Modelling the implications of regular increases in tobacco taxation in the tobacco endgame

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ABSTRACT

Objective We examine the potential role for taxation in the tobacco endgame in New Zealand, where the goal is to become 'smokefree' (less than 5% smoking prevalence) by 2025.

Design Modelling study using a dynamic population model.

Setting and participants New Zealand, Māori and non-Māori men and women.

Interventions Annual increases in tobacco excise tax of 5%, 10%, 15% and 20% (with 10% reflecting the annual increase recently legislated by the New Zealand Government to 2016).

Results With a continued commitment to annual 10% increases in tobacco excise tax, in addition to on-going Quitline and cessation support, New Zealand's smoking prevalence is projected to fall from 15.1% in 2013 to 8.7% (95% uncertainty interval 8.6% to 8.9%) by 2025. This is compared to 9.9% without any further tax rises. With annual tax increases of 20%, the prevalence is projected to fall to 7.6% (7.5% to 7.7%) by 2025. The potential reductions in smoking prevalence are substantial for both Māori and non-Māori populations, although annual tax increases as high as 20% will still only see Māori smoking prevalence in 2025 approaching the non-Māori smoking levels for 2013. Scenario analyses did not suggest that growth of the illicit tobacco market would substantively undermine the impact of tobacco tax rises. Nevertheless, unknown factors such as the gradual denormalisation of smoking and changes to the 'nicotine market' may influence sensitivity to changes in tobacco prices in the future.

Conclusions Regular increases in tobacco taxation could play an important role in helping to achieve tobacco endgames. However, this modelling in New Zealand suggests that a wider range of tobacco endgame strategies will be needed to achieve a smoke-free goal of less than 5% prevalence for all social groups—a conclusion that could also apply in other countries.

INTRODUCTION

Taxing tobacco was unpopular with many public health practitioners in the 1970s and early 1980s, who believed that changing behaviour through increasing price was both ineffective and inappropriate.[1] However, there is now a substantial body of evidence showing benefits of price increase on reducing smoking, and taxing tobacco is now widely accepted as a first-line strategy in tobacco control.[1]

A recent review by the International Agency for Research on Cancer (IARC) estimated that a 10% increase in the price of tobacco would lead to a reduction in tobacco consumption of around 2–5% in high-income countries, and even more in low-income to middle-income countries.[2] To put this into perspective, modelling by Levy et al[4] indicates that an increase in tax to 70% of the retail price (the WHO's MPOWER recommendation[3]) could reduce smoking prevalence to 17% in Finland, 20% in the Netherlands,[5] 21% in Ireland[6] and 25% in Germany[7] by 2030 (see online supplementary table S1).

Finland, New Zealand and Scotland have all declared an ambition to become 'smokefree', but while it is clear that raising tobacco taxes is effective, one-off increases may not be enough in the tobacco 'endgame'. Taxes will need to be both large and frequent,[1] but there are concerns that growth in the market for illicit tobacco products, and tobacco industry strategies to absorb (or exaggerate) the price effects, may undermine or erode the effectiveness of tax increases.[1] The consequences are particularly uncertain in the endgame, where prices may become very high, products increasingly scarce and profit margins reduced.

New Zealand has a goal to become smoke free (<5% smoking prevalence[8]) by 2025.[9][10] Tobacco control policies, including Quitline, cessation support and a 2011–2016 commitment to 10% annual increases in tobacco excise tax (above inflation adjustment), have already reduced the adult smoking prevalence to 15.1%.[11] However, large inequalities exist, with 31% and 35% of the indigenous Māori men and women still smoking, compared with 15% and 11% of non-Māori men and women.[11]

In this research, we examined whether regular increases in tax would be enough to reach the smoke-free goal in New Zealand, what the implications might be for smoking inequalities and how changing taxes and declining prevalence could affect government revenue from tobacco taxes over the next 50 years.

METHODS

Taxation scenarios

We determined the legal price of cigarettes from a survey of prices in online supermarket Countdown (shop.countdown.co.nz/). The survey (n=181) included all product varieties, including cartons and loose tobacco pouches (0.7 g per cigarette equivalent). Since the survey was conducted in mid-February 2013, the 2011 price was back-calculated by adjusting for inflation and removing the effects of excise increases in January 2012 and 2013 (see online supplementary table S2). All prices are presented in 2011 New Zealand dollars.

