Estimating the effect of transitioning to a strength-based alcohol tax system on alcohol consumption and health outcomes: a modelling study of tax reform in England

Damon Morris, Colin Angus, Duncan Gillespie, Abigail K Stevely, Robert Pryce, Luke Wilson, Madeleine Henney, Petra S Meier, John Holmes, Alan Brennan

Summary

Background Increasing the amount of alcohol taxation is among the most effective measures for addressing the rising global burden of alcohol harm. However, less is known about the effect of changing alcohol tax structures. Substantial reforms to UK alcohol taxation structures enacted in August, 2023, mean that all alcohol is taxed based on its ethanol content, beers and ciders sold in on-trade premises (eg, public houses) are taxed at a reduced rate (hereafter called draught relief), and beer and particularly cider remain taxed at lower rates than other alcohol of equivalent strength. We aimed to model the effect of these reforms on alcohol consumption and health and economic outcomes, and the effects of hypothetical alternative scenarios.

Methods The Sheffield Tobacco and Alcohol Policy Model was used to estimate policy effects on alcohol consumption. The model is an individual-based microsimulation that uses data from the Health Survey for England, Living Costs and Food Survey, Hospital Episode Statistics, and the Office for National Statistics. Spending and revenues to retailers and the Government were estimated cumulatively for a 5-year period post-intervention. Policy effects on all-cause deaths, years of life lost, hospital admissions, and admissions costs were estimated cumulatively for a 20-year period post-intervention.

Findings The reform was estimated to decrease mean weekly alcohol consumption per drinker by less than 0·05 (−0·34%) units (1 unit=8 g/10 mL ethanol), and prevent 2307 deaths and 11 510 hospital admissions during 20 years compared with no policy change. Removing draught relief was estimated to prevent 1441 further deaths and 14 247 further admissions. Hypothetical scenarios showed that removing draught relief would only slightly improve public health outcomes, and increasing tax rates for beer and ciders to match other drinks of equivalent strength would reduce consumption by a further 2·5 units per week (−17%) and deaths by approximately 74 465.

Interpretation Alcohol tax structures based on alcohol strength enable tax policy to improve public health in a targeted way. However, the UK reforms are unlikely to substantially improve health outcomes as they do not raise taxes overall. Raising tax rates for the lowest taxed beer and ciders, which are favoured by those who consume harmful amounts of alcohol, could achieve substantially greater public health benefits and reduce health inequalities.

Funding National Institute for Health and Care Research and UK Prevention Research Partnership.

Sheffield Addictions Research Group, School of Medicine and Population Health, University of Sheffield, Sheffield, UK (D Morris PhD, C Angus MSc, D Gillespie PhD, A K Stevely PhD, R Pryce PhD, L Wilson PhD, M Henney MSc, Prof J Holmes PhD, Prof A Brennan PhD); **SPECTRUM Consortium, Edinburgh, UK** (D Morris, C Angus, D Gillespie, A Brennan); **MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, Glasgow, UK** (Prof P S Meier PhD)

Correspondence to:
Dr Damon Morris, Sheffield Addictions Research Group, School of Medicine and Population Health, University of Sheffield, Sheffield S1 4DA, UK
d.j.morris@sheffield.ac.uk

Introduction

Alcohol consumption is a major global risk factor for hospitalisations and premature mortality.[1,2] In 2021, harmful use of alcohol resulted in 1·8 million deaths globally (2·7% of all deaths) and 72·3 million disability-adjusted life-years.[3] In England in 2022, there were 7912 alcohol specific deaths, which is the highest figure since records began, and 942 260 hospital admissions were linked to alcohol.[4] Increasing alcohol taxes annually[5] is considered one of the best buy actions by WHO to address the burden of alcohol harm due to its affect on alcohol prices and consumer behaviour.[6–9] Alcohol taxes raise revenue for governments which could be spent on addressing the burden that alcohol consumption places on health-care systems. Although almost every country

in the world levies some form of alcohol taxation, tax structures are rarely designed in a way that maximises public health.

Tax on alcohol in the UK (referred to as duty) is set at rates that differ across beverage type (eg, beer, wine, and spirits) and by alcoholic strength categories. Duty raises the cost of producing and selling alcohol, increasing retail prices. Until recently, cider and wine were taxed based on the volume of the product (unitary taxation). However, a reformed duty structure implemented in August, 2023, now taxes all alcohol by ethanol volume (volumetric taxation) in which duty per unit of alcohol rises as alcohol content rises, in line with WHO recommendations (figure 1).[10,11] The new structure substantially reduces disparities in taxation both across and within

Research in context

Evidence before this study
Previous studies on the effect of switching to strength-based alcohol taxation were identified by searching MEDLINE and PubMed databases on Aug 2, 2024, using the search terms "alcohol", "strength", and "tax" with no cutoff date and English language studies only. Six studies were identified that have analysed the potential effects of changing alcohol taxation structures. Evidence from modelling hypothetical policies in the UK, EU, Australia, Canada, and the Americas show that switching to a strength-based system of alcohol taxation can improve public health outcomes and that this would be more effective at reducing harmful drinking than simply increasing tax rates within existing structures that are not based on strength. There have, however, been no studies of actual changes to an entire system of alcohol taxation that have occurred in practice.

Added value of this study
To our knowledge, this is the first modelling study on the health and economic effects of a planned and implemented, rather than hypothetical, change to a wholly volumetric system of alcohol taxation. It examines changes to the UK alcohol tax structures in which wine and cider were taxed based on product volume to a new system in which all products are taxed on alcohol content. The UK alcohol tax system reforms are estimated in this study to have improved public health outcomes, reducing deaths (–2300) and hospitalisations (–14 200) during the 20 years following the reforms. These gains could, however, be improved on if the reduced taxation rates for some ciders and beers sold in bars, public houses, and

clubs—known as draught relief—were abolished. Abolishing draught relief could prevent an additional estimated 1400 deaths. Further improvements to health outcomes are estimated if alcohol tax rates were equalised for all products between 3·5% and 8·4% alcohol content, with an additional estimated 75 000 deaths that could be prevented by taxing beer and cider at this level of alcohol strength, the same as wine and spirits.

