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Scalable Health Intervention Evaluation

Tobacco endgame intervention impacts on health gains and Maori:non-Maori health inequity: a simulation study of the Aotearoa/New Zealand Tobacco Action Plan

Ait Ouakrim D, Wilson T, Waa A, Maddox R, Andrabi H, Mishra SR, Summers JA, Gartner CE, Lovett R, Edwards R, Wilson N, Blakely T.

Tob Control 2023: tc-2022-057655.

https://mspgh.unimelb.edu.au/shine

TOBACCO ENDGAME
NHMRC Centre of Research Excellence

Context

The BODE[3] Program, Uni Otago (NZ; myself and Nick Wilson Directors), has undertaken tobacco control modelling for some years:

- E.g. Van der Deen et al. Impact of five tobacco endgame strategies on future smoking prevalence, population health and health system costs. *Tob Control 2018;* 27(3): 278-86.
- BODE[3] modelling found to be highest quality of 25 international tobacco models in recent review (Cheung et al, Tob Control 2022)

In the last 1-2 years, we have been building 'next generation' of SHINE models at Uni Melb, in Python with a tobacco-vaping Markov life history model that feeds into a proportional multistate lifetable model:

- e.g. Blakely et al. Proportional multistate lifetable modelling of preventive interventions: concepts, code and worked examples. *Int J Epidemiol* 2020; 49(5): 1-13.

Many researchers in NZ have been researching and advocating for an endgame plan for a decade or more. The argument was strengthened by tobacco being a major (modifiable) cause of Māori:non-Māori inequalities (Indigenous: non-Indigenous). Then in 2021-22 the NZ Government became very serious about an endgame, and in particular denicotinisation.....

…. and we were asked to model an Endgame Package for the NZ Government, to inform its Action Plan (launched Dec 2021) and the *Regulatory Impact Statement* underpinning it.

This presentation presents that modelling.

Objectives of this presentation

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Estimate the health impacts of

smoking prevalence, mortality and health adjusted life year impacts (including changes in Māori: non-Māori inequality)

and cost impacts

health expenditure and income productivity (using linked health-tax data to estimate income loss when acquiring disease, and hence income gain when not acquiring tobacco-related disease **)

of five tobacco endgame strategies implemented from 2022-23 onwards

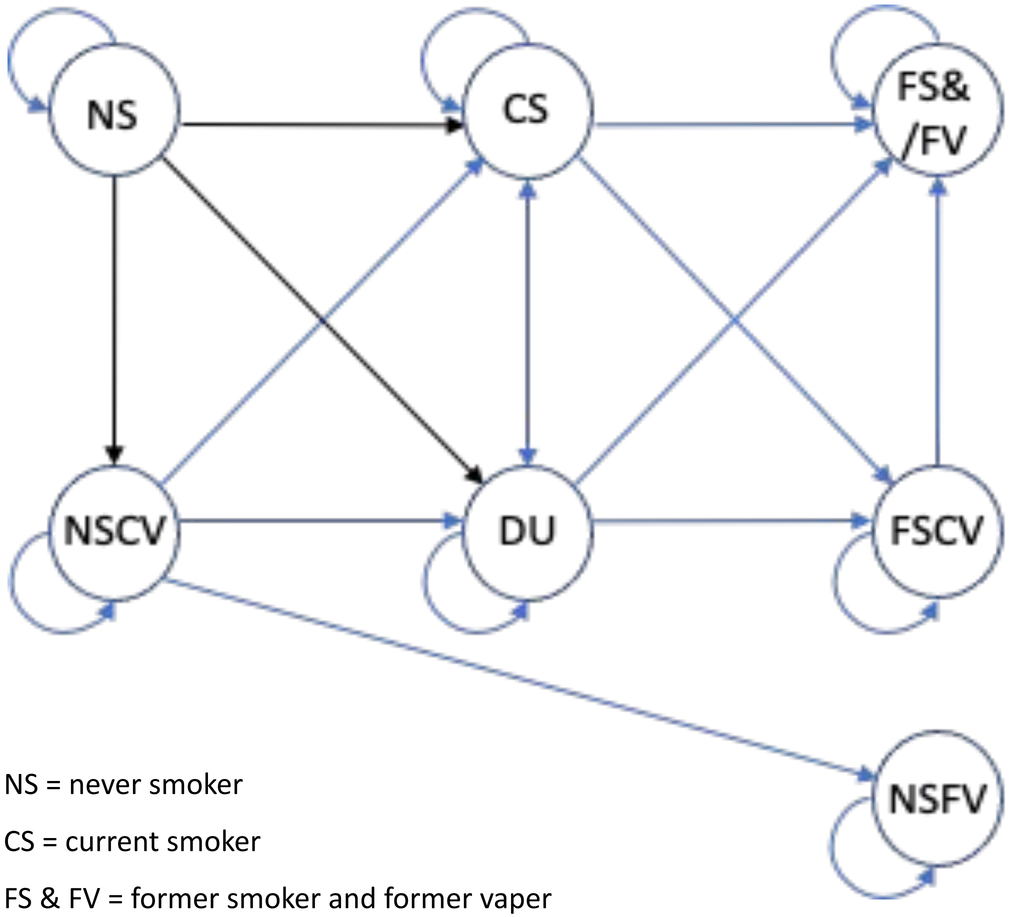
a) Denicotinize all sold tobacco; b) Denic + media; c) 95% reduction in retail; d) tobacco-free generation; e) all combined

** Blakely T, Kvizhinadze G, Atkinson J, Dieleman J, Clarke P. Health system costs for individual and comorbid noncommunicable diseases: An analysis of publicly funded health events from New Zealand. *PLoS Med 2019;* ***16(1): e1002716.***
** Blakely T, Sigglekow F, Irfan M, Mizdrak A, Dieleman J, Bablani L, Clarke P, Wilson N. Disease-related income and economic productivity loss in New Zealand: A longitudinal analysis of linked individual-level data. *PLoS Med 2021;* ***18(11): e1003848.***

Endgame policies, and brief notes on specification

Policy	Effect	Source
Denicotinize	- **90% reduction in initiation by 5 years** after implementation then held constant thereafter **(95% UI: 78.5% to 97.4%)** - **85% reduction in prevalence by 5 years** after implementation due to quitting or switching to vaping. For 6th and later years, the transition to quitting or vaping were twice those in BAU (**95% UI: 67.1% to 96.3%)**	- Walker et al. 2012 (*The combined effect of very low nicotine content cigarettes, used as an adjunct to usual Quitline care (nicotine replacement therapy and behavioural support), on smoking cessation: a RCT.*) - Expert knowledge elicitation
Denicotinize + enhanced* media campaign	As above, plus: - Years 1 to 5: above, **plus twice the absolute contribution of the routine media/Quitline campaign to net cessation** (i.e. 1.055% * 2)	- As above + Nghiem et al. 2018 (*A national quitline service and its promotion in the mass media: modelling the health gain, health equity and cost-utility*)
Retail outlet reduction	- **19.2% reduction in initiation** from 2023 onwards - Year 1: **19.2% increase in BAU transition probability of quitting tobacco smoking** (**95% UI: 12.9% to 26.9%**; applied as 9.6% increase in prob. of quitting and 9.6% increase in prob. of switching to vaping)	- van der Deen et al. 2019 (Theoretical impacts of a range of major tobacco retail outlet reduction interventions: modelling results in a country with a smoke-free nation goal) - Edwards et al. 2021 (*Support for New Zealand's Smokefree 2025 goal and key measures to achieve it: findings from the ITC New Zealand Survey*)
Smokefree generation	- **90% reduction in initiation by 10 years** after implementation **(95% UI:78.5% to 97.4%)**	- NZ MoH 2021
Combined	- Combined above	- na

Tobacco and vaping life history Markov model



NS = never smoker

CS = current smoker

FS & FV = former smoker and former vaper

NSCV = never smoker current vaper

DU = dual user

FSCV = former smoker current vaper

NSFV = never smoker former vaper

Key model design assumptions

- Smoking initiation (transition from NS to CS or DU) and vaping initiation (transition from NS to NSCV) were assumed to occur at age 20 years.
- Any quitting of smoking was assumed permanent, parameterized as a 'net' cessation rate (i.e. the net of quit attempts and relapse) from CS and DU to either FSCV or FSFV.
- The FSFV, FSCV and NSFV states were additionally modelled as 20-year tunnel states that the cohort progressed through each year, allowing the model to identify how many years each cohort was from quitting so as to reflect decaying impacts of smoking on disease incidence by time since quit

Proportional multistate lifetable model (PMSLT)

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The simulation is based on an established PMSLT model composed of:

1) Main cohort lifetable simulating the entire 2020 New Zealand population using projected all-cause mortality/morbidity rates by sex, age and ethnicity (Māori and non-Māori).

