Supplementary material

Cost-effectiveness and productivity impacts of call-back telephone counselling for smoking cessation

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Contents

Model design and input data

Time lags

Disease generally does not arise immediately after taking up smoking and can take many years to develop depending on the specific disease. Ideally, the average number of years people have been smoking by age and sex would be combined with evidence on the distribution of time about when the disease tends to develop. However, in the absence of such data, a simplifying assumption was made that the number of years that people have been smoking is implied by their age and that the age-based relative risks inherently contain greater risks at older ages. This approach has precedent in other tobacco cessation economic models.[23,24] A scenario analysis was conducted where time lags were applied to the development of each disease. The number of years applied to the time lag was informed by a cost of alcohol use report, where a simplifying assumption of 10 years was applied to those diseases in the costing report that adopted a smoking impact ratio approach.[9]

Relapse

The probability of relapse (taking up smoking again after quitting) was sourced from an economic evaluation of smoking cessation interventions in the UK.[23] The probability of relapse was highest in the first 5 years and then fell between years 5 and 10, then again after 10 years to a probability close to zero. The probability that relapsed smokers quit again is the background quit rate without adjustment for subsequent attempts.

Other methods

The analysis calculates the cost effectiveness for the health care perspective and a limited societal perspective (limited because we have not included the full range of societal impacts, such as environmental impacts). The latter includes three productivity measures in addition to health care costs: absenteeism (temporary days away from work due to illness or injury), lost productivity due to reduced participation in the labour force (long term away from work due to illness or injury), and productive years of life lost due to premature death (years between death and normal retirement age when the person would have otherwise been working). A lifetime time horizon was adopted in the base case by running the model for 80 years, with the majority of smokers aged at least 20. The time horizon was varied between 5 and 85 years in sensitivity analysis. The analysis adopted a 5% discount rate for the base case to account for the present value of future costs and benefits. This was based on the guidelines for economic evaluation for submissions to the Pharmaceutical Benefits Advisory Committee.[26] The discount rate was varied between 0% and 10% in sensitivity analysis.

Other limitations

Precise time lags between taking up smoking and disease onset were not included in the base case but approximations were applied in a sensitivity analysis. Rather, a simplifying assumption was made that the

age-based relative risks due to smoking sufficiently account for smoking years. Ideally, data on the length of time people have been smoking should be combined with robust evidence on how relative risks change over time. However, this is unlikely to change the conclusions of the analysis.

Although more complex methods such as deriving smoking impact ratios have been used in burden of disease and cost of illness studies, those analyses relate to a specific snapshot in time for the entire population, whereas this analysis considers a hypothetical cohort of quitline clients and the progression of disease over the entire lifetime. The ECCTC model approach sufficiently approximates risk and disease progression using data from robust evidence sources and maintains internal model consistency for a large number of diseases.

Another potential limitation was that the reduction in relative risk of developing a disease for former smokers was taken from available evidence and assumed to return to the same as the general population after 20 years. More sophisticated methods such as regression equations could be applied to slowly reduce the relative risk over time. Despite contributing more accuracy to the model, such enhancements would be unlikely to change overall conclusions. As per previously published tobacco control economic analyses, the model assumes individuals only experience one disease at a time.[23,31] Unfortunately,—unlike what has been analysed for the New Zealand population[32]—to our knowledge, published data on individual costs of disease in Australia for calculating the costs of disease at different stages of disease progression and comorbidities with regression analysis are unavailable. Consequently, the model derives per person costs of disease from the AIHW estimates which simply divide total disease expenditure by the prevalence of that disease.[6] Although costs based on individual-level data would add precision to the model, it would be unlikely to change the overall conclusions.