We modelled smoking prevalence forward from the year 2011 with annual increases in excise of 0%, 5%, 10%, 15% and 20%. Cigarette prices were calculated each year until 2060, taking the changing excise amount, good and services tax (15% of legal

price, including tax), tax pass-through and illicit market activity into account (see online supplementary table S3).

Pass-through of price changes to smokers depends on market competition and desired profit margins. In the US and EU price changes have sometimes been fully passed on to smokers, sometimes absorbed by tobacco companies or sometimes over-shifted, with companies raising the price more than can be attributed to the tax.[2] Therefore, we evaluated effects of a 100% pass-through of the tax, as well as 20% under-shifting and over-shifting of the price change. In evaluating the under-shifting scenario, we assumed that tobacco companies would have a minimum margin for production costs and profits of 2011NZ$0.06 per stick, based on the lowest price for manufactured cigarettes (2009US$0.81 per stick in the Philippines) in Global Adult Tobacco Survey data from 15 countries.[12]

Estimates of the illicit share of cigarette trade, range from 1% (eg, New Zealand) to 40–50% (eg, Georgia, Albania).[13] While New Zealand's illicit market is small and unlikely to expand substantially due to its relative remoteness, high border security and minimal activity in cigarette manufacturing, there is no precedent for estimating illicit market activity when tobacco prices reach very high levels. Therefore, we modelled smoking prevalence with four different scenarios of illicit market activity: (1) market share remains stable at 1%; (2) market share slowly increases by 1% per year (base-case assumption), (3) market share more rapidly increases by 5% per year; and (4) market share very rapidly increases by 20% per year. For the three scenarios with increasing illicit market share, we assumed a maximum market share of 50%, based on the highest global estimates.[13]

The illicit price of cigarettes is influenced by factors such as product quality, size of the market, competition among suppliers, desired profit (taking costs of production, distribution and retail into account) and the risks involved (fines or imprisonment). While there is no tax component in the illicit price, potential profits must be balanced against price incentives for illegal purchase by smokers. From analysis of illicit and legal cigarette prices in China (illicit price=25% of the legal price) and the UK (illicit price=50% of the legal price),[13] Joossens et al estimated a formula for calculating illicit price based on the legal price minus two-thirds of the tax amount. This is based on an assumption that a third of the tax 'saving' becomes profit and two-thirds of the 'saving' is passed on to consumers.

With no available data on the illicit price of cigarettes in New Zealand, we modelled smoking prevalence with three different illicit price scenarios: (1) illicit price equal to the legal price minus two-thirds of the tax (base-case assumption, based on the Joossens et al estimate); (2) illicit price equal to 25% of the legal price (the low 25% proportion seen in China[13]); and (3) illicit price equal to 65% of the legal price (estimate from Australia, where illicit tobacco is primarily from domestically grown untaxed tobacco rather than smuggling from other countries[13]).

In addition, we examined 'best-case' and 'worst-case' combinations of the illicit market, illicit price and tax pass-through assumptions. The best-case scenario (from a public health perspective) combines the illicit price equal to 65% of the legal price, a stable 1% illicit market and tax pass-through of 120%. The worst-case scenario combines the illicit price equal to 25% of the legal price, the illicit market share increasing rapidly by 20% per year to a maximum of 50% of the market and tax pass-through of 80%.

Change in tobacco consumption with change in price
The IARC has extensively reviewed the literature on consumer responses to a change in price of tobacco (price elasticity).[2]

Most studies from high-income countries suggest an increase in price of 10% will lead to a fall in cigarette consumption of around 2–5% (price elasticity of −0.2 to −0.5), with around half of the effect due to a reduction in smoking prevalence and half due to a reduction in smoking intensity.[2] There is also good evidence that young people are more price sensitive than older people[2] and some evidence that there may be a social gradient in the price response, with more deprived groups (eg, lower income populations) showing greater responsiveness to changes in price.[14]

Estimates of the overall price elasticity of demand for tobacco in New Zealand (−0.47 for manufactured cigarettes over the 2002–2011 period[15]) are consistent with this international literature. Based on the IARC findings, we assumed that half of this elasticity effect would be due to a reduction in smoking prevalence and half would be due to a reduction in smoking intensity. Applying an age gradient used by Levy et al[4 16] in their recent analyses of tobacco taxes in the UK and Finland, we derived age group-specific prevalence elasticity values of −0.38 (15–20 years), −0.29 (21–24 years), −0.19 (25–34 years) and −0.10 (35+ years), which were consistent with the overall population prevalence elasticity effect in New Zealand. We also evaluated outcomes with a prevalence elasticity of −0.2 across all ages, which is the lower (more conservative) end of the estimated range of price elasticity values in high-income countries.