2) Proportions of the cohort also reside in 16 subsidiary tobacco-related disease lifetables according to prevalence at baseline (i.e. start of model), and in future years based on BAU disease-specific incidence, case fatality and remission rates.
   - *The tobacco related disease are: coronary heart disease, stroke, chronic obstructive pulmonary disease (COPD), lower respiratory tract infection (LRTI), and twelve cancers (lung, oesophageal, stomach, liver, head and neck, pancreas, cervical, bladder, kidney, endometrial, melanoma, and thyroid).*

3) Each disease lifetable estimates the difference between intervention and BAU in disease mortality and morbidity rates (and health expenditure and income) due to the intervention's changes in smoking and vaping rates…..

4) …. which are then 'summed up' in an overarching all-cause mortality and morbidity lifetable

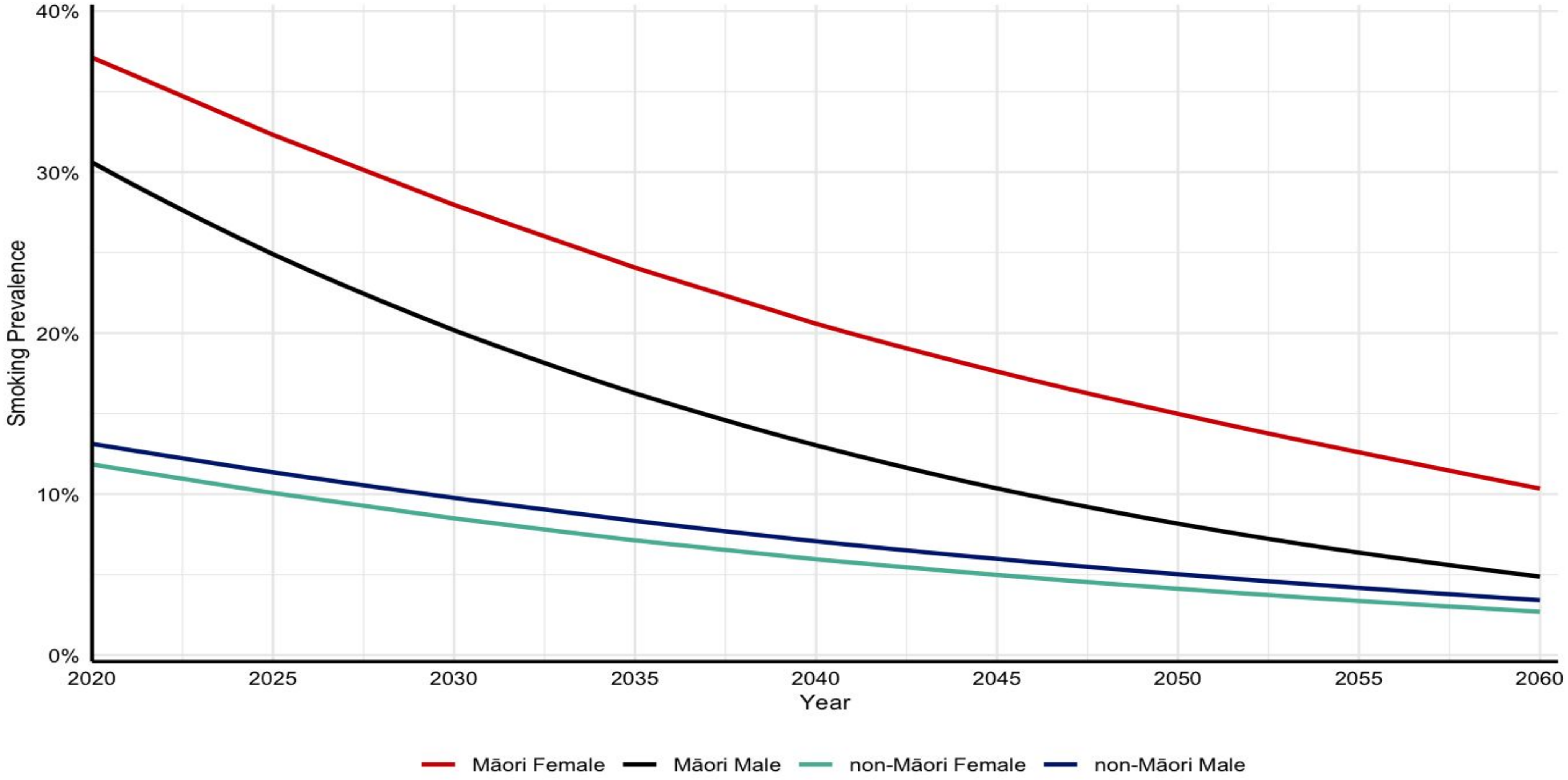
See this for details: Blakely T, Moss R, Collins J, Mizdrak A, Singh A, Carvalho N, Wilson N, Geard N, Flaxman A. Proportional multistate lifetable modelling of preventive interventions: concepts, code and worked examples. *Int J Epidemiol 2020;* ***49(5): 1-13.***

Harm of vaping relative to smoking

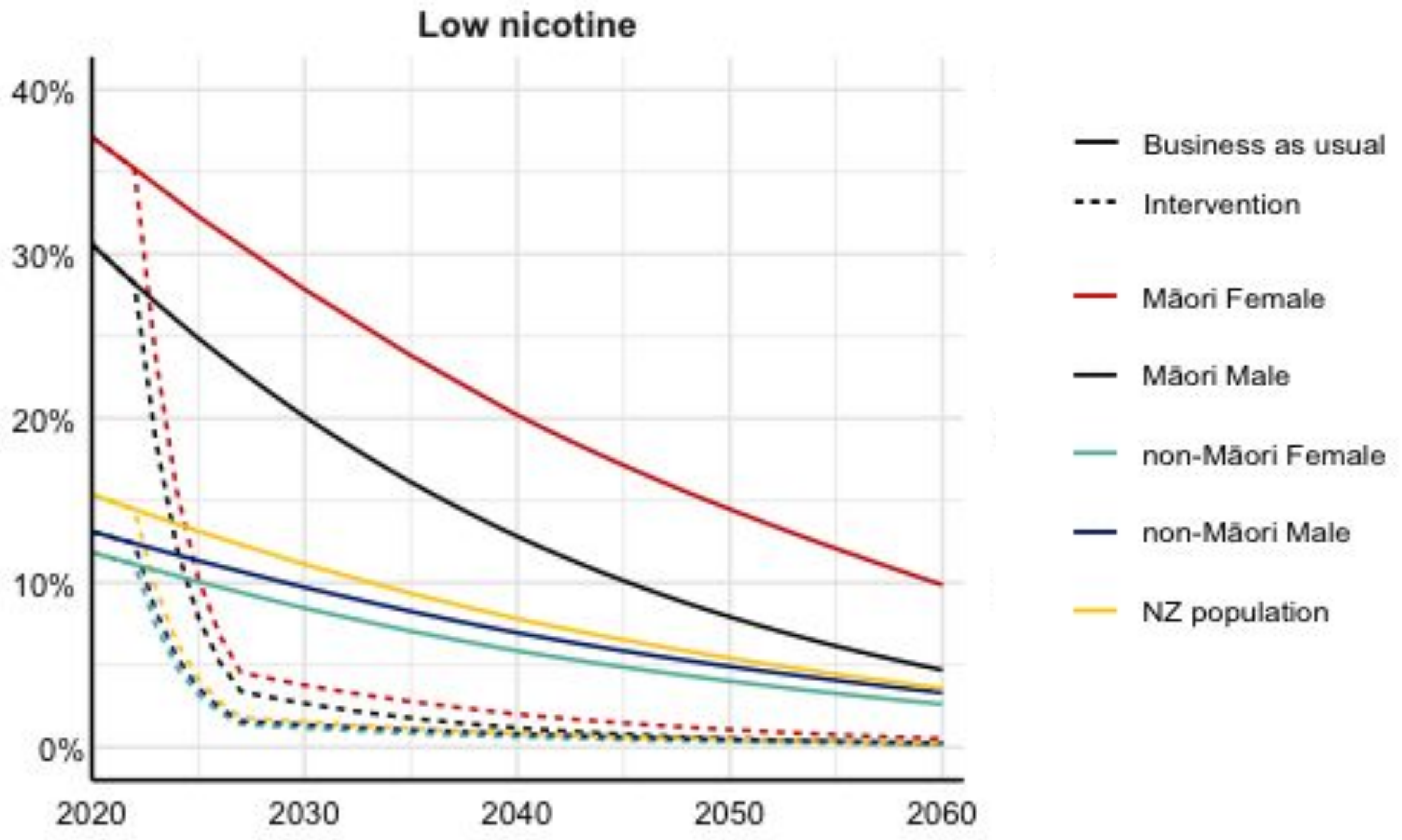
- Arguably, the hardest input parameter in this study to work out!
- After considering and trialing cross-walking toxicology studies by disease, we defaulted to ‘simply’ assuming 5% to 20% of the harm of tobacco
- For this paper, the results are not too sensitive to this vaping harm as:
  - Vaping relatively uncommon compared to smoking
  - Harm less than smoking

