Economic effects for citizens and the government of a country-level tobacco endgame strategy: a modelling study

Driss Ait Ouakrim,[1] Tim Wilson,[1] Samantha Howe ,[1] Philip Clarke,[2] Coral E Gartner ,[3] Nick Wilson,[4] Tony Blakely [1]

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[1]Population Interventions Unit, The University of Melbourne School of Population and Global Health, Melbourne, Victoria, Australia
[2]Health Economics Research Centre, University of Oxford Nuffield Department of Medicine, Oxford, UK
[3]School of Public Health, University of Queensland, Herston, Queensland, Australia
[4]Department of Public Health, University of Otago, Wellington, New Zealand

Correspondence to
Dr Driss Ait Ouakrim, Population Interventions Unit, The University of Melbourne School of Population and Global Health, Melbourne, VIC 3053, Australia;
driss.aitouakrim@unimelb.edu.au

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ABSTRACT

Background Aotearoa-New Zealand (A/NZ) was the first country to pass a comprehensive commercial tobacco endgame strategy into law. Key components include the denicotinisation of smoked tobacco products and a major reduction in tobacco retail outlets. Understanding the potential long-term economic impacts of such measures is important for government planning.

Design A tobacco policy simulation model that evaluated the health impacts of the A/NZ Smokefree Action Plan was extended to evaluate the economic effects from both government and citizen perspectives. Estimates were presented in 2021 US$, discounted at 3% per annum.

Results The modelled endgame policy package generates considerable growth in income for the A/NZ population with a total cumulative gain of US$31 billion by 2050. From a government perspective, increased superannuation payments and reduced tobacco excise tax revenue result in a negative net financial position and a cumulative shortfall of US$11.5 billion by 2050. In a sensitivity analysis considering future labour force changes, the government's cumulative net position remained negative by 2050, but only by US$1.9 billion.

Conclusions A policy such as the A/NZ Smokefree Action Plan is likely to produce substantial economic benefits for citizens, and modest impacts on government finances related to reduced tobacco tax and increases in aged pensions due to increased life expectancy. Such costs can be anticipated and planned for and might be largely offset by future increases in the size of the labour force and the proportion of people 65+ years old working in the formal economy.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Multiple countries have set targets to achieve a commercial tobacco endgame to permanently reduce tobacco smoking prevalence to minimal levels (usually ≤5%) within a short time frame. A recently published modelling study that simulated the recent tobacco endgame legislation introduced in Aotearoa/New Zealand (A/NZ) suggested it would substantially reduce smoking prevalence and produce large health gains for the population.

⇒ Modelling studies of individual endgame strategies suggest that their implementation can lead to health system savings and higher productivity. To our knowledge, the potential effects of combined endgame strategies on overall citizen income, and government revenue and expenditure, have not been modelled previously.

INTRODUCTION

Smoking is a leading cause of avoidable morbidity and mortality.[1] Globally, the annual economic loss due to smoking has been estimated at US$1436 billion, equivalent in magnitude to 1.8% of the world's annual gross domestic product (GDP).[2] In the USA alone, the annual loss in income and unpaid household production due to tobacco consumption has been estimated at $436 billion per annum—equivalent to 2.1% of the 2020 GDP for that country.[3]

In response to the health and economic losses due to tobacco use, commercial tobacco endgame strategies are increasingly considered a viable approach to tackle the tobacco epidemic.[4] An endgame approach moves beyond the business-as-usual (BAU) model of incremental policy change to a deliberative strategy to permanently reduce tobacco smoking to minimal levels within a short time frame, or a complete phase out of the commercial tobacco market. The endgame concept is often interpreted as a smoking prevalence goal of ≤5% in the adult population with a plan for achieving it.[5] As of early 2023, 10 countries (including Aotearoa-New Zealand (A/NZ), England, Scotland, Ireland, USA, Canada, Australia, Sweden, Finland and Bangladesh) have announced goals to reach the ≤5% target between 2025 and 2040.[6]

Among these countries, A/NZ was the first to pass into law a package of policies aiming to reduce smoking prevalence to ≤5% prevalence before 2030 and to reduce the inequity in smoking rates between the Māori (Indigenous) and non-Māori populations. If operationalised, the Smokefree Environments and Regulated Products (Smoked Tobacco) Amendment Act, which was passed by the parliament in December 2022,[7] would reduce the nicotine content of all smoked tobacco products to non-addictive levels, reduce the number of tobacco retail outlets by at least 90% and ban tobacco sales to anyone born after 2008.[8] We recently evaluated the potential health impacts of these policies and found that their implementation would deliver large health and equity gains compared with a BAU approach. According to our modelling, a combined tobacco endgame policy package would lead to a gain of 594 000 health-adjusted life-years (HALYs;

WHAT THIS STUDY ADDS

⇒ This study evaluates the potential economic impacts of the commercial tobacco endgame legislation in A/NZ. We modelled the economic impacts by 2050 of four key measures: denicotinisation of smoked tobacco products, enhanced antismoking mass media campaigns, 90% reduction in the number of tobacco retail outlets and a smoke-free generation law that bans sale of tobacco to anyone born after 2008.

⇒ Our model projected large economic gains for consumers from the tobacco endgame package resulting from a sharp reduction in smoking prevalence, and associated morbidity and mortality.

⇒ For the A/NZ Government, the policy package is projected to result in reduced healthcare costs, and increased income tax and goods and services tax (GST) revenue. However, these gains are offset by increased superannuation (ie, pension) payments resulting from a greater number of individuals living past the age of pension eligibility (65 years in A/NZ), as well as large reductions in tobacco excise tax revenue.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Our study provides estimates of the likely economic impacts of a commercial tobacco endgame policy. Its findings can be useful to the public and decision-makers and inform the design of future tobacco endgame strategies.

