Modelling the impacts of tobacco denicotinisation on achieving the Smokefree 2025 goal in Aotearoa New Zealand

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ABSTRACT

AIM: To provide preliminary high-level modelling estimates of the impact of denicotinisation of tobacco on changes in smoking prevalence in Aotearoa New Zealand relative to the New Zealand Government's Smokefree 2025 goal.

METHODS: An Excel spreadsheet was populated with smoking and vaping prevalence data from the New Zealand Health Survey and we projected business-as-usual trends. Using various parameters from the literature (New Zealand trial data, New Zealand EASE-ITC Study results), we modelled the potential impact of denicotinisation of tobacco (with no other tobacco permitted for sale) out to 2025. In addition to the base case (considered most likely), Scenario 1 used estimates from a published expert knowledge elicitation process, and Scenario 2 considered the addition of extra mass-media campaign and Quitline support to the base case.

RESULTS: With the denicotinisation intervention, adult daily smoking prevalences were estimated to decline to under 5% by 2025 for the European/Other ethnic grouping (in the base case and both scenarios) and in one scenario (Scenario 1) for Māori (2.5%). However, prevalence did not fall below 5% in the base case for Māori (7.7%) or in Scenario 2 (5.2%). In the base case, vaping was estimated to increase to 7.9% in the adult population by 2025, and up to 10.7% in one scenario (Scenario 1).

CONCLUSIONS: This preliminary high-level modelling suggests that mandated denicotinisation has a plausible chance of achieving the New Zealand Government's Smokefree 2025 goal. The probability of success would increase if supplemented with interventions such as mass-media campaigns offering Quitline support (especially if predominantly designed for a Māori audience). Nevertheless, there is much uncertainty with these results and more sophisticated modelling is forthcoming.

Tobacco smoking caused an estimated 4,790 attributable deaths in Aotearoa New Zealand in 2019 (95% uncertainty interval (UI): 4,510 to 5,100).[1] The total health loss, including morbidity, in 2019 was estimated at 116,000 disability-adjusted life years (DALYs) lost (95%UI: 108,000 to 125,000).[1] Furthermore, smoking causes health inequities and results in poorer health for Māori relative to non-Māori.[2,3] Exposure to second-hand smoke causes an estimated 347 additional attributable deaths per year in New Zealand, and an additional 9,022 lost DALYs per year.[4]

This high health burden means that the health benefits of tobacco control can be extremely large. The highest-impact intervention in one modelling study (of a sinking lid on tobacco sales) estimated a saving of 1.21 million quality-adjusted life years (QALYs) and NZ$1.71 billion in cost-savings to the health system (lifetime impacts for the population alive in 2011 and undiscounted estimates).[5] These gains are very large when compared with the majority of health sector interventions in an online league table with hundreds of New Zealand and Australian interventions.[6] Other likely benefits from

enhanced tobacco control include reduced health inequities (as Māori would potentially receive the greater per capita health gain)[5] and large economic benefits (as reduced illness among workers will improve productivity). For example, one New Zealand study reported that "the majority of the health benefit over a 10-year horizon from increasing tobacco taxes is accrued in the working-age population (20-65 years)."[7]

In April 2021, the New Zealand Government published a discussion document outlining proposals for an action plan to realise the Smokefree 2025 goal.[8] One of the major potential interventions in this discussion document was the reduction of nicotine in smoked tobacco products to very low levels (ie, to levels that are likely to be non-addictive). International interest in this particular "denicotinisation" policy measure is increasing and the US Food and Drug Administration has announced its intention to introduce a risk-proportionate regulatory framework for nicotine products.[9] As such, it issued an Advance Notice of Proposed Rulemaking that recommends developing a tobacco-product standard for minimal or non-addictive nicotine levels in cigarettes.[10] Recent media reports suggest introducing a mandated reduced-nicotine policy for cigarettes is currently under active consideration by the US Administration.

