Cost-effectiveness of raising alcohol excise taxes to reduce the injury burden of road traffic crashes

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ABSTRACT

Background Alcohol is an important risk factor for road transport injuries. We aimed to determine if raising alcohol taxes would be a cost-effective intervention strategy for reducing this burden.

Methods We modelled the effect of a one-off increase in alcohol excise tax (NZ$0.15 (US$0.10)/standard drink) on alcohol consumption in New Zealand, using price elasticities to determine change in on-trade and off-trade sales of beer, cider, wine, spirits and ready-to-drink products. We simulated change in alcohol-attributable motor vehicle and motorcycle injuries, by age, sex and ethnicity, over the lifetime of the current population, and from changes in injuries, we determined changes in costs of health care, productivity, crime and vehicle damage.

Results The modelled increase in tax led to a net 4.3% reduction in pure alcohol consumption and a 27% increase in excise tax revenue. Lifetime population health improved by 640 quality-adjusted life years (95% uncertainty interval: 450 to 860) and costs of treating transport injuries reduced by NZ$3.6 million ($0.88 million to $6.8 million), although this was countered by a $3.8 million ($2.9 million to $4.8 million) increase in costs of treating other diseases. Health care costs were far outweighed by a $240 million ($130 to $370 million) reduction in lost productivity, crime and vehicle damage costs. Cost-effectiveness was not highly sensitive to price elasticity values, discount rates or time horizons for measurement of outcomes.

Conclusion Raising alcohol excise tax in this high-income country would be highly cost-effective and could lead to substantial cost-savings for society.

BACKGROUND

Road traffic crashes are responsible for around 1.25 million deaths each year.[1] Globally, there are 1.8 billion registered vehicles on the roads and that number is rapidly rising.[2] To address the burden, the WHO has identified a range of road safety improvement measures addressing design and maintenance of road networks, vehicle safety features and road safety rules, including enforcement of blood alcohol concentration limits.[1]

Alcohol is an important risk for road crashes; drivers consuming alcohol are at higher risk of a crash and that risk increases with an increasing blood alcohol content.[3] In New Zealand, the prevalence of hazardous or high-risk drinking has risen significantly in recent years.[4] Currently, around four out of five adults drink alcohol, and around one in five of all drinkers consume alcohol at hazardous levels.[4] Road traffic crashes attributable to alcohol, are primarily associated with this high risk hazardous drinking behaviour.[5]

Thanks to substantial road safety improvements, the overall rate of transport injuries in New Zealand is less than half of what it was in the early 1990s. However, what was a steady decline in rates has plateaued in the last 5 years, and deaths among young adults (15–24 years) in particular remain stubbornly high.[6] In 2016, around a third of all deaths in young men and a quarter of all deaths in young women were the result of transport injuries.[6]

There is good evidence that raising the price of alcohol is an effective way of reducing alcohol consumption and alcohol-related harm.[7 8] The relationship between changing price and alcohol consumption is likely to vary based on both the type of drink (eg, beer, wine and spirits) and whether it is purchased on-trade (eg, in hotels, bars and restaurants) or off-trade (eg, in supermarkets, bottle shops and convenience stores).[9 10] Pricing policies are recommended in the Global Strategy to Reduce the Harmful Use of Alcohol,[11] but while a majority of countries have implemented taxes, few have also implemented measures to ensure taxes are adjusted for inflation and changes in income, set a minimum price or ban discounting and below-cost sales.[12]

New Zealand has a volumetric excise tax on alcohol, with rates that are tiered according to alcohol content.[13] A small levy that funds alcohol research and a goods and services tax (GST) of 15% are also applied. While the alcohol excise and levy are annually adjusted for inflation, the overall rate of tax is low in comparison with rates in similar countries, such as Australia and the UK. In this study, we evaluate the potential cost-effectiveness of raising alcohol taxes to address the road injury burden in New Zealand.

METHODS

Tax effects on alcohol consumption

We modelled the effect of a one-off increase in current excise tax rates of 15 cents (NZ$0.15) per standard drink (10 g of pure alcohol), which would bring New Zealand average tax rates in line with the UK[14] and Australia[15 16] (figure 1). The alcohol levy,[17] which is calculated per litre of pure alcohol, and GST were subsequently applied.