While there is some evidence that price sensitivity may be influenced by social position, including ethnicity,[14] there is no direct evidence of a difference in price sensitivity between Māori and non-Māori New Zealanders. Scrutiny of all studies reporting elasticity values by ethnicity, income or education in the IARC Review (see online supplementary tables S4 and S5) strongly suggested that price elasticity is higher (more elastic) with greater deprivation, but there was too much heterogeneity in the elasticity values to determine a summary measure of the effect. Therefore, we did not adjust elasticity values for ethnicity in primary analyses, but did evaluate an additional scenario in which we increased price sensitivity for Māori relative to non-Māori, adjusting elasticity values to reflect a 50% difference (see online supplementary table S6).

We modelled the effect of the price change only in the year that it first occurs (ie, assuming trends in initiation and cessation then return to what they would be without any increases in tax). Our overall price elasticity of demand for New Zealand (−0.47 from Tait et al[15]) is close to an earlier estimate of the long-run price elasticity in New Zealand (at −0.45 in O'Dea et al[17]), thus it should be capturing some of the additional reduced uptake and increased quitting in the few years after each tax rise. However, we also modelled two scenarios that additionally capture a lagged (or persisting) effect of price increases in the subsequent year for: (1) initiation; and (2) both initiation and cessation.

Prevalence projection model
Prevalence of smoking was simulated over time using dynamic modelling methods developed by Gartner et al,[18] based on the methods of Mendez et al.[19] Readers are referred to the Gartner and Mendez papers for a full description of the underlying mathematical methods, and to previous work on its application to New Zealand by Ikeda et al[20] and updated in 2014 with new census data on smoking (van der Deen FS, Ikeda T, Cobiac LJ, Wilson N, Blakely T. Projecting future smoking prevalence to 2025 and beyond in New Zealand using smoking prevalence data from the 2013 census. *New Zealand Medical Journal, under review*). In this paper, we describe our application of the model to simulating taxation scenarios in New Zealand. The

online supplement provides a diagram of the model structure (see online supplementary figure S1) and tables of data inputs (see online supplementary tables S7 and S8).

We carried out the modelling in two stages. First, we used observed population, mortality rates, smoking prevalence and smoker mortality risks (see online supplementary table S9) to determine current probabilities of smoking uptake and cessation (see online supplementary table S10). We assumed uptake occurs by age 20 years, and cessation reflected the change in smoking prevalence at ages 20–34, 35–54 and 55+ years, capturing the annual net effect of current smokers quitting and former smokers relapsing in each age group.

We based these calculations of uptake and cessation on changes in smoking prevalence between the 2006 and 2013 Censuses. Since the 2013 Census prevalence included the effects of tax increases between 2010 and 2013, we first removed these effects using price elasticities and adjusting for inflation, so that we could determine the probabilities of uptake and cessation without any tax effects.

Since we did not have Census data for 2011 (our baseline year for forward projections) we back-estimated smoking prevalence in 2011, which included the effects of tax increases already implemented in mid-2010 (17%) and January 2011 (10%), using the same price elasticity and inflation-adjustment methods.

We then used the derived uptake and cessation probabilities, along with forecast population, mortality and smoker mortality risk trends, to simulate prevalence of smoking into the future under a 'no tax increases' scenario (assuming current uptake and cessation trends continue indefinitely) and with the additional effects of annual increases in tobacco tax.

To determine the additional effects of annual tax increases on the smoking prevalence, we assumed a non-linear demand curve with a constant price elasticity of demand, such that:

$$\log Q_{a,t+1} = \log Q_{a,t} + \varepsilon_a \log\left(\frac{P_{t+1}}{P_t}\right)$$

where: $Q_{a,t}$ is the prevalence of smoking at age a and time t; $Q_{a,t+1}$ the prevalence of smoking at age a and time t+1, after the increase in excise; P_t the price of a pack at time t; P_{t+1} the price of a pack at time t+1, after the increase in excise; and ε_a the elasticity applied to smoking prevalence at age a.