Several reviews and commentaries, and many individual studies,[11–39] have also investigated the impact of very low nicotine cigarettes (VLNCs), which are generally defined as having around 0.4mg or less nicotine per gram of tobacco or per cigarette. Overall, this work has concluded that most people who smoke and who are provided with VLNCs find these cigarettes unrewarding. As a result, study participants often cut down on the number of cigarettes per day, have similar or lower biomarkers of exposure to toxins, experience fewer withdrawal effects, make more quit attempts and become more likely to quit successfully (see elsewhere[40] for a recent review of these issues).

Modelling studies also suggest that a mandated VLNC policy would result in substantial reductions in smoking prevalence and gains in population health.[41,42] A historical modelling study has also estimated that, had the tobacco industry introduced VLNCs when the health effects of smoking were established in the 1960s, millions of lives would have been saved.[43]

The VLNC/denicotinisation approach aligns with the findings of a government inquiry in 2010 by the Māori Affairs Committee, which recommended reducing the additives and nicotine in tobacco to help achieve the proposed Smokefree 2025 goal (recommendation 9).[44] This approach has public support. For example, 80% of respondents in a recent New Zealand survey of people who smoke, or who have recently quit (n=1,090, including 363 Māori), supported mandated VLNCs, provided alternative nicotine products were available.[45] In the next wave of this survey (n=1,020, including 394 Māori), 73% of respondents supported this proposed policy.[46] International studies have also reported very strong support for this policy.[47,48]

Given this support and earlier calls for VLNCs, we modelled the likely impact of denicotinisation to inform the New Zealand Government's upcoming decision-making.

Methods

Base case analysis assumptions

We assumed the following steps and input parameters for the analysis of our base case (considered most likely):

1. Consultation and deliberation via parliamentary processes (eg, select committee) on the proposed denicotinisation law was assumed to occur in late 2021. In 2021 and 2022, the business-as-usual (BAU) downward trends in smoking prevalence for all groups would be as per the average trend for the eight-year period between 2011/2012 and 2019/2020[49] (the period for which the New Zealand Health Survey (NZHS) was run continuously). For the more recently collected data on vaping in the NZHS (ie, daily e-cigarette use), we used the pattern between 2018/2019 and 2019/2020 (NZHS data[50]) for the BAU trend. The European/Other ethnic grouping includes all New Zealanders who are not Māori, Pacific peoples or Asian peoples in the NZHS data.
2. The denicotinisation law was assumed to pass in 2022 with an imple-

mentation date of early 2023 (ie, from which point the only tobacco permitted for sale in New Zealand would be denicotinised tobacco).

3. We assumed that in 2023 and each subsequent year the initiation of smoking in the 18–24-year-old age-group would reduce by 75% (due to the non-addictive nature of the denicotinised tobacco). Thus, in each year there would be a reduction of around 6,500 smokers (one seventh of the 61,000 smokers in this age-group multiplied by 75%; NZHS data for 2019/2020[49]). Although this 75% value is very uncertain, we considered it reasonable, given what is known about VLNCs (see the introduction, above). However, we note others have estimated a lower value of 50%,[51] which we use in Scenario 1. We did not estimate the proportion that would have taken up vaping instead.
4. We assumed that 33% of smokers would quit in 2023, as per the New Zealand trial data for such products (more specifically, in a trial of 1,410 people, 33% had quit at six months with no reported difference in impact between Māori and non-Māori[31]). The remaining 67% were assumed to continue smoking, using either denicotinised tobacco or regular tobacco (obtained via illicit supply or via home-grown tobacco for personal use, which is legal in New Zealand). Those who would quit were assumed to become either quitters or vapers as per the ratios identified in the EASE-ITC Study (preliminary data were supplied by the principal investigator of this study). Respondents in this study answered the following question: "Which one of the following would you be most likely to do if the amount of nicotine in cigarettes was greatly reduced so that they are no longer addictive?" Response options included: "quit smoking entirely" (13.5% of respondents; a mix of smokers and recent quitters gave this answer) and "switch to vaping/e-cigarettes" (13.2% gave this answer). We assumed there would be no major reductions in the accessibility of vaping products in the time-period studied.
5. We assumed that there would be the same impact in 2024 and 2025 as there would be in 2023 (ie, 33% of smokers using denicotinised tobacco would quit per year). We assumed that this relatively high rate of quitting would be sustained due to the non-addictive nature of the denicotinised tobacco product and the growing denormalisation of smoking as additional tobacco control measures described in the action plan for a smokefree Aotearoa are implemented.