Baseline annual volume of alcohol sales and retail prices, were determined for beer, cider, wine, spirits and ready-to-drink beverages (RTDs), both on-trade and off-trade, from Euromonitor[18] data for New Zealand. We then estimated changes in purchasing within each drink category based on increased prices, using own-price and cross-price

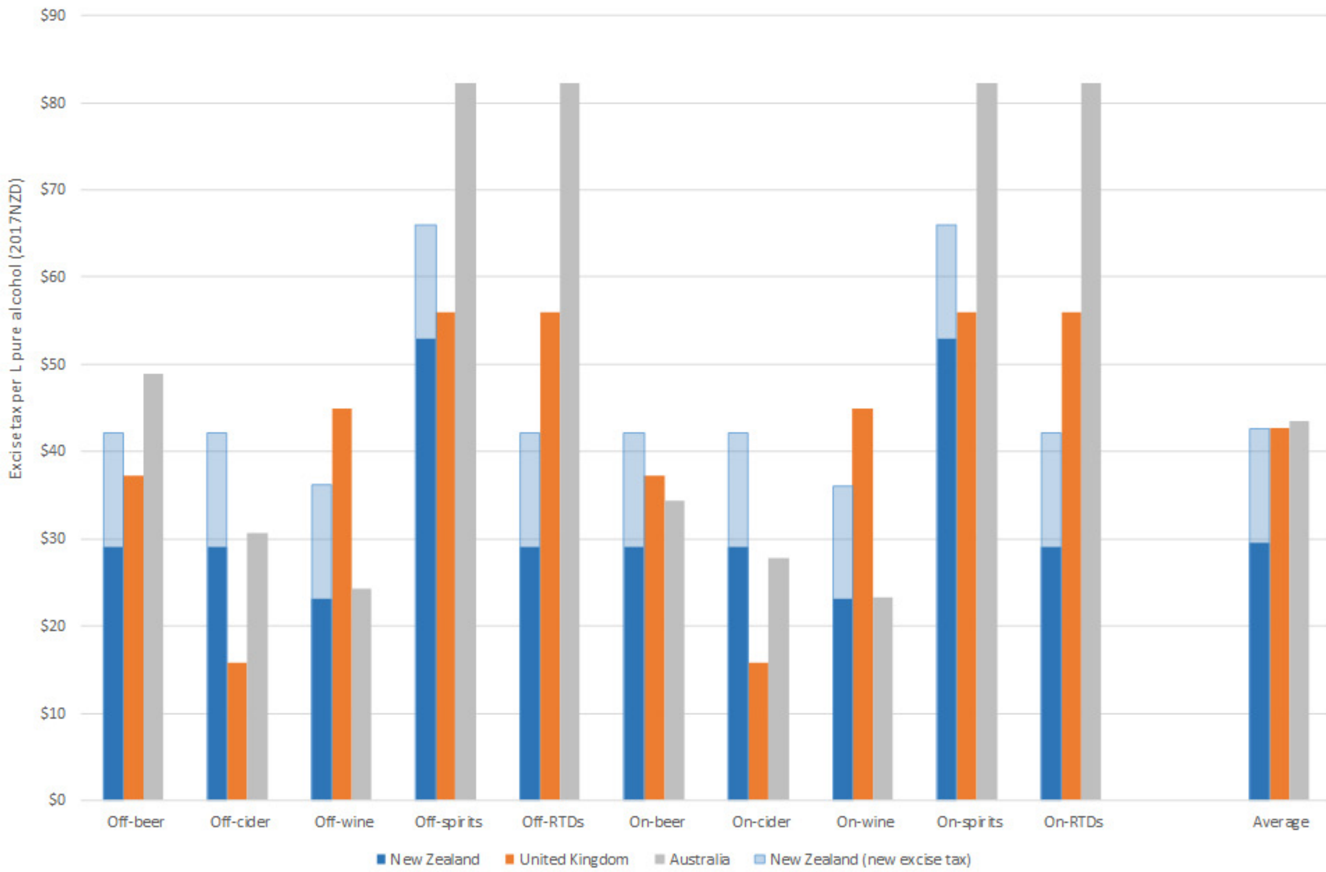

Figure 1 International comparison of alcohol excise tax rates (Note: New Zealand,[13] UK[14] and Australian[15 16] taxes applied to each drink category based on average alcohol content and value as forecast for New Zealand in 2017[18]).

elasticity estimates (online supplementary text S1). An own-price elasticity quantifies the percentage change in demand for a product with a change in price of that particular product. For example, an elasticity of −0.5 for on-trade beer means that a 1% increase in price of on-trade beer results in a 0.5% reduction in demand for on-trade beer. A cross-price elasticity quantifies the percentage change in demand for the product (eg, on-trade beer) with a change in price of another product (eg, on-trade wine).