Using these methods, and allowing for smoking and ethnic-specific mortality rates, smoking prevalence was predicted annually from 2011 to 2061, for Māori males, Māori females, non-Māori males and non-Māori females, for each of the taxation scenarios.

Change in revenue
We determined the change in New Zealand Government revenue over time from the annual change in excise tax per

cigarette and the change in prevalence of smokers, taking changes in smoking intensity into account. Self-reported smoking intensity, measured in daily cigarette consumption by age and sex, was found to follow a Weibull distribution in New Zealand (see online supplementary table S11). To adjust for potential under-reporting, we scaled the intensity distributions so that the self-reported prevalence and intensity of smoking matched the total volume of tobacco sold in New Zealand in 2011 (3.3 billion cigarette equivalents[21]). This sales adjustment increased mean cigarette consumption from 10 to 14 cigarettes per day.

To determine the change in intensity of smoking with an increase in excise, we shifted the mean of the Weibull distribution, by age and sex, assuming the same non-linear relationship between quantity and price we applied to smoking prevalence (see equation above), where:

$Q_{a,t}$ is the intensity of smoking measured in cigarettes per day, at age a and time t;

$Q_{a,t+1}$ the intensity of smoking measured in cigarettes per day, at age a and time t+1, after the increase in excise; and

ε_a the elasticity applied to smoking intensity at age a.

We applied elasticity values to smoking intensity, by age, equivalent to the elasticity values applied to smoking prevalence, consistent with findings from the IARC Review that the effect is split approximately equally between smoking prevalence and intensity.[2]

Uncertainty analysis
We derived uncertainty intervals for all predictions using Monte Carlo simulation. The uncertainty distributions applied to input parameters are summarised in online supplementary table S8.

RESULTS
With a continuation of recent trends in smoking uptake and cessation, and no tax increases, the prevalence of smoking in New Zealand is projected to fall to 9.9% (95% uncertainty interval 9.8% to 10%) by 2025, well above the smoke-free goal of <5% (table 1). The projections suggest that even annual increases in excise as high as 20%, will not ensure that New Zealand reaches the goal (see online supplementary figure S2).

Smoking is projected to fall among both Māori and non-Māori New Zealanders, but it will take annual increases in excise of at least 20%, if Māori smoking is to reach the smoking levels in 2025 that the non-Māori population have today (2013).

With no increases in excise or other changes in the tobacco market, the price of tobacco would remain stable at 2011NZ $0.70 per stick (legal price), and revenue from cigarette sales would steadily decline as the prevalence of smoking falls over time (table 2). However, increases in excise, raising the price of cigarettes, will instead ensure a steady increase in revenue to at

Table 1 The projected prevalence of daily adult smoking in 2025 with increases in tobacco excise tax of between 0% and 20%

Scenario	Non-Māori men (%)	Non-Māori women (%)	Māori men (%)	Māori women (%)	Total (%)	Year when <5% prevalence reached for adult population
No tax increase (0%)	9.3 (9.2 to 9.4)	6.9 (6.8 to 7)	20 (20 to 21)	21 (20 to 21)	9.9 (9.8 to 10)	2046
Annual 5% increase in excise	8.8 (8.7 to 9)	6.6 (6.4 to 6.7)	19 (19 to 20)	20 (19 to 20)	9.4 (9.3 to 9.5)	2043
Annual 10% increase in excise	8.2 (8.1 to 8.4)	6.1 (6 to 6.3)	18 (17 to 18)	18 (18 to 19)	8.7 (8.6 to 8.9)	2039
Annual 15% increase in excise	7.7 (7.5 to 7.8)	5.7 (5.6 to 5.9)	17 (16 to 17)	17 (17 to 18)	8.2 (8 to 8.3)	2036
Annual 20% increase in excise	7.2 (7 to 7.3)	5.4 (5.2 to 5.5)	15 (15 to 16)	16 (16 to 16)	7.6 (7.5 to 7.7)	2034

Mean and 95% uncertainty intervals presented.

