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Interventions to reduce alcohol's harms to health: a modelling study

Protocol

SEPTEMBER 2023

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Notes on revision

The core results from this report were submitted to the Journal *Addiction* for publication. During the peer-review process, the reviewers highlighted an error with our estimate for tourist consumption. The updated report has incorporated other reviewer comments, including the correction of the tourist consumption estimate. Article DOI 10.1111/add.16331.

Conflict of interest statement

Dr Jones' involvement in this project predated her employment at Te Hiringa Hauora. The authors have no other conflict of interests to declare. No authors have received funding from the alcohol industry.

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Introduction

This protocol report is a supplement to the main results report entitled, 'Interventions to reduce alcohol's harms to health: a modelling study', and describes the study's methods, including information additional to that found within the main report.

The model's population replicates the 2018 Aotearoa population by ethnicity (Māori/non-Māori), and by age and sex by using the adjusted 2018 Aotearoa Census population estimates.[1] The 2018 Census estimates consist of combined census forms and administrative data; the methods involve a degree of imputation. There are documented methodological considerations for the NZ Census 2018. The variables used in our analysis are 'Priority level 1' and have received an overall quality rating of 'very high quality' in the *Initial Report of the 2018 Census External Data Quality Panel*.[2] The model uses a proportional multi-state life-table design[3] that divides the 2018 Aotearoa population into 5-year age, sex, and ethnicity (Māori/non-Māori) cohorts.

We modelled four hypothetical scenarios: 1) business as usual (BAU) which assumed no changes in alcohol consumption or policy settings; 2) an intervention package scenario that included a 50% tax increase, a complete marketing ban and reduced off-licence outlet trading hours and density; 3) variations of higher tax increases and the extent of marketing restrictions; and 4) a scenario where the Government acted on the key 2010 Law Commission recommendations.

Alcohol consumption

Data sources

Alcohol consumption data were used to simulate current drinking patterns in Aotearoa (Table 1), specifically: measures of alcohol consumption drawn from data in the nationally-representative New Zealand Health Survey (NZHS) 2017/18,[4] Statistics New Zealand Alcohol Available for Consumption[5] and NZ-specific derived estimates from the WHO Global Information System on Alcohol and Health (GISAH).[6] Following a review of options, these sources were selected based on adherence to one or more of the following criteria: representativeness of the 2018/2019 Aotearoa population, quality of ethnicity measurement, general quality of data, compatible population age (15 years and older), and replicability for future monitoring of alcohol-related harms. We calculated alcohol consumption inputs for two populations: Māori and non-Māori. We adapted methods from Kehoe et al for modelling population-level alcohol consumption[7] and calculated the distributions of alcohol consumption across ethnicity-sex-age groups.

Table 1. Aotearoa data used within alcohol consumption analysis

Data	Description	Measures	Subgroups	Additional considerations*
New Zealand Health Survey 2018/19	Population-based survey. Nationally representative (15 years and older). Data collection from 1 July 2018 to 30 June 2019 via computer-assisted personal interview. Sample size of 13,572 respondents with an 80% response rate (weighted). Analytic sample: n=13,572. Publicly accessible via Stats NZ CURF procedures. Analysed using SPSS.	Prevalence of lifetime abstainers, former drinkers; relative consumption of alcohol between Māori and non-Māori.	Ethnicity, sex, age	While reporting of drinking status (i.e., abstainer, former drinker) is generally accurate, underreporting of the frequency and quantity of alcohol use is a known limitation of self-report surveys. The Kehoe methodology accounts for key limitations associated with underreporting.
Stats NZ alcohol available for consumption: year ended December 2019	National statistics; year 2019. Stats NZ collects data from New Zealand Customs Service (excise duty taxes on alcohol produced for local consumption), which are integrated with Stats NZ data on imports. Publicly accessible online. Analysed in Microsoft Excel.	Recorded per capita alcohol (litres of ethanol per person per year aged 15+ for total population)	Not available	Data quality is dependent on the quality of excise duty taxation data and import data. Not specific to ethnicity, sex, or age. Does not reflect unrecorded consumption or account for differences due to tourism.
WHO Global Information System on Alcohol and Health (GISAH)	Global alcohol indicator tool; year 2019. NZ-specific data points derived or modelled from multiple data sources (including NZ data) using the GISAH methodology. Key data inputs include Stats NZ alcohol national statistics. publicly accessible online. Analysed in Microsoft Excel	NZ-specific unrecorded alcohol (as % of recorded); tourist alcohol (as % of total [recorded + unrecorded] alcohol)	Not available	Includes NZ data (e.g., Stats NZ, alcohol surveys, tourism statistics), but unclear to what degree estimates are informed by NZ data versus modelling methods. Not specific to ethnicity, sex, or age.