Price elasticity values are derived from regression analyses of cross-sectional or longitudinal data sets containing variations in price and demand (eg, purchase or sales) for alcohol products in a population. These studies do not provide rigorous evidence of a causal effect in the way that a randomised controlled trial can do but do provide a means of estimating a potential impact of a population-wide tax intervention, where it is not feasible to conduct such a trial.

In applying price elasticity values to estimate the effect of an increase in alcohol tax on alcohol consumption, we assumed that the industry would fully pass on the tax effects to consumers and that the change in purchasing would translate directly into a change in consumption (ie, that there would be no change in behaviour with regard to waste, home-brewing and so on).

Since there were no recent price elasticity estimates available for New Zealand, we applied values from the UK,[10] which has a similar volumetric excise tax structure to New Zealand. To examine the sensitivity of model outcomes to the alcohol price elasticities, we also evaluated cost-effectiveness using Australian price elasticity data. In these analyses, we omitted calculations for cider (not included in the Australian data due to insufficient purchases, and not a large component of alcohol purchases in New Zealand) and budget-weighted price elasticities for beer (from regular and moderate strength beer) and wine (from bottled and cask wine), which had been separately categorised due to different rates of taxation in Australia.

Current prevalence of drinking alcohol, prevalence of high-risk behaviour (6+ drinks in one drinking occasion) among those who drink, and average daily alcohol consumption for high-risk drinkers and all other drinkers, were estimated from the New Zealand Health Survey.[4] To account for survey under-reporting, we fitted gamma distributions to average alcohol consumption, by age, sex and ethnicity, then scaled the mean of all distributions up until the total alcohol consumption reflected the total volume of alcohol sales reported for New Zealand in Euromonitor[18] data.

Modelling health effects of changes in alcohol consumption

From the change in alcohol consumption, we determined the change in risk of motor vehicle and motorcycle road deaths and injuries using a population impact fraction approach (online supplementary text S1). In these calculations, we applied dose–response relative risk curves for high-risk (binge) drinkers.[19] These relative risks were adjusted to reflect the proportion of the day spent at increased risk, using a function that predicts exposure time based on estimated rates of alcohol clearance by the liver.[5]

To model the future health impact of alcohol consumption changes in the New Zealand population, we used multistate life-table modelling methods used previously to model the health impacts of alcohol taxes in Australia[20] and Denmark,[21] and previously adapted in New Zealand for modelling health impacts of tobacco taxes.[22] In these analyses, we focused on modelling the impact of changes in alcohol intake on motor vehicle and motor cycle road transport injuries. Baseline injury rates were derived by age (5-year age groups), sex and ethnicity (Māori/non-Māori), from recorded hospitalisations and deaths (see online supplementary table S1 for International Classification of Diseases (ICD)-10 codes).

Using the multistate life-table model, we simulated 5-year age, sex and ethnicity cohorts in the current population, over time until all were dead. By examining the difference between model simulations under baseline conditions (ie, with no changes in drinking behaviour) and under the effects of increased alcohol taxes, we determined the impact of the tax increase on years of life that would be lived by Māori and non-Māori populations. Then, by weighting the years of life lived for time spent in ill-health (due to transport-related injuries and other conditions), we determined the quality-adjusted life-years (QALYs) that could be gained.

We weighted ill-health using rates of disability derived from Global Burden of Disease[23] and New Zealand Burden of Disease[24] analyses. Since the New Zealand analyses did not report transport injuries by mode (eg, motor vehicle and motorcycle), we used mode-specific rates from the Global Burden of Disease study, applying Māori/non-Māori road transport injury rate ratios from the New Zealand study to determine ethnicity-specific disability rates. The background rates of disability (ie, from all causes, including transport injuries) were derived from the New Zealand Burden of Disease[24] study.

