ORIGINAL RESEARCH ARTICLE

Appl Health Econ Health Policy 2011; 9 (3): 183-196
1175-5652/11/0003-0183/$49.95/0

Cost Effectiveness of Tobacco Control Policies in Vietnam

The Case of Population-Level Interventions

Hideki Higashi,[1] *Khoa D. Truong,*[2,3] *Jan J. Barendregt,*[1] *Phuong K. Nguyen,*[2] *Mai L. Vuong,*[2] *Thuy T. Nguyen,*[2] *Phuong T. Hoang,*[2] *Angela L. Wallace,*[1] *Tien V. Tran,*[2] *Cuong Q. Le*[2] and *Christopher M. Doran*[4,5]

1 School of Population Health, The University of Queensland, Brisbane, Queensland, Australia
2 Health Strategy and Policy Institute, Hanoi, Vietnam
3 Department of Public Health Sciences, Clemson University, Clemson, South Carolina, USA
4 National Drug and Alcohol Research Centre, The University of New South Wales, Sydney, New South Wales, Australia
5 Hunter Medical Research Institute, Newcastle, New South Wales, Australia

Abstract

Background: Tobacco smoking is one of the leading public health problems in the world. It is also possible to prevent and/or reduce the harm from tobacco use through the use of cost-effective tobacco control measures. However, most of this evidence comes from developed countries and little research has been conducted on this issue in developing countries.

Objective: The objective of this study was to analyse the cost effectiveness of four population-level tobacco control interventions in Vietnam.

Methods: Four tobacco control interventions were evaluated: excise tax increase; graphic warning labels on cigarette packs; mass media campaigns; and smoking bans (in public or in work places). A multi-state life table model was constructed in Microsoft® Excel to examine the cost effectiveness of the tobacco control intervention options. A government perspective was adopted, with costing conducted using a bottom-up approach. Health improvement was considered in terms of disability-adjusted life-years (DALYs) averted. All assumptions were subject to sensitivity and uncertainty analysis.

Results: All the interventions fell within the definition of being very cost effective according to the threshold level suggested by the WHO (i.e. <GDP per capita). Graphic warning labels on cigarette packs was the most cost-effective option, followed by excise tax increases, mass media campaigns, public smoking bans and work place smoking bans. If the cost offset was included in the analysis, all interventions would provide cost savings to the government health sector.

Conclusions: All four interventions to reduce the harm from tobacco use appear to be highly cost effective and should be considered as priorities in the context of Vietnam. The government may initially consider graphic warning labels and tax increase, followed by other interventions.

Background and Objective

Tobacco smoking is one of the leading public health problems in the world.[1] Smoking causes sickness and death, and generates significant financial costs. Vietnam has one of the highest rates of male smoking in the world. Findings from national surveys suggest rates of smoking among male adults in excess of 50%.[2-4] Conversely, smoking is not a common practice among females in Vietnam.

Tobacco control initiatives have only recently been developed in Vietnam. In 1989, the Ministry of Health (MOH) set up the Steering Committee on Tobacco Control, with the aim of reducing smoking and smoking-related mortality.[5] Several interventions for tobacco control have been adopted, including smoking bans in designated public places and imposition of higher excise tax.[5,6] In 2000, the Government launched the National Tobacco Control Policy 2000–2010 (NTCP). The policy highlights key intervention areas, including dissemination of health messages, a ban on advertising, health warnings, tax and price control, cessation support and smoke-free areas.[7] Progress has been made since its launch: anti-tobacco messages are broadcast through mass media, a ban on advertising tobacco products is in place, fine systems for smoking bans in public places are in place, health warning text messages are printed on cigarette packs and there have been increases in the excise tax rate on tobacco.[5,6] Despite some evidence of success (such as with smoking bans in cinemas, theatres and city buses),[6] resource constraints and competing issues have meant that the NTCP has not been implemented in its entirety.

This study was conducted as part of the 'Vietnam Evidence for Health Policy' (VINE) project.[8] This 5-year project is a collaborative endeavour between The University of Queensland, Australia, the Vietnamese MOH and other institutions in Vietnam, and aims to develop the local capacity for research that informs health policy through three components: mortality study, burden of disease (BOD) analysis and cost-effectiveness and policy analyses. Results from the BOD study[9] highlighted chronic diseases (including cardiovascular disease, cancer and chronic respiratory disease) as the leading causes of morbidity and mortality in Vietnam.

The information provided clearly suggested that tobacco smoking is one of the major impediments to population health in Vietnam. Given the magnitude of tobacco-related health problems and the limited resources available in Vietnam, this study aims to provide policy makers with information on the cost effectiveness of a range of interventions intended to reduce the harm associated with tobacco misuse.

Methods

Interventions

Four tobacco control interventions were examined in this analysis: excise tax increase, graphic warning labels on cigarette packs, mass media campaigns and smoking bans (in public or work places).

Excise Tax Increase

Vietnam employs an *ad valorem* tax system, where the excise tax is charged as a proportion of cigarette price. In 2006 (base year), the tax rate was standardized at 55% for all cigarette and cigar products and had increased to 65% in 2008.[6] The intervention for this study was defined as several scenarios in which the excise tax increased from the base-year level. The scope of intervention included initial investments in passing legislation, media advocacy in the first year and ongoing management and monitoring activities over 5 years.

Graphic Warning Labels on Cigarette Packs

Since 2008, cigarette packs have carried a warning message in Vietnamese text without graphic image, covering 30% of the pack surface.[6] For this study, the intervention was defined as both text and pictorial messages covering 50% of the pack surface. The scope of the intervention included initial investment in passing legislation, development of pictorial label, mass media advocacy in the first year, 5 years of ongoing management and 10 years of law-enforcement activities.

