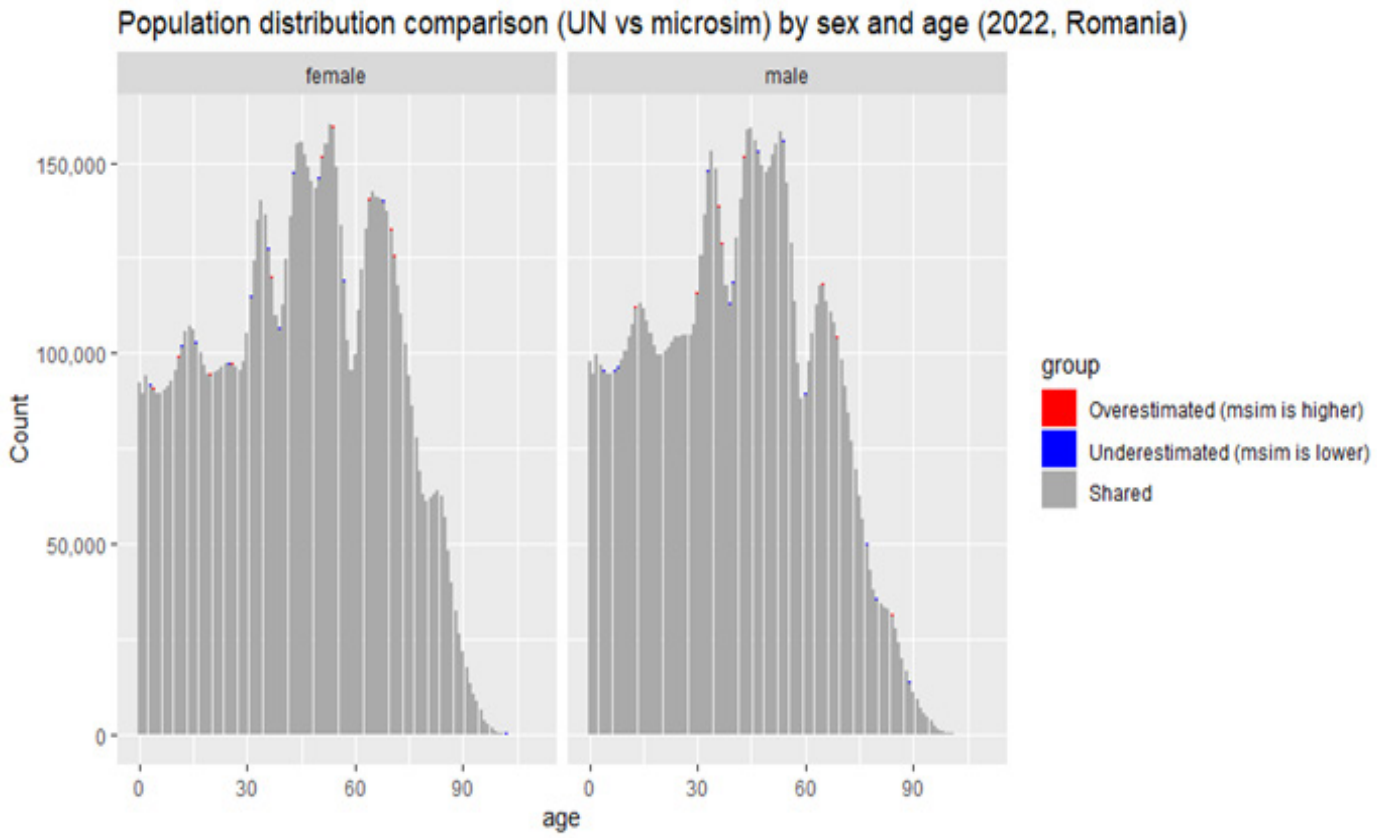


Figure 32. Representation of HealthLumen's microsimulation virtual population (UN population data input vs. microsimulation output) comparison for the year 2022 stratified by age and sex in France, Netherlands, and Romania, respectively.

Figure 33 presents the mortality input vs. output data for chronic liver disease (per 100,000 population) in the start year of the simulation. There is alignment between the inputs and outputs of the mortality chronic liver disease (CLD) data in each country. Slight differences are due to differences in input data year, calibration against the current age-sex population distribution, and alcohol/BMI trends of each country in 2022. The final 'pink' bar presents the Sheffield alcohol model data input for alcoholic liver disease per 100,000 in Wales (ICD-10 code: K70).