Modelling effects on costs

We calculated the effects of a tax on the future costs of healthcare related to treatment of road transport-related injuries (fatal and non-fatal) and costs of healthcare for other disease and injuries that occur in added years of life. The costs of healthcare in added years of life were divided into an average annual cost and a cost in the last year of life (due to the high costs associated with end of life care). Costs were derived from New Zealand Health-Tracker data using methods described previously, with a 1-year cure time applied to road injury.[25]

We also calculated costs to society associated with loss of output from temporary disability arising from road traffic crashes, legal and court proceedings and vehicle damage using estimates of fatal and serious injury costs due to road transport crashes from the New Zealand Ministry of Transport.[26] The costs of changing legislation to raise the alcohol excise amount were based on previous cost estimates for changing laws in New Zealand.[27]

Cost-effectiveness analyses

We evaluated cost-effectiveness of an alcohol tax increase from a societal perspective. However, we also evaluated cost-effectiveness from a health sector only perspective (ie, including only effects on QALYs and healthcare costs) to facilitate future league table comparison of alcohol tax increases with other New Zealand public health interventions (eg, tobacco tax increases[22] and falls prevention[28]). For the same comparative purposes, we modelled all QALY and cost outcomes for a baseline population year of 2011, deflating costs back to 2011 using the New Zealand consumer price index[29] where necessary.

For base case analyses, we modelled QALYs and costs over the lifetime of the population, discounting future outcomes back to current values at a rate of 3%.[30] In sensitivity analyses, we also examined outcomes over time horizons of 5, 10, 20 and 40 years, and with future outcomes discounted at rates of 0% and 6%.

We derived 95% uncertainty intervals (95% UIs) for all QALY and cost outcomes using Monte Carlo analyses (5000 iterations) based on uncertainty around model input parameters (online supplementary table S1). Probability of cost-effectiveness was also calculated by comparison with a cost-effectiveness threshold of NZ$45 000 per QALY (our research programme takes the WHOapproach of using per capita gross domestic product (GDP) as a threshold, with NZ$45 000 being the New Zealand GDP per capita in 2011.[31] All outcomes are reported to two significant figures.

RESULTS

Effect on alcohol purchasing

Price elasticity analyses suggest that an increase in alcohol taxes of 15 cents per standard drink would lead to a reduction in purchase of off-trade beer (−11%), cider (−7.4%), wine (−1.2%), spirits (−2.5%) and RTDs (−13%) and on-trade beer (−6.9%). However, these reductions would be countered by an increase in on-trade cider (2.0%), wine (5.0%), spirits (0.51%) and RTDs (7.4%). Taking current New Zealand sales volumes into account, the biggest impacts of these changes would be on purchase of beer and, to a lesser extent, RTDs and wine (figure 2). The overall net effect across the different drink categories was a 4.3% reduction in sales of pure alcohol in year 1 (equivalent to 1.5 million litres of pure alcohol). Total excise from alcohol taxes increased by $370 million.

Population health and cost implications

The modelled reduction in alcohol consumption led to 110 (95% UI 89 to 140) fewer deaths from road transport injuries in the 2011 population. Men benefited relatively more than women (standardised rate ratio 5.5) and Māori benefited relatively more than non-Māori (standardised rate ratio 1.8). While there was estimated to be some increase in burden of other non-modelled diseases, such as cardiovascular disease and cancer (due to deaths from road transport injuries being averted or delayed), these effects were outweighed by the reduced mortality and morbidity from road transport injuries. Over the lifetime of the population, there was a net health gain of 640 (450–850) QALYs.

The modelled costs of treating road transport-related injuries reduced by $3.6 million ($0.88 million to $6.8 million), but this was countered by a $3.8 million ($2.9 million to $4.8 million) increase in costs of treating other non-modelled diseases in added years of life. Overall, however, the magnitude of changes in healthcare costs were dwarfed by a $240 million ($130 million to $370 million) reduction in costs of other social harms, including costs of lost output due to temporary disability, legal and court proceedings and vehicle damage.

There were some differences in when the health gains and costs would occur over time, after implementation of the alcohol excise tax. A large proportion of the road transport injury and societal costs that were averted occurred earlier in the future (eg, in the first 10 years), in comparison with the non-modelled disease treatment costs and gains in health (figure 3).