Implications of all the available evidence
The evidence shows that reform to a strength-based system of alcohol taxation can produce public health benefits and allow tax policy to target people who drink more alcohol who are at the most risk of alcohol-related health harms. An alcohol excise tax structure based on alcohol strength is better configured to allow tax policy to be able to improve public health in a targeted way. With many countries around the world operating an alcohol tax regime based on tax by volume or value of product rather than alcoholic strength, the findings from this study and previous studies can inform future decisions on alcohol taxation structures. The results from additional hypothetical scenarios in this study show that when tax policy has both public health and economic objectives—such as the draught relief modelled here—public health benefits could be limited. If rates of taxation are set at lower levels for some alcohol products to favour local patterns of production and consumption, as is the case with cider in the UK, the public health benefits of strength-based alcohol taxation might not be fully realised. The evidence in this study highlights the need to combine reform of tax structure with increases in rates of taxation.

beverage categories and ensures products with higher alcohol content are more expensive, better aligning with minimising alcohol health harms. Previously, consumers often paid less tax per unit of alcohol (1 UK unit=8 g ethanol) if they purchased a wine or cider with a higher alcohol-by-volume (ABV), which incentivised production and consumption of higher strength alcohol.

Two inconsistencies persist in the new duty structure due to the Government also seeking to support the societal and economic roles of public houses and small cider producers.[12] First, the reforms introduce a draught relief, which lowers duty rates for alcohol sold in the on-trade (eg, public houses and restaurants) relative to the off-trade (eg, supermarkets).[13] Specifically, it reduces duty rates by 9·2% for beers and ciders below 8·5% ABV sold on draught (ie, from a keg or barrel rather than a can or bottle). Second, most beers and particularly ciders are still taxed at a lower rate than other alcohol, which is important as there is clear evidence of harm to public health arising from the low cost of cider. Higher strength white ciders are often purchased in large volumes by individuals with severe alcohol dependence.[14,15]

Although volumetric taxation is recommended by WHO, many countries do not adopt this approach.[16,17] There is a shortage of evidence on changing the basis of taxation but the available studies of hypothetical reforms suggest there are public health benefits to changing the basis of taxation.[18–23] Examining the effects of an actual switch from unitary to volumetric taxation will provide key evidence on the efficacy of adopting such a taxation system in which one did not previously exist. As the UK reforms are a complex intervention with several components and potentially conflicting objectives, a model-based appraisal is useful to understand the potential effect of the UK alcohol duty reform itself as implemented in 2023, and hypothetical additional policies that might help to realise the potential public health benefits.

This study aimed to produce evidence on the effect of switching to strength-based alcohol taxation by appraising the UK reforms of 2023. We used the Sheffield Tobacco and Alcohol Policy Model[24] to model the effects on alcohol consumption, consumer spending, mortality, hospital admissions, costs of admissions, revenues to government, and retailer revenues. We have addressed

three questions: (1) what are the potential effects on alcohol consumption, health, and economic outcomes of the implemented duty reforms?; (2) what would be the effect of withdrawing draught relief for on-trade beer and ciders?; and (3) what would be the potential effect of additional reforms, addressing the lower duty rates for beer and cider?[13,25]

Methods

Model overview

The modelling was undertaken using the Sheffield Tobacco and Alcohol Policy Model (version 2.4.2) for England,[24] which builds on previous modelling using the Sheffield Alcohol Policy Model[26] by adding life course dynamics, incorporating new evidence on how consumers[27] and retailers[28–30] respond to price changes, and evidence on smoking-related behaviours and associated health outcomes. Note that although alcohol duty policy is set centrally for all regions of the UK, the setting for this study is England only. We have presented an overview of the model here, and a detailed description in the appendix (pp 4–36).

The Sheffield Tobacco and Alcohol Policy Model is a dynamic micro-simulation of the population of England aged 18–89 years, beginning Jan 1, 2017, and progressing in 1-year steps until Dec 31, 2042, tracking individuals' trajectories in alcohol consumption as they age. In each year, changes to alcohol duty cause changes in consumption through changing the price of alcohol. Intervention groups were compared with a control group in which the pre-2023 duty structure is maintained. Alcohol duty rates increase by Retail Price Index inflation each year after 2023, in line with the Office for Budget Responsibility assumptions.[31] Simulated individuals were stratified into 800 population subgroups (appendix p 4).

Alcohol consumption

The simulated population of 200 000 individuals has been derived from pooled 2016, 2017, and 2018 Health Survey for England data, which is an annual nationally representative survey of households in England that collects data on individuals' alcohol consumption. Consumption (units of alcohol consumed per week) is split into four beverage types (combined beer and cider, wine, spirits, and ready-to-drink beverages). As the Health Survey for England combines beer and cider consumption and does not separate on-trade from off-trade consumption, we separated beer and cider and separated on-trade from off-trade consumption to produce ten beverage categories using the Living Costs and Food Survey, which is an annual nationally representative survey of UK households that collects data on individuals' alcohol purchases during a 2-week period. Underestimation of alcohol consumption is a known issue with population surveys,[32,33] affecting both inputs to the model and epidemiological evidence on risk of harm.
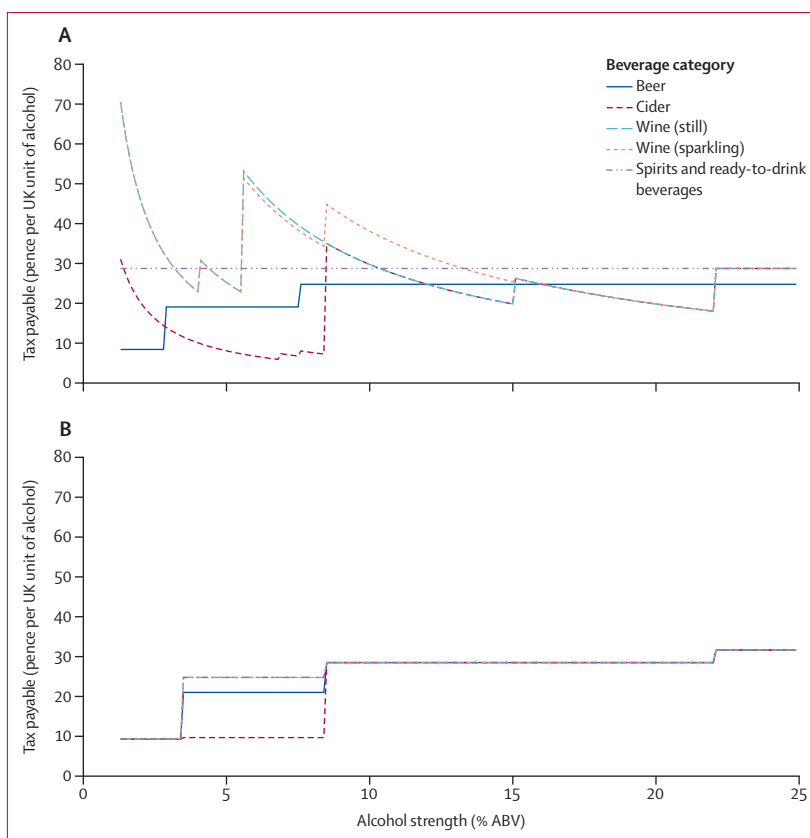