Figure S1: State transition diagram

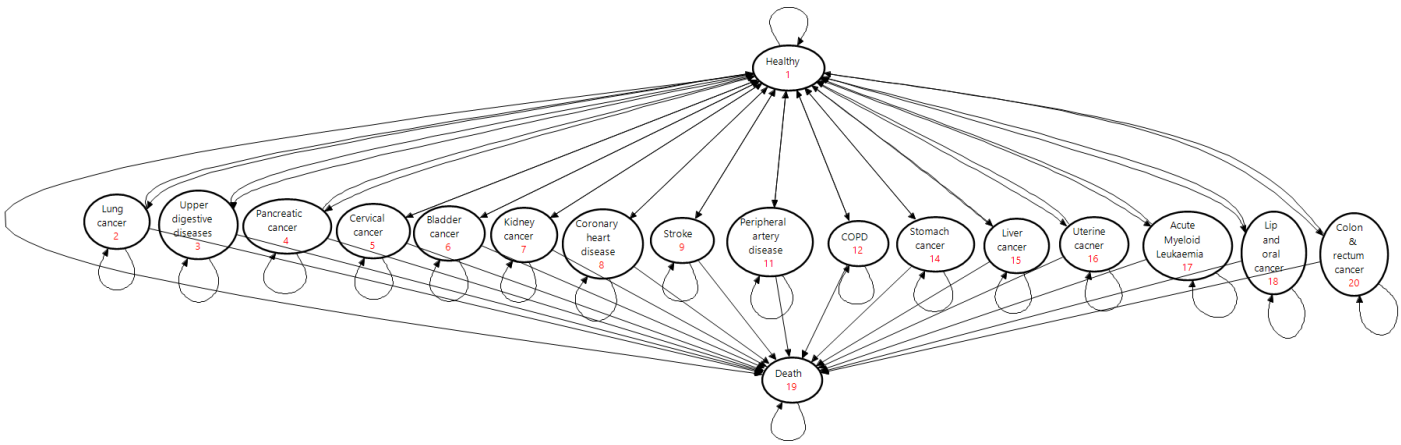


Table S1: Health state utilities input data

Health state	Utility value	Source
Healthy smoker	0.8486	NICE[1]
Healthy former smoker	0.8669	NICE[1]
All cancers, first year	Event disutility of 0.288	Salomon 2012[2]
All cancers, subsequent years	Healthy utility less 0.451	Salomon 2012[2]
All cancers, final year of life	Healthy utility less 0.540	Salomon 2012[2]
Coronary heart disease, first year	Event disutility of 0.074	Salomon 2012[2]
Coronary heart disease, subsequent years	Healthy utility less 0.0785	Salomon 2012[2]
Coronary heart disease, final year of life	Healthy utility less 0.179	Salomon 2012[2]
Upper digestive diseases	Healthy utility less 0.231	Salomon 2012[2]
Stroke, first year	Event disutility of 0.074	Salomon 2012[2]
Stroke, subsequent years	Healthy utility less 0.316	Salomon 2012[2]
Peripheral artery disease	Healthy utility less 0.014	Salomon 2012[2]
Chronic obstructive pulmonary disease	Healthy utility less 0.153	Salomon 2012[2] weighted by COPD severity prevalence from BOLD study[3]

Table S2: Disease costs

Disease	Annual cost for males	Annual cost for females
Tracheal, bronchus and lung cancer	$29,095	$28,503
Upper digestive system diseases	$845	$882
Pancreatic cancer	$27,472	$23,274
Cervical cancer	Not applicable	$43,733
Bladder cancer	$35,855	$28,667
Kidney cancer	$37,305	$35,588
Ischemic heart disease	$2,392	$1,509
Stroke	$2,713	$3,089
Peripheral artery disease	$4,166	$3,801
Chronic obstructive pulmonary disease	$1,739	$1,430
Stomach cancer	$34,679	$36,349
Liver cancer	$28,483	$20,813
Uterine cancer	Not applicable	$24,671
Colon and rectum cancer	$47,250	$44,733
Acute myeloid leukemia	$51,269	$44,071
Lip and oral cavity cancer	$21,755	$23,707

All figures are Australian dollars, AU$

Source: Australian Institute of Health and Welfare, Health system spending per case of disease and for certain risk factors. Available from: https://www.aihw.gov.au/reports/health-welfare-expenditure/health-system-spending-per-case-of-disease [4]

Table S3: Sex-based weekly employee earnings

	Male	Female
15-19	$381.72	$274.61
20-24	$809.92	$730.97
25-29	$1,260.46	$1,085.26
30-34	$1,601.27	$1,241.95
35-39	$1,926.87	$1,298.09
40-44	$1,980.54	$1,319.55
45-49	$2,085.75	$1,276.98
50-54	$2,106.21	$1,204.34
55-59	$1,795.84	$1,180.95
60-64	$1,847.19	$1,117.79
65-69	$1,550.19	$1,114.72
70+	$1,444.77	$1,361.46

All figures are Australian dollars, AU$
Source: Australian Bureau of Statistics, Survey of Income and Housing 2017-18

