# Net population health and cost impacts of legalizing domestic sale of vaporized nicotine products: a simulation study

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On behalf of co-authors: Frederieke S. Petrović-van der Deen (BODE[3] Otago), Nick Wilson (BODE[3] Otago), Anna Crothers (UoQ), Christine Cleghorn (BODE[3] Otago), Coral Gartner (UoQ)

*Potential Country-level Health and Cost Impacts of Legalizing Domestic Sale of Vaporized Nicotine Products*. Epidemiology 2019, 30:396-404.

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## Structure

- Context and our position (in highly contentious environment)
- Exact research question, and using simulation models as an 'answering process'
- Model structure
- Input parameters – and their uncertainty!
- Results
- How this intervention compared to other tobacco control and wider public health interventions
- So what? Implications and policy

## Context – and our position

Context:

- E-cigarettes are highly controversial
- There are a range of views among the public health community
- Australia does not allow sale of nicotine containing fluid; NZ has liberalized (similar to UK & US)
- The likely public health outcomes of this liberalization are an important research question

Our position:

- We are not lobbyists and are not industry affiliated or funded; we are researchers trying to quantify net impacts, to improve the evidence-base upon which public health and policy discussions happen
- Simulation models can help quantify net benefits and harms. Prior to our study, 8 simulation studies:
  - 6 net beneficial for health; 1 not; 1 dependent on scenarios
- Our study (published this year) has two advances:
  - We explicitly incorporate uncertainty (as was known at the time)
  - Include impacts on health expenditure



## Research question

What is the net health impact (and health expenditure impact) of liberalization of the nicotine vaping product market in New Zealand (NZ), compared to a business-as-usual scenario of no nicotine vaping products?

Specifics:

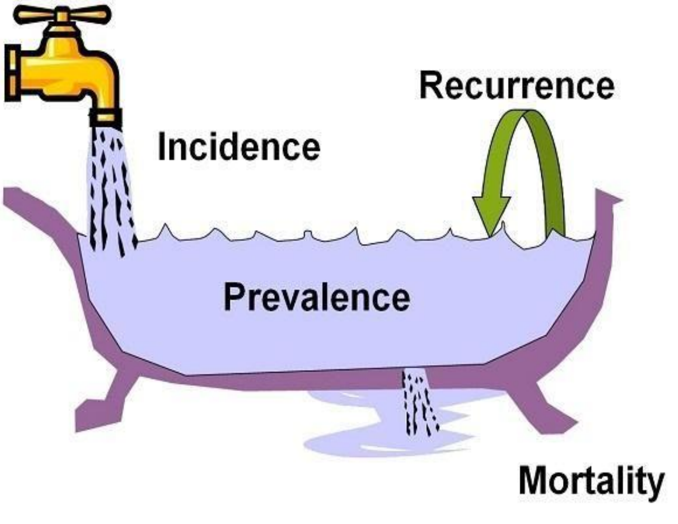
- Health gain in health adjusted life years (HALYs), for the entire NZ population alive in 2011 over the remainder of their lives. 0% discount rate (unless stated otherwise).
- Ditto health system expenditure.

# Methods – baseline data

Business-as-usual:

- Included 16 tobacco-related diseases
- Disease-specific incidence, case fatality, prevalence from range of sources, brought together with DISMOD to ensure consistency:
- Allowed for future 'business-as-usual' trends in smoking prevalence, mortality and disease epidemiology
- Morbidity incorporated using years lived with disability (YLDs) from NZ BDS
- Costs in each state from rich linked NZ data, 2011 $