Measures and inputs analysis

We used NZHS 2018/19 data to calculate relative consumption of alcohol across different population groups. Details on the NZHS 2018/19 are reported elsewhere.[8,9] Survey respondents were excluded from the analysis if data on ethnicity, sex, or age was missing, or if the survey question used to calculate the measure had a response missing. Survey questions about 'standard drinks' were accompanied with a show card depicting how many standard drinks that each of a range of common alcohol beverage types and container sizes equated to.

Relative consumption (by ethnicity, sex, age category) is calculated for two populations – Māori and non-Māori. Within each population, the relative consumption is specific to sex and age category, and is the mean number of standard drinks divided by the population (Table 2).

For example, in the non-Māori population, the mean number of standard drinks per day was 0.78 (ratio of 1). For non-Māori 'Female 15-24 years', the mean number of standard drinks per day was 0.38, which equated to a relative consumption of 0.48 (i.e., approximately half of the non-Māori population amount).The key NZHS questions were 'How often do you have a drink containing alcohol?' and 'Looking at the Showcard, how many drinks containing alcohol do you have on a typical day when you are drinking?', referring to one standard drink. We multiplied the responses using a standard frequency-quantity approach[10] and performed additional unit conversions to yield number of standard drinks per day. We then calculated the mean number of standard drinks per person aged 15+ per day by ethnicity, sex, and age category. The relative consumption was then calculated.

Table 2. Relative consumption of alcohol for Māori and non-Māori

	Survey recorded mean number of standard drinks per day	Ratio	Survey recorded mean number of standard drinks per day	Ratio
	Māori		Non-Māori	
Total	**0.85**	**1**	**0.78**	**1**
Female 15-24	0.52	0.61	0.38	0.48
Female 25-34	0.54	0.63	0.36	0.46
Female 35-44	0.84	0.98	0.49	0.62
Female 45-54	0.75	0.88	0.65	0.83
Female 55-64	0.68	0.79	0.60	0.77
Female 65-74	0.33	0.39	0.48	0.62
Female 75+	0.21	0.25	0.45	0.58
Male 15-24	0.92	1.08	0.92	1.17
Male 25-34	0.96	1.13	0.91	1.17
Male 35-44	1.21	1.42	1.00	1.29
Male 45-54	1.37	1.60	1.23	1.57
Male 55-64	1.29	1.52	1.40	1.79
Male 65-74	1.16	1.37	1.29	1.65
Male 75+	0.94	1.10	0.78	1.00

We calculated the measures of per capita consumption by ethnicity for two populations (i.e., Māori, non-Māori). We used three data sources across several analytical steps: NZHS, Stats NZ Alcohol available for consumption, and the WHO GISAH.

Per capita consumption is the litres of ethanol per person aged 15+ in 2018 (Table 3). Stats NZ reports that for the entire NZ population in 2019, the litres of ethanol per person aged 15+ was 8.92L. This value is considered 'recorded' alcohol. We performed adjustments using NZ-specific data for 2019 from GISAH. According to GISAH, 'unrecorded' alcohol in NZ is 14.29% the size of recorded alcohol (i.e., 1.27 L), summing to a 'total' alcohol value of 10.16 L. GISAH reports that the NZ population consumes more alcohol outside of NZ than tourists visiting NZ consume within the country. This equates to a 2.88% increase in total alcohol (i.e., 0.29 L). When added together, total alcohol and tourist alcohol equals 10.49 L, which is the per capita alcohol consumption for NZ. Lower and upper estimates were also calculated to use in uncertainty analyses.

Since per capita consumption was not specific to ethnicity, we used NZHS data to produce ethnicity-specific ratios (Table 3), following the methods used for relative consumption. The difference is that we calculated the mean number of standard drinks per person aged 15+ per day for Māori, non-Māori, and the total NZ population. We constructed ratios from these values (1.08 for Māori; 0.99 for non-Māori). Multiplying the per capita consumption value of 10.49 L by each ratio yields a per capita consumption estimate for Māori of 11.32 L and for non-Māori of 10.37 L.