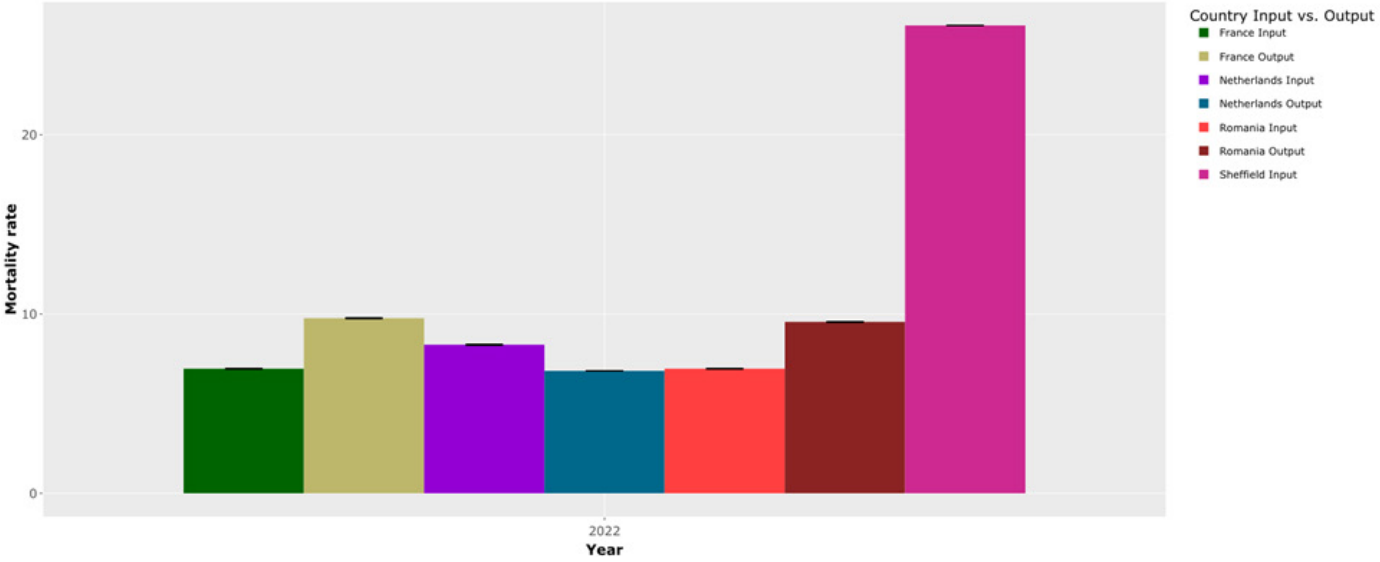


Figure 33. Representation of mortality inputs compared to outputs for CLD for each country for the year 2022 and compared against the Sheffield model alcoholic liver disease input data for Wales.

Predictive validity

Validating the risk factor projection model
Body mass index (BMI) data from the Health Survey for England (HSE) dataset for the years 2004-2014 were randomly adjusted using R statistics software. 80% of this data was randomly selected to be used as a training dataset and the remaining 20% as the test dataset. This same random generation was carried out 5 times to obtain 5 sets of training and test data respectively.

Using regression methods, the real data, plus each training and test dataset was used to estimate the prevalence of normal, pre-obese, and obesity from the observed data projecting the data from 2004 to 2020. Statistical methods for validation showed that the unaltered training and test data follow with the confidence intervals of each other, illustrating both the robustness of the projection model even when data are missing.

Prediction Accuracy

The data for the years 2004-2014 were split into two datasets (2004-2008 and 2009-2014).
The 2004-2008 subset was used to make projections of BMI prevalence to 2020.

The predicted BMI prevalence for 2009-2014 was compared with the actual data points for the same year (Figure 34). A similar level of robustness was observed for alcohol consumption projections using the same predictive tool (Figure 35).