Mass Media Campaigns

The intervention for this study was defined as the implementation of a series of mass media campaigns over 5 years (television, radio, newspaper, journal, internet and electronic billboards). The scope of the intervention included development of educational messages for different media, and overall management and operational activities over 5 years.

Smoking Ban

The intervention for this study was defined as the expansion of smoking bans to all public places or work places. The distinction between the two was made because effects of the intervention can differ significantly depending on the setting. The scope of the intervention included initial investment in passing legislation, mass media advocacy in the first year, production of non-smoking signs in different forms in the first and sixth years, 5 years of ongoing management and 10 years of law-enforcement activities.

Modelling

The model was designed to reflect the costs and effects of the interventions to derive the incremental cost-effectiveness ratio (ICER) among the base population. The model uses the Markov chain technique, and comprises two sub-models: a smoking prevalence model and an epidemiological model (the details of the methods are provided in the Supplemental Digital Content 1, http://links.adisonline.com/APZ/A34).

Smoking Prevalence Model

The smoking prevalence for the cohorts was determined using smoking uptake and cessation rates estimated using an approach similar to that of Gartner et al.[10] Figure 1 is a schematic depiction of the prevalence model, which was constructed in Microsoft® Excel.

The population for this model was estimated from the 1999 census,[11] following a population dynamic based on age-specific fertility rate, sex ratio at birth and age-specific mortality rate. The population between 1993 and 1998 was back-calculated from the 1999 data. Smoking prevalence data were obtained from the Vietnam Living Standard Survey (VLSS) 1993[2] and 1998,[3] and the Vietnam Household Living Standard Survey (VHLSS) 2006.[12] The details of other data sources are summarized in table I.

The estimation process employed the weighted least-square method, where the uptake and cessation rates were fitted to the observed prevalence at three time-points. The estimated parameters were assumed to be constant for the rest of the lives of the cohort unless they were subject to intervention effects (see the Supplemental Digital Content for the estimated smoking uptake and cessation rates).

Epidemiological Model

The epidemiological model links the smoking status of the cohorts and the anticipated health outcomes. We developed a multi-state life table model in Microsoft® Excel to examine the cost effectiveness of the tobacco control interventions. The multi-state life table allows the cohort to

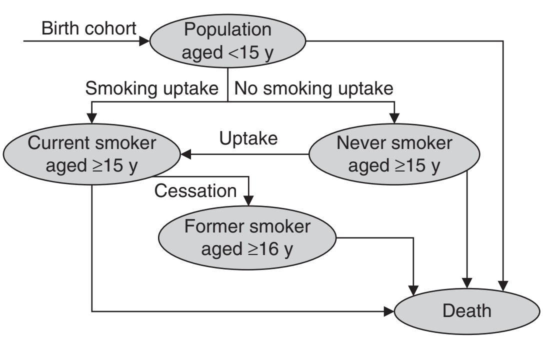

Fig. 1. Smoking prevalence model.

Table I. Data sources

Parameters	Sources of information	Remarks
Smoking prevalence model		
Population	Census 1999[11]	1 y age group
Age-specific fertility rate	Population change survey 2006[13]	5 y age group: 15–49 y
Sex ratio at birth	Population change survey 2006[13]	
Mortality rate (overall)	WHO life table for member states,[14] VINE project	5 y age group
Mortality RR (smoking status)	CPS-II (M Thun, personal communication)	5 y age group: ≥30 y
Smoking prevalence	VLSS 1993[2] and 1998,[3] VHLSS 2006[12]	5 y age group
Epidemiological model		
Population	VINE project	5 y age group
Mortality rate (overall)	VINE project	5 y age group
Mortality RR (smoking status)	CPS-II	5 y age group: ≥30 y
PYLD	Thailand national burden of disease study 1999[15]	10–15 y age group (assumed to be similar to Thailand)
Disease parameters (incidence, prevalence, case fatality, remission, disability weight, etc.)	VINE project	5 y age group
RR (smoking and disease)	CRA and literature[16-19]	
Intervention costs		
Strategy development	State budget regulation	
Human resource requirements	State budget regulation	
Media and advocacy	Government expenses, market data	
Programme supplies	Government expenses, market data	
Overhead costs	Government expenses, state budget regulation	

CPS-II = American Cancer Society's Cancer Prevention Study phase II; **CRA** = comparative risk assessment; **PYLD** = prevalent years lived with disability; **RR** = relative risk; **VHLSS** = Vietnam Household Living Standard Survey; **VINE** = Vietnam Evidence for Health Policy; **VLSS** = Vietnam Living Standard Survey.

have multiple health conditions under certain assumptions: the incidence of each disease should be independent from all causes of death except its own disease-specific mortality; disease incidences are independent of each other; and all causes of death are independent of each other (see the Supplemental Digital Content for details).[20] Smoking prevalence was modelled as the risk factor for selected smoking-related diseases, including ischaemic heart disease (IHD); cerebrovascular accident (CVA); cancer (lung, mouth and oropharynx, oesophagus, pancreas, bladder, stomach); chronic obstructive pulmonary disease (COPD); and lower respiratory tract infections (LRTI).

The reference year was 2006. Demographic information for the base-year population and other epidemiological parameters were obtained from the other components of the VINE project (see table I for details of information sources). We divided the target population into fourteen 5-year age groups of ≥15 years of age in the base year and followed these multiple cohorts for their lifetimes. These subgroups were further divided into three exposure categories: never smokers, current smokers and ex-smokers. Subjects can move from one category to another on an annual cycle based on smoking uptake rate and cessation rate. The conceptual model is provided in figure 2.