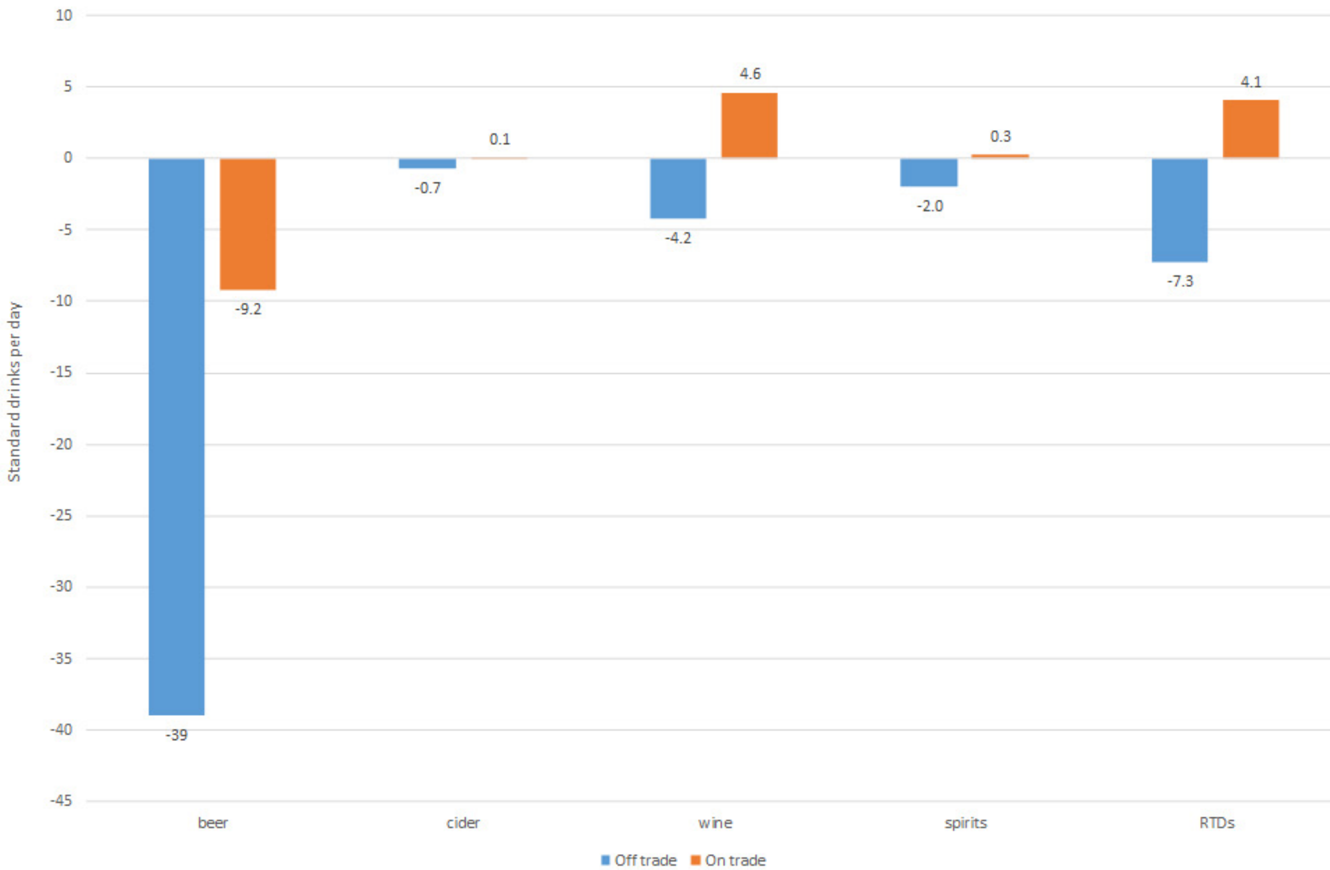

Figure 2 Modelled impact of the tax increase on alcohol purchases by beverage type in New Zealand. RTD, ready-to-drink.