Results

Projections of smoking prevalence (daily smoking, population aged 20+ years) in Aotearoa New Zealand under business-as-usual



Smoking prevalence (daily, 20+ year population) in Aotearoa New Zealand: business-as-usual vs. interventions



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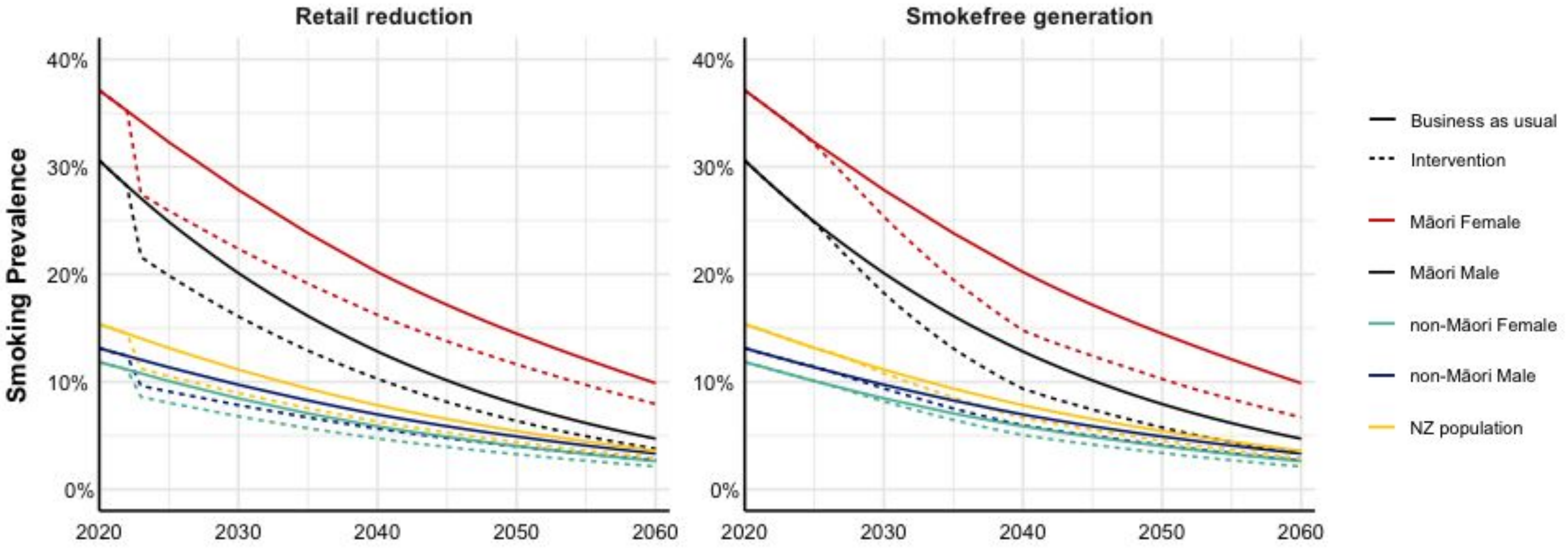

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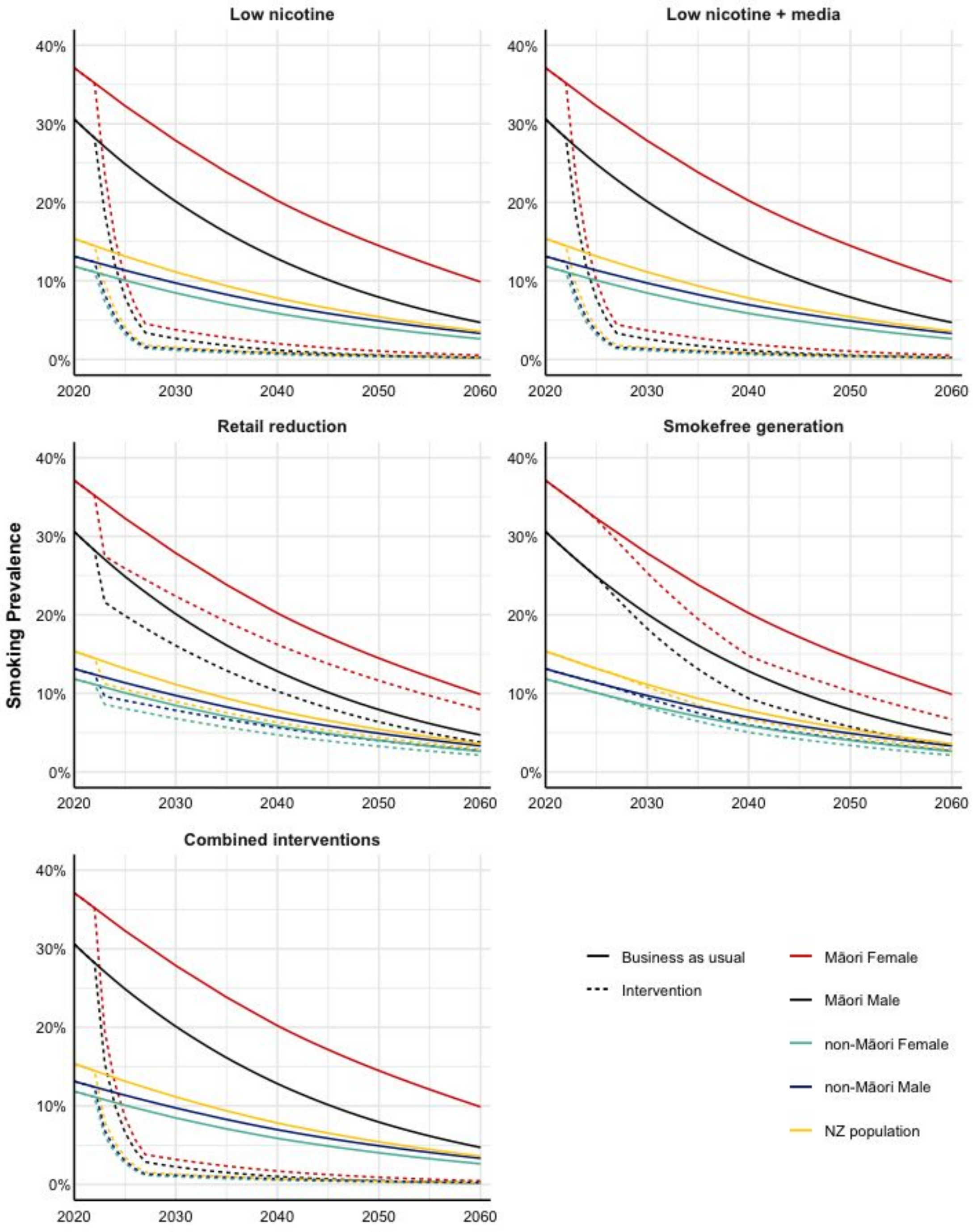
Smoking prevalence (daily, 20+ year population) in Aotearoa New Zealand: business-as-usual vs. interventions



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Estimated smoking prevalence (20+ year olds) in NZ by policy scenario

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Policy	Sex ethnic	2020 (base year)	2025	(2025 95% UI)			
Business as usual	Māori Female	37.1%	32.3%	(31.7% to 32.7%)			
	non-Māori Female	11.8%	10.1%	(9.5% to 10.5%)			
	Māori Male	30.6%	24.9%	(24.1% to 25.5%)			
	non-Māori Male	13.1%	11.3%	(10.5% to 12.0%)			
Low nicotine	Māori Female	37.1%	10.3%	(6.7% to 14.6%)			
	non-Māori Female	11.8%	3.2%	(2.2% to 4.4%)			
	Māori Male	30.6%	7.9%	(5.3% to 11.1%)			
	non-Māori Male	13.1%	3.6%	(2.6% to 4.9%)			
Low nicotine + media	Māori Female	37.1%	10.0%	(6.5% to 14.0%)			
	non-Māori Female	11.8%	3.1%	(2.1% to 4.2%)			
	Māori Male	30.6%	7.7%	(5.1% to 10.7%)			
	non-Māori Male	13.1%	3.5%	(2.5% to 4.7%)			
Retail reduction	Māori Female	37.1%	25.9%	(24.1% to 27.4%)			
	non-Māori Female	11.8%	8.0%	(7.4% to 8.6%)			
	Māori Male	30.6%	19.9%	(18.4% to 21.2%)			
	non-Māori Male	13.1%	9.1%	(8.2% to 9.9%)			
Smokefree generation	Māori Female	37.1%	32.1%	(31.4% to 32.7%)			
	Māori Male	30.6%	24.8%	(24.0% to 25.6%)			
	non-Māori Female	11.8%	10.1%	(9.6% to 10.6%)			
	non-Māori Male	13.1%	11.4%	(10.6% to 12.1%)			
Combined interventions	Māori Female	37.1%	8.6%	(5.6% to 12.0%)			
	non-Māori Female	11.8%	2.7%	(1.8% to 3.6%)			
	Māori Male	30.6%	6.6%	(4.4% to 9.1%)			
	non-Māori Male	13.1%	3.0%	(2.1% to 4.1%)			