95% uncertainty interval (UI): 443 000 to 738 000; 3% discount rate) over the remaining lifetime of the 5.08 million A/NZ population alive in 2020.[9]

Despite the unprecedented potential for a commercial tobacco endgame to benefit the population (increasing health, equity and productivity and reducing healthcare expenditure), phasing out commercial tobacco sales often raises concerns about economic impacts on governments from loss of tobacco taxes. No previous analysis has evaluated the potential fiscal impacts of a comprehensive national tobacco endgame strategy. In this study, we quantify the potential economic effects of the Smokefree Aotearoa 2025 Action Plan from both government and citizen perspectives.

METHODS

We used a previously published simulation model[9] developed to evaluate the health impacts of the A/NZ Smokefree Action Plan. Details of the model's methodology, design, assumptions and epidemiological parameters have been reported elsewhere.[9–12] Briefly, the simulation is based on the combination of two models: first, a Markov process simulating the population's smoking and vaping life history based on seven states (see online supplemental figure 1). Movements between the different states are determined by transition probabilities, which reflect BAU and additional superimposed effects of the intervention (see below). Second, a proportional multistate lifetable (PMSLT) composed of a main cohort lifetable, which simulates the evolution of A/NZ population from 2020 using projected all-cause mortality and morbidity rates. For this analysis, we evolved the model from a closed-cohort to an open-cohort simulation by including births and migration using projections from Stats NZ (the A/NZ official data agency). In parallel, in the BAU scenario, proportions of the cohort also reside in 16 subsidiary tobacco-related disease lifetables according to prevalence at baseline, and in future years based on BAU disease-specific incidence, case fatality and remission rates (where appropriate for example, for treated cancers). The tobacco-related diseases in the model are coronary heart disease, stroke, chronic obstructive pulmonary disease, lower respiratory tract infection and the following cancers: lung, oesophageal, stomach, liver, head and neck, pancreas, cervical, bladder, kidney, endometrial, melanoma and thyroid.

Economic outcomes

We evaluated the potential economic impacts of the Smokefree Aotearoa 2025 Action Plan from the government's perspective and the citizens' perspective, including the direct and indirect costs of tobacco use. From the citizens' perspective, we calculated changes to income (indirectly impacted by tobacco-related morbidity and mortality) and expenditure on tobacco products. From the government's perspective, we calculated taxation revenue (from income tax, goods and services tax (a form of value-added tax) and tobacco excise tax), health system expenditure and superannuation payments. Table 1 lists the economic input parameters included in the model and their sources. We identified baseline estimates of total population income, total government income tax revenue, goods and services tax (GST) revenue, tobacco excise tax revenue, superannuation expenditure and health expenditure for the year 2021 from the financial statement of the Government of A/NZ.[13] Within each disease lifetable, these parameters were allocated by 5-year age groups to proportions of the cohort as follows: income was attached to cohorts aged 20–64 years, superannuation payments were attached to cohorts aged 65 years and older, tobacco excise was attached to the proportion smoking. Health expenditure by disease was attached to disease states in all cohorts. The model was calibrated to produce values that match the baseline economic parameter estimates after one cycle run (ie, 2021). Table 2 presents the economic outcomes produced by the model and their calculation method.

For each simulated year, a population impact fraction (PIF) is calculated for each tobacco-related disease. The generic formula[14] is:

$$PIF_{idt} = \frac{\sum_{j=1}^{n} P_j RR_{idj} - \sum_{j=1}^{n} P'_j RR_{idj}}{\sum_{j=1}^{n} P_j RR_{idj}}$$

where:

i subscripts each sex by age by ethnic group.

d subscripts each disease.

t subscripts each time step or yearly cycle.

j subscripts each category of smoking or vaping (the seven states in online supplemental figure 1, plus 20 additional tunnel states for each of those quitting smoking and/or vaping and people who switched completely from smoking to vaping).

RR is the incidence rate ratio for disease d and smoking–vaping state j, and possible varying by demographics (eg, by sex and age, but not by ethnic group). (Note the RR does not vary by time step t.)

These PIFs are the percentage change (compared with BAU) in incidence rates for each smoking-related disease, by sociodemographics and year, that are transferred to the PMSLT.

Within each disease lifetable, the endgame intervention is run in parallel to BAU with different disease incidence rates given changes in smoking and vaping prevalence over time (see online supplemental figure 1). Each disease lifetable estimates the difference between intervention and BAU in disease mortality, morbidity and the modelled economic outputs (table 2). These

Table 1 Base year (2021) annual cost inputs to the modelling and application within model

Parameter	Value	Source	Model application
Total population income	$124.5 billion	33	Disaggregated to expected income per citizen, by sex and age (those 20–64 years old only). Gamma distribution, SD=±10% of mean
Income loss due to tobacco-related diseases	N/A	34	Each tobacco-related disease had an income loss attached (by sex and age). Independent gamma distributions, SD=±10% of expected income loss from disease. Not used in BAU. Under the intervention scenario, the difference in income loss (usually a gain in income as less disease) between intervention and BAU was added to the expected average citizen income above.
Total health system expenditure	$15.52 billion	13	Disaggregated to expected health system expenditure per person, by sex and age. Gamma distribution, SD=±10% of mean
Health system expenditure for tobacco-related diseases	N/A	34	Each tobacco-related disease (by sex and age by phase (first year of diagnosis, last year of life if dying of disease, otherwise prevalent with disease)) had an expenditure attached. Independent gamma distributions, SD=±10% Not used in BAU. Under the intervention scenario, the difference in disease expenditure (usually a reduction as less disease) between intervention and BAU was added to the expected average health system expenditure above.
Income tax revenue	$32.93 billion	13	Divided by population income to give income tax rate (32.93/124.5=26.45% of total population income).
GST revenue	$17.41 billion	13	Divided by population income to give GST rate (17.41/124.5=13.98% of total population income).
Tobacco excise revenue	$1.11 billion	13	Divided by size of the smoking population in 2021 to give tobacco excise tax rate ($1922.7 per annum per person who smokes).
Proportion of the price (before GST) per pack of 25 cigarettes in A/NZ collected by government as excise tax*	55%	35	Tobacco excise revenue (above) divided by this value to give estimated total tobacco expenditure, then divided by size of the smoking population in 2021 to give population tobacco expenditure rate ($3495.8 per annum per person who smokes).
Superannuation expenditure revenue	$11.28 billion	13	Divided by number of people 65+ years old in 2021 to give superannuation expenditure rate ($13 534.1 per annum per person aged 65+ years).