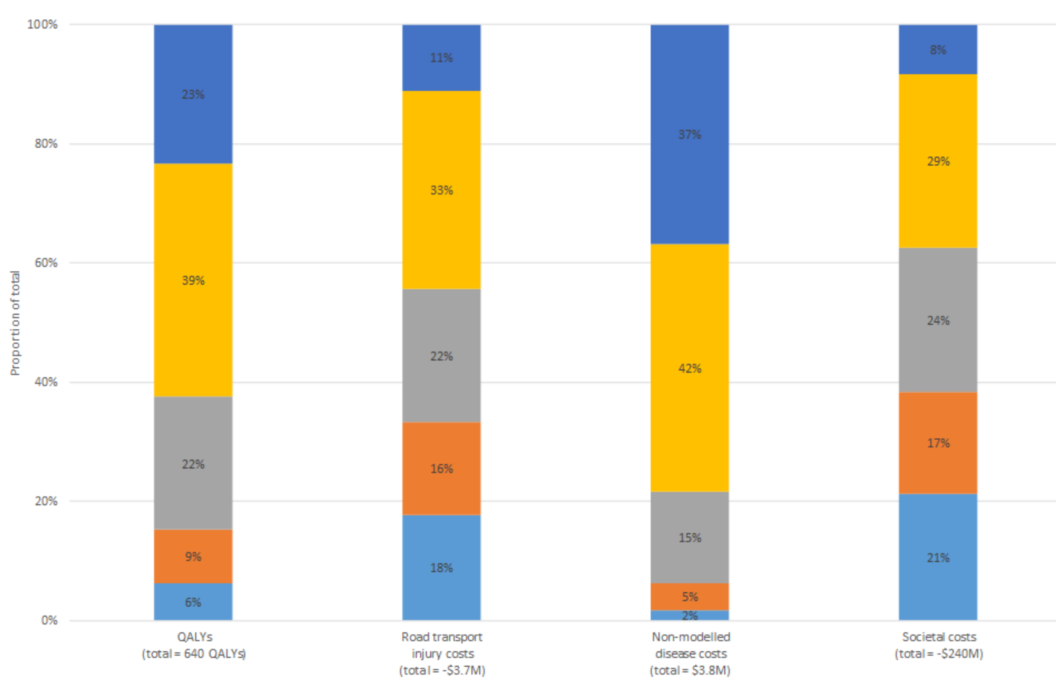

Figure 3 Variation in when health gains and costs accrue (see online supplementary figure S2 for undiscounted results). QALYs, quality-adjusted life-years.

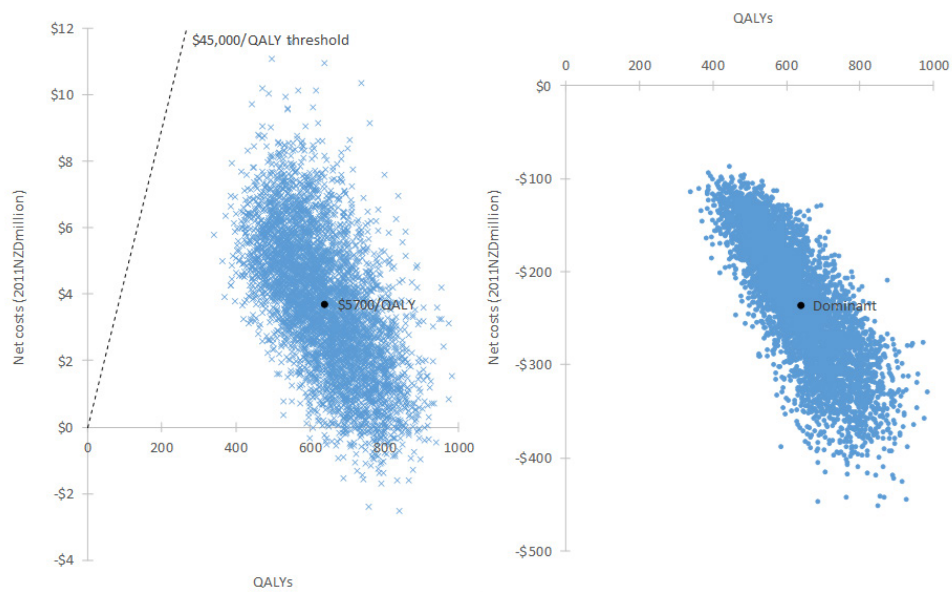

Figure 4 Cost-effectiveness of raising alcohol excise tax in New Zealand when analysed from a health sector perspective (left) and societal perspective (right). QALY, quality-adjusted life-year.