Estimated smoking prevalence (20+ year olds) in NZ by policy scenario

Policy	Sex ethnic	2020 (base year)	2025	(2025 95% UI)	2030	2035	2040
Business as usual	Māori Female	37.1%	32.3%	(31.7% to 32.7%)	27.8%	23.8%	20.2%
	non-Māori Female	11.8%	10.1%	(9.5% to 10.5%)	8.5%	7.1%	5.9%
	Māori Male	30.6%	24.9%	(24.1% to 25.5%)	20.1%	16.1%	12.8%
	non-Māori Male	13.1%	11.3%	(10.5% to 12.0%)	9.7%	8.3%	7.0%
Low nicotine	Māori Female	37.1%	10.3%	(6.7% to 14.6%)	3.8%	2.8%	2.0%
	non-Māori Female	11.8%	3.2%	(2.2% to 4.4%)	1.2%	0.8%	0.6%
	Māori Male	30.6%	7.9%	(5.3% to 11.1%)	2.7%	1.8%	1.2%
	non-Māori Male	13.1%	3.6%	(2.6% to 4.9%)	1.4%	1.1%	0.8%
Low nicotine + media	Māori Female	37.1%	10.0%	(6.5% to 14.0%)	3.7%	2.7%	2.0%
	non-Māori Female	11.8%	3.1%	(2.1% to 4.2%)	1.1%	0.8%	0.6%
	Māori Male	30.6%	7.7%	(5.1% to 10.7%)	2.6%	1.7%	1.2%
	non-Māori Male	13.1%	3.5%	(2.5% to 4.7%)	1.3%	1.0%	0.8%
Retail reduction	Māori Female	37.1%	25.9%	(24.1% to 27.4%)	22.3%	19.1%	16.2%
	non-Māori Female	11.8%	8.0%	(7.4% to 8.6%)	6.8%	5.7%	4.7%
	Māori Male	30.6%	19.9%	(18.4% to 21.2%)	16.1%	12.9%	10.3%
	non-Māori Male	13.1%	9.1%	(8.2% to 9.9%)	7.8%	6.7%	5.6%
Smokefree generation	Māori Female	37.1%	32.1%	(31.4% to 32.7%)	26.2%	20.2%	15.4%
	Māori Male	30.6%	24.8%	(24.0% to 25.6%)	18.9%	13.6%	9.7%
	non-Māori Female	11.8%	10.1%	(9.6% to 10.6%)	8.3%	6.6%	5.2%
	non-Māori Male	13.1%	11.4%	(10.6% to 12.1%)	9.6%	7.7%	6.1%
Combined interventions	Māori Female	37.1%	8.6%	(5.6% to 12.0%)	3.2%	2.3%	1.7%
	non-Māori Female	11.8%	2.7%	(1.8% to 3.6%)	1.0%	0.7%	0.5%
	Māori Male	30.6%	6.6%	(4.4% to 9.1%)	2.2%	1.5%	1.0%
	non-Māori Male	13.1%	3.0%	(2.1% to 4.1%)	1.2%	0.9%	0.7%

Estimated smoking prevalence (20+ year olds) in Aotearoa New Zealand by policy scenario for 2020, 2025, 2030, and 2040, by sex and ethnicity

Policy	Population	2020		2025		2030		2035		2040	
		Prevalence	95% UI	Prevalence	95% UI	Prevalence	95% UI	Prevalence	95% UI	Prevalence	95% UI
Business as usual	Māori Female	37.1%	(37.1% to 37.1%)	32.3%	(31.7% to 32.7%)	27.8%	(26.9% to 28.6%)	23.8%	(22.7% to 24.8%)	20.2%	(19.1% to 21.3%)
	non-Māori Female	11.8%	(11.8% to 11.8%)	10.1%	(9.5% to 10.5%)	8.5%	(7.6% to 9.2%)	7.1%	(6.0% to 8.1%)	5.9%	(4.8% to 7.0%)
	Māori Male	30.6%	(30.6% to 30.6%)	24.9%	(24.1% to 25.5%)	20.1%	(18.8% to 21.2%)	16.1%	(14.6% to 17.6%)	12.8%	(11.1% to 14.6%)
	non-Māori Male	13.1%	(13.1% to 13.1%)	11.3%	(10.5% to 12.0%)	9.7%	(8.5% to 10.8%)	8.3%	(6.9% to 9.7%)	7.0%	(5.5% to 8.6%)
Low nicotine	Māori Female	37.1%	(37.1% to 37.1%)	10.3%	(6.7% to 14.6%)	3.8%	(2.5% to 5.4%)	2.8%	(1.8% to 4.0%)	2.0%	(1.3% to 3.0%)
	non-Māori Female	11.8%	(11.8% to 11.8%)	3.2%	(2.2% to 4.4%)	1.2%	(0.8% to 1.6%)	0.8%	(0.6% to 1.2%)	0.6%	(0.4% to 0.9%)
	Māori Male	30.6%	(30.6% to 30.6%)	7.9%	(5.3% to 11.1%)	2.7%	(1.8% to 3.8%)	1.8%	(1.2% to 2.6%)	1.2%	(0.8% to 1.8%)
	non-Māori Male	13.1%	(13.1% to 13.1%)	3.6%	(2.6% to 4.9%)	1.4%	(1.0% to 1.9%)	1.1%	(0.7% to 1.5%)	0.8%	(0.6% to 1.2%)
Low nicotine + media	Māori Female	37.1%	(37.1% to 37.1%)	10.0%	(6.5% to 14.0%)	3.7%	(2.4% to 5.2%)	2.7%	(1.8% to 3.8%)	2.0%	(1.3% to 2.8%)
	non-Māori Female	11.8%	(11.8% to 11.8%)	3.1%	(2.1% to 4.2%)	1.1%	(0.8% to 1.6%)	0.8%	(0.5% to 1.2%)	0.6%	(0.4% to 0.9%)
	Māori Male	30.6%	(30.6% to 30.6%)	7.7%	(5.1% to 10.7%)	2.6%	(1.7% to 3.7%)	1.7%	(1.1% to 2.5%)	1.2%	(0.7% to 1.7%)
	non-Māori Male	13.1%	(13.1% to 13.1%)	3.5%	(2.5% to 4.7%)	1.3%	(0.9% to 1.9%)	1.0%	(0.7% to 1.5%)	0.8%	(0.5% to 1.2%)
Retail reduction	Māori Female	37.1%	(37.1% to 37.1%)	25.9%	(24.1% to 27.4%)	22.3%	(20.7% to 23.8%)	19.1%	(17.6% to 20.5%)	16.2%	(14.8% to 17.5%)
	non-Māori Female	11.8%	(11.8% to 11.8%)	8.0%	(7.4% to 8.6%)	6.8%	(6.0% to 7.6%)	5.7%	(4.8% to 6.6%)	4.7%	(3.9% to 5.8%)
	Māori Male	30.6%	(30.6% to 30.6%)	19.9%	(18.4% to 21.2%)	16.1%	(14.6% to 17.5%)	12.9%	(11.4% to 14.4%)	10.3%	(8.8% to 11.9%)
	non-Māori Male	13.1%	(13.1% to 13.1%)	9.1%	(8.2% to 9.9%)	7.8%	(6.8% to 8.9%)	6.7%	(5.5% to 8.0%)	5.6%	(4.5% to 7.1%)
Smokefree generation	Māori Female	37.1%	(37.1% to 37.1%)	32.1%	(31.4% to 32.7%)	26.2%	(25.1% to 27.3%)	20.2%	(18.9% to 22.1%)	15.4%	(14.1% to 19.0%)
	Māori Male	30.6%	(30.6% to 30.6%)	24.8%	(24.0% to 25.6%)	18.9%	(17.6% to 20.2%)	13.6%	(12.2% to 15.6%)	9.7%	(8.3% to 12.8%)
	non-Māori Female	11.8%	(11.8% to 11.8%)	10.1%	(9.6% to 10.6%)	8.3%	(7.5% to 9.1%)	6.6%	(5.7% to 7.7%)	5.2%	(4.3% to 6.7%)
	non-Māori Male	13.1%	(13.1% to 13.1%)	11.4%	(10.6% to 12.1%)	9.6%	(8.4% to 10.7%)	7.7%	(6.5% to 9.2%)	6.1%	(4.9% to 8.1%)
Combined interventions	Māori Female	37.1%	(37.1% to 37.1%)	8.6%	(5.6% to 12.0%)	3.2%	(2.1% to 4.5%)	2.3%	(1.5% to 3.3%)	1.7%	(1.1% to 2.5%)
	non-Māori Female	11.8%	(11.8% to 11.8%)	2.7%	(1.8% to 3.6%)	1.0%	(0.7% to 1.4%)	0.7%	(0.5% to 1.0%)	0.5%	(0.4% to 0.8%)
	Māori Male	30.6%	(30.6% to 30.6%)	6.6%	(4.4% to 9.1%)	2.2%	(1.5% to 3.2%)	1.5%	(1.0% to 2.2%)	1.0%	(0.7% to 1.5%)
	non-Māori Male	13.1%	(13.1% to 13.1%)	3.0%	(2.1% to 4.1%)	1.2%	(0.8% to 1.6%)	0.9%	(0.6% to 1.3%)	0.7%	(0.5% to 1.0%)