Table 3. Calculation of alcohol per capita for Māori and non-Māori

Measure	Total population	Māori	Non-Māori
RECORDED ALCOHOL from Stats NZ 2019, reported here in litres of ethanol per person per year aged 15+ for total population	8.92 litres	-	-
UNRECORDED ALCOHOL (14.29% of recorded alcohol) from NZ-specific GISAH estimates	1.27 litres	-	-
TOTAL ALCOHOL is sum of recorded alcohol and unrecorded alcohol	10.16 litres	-	-
TOURIST ALCOHOL (2.88% of total alcohol) from NZ-specific GISAH estimates	0.29 litres	-	-
ALCOHOL PER CAPITA is sum of total alcohol and tourist alcohol	10.49 litres	-	-
MEAN NUMBER OF STANDARD DRINKS PER PERSON PER DAY is calculated from the NZHS 18/19. Values for total population, Māori and non-Māori	0.79 drinks	0.85 drinks	0.78 drinks
RATIO OF ETHNICITY-SPECIFIC NZHS MEAN NUMBER OF STANDARD DRINKS PER PERSON PER DAY to total value (Māori divided by total) (non-Māori divided by total)	-	1.08	0.99
ETHNICITY SPECIFIC ALCOHOL PER CAPITA (litres of ethanol per person aged 15+ per year) is the product of the ethnicity-specific ratio and alcohol per capita	-	11.33 litres	10.37 litres

*Note: Positive value indicates that New Zealanders consume more alcohol outside of NZ than tourists consuming within NZ

Modelled alcohol consumption

We used the Kehoe et al gamma distribution for modelling population alcohol consumption using the specified inputs (Table 4). We converted per capita litres per year to grams per day using the below formula:

*Grams per day = L per year * Conversion for ml to gram * conversion year to day *0.8 (correction factor).*

Consumption was split across different population groups by multiplying overall consumption by relative consumption within each age-ethnic-sex grouping. This provided the mean consumption in a group. Using the Kehoe et al constant to get the standard deviation, from there the gamma distribution parameters were estimated. These were included within the overall model.

Table 4. Alcohol consumption in grams of ethanol (10g ethanol = 1 standard drink) by sex, age and ethnicity in business as usual (BAU) scenario

Sex	Age	Māori	Non-Māori
Female	15-24	14.9	10.8
	25-34	15.4	10.3
	35-44	24.0	13.9
	45-54	21.6	18.6
	55-64	19.4	17.3
	65-74	9.6	13.9
	75-99	6.1	13.0
Male	15-24	26.5	26.2
	25-34	27.7	26.2
	35-44	34.8	28.9
	45-54	39.2	35.2
	55-64	37.2	40.1
	65-74	33.6	37.0
	75-99	27.0	22.4

Diseases and injuries

Alcohol-attributable diseases and injuries

Diseases and injuries attributable to alcohol in Aotearoa were simulated.[11] The alcohol-attributable conditions included within this study were aligned with the 2016 Global Burden of Disease (GBD) Study, a comprehensive and up-to-date evidence review.[11] The GBD Study identifies the risk relationship between average daily alcohol consumption and 19 alcohol-related conditions. We used these dose-response relationships between alcohol and illness,[11] which are conservative estimates of the overall negative impact of alcohol on health (i.e., they likely underestimate the total adverse effects of alcohol on health).[12] The dose is based on grams of pure ethanol and the theoretical minimum risk exposure level (TMREL) is zero alcohol consumption. The GBD dose-response relationships exclude some conditions associated with alcohol-related harm, particularly those for which evidence is still emerging, such as mental health conditions. The study does not include illness due to others' alcohol consumption, such as Fetal Alcohol Spectrum Disorder (FASD). We included 15 alcohol-related disease and injuries: alcohol use disorders, cancers (breast, colorectal, mouth and neck, liver), cardiovascular diseases (stroke, coronary disease, hypertensive heart disease), other diseases (diabetes mellitus type 1 and type 2, cirrhosis and other chronic liver diseases, lower respiratory tract infections), and injuries (transport, self-harm, interpersonal violence, other unintentional injuries).