Cost-effectiveness

From a health sector perspective (ie, excluding all non-health impacts), the increase in alcohol excise tax had 100% probability of being cost-effective against a $45 000/QALY threshold (figure 4). From a societal perspective (ie, including the social harms), it also had 100% probability of being 'dominant' (ie, cost-saving).

The alcohol excise tax increase remained cost-effective from a health sector perspective (ie, under $45 000/QALY) and dominant from a societal perspective, with variations in discount rate (0%, 3% and 6%). However, the magnitude of health and cost outcomes did vary (table 1). The cost-effectiveness was also not sensitive to the choice of price elasticities (Australian or UK). While the choice of elasticities did have an effect on switching between drink types or between on-trade and off-trade purchases (online supplementary figure S1), the net effects on alcohol consumption (−4.5%) and revenue (+$370 million) were almost identical to base case results.

Cost-effectiveness also varied little with change in the time horizon for measurement of outcomes. From a health sector-only perspective, the median cost-effectiveness ratio did exceed the favourable threshold ($45 000/QALY) at the shortest 5-year time horizon, but the cost-effectiveness ratio was favourable at all other measured time horizons (10+ years). From a societal perspective, the intervention remained cost-saving over all time horizons evaluated.

DISCUSSION

In this modelling study of a high-income country, raising excise tax on alcohol is very likely to be a cost-effective intervention. Alongside the injury-reduction health benefits, it could

Table 1 Sensitivity of cost-effectiveness analyses to variation in discount rate, time horizon and price elasticities

	Health perspective			Societal perspective		
Scenario	Median ICER ($/QALY)	P (cost-effective) (%)	P (cost-saving) (%)	Median ICER ($/QALY)*	P (cost-effective) (%)	P (cost-saving) (%)
Base case†	$5900	100	2.7	Dominant	100	100
Discount rate						
0%	$5000	100	0.68	Dominant	100	100
6%	$9100	100	2.0	Dominant	100	100
Time horizon						
40 years	$5700	100	7.1	Dominant	100	100
20 years	$9900	100	4.6	Dominant	100	100
10 years	$27 000	78	0.34	Dominant	100	100
5 years	$76 000	22	0	Dominant	100	100
Price elasticities						
Australian	$5600	100	3.4	Dominant	100	100

Notes: all figures are rounded to two significant figures. QALYs and costs are reported in online supplementary table S2.
*In this context, a 'Dominant' cost-effectiveness ratio means that the increase in alcohol excise tax leads to a population health gain at a net cost-saving to society, in comparison with current alcohol excise tax rates.
†In the base case scenario, cost-effectiveness was analysed with a 3% discount rate, over a lifetime horizon, with price elasticities from the UK.
ICER, incremental cost-effectiveness ratio; P, probability; QALYs, quality-adjusted life-years.

substantially reduce costs to society associated with healthcare, lost productivity from injuries, legal costs and vehicle damage.

The increase in alcohol tax was estimated to be cost-saving from a societal perspective. It is also likely that it would be cost-saving from a health sector perspective if injury and non-communicable disease impacts beyond our road transport injury focus were considered. There are a range of non-transport injuries (eg, from falls, drowning, self-harm)[32] and non-communicable diseases (eg, cancers, alcohol dependence and liver cirrhosis)[33] that are associated with alcohol intake. Overall, motor vehicle and motorcycle road transport injuries are responsible for less than a tenth of the overall disease burden attributable to alcohol use in New Zealand.[6]

There is some evidence that consumption of alcohol is protective against myocardial infarction, but there is a net increased death rate with intakes of more than 100 g per week and for some cardiovascular diseases (eg, stroke) regardless of level of intake.[34] The number of deaths averted by alcohol use in New Zealand are heavily outweighed by the number of deaths prevented (389 vs 1679 in 2016, ie, approximately one death prevented for every four deaths caused by alcohol).[6] Furthermore, the most recent Global Burden of Disease study shows that when taking risk of all diseases into account, and including both the impact on mortality and morbidity, the burden is minimised with zero consumption of alcohol.[35]

Modelling of alcohol tax increases in Australia[20] and Denmark,[21] which took both harmful and protective effects into account, found that the loss of cardiovascular protective effects would be far outweighed by beneficial reductions in injuries, cancers and other non-communicable diseases. Both studies found that increasing alcohol taxes would be cost-saving from a health sector perspective. UK modelling also found that alcohol tax increases were likely to be cost-saving from a societal perspective,[36] which concurs with our findings for New Zealand.