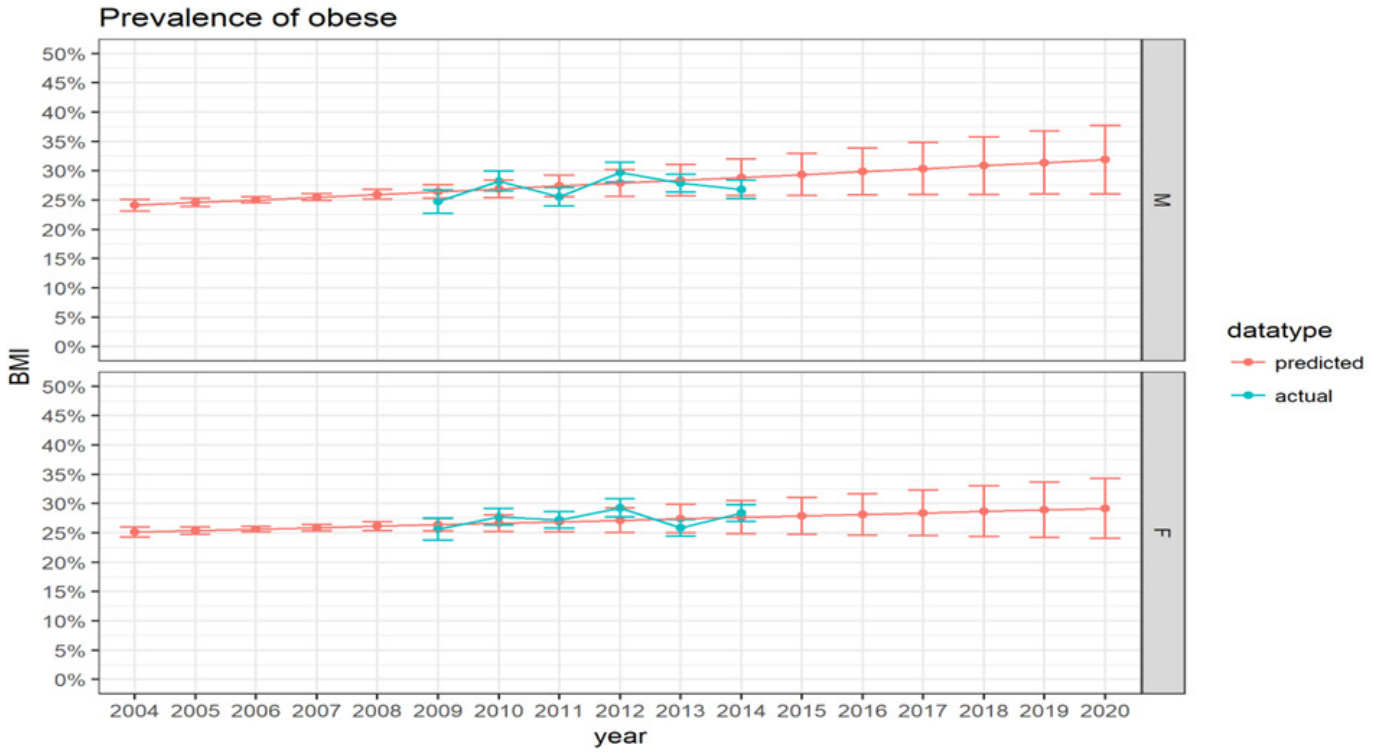


Figure 34. Predictive accuracy of the model for obesity

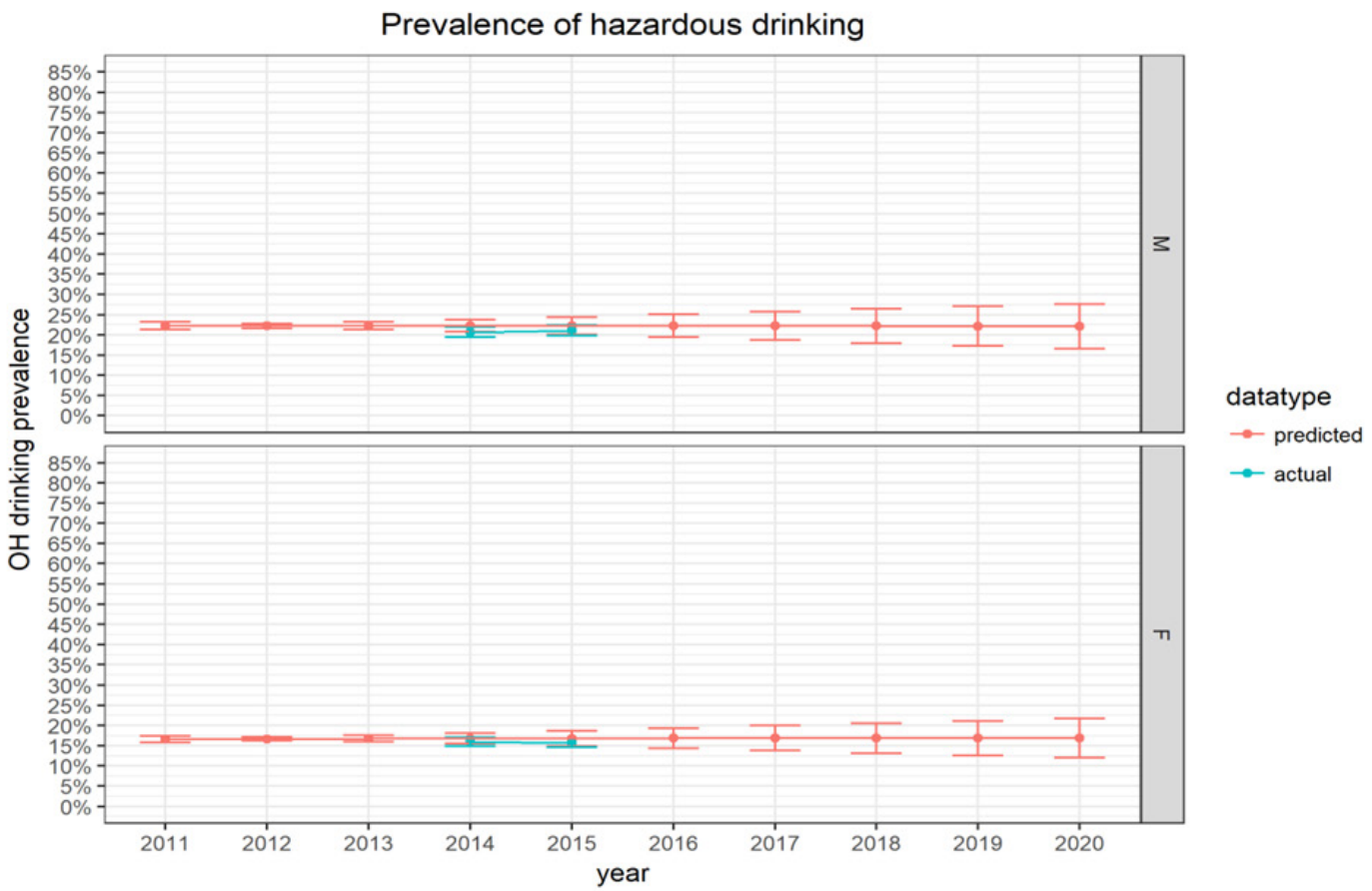


Figure 35. Predictive accuracy of the model for alcohol consumption

Methods

Calculating Cross Validation R-square for risk factor projections

Obesity

R-Square of the training and validation sets

- Firstly, the predictive sum of squared error (PRESS) was estimated for each set of both the training and the test data using the formula: $\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$ where n is the number of data points, y $\hat{y}_i$ the predicted dependent variable and y_i the experimental dependent variable.
- Secondly, the total sum of squares (TSS) for the unaltered HSE data was estimated using the formula: ∑_(i=1)^n(y_i- y)^2 where n is the number of data points and y_i is the mean of $y_{i.....n}$.
- $R2 = \max\left\{1 - \frac{PRESS}{TSS}\right\}$ where the set in the curly brackets from which the maximum R2 is chosen refers to R2 from the 5 folds of cross validation for both males and females.
- The training R2 is estimated to be 0.28 for normal weight, 0.20 for pre-obese and 0.53 for obesity.
- The test R2 is estimated to be 0.25, 0.12, and 0.50 for normal, pre-obese, and obese respectively.
- The test and training R2 values are considerably low when compared to the R2 of the unaltered data (Figure 36). However, overlay plots of the predicted BMI prevalence by BMI category and validation fold for the training and test data, and the predicted and actual BMI prevalence by BMI category from the unaltered data shows the predicted training and test values, and the predicted unaltered and actual unaltered data points fall in the confidence limits of each other showing the robustness of the model to missing data.