Table S4: Sex-naïve weekly employee earnings

	Males and females
15-19	$326.28
20-24	$771.10
25-29	$1,179.56
30-34	$1,437.01
35-39	$1,639.83
40-44	$1,666.31
45-49	$1,685.29
50-54	$1,665.58
55-59	$1,499.56
60-64	$1,493.40
65-69	$1,353.38
70+	$1,416.64

All figures are Australian dollars, AU$
Source: Australian Bureau of Statistics, Survey of Income and Housing 2017-18

Table S5: Distribution parameters used in probabilistic sensitivity analysis

Parameter	Distribution	Alpha	Beta
Background quit proportion Quitline	Beta	22.79	610.31
Background quit proportion Cochrane	Beta	1,004	11,880
Natural log of relative risk for the Quitline intervention*	Normal	1.332	0.441
Natural log of relative risk for the Cochrane intervention*	Normal	0.322	0.077
Probability of relapse up to 5 years	Beta	564.7	3779.1
Probability of relapse up to 10 years	Beta	14.9	481
Probability of relapse after 10 years	Beta	10.3	11.4

* Logged relative risks for intervention effectiveness are exponentiated back to natural units after drawing from the normal distribution.
Source of probability of relapse: Keeney et al.[5]

Detailed sensitivity analysis results

Sensitivity analysis 1 – Cochrane effectiveness data

The effectiveness of the Victorian Quitline service is more effective than the findings of a meta-analysis conducted as part of a Cochrane systematic review of telephone-based cessation services, with a relative risk of 3.79 (95% CI 1.5 to 8.4) compared with 1.38 (95% CI 1.19 to 1.61). This is based on the proportion of people that are successfully abstinent at the end of 12 months due to the intervention compared with the background quit proportion of 3.6% for Victorian smokers and 7.79% for the pooled cohort of the Cochrane meta-analysis. Differential effectiveness could exist due to several reasons, including the behavioural methods and intensity of the call-back telephone service itself, underlying prevalence of smoking in the population of interest, and the background reduction of smoking prevalence from year to year sans intervention.

As expected, the reduced effectiveness results in reduced cost effectiveness (Table 6). For the health care perspective, the mean ICER was no longer dominant at AU$14,204 per QALY. This is still considered cost effective because the ICER is substantially lower than the commonly used AU$50,000/QALY threshold. The credible interval for the ICER remains below AU$50,000/QALY and the credible interval for the incremental NMB remains positive. For the societal perspective, the ICER remains dominant but has credible intervals that slightly cross cost-effectiveness thresholds. Credible intervals may be wider for the series of sensitivity analyses compared with the base case analysis because only 2,000 Monte Carlo simulation runs were conducted instead of 3,000 due to model run time.

In summary, Quitline Victoria is likely to remain cost effective under the lower effectiveness estimate and further research should be conducted to monitor the ongoing effectiveness of the service to inform future evaluations.

Table S6: Incremental results per person, sensitivity analysis 1 - Cochrane effectiveness data

Strategy	Cost ($)	Effectiveness (QALYs)	Incremental cost ($)	Incremental effectiveness (QALYs)	ICER ($/QALY)	INMB	Smokers (%)	Incremental smokers (n)
Health care perspective								
Do nothing	$19,744	11.601	-	-	-	-	22.77%	-
	($19,572 to $19,949)	(11.584 to 11.616)					(21.63% to 24.14%)	
Quitline	$19,906	11.612	$162	0.011	$14,204	$408	22.47%	-24
	($19,759 to $20,080)	(11.597 to 11.628)	($112 to $209)	(0.005 to 0.019)	($6,633 to $38,195)	($62 to $810)	(21.33% to 23.79%)	(-37 to -16)
Societal perspective								
Do nothing	$202,712	11.601	-	-	-	-	22.77%	-
	($201,065 to $204,487)	(11.584 to 11.616)					(21.63% to 24.14%)	
Quitline	$202,640	11.612	-$72	0.011	Dominant	$642	22.47%	-24
	($200,989 to $204,149)	(11.597 to 11.628)	(-$606 to $364)	(0.005 to 0.019)	(Dominant to $68,556)	(-$102 to $1,514)	(21.33% to 23.79%)	(-37 to -16)

All figures are Australian dollars, AU$

ICER: incremental cost-effectiveness ratio; NMB: net monetary benefit

Figures are the mean of all simulation runs followed by the 95% credible interval in parentheses.