# Concept of a multistate lifetable (MSLT)



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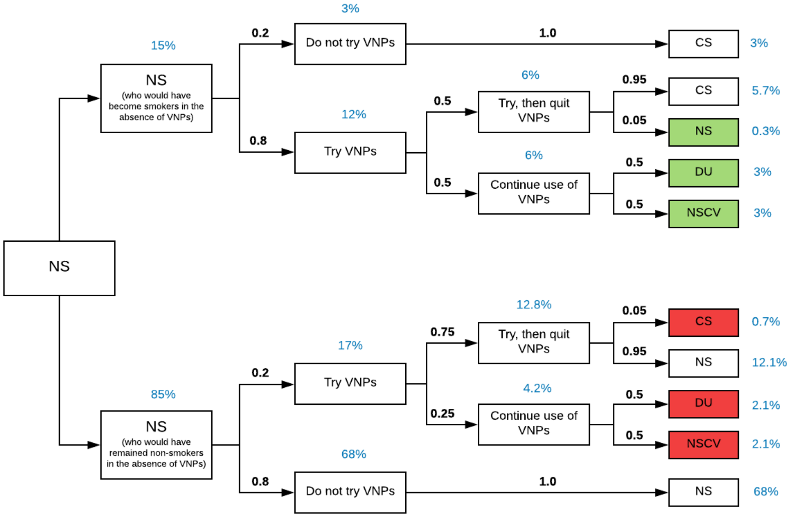
Intervention:

- 'Pre-model' of how nicotine liberalization will 'play out' in terms of use of nicotine vaping products and changes in tobacco smoking

# Transitions among 20-year old never smokers to never smoker, current smoker, dual user or never smoker current vaper




**Legend:**

NS = never smoker

CS= current smoker

DU = dual user

NSCV = never smoker, current vaper

FSCV = former smoker, current vaper

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# Critical input parameters: vaping prevalence

- Prevalence of DU, FSCV, and NSCV in base year 2011 (Source: Zhu et al *)
- Scenario analyses used around this (e.g. definition of what frequency of varying constitutes regular vaping varies by source), in addition to probabilistic uncertainty using intervals below

| | Prevalence of vaping categories in population | | |
|---|---|---|---|
| Age group | DU (11.5%) (95%UI) | FSCV (13.2%) (95%UI) | NSCV (0.3%) (95%UI) |
| 18-24 | 16.3% (10.5%-23.2%) | 18.7% (12.1%-26.7%) | 0.43% (0.27%-0.61%) |
| 25-44 | 13.9% (8.8%-19.6%) | 16.0% (10.4%-22.7%) | 0.36% (0.23%-0.52%) |
| 45-64 | 10.5% 6.9%-15.1%) | 12.1% (7.8%-17.2%) | 0.28% (0.17%-0.39%) |
| 65+ | 4.3% (2.7%-6.1%) | 5.0% (3.2%-7.1%) | 0.11% (0.07%-0.16% |

**Legend:**

DU = dual user

NSCV = never smoker, current vaper

FSCV = former smoker, current vaper

** Zhu SH, Zhuang YL, Wong S, Cummins SE, Tedeschi GJ. E-cigarette use and associated changes in population smoking cessation: evidence from US current population surveys. BMJ. 2017;358:j3262*



# Critical input parameter: impact of e-cig liberalization on background tobacco cessation rates

- RCTs provide cessation rates among participants – not in the general population
- The largest and most recent population-level study, led by Zhu et al, found that the population-wide cessation rate (3 months) in the US increased from 4.5% to 5.6% since the introduction of VNPs, or a 24% increase
- We used estimates from two meta-analyses to adjust the 24% estimate for potential relapse back to tobacco net cessation (assumed equilibrated at 24 months), an increase in population cessation rates of **14%**.
- We doubled the uncertainty range (given transporting it to another context) such that the 95% UI ranged from **1.4% to 28%** (about the 14% central estimate).

## Critical input parameters: vaping cessation

- Due to scarce data on vaping cessation patterns, annual net vaping quit rates were assumed to be at the same rate as the annual net cessation rates for smokers.
- This assumption is in line with previous models.

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## Critical input parameters: harm of vaping relative to smoking

- Due to absence of long-term follow-up studies on the health outcomes of vapers, there is genuine uncertainty.
- The two reviews published in 2018 on VNPs by the Public Health England and National Academies of Sciences, Engineering, and Medicine:
  - Estimates of relative health harm ranged from below 0.5% (cancer risks) to as high as 50%
  - both reports suggesting most agreement around the 5% figure
- We specified the relative harm for those who were vaping only as a logistic distribution with a median of **5%** (with wide uncertainty! **95% UI: 0.5% to 38%**).