Assumptions for the Scenario 1 analysis (alternative parameters)

As an alternative approach, we considered expert knowledge elicitation work by Apelberg et al,[51] which has also been used in other modelling work examining denicotinisation in the US.[43] Apelberg et al gave the following values when using the 50th percentile estimates from the elicitation exercise (though we have averaged the values for male and female smokers):

In the first year, when only denicotinised cigarettes were permitted on the New Zealand market (the year 2023, as per above):

- 50% reduction in initiation (in contrast to the 75% we used in the base case)
- 20% of smokers quit and do not switch products (ie, end use of nicotine completely)
- 37.5% of smokers quit and switch to non-combustible tobacco products (we assumed these products would be e-cigarettes in New Zealand)

In the second year and each subsequent year up to and including 2025, the respective values were:

- 50% reduction in initiation
- 14.3% quit
- 38.3% switch (to vaping as per the first year detailed above)

Assumptions for the Scenario 2 analysis (extra campaign/Quitline support)

We also considered the impact of promoting cessation via mass media, as well as Quitline support, to the base case's denicotinisation intervention. The impact of New Zealand's Quitline has been well established via multiple studies (including randomised trials) and via a detailed New Zealand modelling study that included media campaign impacts.[52] We used the results from this modelling study to consider the impact of doubling mass-media campaign expenditure with Quitline support (a "campaign/service" package). That is, in normal times, the routine campaign/Quitline support (taking Māori men and women combined) accounted for 1.055% of the estimated 4.2% background net cessation rate (a 25.1% contribution (1.055/4.2)) in the 35–54-year-old age-group (see in the publication by Nghiem et al[52]: Table 2 for the 1.055% value and Table A2 for the 4.2% value in the main text and Supplementary file respectively). The equivalent proportion from this package for non-Māori was 21.2%. We then applied these two proportions to enhancing the cessation rate associated with denicotinisation. In other words, this extra intervention package was assumed to increase the annual cessation rate from 33% (for denicotinisation as per Walker et al[31]) to 41% for Māori and from 33% to 40% for European/Other.

The results for the base case and scenario analyses were generated in an Excel spreadsheet, which is available on reasonable request from any of the six authors.

Results

Estimates for the modelled base case and scenario analyses are detailed in Table 1 and Figures 1–3. In the base case and both scenarios there were major reductions in smoking prevalence for both Māori and European/Other compared to the BAU projection. If achieving the Smokefree 2025 goal is assumed to involve adult daily smoking prevalences of under 5%, then Scenario 1 would achieve the goal for both Māori and European/Other (prevalences at 2.5% and 0.9% respectively in 2025). However, the estimates for Māori in the base case (7.7% in 2025) and Scenario 2 (5.2% in 2025) do not realise the Smokefree 2025 goal. Vaping was estimated to increase to 7.9% (in 2025) in the base case and to 10.7% (in 2025) in Scenario 1 (Table 1, Figure 3).

Discussion

Main findings and interpretation

These preliminary high-level modelling results suggest that a tobacco denicotinisation law could come close to achieving, or potentially achieve, the New Zealand Government's Smokefree 2025 goal. However, to be more certain about achieving the goal for Māori, denicotinisation would probably need to be supplemented with mass-media campaigns and enhanced Quitline support that goes beyond doubling of the current level (as per Scenario 2). Targeting these campaigns to Māori audiences could build on the success of "by Māori, for Māori" campaigns in the past (eg, the It's About Whānau campaign[53,54]). The addition of other complementary strategies, as outlined in the discussion document,[8] could also increase the likelihood that the prevalence of smoking falls below 5% among Māori.

However, a partial consequence of these potential outcomes following denicotinisation would probably be a rise in vaping prevalence (as per Figure 3). Vaping still typically involves nicotine addiction, ongoing costs to users and potential long-term harms to health, which are likely to be higher than previously thought.[55,56] Nevertheless, our estimates of vaping prevalence may be over-stated if ex-smokers who vape were to subsequently quit vaping at higher levels than seen to date. On the other hand, our estimates do not consider a potential increase in the uptake of vaping among those who won't initiate smoking because denicotinised tobacco is non-addictive.