Diseases and injuries data sources

To model disease and injury in the Aotearoa population, we obtained anonymous person-level data from the following Ministry of Health national collections: PHO Enrolment, Laboratory Claims, Cancer Registry, National Health Index (NHI), National Minimum Dataset (NMDS), National Non-admitted Patient Collection (NNPAC), General Medical Subsidy (GMS), Mortality, Pharmaceutical Claims, and the Programme for the Integration of Mental Health Data (PRIMHD). We linked these datasets using an anonymous identifier (custom encrypted National Health Index number) to extract the numerators and denominators used to produce these rates of disease and injury.

Disease rate denominators

We created a health service user (HSU) population, which we used to extract denominator information for the rates of disease and injury. For each financial year, people were included in the health service user population if they were enrolled with a PHO during the financial year, or had health system contact as recorded in the following collections: PHO Enrolment (last consulation date), Laboratory Claims, Cancer Registry, NMDS, NNPAC, GMS, Mortality, Pharmaceutical Claims, or PRIMHD. Overseas residents were excluded from the health service user population. This was those who had a domicile code of '9999'—indicating an overseas domicile—as recorded in the NHI, Cancer Registry, Mortality collection, NMDS, NNPAC, PHO Enrolment collection or PRIMHD for the financial year, or those who had an overseas health service purchaser recorded in the NMDS in the financial year.

A person's ethnicity can change over time, and may be different across collections. We summarised ethnicity information from collections where the ethnicity had been reported directly by the health service provider, or where a historical record of the ethnicity on the NHI around the time the health service had been retained in the collection: the NHI, Mortality, NMDS, NNPAC, PHO enrolment collection and PRIMHD. People in the HSU population were grouped as Māori if their ethnicity was recorded as Māori in any of these collections in the five years up to and including the financial year of interest. All others were grouped as non-Māori. We chose this method because the Māori HSU population generated using this algorithm was the closest to the Statistics NZ Māori estimated resident population (ERP) for the same time periods, compared with HSU populations generated with other ethnicity sources. For example, using the NHI alone, which resulted in an undercount of Māori in the HSU population compared with the Statistics NZ Māori ERP.

Gender in the HSU population was determined using the most commonly reported gender for the health service user across the following collections: NHI, Mortality, Cancer Registry, NMDS, NNPAC, PRIMHD and the PHO enrolment collection. Disease rates were only produced for males and females (due to small numbers for other genders). Age was based on the most commonly reported date of birth for the health service user across these collections, and was calculated as at the end of the financial year (or the date of death, if the person had died). Disease rates were produced from national collections data for 5-year age groups.

The HSU population was used to generate denominators for the raw incidence, prevalence and mortality rates that we calculated. Person-time at risk was used for denominators in the incidence and mortality rates for the financial year of interest. Prevalence was calculated as a point prevalence estimate as at 30 June of the financial year (i.e., the financial year end); the prevalence denominator was the HSU population as at 30 June for that financial year.

Disease rate numerators

The demographic information (age, gender, ethnicity) from the HSU population used in the disease rate denominator was used to define numerator demographic groups, in order to reduce numerator-denominator bias. Numerator-denominator bias has been noted as a significant issue for New Zealand health research in the past, especially in the calculation of mortality rates by ethnicity.[13,14] Numerator counts were extracted for the following diseases and injuries: alcohol use disorder, cancers (breast, colorectal, mouth and neck, liver), cardiovascular diseases (stroke, coronary disease, hypertensive heart disease), other diseases (diabetes mellitus type 1 and type 2, cirrhosis and other chronic liver diseases, lower respiratory tract infections), and injuries (transport, self-harm, interpersonal violence, other unintentional injuries).

Smoothing and disease rate modelling

The raw incidence, prevalence and mortality rates estimated using the Ministry of Health national collections were then smoothed (across single years of age) and a set of disease and injury parameters were modelled using the disbayes package in R.[15] This produced a mathematically consistent set of incidence, prevalence, and mortality rates within a given disease and time period, and produced estimates of case-fatality. The modelled disease parameters were then used as inputs for the alcohol model.

Disability rates

Disability rates account for time spent in ill health[16] and were calculated from Aotearoa-specific GBD results by dividing years lived with disability by the population count of each illness in each age and sex strata.[11] The disability rates were applied to each illness.