Cost in the second column refers to the combination of all costs included for the relevant perspective. For the health care perspective this includes the cost of telephone call-back service and any disease expenditure savings due to averted illness. The societal perspective includes health care costs as well as the productivity measures absenteeism, lost workforce participation and years of productive life years lost due to premature mortality.

The proportion of smokers is based on the smoking status of a microsimulation at the end of the timeframe, essentially at the point of death in the base case.

Costs for the 'Do nothing' scenario are essentially the costs of tobacco-related disease. Costs for the Quitline intervention include the costs of disease plus the cost of the intervention and cost savings due to disease averted.

Net monetary benefit is calculated using a $50,000/QALY cost-effectiveness threshold.

Sensitivity analysis 2 – same earnings for both sexes

In the base case age- and sex-based earnings are used in the monetisation of the productivity measures for the societal perspective (absenteeism, lost workforce participation and years of productive life lost due to premature mortality). Although technically favourable based on an accurate representation of how much people are actually paid, this approach is inherently inequitable by valuing a year (or day) worked by males higher than females at most ages. The implication of this is that the prevention of diseases that occur at a higher rate in males is valued higher. This sensitivity analysis switched the input data to use earnings for all persons, essentially averaging the earnings amounts for the entire cohort regardless of sex. The earnings are still age based.
Under this scenario, Quitline remained dominant for both perspectives. The incremental effectiveness and number of incremental smokers is slightly different to the base case due to the random nature of microsimulation, where the simulation cohort is randomly drawn from the Victorian smoking population distribution, and only 2,000 Monte Carlo simulation runs are conducted for all sensitivity analyses compared with 3,000 in the base case due to model run time.

Table S7: Incremental results per person, sensitivity analysis 2 - same earnings for both sexes

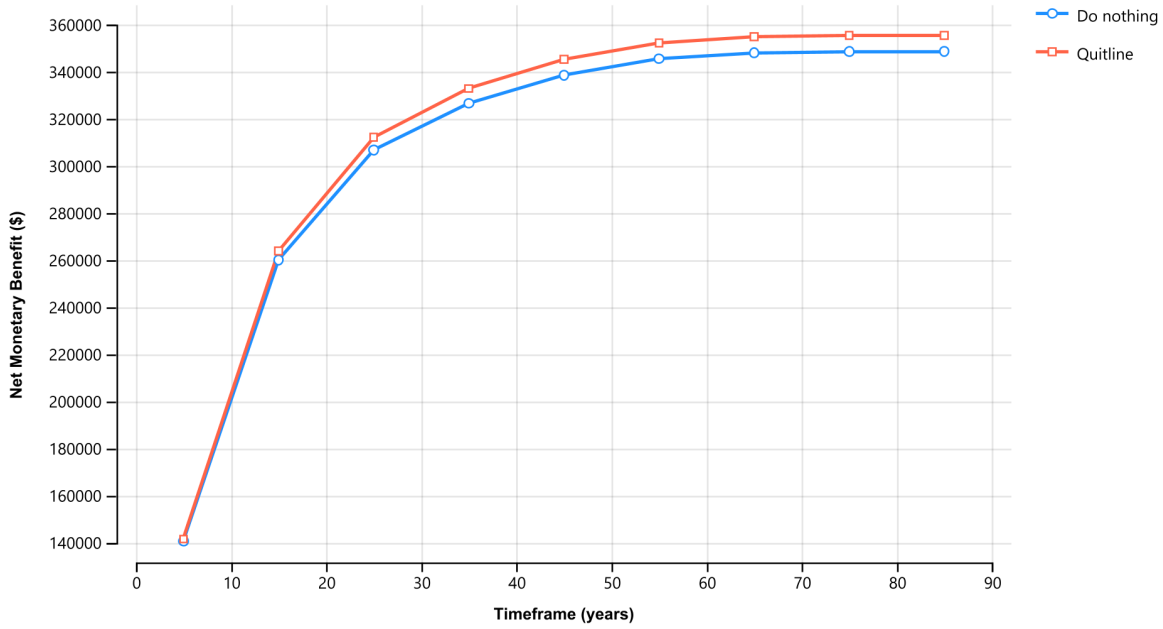
Strategy	Cost ($)	Effectiveness (QALYs)	Incremental cost ($)	Incremental effectiveness (QALYs)	ICER ($/QALY)	INMB	Smokers (%)	Incremental smokers (n)
Health care perspective								
Do nothing	$21,643	11.397	-	-	-	-	43.41%	-
	($21,253 to $21,952)	(11.307 to 11.480)					(32.46% to 55.85%)	
Quitline	$21,420	11.466	-$223	0.069	Dominant	$3,676	41.03%	-191
	($20,521 to $21,985)	(11.348 to 11.624)	(-$886 to $77)	(0.014 to 0.188)	(Dominant to $3,946)	($656 to $10,308)	(29.55% to 54.00%)	(-492 to -35)
Societal perspective								
Do nothing	$209,353	11.397	-	-	-	-	43.41%	-
	($203,152 to $215,805)	(11.307 to 11.480)					(32.46% to 55.85%)	
Quitline	$203,915	11.466	-$5,438	0.069	Dominant	$8,891	41.03%	-191
	($190,866 to $213,093)	(11.348 to 11.624)	(-$15,614 to -$613)	(0.014 to 0.188)	(Dominant to Dominant)	($1,337 to $24,853)	(29.55% to 54.00%)	(-492 to -35)

