

Can indirect methods be used as an approximation to estimate alcohol excise taxation revenue?

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Abstract

Introduction: Alcohol excise taxation is one of the World Health Organization's (WHO) "best buys" for reducing alcohol consumption and attributable harms. Despite its proven effectiveness, alcohol taxation remains globally underused, partly due to Member States' concerns about potential revenue losses. Robust estimation methods are essential to predict future revenues after policy changes. This study compares two approaches for estimating alcohol excise tax revenue *per capita* and assesses their validity against reported figures.

Methods: Reported alcohol excise tax revenue *per capita* for 2022 was retrieved from official government sources for 17 countries in the European Union and the United Kingdom. These figures were compared to estimated values generated using two different methods: (a) a tax-and-consumption-based approach using beverage-specific tax and consumption data, and (b) an excise share-based approach using the linear relationship between excise tax share and revenue. Comparisons were made using visual inspection of scatterplots, relative error plots, and Bland-Altman plots, correlation analysis and linear regression models.

Results: Both methods showed strong correlation with reported revenue (tax-and-consumption-based: $r = .959$; excise share-based: $r = .857$) and high explained variance of the reported revenue. The tax-and-consumption-based method demonstrated higher precision, narrower limits of agreement, and significantly better model fit.

Conclusion: Both methods provide useful alternatives in the absence of reported data, but the tax-and-consumption-based approach offers a more accurate and consistent estimate of alcohol excise tax revenue *per capita*. These findings support its use in global monitoring and fiscal modelling, particularly in the context of WHO technical support to Member States.

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Introduction

Alcohol consumption is a major risk factor for disease, injury, and premature death worldwide, contributing substantially to the global burden of diseases (World Health Organization (WHO), 2024a), and incurring high economic costs (Manthey et al., 2021). Among the available alcohol control measures, increasing excise taxation is widely recognised as one of the most effective policy tools to reduce alcohol consumption level and consequently attributable harms (Babor et al., 2023). The World Health Organization (WHO) has identified alcohol taxation as one of its three “best buys” — the most cost-effective policy options for reducing alcohol consumption and attributable harm (WHO, 2013) — and more recently as a “quick buy,” referring to interventions capable of delivering measurable public health benefits within five years (Galea et al., 2025). In addition to its health benefits, increasing excise taxes can raise government revenue that may be reinvested in public health, social protection, or other public services. Although alcohol excise tax revenues in Europe remain well below the estimated public costs associated with alcohol-related harm, they can help offset at least some of the externalities caused by alcohol consumption. (Manthey et al., 2024).

In recent years, there has been renewed interest in better understanding the role of alcohol taxation within broader fiscal and health policy frameworks. Researchers and policymakers have increasingly focused on alcohol tax share — the portion of the retail price that is collected as tax revenues by the government, expressed as a percentage — revenue generation, and the interlinkages between price, consumption, and affordability indicators (Neufeld et al., 2022; Wall & Casswell, 2013). However, research that specifically considers alcohol excise tax revenue remains limited, including the European region. Existing analyses are largely confined to studies by Manthey and colleagues (2024) and Rehm and colleagues (2025). While data on alcohol tax structures, rates, and retail prices are now collected biannually by WHO and reported in the Global Report on the Use of Alcohol Taxes (WHO, 2023) as part of global surveillance efforts, official data on alcohol excise tax revenue are often not publicly available or are inconsistently reported, making cross-country comparisons and time series analyses difficult. In many countries, excise revenue is not published in a disaggregated, alcohol-specific format, is grouped with other goods such as tobacco or soft drinks, or is only available through internal or non-public finance systems. In contrast, tax structures and consumption data are more readily available and systematically collected through WHO mechanisms. This disparity complicates efforts to evaluate tax system performance and planning and forecasting the impact of fiscal reforms, highlighting the value of robust estimation methods to fill these critical data gaps.

Given these data limitations, we explore two approaches to indirectly estimate alcohol excise tax revenue *per capita* using available tax and consumption indicators. The first — referred to here as the excise share-based method — builds on a model developed by Rehm and colleagues (2025),

which identified a strong linear association between overall excise tax share and *per capita* revenue in European Union (EU) countries. Although not originally intended for revenue estimation, we applied this relationship to predict revenue based on tax share. The second — the tax-and-consumption-based method — was newly developed in this study and combines beverage-specific excise tax rates, as reported in the Global Report on the Use of Alcohol Taxes (WHO, 2023), with recorded alcohol consumption data, to estimate *per capita* revenue. While alcohol may also be subject to other forms of taxation (e.g., value added tax), we focused on excise taxation only, as these taxes decrease affordability of alcohol specifically in comparison to other goods, and thus have been shown crucial to impact consumption (Wall & Casswell, 2013).