We must emphasise the uncertainty of these high-level modelling results, given the incomplete international experience on the effects of denicotinising a country's entire tobacco supply. Therefore, these results should be considered preliminary until more sophisticated modelling analyses are performed (eg, similar to the much more elaborate tobacco-control modelling studies

Table 1: Estimated daily smoking and daily vaping prevalences (%) for BAU projection and the base case model and for two scenario analyses as a result of a tobacco denicotinisation policy (in New Zealand adults aged 15+ years, mid-year estimates).

Population group	Years up to, and including, the Smokefree 2025 goal					
	2020*	2021 (law debated)	2022 (law passed)	2023 (law comes into force)	2024 (2nd year of the law)	2025 (year of the Smokefree 2025 goal)
BAU						
Māori smoking	28.7	27.7	26.8	25.9	25.0	24.2
European/Other smoking	10.1	9.6	9.2	8.8	8.4	8.0
Base case intervention (denicotinisation)						
Māori smoking	28.7	27.7	26.8	17.7	11.7	7.7
European/Other smoking	10.1	9.6	9.2	6.1	4.0	2.7
Total population** smoking	11.1	11.1	10.6	7.0	4.6	3.1
Total population vaping	3.5	3.8	4.2	6.0	7.1	7.9
Scenario 1 (parameters based on expert elicitation work for the US by Apelberg et al[51])						
Māori smoking	28.7	27.7	26.8	11.3	5.3	2.5
European/Other smoking	10.1	9.6	9.2	3.9	1.8	0.9
Total population smoking	11.1	11.1	10.6	4.5	2.1	1.0
Total population vaping	3.5	3.8	4.2	8.2	9.9	10.7
Scenario 2 (adding to the base case by doubling mass media campaign/Quitline support)						
Māori smoking	28.7	27.7	26.8	15.5	9.0	5.2
European/Other smoking	10.1	9.6	9.2	5.4	3.2	1.9
Total population smoking	11.1	11.1	10.6	6.3	3.7	2.2
Total population vaping	3.5	3.8	4.2	6.0	7.0	7.6

* New Zealand Health Survey data for 2019/2020.[49] Technically, for the 2020 year these data were collected during 2019/2020 year with some data collection limited by the COVID-19 pandemic in early 2020.

** In addition to the ethnic groups detailed in this table, the total population in the New Zealand Health Survey also comprises Pacific peoples and Asian peoples.

Figure 1: Estimated daily smoking prevalence among Māori for the BAU projection and as a result of a tobacco denicotinisation policy (as per data in Table 1).