Intervention selection

Our approach considered which interventions would bring the greatest health gain for Māori, the potential for impact (with strong consideration for the WHO SAFER strategies), and relevance to current policy. We conducted two stakeholder engagement workshops to discuss possible intervention options. The first workshop focused on interventions' importance to Māori and consisted of the University of Otago research team, Māori health and Māori alcohol researchers and practitioners. Representative organisations included Te Hiringa Hauora, University of Auckland, SHORE & Whāriki Research Centre, Hāpai te Hauora, Kookiri ki Taamakimakaurau Trust, the Cancer Society, MoH Māori health team and National Hauora Coalition. The second workshop involved alcohol and health experts from Government organisations, the heath sector and academia. Representative organisations included Te Hiringa Hauora, Alcohol Healthwatch, Accident Compensation Company Corporation, Ministry of Health, Ministry of Justice, University of Otago, SHORE & Whāriki Research Centre, Cancer Society, District Health Boards and HealthSpace.

Both workshops strongly recommended interventions focused on tax, availability and marketing. They also recommended that the project emphasise health inequities and the potential of interventions to reduce or exacerbate them. The Māori stakeholder group recommended that the project focus on the cost of Government inaction in relation to the key 2010 Law Commission recommendations.

Intervention effect size

Tax

There are a number of alcohol price elasticity reviews,[17-20] each with their own limitations and specificities which may not be immediately applicable to the Aotearoa context. Previous efforts to examine price elasticities in NZ have had notable limitations, such as a lack of differentiation by alcohol beverage type[21] or out-dated data sources.[22] After reviewing these options, we adopted the Ministry of Justice (MoJ)[23] advice that future modelling studies incorporate the updated UK price elasticities which were published later in 2014.[20] To determine which tax scenarios to model, we considered the MoJ modelled tax increases of 82%, 107% and 133% which met minimum unit prices of $1.00, $1.10 and $1.20, respectively. The Law Commission's recommendation was a 50% increase in tax. Altogether, we used the MoJ and Law Commission tax increases in our scenarios. We used linear interpolation using the effect sizes from the MoJ report to estimate the effect size of any given alcohol tax increase on alcohol consumption.[23] Thus, 50%, 82% 107% and 133% increases in alcohol tax resulted in estimated reductions in alcohol consumption of 7.6% (95%CI 5.64%, 9.56%), 12.2% (95%CI 10.22%, 14.14%), 15.8% (95%CI 13.83%, 17.75%) and 19.5% (95%CI 17.57, 21.48%), respectively.

Availability

Defining priority communities

To assess the potential health equity implications of the proposed availability interventions, we generated neighbourhood classifications using 2018 census data[24,25] and the New Zealand Index of Socioeconomic Deprivation (NZDep2018).[26] The spatial unit of analysis was Statistical Area 1 (SA1) which is a small geographic unit classified by Statistics New Zealand usually between 100-200 people, with a maximum population of ~500 people.[24] We linked 2018 census data to each Statistical Area 1 (SA1), which includes information on the resident population, as well as the age and ethnicity of residents.

Communities with a high proportion of Māori or Pacific were defined as a Māori population >=15% and Pacific population >= 8%, respectively (2018 census Māori were 16.5% and Pacific 9% of the total population).[27] Ethnicity data in the 2018 census are not prioritised, so individuals who report multiple ethnicities are counted more than once. Communities of high deprivation were defined by an NZDep 2018 measure, an area-based classification system for deprivation, between eight and 10.[26] These classifications, while crude, help us investigate any differential alcohol availability. We also used the 2018 urban/rural form classification (UR2018) from the Statistics New Zealand geographic data service to examine differences based on rurality.[25]

Outlet density

To measure outlet density in Aotearoa, we retrieved a validated geocoded dataset of alcohol outlets in the Alcohol Regulatory and Licensing Authority (ARLA) licence registry (2015-2018 version) from the University of Canterbury (UC) GeoHealth Laboratory.[28] We reduced our dataset to off-licence outlets with specific classifications (final sample = 2,426 outlets). We spatially matched off-licence outlets to SA1s to extract the total number of outlets in each community. We used the total population aged 15+ in each SA1 to create our denominator for each community type. Table 5 shows the off-licence outlet density as the number of outlets per 100,000 population by community type.