This study aimed to assess the accuracy, precision, and consistency of alcohol excise tax revenue estimates generated using these two approaches — excise share-based and tax-and-consumption-based methods — by comparing them to reported revenue data from 17 countries of the EU and the United Kingdom (UK). The findings aim to provide evidence on the extent to which revenue gains from alcohol tax reform can be estimated in settings where reported data are lacking, and thus support efforts to strengthen alcohol taxation monitoring systems and inform fiscal policy discussions with ministries of finance and health. This is particularly relevant in the context of WHO’s ongoing technical support to countries considering excise tax reform, where reliable projections are often required to address concerns about potential revenue loss.

Methods

Settings

This study included countries in the EU and the UK. Countries were included if they met two criteria: (a) publicly available data could be retrieved on reported alcohol excise tax revenue *per capita* for the year 2022, and (b) sufficient information was available for all three beverage types (beer, wine, and spirits) to enable estimation of alcohol excise tax revenue *per capita* using both the excise share-based and tax-and-consumption-based approaches. A total of 17 countries met these criteria and were included in the analysis: Austria, Belgium, Cyprus, Denmark, Estonia, Finland, Germany, Ireland, Italy, Lithuania, Poland, Portugal, Romania, Slovenia, Spain, Sweden, and the UK. Of the remaining 11 countries, France, Luxembourg and Malta did not have information on tax rates and shares of any alcoholic beverage for 2022, and Czechia and Latvia were missing information for wine only. For Bulgaria, Croatia, Greece, Hungary, Netherlands, and Slovakia, no publicly available data could be retrieved on reported alcohol excise tax revenue *per capita* for the year 2022.

Reported revenue data

Alcohol excise tax revenue data were systematically retrieved from the official websites of national governmental agencies and statistical institutes for the year 2022. All publicly available figures related to alcohol excise tax

revenue were collected, whether reported as an overall total (as was the case for most countries) or disaggregated by beverage type. A complete list of data sources and the reported revenue values in original currency are provided in the supplementary materials.

To enable comparability across countries, reported revenue values were standardised as *per capita*, i.e. by dividing them by the population aged 15 years and older in the corresponding year, using data from the United Nations World Population Prospects database (United Nations - Department of Economic and Social Affairs - Population Division, 2022). All monetary values were converted to Euros (€) using official exchange rates published by the World Bank, 2022 averages (The World Bank, 2025), as this was the currency used by most countries.

Other data sources

Beverage-specific recorded alcohol *per capita* (among adults aged 15 years and older) consumption (APC) data were drawn from harmonised, country-specific exposure estimates published by the WHO Global Monitoring System on Alcohol and Health (WHO, 2025a) for 2022.

Data on tax structures, prices, and excise tax share were collected between July 2022 and June 2023 by the WHO Regional Office for Europe as part of the biannual Global Report on the Use of Alcohol Taxes (WHO, 2023), and tax shares are available in the WHO's Global Health Observatory portal (WHO, 2024b). Tax rates and prices were reported for the most sold brand of 330ml beer and 750ml spirits at global level; in addition, for countries in the WHO European Region, information was also collected for the most sold brand of 750ml wine. The "most sold brand" was identified by countries using available market data, or, when such data were not available, based on expert judgment by national authorities. In most countries, national level brand-specific price statistics were not available, thus the retail price data were collected from one drink specialist or independent small grocery store usually in the capital city of the country. The data were reported and validated by officials from the Ministries of Health and Finance of WHO Member States. Excise tax shares were calculated according to a standardised WHO protocol based on reported retail prices and applicable excise tax rates. Further details on the data collection process and definitions used can be found in the Technical Notes section of the Global Report on the Use of Alcohol Taxes (WHO, 2023).