The epidemiological parameters for smoking-related diseases (e.g. incidence, prevalence and case fatality rate) all drive the transition of cohorts between four states on the multi-state life-table, i.e. healthy; disease (caused by smoking); death from smoking-related diseases; and death from other causes by means of incidence, remission, case fatality and background mortality rates. The majority of the epidemiological parameters for the selected tobacco-related diseases were obtained from the BOD component of the VINE project.[8] Whilst BOD results for IHD, CVA and COPD provided all information required for the cost-effectiveness model, some of the parameters (i.e. case fatality rates or remission rates) for cancers and LRTI were not explicitly reported. In such cases, we ran the DisMod II software to calculate the missing parameters.[21]

Health outcomes were driven by incidence of smoking-related diseases. Whilst the BOD study provided the cross-sectional incidence rate for 2006, we converted them to cohort incidence rates by means of potential impact fraction (*PIF*), which takes the form of equation 1:

$$PIF = \frac{\sum_{c=1}^{2} Prev_c RR_c - \sum_{c=1}^{2} Prev_c{}^{*} RR_c}{\sum_{c=1}^{2} Prev_c RR_c} \qquad \text{(Eq. 1)}$$

where *Prev* is the cross-sectional smoking prevalence in 2006, *Prev** is the future smoking prevalence of the cohort (with and without interventions), *RR* is the relative risk of smoking to develop the disease and *C* is smoking status category (1 = non-smoker, 2 = smoker). The difference between the *PIF* with and without interventions provides the difference in the cohort incidence of smoking-related diseases. Changes in incidence in turn lead to changes in disease prevalence and mortality, which were converted to generic disability-adjusted life-years (DALYs) by using the disability weights from the BOD study under the VINE project.[8] The BOD study utilized Dutch disability weights determined using the person trade-off method.[22]

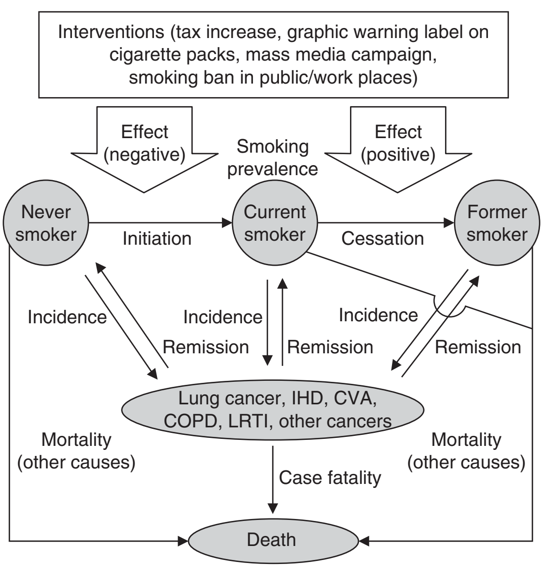

Fig. 2. Epidemiological model. **COPD** = chronic obstructive pulmonary disease; **CVA** = cerebrovascular accident; **IHD** = ischaemic heart disease; **LRTI** = lower respiratory tract infection.

Perspective

Although a societal perspective is recommended by some economic evaluation guidelines,[23] we used the Vietnam Government perspective, given that our aim was to provide advice on tobacco control measures that the Government would be responsible for implementing. A governmental perspective limits the inclusion of cost items to those borne by the government only. The effect side of this perspective implies that the government is interested in the improvement of population health, expressed as DALYs averted, from the relevant interventions.

Intervention Cost

The CostIt program developed by the WHO was used to guide the identification of resources used in the development, implementation and enforcement (if required) of each intervention. CostIt provides a standardized and context-specific analytic framework for collecting and estimating economic costs related to interventions.[23] Using this framework, resource use was grouped into five main categories: strategy development, human resource requirements, media and advocacy, programme supplies and overhead costs (rent, automobiles, equipment, utilities and office supplies). Different sources of data were used to measure and value resource use. The bottom-up ingredient approach was used predominantly in the measurement phase, while the top-down approach was used to generate estimates of unit prices from budget and other government reports. All assumptions and resource items were checked with national experts to ensure the costing templates captured the full spectrum of resource use and appropriate values were being used.

Table II outlines the resource use, measurement and value for the excise tax intervention. 'Strategy development and evaluation' includes the cost of developing the law, development of decrees to guide law implementation and costs for reviewing the

Table II. Cost breakdown for excise tax increase[a]