It is important to note that the alcohol tax modelling studies in Australia, Denmark and the UK and our study in New Zealand have all relied on economic analyses of own-price and cross-price elasticities to quantify how people change their alcohol purchases in response to changes in prices. Price elasticities are generally derived econometrically from cross-sectional survey or panel data that contain variations in price of alcohol products and self-reported consumption or purchasing. In these analyses, it is not possible to control for all effects that may influence alcohol intake behaviour, other than price, in the same way that a randomised controlled trial can aim to achieve.

Additionally, in our New Zealand study, we were reliant on UK price elasticity estimates, since up-to-date price elasticities are not available for New Zealand. Price was found to have a strong effect on alcohol consumption in New Zealand between 1983 and 1991,[37] but subsequent changes in drinking culture have reduced the applicability of the elasticity values to current drinking in New Zealand. There are a range of factors that are likely to influence the generalisability of price elasticity values, such as income, drinking culture (eg, preference for drinking in bars/pubs or at home), the range of products available on the market and their current prices. New Zealand has a volumetric tax rate, with rates tiered according to alcohol volume, which is very similar to the alcohol tax structure in the UK. However, there are potentially differences in the drinking culture. For example, less alcohol is sold on-trade in New Zealand than in the UK (27% vs 40% in 2016.[18]

Australia has a very similar drinking culture to New Zealand. When we modelled alcohol consumption effects using price elasticity data from Australia (with some approximations of price elasticity values to accommodate different taxation categories), we found that while there were some differences in switching between products with the different elasticities, the overall impact on alcohol consumption and long-term health and societal implications were virtually identical.

In these analyses, we have evaluated a modest one-off 15 cents (US$10 cents) per standard drink increase in current taxes, which would bring the average rate of alcohol tax in New Zealand in line with averages in the UK and Australia (figure 1). However, there are a range of other tax scenarios that could also be considered, including larger tax increases or annual increases in the tax rate (over-and-above Consumer Price Index), as is currently legislated for tobacco in New Zealand. A mix of tax increases and the setting of minimum prices could also be studied. The latter have the advantage of potentially being more acceptable to some sectors of the retail industry (eg, bars and restaurants) as minimum pricing will largely impact supermarkets and other off-trade retailers.

There are many countries that could potentially benefit from raising alcohol excise taxes. China and the USA, for example, have higher transport injury mortality than New Zealand. The WHO has set a Global Road Safety Performance Target[38] of a 50% reduction in road traffic injuries and fatalities due to alcohol and other drugs by 2030. Reductions in alcohol consumption (4.3% in New Zealand) would also contribute to achieving the WHO target of a 10% reduction in harmful alcohol use by 2030.[39] Furthermore, the relatively modest increase in alcohol excise tax modelled in this study led to a substantial $370 million (approximately US$250 million) increase in alcohol tax revenue. This revenue could help fund other measures to further reduce harm from alcohol (eg, banning alcohol industry advertising and sponsorship), to improve road safety (eg, reducing speed limits and running mass media campaigns) and to reduce car usage (eg, building separate cycleways for commuting).

What is already known on the subject

- A total of 1.25 million people die each year in road traffic crashes.
- Alcohol is an important risk factor for road traffic crashes and transport-related injuries.
- An increase in the price of alcohol is associated with a reduction in purchasing of alcohol, with effects that vary based on both the type of drink (eg, beer, wine and spirits) and whether they are purchased on-trade or off-trade.

What this study adds

- Modelling suggests that raising alcohol taxes in this high-income country (New Zealand) would be cost-effective from a health sector perspective, and cost-saving from a societal perspective, when considering reductions of costs associated with lost productivity, crime and vehicle damage.
- A relatively modest increase in alcohol excise tax would also produce a substantial increase in alcohol tax revenue, which could help fund additional measures to address road safety and harmful alcohol consumption.

Contributors LJC and NW conceptualised the study. LJC and AM designed the model. LJC carried out the analyses and wrote the first draft. All authors contributed to the interpretation of results and final preparation of the manuscript.

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Competing interests None declared.

Patient consent Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

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