Excise share-based method

The excise share-based approach estimated alcohol excise tax revenue based on the previously established linear relationship between the share of excise taxes in the final retail price of alcohol and the *per capita* alcohol excise tax revenue. This relationship was originally derived by Rehm and colleagues (2025), who applied linear regression across a cross-section of countries in the EU and UK, using 2022 data converted to €. The resulting model estimated excise tax revenue *per capita* (in €) as a linear function of the overall excise tax share (as a proportion of the final retail price), with the regression constrained to a zero intercept:

$$\text{Excise revenue} = \beta \times \text{Overall excise tax share}$$

The estimated regression coefficient was $\beta = 586.9$ (95% CI [495.6, 678.1]), expressed in € *per capita*.

Using this method, revenue was estimated by multiplying each country's overall excise tax share by the regression coefficient. The overall excise tax share was calculated for each country as a weighted average of the beverage-specific shares for beer, wine, and spirits, using the relative contribution of each beverage to total recorded alcohol consumption (in litres of pure alcohol) as weights (available in supplementary materials).

Tax-and-consumption-based method

The tax-and-consumption approach estimated alcohol excise tax revenue *per capita* by combining tax rates with recorded alcohol consumption data at the national level and disaggregated by beverage type (beer, wine, and spirits). Excise tax structures included both specific taxes (based on alcohol content or product volume) and *ad valorem* taxes (based on product value). For specific excise taxes, the tax amount per litre of beverage was calculated by multiplying the alcohol content or volume by the corresponding rate. For *ad valorem* taxes, the tax amount per litre was calculated using the applicable tax base (e.g., producer price), as reported by each country. Total excise tax revenue was calculated separately for each beverage by multiplying the estimated tax amount per litre of product by the total volume of beverage from recorded sources, which was derived by converting recorded APC (in litres of pure alcohol) using beverage-specific alcohol by volume (ABV). The detailed methodology, including inputs and intermediate calculations are available in supplementary materials.

Revenue values across beer, wine, and spirits were then summed to obtain the total excise tax revenue *per capita* for each country. All monetary estimates were converted to € using official exchange rates published by the World Bank, 2022 averages (The World Bank, 2025).

Statistical analysis

We assessed the agreement between estimated and reported alcohol excise tax revenue *per capita* using both visual and numerical methods. Estimates from the excise share-based and tax-and-consumption-based approaches were each compared to the reported values.

First, scatterplots were produced to visually compare reported versus estimated revenues and assess overall alignment. Relative errors were calculated for each country and method as the difference between estimated and reported revenue, expressed as a percentage of the reported value. Countries were classified according to the magnitude of the relative errors (above or below $\pm 10\%$).

To formally assess agreement, we applied Bland-Altman analysis for each estimation method. The Bland-Altman plots display the mean of estimated and reported values on the x-axis, and the difference (estimated-reported) on the y-axis, with horizontal lines indicating the mean difference

(bias) and 95% limits of agreement (mean $\pm$ 1.96 SD of the differences). This allowed evaluation of both systematic bias and variability across countries.

Pearson's correlation coefficient was used to assess the strength of association between estimated and reported values. We also fitted linear regression models to assess how well each estimation method predicted the reported excise tax revenue *per capita*. Two separate models were constructed with reported revenue as the dependent variable and either the excise share-based estimate or tax-and-consumption-based as the independent variable. Model performance was assessed using the R^2 , and Akaike Information Criterion (AIC). To formally compare the two non-nested linear models, we applied the Davidson-MacKinnon J test. The J test evaluates whether the predicted values from one model improves the model fit when included in the regression of the other. For example, if including the excise share-based estimates improves the fit of the tax-and-consumption-based model, this suggests the excise share-based approach captures variance not explained by the tax-and-consumption-based method. The test is performed in both directions to assess whether either model consistently outperforms the other.

All analyses were conducted in R, version 4.3.3 (R Core Team, 2024), and an alpha level of 0.05 was used to determine statistical significance.

Ethical considerations

This study did not involve human participants, personal data, or experimental interventions. All data were obtained from publicly available sources or from the World Health Organization through established global surveillance activities. As such, ethics approval from an institutional review board was not required.

Results

Reported alcohol excise tax revenue *per capita* for 2022, alongside excise share-based and tax-and-consumption-based estimates for the same year, are presented in Table 1. Reported revenue varied widely across the 17 countries included in the analysis, ranging from €19.6 in Romania to €314.5 in Finland. Similar ranges were observed for both estimation methods: excise share-based estimates ranged from €22.6 in Italy to €268.0 in Sweden, while tax-and-consumption-based estimates ranged from €20.8 in Italy to €309.4 in the UK.