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## Critical input parameters: harm of dual use relative to just smoking

- NASEM concluded there is some limited evidence for a reduction in symptom exacerbations in patients with chronic obstructive pulmonary disease (COPD) or for asthma exacerbations among DU.
- The PHE Report concluded (based on one study) dual use of VNPs and tobacco cigarettes was:
  - "unlikely to be associated with substantial reductions in harm, particularly when there is no substantial reduction in the number of cigarettes smoked"
- Based on these conclusions, we estimated a minimal reduction in the relative harm of vaping for DU compared to smoking with a median of **95% (95% UI: 65% to 99.5%)**.
  - (Mirror-image of the harm distribution for NSCV & FSCV on previous slide)



## Results

## Lifetime health gains (in QALYs) and health system cost-savings for the NZ population alive in 2011 under the intervention base-case compared to BAU (0% discounting‡)

| | Remaining lifetime (with 95% uncertainty intervals) | | First ten years: 2011 to 2022 (% of lifetime for age group) † | | Second ten years: 2021 to 2030 (% of lifetime for age group) † | |
|---|---|---|---|---|---|---|
| Age-group (at baseline) | QALYs gained | Net cost-savings ($NZ million 2011) | QALYs gained | Cost-savings ($NZ million) | QALYs gained | Cost-savings ($NZ million) |
| 0-14 year olds | | | | | | |
| 15-24 year olds | | | | | | |
| 25-44 year olds | | | | | | |
| 45-64 year olds | | | | | | |
| 65+ year olds | | | | | | |
| All ages combined | **236,000** (27,000 to 457,000) | **$3,420** ($370 to $7,050) ‡ | | | | |
| Per capita* | | | | | | |
| % change** | | | | | | |

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| Per capita* | **0.054** | **$780** | | | | |
| % change** | **0.14%** | **0.43%** | | | | |

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| 0-14 year olds | 68,100 (-23,900 to 188,000) | $1,010 (-$530 to $2,930) | | | | |
| 15-24 year olds | 59,100 (13,000 to 117,00) | $930 ($218 to $1,910) | | | | |
| 25-44 year olds | 72,000 (13,200 to 126,000) | $1,070 ($257 to $1,910) | | | | |
| 45-64 year olds | 35,000 (-1200 to 61,200) | $400 ($11 to $712) | | | | |
| 65+ year olds | 1,690 (-4,020 to 3,950) | $11 (-$24 to $26) | | | | |
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| 15-24 year olds | 59,100 (13,000 to 117,00) | $930 ($218 to $1,910) | **52** (0.09%) | | **662** (1.12%) | |
| 25-44 year olds | 72,000 (13,200 to 126,000) | $1,070 ($257 to $1,910) | **924** (1.3%) | | **3,400** (4.7%) | |
| 45-64 year olds | 35,000 (-1200 to 61,200) | $400 ($11 to $712) | **1,820** (5.2%) | | **5,960** (17.0%) | |
| 65+ year olds | 1,690 (-4,020 to 3,950) | $11 (-$24 to $26) | **240** (14.3%) | | **689** (41.2%) | |
| All ages combined | 236,000 (27,000 to 457,000) | $3,420 ($370 to $7,050) ‡ | **3,040** (1.3%) | | **10,775** (4.6%) | |
| Per capita* | 0.054 | $780 | | | | |
| % change** | 0.14% | 0.43% | | | | |