All figures are Australian dollars, AU$
ICER: incremental cost-effectiveness ratio; NMB: net monetary benefit
Figures are the mean of all simulation runs followed by the 95% credible interval in parentheses.
Cost in the second column refers to the combination of all costs included for the relevant perspective. For the health care perspective this includes the cost of telephone call-back service and any disease expenditure savings due to averted illness. The societal perspective includes health care costs as well as the productivity measures absenteeism, lost workforce participation and years of productive life years lost due to premature mortality.
The proportion of smokers is based on the smoking status of a microsimulation at the end of the timeframe, essentially at the point of death in the base case.
Costs for the 'Do nothing' scenario are essentially the costs of tobacco-related disease. Costs for the Quitline intervention include the costs of disease plus the cost of the intervention and cost savings due to disease averted.
Net monetary benefit is calculated using a $50,000/QALY cost-effectiveness threshold.

Sensitivity analysis 3 – time horizon

As the time horizon of the model decreases, there is less opportunity for the simulation cohort to accumulate health benefits and cost offsets (from reduced health care expenditure). This would be expected to result in reduced cost effectiveness of Quitline relative to the 'do nothing' approach. The time horizon was set to 80 years in the base case, which is essentially a lifetime time horizon considering that the majority of Victorian Smokers are at least 20 years old, and varied between 5 years and 85 years in this sensitivity analysis. The NMB of both strategies reduces with lower time horizons as expected and the incremental NMB (space between the two lines) remains positive at all points, indicating sustained conclusions of cost effectiveness across all timeframes (Figure 2).