	Price	Quantity	Cost, y 1
Strategy development and evaluation			
Costs to develop/revise law			200 000 000
Decree development to guide law implementation			50 000 000
Law review			50 000 000
Human resource requirements			
National programme management (including monitoring and evaluation)			
Steering committee	100 000	13 × 0.1[b]	130 000
Director	55 665 792	1 × 0.1[b]	5 566 579
Programme officers	27 985 824	10 × 0.1[b]	27 985 824
Administrative officers	27 985 824	1 × 0.1[b]	2 798 583
Secretary	27 985 824	1 × 0.1[b]	2 798 583
Accountant	25 462 512	1 × 0.1[b]	2 546 251
Logistics officer	15 904 512	1 × 0.1[b]	1 590 451
Driver	23 933 232	1 × 0.1[b]	2 393 323
Law enforcement/inspection			
Inspectors at General Tax Bureau	23 716 800	1	23 716 800
Additional personnel at 63 Provincial Tax Bureau	1 976 400	378	747 079 200
Tobacco smuggling control at 12 hot spots, two staff per spot	23 716 800	24	569 203 200
Media and advocacy			
National meetings (two) to publicize revised tax law			
Presentation/reports (three per meeting)	500 000	6	3 000 000
Meeting host	200 000	2	400 000
Participants (150 per meeting; per diem: VND90 000 per person)	90 000	300	27 000 000
Transportation for 126 participants from 63 provinces	500 000	126	63 000 000
Support staff for meetings	70 000	100	7 000 000
Meeting rooms	5 000 000	2	10 000 000
Local meetings to publicize revised tax law (63 provinces, 40 participants per meeting)			
Presentation/reports (two per meeting)	300 000	126	37 800 000
Meeting host	200 000	63	12 600 000
Per diem and transportation for 40 participants per province	210 000	2520	529 200 000
Support staff for meetings	70 000	567	39 690 000
Meeting rooms	500 000	63	31 500 000
Programme supplies			
Tax law booklets for 17 tobacco enterprises and 63 Provincial Tax Bureaus (three booklets per unit)	20 000	240	4 800 000
Document translation			10 000 000
Rent, utilities, equipment, office supplies			
Standard government budget allocation of 66.67% of human resource costs (law enforcement/inspection)			893 332 800
TOTAL			**3 355 131 594**

a All costs are presented in VND, year 2006 values.

b Distributed to four interventions with different weights: 10% for graphic label warning, 10% for excise tax, 30% for smoking ban, 50% for mass media campaign.

VND = Vietnamese dong.

law. 'Human resource (HR) requirements' include the cost of personnel time required to discuss, develop and manage the intervention at the national level and the cost of law enforcement efforts associated with inspection and enforcement. The key costs associated with HR issues are allowances for people to attend meetings and the relative proportion of their time devoted to the intervention once it is implemented. 'Media and advocacy' involves strategies and meetings to advertise the law and disseminate the new legislation to the population. 'Programme supplies' include the cost of booklets to explain the new law and translation of law (which is a common requirement for new laws). 'Rent, utilities, equipment, office supplies' costs are apportioned using a formula advised by the Government, which considers such expenses equivalent to two-thirds the cost of HR. Time and resource constraints prohibited a more detailed assessment of expenses related to rent and utilities. Table II reports costs for year 1 only. The breakdown costs for other interventions are provided in the Supplemental Digital Content.

In the modelling, costs were calculated for a 5-year period, with an additional 5 years for enforcement if necessary, and were discounted to the base year at an annual rate of 3% as suggested by the WHO.[23] Costs from different years were adjusted to the base year of 2006 by means of the GDP deflator.

Intervention Effect

Information on the effects of each intervention was obtained from the literature. We first referred to systematic reviews, if any, to identify studies of potentially acceptable quality. We then examined the quality of individual studies with information on smoking uptake or cessation. In some cases, this screening criterion left only one study. If this was not the case, the varied interventions employed in each study were examined and the study with the most comparable intervention was selected. However, many of the studies reported the effects as odds ratios (OR), which tend to overestimate the intervention effects. If this was the case, we constructed a 2×2 table from the information available from the literature for each intervention. As most studies adjusted the statistical analysis without providing sufficient detail of the adjustment, such tables did not provide the same OR as reported. We resorted to a relatively clumsy approach to adjusting the table in a way that best fit the reported OR and 95% confidence interval (CI) by means of the Solver function in Microsoft® Excel.[24] We then derived the relative risk (RR) from the adjusted 2×2 table.

Table III provides the effect sizes estimated for each intervention. We assumed a 10-year effect for all interventions. The smoking uptake and cessation rates were modelled to return to the same level as the *status quo* after that. Health gains arising from the interventions were expressed as DALYs averted. We discounted the averted DALYs by 3% as suggested by the WHO.[23]

Cost Offset

Smoking-related diseases prevented as a result of the interventions could result in savings of healthcare expenditure that otherwise would have been spent in the future. Ross et al.[35] estimated the inpatient costs for IHD, COPD and lung cancer in Vietnam. Whilst other smoking-related diseases were not covered, these three diseases contribute most to tobacco-related healthcare costs.[36] Given the aim of this study, we limited the inclusion of costs to those that could be offset from the government's health sector. Furthermore, by comparing the number of patients who received healthcare services in Ross et al.[35] against the prevalent number of cases estimated by the VINE BOD study, we proportionately decreased the unit cost per case for each disease to account for those who do not receive healthcare services anyway. In line with intervention costs, we discounted the cost offset by 3%.

Uncertainty Analysis

Monte Carlo simulation was conducted to provide the uncertainty interval (UI) of ICERs. Key input parameters were provided appropriate distributions including Beta, log-Normal, Triangular and Dirichlet (details are provided in the Supplemental Digital Content). Ersatz software[37] was employed to perform the simulation by re-sampling the values of parameters many times from those distributions. The ICERs reached

Table III. Intervention effects converted from various sources

Intervention (and original sources of information)	Affected behaviour	RR or price elasticity [mean (95% CI)]
Excise tax increase[25-27]	Uptake	–1.175[a,b]
	Smoking participation[c]	–1.039 (–2.068, –0.010)[a]
Graphic warning label[28,29]	Uptake[d,e]	0.739 (0.60, 0.90)
	Cessation[d]	1.781 (1.23, 2.62)
Mass media campaign[30,31]	Uptake	0.857 (0.755, 0.974)
	Cessation	1.496 (1.171, 1.913)
Smoking ban (public places)[28,32]	Uptake	0.947 (0.897, 0.998)
	Cessation	2.217 (1.249, 3.936)
Smoking ban (work places)[33]	Uptake[f]	1.000 (1.000, 1.000)
	Cessation[g]	1.232 (1.100, 1.426)

a These parameters resemble price elasticity.

b The confidence interval was not given.

c This effect is modelled as a one-off impact in 2007.

d These parameters were adjusted under the assumption that the intervention does not affect smokers who consume tobacco products other than cigarettes.

e Effect on smoking uptake was assumed to be half the effect on cessation based on the discussion on the effects of warning labels provided in Levy et al.[29]

f Two studies reported insignificant effects on smoking uptake,[33,34] and so was considered as not having effects.

g We followed the assumptions used by Levy et al.[29] in adjusting for those who do not work in indoor settings.