Table 2 The projected legal price per stick and annual excise tax revenue from tobacco excise in 2025, with increases in tobacco excise tax of between 0% and 20%

Scenario	Legal price per stick in 2025 (2011NZ$)	Annual excise revenue in 2025* (2011NZ$billion)
No tax increase (0%)	$0.70 ($0.59 to $0.81)	$1.06 ($0.68 to $1.5)
Annual 5% increase in excise	$1.10 ($0.95 to $1.20)	$2.0 ($1.3 to $2.8)
Annual 10% increase in excise	$1.80 ($1.70 to $1.90)	$3.5 ($2.3 to $5.0)
Annual 15% increase in excise	$3.20 ($3.10 to $3.30)	$6.2 ($4.1 to $8.7)
Annual 20% increase in excise	$5.60 ($5.50 to $5.70)	$10.4 ($6.5 to $15.1)

Mean and 95% uncertainty intervals presented.
*GST is not included in the excise revenue figures presented in the table.

least 2025, despite falling numbers of smokers and shrinking tobacco sales.

Changes to the elasticity assumptions, including removing the age-gradient, adding ethnicity differences in price sensitivity (Māori 50% greater than non-Māori) and changing attribution of behaviour change between prevalence and intensity (25% attributed to changing prevalence rather 50%), have little impact on projected smoking prevalence (table 3) or revenue (table 4) in 2025. Assuming that price changes have a more persistent effect on smoking initiation (ie, that smoking uptake is influenced by incremental price changes in the current and previous year) also has little impact, but additionally assuming a persistent effect for cessation had the largest impact on smoking prevalence in 2025 (7.8% vs 8.7%; table 3).

Our variations in tax pass-through, illicit market share and illicit market price also had relatively little impact on smoking prevalence (table 3) and revenue (table 4) in 2025. Even with the best-case and worst-case combinations of assumptions (figure 1), the projected 2025 smoking prevalence, with an annual 10% increase in excise, only varied between 8.5% at best and 9.2% at worst (compared with 8.7% under base case).

Smoking prevalence does not increase with rapid expansion of illicit market activity, but the fall in prevalence may initially be slower than would occur without any tax changes, if rapid increases in illicit market activity counter the price effects of tax increases (figure 1). However, continued annual increases in excise ensure that smoking prevalence then falls more quickly if illicit market activity stabilises or reaches some plausible maximum. In our worst-case scenario modelling, with a maximum market share of 50% for illicit tobacco, and 10% annual increases in excise, the benefits of the tax increases in reducing smoking prevalence would begin after 7 years.

DISCUSSION

The New Zealand Government has committed to becoming smoke free (smoking prevalence <5%) by 2025. Tobacco control initiatives, including recent removal of tobacco retail displays, Quitline, extensive cessation support and annual 10% increases in tobacco excise (since 2011), have already helped lower smoking prevalence from 20.7% in 2006 to 15.1% in 2013. Our modelling shows that continued commitment to these strategies is likely to reduce smoking prevalence to 8.7% by 2025. While annual 10% increases in tobacco excise are currently legislated until 2016, the modelling suggests that the New Zealand Government will not only need to continue regular tax increases beyond 2016, but also consider substantially higher tax levels and/or a wider range of tobacco endgame strategies, if it is to meet the smoke-free goal by 2025.

Although recently there have been strong declines in smoking prevalence among Māori New Zealanders (42.2% in 2006 to

Table 3 The projected prevalence of daily adult smoking in 2025, with a 10% annual increase in excise tax, under a range of modelling assumptions