Figure 1 summarises the agreement between estimated and reported revenue using scatterplots, relative error plots, and Bland-Altman plots. In the scatterplots comparing estimated and reported values, the tax-and-consumption-based estimates were more tightly clustered around the identity line, indicating closer alignment with reported revenue. In contrast, the excise share-based estimates showed greater dispersion, particularly for countries at the lower and higher ends of the revenue distribution.

Relative error plots confirmed that the tax-and-consumption-based method returned estimates within $\pm 10\%$ of reported values for approximately half of the countries and tended to underestimate revenue in most cases. The excise share-based method exhibited larger deviations overall, with six countries exceeding $\pm 50\%$ relative error.

Bland-Altman plots showed minimal average bias for both methods, with mean differences between estimated and reported values close to zero. However, the 95% limits of agreement were substantially narrower for the tax-and-consumption-based method, indicating greater precision and consistency across countries. Both methods showed a trend toward larger estimation errors at higher revenue levels, with such tendency being clearer for the excise share-based approach.

Table 1

Reported and estimated alcohol excise tax revenue per capita by country, 2022 (in €)

Country	Reported	Excise share-based method	Tax-and-consumption-based method
Austria	49.9	41.1	51.8
Belgium	54.0	101.9	64.6
Cyprus	37.2	65.2	25.9
Denmark	105.6	76.4	102.5
Estonia	218.4	214.9	187.3
Finland	314.5	217.1	238.1
Germany	44.2	70.1	41.6
Ireland	304.3	207.4	304.8
Italy	28.6	22.6	20.8
Lithuania	188.4	205.3	167.9
Poland	89.6	167.7	86.2
Portugal	31.1	38.4	33.1
Romania	19.6	52.4	34.0
Slovenia	69.3	69.5	75.4
Spain	30.4	56.7	31.0
Sweden	179.2	268.0	181.8
United Kingdom	263.7	215.1	309.4

The Pearson correlation between estimated and reported values was very high for both the excise share-based method ($r = .872$, 95% CI [0.674, 0.953]) and the tax-and-consumption-based method ($r = .971$, 95% CI [0.921, 0.990]; Table 2). Results from linear regression models also showed better performance for the tax-and-consumption-based estimates, which explained more variance in the reported values ($R^2 = .944$) and had a lower AIC (162) than the excise share-based estimates ($R^2 = .760$, AIC = 187). When testing whether the excise share-based estimates added explanatory value to the tax-and-consumption-based model, the result was not statistically significant ($p = .272$). In contrast, adding the tax-and-consumption-based estimates

to the excise share-based model significantly improved model fit ($p < .001$), indicating that the tax-and-consumption-based approach captured variation not explained by the excise share-based method.

Figure 1

Comparison of tax-and-consumption-based and excise share-based estimates of alcohol excise tax revenue per capita (in €) with reported values in 2022, using scatterplots, relative errors, and Bland–Altman plots.