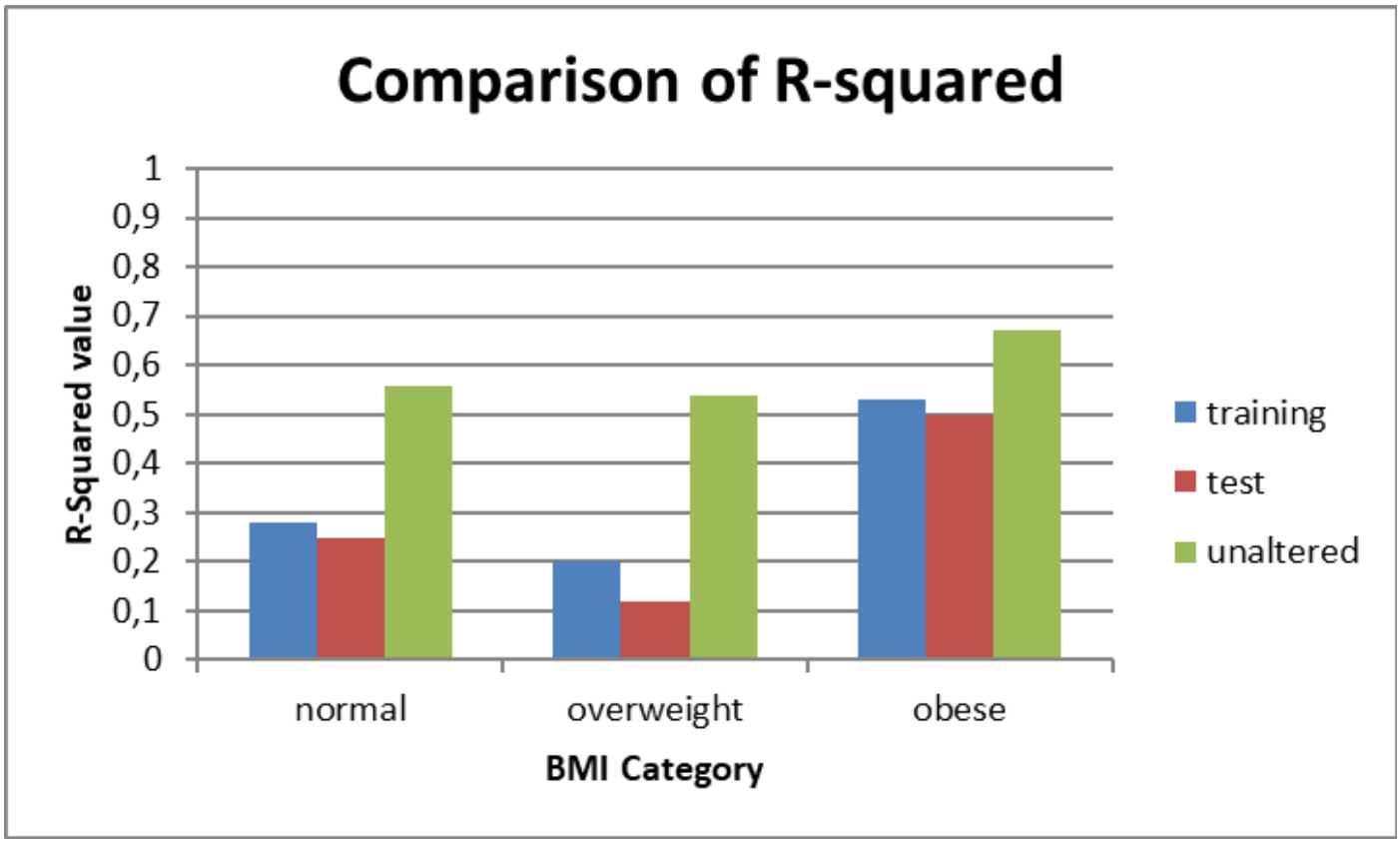


Figure 36. Comparison of R-squared values of the test, training, and unaltered BMI data

R2 of the unaltered data (data without cross validation)

- The goodness of fit of the BMI projection module without cross validation was also estimated using PRESS and TSS (see formula for PRESS and TSS above). PRESS was calculated from the predicted and experimental 2004-2014 data points, and TSS from the experimental 2004-2014 data points of HSE. R2 was estimated using R2 =max{1 – PRESS/TSS} where the set of R2 in the curly braces from which the maximum R2 is chosen refers to R2 of males and females predictions respectively.
- The estimated coefficient of determination were 0.56 for normal weight, 0.54 for pre-obese and 0.67 for obesity.
-

This indicates that the model can account for 56%, 54% and 67% of the variation in the response variables for normal weight, pre-obese and obesity respectively. These are good r-squared values, since plots of actual versus predicted values show that the predicted and actual data points fall in the confidence limits of each other.

Glossary

- "actual"- observed BMI prevalence by BMI category for the years 2004-2014
- "predicted"- predicted BMI prevalence by BMI category estimated by the projection module for the years 2004-2014. This aims to replicate the 'real/actual' data
- "test 1-5"- predicted BMI prevalence by BMI category estimated by the projection module from the test set data for the years 2004-2014. For example, "test 1" refers to fold 1 of the test set.
- "train 1-5"- predicted BMI prevalence by BMI category estimated by the projection module from the training set data for the years 2004-2014. For example, "train 4" refers to the fourth fold of the training data.