Scenario	Non-Māori men (%)	Non-Māori women (%)	Māori men (%)	Māori women (%)	Total (%)	Year <5% prevalence
Annual 10% increase in excise (base-case*)	8.2 (8.1 to 8.4)	6.1 (6 to 6.3)	18 (17 to 18)	18 (18 to 19)	8.7 (8.6 to 8.9)	2039
Persisting impact: initiation†	7.9 (7.7 to 8.1)	5.9 (5.7 to 6)	17 (16 to 17)	17 (17 to 18)	8.3 (8.2 to 8.5)	2035
Persisting impact: cessation†	7.3 (7.1 to 7.5)	5.4 (5.2 to 5.6)	16 (15 to 16)	16 (16 to 17)	7.8 (7.6 to 8)	2034
Elasticity: −0.2 at all ages (prevalence)	7.9 (7.7 to 8.1)	5.9 (5.7 to 6)	17 (17 to 18)	18 (17 to 18)	8.4 (8.3 to 8.6)	2038
Elasticity: 50% higher for Māori	8.4 (8.2 to 8.5)	6.2 (6.1 to 6.3)	17 (17 to 18)	18 (17 to 18)	8.7 (8.6 to 8.8)	2039
Elasticity: prevalence proportion 25%	8.8 (8.6 to 8.9)	6.5 (6.4 to 6.6)	19 (19 to 19)	20 (19 to 20)	9.3 (9.2 to 9.4)	2042
Illicit market: stable at 1%	8.2 (8 to 8.3)	6.1 (5.9 to 6.2)	18 (17 to 18)	18 (18 to 19)	8.7 (8.5 to 8.8)	2039
Illicit market: +5% per year to 50%	8.5 (8.4 to 8.7)	6.3 (6.2 to 6.4)	18 (18 to 19)	19 (18 to 19)	9 (8.9 to 9.1)	2040
Illicit market: +20% per year to 50%	8.5 (8.4 to 8.6)	6.3 (6.2 to 6.4)	18 (18 to 19)	19 (18 to 19)	9 (8.9 to 9.1)	2040
Tax pass-through: 80%	8.3 (8.2 to 8.5)	6.2 (6 to 6.4)	18 (18 to 19)	19 (18 to 19)	8.8 (8.7 to 9)	2039
Tax pass-through: 120%	8.1 (8 to 8.3)	6 (5.9 to 6.2)	18 (17 to 18)	18 (18 to 19)	8.6 (8.5 to 8.7)	2039
Illicit price: 25% of legal price	8.4 (8.2 to 8.6)	6.2 (6.1 to 6.4)	18 (18 to 19)	19 (18 to 19)	8.9 (8.7 to 9)	2039
Illicit price: 65% of legal price	8.2 (8.1 to 8.4)	6.1 (6 to 6.2)	18 (17 to 18)	18 (18 to 19)	8.7 (8.6 to 8.8)	2039
Best-case‡	8 (7.9 to 8.2)	6 (5.9 to 6.1)	17 (17 to 18)	18 (18 to 18)	8.5 (8.4 to 8.7)	2038
Worst-case‡	8.7 (8.5 to 8.9)	6.4 (6.3 to 6.6)	19 (18 to 19)	19 (19 to 20)	9.2 (9 to 9.4)	2040

Mean and 95% uncertainty intervals presented.
*Base-case scenario has illicit price set at the legal price minus two-thirds of the tax, 100% tax pass-through and illicit market share increasing by 1% per year to a maximum of 50% of the market.
†The base-case scenario assumes that price increases in a given year have an effect on initiation and quitting in that year only. In these scenario analyses, we assume that price increases in the current and previous year have an impact on prevalence (via initiation and cessation, respectively), with the same price elasticities as the base-case analysis.
‡Best-case scenario (from a public health perspective) has illicit price set at 65% of the legal price, 120% tax pass-through and illicit market share stable at baseline estimate of 1%. Worst-case scenario has illicit price set at 25% of the legal price, 80% tax pass-through and illicit market share increasing rapidly (20% per year to a maximum of 50% of the market).

Table 4 The projected legal price per stick and annual revenue from tobacco excise tax in 2025, with a 10% annual increase in excise, under a range of modelling assumptions