All costs presented are annual amounts, in 2021 US$ (calculated using NZ-US OECD PPP of 1.4684).
*Ratio of tobacco industry revenue to excise tax revenue is 45%/55%.[35]
A/NZ, Aotearoa/New Zealand; BAU, business as usual; GST, goods and services tax; N/A, not applicable; OECD, Organisation for Economic Co-operation and Development ; PPP, purchasing power parity.

differences are calculated at the end of each 1-year cycle then added to matching entities in the all-cause or main lifetable.

Intervention

Intervention effects were reflected in the model through changes in population movements (ie, transition probabilities) between smoking and vaping states. The endgame policy package considered in the model combines the effects of four separate interventions included in the Smokefree Aotearoa 2025 Action Plan: (1) denicotinisation, (2) enhanced mass media campaign, (3) 95% reduction in the number of tobacco retail outlets and (4) smoke-free generation. Parameterisations of the individual policies and the combined smoke-free policy package are described in online supplemental table 1. This paper focuses on the combined effect of these interventions if implemented as a single policy package in 2023.

Sensitivity analysis: dynamic retirement age scenario

The economic outcomes that we have included in our model are based on transfer payments between government and citizens and are heavily dependent on the evolution of the labour force in A/NZ. Therefore, our projection of the net government position (ie, once all the transfers have been considered) is likely to be sensitive to the size and participation of the working-age population. The latest report from Statistics NZ's national labour force projections estimates that by 2043, the median size of the labour force in A/NZ will rise by 17.2% compared with 2020. Over the same period, the proportion of the labour force aged 65 years and older is projected to increase from 6% in 2020 to 7–11% in 2043 and 7–15% in 2073.[15]

To test the sensitivity of our model to these labour force evolutions, we developed an alternative endgame scenario with a 'dynamic' age of retirement and access to superannuation

Table 2 Aggregate differences in economic outputs between tobacco endgame and BAU

Output	Calculation
ΔPopulation income	Population income$_{Intervention}$–population income$_{BAU}$
ΔAfter tax population income	(ΔPopulation income)×(1–income tax rate*)
ΔGST revenue	(ΔPopulation income)×GST rate*
ΔIncome tax revenue	Income tax rate*×Δpopulation income
ΔTobacco excise revenue	(Number of people who smoke$_{Intervention}$–number of people who smoke$_{BAU}$)×tobacco excise tax rate*
ΔHealth system expenditure	Total health expenditure$_{Intervention}$–total health expenditure$_{BAU}$
ΔGST revenue from tobacco sales	0.15/1.15×(number of people who smoke$_{Intervention}$–number of people who smoke$_{BAU}$)×tobacco expenditure rate*
ΔPopulation expenditure on tobacco	(Number of people who smoke$_{Intervention}$–number of people who smoke$_{BAU}$)×tobacco expenditure rate*
ΔSuperannuation expenditure	(Difference in population aged 65+† between endgame and BAU)×superannuation expenditure rate*
ΔGovernment net position	ΔIncome tax revenue+Δtobacco excise revenue+ΔGST revenue–Δhealth system expenditure–Δsuperannuation expenditure

*Parameter from table 1.
†Age of superannuation entitlement varies under sensitivity analysis scenario with dynamic retirement age.
BAU, business as usual; GST, goods and services tax.

(ie, pension payments). Under this scenario, the threshold age increases each year so that the citizen morbidity rate (people who do and do not smoke combined) under the intervention matches the morbidity rate of a 65-year-old under BAU (ie, without the tobacco endgame intervention). That is, the dynamic scenario captures the contribution that a prevention programme such as the A/NZ tobacco endgame legislation might make to the healthiness and hence productivity of the population.

This first involved measuring prevalent years lived with disability (pYLDs; measure of average morbidity for a given population) for those aged 65–70 years old, for each year up to 2050, as follows:

$$\text{pYLD} = \frac{1 - (\textit{Health Adjusted Life Years (HALYs)})}{\textit{Person Years (PYs)}}$$

Second, for each year, the updated age of superannuation entitlements (ie, the dynamic retirement age) was calculated as follows:

$$\textit{Dynamic yearly retirement age} = 65 + \left(\frac{\textit{BAU pYLDs}_{65\ yrs} - \textit{Endgame pYLDs}_{65\ yrs}}{\textit{Endgame pYLDs}_{66yrs} - \textit{Endgame pYLDs}_{65yrs}} \right)$$

HALYs and PYs for the above equation were calculated within the PMSLT for both BAU and the alternative endgame scenario.[16]

All scenarios were run 2000 times in Monte Carlo simulation. A 3% discount rate per annum was applied to all economic measures. Undiscounted results are provided in the online supplemental material. Estimates were calculated in 2021 NZ$ then converted to US$ using a 2021 NZ-US Organisation for Economic Co-operation and Development purchasing power parity adjustment of 1.4684.