RR = relative risk.

convergence at 800–1000 iterations, but we increased the number to 2000 times to be certain.

Model Validation

The constructed model was assessed for several types of validities. Veerman et al.[38] suggested three validities relevant to health impact assessment: plausibility (face validity), formal validity (verification) and predictive validity. Face validity was supported by the previous publication of other articles, e.g. Mendez et al.,[39] Gartner et al.[10] and Barendregt et al.,[20] which framed the basis of the model. The formal validity was assessed using stress tests on the spreadsheet model; no anomalies were found. The predictive validity is often unattainable due to difficulties associated with evaluating health outcomes from a particular policy instrument (see Veerman et al.[38] for details) and thus was not confirmed in this study.

Results

The intervention cost, health gain, net cost and ICER for each intervention are provided in tables IV–VI.

Intervention Cost

Affixing a graphic warning label to cigarette packaging was the least costly intervention, followed by a tax increase (table IV). Although the degree of excise tax increase can vary depending on the policy, the intervention cost would not. Mass media campaign costs were significantly higher than these two interventions. Whilst this intervention does not require legislative arrangements, the need for major operational inputs for various media meant that the government would have to allocate sufficient recurrent costs to its implementation. Smoking bans required the largest resource of the four interventions. Whilst it is of a legislative nature, effective implementation would require significant resources for monitoring and law enforcement.

Health Gain

Health gains from tax increases varied depending on the degree of increase (table V). Raising excise tax from the base-year level of 55% to the current level (65% since 2008) would have already averted more than a million DALYs in the future.

Table IV. Intervention cost[a]

Resource component (10 years' total)	Tax increase	Graphic pack warning label	Mass media campaign	Smoking ban (public/work)
Strategy development and evaluation	300	90	0	90
Human resource requirements	6537	922	1085	122371
Media and advocacy	761	83	145751	1863
Programme supplies	15	0	0	47583
Rent, utilities, equipment, office supplies	4214	397	723	41943
Total	**11827**	**1492**	**147559**	**213850**

a All costs are presented in Vietnamese dong (× millions), year 2006 values.

A tax increase up to 75% or 85% would further avert future DALYs. Smoking bans may retrieve substantial health gains if implemented effectively. A ban in public places would avert 3 million DALYs, which provides the largest health gain next to an increase in tax up to 85%. However, a ban on smoking in work places would provide the least health gain amongst the compared interventions. This was due to the relatively small number of people working indoors in Vietnam, and because it does not have a significant effect on the rates of smoking uptake amongst younger people. Graphic warning labels may also be an effective intervention, which could yield health outcomes similar to those of a ban on smoking in public places. Health gains from a mass media campaign were reasonable, and were comparable to an increase in tax to 65%. Males would benefit

Table V. Health gain and net cost[a]

Intervention	DALYs averted		Net cost[b]	
	median	95% UI	median	95% UI
Tax increase from 55% to 65%	1390	599, 3414	–547	–1360, –230
male	1253	527, 3097		
female	125	39, 379		
Tax increase from 55% to 75%	2788	1236, 6700	–1116	–2707, –483
male	2514	1062, 6184		
female	249	75, 693		
Tax increase from 55% to 85%	4050	1743, 10191	–1630	–4071, –680
male	3653	1595, 9148		
female	369	105, 1175		
Graphic pack warning label	2996	1257, 5472	–1263	–2505, –503
male	2380	1011, 4298		
female	470	103, 2072		
Mass media campaign	1873	849, 3282	–643	–1319, –202
male	1494	690, 2568		
female	286	76, 1265		
Smoking ban (public)	3099	602, 7123	–1079	–2754, –28
male	2683	452, 6287		
female	389	80, 1111		
Smoking ban (work)	637	261, 1223	–47	–292, 108
male	559	232, 1082		
female	72	28, 179		

a DALYs averted are presented as thousands; costs are presented in Vietnamese dong (billions), year 2006 values.

b Intervention cost + cost offset.

DALY = disability-adjusted life-year; **UI** = uncertainty interval.

Table VI. Incremental cost-effectiveness ratio (ICER)

Intervention	Without cost offset (VND per DALY averted)		With cost offset[a]
	median	95% UI	
Graphic pack warning label	500	300, 1 200	Dominates
Tax increase from 55% to 85%	2 900	1 100, 6 700	Dominates
Tax increase from 55% to 75%	4 200	1 700, 9 900	Dominates
Tax increase from 55% to 65%	8 600	3 400, 20 100	Dominates
Smoking ban (public)	67 900	28 200, 332 000	Dominates
Mass media campaign	78 300	43 700, 176 300	Dominates
Smoking ban (work)	336 800	169 300, 822 900	Dominates
WHO threshold: cost effective (<GDP per capita × 3)	34 629 900		
WHO threshold: very cost-effective (<GDP per capita)	11 543 300		
Purchasing Power Parity 2006	$US1 = VND3208.37[40]		

a All values were negative ICERs, which indicate that the interventions are all cost saving.