Procedure for cross validation

- Alcohol (ALC) data for the years 2011-2015 were randomly permuted using the "sample" function of R without replacement.
- 80% of the randomly permuted data were selected as the training set and the remaining 20% as the test set. This procedure was repeated five times to obtain five sets of training and test data respectively.
- The projection software allows users to build multivariate non-categorical regression models. The programme was used to estimate the actual prevalence of hazardous, harmful, and moderate drinking from the HSE data (thus experimental prevalence of hazardous, harmful, and moderate drinkers).
- This software was also used to produce the predicted hazardous, harmful, and moderate drinking prevalence for each of the test and training sets respectively by projecting ALC drinking prevalence from 2011 to 2020 and using the predicted prevalence for each ALC drinking category for 2011-2015 in the calculation of R-square parameters.

Calculating Cross Validation R-square

R-Square of the training and validation sets

- Firstly, the predictive sum of squared error (PRESS) was estimated for each set of both the training and the test data using the formula: $\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$ where n is the number of data points, $\hat{y}_i$ the predicted dependent variable and y_i the experimental dependent variable.
- Secondly, the total sum of squares (TSS) for the unaltered HSE data was estimated using the formula: $\sum_{i=1}^{n}(y_i - \bar{y})^2$ where n is the number of data points and $\bar{y}$ is the mean of $y_{i.....n}$.
- R2 =max{1 – PRESS/TSS} where the set in the curly braces from which the maximum R2 is chosen refers to R2 from the 5 folds of cross validation for both males and females.
- The training R2 is estimated to be 0.51 for hazardous, 0.84 for harmful and 0.96 for moderate drinkers.
- The test R2 is estimated to be 0.09, 0.76, and 0.81 for hazardous, harmful and moderate drinkers respectively
- Figure 37 shows a very low-test R-squared value for hazardous drinkers relative to the training and unaltered data. This could be due to skewness of data during the random selection for the validation folds. It should also be noted that we are dealing with a continuous variable and it is highly unlikely to predict exact figures. However, overlay plots of the predicted alcohol drinking prevalence by category and validation fold for the training and test data, and the predicted and actual alcohol drinking prevalence by category of the unaltered data show the predicted training and test values, and the predicted unaltered and actual unaltered alcohol drinking prevalence by category all fall in the confidence limits of each other - this shows the model is robust.

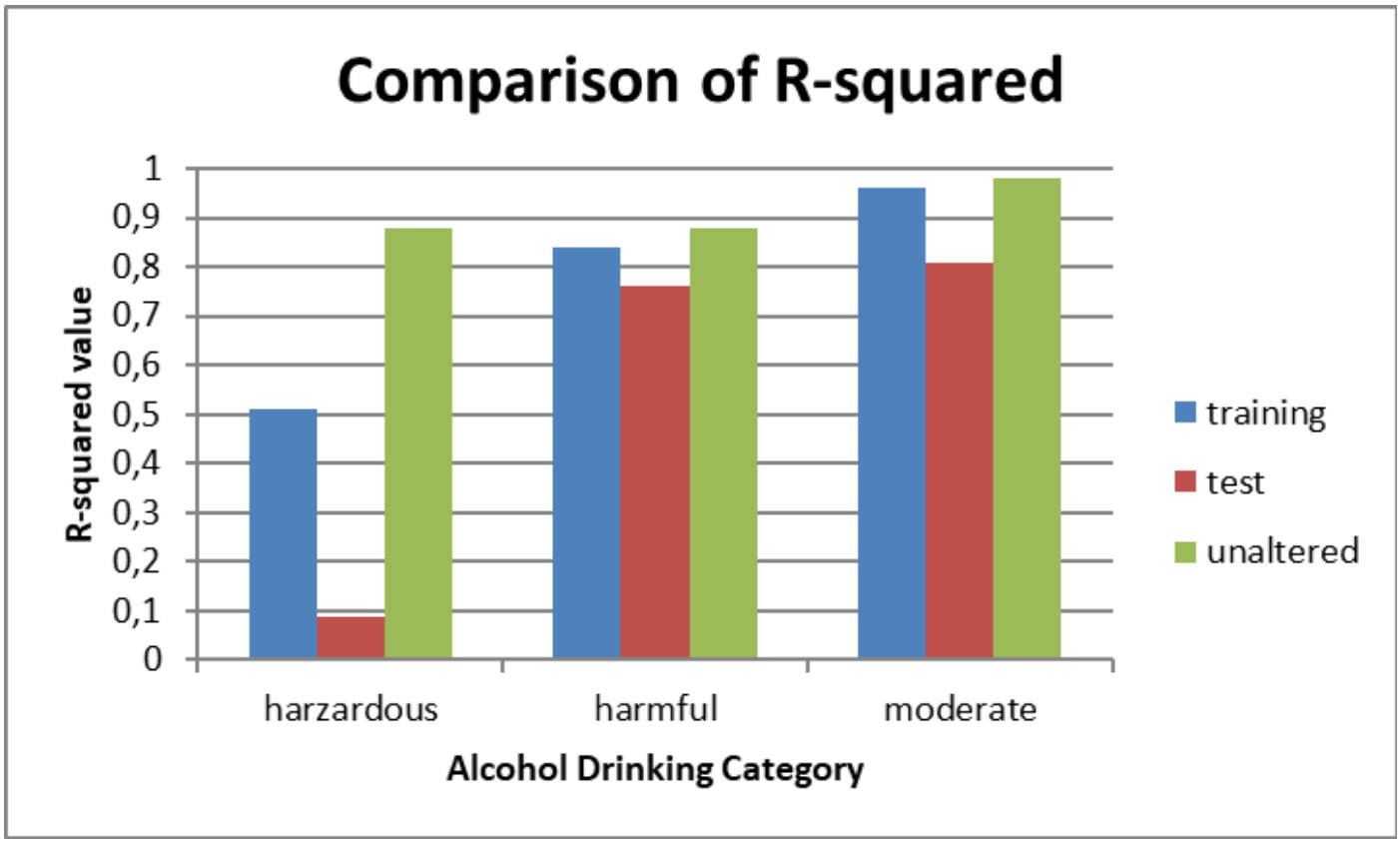


Figure 37: Comparison of the R-squared of the test, training, and unaltered alcohol drinking data