Deaths averted during 2020-30 and 2031-40, by policy

	Year	Denicotinisation		Denicotinisation + media		Retail reduction		Tobacco-free generation		Combined interventions	
		Est	95%UI	Est	95%UI	Est	95%UI	Est	95%UI	Est	95%UI
Female Māori (n= 428,948)	2020 to 2030	**260**	(192 to 332)								
	2031 to 2040	**1,800**	(1540 to 2090)								
Female Non-Māori (n=2,132,141)	2020 to 2030	**279**	(209 to 356)								
	2031 to 2040	**1,950**	(1660 to 2290)								
Male Māori (n= 425,740)	2020 to 2030	**139**	(104 to 178)								
	2031 to 2040	**871**	(749 to 1000)								
Male Non-Māori (n= 2,099,493)	2020 to 2030	**325**	(247 to 409)								
	2031 to 2040	**1,980**	(1650 to 2350)								
All (n= 5,086,322)	2020 to 2030	**1,000**	(757 to 1270)								
	2031 to 2040	**6,600**	(5630 to 7690)								

Deaths averted during 2020-30 and 2031-40, by policy

	Year	Denicotinisation		Denicotinisation + media		Retail reduction		Tobacco-free generation		Combined interventions	
		Est	95%UI	Est	95%UI	Est	95%UI	Est	95%UI	Est	95%UI
Female Māori (n= 428,948)	2020 to 2030	**260**	(192 to 332)	**263**	(201 to 338)	**88**	(66 to 114)	**0.55**	(0.45 to 0.68)	**289**	(231 to 354)
	2031 to 2040	**1,800**	(1540 to 2090)	**1,810**	(1540 to 2110)	**446**	(332 to 587)	**13**	(11 to 15)	**1,880**	(1630 to 2170)
Female Non-Māori (n=2,132,141)	2020 to 2030	**279**	(209 to 356)	**283**	(215 to 362)	**98**	(75 to 125)	**0.44**	(0.36 to 0.53)	**313**	(249 to 383)
	2031 to 2040	**1,950**	(1660 to 2290)	**1,970**	(1650 to 2310)	**506**	(383 to 654)	**8.4**	(7.1 to 9.7)	**2,050**	(1740 to 2390)
Male Māori (n= 425,740)	2020 to 2030	**139**	(104 to 178)	**141**	(107 to 181)	**49**	(38 to 63)	**0.01**	(0 to 0.01)	**157**	(124 to 191)
	2031 to 2040	**871**	(749 to 1000)	**877**	(753 to 1020)	**225**	(170 to 289)	**3.6**	(3.1 to 4.2)	**915**	(794 to 1050)
Male Non-Māori (n= 2,099,493)	2020 to 2030	**325**	(247 to 409)	**330**	(255 to 417)	**114**	(89 to 142)	**0.18**	(0.15 to 0.23)	**365**	(292 to 443)
	2031 to 2040	**1,980**	(1650 to 2350)	**2,000**	(1660 to 2370)	**510**	(388 to 652)	**3.6**	(3 to 4.3)	**2,080**	(1750 to 2450)
All (n= 5,086,322)	2020 to 2030	**1,000**	(757 to 1270)	**1,020**	(779 to 1300)	**349**	(271 to 441)	**1.2**	(0.98 to 1.4)	**1,120**	(897 to 1370)
	2031 to 2040	**6,600**	(5630 to 7690)	**6,660**	(5640 to 7780)	**1,690**	(1280 to 2170)	**29**	(25 to 33)	**6,940**	(5930 to 8020)

Health gain (in HALYs gained) per 1000 people alive in 2020 (base-year) in Aotearoa New Zealand by the modelled policies, by timeline into the future (3% discount rate)

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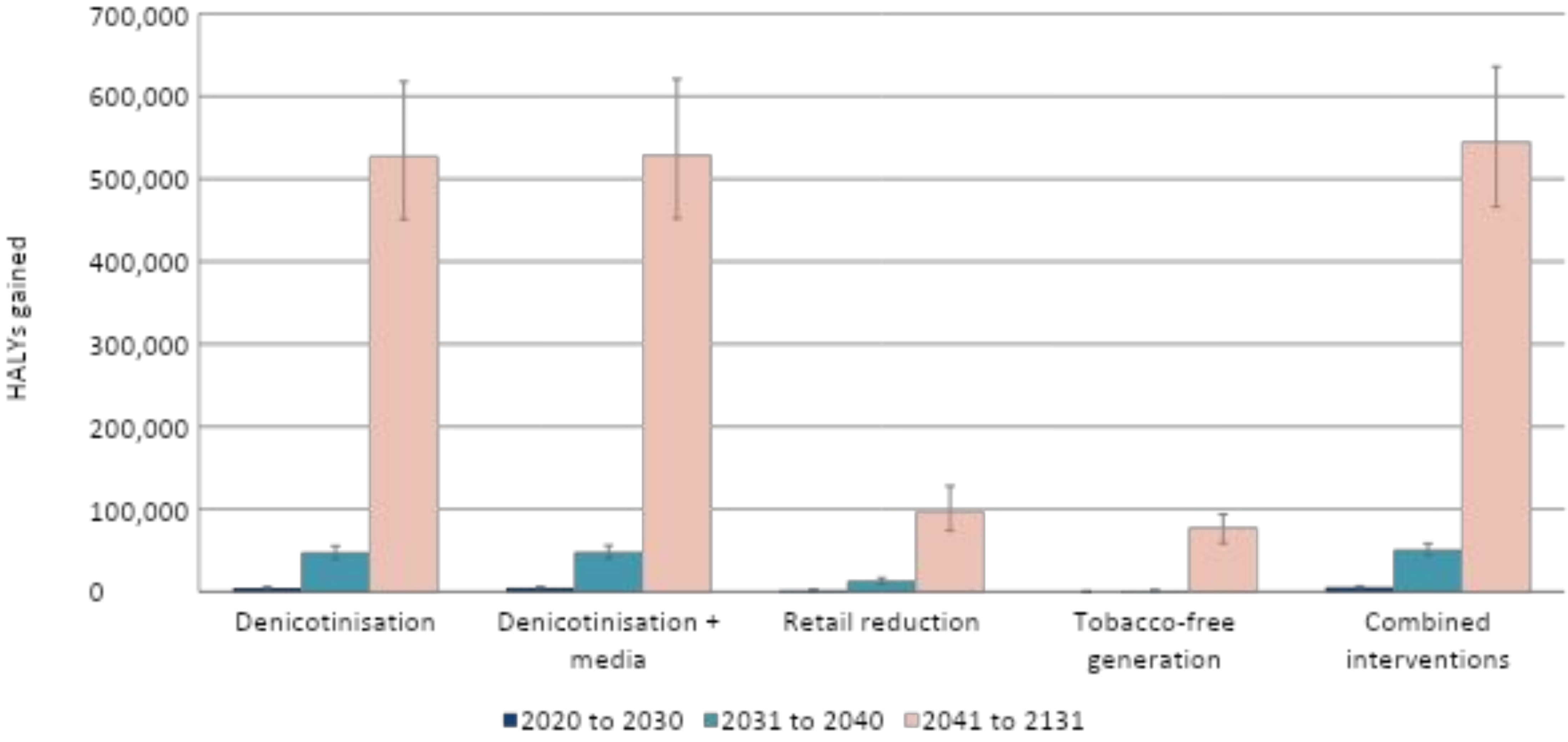