RESULTS

Figure 1 shows the annual differences in costs between the endgame scenario and BAU. Table 3 presents the cumulative expenditure and revenue estimates.

For the endgame scenario compared with BAU, health system expenditure savings discounted at 3% per annum are projected to peak in 2044 at US$65 million (95% UI: 49 to 83) before decreasing to US$53 million (95% UI: 35 to 72) in 2050. The health system is projected to save a cumulative total of US$1.34 billion (95% UI: 1.02 to 1.7) by 2050. Conversely, government expenditure in superannuation benefits will increase by a cumulative total of US$1.18 billion (95% UI: 0.93 to 1.44), over the same period, due to people living longer.

Population income (after tax) increases relative to BAU on average by US$5 million every year after the introduction of the policy (ie, 2023), reaching US$138 million annually (95% UI: 113 to 166; discounted at 3% per annum) in 2050. This represents a projected cumulative income gain of US$1.8 billion (95% UI: 1.4 to 2.1) by 2050. This increase in income leads to a parallel increase in government income tax revenue.

If money not spent on cigarettes is diverted to other expenditures in the economy, then the effective increase in cumulative disposable income is projected to be US$31.16 billion (95% UI: 24.3 to 37.4) by 2050. Assuming the increase in disposable income is fully spent in the economy, government GST revenue increases by a cumulative total of US$1.24 billion (95% UI: 0.99 to 1.48) by 2050.

Annual government revenue from tobacco excise for the endgame scenario compared with BAU falls rapidly to a maximum of US$735 million (95% UI: 608 to 837) less revenue in 2027. The cumulative excise tax revenue foregone by 2050 is US$13.5 billion (95% UI: 10.5 to 16.4).

The net of revenue and expenditure differences between the endgame and BAU from the government perspective is dominated by the reduced tobacco excise tax revenue. There is a net shortfall for the government in every year out to 2050, and a cumulative negative net fiscal position of US$11.51 billion (95% UI: 8.7 to 14.0) by 2050.

The results of the scenario analysis that sees the age of retirement and eligibility for superannuation increase over time, whereby the new threshold age has the same morbidity as those aged 65 years old in BAU, are presented in figure 2 (see also online supplemental table 2). Under this scenario, the age threshold for entitlement to superannuation becomes 65.2 years in 2030, 65.5 years in 2040 and 65.8 years in 2050. The government's net annual position compared with BAU becomes positive by 2037 (figure 2)—due to changes in income tax revenue and superannuation payments. This scenario still results in a net cumulative shortfall to the government of US$1.89 billion (95% UI: −4.74 to 1.01) by 2050 but is only 14% of the similar shortfall with a static age (online supplemental table 2).

Undiscounted results, for scenarios with and without the dynamic age of retirement, are presented in the online supplemental tables 3 and 4, and figures 2 and 3.

DISCUSSION

Our modelling suggests that the Smokefree Aotearoa 2025 Action Plan passed into law by the A/NZ Government in 2022 is likely to produce substantial economic benefits for the population in addition to the previously calculated[9] health and health equity benefits. From the perspective of citizens, a cumulative gain in post-tax income of US$1.8 billion was seen by 2050, resulting from reduced tobacco-related morbidity and mortality in the working-age population. This was also met with a cumulative gain in disposable income by US$29 billion by 2050, due to reduced expenditure on tobacco. From a government revenue perspective, both gains and losses were observed. A reduction in healthcare expenditure by US$1.3 billion, and a combined increase of US$1.9 billion in income tax and GST revenue resulted from the policy package. However, due to increased superannuation payments and reduced tobacco excise tax revenue, the government would experience a cumulative shortfall of US$11.5 billion by 2050.

To our knowledge, our study is the first to evaluate the potential fiscal consequences of implementing a tobacco endgame strategy from both government and citizen perspectives. Our estimates are consistent with a large body of evidence documenting the detrimental impact of tobacco spending on household budgets, particularly for the most disadvantaged socioeconomic categories.[17] An analysis of A/NZ census data has estimated that among low-income households with at least one member who smokes, up to 14% of the non-housing budget was spent on tobacco.[18] Similar findings have been reported in other high-income countries[19] as well as low-income[20 21] and middle-income countries.[22 23] A recent modelling study evaluating the economic loss attributable to cigarette smoking in the USA estimated the total loss in annual population income in 2020 at US$735.1 billion.[3] In A/NZ, smoking is strongly concentrated among Indigenous Māori and people on low incomes[24]; therefore, our estimated increases in disposable income would represent a pro-equity income transfer.

From a government revenue perspective, our findings show an overall shortfall of revenue, largely because of foregone excise tax revenue under the endgame policy scenario. A/NZ has one of the world's highest tobacco excise taxes. In 2021,