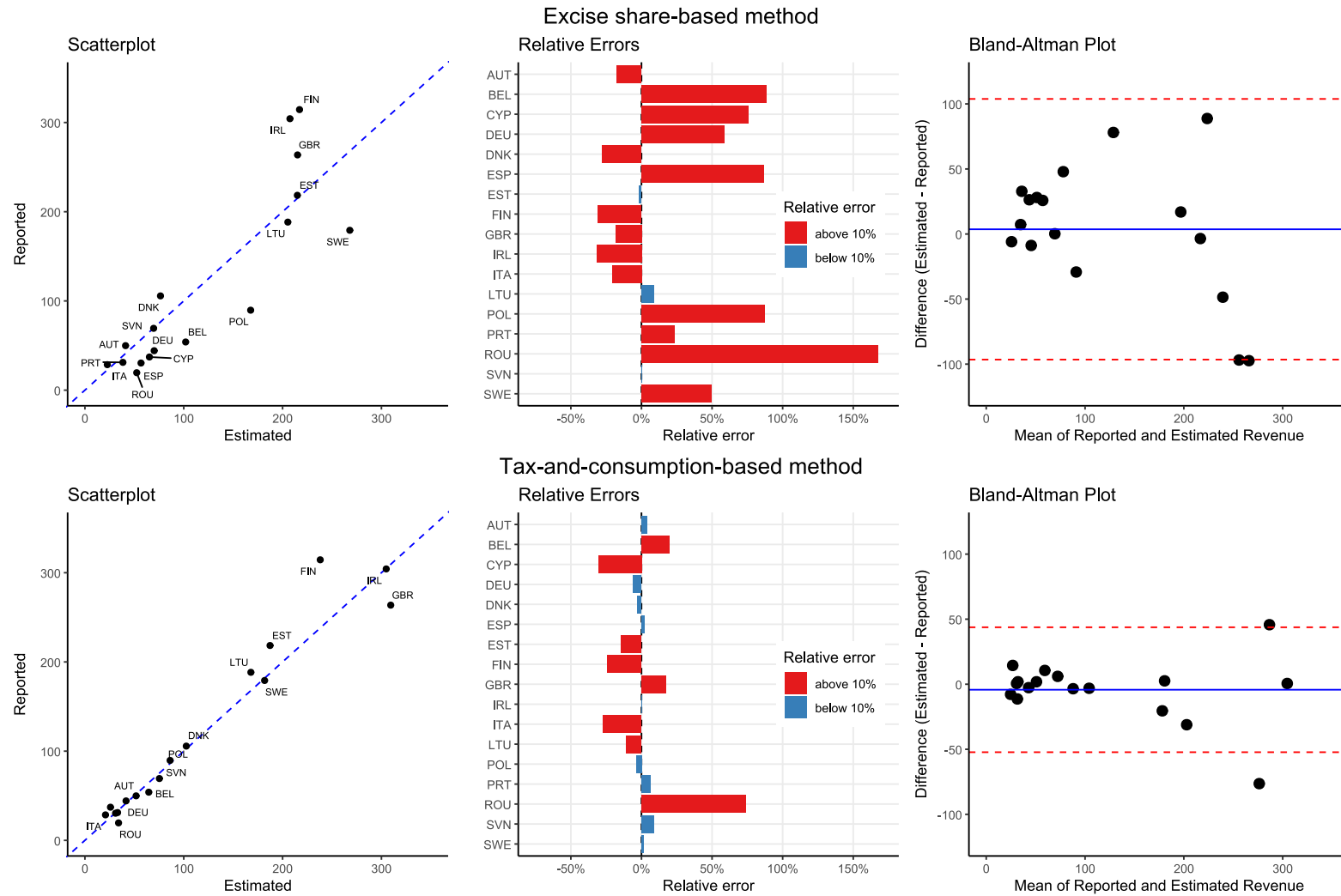


Table 2***Comparison of estimation methods against reported alcohol excise tax revenue per capita.***

Estimated revenue	Pearson's correlation with reported revenue (95%CI)	Linear model			Davidson-MacKinnon J test	
		df	AIC	R ²	Model tested	p-value ¹
Tax-and-consumption-based (M1)	0.959 [0.886, 0.985]	3	162	0.944	M1 + fitted(M2)	0.272
Excise share-based (M2)	0.857 (0.639-0.947)	3	187	0.760	M2 + fitted(M1)	<0.001

¹ p-value from the Davidson–MacKinnon J test. A significant result ($p < 0.05$) indicates that the fitted values from the alternative model (e.g. M1 + fitted(M2)) significantly improve the explanatory power of the baseline model (e.g. M1).

Discussion

This study compared two methods for estimating alcohol excise tax revenue *per capita* — a tax-and-consumption-based approach and an excise share-based approach — against reported revenue data for 17 countries in the EU and the UK. Both methods showed a strong correlation with the reported data and explained a substantial share of the variance in excise revenue, suggesting that both could serve as a basis for revenue prediction. However, when compared directly against each other, the tax-and-consumption-based method consistently outperformed the excise share-based approach across several indicators, including higher correlation with reported values, greater precision, and better fit in linear regression models. While both methods showed minimal average bias, the excise share-based estimates exhibited wider limits of agreement and more pronounced deviations at higher revenue levels. Relative errors were more pronounced in low-revenue countries, likely due to the greater sensitivity of percentage differences at low values and the limited representativeness of single-product data in more heterogeneous markets. The stronger performance of the tax-and-consumption-based method likely reflects its use of more detailed, beverage-specific input data, which allows estimates to better reflect national tax structures and consumption patterns. On the other hand, the excise share-based approach applies a single coefficient derived from the association between overall excise tax share and revenue across countries, which may not capture all the details of country-specific differences in tax design or pricing structures.