| Scenario	Legal price per stick in 2025 (2011NZ$)	Annual tax revenue in 2025 (2011NZ$billion)
Annual 10% increase in excise (base-case*)	$1.80 ($1.70 to $1.90)	$3.5 ($2.3 to $5.0)
Elasticity: −0.2 at all ages (prevalence)	$1.80 ($1.70 to $1.90)	$3.3 ($2.2 to $4.7)
Elasticity: 50% higher for Māori	$1.80 ($1.70 to $1.90)	$3.6 ($2.3 to $5.2)
Elasticity: prevalence proportion 25%	$1.80 ($1.70 to $1.90)	$3.4 ($2.1 to $4.8)
Illicit market: stable at 1%	$1.80 ($1.70 to $1.90)	$3.5 ($2.2 to $5.0)
Illicit market: +5% per year to 50%	$2.00 ($1.90 to $2.10)	$3.7 ($2.4 to $5.2)
Illicit market: +20% per year to 50%	$1.40 ($1.30 to $1.50)	$3.6 ($2.3 to $5.2)
Tax pass-through: 80%	$1.40 ($1.30 to $1.50)	$3.5 ($2.2 to $5.0)
Tax pass-through: 120%	$1.70 ($1.60 to $1.70)	$3.5 ($2.2 to $4.9)
Illicit price: 25% of legal price	$2.10 ($2.00 to $2.20)	$3.6 ($2.2 to $5.2)
Illicit price: 65% of legal price	$1.80 ($1.70 to $1.90)	$3.5 ($2.2 to $5.0)
Best-case†	$1.90 ($1.80 to $2.00)	$3.4 ($2.2 to $4.9)
Worst-case‡	$2.20 ($2.10 to $2.30)	$3.7 ($2.4 to $5.3)

Mean and 95% uncertainty intervals presented.
*Base-case scenario has illicit price set at the legal price minus two-thirds of the tax, 100% tax pass-through and illicit market share increasing by 1% per year to a maximum of 50% of the market.
†Best-case scenario (from a public health perspective) has illicit price set at 65% of the legal price, 120% tax pass-through and illicit market share stable at baseline estimate of 1%.
‡Worst-case scenario has illicit price set at 25% of the legal price, 80% tax pass-through and illicit market share increasing rapidly (20% per year to a maximum of 50% of the market).

32.7% in 2013), the gap between Māori and non-Māori health attributable to smoking is likely to remain large for some time yet. Even with tax increases at double the current rate of 10%
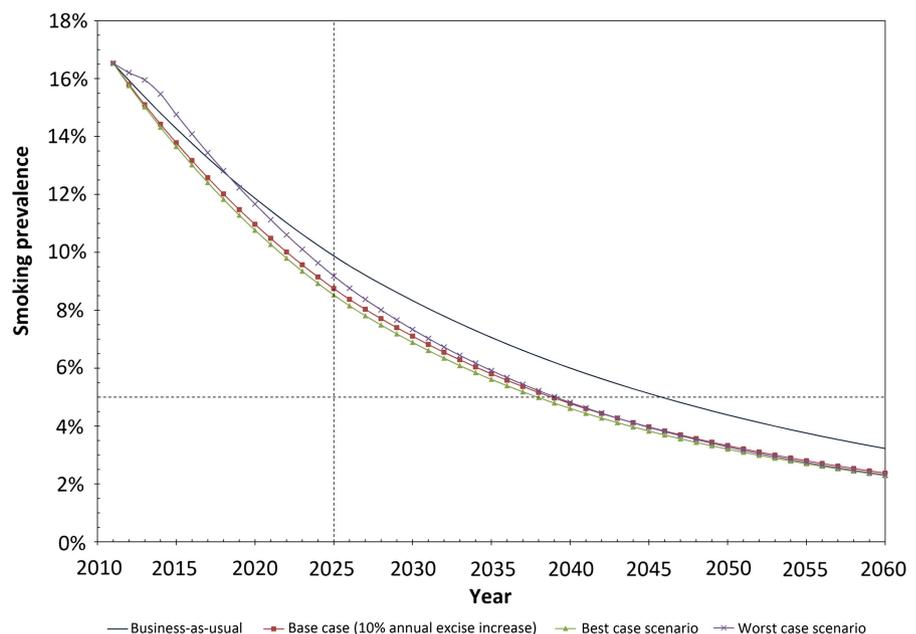
annually, Māori smoking prevalence is only likely to approach current (2013) non-Māori smoking prevalence by 2025.

There are concerns that tobacco taxes may be socially regressive.[22] By 2025 a single cigarette is projected to legally cost 2011NZ$1.80 with 10% annual excise increase (2011NZ$5.60 with 20% annual excise increase). The Government could consider intensifying cessation support and/or adjusting social welfare payments, to address financial hardship experienced by those who continue smoking at current levels of intensity. With an annual 10% increase in excise, revenue from the sale of tobacco products is projected to increase from around 2011NZ $1.3 billion in 2011[21] to around 2011NZ$3.7 billion by 2025, and there is evidence that New Zealand smokers would generally accept tobacco tax rises if they were dedicated specifically for tobacco control.[23 24] However, further research is needed to identify which intervention strategies would be most cost-effective in the New Zealand context.