Figure 1: **The UK alcohol duty system before (A) and after (B) the duty reform**
1 UK unit=10mL/8g of pure alcohol. ABV=alcohol-by-volume. Reproduced from HM Revenue & Customs.[11]

Previous analyses have suggested that this underestimation of alcohol consumption could make the results more conservative.[34]

Ethical approval and informed consent were not required because the study used de-identified secondary data.

Prices

Price distributions describing how purchases are spread across prices (expressed as price per unit of alcohol) were derived from 2006–18 Living Costs and Food Survey data. Distributions were derived for each of the ten beverage types in each of the 800 modelled subgroups (ie, 8000 distributions in total), and then matched to individuals. Prices and other monetary variables in the model were all deflated using the Retail Price Index to 2017. To estimate the effect of duty changes on the alcohol price distributions, the model calculates the expected change at each price point implied by the change in average duty per unit. Average duty per unit is calculated for each beverage category as the weighted average of duty rates, in which the weights are the proportions of alcohol consumed within each of the four ABV strength categories to which different duty rates apply. The weights were derived using product-level alcohol consumption data

See **Online** for appendix

	Beer	Cider	Wine	Spirits and ready-to-drink beverages
Duty reform (alcohol strength [alcohol-by-volume])				
0–1·2%	0·00	0·00	0·00	0·00
1·3–3·4%	9·27 (8·42)*	9·27 (8·42)*	9·27	9·27
3·5–8·4%	21·01 (19·08)*	9·67 (8·78)*	24·77	24·77
8·5–22%	28·50	28·50	28·50	28·50
>22%	31·64	31·64	31·64	31·64
Duty reform and no draught relief				
0–1·2%	0·00	0·00	0·00	0·00
1·3–3·4%	9·27 (9·27)†	9·27 (9·27)†	9·27	9·27
3·5–8·4%	21·01 (21·01)†	9·67 (9·67)†	24·77	24·77
8·5–22%	28·50	28·50	28·50	28·50
>22%	31·64	31·64	31·64	31·64
Duty reform and cider escalator				
0–1·2%	0·00	0·00	0·00	0·00
1·3–3·4%	9·27 (8·42)*	9·27 (8·42)*	9·27	9·27
3·5–8·4%	21·01 (19·08)*	9·67 (8·78)*	24·77	24·77
8·5–22%	28·50	28·50	28·50	28·50
>22%	31·64	31·64	31·64	31·64
Duty reform and equalisation				
0–1·2%	0·00	0·00	0·00	0·00
1·3–3·4%	9·27 (8·42)†	9·27 (8·42)†	9·27	9·27
3·5–8·4%	24·77 (22·49)†	24·77 (22·49)†	24·77	24·77
8·5–22%	28·50	28·50	28·50	28·50
>22%	31·64	31·64	31·64	31·64

Cost per litre of pure alcohol is in £. *Indicate the draught relief duty rates. †Indicate changes from the alcohol duty reform scenario.

Table 1: **Duty rates for alcohol products in 2023 by alcohol-by-volume under the reformed UK alcohol duty system and additional hypothetical scenarios**

from Kantar Alcovision data 2017–19 (appendix p 12). Expected price changes were then adjusted to reflect evidence that retailers do not pass duty changes uniformly through to prices. In practice, alcohol retailers typically under-shift—that is, they do not increase retail price by the full amount of a duty change (appendix pp 28–29).[28–30] A key assumption of the model is that there is no supply-side response to duty changes other than this tax passthrough, such as product reformulation or marketing strategies.

Effects on consumption and health outcomes
Changes in price affect consumption via price elasticities of demand, as estimated by Pryce and colleagues.[27] Elasticities measure the percentage change in consumption of a product that arises from a one percent change in its own price (own-price elasticities), or prices of other products (cross-price elasticities). There are separate elasticities for participation (consume or not), and conditional consumption (amount consumed). Consumption affects health across 84 different disease categories

identified by the ICD-10 classification, which can be wholly or partly attributed to alcohol, tobacco, or both (appendix pp 9–11). The model predicts morbidity and mortality based on alcohol and tobacco consumption. Data on morbidity rates by condition come from Hospital Episode Statistics and data on mortality come from the Office for National Statistics for the years 2013–18.

Policy scenarios
We modelled four interventions: (1) "duty reform, which models the policy as implemented by the UK Government in August, 2023."[35] In addition, we modelled three hypothetical scenarios: (2) no draught relief, which removes draught relief for beer and cider; (3) cider escalator, which incrementally raises cider duty at 3·5–8·4% ABV by implementing an increase of 2% above Retail Price Index inflation to the duty rates for cider in each year after 2023, which would close the gap after 40 years; and (4) equalisation, which increases duty rates for beer and cider at 3·5–8·4% ABV to equal those for wine and spirits immediately in 2023. Table 1 summarises the 2023 duty rates for each of the four scenarios. Modelling these four policy options shows the estimated effects of the implemented reforms and the potential effect of future changes to strengthen their public health impact. Note that the reforms included a temporary easement for some wine products for 18 months from August, 2023.[36] Due to data limitations, we did not model the wine easement; instead we have implemented the full reform for all alcohol products immediately in 2023. The long-term effect of the wine easement is likely to be negligible due to its temporary status.