R2 of the unaltered data (data without cross validation)

- The goodness of fit of the projection program without cross validation was also estimated using PRESS and TSS (see formula for PRESS and TSS above). PRESS was calculated from the predicted and experimental 2004-2014 data points, and TSS from the experimental 2004-2014 data points of HSE. R2 was estimated using R2 =max{1 – PRESS/TSS} where the set of R2 in the curly brackets from which the maximum R2 is chosen refers to R2 of males and females predictions respectively.
- The estimated co-efficient of determination were 0.88 for hazardous, 0.88 for harmful and 0.98 for moderate drinkers.
- This indicates that the model can account for 88% of the variation in the response variables for hazardous and harmful drinkers respectively, and 98% of the same parameter for moderate drinkers. These high R-squared values in themselves shows a very good fit of the model to the data. In addition, the predicted and actual values fall in the confidence limits of eachother and this reaffirms the robustness of our alcohol model.

Glossary

The data sets investigated include:

- "actual"- experimental ALC drinking prevalence by ALC drinking category estimated by the projection module for the years 2011-2015
- "predicted"- predicted ALC drinking prevalence by ALC drinking category estimated by the projection module for the years 2011-2015
- "test 1-5"- predicted ALC drinking prevalence by ALC drinking category estimated by the projection module from the test set data for the years 2011-2015. For example, "test 1" refers to fold 1 of the test set.
- "train 1-5"- predicted ALC drinking prevalence by ALC drinking category estimated by the projection module from the training set data for the years 2011-2015. For example, "train 4" refers to the fourth fold of the training data.

Prediction Accuracy

- The HSE ALC data for the years 2011-2015 was split into two datasets (2011-2013 and 2014-2015)
- The 2011-2013 subset was used to make projections of ALC drinking prevalence to 2020.
- The predicted ALC prevalence for 2014-2015 was compared with the actual data points for the same year
- The comparison of actual vs predicted ALC drinking prevalence by ALC drinking category and sex for 18-100 year olds and ALC drinking prevalence by ALC drinking category, five-year age-group and sex.

Cross Validity

Table 28 provides a comparison of methods and results between the HepaHealth microsimulation, OECD microsimulation [74], and Sheffield Markov model which each provide some outputs related to the impact of Minimum unit pricing and alcohol tax on different populations. France results are compared here.

The Hepahealth modelling method is more comparable with the OECD microsimulation [75] than the Sheffield Markov model. However, comparability with the OECD model is difficult given different years and data inputs have been used plus there is a lack of detail on some of the methodology, with no baseline values presented or provision of data inputs for direct comparison.

The results show that MUP €0.50 has a larger impact on disease cases in the Hepahealth model than in the OECD model. However, this may be due to the MUP input data such that the impact of MUP is higher in the Hepahealth model compared with the OECD model and that the impact of MUP has an immediate impact on cases but impacts mortality later in the simulation. There was a lower impact of MUP on mortality in the 9-year HepaHealth model than in the 30-year OECD model. The data provided by OECD was an annual average, so the longer run of the OECD model to 2050 would incorporate larger impacts on mortality as the simulation progresses pushing up the annual average. Modelling further into the future would accrue additional impacts. For both models, MUP was observed to have a larger impact in France than the Netherlands and this may be due to higher alcohol consumption in France compared with the Netherlands. Importantly both models show the value of MUP in these countries in reducing both disease burden and death.

It was not possible to directly compare with the Sheffield policy model because:
i. The diseases included in each model are different: HL/OECD include a number of ICD codes for CLD, as compared with alcoholic liver disease in the Sheffield model (ICD K70) (Table 28) so we are not comparing like with like.

ii. Different countries - as shown in the mortality rate from alcoholic liver disease in Wales is 2.5 times that of all chronic liver disease in the three HepaHealth countries (see footnote 1 for ICD-10 codes).

iii. BMI is accounted for in the HL/OECD models as a joint risk for CLD incidence which would not be relevant to specific analysis of alcoholic liver disease alone.

iv. Older input data are included (2010-2013) from Wales compared with the HepaHealth (GBD 2019) and OECD (GBD 2015) models.

v. The method is a combination of partitioning and Markov models implying that analysis is based on average consumption in groups (e.g. via a population attributable fraction method), as opposed to an individual level approach (as per the HepaHealth and OECD models). Further detail of an individual level approach is provided in the sub-appendix 1 below.

vi. Population dynamics are not included. That is, taking account of changing distributions of age over time or immigration. We know that populations are ageing and this is an important variable when considering the burden of NCDs as age is likely to drive up disease incidence. In the countries included in HepaHealth II, the over 65 population across each country modelled is projected to increase over the next five years (Romania - 2.1%, France 8.9%, Netherlands 12%) based on UN population statistics. This means that more people are living longer/mortality rates are falling.

vii. Both a mean exposure and acute exposure to alcohol (binge drinking) are included. The HepaHealth model did not include a mechanism around binge drinking as regression analyses between mean and acute exposures were not available in the regions of interest which would have avoided double counting. However, the conditions of interest were not related to binge drinking at the time of analysis. By taking this conservative approach, the HepaHealth model could underestimate the impact of alcohol policy.

viii. The model impacts death directly, rather than disease onset. The OECD model states 'conservatively, risk factors only affect disease incidence, and are not associated with fatality directly' [76].