Our projections of reaching 8.7% national smoking prevalence by 2025 are somewhat more optimistic than the projections of the SimSmoke model in a range of other countries (eg, 17% in Finland and 20% in the Netherlands by 2030) and the projections of the DYNAMO-HIA model (11% in the Netherlands by 2025). Further comparisons can be seen in online supplementary table S1. However, these previous analyses were of one-off increases in taxation rather than a continuing series of tax increases as have recently been implemented in New Zealand. Furthermore, the initial prevalence of smoking in the New Zealand model is already relatively low (15.1% in the 2013 Census) compared to most other countries.

There are also some differences in our modelling methods. For example, we simulated the effects of higher mortality among smokers (and former smokers) on future smoking prevalence, which the SimSmoke model does not. In addition, using national data linkage studies from New Zealand,[25 26] we could model the mortality risks by age, sex, level of smoking and ethnicity for the New Zealand population and project these risks forward in time based on historic ethnic-specific trends; rather than relying on the American Cancer Society's Cancer Prevention Study II from the 1980s to define relative risks of mortality among current and former smokers (as in previous modelling for Australia[18] and Vietnam[27]).

Figure 1 The decline in smoking prevalence over time with no annual increase in tobacco tax compared with annual increases in tobacco excise tax of 10%, under base case, best-case and worst-case scenarios.

Research paper

A key uncertainty in all modelling projections of tobacco tax effects is the stability of price elasticities of demand. Ongoing denormalisation of tobacco smoking and changing economic conditions could influence the future elasticity of demand in response to price changes. It can be noted that price elasticities for much more expensive drugs, such as marijuana (−0.15 to −0.31), cocaine (−0.53 to −0.56) and heroin (−0.47 to −0.54),[28] are not dissimilar. However, price elasticities would also most certainly change with increasing availability of nicotine substitutes such as e-cigarettes, with removal of cigarette additives such as sugars and menthol or with a phase-down in the nicotine content of cigarettes.

Very high tobacco prices could theoretically lead to an increase in home-grown tobacco. While this is currently legal in New Zealand for personal use, it is not an easy crop to grow (part of the reason its commercial production was limited to a small region[29] before being discontinued). The curing and processing is also much more demanding than in the production of marijuana, and the final product is relatively harsh to smoke for those accustomed to manufactured cigarettes with their added sugars, menthol or other additives.[30] For these reasons, we suspect that home growing of tobacco for personal use is only every likely to remain a minority pursuit in a high tobacco tax environment in New Zealand.

The illicit trade in tobacco is always likely to be quite low in relatively isolated islands, such as New Zealand and Australia. However, potential for smuggling is higher in countries that are in close proximity to other countries with much lower taxes (eg, in Europe). While measures to address tobacco industry supply of tobacco to the illicit market could be helpful, regional tax harmonisation[31] could also reduce incentives for large-scale smuggling of tobacco. Our modelling also suggests that while rapid increases in illicit trade may initially counter the price effects of tax increases, the magnitude of long-term reductions in smoking prevalence will far outweigh any short-term effects of increases in illicit trade, if taxes are regularly increased.

CONCLUSION

Regular increases in tobacco taxation can potentially play an important role in the tobacco endgame in New Zealand. With a continued commitment to annual 10% increases in tobacco excise, New Zealand is projected to reach a smoking prevalence of 8.7% (8.6% to 8.9%) by 2025. However, a wider range of tobacco endgame strategies will be needed if New Zealand is to rapidly narrow the gap between Māori and non-Māori smoking and meet the smoke-free goal of less than 5% prevalence by 2025.

What this paper adds

▶ Modelling projections show that sustained increases in tobacco taxation (over-and-above inflation) are likely to play an important role in the tobacco endgame.
▶ Scenario analyses do not suggest that growth in the illicit tobacco market will substantively undermine the impact of sustained tobacco tax rises.
▶ However, New Zealand will need to consider a wider range of tobacco endgame strategies, particularly for the indigenous Māori population, if it is to become smoke free by 2025.

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