Health gain (in HALYs gained) for people alive in 2020 (base-year) in Aotearoa New Zealand by the modelled policies, by timeline into the future (3% discount rate)

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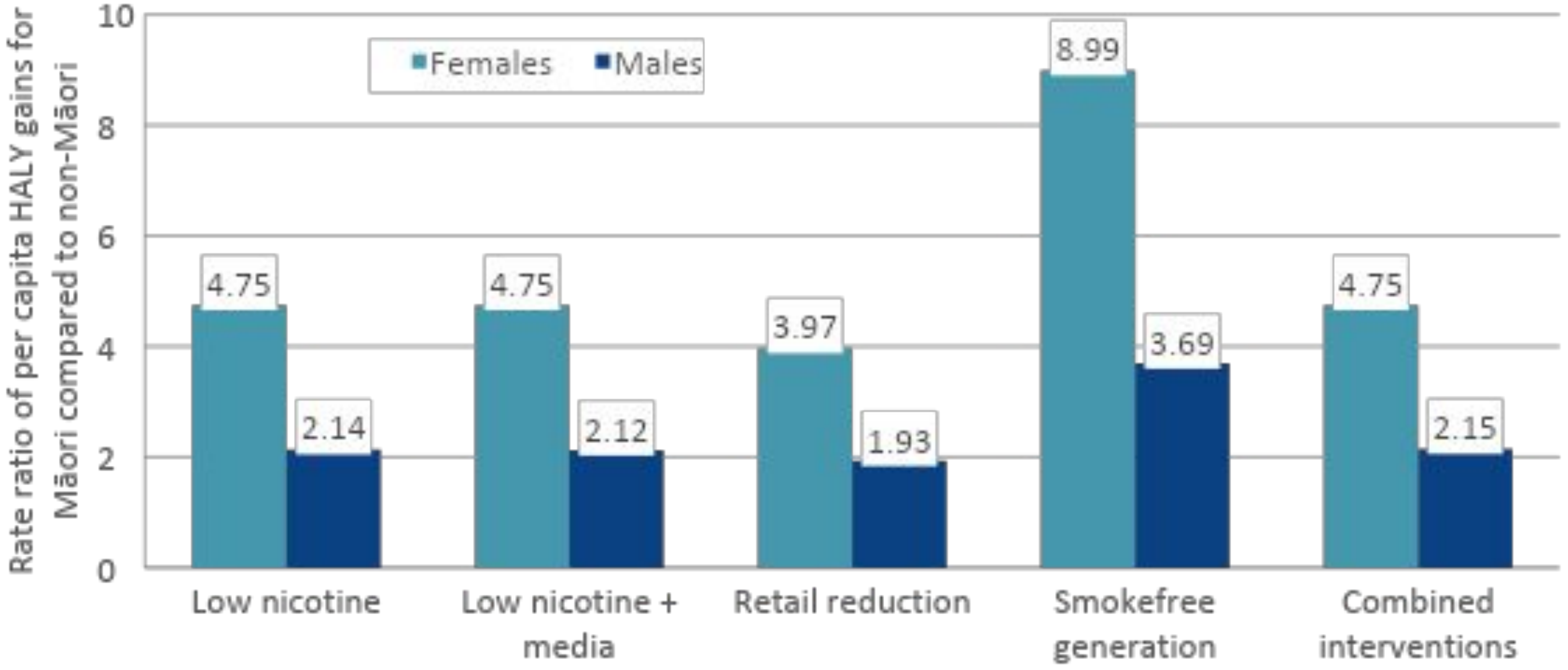
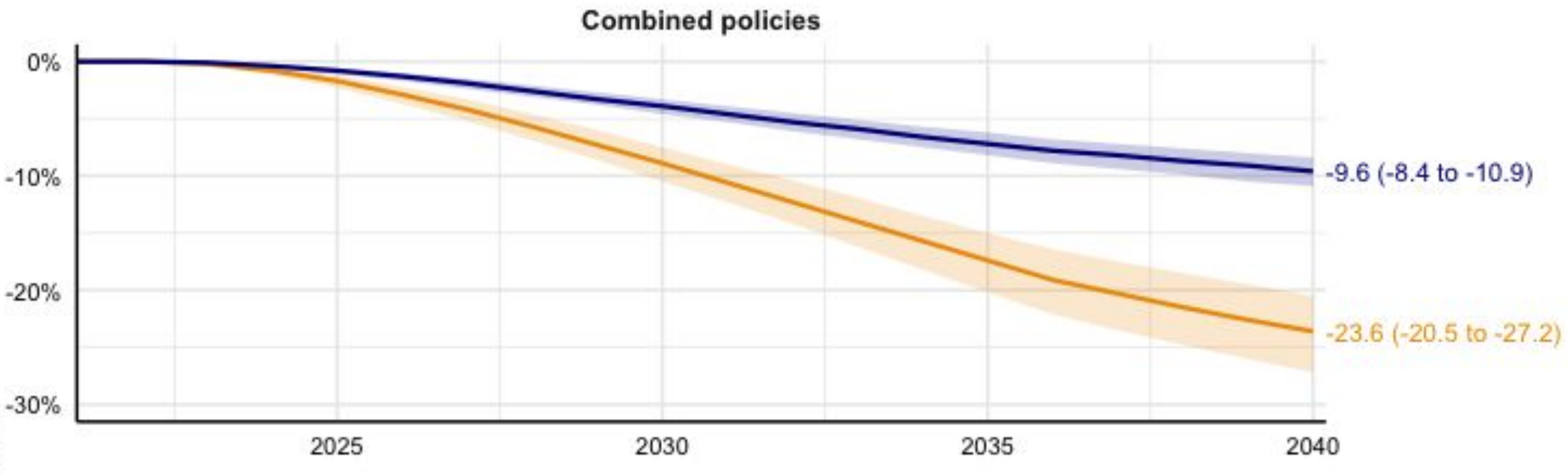
	Year	Denicotinisation		Denicotinisation + media		Retail reduction		Tobacco-free generation		Combined interventions	
		Estimate	95% UI	Estimate	95% UI	Estimate	95% UI	Estimate	95% UI	Estimate	95% UI
Female Māori	2020 to 2030	945	(665 to 1,250)	963	(700 to 1,270)	339	(255 to 436)	23	(19 to 27)	1080	(845 to 1,340)
	2031 to 2040	10700	(8,910 to 12,400)	10700	(9,110 to 12,500)	2830	(2,130 to 3,670)	318	(269 to 378)	11400	(9,870 to 13,000)
	All	166000	(147,000 to 187,000)	167000	(147,000 to 189,000)	28600	(21,500 to 37,200)	31800	(24,000 to 36,800)	172000	(153,000 to 193,000)
Female Non-Māori	2020 to 2030	1440	(1,040 to 1,880)	1470	(1,100 to 1,910)	528	(409 to 673)	22	(18 to 27)	1650	(1,300 to 2,030)
	2031 to 2040	14800	(12,300 to 17,300)	14900	(12,600 to 17,500)	4030	(3,100 to 5,200)	329	(274 to 398)	15800	(13,600 to 18,200)
	All	162000	(137,000 to 192,000)	163000	(137,000 to 194,000)	33400	(25,300 to 44,000)	16400	(12,300 to 20,300)	168000	(142,000 to 199,000)
Male Māori	2020 to 2030	590	(424 to 773)	602	(447 to 787)	216	(166 to 276)	16	(14 to 20)	680	(535 to 838)
	2031 to 2040	6120	(5,140 to 7,110)	6160	(5,240 to 7,200)	1660	(1,270 to 2,130)	227	(190 to 271)	6550	(5,670 to 7,490)
	All	78900	(67,900 to 91,200)	79200	(68,200 to 92,100)	14600	(11,200 to 19,000)	13500	(10,400 to 16,500)	81700	(70,900 to 94,400)
Male Non-Māori	2020 to 2030	1590	(1,180 to 2,040)	1630	(1,240 to 2,100)	586	(461 to 729)	24	(19 to 28)	1830	(1,470 to 2,240)
	2031 to 2040	15900	(13,200 to 18,700)	16000	(13,400 to 18,900)	4320	(3,360 to 5,500)	340	(283 to 412)	17000	(14,500 to 19,700)
	All	171000	(140,000 to 210,000)	173000	(141,000 to 210,000)	35100	(26,400 to 46,200)	17300	(12,600 to 22,400)	178000	(146,000 to 215,000)
All	2020 to 2030	4570	(3,310 to 5,930)	4650	(3,500 to 6,060)	1670	(1,300 to 2,110)	85	(70 to 101)	5250	(4,170 to 6,440)
	2031 to 2040	47400	(39,800 to 55,300)	47800	(40,500 to 56,000)	12900	(9,900 to 16,500)	1210	(1,020 to 1,460)	50700	(43,700 to 58,300)
	All	579000	(495,000 to 677,000)	582000	(497,000 to 680,000)	112000	(85,100 to 146,000)	78900	(59,800 to 95,200)	600000	(515,000 to 698,000)