Modelled outcomes and sensitivity analyses
Reported outcomes were mean units of alcohol and mean spending, both per drinker per week in 2023. Retail revenues and revenues from duty receipts plus value added tax (VAT) have been reported as cumulative figures during 5 years to align with the 5-year economic forecasting undertaken by the UK Government when setting tax policy. Health outcomes modelled were deaths (from all causes) each year, total years of life lost due to deaths, hospital admissions, and the costs of those admissions. Health outcomes were reported cumulatively during 20 years. Although we focus on alcohol consumption and spending, cross-price effects mean that changes in alcohol prices affect tobacco consumption, and the reported health outcomes include the effect of changes in smoking (appendix p 43). All monetary outcomes are undiscounted and reported in 2017 prices. Uncertainty could not be quantified due to data and computational limitations. All estimates should be considered approximates. We undertook sensitivity analyses of the price elasticities used by modelling scenarios with cross-price elasticities to tobacco set equal to zero, and using alternative price elasticities for alcohol estimated by HM Revenue & Customs.[37] We also undertook an additional analysis to

	Moderate drinking*, non-smoking	Moderate drinking*, smoking	Hazardous drinking†, non-smoking	Hazardous drinking†, smoking	Harmful drinking‡, non-smoking	Harmful drinking‡, smoking	Any drinking
Number of people who drink alcohol (millions)							
Number	20·8	3·4	7·3	1·5	1·9	0·6	35·5
% of population	47·9%	7·8%	16·7%	3·5%	4·3%	1·5%	81·7%
Alcohol consumption, mean units§ per person per week							
All deprivation groups	4·9 (SD 3·7)	4·9 (SD 3·7)	24·6 (SD 8·5)	25·9 (SD 8·9)	69·3 (SD 24·8)	76·9 (SD 27·2)	14·5 (SD 19·8)
IMDQ1—least deprived	5·2 (SD 3·8)	5·8 (SD 3·9)	24·2 (SD 8·2)	26·0 (SD 9·0)	66·0 (SD 22·5)	74·4 (SD 25·4)	14·5 (SD 18·0)
IMDQ5—most deprived	4·5 (SD 3·6)	4·4 (SD 3·5)	25·1 (SD 8·9)	26·1 (SD 9·0)	72·4 (SD 25·5)	78·3 (SD 28·2)	15·0 (SD 22·2)
Alcohol spending, mean cost per person per week in £							
All drinkers	13·61 (SD 12·70)	13·57 (SD 12·73)	43·35 (SD 21·33)	45·73 (SD 22·15)	92·4 (SD 47·16)	97·66 (SD 44·97)	26·75 (SD 29·77)
Annual tax and retail revenues (£billion)							
Retail revenue to off-trade alcohol	1·62	0·25	3·28	0·64	2·27	0·76	8·82
Retail revenue to on-trade alcohol	8·57	1·38	7·05	1·63	2·95	1·11	22·69
Tax revenue—alcohol duty plus VAT	4·57	0·76	6·06	1·35	3·78	1·42	17·94
Alcohol and tobacco attributable health outcomes (rates per 100 000 people)							
Deaths	45	510	99	357	380	639	142
Hospital admissions	251	1526	860	1543	2995	3973	765

Data show mean weekly alcohol consumption, mean weekly spending, annual revenues to retailers and government, and health outcomes. IMDQ=Index of Multiple Deprivation Quintile. VAT=value-added tax. *Moderate drinking=under 14 units per week. †Hazardous drinking=14–35 (female) or 14–50 (male) units per week. ‡Harmful drinking=more than 35 (female) or 50 (male) units per week. §1 UK unit=10 mL/8 g of pure ethanol.

Table 2: Baseline population characteristics in 2023

estimate the relative importance of cider and beer in the equalisation scenario.

Role of the funding source

The funders had no role in study design, data collection, analysis, interpretation, or writing of the report.

Results

All results here are modelled outputs. Table 2 shows modelled outcomes in 2023 with no policy change. 81·7% of the population of England older than 18 years consume alcohol regularly. Mean weekly alcohol consumption per person who drinks alcohol was estimated at 14·5 units. Consumption was estimated to be 3·4% higher in the most deprived quintile (15·0 units) than the least deprived (14·5 units), and those smoking were found to drink more than non-smokers among people drinking hazardous and harmful amounts of alcohol (table 2). 2·5 million adults (5·8%) were estimated to drink alcohol at harmful amounts. Of those who consume harmful amounts of alcohol and smoke, alcohol consumption in the most deprived areas was estimated to be 3·9 units (5·2%) per week more than those in the least deprived areas. People who consume harmful levels of alcohol who smoke were estimated to consume 7·6 units per week (11·0%) more than those who are non-smokers. Tax revenue to government from alcohol was estimated at £17·9 billion for the year, and revenue to retailers £31·5 billion (table 2).

Figure 2 shows the proportionate changes in real-terms average duty per unit arising from the 2023 reform,

relative to the no-reform control group. The duty reforms were estimated to lead to a small decrease in average duty per unit paid for off-trade beer (–0·5%), cider (–0·8%), and spirits (–0·5%). Due to draught relief, duties would decline more in the on-trade for beer (–9·5%) and cider (–10·7%). Ready-to-drink beverages saw a large decrease in average duty (–18·9% off-trade, –36·8% on-trade) but represented only 1·8% of alcohol consumption. This large decrease in duty for ready-to-drink beverages is because ready-to-drink beverages, which are typically around 5% ABV, were subject to the same flat rate of duty per litre of ethanol as spirits, which were typically more than 20% ABV pre-reform. Under the reformed duty system, lower strength spirits and ready-to-drink beverages are subject to a lower rate of duty. Wine is the only category for which average duty was estimated to increase (8·8% off-trade, 6·8% on-trade). Duty would increase overall for off-trade alcohol (3·3%) and decline for the on-trade (–4·9%), resulting in an increase in average duty per unit of 0·8% across all beverage categories, which is mainly due to average wine duty increasing offsetting decreases for all other product categories.