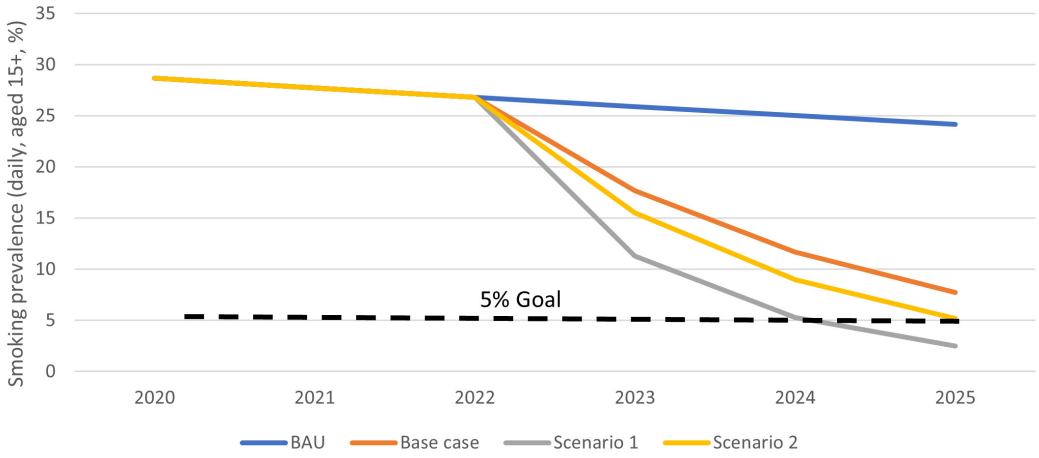
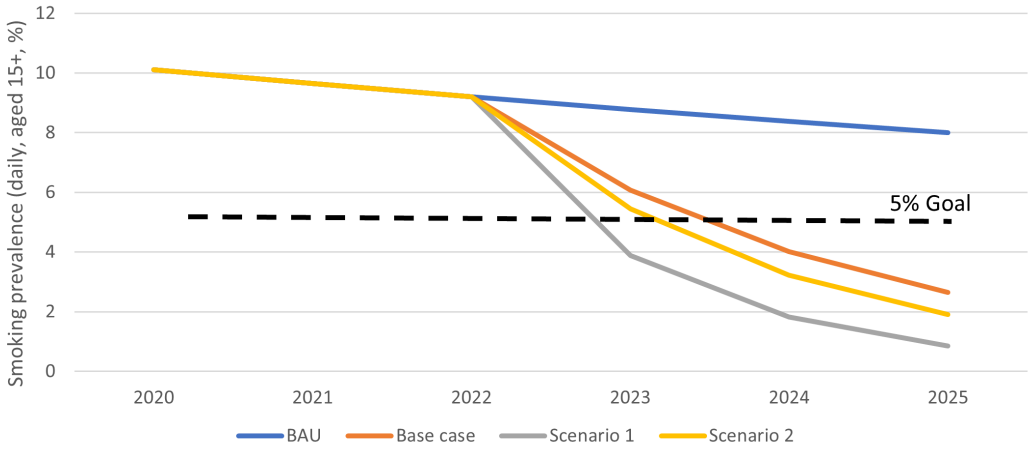


Figure 2: Estimated daily smoking prevalence among European/Other in the BAU projection and as a result of a tobacco denicotinisation policy (as per data in Table 1).



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previously conducted in New Zealand). Such modelling is currently underway using a Python platform, and it will capture more epidemiologically precise details. It will also quantify impacts on QALYs saved, impact on health inequities (by ethnicity and potentially socioeconomic status) and savings in costs to the New Zealand health system. As such, it is similar to past tobacco[5,7,52,57–60] and e-cigarette modelling[61,62] by the BODE[3] programme.