DALY = disability-adjusted life-year; **UI** = uncertainty interval; **VND** = Vietnamese dong.

by 5- to 10-fold more DALYs averted than females, which is not surprising given that, in Vietnam, it is primarily males who smoke tobacco.

Incremental Cost-Effectiveness Ratio

All ICERs were compared against the *status quo* scenario in the base year with the existing interventions at that time (table VI). All interventions were 'very cost effective' given the WHO threshold definition of <GDP per capita (without cost offsets).[41,42] When we accounted for cost offsets, the ICERs of all interventions became negative, which indicates that the intervention 'dominates' (or is 'cost saving'). However, there were substantial differences in the results between interventions.

The graphic warning label intervention was the most cost-effective option. Tax increase was the second most cost effective, even with a relatively small level of increase. The ICERs of the three scenarios (i.e. tax increase up to 65%, 75% and 85%) imply that a higher tax raise would be more cost effective. The ICERs for a mass media campaign and smoking bans were significantly higher than the previous two interventions, which could largely be explained by the substantial differences in intervention costs.

Given the information on ICERs, the Government may first consider graphic warning labels on cigarette packs and then an increase in excise tax. Smoking bans in public places or mass media campaigns, between which the ICERs are

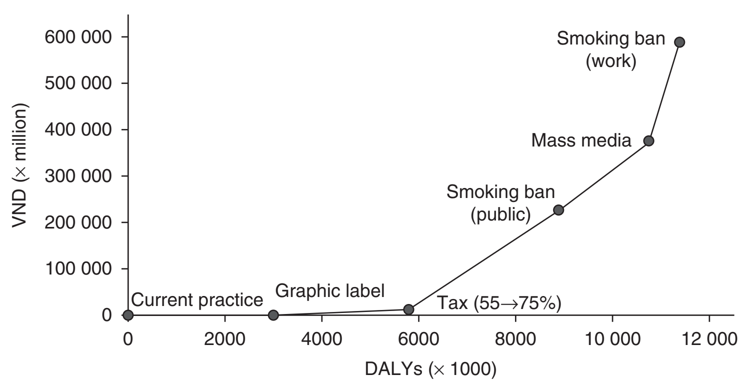

Fig. 3. Expansion pathway (without cost offset). **DALYs** = disability-adjusted life-years; **VND** = Vietnamese dong.

not statistically different, may be considered as the next priorities, whilst smoking bans in work places may be the last to be considered. A sensitivity analysis on mass media campaigns by aligning the duration of effect with the implementation period (both 5 years) did not change the position of the intervention. The expansion pathway of these intervention options is provided in figure 3.

Discussion

This study examined the cost effectiveness of a range of interventions to reduce the burden of tobacco-related harm in Vietnam. The results suggest that the modelled interventions are all highly cost effective (without cost offset) or cost saving (with cost offset). As can be seen in table V, males are the major beneficiaries of the interventions given they have the most to benefit from reducing their higher levels of tobacco use.

A review of the literature revealed a scarcity of comparable studies with a similar focus. Ranson et al.[43] estimated the global and regional cost effectiveness of cigarette price increase, nicotine-replacement therapy and other non-price interventions as part of a World Bank report.[44] For the East-Asia and Pacific region, the cost-effectiveness ratio of a 10% price increase was $US2–50 per DALY averted (year 1995 values). If we compare this with a tax increase of 65% in our study, the converted ICER is $US2.20 per DALY averted (adjusted to 1995 using the GDP deflator and converted using the 1995 purchasing power parity). The other non-price interventions from the same study included a comprehensive ban on cigarette advertising, a ban on smoking in public places, prominent warning labels and mass consumer information. With an assumed intervention effect of a 2–10% decrease in prevalence, the cost-effectiveness ratio in the East-Asia and Pacific region was $US25–510 per DALY averted. The corresponding interventions in our study demonstrated ICERs of $US0.13–86 per DALY averted. A major difference of the Ranson et al.[43] study, compared with ours, was the top-down approach employed to estimate the costs, which were assumed at 0.005–0.02% of the gross national product. Although not immediately comparable, their study suggested that population-level interventions are indeed cost effective in the region.

A number of limitations to our analyses are worth noting. Smoking uptake and cessation rates were estimated from data from three surveys (VLSS 1993 and 1998 and VHLSS 2006). The data from the National Health Survey (NHS) 2002[4] were treated as an outlier and were not included in this analysis due to the differing characteristics between the NHS and other surveys (i.e. size, survey questions, coverage). Information on smoking relapse was not available from these survey data. Modelling the change in smoking behaviours based on these data implies that the estimated smoking uptake rate involves both first-time initiation and relapse. Therefore, the intervention effects on smoking uptake were assumed to apply equally for relapse as for first-time initiation. Similarly, we were only able to capture the net increase or decrease of smokers as a cohort without distinguishing between initiators and quitters, who cancel each other out at the individual level. This prompted us to assume that there were only initiators or quitters in a given year for a given age cohort.

Predicting the smoking prevalence for females was another issue, since any estimation from past trends may not provide a plausible picture for the future. The model projected a slight increase in future prevalence, with a relatively wide uncertainty interval. Nonetheless, the impact of such uncertainties is not likely to significantly affect the result, given the small representation of female smokers in this analysis.

The effects of various interventions were difficult to model. We were not able to identify sufficient studies from Vietnam investigating the effects of the interventions (except for the tax increase). Such information was also not sufficient in the international literature, particularly if we targeted the effects on smoking uptake and cessation rates rather than prevalence itself. Synergistic effects obtained by implementing two or more interventions were not available, and so multiple interventions may yield larger or smaller health gains than the sum of individual intervention effects. As most of the evidence was obtained from Western countries, the effects may be over- or under-estimated in the Vietnamese situation.