Table 5. Population-weighted off-licence outlet densities for different communities in Aotearoa

Community		SA1,[a] n	Total population [b]	Off-licence outlets	Outlets per 100,000 people
Total		29,386	3,776,355	2,383	63.1
Ethnicity	European	10,754	1,435,287	989	68.9
	Māori	11,188	1,391,058	1,037	74.5
	Pacific	7,146	925,533	548	59.2
Ethnicity	Non-Māori	18,198	2,385,297	1,346	56.4
	Māori	11,188	1,391,058	1,037	74.5
Deprivation [c]	Low	8,503	1,099,215	341	31.0
	Moderate	11,902	1,523,613	951	62.4
	High	8,981	1,153,527	1,091	94.6
Rurality	Urban	24,351	3,166,386	376	63.4
	Rural	5,035	609,969	2,007	61.6

[a] Number of communities defined by Statistical Area 1 (SA1) 2018.
[b] Total number of people aged 15+ within these communities.
[c] Neighbourhood deprivation measured using the New Zealand Index of Socioeconomic Deprivation (NZDep2018). High deprivation 8-10; moderate 4-7; low 1-3.

We modelled changes in consumption by reductions in outlets per 100,000 population as done in two previous studies.[29,30] The Swedish study modelled an increase from five outlets per 100,000 population (current policy) against an increase to 75 outlets per 100,000 population (modelled intervention). The authors estimated an increase of 16.4% (95%CI: 14.7%, 18.2%) in consumption as a result of this increase. The Finnish study modelled a reduction in outlets from 5,165 (~9 per 100,000) to 251 (~0.5 per 100,000) and estimated total alcohol consumption would decrease by 14.4% (95%CI: 12.83%, 15.8%). Both studies again applied a decay effect where the impact of the first 10 outlets per 100,000 population increased consumption more than subsequent 10 outlets. The final effect size can be determined using the following formula:

=EXP((INT-BAU)*(LN(1+(SW Coefficient/10))))-1

Where:

INT = The number of alcohol outlets per 100,000 population in the intervention scenario
BAU = The number of alcohol outlets per 100,000 population in the business as usual scenario
SW Coefficient = is the appropriate coefficient from Stockwell 2017[31] Table on page 68

In the New Zealand context, this is EXP((**5-63**)*(LN(1+(**0.0156/**10))))-1 = -0.08644.

We modelled a decrease from 63.1 to 5 outlets per 100,000 people. The outlet reduction is estimated to reduce alcohol consumption by -8.64% (-7.02% to -10.26%) or equivalent to ~2% per 10 outlets per 100,000 people after applying a decay effect. The decay effect adjusts for the likelihood that each additional outlet will have less impact than the one that preceded it (e.g., the 20th outlet will likely have a greater relative impact than the 21th outlet or 60th outlet etc).[29-31]

Trading hours

Currently, the national trading hours for Aotearoa off-licence outlets are from 7am to 11pm, a total of 112 hours per week. A 2018 systematic review of natural experiments assessing the impact of changes in trading hours and days of operation included six studies.[32] Consistent with previous modelling studies,[29,30] we applied the effect size for a reduction in one day of sale from the Sherk et al 2018 meta-analysis.[32] We applied the same decay function used in previous studies.[29,30] We estimated that reducing trading hours from 112 to 50 per week, with a maximum closing time of 8pm, would decrease alcohol consumption by 9.24% (95%CI: 7.34%, 11.14%).

Marketing

Despite strong evidence linking alcohol marketing exposure and consumption,[33-35] there have been relatively few studies assessing the impact of alcohol marketing restrictions or bans.[36] One modelling study of 20 OECD countries, including New Zealand, using 26 years of time series data, estimated bans could reduce alcohol consumption by ~9% for complete bans, and ~5% for partial bans (bans on one beverage or media).[37] This study has been used to inform recent Organization for Economic Co-operation and Development (OECD) modelling[38] and other peer-reviewed modelling studies.[19,30] We determined that applying the Saffer 2002[37] effect sizes of 8.89% (95%CI: 5.06%, 12.90%) for a complete ban and 4.86% (95%CI: 0.94%, 8.78%) for a partial ban was appropriate given the limited evidence base and the major developments in the effectiveness of alcohol marketing since its publication.