All policies gain more health per capita for Māori, especially for smokefree generation:

Relative risks of HALYs per capita gain for Māori c.f. non-Māori

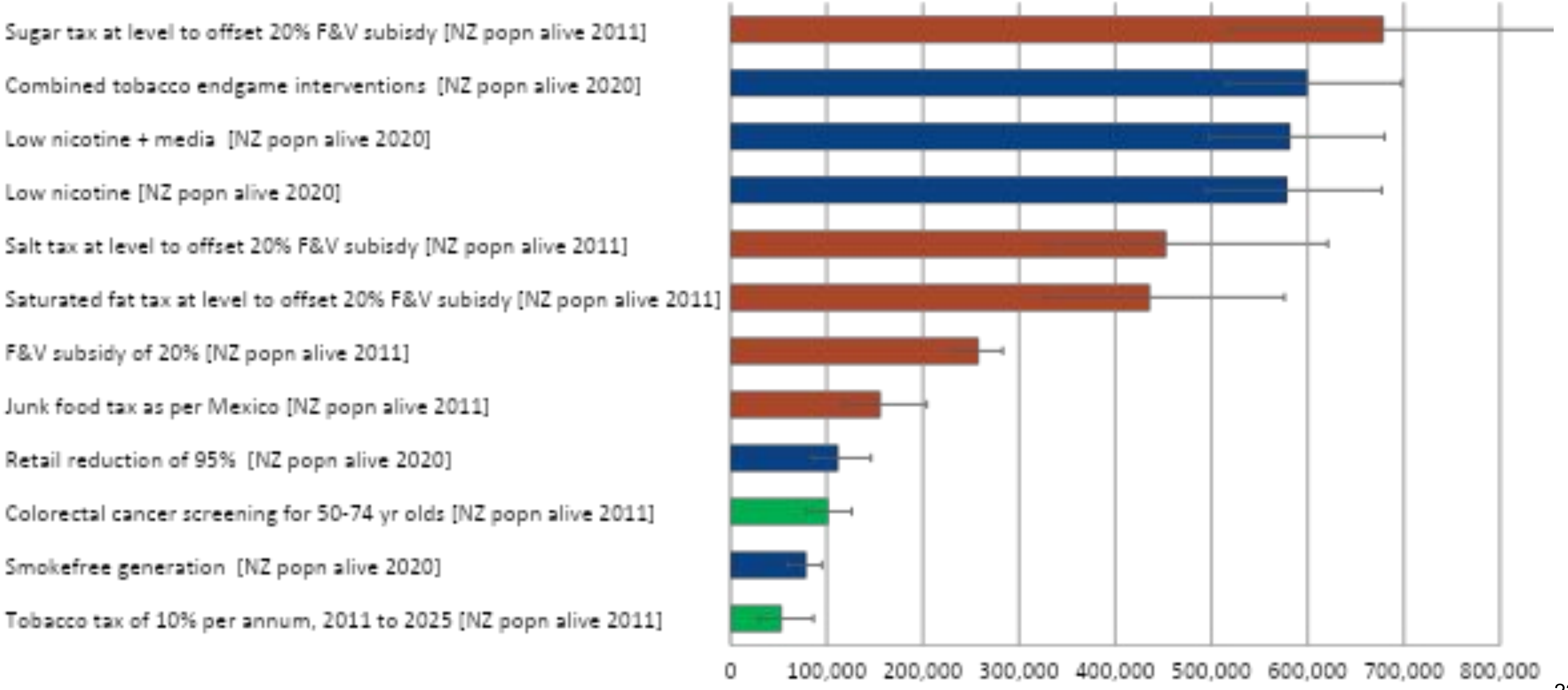


The all-cause mortality gap (age-standardized rate difference for 45+ yr olds) is projected to decrease by up to 20% for females and 10% for males (c.f. BAU) for a low-nicotine policy



I suspect that no other feasible policy in NZ would decrease ethnic inequalities in all-cause mortality by this much

How do these tobacco endgame interventions compare with other population-wide interventions? (3% DR HALYs)



Health expenditure savings and income gains

(NB: using earlier version of model to previous slides, as provided to NZ MoH)

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Health expenditure savings:

- Due to less tobacco-related disease, and even accounting for people living longer and getting other diseases (with costs), the combined endgame package saved the NZ health sector:
  - NZ$1.3 billion between 2021-2040 (3% discount rate; approx. $US850 million)

    Which is equivalent to 6.4% of Vote-Health in 2020
  - NZ$5.6 billion over the remainder of the 2020 NZ population's lifespan (3% discount rate; approx. $US4 billion)

    Which is equivalent to 26% of Vote-Health in 2020

Income gains (as measure of productivity gains):

- Due to less tobacco-related disease, and even accounting for people living longer and getting other diseases, the combined endgame package increased NZ 25-64 yr old total income:
  - NZ$1.4 billion between 2021-2040 (3% discount rate; approx. $US1 billion)

    Which is equivalent to 0.4% of NZ's total GDP in 2020
  - NZ$5.9 billion over the remainder of the 2020 NZ population's lifespan (3% discount rate; approx. $US4.1 billion)

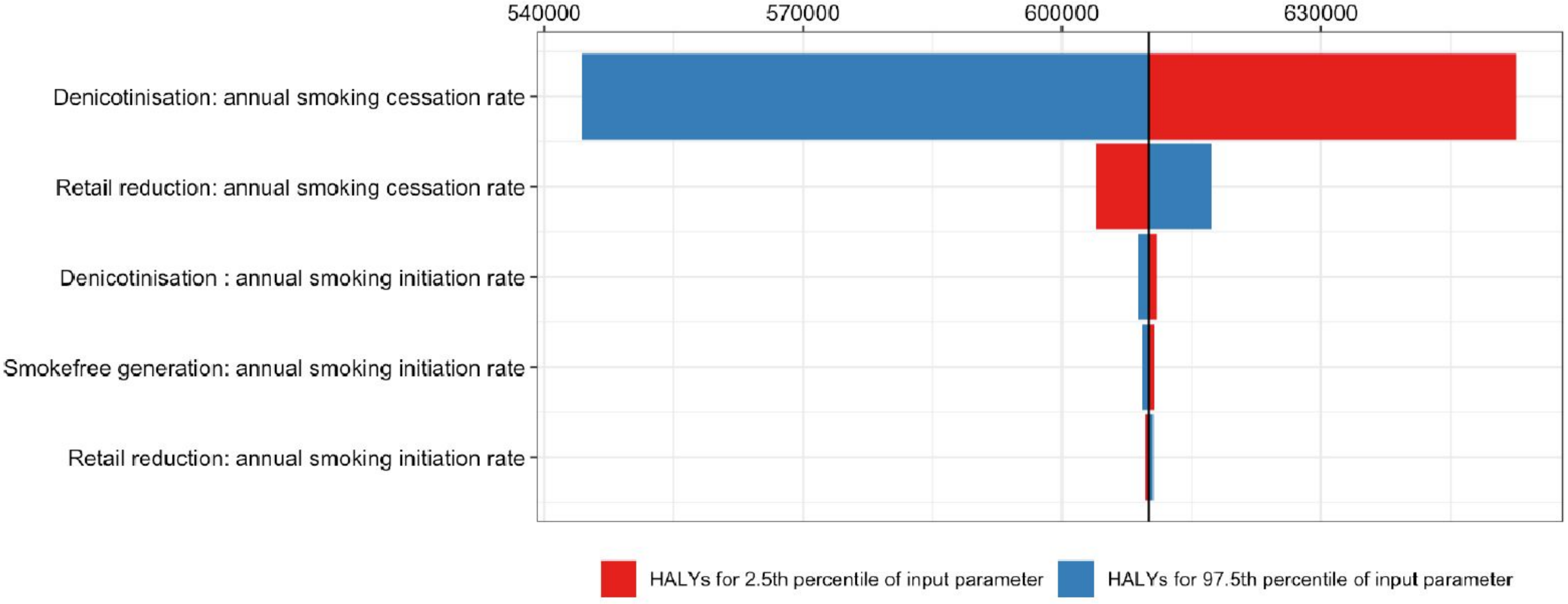
    Which is equivalent to 1.8% of NZ's total GDP in 2020

Note: these estimates were important in the Regulatory Impact Statement, and at Cabinet, for assisting the Action Plan's adoption by Govt (as dispelled the argument that lost tobacco taxes are a major concern)

Reflections on uncertainty

- “A key principle of this study is that even if as a research community we do not have ideal data, decision-makers and society need the best estimates we can produce, with appropriate depiction and caveats about inevitable uncertainty.”
- HALYs: propagating all uncertainty through the model, yes, wide 95% UI (440,000 to 740,00 for 3% discount rate over remaining lifespan) … but still large and clearly ‘bigger’ than most other interventions one models or considers for policy making
- Tornado plot used to work out which input parameter uncertainty leads to most output uncertainty – cessation due to denicotinisation clearly the major source of uncertainty for total package.