The same argument would apply for smoking-related health risks, which were obtained from the comparative risk assessment (CRA), which used data from the CPS-II (American Cancer Society Cancer Prevention Study – phase II) in the USA.[45] Although several studies on health risks of smoking have been conducted in China,[46-48] which may have smoking patterns closer to those in Vietnam, the relatively early stage of the smoking epidemic in China has yet to reflect the full health effects, which could underestimate the true outcomes from smoking over the next few decades as the stage of the epidemic matures.[16,49,50] Lam et al.[51] argued that smoking risks in China would become closer to those in the US and the UK as the follow-up periods of cohorts lengthen. Given these issues, we opted to use CRA (CPS-II) as the most robust source of information to approximate the future health risks of smoking in our study. Testing for the use of parameters from a recent study in China[47] increased the ICERs, which nevertheless lay far below the threshold levels.

Smoking prevalence was used as the risk factor for determining the health outcome of the population. Whilst the risk of developing cardiovascular disease adjusts fairly quickly to changes in smoking status, it may take many years to see a real change in the risks of cancer.[52] Such time lapses were not incorporated in this model due to further complexities involved. However, we performed a sensitivity analysis by including the unofficial disease-specific RRs for former smokers provided by the American Cancer Society, which were estimated from the CPS-II data.[52] Overall, the ICERs were 10–25% higher than those in table VI, which did not materially alter our findings that all interventions were far below the threshold level of being very cost effective (see the Supplemental Digital Content for alternative results). Furthermore, the estimation method was different from the one employed in the CRA for the RRs of current smokers, and so the values between the current and former smokers are inconsistent. Therefore, we preferred not to include the RRs for former smokers in the model. Nonetheless, it should be noted that the health gains from interventions may potentially be overestimated in this analysis. On the other hand, the limited number of smoking-related diseases included in the model potentially implies an underestimation of health gains, although they cover about 90% of the disease burden attributable to tobacco smoking.[8]

The cost-saving result should be treated as indicative only. Whilst the short-term future costs related to the treatment of smoking-related diseases would reduce, the extra life-years gained as a result of a reduction in smoking rates may increase the healthcare costs for non-smoking-related diseases in later life.[53] Although there is no agreement over the inclusion or exclusion of such unrelated future costs in economic evaluations, Drummond et al.[54] suggested two conditions under which it may be worth trying to include them: if the provision of additional care in added life-years is a necessary consequence of the programme being evaluated; and if the data are available. Neither of them applied in our case so they were not included in the analysis. Drummond et al.[54] further argued that the inclusion of such future indirect costs would have little impact on the cost-effectiveness ratio due to heavy discounting, which would hold in our case. Nonetheless, it is worth noting that the cost-saving result may provide a misleading impression to decision makers.

Conversely, the study has a number of strengths. Costing employed a bottom-up ingredient-based approach, which provided detailed information on potential resource use, measurement and value. Bottom-up costing is difficult and time consuming and as such is not common practice in population-level interventions. The epidemiological model was constructed with the latest available local information on population, mortality and disease epidemiology provided by other components of the VINE project. In the absence of such critical inputs from the other segments of the project, the model would have relied on further assumptions, which might have undermined the validity of the results.

Finally, it would be worth noting that cost effectiveness is not the sole criterion for decision making. Policy formulation involves a dynamic process with complex political interactions between stakeholders over competing agenda. Decision makers typically refer to multiple criteria in setting priorities. An example can be drawn from the 'second-stage filter analysis' employed for the Australian Assessing Cost Effectiveness initiative, in which various criteria for priority setting are considered and qualitative judgments made (e.g. equity implications, acceptability to stakeholders, feasibility of implementation, etc.[55]). Given that cost effectiveness analysis does not provide all information needed for decision making, another study on tobacco control policy is underway under the VINE project, which, upon completion, would significantly complement our findings.

Conclusions

This study is the first attempt to provide an evidence base on cost effectiveness of tobacco-control interventions in Vietnam. Although there are uncertainties surrounding the analysis, the cost-effectiveness results are significantly lower than the WHO threshold level. The findings remained robust in sensitivity analysis, and the overall results from this study suggest that all interventions would be very cost effective. Despite that cost effectiveness is not the sole criterion for decision making, the findings provide a strong message to the government that tobacco control should be a high priority for discussion in the policy agenda to promote population health in Vietnam.

Acknowledgements

This research was supported by the Atlantic Philanthropies under the 'Developing the Evidence Base for Health Policy in Vietnam' project. The agency had no role in the design and conduct of the study; collection, management, analysis and interpretation of the data; or preparation, review or approval of the manuscript.

The authors would like to extend their highest appreciation to the individuals from the School of Population Health, The University of Queensland, including Dr Coral E. Gartner for her significant advice on tobacco issues and prevalence modelling, and Associate Professor Peter S. Hill and Dr Anh D. Ngo for their extended support in facilitating the study.

Jan J. Barendregt owns EpiGear, which sells the Ersatz software used in the analysis.