Table 28: Cross-validation table

Parameter	HepaHealth	OECD [75]	Sheffield [24]
Type of models and its advantages	Microsimulation methods with granular inputs and outputs: each individual is modelled, dynamics included, heterogeneity of populations is captured.	Microsimulation methods with granular inputs and outputs: each individual is modelled, dynamics included, heterogeneity of populations is captured	Markov model for mortality module with 2 states: alive and dead Partitioning model for the morbidity module as opposed to individual level modelling.
Population Country	Dynamic population, taking account of ageing over time and fertility rates. The over 65 population across each country modelled is increasing over the next five years (Romania - 2.1%, France 8.9%, Netherlands 12%). France Netherlands as examples	Dynamic population, the model is used to predict the health and economic outcomes of the population of a country or a region up to 2050. Mortality projected based on life expectancy projections. France and Netherlands used as an example here	Static population, age-sex distribution divided into different subgroup Demographic information – General Lifestyle Survey (GLF) (2008 and 2011) Wales used as an example here (HepaHealth countries not modelled)
Risk factor data	Dynamic trends in BMI (taking account of increase in obesity over time) on liver conditions. Static trends in alcohol consumption. Each individual has an alcohol consumption level (units per week). Binge drinking not included. The relationship between binge drinking/ dependence quantity of alcohol consumed was not modelled as part of the HepaHealth due to data limitations and also since the outcomes of interest focussed on NCDs rather than acute/injury/violence outcomes. Definition used: Data from WHO GSRAH [77], 1 unit = 8g/day (WHO)	Dynamic trends in BMI (assumed from methods but not regression presented) Static trends in alcohol consumption (assumed), each individual has an alcohol consumption level and may be a binge drinker or abstainer. The relationship between binge drinking/ dependence quantity of alcohol consumed was modelled using Canada datasets to model injuries. Data from IHME redistributed according to GISAH, 1 unit = 13.6 g per day (based on Canadian data)	The population is divided into 3 drinker groups based on current consumption data. Each group is tagged with a mean alcohol consumption. In addition to mean alcohol consumption, risks associated with patterns of drinking (peak day consumption) and type of alcohol are added. The relationship between binge drinking/ dependence quantity of alcohol consumed was modelled using Welsh datasets to link alcohol and crimes / other acute outcomes Definition used: 1 unit = 8g of ethanol

Parameter	HepaHealth	OECD [75]	Sheffield [24]
Disease epidemiology	Includes disease incidence, mortality, survival, relative risk data, disability weights. Individuals contract a disease based on relative risks before dying from it. Time lag effects are modelled.	Includes disease incidence, mortality, survival, relative risk data, disability weights. Individuals contract a disease based on relative risks before dying from it.	Mortality rates and hospitalisation data input. Subgroup analysis (rather than individual): Alcohol attributable fraction and potential impact fraction are used Time lag effects are modelled.
Data inputs	CLD: Data are drawn from GBD IHME tool Liver cancer: Ferlay et al [11]	Data are drawn from GBD IHME tool.	Mortality rates for alcohol-related diseases – Office for National Statistics (ONS) mortality data – 2012 Includes hospital admission rates (from 2010-2013)
ICD-10 codes	CLD ICD codes: I85-I85.9, I98.2, K70-K71, K71.3-K72, K72.1-K75, K75.2, K75.4-K76.2, K76.4-K77.8, R16-R18.9, Z52.6, Z94.4. Liver cancer: C22	Not reported (labelled 'cirrhosis')	K70
Policy scenario	% reduction assumed in start year and individuals stay on that same trajectory until the end of the simulation assuming the policy remains in place. MUP reduction was applied to each individual and the impact varied depending on which alcohol group they were part of.	% reduction assumed in start year and individuals stay on that same trajectory until the end of the simulation assuming the policy remains in place. MUP reduction was applied to each individual and the impact varied depending on which alcohol group they were part of.	The policy seems to be applied every year for 20 years (assumed)
MUP 0.50	MUP 0.50 -2.2%, -2% and -7.2% reduction for low, moderate and high risk group respectively	-0.6% to -3.3% (methods unclear)	MUP -0.50 -2.2%, 2% and -7.2% reduction for low, moderate and high risk group?
Tax	(volumetric)		
Time horizon	2022-2030 (9 years)	2020-2050 (30 years)	20 years

Parameter	HepaHealth	OECD [75]	Sheffield [24]
Results			
comparison			
France CLD/Cirrhosis with MUP €0.50			
Baseline mortality	6702 (in 2030)	Not provided	340 (WALES)
Reduction in CLD Mortality	19 (in 2030)	242 (average across years)	21 (in 20th year) (WALES)
% reduction in mortality from baseline	0.3	Not available	6.2
Reduction in DALY	10,229	29,557	Not reported
Reduction in cases	248 (incidence reduction in 2030)	68 (average?)	Not reported
Netherlands CLD with MUP €0.50			
Baseline Mortality	1275 (in 2030)	Not provided	As above
Reduction in CLD Mortality	18 (in 2030)	42	-
% reduction in mortality from baseline	1.4	Not available	
Reduction in DALY	1465	4697	-
Reduction in cases	46 (incidence reduction in 2030)	18	-

Historical validation - Mortality trends

Historical mortality rate trends for CLD from the literature (see list below) for Scotland [78], France [8], and globally [8] can be compared with the HealthLumen projections. The published CLD mortality rate for France does align reasonably well with the HealthLumen projection for France. Inclusion of static alcohol projections and population ageing likely explains the plateau in projected trends. Dynamic alcohol projections showing a decrease in consumption would likely mirror the downward trends in the observed historical data. Further work could back validate the projections provided in the Phase 1 report (Appendix 6, Phase 1 report).