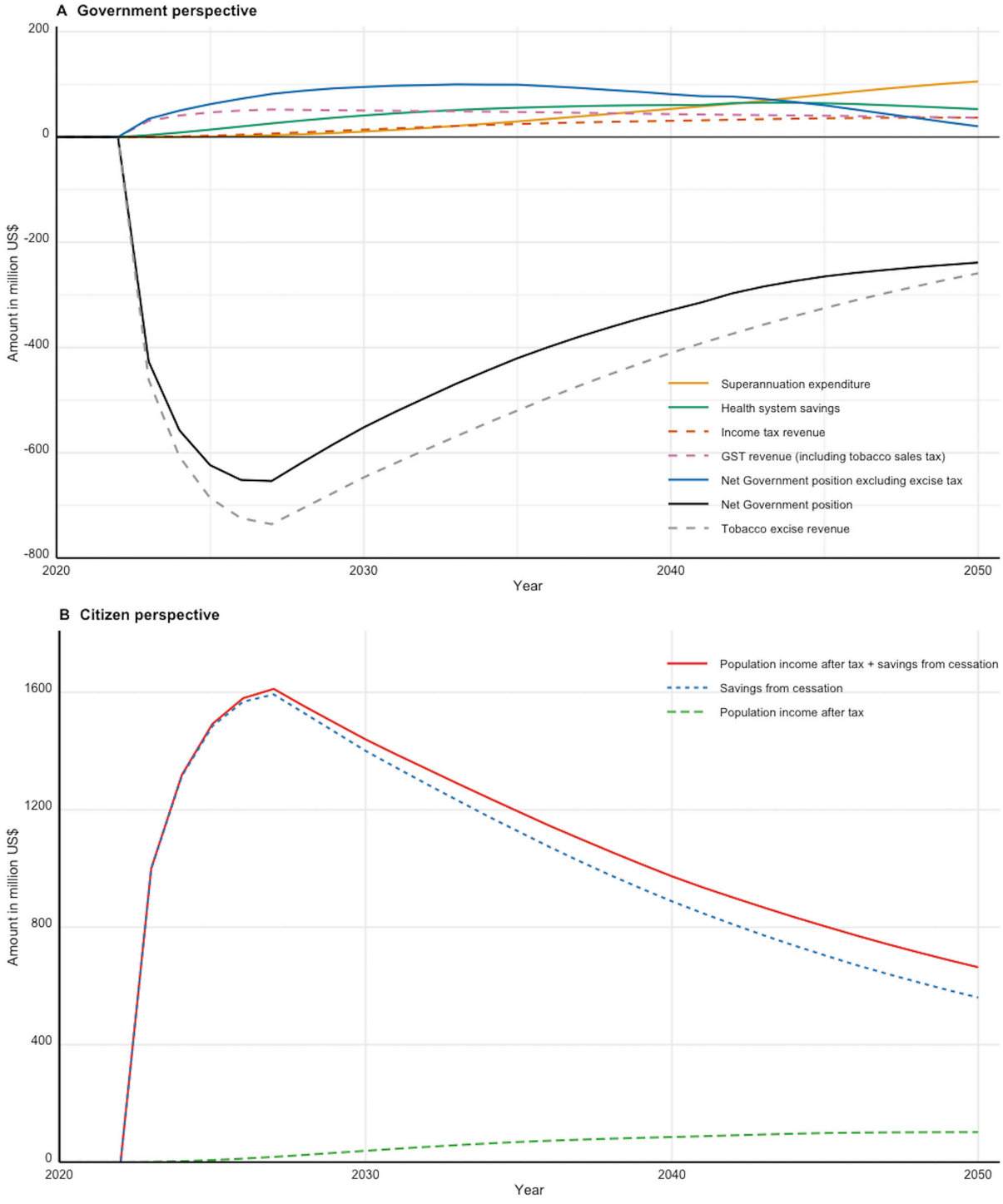

Figure 1 Estimated annual differences in revenue and expenditure (2021 US$; 3% annual discount rate) between the tobacco endgame scenario and BAU. BAU, business as usual; GST, goods and services tax from A/NZ Government and Citizen perspectives.

the pack price of 20 Marlboro cigarettes was NZ$36.9 (US$25) with excise tax and GST representing 70% of the price. Despite clear direct financial benefits (from reduced health expenditure and increases to both GST from higher population income and income tax revenue), the government's long-term net position remains negative in our primary analysis with a fixed age eligibility to superannuation benefit, due to the decline of excise tax revenue (figure 1). This decrease in revenue is a logical consequence of successfully reducing smoking prevalence and was identified in the Regulatory Impact Statement preceding the legislation.[8]

Tobacco excise tax revenue also decreased under BAU—this is again a logical result of the underlying decreasing trend in smoking prevalence.[24] The endgame policy simply accelerates the rate of decline of this revenue source. In 2019/2020, tobacco tax revenue was about 1.7% of annual A/NZ Government revenue,[13] which is relatively small compared with annual variation in government revenue arising from typical macroeconomic fluctuations and natural hazards that have impacted A/NZ in recent decades (major earthquakes, major storms and the COVID-19 pandemic).

Table 3 Projected changes in cumulative expenditure and revenue due to the Aotearoa-New Zealand's tobacco endgame strategy compared with BAU (2021 PPP US$ billions; 3% annual discount rate)

	By 2030		By 2040*		By 2050*	
Revenue/expenditure items	**Estimate**	**95% UI**	**Estimate**	**95% UI**	**Estimate**	**95% UI**
Government perspective						
Expenditure						
Health system	−0.18	−0.22 to −0.14	−0.73	−0.90 to −0.57	−1.34	−1.70 to −1.02
Superannuation expenditure	0.03	0.02 to 0.04	0.35	0.28 to 0.43	1.18	0.93 to 1.44
Revenue						
Income tax revenue	0.05	0.04 to 0.06	0.30	0.24 to 0.35	0.65	0.52 to 0.77
GST revenue (including tobacco sales tax)	0.37	0.3 to 0.44	0.84	0.68 to 0.99	1.24	0.99 to 1.48
Tobacco excise revenue	−5.24	−6.16 to −4.24	−10.35	−12.26 to −8.24	−13.56	−16.39 to −10.53
Net government position (∑revenue−∑expenditure)	−4.67	−5.49 to −3.77	−8.83	−10.52 to −6.96	−11.51	−14.03 to −8.77
Citizen perspective						
Population income after tax	0.14	0.11 to 0.17	0.82	0.66 to 0.98	1.80	1.46 to 2.15
Savings from cessation (reduced tobacco expenditure)	11.35	13.35 to 9.19	22.41	26.55 to 17.83	29.36	35.49 to 22.80
Population income after tax+savings from cessation	11.49	9.30 to 13.50	23.20	18.50 to 27.45	31.16	24.35 to 37.47

The 2020 NZ$ converted to 2021 US$ using NZ-US OECD PPP of 1.4684.
*Includes estimate to left, as cumulative over time.
BAU, business as usual; GST, goods and services tax; OECD, Organisation for Economic Co-operation and Development; PPP, purchasing power parity; UI, uncertainty interval.