Tornado Plot for lifetime HALYs gained, 3% discount rate



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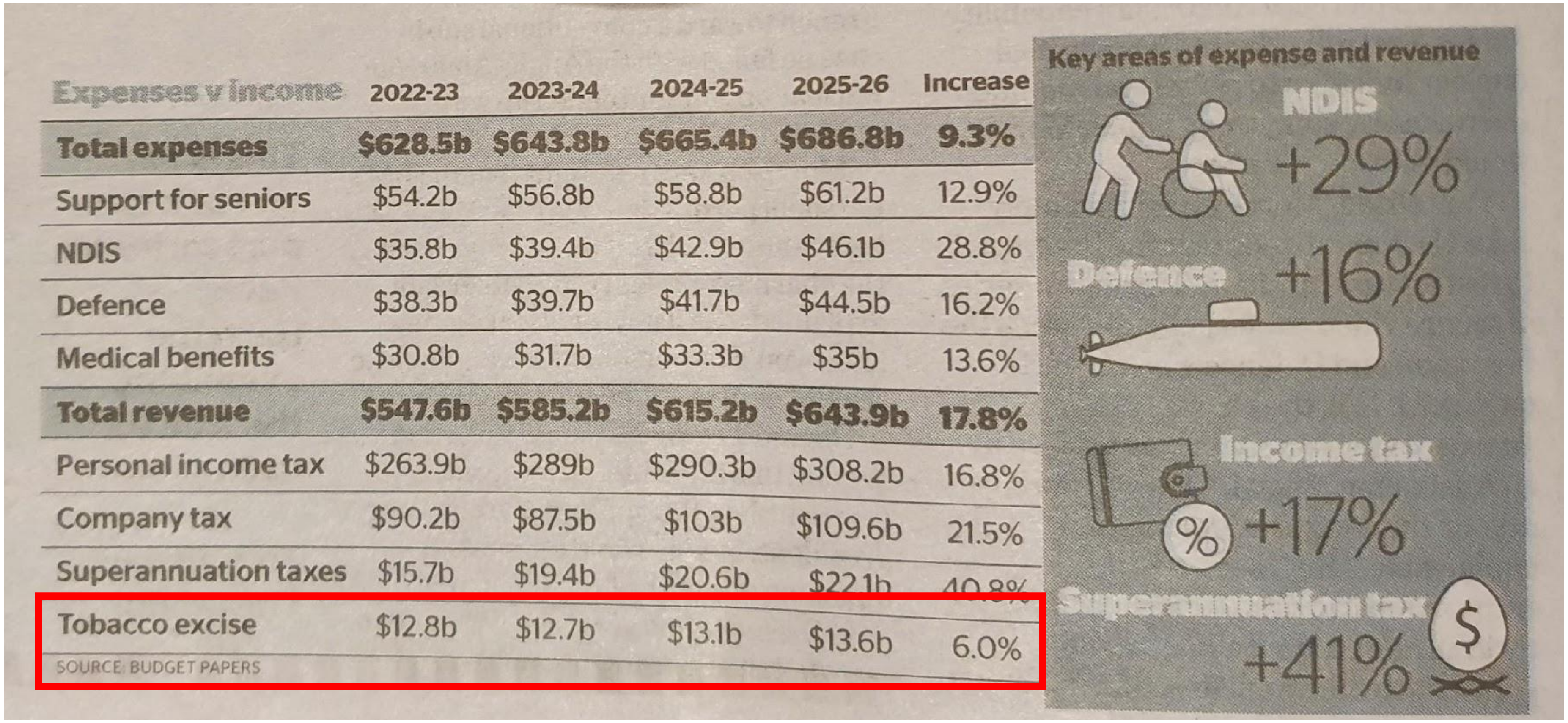
- Tornado plot used to work out which input parameter uncertainty leads to most output uncertainty – cessation due to denicotinisation clearly the major source of uncertainty for total package.
- There are also model structure uncertainties (e.g. discount rate, life history model, illegal market [we did not include, but we have found it in previous modelling for NZ to not be too large an impact)
- Since we started the modelling, vaping prevalence has jumped more than forecast. Highlighting the uncertainty about BAU forecasts! This will probably not effect overall results much, **but** in modelling we are now doing for Australia we are moving to a new system where we have multiple BAU scenarios – not just one.

Tobacco tax revenue 'counts' for countries now dealing with large deficits post COVID-19

Infographic in The Age, May 2022, in analytical piece about $1 trillion deficit Australia has – and what to do about it.



Expenses v income	2022-23	2023-24	2024-25	2025-26	Increase
Total expenses	**$628.5b**	**$643.8b**	**$665.4b**	**$686.8b**	**9.3%**
Support for seniors	$54.2b	$56.8b	$58.8b	$61.2b	12.9%
NDIS	$35.8b	$39.4b	$42.9b	$46.1b	28.8%
Defence	$38.3b	$39.7b	$41.7b	$44.5b	16.2%
Medical benefits	$30.8b	$31.7b	$33.3b	$35b	13.6%
Total revenue	**$547.6b**	**$585.2b**	**$615.2b**	**$643.9b**	**17.8%**
Personal income tax	$263.9b	$289b	$290.3b	$308.2b	16.8%
Company tax	$90.2b	$87.5b	$103b	$109.6b	21.5%
Superannuation taxes	$15.7b	$19.4b	$20.6b	$22.1b	40.8%
Tobacco excise	$12.8b	$12.7b	$13.1b	$13.6b	6.0%

SOURCE: BUDGET PAPERS

Conclusions

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- Tobacco endgame policies, in particular **low nicotine (aka denicotinisation)**, has:
  - Major health gains
  - Strong reduction in ethnic inequalities in mortality
    - Low nicotine is forecast to reduce all-cause mortality inequalities for Māori c.f. non-Māori by nearly 25% for females and 10% for males by 2040 – these are *huge* reductions in mortality inequalities
- A **smokefree generation** gains little health for many decades but does have the highest per capita ratio gain for Māori c.f. non-Māori.
- Our estimate of **retail outlet restriction** impacts uses 'travel time converted to cost that acts like a price change'. In the absence of natural experiments, we can do no better – but we suspect we have underestimated the health gains from retail outlet reductions (due to denormalization)
- Strengths of our analyses: high quality models, includes vaping impacts
- Weaknesses: many assumptions necessary (e.g. timing and extent of denic impacts – but we did carefully build on available evidence, and work with experts)
- **SHINE (Scalable Health Intervention Evaluation) at Uni Melb is new modelling infrastructure. We welcome inquiries for collaborative modelling in your country or region.**

Deaths averted during 2020-30 and 2031-40, by policy

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	Year	Denicotinisation		Denicotinisation + media		Retail reduction		Tobacco-free generation		Combined interventions	
		Est	95%UI	Est	95%UI	Est	95%UI	Est	95%UI	Est	95%UI
Female Māori (n= 428,948)	2020 to 2030	**260**	(192 to 332)								
	2031 to 2040	**1,800**	(1540 to 2090)								
Female Non-Māori (n=2,132,141)	2020 to 2030	**279**	(209 to 356)								
	2031 to 2040	**1,950**	(1660 to 2290)								
Male Māori (n= 425,740)	2020 to 2030	**139**	(104 to 178)								
	2031 to 2040	**871**	(749 to 1000)								
Male Non-Māori (n= 2,099,493)	2020 to 2030	**325**	(247 to 409)								
	2031 to 2040	**1,980**	(1650 to 2350)								
All (n= 5,086,322)	2020 to 2030	**1,000**	(757 to 1270)	**1,020**	(779 to 1300)	**349**	(271 to 441)	**1.2**	(0.98 to 1.4)	**1,120**	(897 to 1370)
	2031 to 2040	**6,600**	(5630 to 7690)	**6,660**	(5640 to 7780)	**1,690**	(1280 to 2170)	**29**	(25 to 33)	**6,940**	(5930 to 8020)

Population impact fraction to connect the smoking-vaping model to the PMSLT

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For each sex by age by ethnic group, for each annual time step into the future, a population impact fraction (PIF) is calculated for each tobacco-related disease. The generic formula [22] 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 category of smoking or vaping (the seven, plus 20 additional tunnel states for each of FSFV and FSCV)
RR is the incidence rate ratio for disease d and smoking-vaping state j, and possible varying by demographics (e.g. by sex and age, but not by ethnic group). (Note the RR does not vary by time step t.)