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| **0-14 year olds** | **68,100** (-23,900 to 188,000) | **$1,010** (-$530 to $2,930) | **5** (0.01%) | **$0** (0.00%) | **57** (0.08%) | **$2** (0.16%) |
| **15-24 year olds** | **59,100** (13,000 to 117,00) | **$930** ($218 to $1,910) | **52** (0.09%) | **$1** (0.08%) | **662** (1.12%) | **$23** (2.49%) |
| **25-44 year olds** | **72,000** (13,200 to 126,000) | **$1,070** ($257 to $1,910) | **924** (1.3%) | **$25** (2.3%) | **3,400** (4.7%) | **$161** (14.8%) |
| **45-64 year olds** | **35,000** (-1200 to 61,200) | **$400** ($11 to $712) | **1,820** (5.2%) | **$53** (13.1%) | **5,960** (17.0%) | **$164** (40.6%) |
| **65+ year olds** | **1,690** (-4,020 to 3,950) | **$11** (-$24 to $26) | **240** (14.3%) | **$4** (35.1%) | **689** (41.2%) | **$6** (55.3%) |
| **All ages combined** | **236,000** (27,000 to 457,000) | **$3,420** ($370 to $7,050) ‡ | **3,040** (1.3%) | **$83** (2.4%) | **10,775** (4.6%) | $356 (10.3%) |
| **Per capita*** | **0.054** | **$780** | | | | |
| **% change**** | **0.14%** | **0.43%** | | | | |

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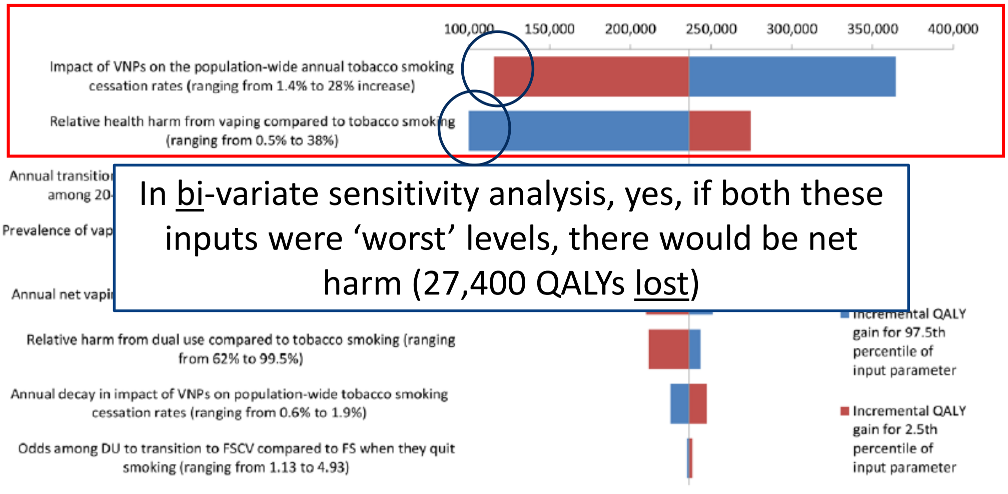
## Tornado plot showing that 2 most influential inputs driving overall uncertainty are: impact on population smoking cessation rates; relative harm of vaping nicotine




In bi-variate sensitivity analysis, yes, if both these inputs were 'worst' levels, there would be net harm (27,400 QALYs lost)

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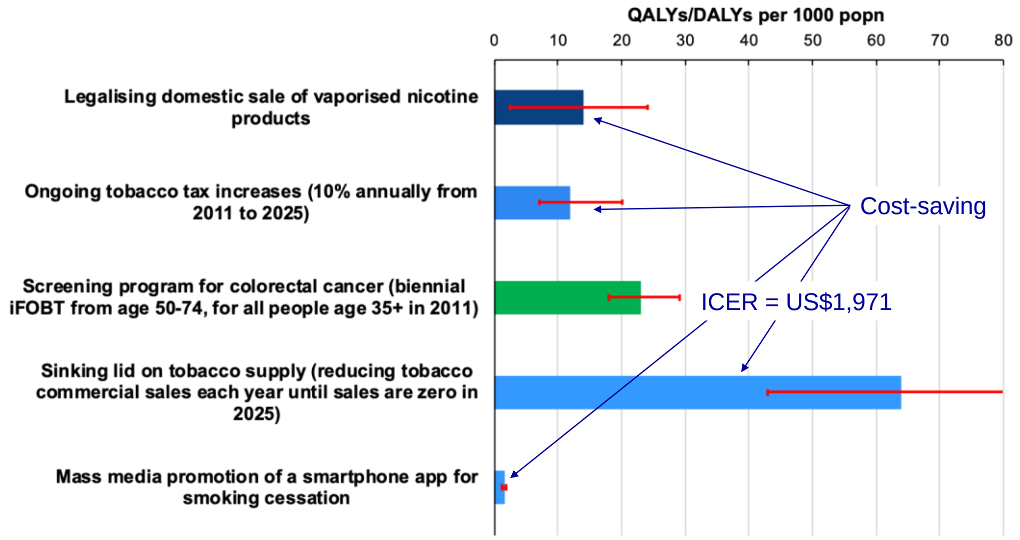
# QALYs gained per 1000 people in total population: 3% DR; NZ evaluations