These findings have practical implications for global and regional alcohol policy monitoring. Although it requires more detailed input data and more extensive calculations, the tax-and-consumption-based method offers a transparent and replicable way to estimate alcohol excise tax revenue when official figures are unavailable or not comparable. This is particularly relevant for WHO's ongoing technical support to member states undertaking alcohol tax reforms, where robust revenue estimates are often needed to model policy impacts and address concerns about potential revenue losses. As part of these efforts, WHO has launched the *3 by 35 Initiative* (WHO, 2025b), which aims to increase taxes on alcohol, tobacco, and sugary drinks to reduce consumption

and generate sustainable domestic revenue for health and development.

To our knowledge, this is the first study to empirically compare these two estimation approaches against reported revenue data. Its strengths include the use of harmonised, country-specific tax and consumption data, a consistent reference year, and a focus on *per capita* revenue, which facilitates comparability across countries. However, several limitations should be acknowledged. First, publicly available revenue figures may not always reflect actual revenue from alcohol excise taxes alone but also some other intermediate taxes that are alcohol-specific, such as import duties or packaging levies, which may lead to bias — but such cases appear to be relatively rare and marginal in magnitude. Second, the tax-and-consumption-based method relies exclusively on data for the best-selling brand of each type of beverage, which may not be representative for the average values of price and thus tax share for the respective category. In addition, the variability in national markets is not captured, which may be especially significant in more competitive or diverse markets. Finally, both approaches consider only beer, wine, and spirits consumption, and thus may underestimate *per capita* revenue in countries where other beverages (e.g., cider or mixed products) account for a significant share of the market.

While our study focused on EU Member States and the UK, both the excise share-based and tax-and-consumption-based approaches could, in principle, be applied elsewhere, provided that comparable input data are available and of sufficient quality. However, their applicability to non-EU contexts warrants further consideration. The excise share-based model was developed using data from EU and UK countries only, and the relationship between excise share and revenue may differ in settings with distinct tax structures, consumption patterns, or enforcement capacities. Additionally, many non-EU countries may have less standardised tax systems or apply multiple layers of taxation—such as national and subnational excise duties, import tariffs, or mixed systems—which could require methodological adaptations for accurate revenue estimation.

Improving the availability, transparency and predictability of alcohol excise revenue data should remain a priority for both research and policy. While estimation methods provide

useful alternatives in the absence of official data, their reliability ultimately depends on the quality and granularity of input data. Regular reporting of alcohol excise revenue — ideally through a centralised and publicly accessible platform, such as integration into WHO's Global Report on the Use of Alcohol Taxes — would improve cross-country comparability and enable more rigorous monitoring of fiscal policy impact. In the meantime, hybrid approaches that combine product-level data with excise share-based estimation may offer a promising direction for future research.

While both methods were assessed for their accuracy in estimating current revenue, they differ in their potential use for modelling future tax scenarios. The tax-and-consumption-based method can be extended to estimate the impact of tax changes by incorporating assumptions about consumption responses based on price elasticities, though the accuracy of such projections depends on the appropriateness of the elasticity values for the size and direction of change. The excise share-based method, in contrast, does not explicitly account for behavioural or market responses. If the relationship between excise share and revenue is non-linear—particularly at very high or very low tax shares—this could lead to biased or less accurate projections when applying the method beyond its original context.

Conclusion

In conclusion, while both methods demonstrated strong predictive capacity, this study finds that the tax-and-consumption-based approach provides a more accurate and precise estimation of alcohol excise tax revenue *per capita*. These findings support its use in global monitoring efforts and for providing technical assistance to countries implementing alcohol tax reforms. Beyond its use in revenue estimation, this approach could also be combined with estimates of the economic costs of alcohol-related harm to support more comprehensive fiscal policy modelling. Such integration could help inform calculations of optimal tax levels and strengthen the case for alcohol taxation as a public finance and public health measure.

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Conflict of interest

None. Carina Ferreira-Borges and Maria Neufeld are staff members of the World Health Organization; Daniela Correia, Daša Kokole, and Jürgen Rehm are WHO consultants. The authors alone are responsible for the views expressed here and these do not necessarily represent the decisions or the stated policy of WHO.

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