Modelled estimates showed no change in alcohol consumption (to one decimal place) per person who drinks alcohol. Some effects were found for the three least deprived groups of –0·1 units per person who drinks alcohol (–0·6%) compared with no effect for the most deprived. We estimated a reduction in deaths of approximately –2307 during 20 years, years of life lost of –34 756, hospitalisations of –11 510, and associated cost savings of £29 million. 5-year government revenues from
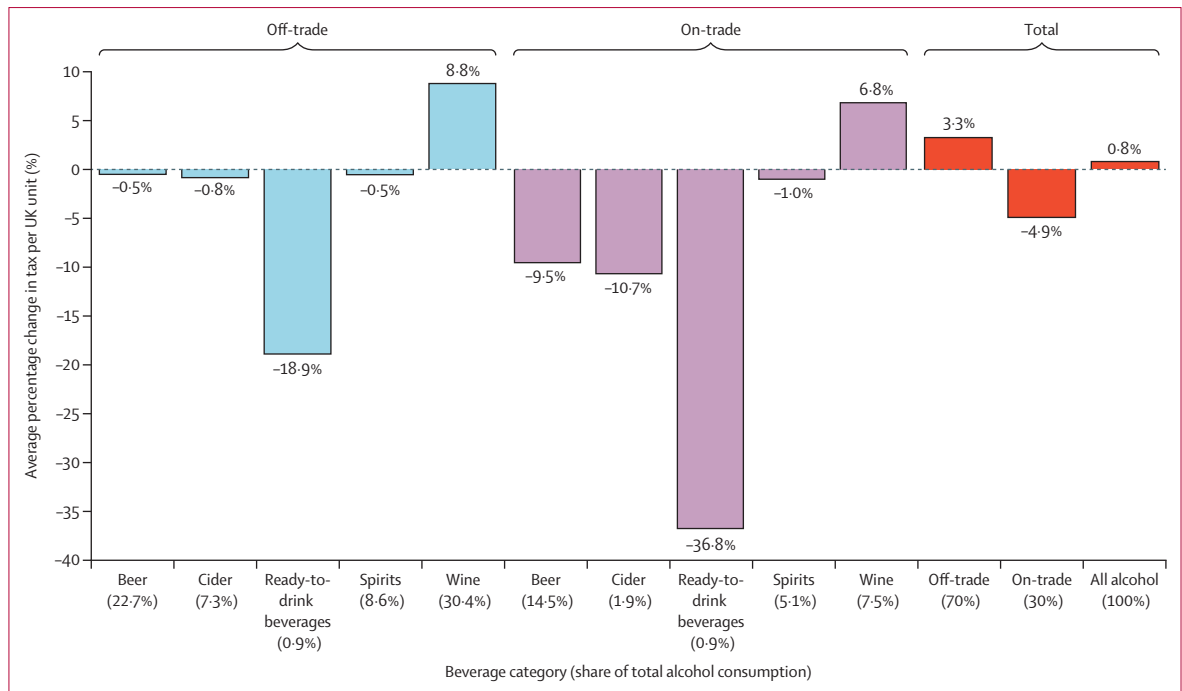
Figure 2: The effect of the UK alcohol duty reform on duty per unit in 2023 by beverage category

alcohol duty and VAT were estimated to increase by £0·2 billion (0·24%; table 3).

Hereafter, policy scenarios are hypothetical enhancements to 2023 reforms, hence, all policy effects are reported relative to the modelled duty reform scenario. If draught relief were removed, estimated mean weekly alcohol consumption in 2023 was estimated at –0·1 units less in the most deprived quintiles, with no overall difference found for the whole population. An additional 1441 deaths and 14 247 hospital admissions during 20 years would be prevented, and would better address health inequalities, with more deaths prevented in the most deprived Index of Multiple Deprivation quintiles. 5-year cumulative revenues to retailers were estimated to be £1·0 billion (–0·8%) lower without draught relief, whereas government alcohol tax revenue was estimated to increase by approximately £0·6 billion (0·6%).

The cider duty escalator applies each year after duty reform implementation in 2023; therefore, the estimated consumption effect in 2023 was identical to the duty reform scenario. Government tax receipts and retail revenues during 5 years would be similar. The escalator was, however, estimated to substantially improve health outcomes during the longer term, preventing approximately 8257 deaths and 72 966 hospitalisations compared with the 2023 duty reform alone.

Rate equalisation in 2023 resulted in much larger and more immediate estimated effects on consumption and health than the escalator. Alcohol consumption was estimated to decrease by around 2·5 units per person who drinks alcohol per week (–17·2%) relative to the

2023 reforms (table 3). Around two-thirds of this estimate was attributable to the cider duty increase and one-third to beer (appendix p 45). This scenario was estimated to yield substantial public health and health inequality benefits, with 74 465 additional deaths and 707 216 hospitalisations prevented, and 12 330 more deaths prevented in the most deprived quintile than the least deprived, which could improve health inequalities. Retail revenue was estimated to decrease substantially during 5 years in both the off-trade (–£7·6 billion, –17·4%) and on-trade (–£3·9 billion, –3·3%) compared with the duty reforms. Alcohol tax revenue was also estimated to be reduced by –£5·9 billion (–6·4%) due to the elastic (larger than one) own-price conditional consumption elasticities for both beer and cider in the off-trade (appendix p 33).

A sensitivity analysis that set cross-price elasticities to tobacco products equal to zero showed similar results to the main analysis. Estimated reductions in deaths are slightly reduced if tobacco is not also considered as alcohol and tobacco are complementary products (appendix p 46), but most of the estimated impact remained. The estimated effects of the 2023 reforms on consumption and harms are sufficiently small that the direction of estimated effects is sensitive to the price elasticity matrix used. Sensitivity analyses (appendix p 47) using elasticities estimated by HM Revenue & Customs[37] resulted in an estimated increase in cumulative deaths (n=715). Only for the equalisation scenario is there a noticeable change in consumption, although it and the associated estimated reduction in cumulative

deaths were of substantially lower magnitudes than in the main analysis.