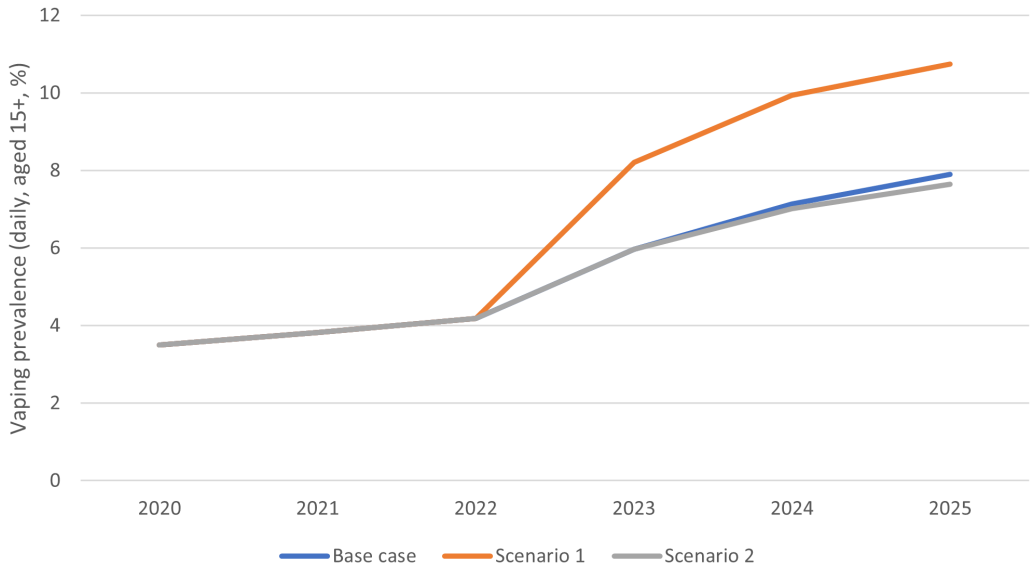
Study strengths and limitations

A strength of this modelling study is that it was relatively simple and therefore it was fairly quick to build the model and easy to check it. Also, we populated the model with detailed New Zealand smoking and vaping data, including a randomised control trial (RCT) using VLNCs conducted in the country. Nevertheless, the overall value of the modelling is limited owing to the constraints with external validation (ie, only clinical trial data) and not real-world, jurisdiction-level experience with denicotinisation.

More specifically, the 33% quit rate from this New Zealand RCT on VLNCs[31] may underestimate the true impact of a denicotinisation intervention, as it was undertaken in a BAU context. That is, participants could easily access regular tobacco from thousands of retail outlets and via social sources, such as friends and family members. Furthermore, vaping products were not widely available when this trial was undertaken and, therefore, were not the viable alternative that they are in 2021. If only denicotinised tobacco were available, the only legal alternatives would be quitting, vaping or pharmaceutical-grade products (eg, nicotine gum and patches). On the other hand, we have assumed that, among the 33% of people estimated to quit, none would relapse (ie, subsequently use either illicit or home-grown tobacco). Also of note was that the New Zealand RCT by Walker et al[31] involved people motivated to quit, given they had called the Quitline and were provided with free access to nicotine replacement therapy. Yet there is also evidence from a small pilot study in New Zealand (n=33 participants) that unmotivated smokers given denicotinised cigarettes (when priced according to nicotine content) experience reduced tobacco dependence and increased quitting activity.[30]

Another limitation is that we did not model potential changes in the size of the illicit and home-grown markets following

Figure 3: Estimated vaping prevalence in the total population for the BAU projection and as a result of a tobacco deionisation policy (as per data in Table 1).



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a denicotinisation law coming into force. In terms of the current size of the illicit market, reviews have noted the limited number of independent (non-tobacco-industry funded) studies for New Zealand.[63] Nevertheless, the most recent independent estimate from 2013 was that illicit products made up only 1.8–3.8% of the New Zealand market.[64] Commentators have also suggested that any increase in illicit trade is likely to be modest and would not undermine the substantial positive effects of a denicotinisation policy in reducing smoking prevalence.[65] Furthermore, New Zealand has very strong border controls and surveillance, which, coupled with its island status and relative geographical isolation, reduces the likelihood that smuggled tobacco would become a major problem (at least compared to European countries). Nonetheless, surveillance and enforcement should ideally be strengthened further during any period of enhanced tobacco control, as suggested in the government's discussion document.[8]

Also, given the difficulties of growing tobacco in much of New Zealand,[66] it seems unlikely that supply via this source would be large. The long curing time and difficulties with mould growth in high-humidity environments are other impediments. Finally, the "roughness" of home-grown products that lack additives (eg, flavours and humectants) may not suit the taste of most New Zealand smokers, especially compared to vaping. Furthermore, the government could reduce the amount of tobacco that may be legally grown for personal use by home-growers, or even require home-growers to have a licence to grow (to allow for occasional spot checks and ensure compliance with the law).

Finally, our study did not include results for smoking and vaping among a range of other groups, including Pacific peoples, Asian peoples and groups with differing socioeconomic status. It also used a one-year modelling cycle and so does not capture more fine-grained monthly changes (eg, associated with increased quitting in advance of the new law being operationalised).

Conclusions

This preliminary high-level modelling suggests that policy-mandated denicotinisation could have a plausible chance of achieving the New Zealand Government's Smokefree 2025 goal. The probability of success would further increase if it were supplemented with other interventions, such as mass-media campaigns and Quitline support (especially if it is predominantly designed for a Māori audience). Nevertheless, there is much uncertainty with these preliminary high-level results and more sophisticated modelling is needed to quantify impacts on QALYs saved and health inequities and to estimate savings in health costs.

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