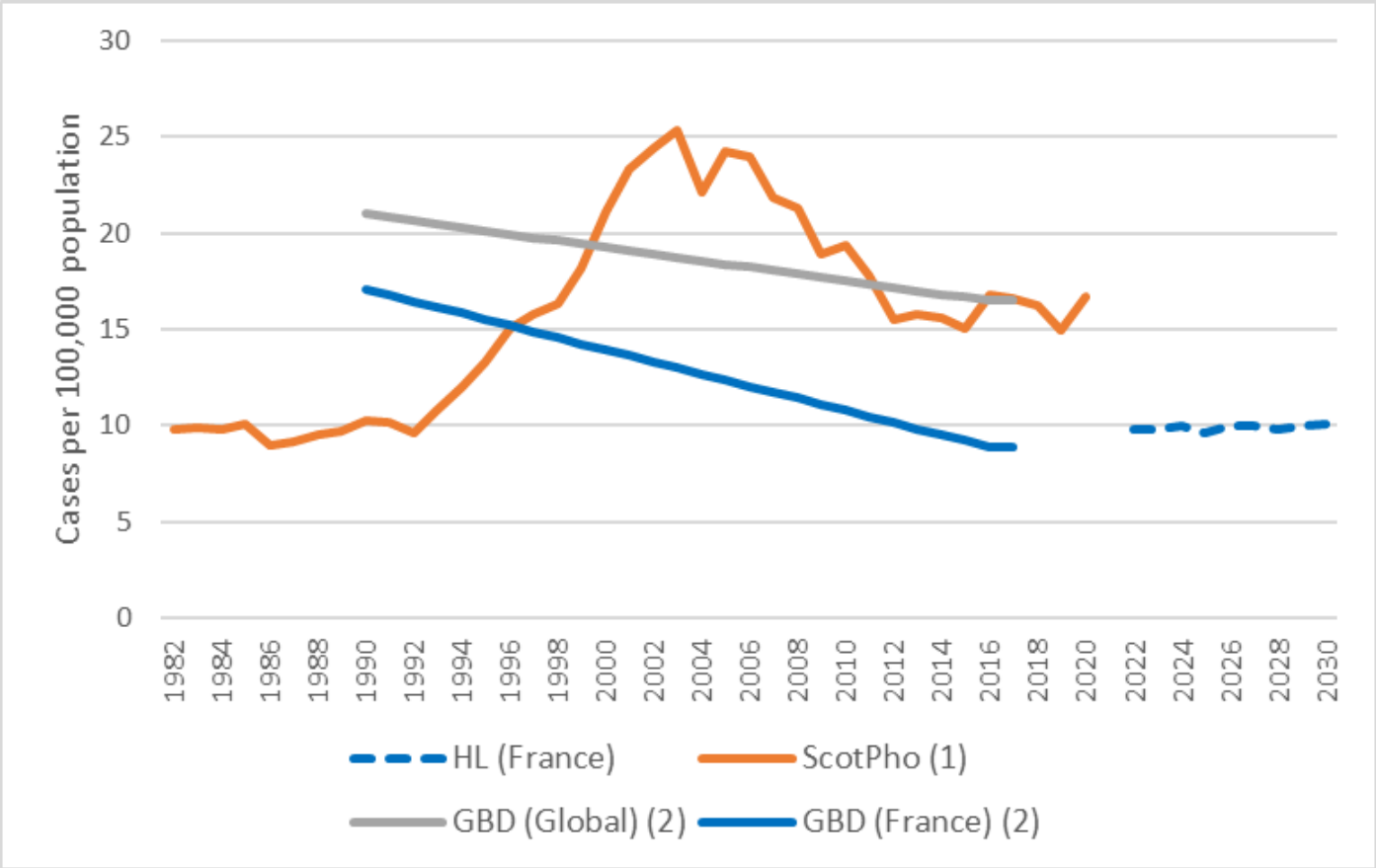


Figure 38. Chronic Liver Disease mortality per 100,000 population by year in France, Scotland, and globally

GBD, Global Burden of Disease; HL HealthLumen, ScotPho, Scotland Public Health Observatory

Sub-appendix 1. Differences between microsimulation and macro models

Table 29. Advantages of using individual level models

Microsimulation (individual level)	Macro models (group level)	Why does this matter?
Continuous dynamic risk factors	Static risk factors	Risk factors result in disease incidence, therefore it's important to take account of how those risk factors have changed over time. If a risk factor is increasing over time, then this will give a very different projection than if the risk factor is held static in the year over time.
Population demographics (age, sex, fertility rates, deaths, births by age)	Total population (or just split by sex)	Accounts for important variation in demographics on disease incidence. For instance, some risk factor related conditions may impact only females, or be more prevalent in the over 65s. Therefore, knowing the 'correct' numbers of these groups in the population is important if the projection is to be accurate.
Population projections	Static population	Takes account of population ageing. Ageing is an important risk factor for NCDs. If the population doesn't age over time in the model, then projections of non-communicable disease will not be accurate.
Epidemiology by age and sex	Total epidemiology values	Accounting for age-sex differences in e.g. the incidence of stroke is important for accuracy of the projections, since an older disease in an older population will have an important impact on the projection compared with an older disease in a younger population for instance. These variables work together to provide an epidemiological basis to the projection, upon which costs can then be more accurately calculated.
Individual level	Averages/cohort	Group averages remove a lot of information from continuous data, which could result in over- or under-estimation of effects.

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