Discussion

This study provides, to our knowledge, the first comprehensive estimate of public health and economic effects of the UK's 2023 alcohol duty reforms using a modelling approach based on a synthetic population representative of the age, sex, and ethnic demographics of England, and patterns of alcohol consumption. The study shows that the public health effect of the reform is likely to be broadly neutral. Our modelled estimates suggest that the reform alone would reduce average alcohol consumption by less than one-tenth of a unit per week while reducing deaths by approximately 2300 during 20 years compared with retaining the previous duty system. Our hypothetical scenarios have shown that draught relief would increase on-trade retailer revenues by £1·0 billion (0·8%) in line with its aim to support public houses and leave consumption relatively unchanged. Thereby our modelling suggests that removing draught relief would not deliver substantially greater public health benefits. Based on our model a cider escalator could deliver substantially improved outcomes whereas equalising duty rates across all beverage types between 3·5% ABV and 8·4% ABV could lead to much greater and more immediate effects with an approximate 17% reduction in alcohol consumption in 2023 and 74 000 fewer deaths during 20 years. The equalisation of duty rates would, however, reduce government alcohol tax receipts and on-trade retailer revenue that the alcohol duty reform was designed to benefit.

These findings suggest that the 2023 UK duty reforms reflect public health recommendations by taxing all alcohol products according to alcoholic strength but largely maintain the status quo regarding the amount of alcohol consumption and health outcomes. Nonetheless, the reformed system means future policy makers can better target duty rate increases at products with high alcohol content that are disproportionately consumed by people who consume harmful amounts of alcohol.[38] Addressing the exceptional status of cider would deliver essential public health benefits, and these findings suggest more generally that the implementation of structural alcohol taxation reforms in other countries will have small effects if such exceptions to the rule are retained. Our findings differ from the UK Government's own policy impact assessment[39] that focused on economic implications and that has estimated a small reduction in revenue from alcohol duty and VAT in comparison with the small increase observed in our results. Whether the model predicts improving or worsening health outcomes depends on the price elasticities assumed. Our sensitivity analyses estimated small increases in alcohol consumption and worsening health outcomes because of the duty reform, in contrast with the main analysis.

	Control (no policy change)	Intervention groups (absolute difference*)		
		Duty reform vs control	vs the duty reform intervention	
			Duty reform and no draught relief	Duty reform and cider escalator	Duty reform and equalisation
Alcohol consumption in 2023 (units† per person per week)					
Population	14·5	0·0	0·0	0·0	–2·5
IMDQ-1 (least deprived)	14·5	–0·1	0·0	0·0	–2·0
IMDQ-2	14·4	–0·1	0·0	0·0	–2·2
IMDQ-3	14·3	–0·1	0·0	0·0	–2·4
IMDQ-4	14·7	0·0	–0·1	0·0	–2·8
IMDQ-5 (most deprived)	15·0	0·0	–0·1	0·0	–3·3
Mean spending in 2023 (cost per person in £ per week)					
All alcohol	26·75	0·14	–0·03	0·00	–1·80
Cumulative 5-year impact (2023–27) on retail and tax revenues (£ billion)					
Retail revenue off-trade alcohol	44·2	–0·4	0·0	–0·1	–7·6
Retail revenue on-trade alcohol	116·5	1·6	–1·0	0·00	–3·9
Alcohol duty plus VAT	90·9	0·2	0·6	–0·1	–5·9
Cumulative 20-year impact (2023–42) on health outcomes					
Total deaths	9 413 863	–2307	–1441	–8257	–74 465
Total deaths IMDQ-1 (least deprived)	1 724 199	–674	–177	–1103	–9549
Total deaths IMDQ-2	1 871 894	–765	–141	–789	–11 730
Total deaths IMDQ-3	1 955 447	–641	24	–1462	–13 115
Total deaths IMDQ-4	1 919 957	424	–719	–2620	–18 192
Total deaths IMDQ-5 (most deprived)	1 942 365	–651	–429	–2282	–21 879
Years of life lost	139 963 334	–34 756	–45 781	–225 711	–2 178 114
Hospital admissions	40 079 449	–11 510	–14 247	–72 966	–707 216
National Health Service admissions costs (£ million)	73 604	–29	–27	–147	–1410

IMDQ=Index of Multiple Deprivation Quintile. VAT=value-added tax. *Note that the three duty reform intervention scenarios are compared with the duty reform scenario rather than no policy change. †1 UK unit=10 mL/8 g of pure ethanol.

Table 3: Effect of modelled policy scenarios on alcohol consumption, alcohol retailer and tax revenues, and health outcomes

The large global literature on the effect of changes in alcohol taxation consistently finds that increasing taxation reduces alcohol consumption and harm.[19,40–47] However, there is less evidence on the effect of changing the basis of taxation. Several studies that have modelled hypothetical volumetric taxation scenarios have found that switching to volumetric taxation, as implemented in the UK reforms, leads to better public health outcomes, including reduced alcohol consumption, deaths, and hospital admissions.[20–22]

Our results appear to be at odds with these studies in finding only small public health benefits from reforming the duty structure; however, this difference is driven by these studies modelling scenarios that assume that all products sold at the same alcoholic strength would be

taxed at the same rate. The UK's lower rates of duty for beer and particularly cider, which is favoured by people who drink harmful amounts of alcohol,[15] go against this assumption. As our results show, removing cider exceptionalism would deliver substantial public health benefits.

Although previous research has shown that volumetric alcohol taxation outperforms simply increasing existing rates of taxation in reducing mortality among those who drink harmful amounts of alcohol and reducing health inequalities,[19] many countries currently do not apply volumetric tax regimes. The EU, for example, requires members to tax wine and spirits by product volume, rather than strength, which could encourage production and consumption of higher strength products.[16] In the Americas, excise taxes are predominantly based on volume of product or retail price.[17] In appraising a recent example of a country switching to a strength-based tax system, this study provides evidence that such a system can improve public health outcomes, but only if appropriate rates of taxation are set. Evidence from Canada concluded that introducing strength-based alcohol taxation that leaves government revenues largely unchanged would have limited effects on consumption and harms to health,[22] consistent with the findings in this study.

Our results have provided an analysis of the effects of transitioning to a strength-based alcohol taxation system based on reforms implemented in the UK in August, 2023. The strengths of this study lie in the detailed modelling, which allows for population heterogeneity by subgroups, capturing the interaction between alcohol and smoking, and a comprehensive analysis of consumption, health, and economic outcomes.