Simulation analysis

Our simulation analysis used an incidence approach which links changes in alcohol consumption to disease incidence (e.g., the first onset of disease) at each year of simulation. Changes in disease incidence resulted in changes in disease prevalence and mortality. In turn, this influenced overall mortality and morbidity in the cohort. The changes in alcohol influence disease incidence through potential impact factions (PIFs), calculated for each risk factor to disease incidence relationships.[39]

A full list of the interventions modelled is listed in Table 6. We evaluated and compared modelled interventions using two main model outputs. We measured health gain using health-adjusted life years (HALYs), which is a population health measure permitting morbidity and mortality to be simultaneously described within a single number.[40] Health gain was also represented as life expectancy (LE), which is the median age at death for a particular population group (five-year age, sex and ethnicity groups) for the youngest cohort members (aged 2 in 2018). Uncertainty intervals were calculated using Monte Carlo analysis whereby the model was run 2,000 times with modelled parameters drawn randomly from their respective probability distributions.

Table 6. Interventions modelled with current policy, proposed intervention and expected effect size

Intervention area	Current policy	Modelled intervention	Modelled effect size (95%CI)	Source and original effect sizes
Taxation	~15% of price	50% increase	-7.6% (-5.64% to -9.56%)	Ministry of Justice modelling of 82%, 107% and 133% alcohol tax increases.[23] Estimated decreases of 12.2%, 15.8% and 19.5%, respectively. Linear interpolation of Ministry of Justice modelling was used to estimate impact for the 50% increase.
		82% increase	-12.2% (-10.22% to -14.14%)	
		107% increase	-15.8% (-13.83% to -17.75%)	
		133% increase	-19.5% (-17.57% to -21.48%)	
Availability, outlet density	63 outlets per 100,000	5 outlets per 100,000	-8.64% (-7.02% to -10.26%) Equivalent to ~2% per 10 outlets per 100,000 people after applying decay effect	Stockwell (2017) estimated that an increase from 5 to 75 outlets per 100,000 population results in an estimated 16.4% (95%CI: 14.7%, 18.2%) increase in consumption. [31] Formula and coefficients for applying decay effect available in Stockwell (2017).
Availability, outlet trading hours	112 hours	8pm closing time and reducing weekly trading hours to 50	-9.24% (-7.34% to -11.14%) Equivalent to ~1.5% per 9 hours reduction after applying the decay effect [32]	Original estimate of 3.4% (95%CI: 2.7%, 4.1%) decrease in consumption for each day reduction in sales (9 hours).[32] Decay effect results in each 9-hour increment has 0.65 the effect of the previous 9-hour increment.
Marketing	Self-regulation	Total ban	-8.98% (-5.06% to -12.9%)	Estimate from regression model using data from 20 OECD countries.[37] Modelled effect size the same as the original effect size reported.
		Partial ban	-4.86% (-0.94% to -8.78%)	
Total intervention package	The total intervention package modelled in the main scenario includes a 50% tax increase; outlet density reduction to five outlets per 100,000 people; outlet trading hours' reduction to 50 hours per week with a maximum closing time of 8pm; a complete ban on all forms of alcohol marketing. The effect sizes of all four alcohol interventions were applied to alcohol consumption sequentially. In total, alcohol consumption was reduced by 30.3% (95%CI: 26.5% to 34.1%)).			

Our first scenario, BAU, assumed no changes in the level of alcohol consumption or to alcohol policy over time. The second scenario was an intervention package scenario that included a 50% tax increase, a complete marketing ban and reduced off-licence outlet trading hours and density. The third scenario examined variations of the extent of marketing restrictions and higher tax increases. The final scenario was where the Government acted on the key 2010 Law Commission recommendations. The differences in alcohol consumption between an intervention and the BAU determined the impacts of the intervention on health outcomes. These impacts were specific to ethnicity (Māori/non-Māori), age, and sex. We also quantified impacts over time in 10-year increments over the full lifetime of the population.

To further examine the interventions' impacts on Māori-specific health inequities, we quantified relative per capita health gains and age-standardised health gains (to eliminate confounding by age).[3] Among the mix of modelled interventions, we identified which interventions gave the least and greatest absolute health gain for Māori, and which interventions reduce inequities (or not) for Māori.

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