Previous analyses that examined the impact of reducing smoking in the USA to 10.4% (the estimated impact of the Institute of Medicine (IOM)-recommended policy package) or to 5.7% (a hypothetical high-impact scenario) by 2025 on a range of economic outcomes also found the high-impact scenario would reduce state government tobacco tax revenue on average by 2.5% due to the greater decline in cigarette sales, while the IOM policy package would produce a 0.5% increase by raising the tax rate.[25]

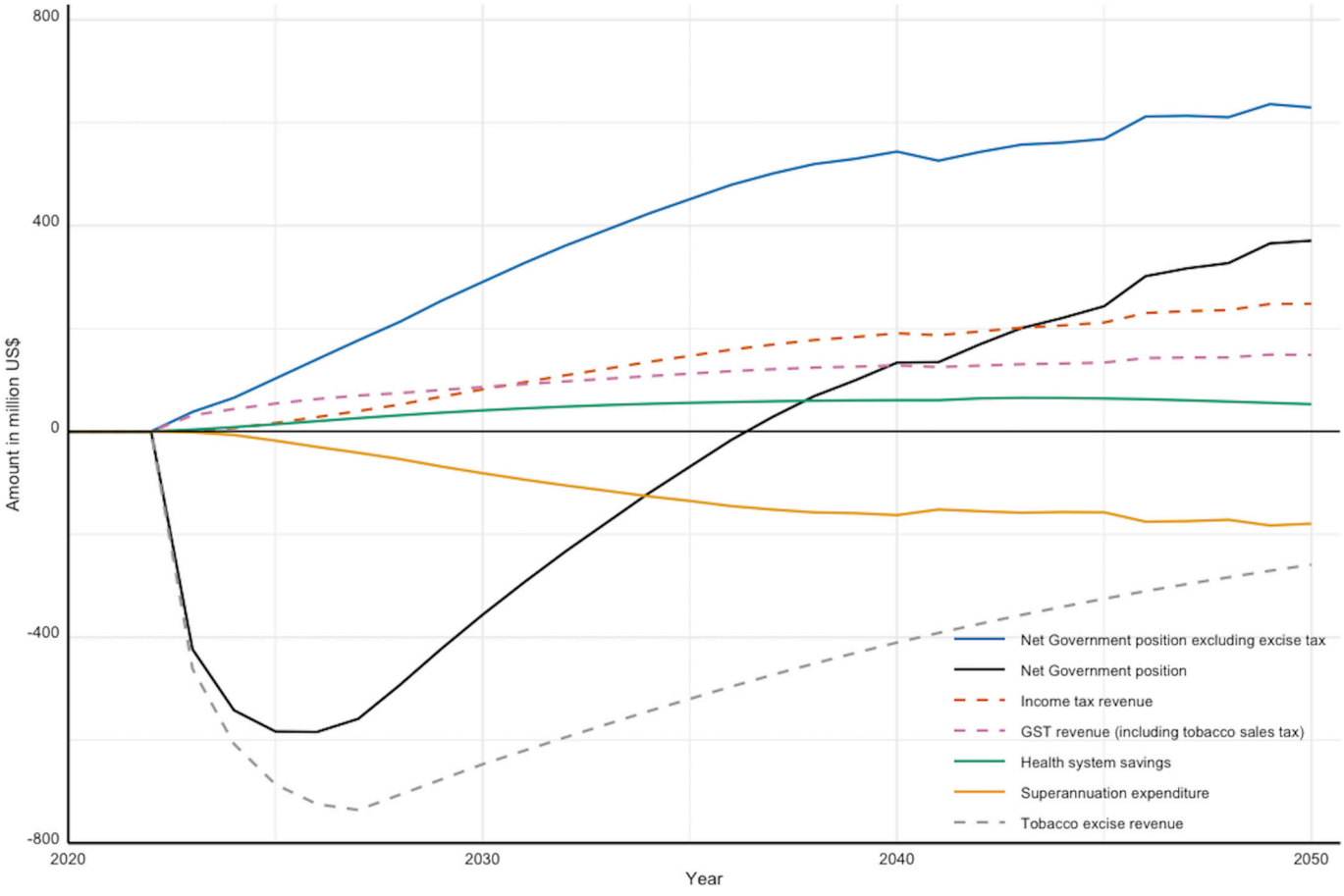

Figure 2 Estimated annual differences in revenue and expenditure (2021 PPP US$; 3% annual discount rate) between tobacco endgame scenario with dynamic retirement age and BAU (government perspective). BAU, business as usual; GST, goods and services tax; PPP, purchasing power parity.

The 2022 A/NZ world first tobacco endgame legislation prioritised health and equity over government revenue. However, for countries and governments who perceive economic priorities as more important than improving health and equity,[5] even a limited cost to government revenue may represent a barrier to comitting to a tobacco endgame. Our modelling, although specific to the A/NZ context, assumes that a tobacco endgame strategy is likely to result in large economic benefits for the population and that revenue foregone by governments is not 'lost' but rather retransferred to citizens. A tobacco endgame may also address a key ethical challenge that tobacco taxation can pose in terms of contributing to financial hardship among low-income households where smoking persists at the pre-tax consumption level.