There are several limitations to our approach. First, we have been unable to fully quantify the uncertainty around the modelled estimates (eg, via a probabilistic sensitivity analysis) due both to the computationally demanding nature of the model and incomplete data on the uncertainty around all key parameters required for a probabilistic sensitivity analysis. We have, however, presented the structural uncertainty around the different sources of available evidence on price elasticities. Second, we have assumed draught relief applies to all on-trade products below 8·5% ABV. In fact, only products dispensed from casks over 40 L are included and our estimates are therefore likely to overestimate the effect of draught relief. However, given the small effect of draught relief, this is unlikely to substantially affect our conclusions. Our economic analyses are limited in only quantifying tax revenues and hospital admissions costs. Consequently, we underestimate the total societal savings from reduced alcohol consumption including, for example, other costs to the health service, reduced work absenteeism, and reductions in alcohol-related crime. There could be non-price market responses to the new duty system that we have not

accounted (eg, introduction of new products, reformulation of existing products, or changes in marketing strategies), and some evidence of non-price response was found in the evaluation of minimum unit pricing in Scotland.[48] Finally, in the absence of detailed individual-level data about alcohol purchases and prices paid that also incorporate information on product ABVs, we have had to map between multiple sources of data. This mapping of multiple data sources means our analyses might not fully capture the extent to which preferences for different strength products differ between population subgroups.

Further research evaluating the duty reforms will deepen understanding of its effects and the authors will be carrying out a large-scale evaluation study that will produce evidence for validation of this study as post-reform data become available. Further research could also explore effects on consumption of no or low alcohol products and how future uprating of duty rates within this structure, including changes to the strength categories used as the basis for taxation, can be adjusted to reduce the alcohol consumption of those who are drinking harmful amounts. Additional measures could also merit consideration for use alongside taxes as part of a broader strategic approach to alcohol problems. Other price-based policies (eg, minimum unit pricing and restrictions on discounting) and wider regulations (eg, restrictions of marketing) could also contribute to reducing alcohol-related harm.

Reforms to UK alcohol duty align with best practice recommendations for public health.[10] Our analysis suggests that the reforms as implemented are unlikely to lead to substantial improvements in public health; however, eliminating the differences in duty rates for beers and ciders from other products sold at the same alcoholic strength would lead to substantial additional health gains while narrowing health inequalities. Implementing a similar structure in other countries, many of which do not tax alcohol by alcohol content, could produce substantial public health benefits.

References
1 Griswold MG, Fullman N, Hawley C, et al. Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2018; **392:** 1015–35.
2 WHO. Global status report on alcohol and health 2018. 2018. https://www.who.int/publications/i/item/9789241565639 (accessed Sept 1, 2024).
3 Global Burden of Disease Collaborative Network. Global Burden of Disease Study 2021 (GBD 2021). 2024. https://vizhub.healthdata.org/gbd-results (accessed Sept 1, 2024).
4 Office for Health Improvement and Disparities. OHID Local Alcohol Profiles for England, 2024. https://fingertips.phe.org.uk/profile/local-alcohol-profiles/data#page/1 (accessed Sept 1, 2024).
5 NHS England. NHS long term plan will help problem drinkers and smokers. 2019. https://www.england.nhs.uk/2019/01/nhs-long-term-plan-will-help-problem-drinkers-and-smokers (accessed Sept 1, 2024).
6 Elder RW, Lawrence B, Ferguson A, et al. The effectiveness of tax policy interventions for reducing excessive alcohol consumption and related harms. *Am J Prev Med* 2010; **38:** 217–29.
7 Chaloupka FJ, Grossman M, Saffer H. The effects of price on alcohol consumption and alcohol-related problems. *Alcohol Res Health* 2002; **26:** 22–34.
8 Xu X, Chaloupka FJ. The effects of prices on alcohol use and its consequences. *Alcohol Res Health* 2011; **34:** 236–45.
9 WHO. Tackling NCDS: 'best buys' and other recommended interventions for the prevention and control of noncommunicable diseases. Geneva, Switzerland: WHO, 2017.
10 WHO. Alcohol pricing in the WHO European Region. 2020. https://www.who.int/publications/i/item/10665-336159 (accessed Sept 1, 2024).
11 HM Revenue & Customs. Alcohol duty rates. 2023. https://www.gov.uk/guidance/alcohol-duty-rates (accessed Sept 1, 2024).
12 Hatchard J, Buykx P, Brennan A, Gillespie D. Options for modifying UK alcohol and tobacco tax: a rapid scoping review of the evidence over the period 1997–2018. *NIHR Open Res* 2023; **3:** 26.
13 HM Treasury. Chancellor unveils a Budget for growth. 2023. https://www.gov.uk/government/news/chancellor-unveils-a-budget-for-growth (accessed Sept 2, 2024)
14 Black H, Gill J, Chick J. The price of a drink: levels of consumption and price paid per unit of alcohol by Edinburgh's ill drinkers with a comparison to wider alcohol sales in Scotland. *Addiction* 2011; **106:** 729–36.
15 Black H, Michalova L, Gill J, et al. White cider consumption and heavy drinkers: a low-cost option but an unknown price. *Alcohol Alcohol* 2014; **49:** 675–80.
16 Angus C, Holmes J, Meier PS. Comparing alcohol taxation throughout the European Union. *Addiction* 2019; **114:** 1489–94.
17 Roche M, Sandoval RC, Monteiro MG. Comparing taxes on alcoholic beverages in the Region of the Americas. *Addiction* 2023; **118:** 1389–95.
18 Vandenberg B, Jiang H, Livingston M. Effects of changes to the taxation of beer on alcohol consumption and government revenue in Australia. *Int J Drug Policy* 2019; **70:** 1–7.
19 Meier PS, Holmes J, Angus C, Ally AK, Meng Y, Brennan A. Estimated effects of different alcohol taxation and price policies on health inequalities: a mathematical modelling study. *PLoS Med* 2016; **13:** e1001963.
20 Vandenberg B, Sharma A. Are alcohol taxation and pricing policies regressive? Product-level effects of a specific tax and a minimum unit price for alcohol. *Alcohol Alcohol* 2016; **51:** 493–502.
21 Doran CM, Byrnes JM, Cobiac LJ, Vandenberg B, Vos T. Estimated impacts of alternative Australian alcohol taxation structures on consumption, public health and government revenues. *Med J Aust* 2013; **199:** 619–22.
22 Stockwell T, Churchill S, Sherk A, Sorge J, Gruenewald P. How many alcohol-attributable deaths and hospital admissions could be prevented by alternative pricing and taxation policies? Modelling impacts on alcohol consumption, revenues and related harms in Canada. *Health Promot Chronic Dis Prev Can* 2020; **40:** 153–64.
23 Sharma A, Vandenberg B, Hollingsworth B. Minimum pricing of alcohol versus volumetric taxation: which policy will reduce heavy consumption without adversely affecting light and moderate consumers? *PLoS One* 2014; **9:** e80936.
24 Morris D, Brennan A, Angus C, Wilson LB, Pryce R, Gillespie D. Tobacco and Alcohol Tax and Price Intervention Simulation Model (TAX-sim): full technical documentation. 2023. https://osf.io/kr23z (accessed Sept 1, 2024).
25 HM Treasury and HM Revenue & Customs. The new alcohol duty system: final consultation response. 2023. https://assets.publishing.service.gov.uk/media/641c2bcf32a8e00012fa9293/M5209_M5348_Alcohol_Duty_Review_consultation_response_FINAL.pdf (accessed Sept 1, 2024).
26 Brennan A, Meier P, Purshouse R, et al. The Sheffield Alcohol Policy Model—a mathematical description. *Health Econ* 2015; **24:** 1368–88.
27 Pryce R, Wilson LB, Gillespie D, Angus C, Morris D, Brennan A. Estimation of integrated price elasticities for alcohol and tobacco in the United Kingdom using the living costs and food survey 2006-2017. *Drug Alcohol Rev* 2024; **43:** 315–24.
28 Ally AK, Meng Y, Chakraborty R, et al. Alcohol tax pass-through across the product and price range: do retailers treat cheap alcohol differently? *Addiction* 2014; **109:** 1994–2002.
29 Wilson LB, Pryce R, Hiscock R, Angus C, Brennan A, Gillespie D. Quantile regression of tobacco tax pass-through in the UK 2013–2019. How have manufacturers passed through tax changes for different tobacco products? *Tob Control* 2021; **30:** e27–e32.
30 Wilson LB, Pryce R, Angus C, Hiscock R, Brennan A, Gillespie D. The effect of alcohol tax changes on retail prices: how do on-trade alcohol retailers pass through tax changes to consumers? *Eur J Health Econ* 2021; **22:** 381–92.
31 Office for Budget Responsibility. Forecasting the public finances. 2011. https://obr.uk/docs/dlm_uploads/obr_briefing1.pdf (accessed Sept 1, 2024).
32 Heeb JL, Gmel G. Measuring alcohol consumption: a comparison of graduated frequency, quantity frequency, and weekly recall diary methods in a general population survey. *Addict Behav* 2005; **30:** 403–13.
33 Meier PS, Meng Y, Holmes J, et al. Adjusting for unrecorded consumption in survey and per capita sales data: quantification of impact on gender- and age-specific alcohol-attributable fractions for oral and pharyngeal cancers in Great Britain. *Alcohol Alcohol* 2013; **48:** 241–49.
34 Angus C, Morris D, Leeming G, et al. New modelling of alcohol pricing policies, alcohol consumption and harm in Scotland. 2023. https://sarg-sheffield.ac.uk/wp-content/uploads/2023/09/sarg-scottish-mup-report-2023.pdf (accessed Sept 1, 2024).
35 HM Treasury. Spring Budget 2023. 2023. https://assets.publishing.service.gov.uk/media/6419c87d8fa8f547c267efca/Web_accessible_Budget_2023.pdf (accessed Sept 1, 2024).