Figure S2: Sensitivity analysis 3 - varied time horizons, societal perspective

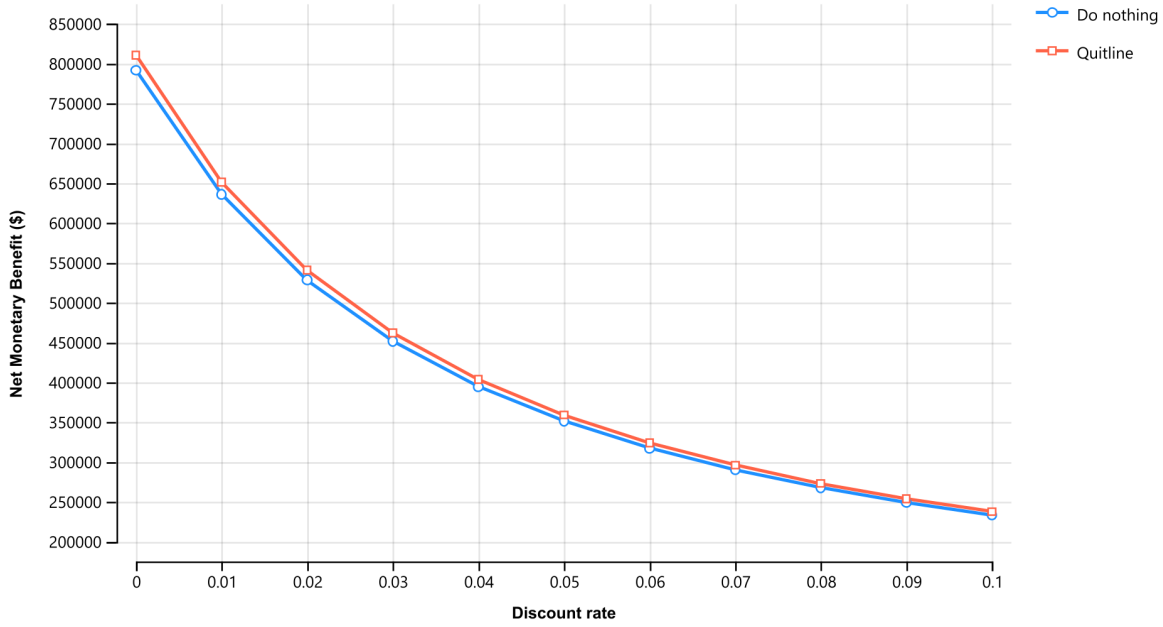


Costs are Australian dollars, AU$
Net monetary benefit was calculated using $50,000 per QALY to represent health benefits.
The Quitline strategy has a higher NMB at all points indicating cost effectiveness at all timeframes.

Sensitivity analysis 4 – discount rate

The Victorian Quitline service remained the dominant strategy at values of the discount rate between 0% and 10% (5% in the base case). Figure 3 shows the NMB (where health effects were valued at AU$50,000 per QALY) for both strategies falling as the discount rate increases because future health and costs (including savings) are valued less in present terms at higher discount rates. This figure also demonstrates that the incremental NMB (space between the lines) increases as the discount rate approaches zero and future health gains and cost savings are valued higher when accumulated to their present-day values.

Figure S3: Sensitivity analysis 4 - discount rate, societal perspective



All costs are Australian dollars, AU$

Sensitivity analysis 5 – time lags

In this scenario analysis time lags were added before the onset of disease. For lung cancer for example, the relative risk of developing lung cancer on top of the normal general population incidence was applied after 10 years. The conclusions of the model do not change under this scenario (Table 9).

Table S8: Time lags before increased risk of disease is applied, sensitivity analysis 5

Time lags	Time lag
Tracheal, bronchus and lung cancer	10
Coronary heart disease	5
Upper digestive diseases	5
Pancreatic cancer	10
Cervical cancer	10
Bladder cancer	10
Kidney cancer	10
Stroke	5
Peripheral artery disease	5
Chronic obstructive pulmonary disease	10
Stomach cancer	10
Liver cancer due to other causes	10
Uterine cancer	10
Colon and rectum cancer	10
Acute myeloid leukaemia	10
Lip and oral cancer	10

Table S9: Incremental results per person, sensitivity analysis 5 - time lags

Strategy	Cost ($)	Effectiveness (QALYs)	Incremental cost ($)	Incremental effectiveness (QALYs)	ICER ($/QALY)	INMB	Smokers (%)	Incremental smokers (n)
Health care perspective								
Do nothing	$18,303	11.759	-	-	-	-	42.95%	-
	($17,865 to $18,608)	(11.677 to 11.840)					(31.76% to 55.16%)	
Quitline	$18,262	11.802	-$41	0.043	Dominant	$2,195	39.98%	-238
	($17,850 to $18,620)	(11.699 to 11.918)	(-$306 to $113)	(0.007 to 0.120)	(Dominant to $10,115)	($268 to $6,303)	(27.67% to 52.96%)	(-597 to -39)
Societal perspective								
Do nothing	$173,379	11.759	-	-	-	-	42.95%	-
	($167,409 to $179,489)	(11.677 to 11.840)					(31.76% to 55.16%)	
Quitline	$170,925	11.802	-$2,454	0.043	Dominant	$4,608	39.98%	-238
	($163,472 to $177,931)	(11.699 to 11.918)	(-$7,108 to -$334)	(0.007 to 0.120)	(Dominant to Dominant)	($705 to $13,097)	(27.67% to 52.96%)	(-597 to -39)

All costs are Australian dollars, AU$

ICER: incremental cost-effectiveness ratio; NMB: net monetary benefit

Figures are the mean of all simulation runs followed by the 95% credible interval in parentheses.

Cost in the second column refers to the combination of all costs included for the relevant perspective. For the health care perspective this includes the cost of telephone call-back service and any disease expenditure savings due to averted illness. The societal perspective includes health care costs as well as the productivity measures absenteeism, lost workforce participation and years of productive life years lost due to premature mortality.

The proportion of smokers is based on the smoking status of a microsimulation at the end of the timeframe, essentially at the point of death in the base case.