Our study estimated an increase in government spending on aged pensions over time due to the reduction in premature mortality from tobacco-related disease—assuming a continued fixed age of eligibility to universal government superannuation. Tobacco companies have previously attempted to promote the 'financial benefits' of smoking to governments in the form of reduced expenditure on aged pensions due to the reduced life expectancy that results from smoking.[26] However, since increasing life expectancy and health is a societal (and government) goal, increased financial costs associated with such health benefits in the form of government superannuation/aged pensions should not be a determining factor in government decision-making regarding policies that have life-extending benefits.[27] Nevertheless, estimating these impacts can assist governments to plan appropriately as a country becomes smoke-free, such as identifying alternative revenue streams to replace tobacco tax.

Acknowledging current Stats NZ projections of a larger and older working-age population in A/NZ, our sensitivity analysis scenario using a 'dynamic' retirement age suggests that the government can achieve a positive net fiscal position despite the reductions in excise tax revenue associated with the endgame policy package. This 'recovery' occurs only 14 years after the introduction of the policy and with minor incremental increases to the age of superannuation entitlement—from 65 years in 2020 to 65.78 years by 2050. Such a policy is consistent with changes being implemented in other similar countries. For example, Australia recently increased the eligibility age for the aged pension from 65 years at 30 June 2017 to 67 years on 1 July 2023.[28] Nevertheless, our dynamic scenario is just that—a scenario. No government would change the retirement age and age of eligibility for universal superannuation benefits by such small increments per annum. Our purpose was to demonstrate how increased healthiness of the population might manifest as one way for society to adjust.

This study used a tobacco policy model ranked top of 15 such models internationally.[29] However, it has several limitations. Our modelling estimates what the future might look like and so has many uncertainties. To capture these uncertainties, we applied a probabilistic sensitivity analysis to the key parameters in our simulation (in line with the recommendations for best practice[30]) to generate uncertainty ranges for the outputs. The model also relies on multiple assumptions and is therefore exposed to the limitations associated with those assumptions (see full discussion of model limitations in the main manuscript and supplemental material of Ait Ouakrim *et al*[9]). In our model, 'retail reduction' was specified as a 95% reduction in the number of tobacco retailers, based on earlier pre-legislation plans. However, the final version of the 'smoke-free bill' adopted a minimum 90% reduction in tobacco retail stores which translates to a maximum of 600 retail outlets. This might slightly overestimate the projected economic benefits and, conversely, underestimate the expenditure associated with the endgame policy package.

Our estimate of the net government position should be interpreted with caution as it is only limited to the macroeconomic outputs considered in the model. For example, the model did not take into account the health benefits (and subsequent economic dividends) that the endgame might produce as a result of lower population exposure to secondhand smoke.[31 32] Similarly, we did not take into account the many government tax revenue sources (such as corporate tax, taxes on payroll and workforce, tax on production, etc) that are likely to increase and benefit from a healthier and more productive population. Finally, our model did not account for the out-of-pocket health expenditure savings for citizens that would result from lower disease and treatment burden associated with quitting and lower uptake of smoking.

Smoking imposes intangible detrimental effects on people and society (for example, the psychological pain associated with chronic addiction, tobacco-related disease and the prospect of premature death). These effects impact quality of life and productivity in the formal and informal economies. But they are hard to value quantitatively, and our model does not take them into account. Consequently, our estimates of both the economic benefits of the tobacco endgame are likely to be underestimates.

CONCLUSION

Our study estimated the expected economic impacts of the Smokefree Aotearoa 2025 Action Plan, demonstrating economic benefits for the A/NZ population, and modest impacts on government revenue and expenditure related to the reduction in tobacco tax and increases in aged pensions due to increased life expectancy. Such costs are relatively small compared with other macroeconomic fluctuations and can easily be anticipated and planned for. These costs could also be offset by future increases in the labour force and the proportion of people 65+ years old working in the formal economy.

Twitter Coral E Gartner @CoralGartner

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ORCID iDs
Samantha Howe http://orcid.org/0000-0002-2793-6197

Coral E Gartner http://orcid.org/0000-0002-6651-8035
Tony Blakely http://orcid.org/0000-0002-6995-4369