36   HM Revenue & Customs. Policy paper: reform of alcohol duty and reliefs. 2023. https://www.gov.uk/government/publications/reform-of-the-alcohol-duty-system/reform-of-alcohol-duty-rates-and-reliefs (accessed Sept 1, 2024).

37   Sousa J. Estimation of price elasticities of demand for alcohol in the United Kingdom. London: HM Revenue and Customs, 2014.

38   Meier PS, Holmes J, Angus C, Ally AK, Meng Y, Brennan A. Estimated effects of different alcohol taxation and price policies on health inequalities: a mathematical modelling study. *PLoS Med* 2016; **13:** e1001963.

39   HM Treasury. Spring budget 2023 policy costings. 2023. https://assets.publishing.service.gov.uk/media/6411603be90e076ccf66d781/Costing_Document_-_Spring_Budget_2023.pdf (accessed Sept 1, 2024).

40   Andreasson S, Holder HD, Norström T, Österberg E, Rossow I. Estimates of harm associated with changes in Swedish alcohol policy: results from past and present estimates. *Addiction* 2006; **101:** 1096–105.

41   Chambers T, Mizdrak A, Herbert S, Davies A, Jones A. The estimated health impact of alcohol interventions in New Zealand: a modelling study. *Addiction* 2024; **119:** 125–36.

42   Ng CS, Au M, Tian L, Quan J. Impact of alcohol taxes on violence in Hong Kong: a population-based interrupted time series analysis. *J Epidemiol Community Health* 2023; **77:** 391–97.

43   Ng CS, Au M, Ma R, Leung JYY, Quan J. The impact of alcohol pricing policies on public health in Hong Kong, China: a modelling study. *Lancet Reg Health West Pac* 2022; **26:** 100510.

44   Neufeld M, Rovira P, Ferreira-Borges C, et al. Impact of introducing a minimum alcohol tax share in retail prices on alcohol-attributable mortality in the WHO European Region: a modelling study. *Lancet Reg Health Eur* 2022; **15:** 100325.

45   Gehrsitz M, Saffer H, Grossman M. The effect of changes in alcohol tax differentials on alcohol consumption. *J Public Econ* 2021; **204:** 104520.

46   Wagenaar AC, Salois MJ, Komro KA. Effects of beverage alcohol price and tax levels on drinking: a meta-analysis of 1003 estimates from 112 studies. *Addiction* 2009; **104:** 179–90.

47   Jiang H, Livingston M, Room R, et al. Modelling the effects of alcohol pricing policies on alcohol consumption in subpopulations in Australia. *Addiction* 2020; **115:** 1038–49.

48   MESAS, Public Health Scotland. Evaluating the impact of alcohol minimum unit pricing in Scotland: Observational study of small retailers, 2020. https://publichealthscotland.scot/media/3092/evaluating-the-impact-of-alcohol-minimum-unit-pricing-in-scotland-observational-study-of-small-retailers.pdf (accessed Sept 1, 2024).