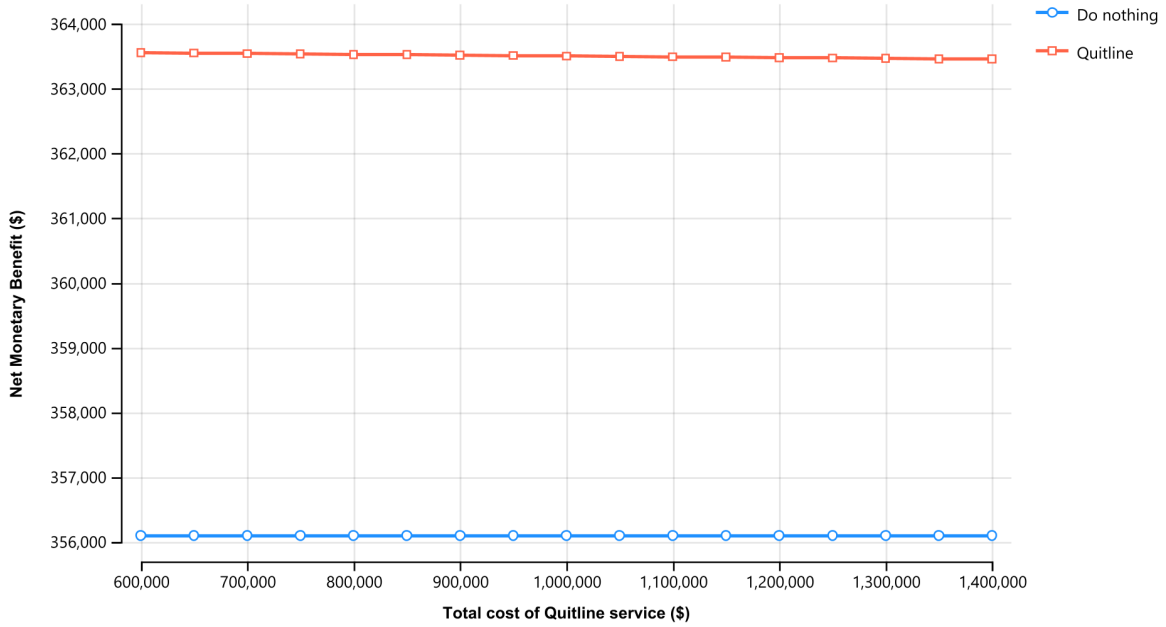
Costs for the 'Do nothing' scenario are essentially the costs of tobacco-related disease. Costs for the Quitline intervention include the costs of disease plus the cost of the intervention and cost savings due to disease averted.

Net monetary benefit is calculated using a $50,000/QALY cost-effectiveness threshold.

Sensitivity analysis 6 – total cost of call-back service

The total cost of Quitline Victoria was varied between AU$600,000 and AU$1,400,000 (AU$1,000,000 in the base case). Increases in the total cost of Quitline decrease the relative cost effectiveness of the intervention but the conclusions of the model do not change (Figure 4).

Figure S4: Sensitivity analysis 6 - total cost of Quitline



All figures are Australian dollars, AU$

References

1. National Institute for Health and Care Excellence. *Tobacco: preventing uptake, promoting quitting and treating dependence, economic modelling report: smoking cessation*. 2020.
2. Salomon JA, Vos T, Hogan DR, et al. Common values in assessing health outcomes from disease and injury: disability weights measurement study for the Global Burden of Disease Study 2010. *The Lancet*. 2012;380(9859):2129-2143. doi:10.1016/s0140-6736(12)61680-8
3. Toelle BG, Xuan W, Bird TE, et al. Respiratory symptoms and illness in older Australians: the Burden of Obstructive Lung Disease (BOLD) study. *The Medical journal of Australia*. Feb 18 2013;198(3):144-8. doi:10.5694/mja11.11640
4. Australian Institute of Health and Welfare. Health system spending per case of disease and for certain risk factors. AIHW. Accessed 2 June 2022, 2022. https://www.aihw.gov.au/reports/health-welfare-expenditure/health-system-spending-per-case-of-disease/contents/risk-factors
5. Keeney E, Welton NJ, Stevenson M, et al. Cost-Effectiveness Analysis of Smoking Cessation Interventions in the United Kingdom Accounting for Major Neuropsychiatric Adverse Events. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research*. Jun 2021;24(6):780-788. doi:10.1016/j.jval.2020.12.012