REFERENCES

1 Ezzati M, Lopez AD, Rodgers A, *et al*. Selected major risk factors and global and regional burden of disease. *Lancet* 2002;360:1347–60.
2 Goodchild M, Nargis N, Tursan d'Espaignet E. Global economic cost of smoking-attributable diseases. *Tob Control* 2018;27:58–64.
3 Nargis N, Hussain A, Asare S, *et al*. Economic loss attributable to cigarette smoking in the USA: an economic modelling study. *Lancet Public Health* 2022;7:e834–43.
4 Malone RE. The race to a tobacco Endgame. *Tob Control* 2016;25:607–8.
5 Moon G, Barnett R, Pearce J, *et al*. The tobacco Endgame: the neglected role of place and environment. *Health Place* 2018;53:271–8.
6 Puljević C, Morphett K, Hefler M, *et al*. Closing the gaps in tobacco Endgame evidence: a scoping review. *Tob Control* 2022;31:365–75.
7 New Zealand Parliament. Smokefree environments and regulated products (smoked tobacco) amendment act 2022 (2022/79). 2022. Available: https://www.parliament.nz/en/pb/bills-and-laws/bills-proposed-laws/document/BILL_125245/smokefree-environments-and-regulated-products-smoked-tobacco
8 Ministry of Health. Regulatory impact statement: Smokefree Aotearoa 2025 action plan. Wellington Ministry of Health; 2021. Available: https://www.health.govt.nz/about-ministry/information-releases/regulatory-impact-statements/regulatory-impact-statement-smokefree-aotearoa-2025-action-plan
9 Ait Ouakrim D, Wilson T, Waa A, *et al*. Tobacco Endgame intervention impacts on health gains and Māori:non-Māori health inequity: a simulation study of the Aotearoa/New Zealand tobacco action plan. *Tob Control* 2023:tc-2022-057655.
10 Blakely T, Cobiac LJ, Cleghorn CL, *et al*. Health, health inequality, and cost impacts of annual increases in tobacco tax: multistate life table modeling in New Zealand. *PLoS Med* 2015;12:e1001856.
11 Pearson AL, Cleghorn CL, van der Deen FS, *et al*. Tobacco retail outlet restrictions: health and cost impacts from multistate life-table modelling in a national population. *Tob Control* 2016:tobaccocontrol-2015-052846.
12 Petrović-van der Deen FS, Blakely T, Kvizhinadze G, *et al*. Restricting tobacco sales to only pharmacies combined with cessation advice: a modelling study of the future smoking prevalence, health and cost impacts. *Tob Control* 2019;28:643–50.
13 Treasury NZ. Financial statement of the government of New Zealand (year ending June 2021). 2021. Available: https://www.treasury.govt.nz/publications/year-end/financial-statements-2021#ministerial-statement
14 Murray CJ, Ezzati M, Lopez AD, *et al*. Comparative quantification of health risks: conceptual framework and methodological issues. *Popul Health Metrics* 2003;1:1–20.
15 Stats New Zealand. National labour force projections: 2020(Base)–2073. 2021. Available: https://www.stats.govt.nz/information-releases/national-labour-force-projections-2020base-2073
16 Blakely T, Moss R, Collins J, *et al*. Proportional multistate lifetable modelling of preventive interventions: concepts, code and worked examples. *Int J Epidemiol* 2020;49:1624–36.
17 National Cancer Institute, World Health Organization. *The Economics of Tobacco and Tobacco Control. National Cancer Institute Tobacco Control Monograph 21. NIH Publication no.16-CA-8029A*. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva, CH: World Health Organization, 2016.
18 Thomson GW, Wilson NA, O'Dea D, *et al*. Tobacco spending and children in low income households. *Tob Control* 2002;11:372–5.
19 Nyakutsikwa B, Britton J, Langley T. The effect of tobacco and alcohol consumption on poverty in the United Kingdom. *Addiction* 2021;116:150–8.
20 Husain MJ, Datta BK, Virk-Baker MK, *et al*. The crowding-out effect of tobacco expenditure on household spending patterns in Bangladesh. *PLoS One* 2018;13:e0205120.
21 Nguyen N-M, Nguyen A. Crowding-out effect of tobacco expenditure in Vietnam. *Tob Control* 2020;29:s326–30.
22 San S, Chaloupka FJ. The impact of tobacco expenditures on spending within Turkish households. *Tob Control* 2016;25:558–63.
23 Wang H, Sindelar JL, Busch SH. The impact of tobacco expenditure on household consumption patterns in rural China. *Soc Sci Med* 2006;62:1414–26.
24 Ministry of Health. Annual data explorer 2021/22: New Zealand health survey tobacco use. 2022. Available: https://minhealthnz.shinyapps.io/nz-health-survey-2021-22-annual-data-explorer/
25 Bearman PS, Neckerman KM, Wright L. *After tobacco: what would happen if Americans stopped smoking*. Columbia University Press, 2011.
26 Ross H. Critique of the Philip Morris study of the cost of smoking in the Czech Republic. *Nicotine Tob Res* 2004;6:181–9.
27 Barendregt JJ, Bonneux L, van der Maas PJ. The health care costs of smoking. *N Engl J Med* 1997;337:1052–7.
28 Department of Social Services (DSS). Seniors benefits & payments - age pension. Canberra DSS, Australian Government; 2023. Available: https://www.dss.gov.au/seniors/benefits-payments/age-pension
29 Huang V, Head A, Hyseni L, *et al*. Identifying best modelling practices for tobacco control policy simulations: a systematic review and a novel quality assessment framework. *Tob Control* 2023;32:589–98.
30 Briggs AH, Weinstein MC, Fenwick EAL, *et al*. Model parameter estimation and uncertainty analysis: a report of the ISPOR-SMDM modeling good research practices task force working group–6. *Med Decis Making* 2012;32:722–32.
31 Callinan JE, Clarke A, Doherty K, *et al*. Legislative smoking bans for reducing secondhand smoke exposure, smoking prevalence and tobacco consumption. *Cochrane Database Syst Rev* 2010;2010:CD005992.
32 Christensen TM, Møller L, Jørgensen T, *et al*. The impact of the Danish smoking ban on hospital admissions for acute myocardial infarction. *Eur J Prev Cardiol* 2014;21:65–73.
33 Stats New Zealand. *Earnings for people in paid employment by region, sex, age groups and ethnic groups*. Wellington: New Zealand Government, Available: https://nzdotstat.stats.govt.nz/wbos/index.aspx?_ga=2.59390884.807928993.1671346727-697363774.1671144874
34 Blakely T, Sigglekow F, Irfan M, *et al*. Disease-related income and economic productivity loss in New Zealand: a longitudinal analysis of linked individual-level data. *PLoS Med* 2021;18:e1003848.
35 Drope J, Hamill S, Chaloupka F, *et al*. The tobacco Atlas. Chicago Vital Strategies and Tobacconomics; 2022. Available: https://tobaccoatlas.org/