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# Is there more uncertainty, and other considerations, that we did not model? Yes

Role of tobacco industry:

- Concerns that legalizing access to nicotine vaping products allows the tobacco industry to live on
- (Counter argument = "gives tobacco industry a 'safer' place to move to")

Disruptive to 'tried and tested tobacco control'

- i.e. stay focused on tobacco: tax, availability, and perhaps tobacco product modification
- (Counter argument = "may enable more restrictions on smoked tobacco products")

We do not know the long term harm profile of nicotine vaping:

- Lung impacts?
- (Counter arguments = "still far lower risk than smoking tobacco" and "can be controlled with regulation of products")

As with all models, our model may have mis-specified uncertainty about some variables, e.g. youth uptake of vaping and lifelong maintenance of vaping habit

- Need to keep updating models as new evidence arises

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## So what?

1. Based on our research, other research and our assessment on tobacco policy options, we suggest:
   - Nicotine vaping products have a potential role – they remain a policy option, even if 'just' limited to cessation
   - If e-cigs are 'liberalized', they should also be strongly regulated, e.g.:
     - Same smoke free environments as tobacco
     - Same restrictions on marketing – especially to kids
     - Strong regulatory framework about constituents of fluid
2. More generally, policy-making is often made in the context of uncertainty. Modelling exercises like ours 'front up' to that uncertainty, and attempt to quantify it – which we believe is useful, and needs ongoing updating as new evidence arises.

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# Methods – multistate lifetable

A multistate lifetable is literally that – a lifetable in which subjects (proportions of a cohort) can be in multiple states simultaneously

| | A | B | C | D | E | F | G | H | I | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | | | | Life table cohort | Deaths in cohort | | | | |
| 2 | sex | age | average mortality rate at age x | probability of dying between age x and x+1 | no. of survivors at age x out of those in year 1 | no. who die between age x and x+1 | no. of person-years lived by cohort to age x+½ | life expectancy | prevYLD rate from all causes | dis… p |
| 3 | | $x$ | $m_x$ | $q_x$ | $l_x$ | $d_x$ | $L_x$ | $e_x$ | $w_x$ | |
| 4 | | | mortality data | $q_x = 1 - EXP(-m_x)$ | $l_0$ = population<br>$l_x = l_{x-1} - d_{x-1}$ | $d_x = q_x \times l_x$ | $L_x = (l_x + l_{x+1})/2$<br>$L_{110+} = l_{110+}/m_{110+}$ | $e_x = \Sigma L_x / l_x$ | from BOD data | $Lw_x =$ |
| 7 | male | 4 | 0.000135194 | 0.0001 | 114928 | 16 | 114920 | 79.14 | 0.026408649 | |
| 8 | male | 5 | 0.00010438 | 0.0001 | 114912 | 12 | 114906 | 78.15 | 0.03374444 | |
| 9 | male | 6 | 8.39192E-05 | 0.0001 | 114900 | 10 | 114895 | 77.16 | 0.03374444 | |
| 10 | male | 7 | 6.41376E-05 | 0.0001 | 114891 | 7 | 114887 | 76.17 | 0.03374444 | |
| 11 | male | 8 | 5.40211E-05 | 0.0001 | 114883 | 6 | 114880 | 75.17 | 0.03374444 | |