References

1. WHO. WHO report on the global tobacco epidemic, 2008: the MPOWER package. Geneva: WHO, 2008
2. General Statistics Office. Vietnam living standard survey (VLSS), 1992–1993. Hanoi: General Statistics Office, 1994
3. General Statistics Office. Vietnam living standard survey (VLSS), 1997–1998. Hanoi: General Statistics Office, 2000
4. Ministry of Health, Vietnam. National health survey, 2001–02. Hanoi: MOH, 2003
5. Ly NK, Nguyen NK, Dang HH, et al. An overview of tobacco use and control in Vietnam. J Pract Med 2006; 533: 5-17
6. Southeast Asia Tobacco Control Alliance. Status of tobacco use and its control: Vietnam report card. Bangkok: SEATCA, 2008
7. Government of Vietnam. National tobacco control policy 2000–2010. Hanoi: Government of Vietnam, 2000
8. Vietnam Evidence for Health Policy (VINE) project. Developing the evidence base for health policy in Vietnam. Brisbane and Hanoi: School of Population Health, The University of Queensland, Health Strategy and Policy Institute, Ministry of Health, Vietnam, 2006
9. Vietnam Evidence for Health Policy (VINE) project. Vietnam burden of disease and injury study 2008. Brisbane and Hanoi: School of Population Health, The University of Queensland, Hanoi School of Public Health, Ministry of Health, Vietnam, 2011
10. Gartner CE, Barendregt JJ, Hall WD. Predicting the future prevalence of cigarette smoking in Australia: how low can we go and by when? Tob Control 2009; 18 (3): 183-9
11. The Central Data Processing Centre. Data and results from the 3% sample of the population and housing census 1/4/1999. Hanoi: The Central Data Processing Centre, 2000
12. General Statistics Office. Result of the Vietnam household living standards survey 2006. Hanoi: General Statistics Office, 2007
13. General Statistics Office. The 2006 population change, labour force and family planning survey. Hanoi: General Statistics Office, 2007
14. WHO. Health statistics and health information systems: life tables for WHO member states. 2006 [online]. Available from URL: http://apps.who.int/whosis/database/life_tables/life_tables.cfm [Accessed 2008 Sep 29]
15. Bundhamcharoen K, Teerawatananon Y, Vos T, et al. Burden of disease and injuries in Thailand, 1999. Nonthabury: Bureau of Health Policy and Planning, Ministry of Public Health, 2002
16. Ezzati M, Lopez AD, Rodgers A, et al., editors. Comparative quantification of health risks. Geneva: WHO, 2004
17. Thun MJ, Apicella LF, Henley SJ. Smoking vs other risk factors as the cause of smoking-attributable deaths: confounding in the courtroom. JAMA 2000; 284 (6): 706-12
18. Ezzati M, Henley SJ, Lopez AD, et al. Role of smoking in global and regional cancer epidemiology: current patterns and data needs. Int J Cancer 2005; 116 (6): 963-71
19. Ezzati M, Henley SJ, Thun MJ, et al. Role of smoking in global and regional cardiovascular mortality. Circulation 2005; 112 (4): 489-97

20. Barendregt JJ, Van Oortmarssen GJ, Van Hout BA, et al. Coping with multiple morbidity in a life table. Math Popul Stud 1998; 7 (1): 29-49
21. Barendregt JJ, Van Oortmarssen GJ, Vos T, et al. A generic model for the assessment of disease epidemiology: the computational basis of DisMod II. Popul Health Metr 2003; 1 (1): 4
22. Stouthard MEA, Essink-Bot ML, Bonsel GJ, et al. Disability weights for diseases in the Netherlands. Rotterdam: Erasmus University, 1997
23. Edejer TTT, Baltussen R, Adam T, et al. Making choices in health: WHO guide to cost-effectiveness analysis. Geneva: WHO, 2003
24. Brown AM. A step-by-step guide to non-linear regression analysis of experimental data using a Microsoft Excel spreadsheet. Comput Methods Programs Biomed 2001; 65 (3): 191-200
25. Van Kinh H, Ross H, Levy D, et al. The effect of imposing a higher, uniform tobacco tax in Vietnam. Health Res Policy Syst 2006 Jun 26; 4 (1): 6
26. Laxminarayan R, Deolalikar A. Tobacco initiation, cessation, and change: evidence from Vietnam. Health Econ 2004; 13 (12): 1191-201
27. Framework Convention Alliance. How big was the global illicit tobacco trade problem in 2006? [factsheet]. Geneva: FCA, 2008
28. Hammond D, McDonald PW, Fong GT, et al. The impact of cigarette warning labels and smoke-free bylaws on smoking cessation. Can J Public Health 2004; 95 (3): 201-4
29. Levy DT, Bales S, Lam NT, et al. The role of public policies in reducing smoking and deaths caused by smoking in Vietnam: results from the Vietnam tobacco policy simulation model. Soc Sci Med 2006; 62 (7): 1819-30
30. Hafstad A, Aaro LE, Engeland A, et al. Provocative appeals in anti-smoking mass media campaigns targeting adolescents: the accumulated effect of multiple exposures. Health Educ Res 1997 Jun 1; 12 (2): 227-36
31. Jenkins CN, McPhee SJ, Le A, et al. The effectiveness of a media-led intervention to reduce smoking among Vietnamese-American men. Am J Public Health 1997; 87 (6): 1031-4
32. Wakefield MA, Chaloupka FJ, Kaufman NJ, et al. Effect of restrictions on smoking at home, at school, and in public places on teenage smoking: cross sectional study. BMJ 2000; 321 (7257): 333-7
33. Longo DR, Johnson JC, Kruse RL, et al. A prospective investigation of the impact of smoking bans on tobacco cessation and relapse. Tob Control 2001 Sep 1; 10 (3): 267-72
34. Patten CA, Gilpin E, Cavin SW, et al. Workplace smoking policy and changes in smoking behaviour in California: a suggested association. BMJ 1995; 4 (1): 36-41
35. Ross H, Trung DV, Phu VX. The costs of smoking in Vietnam: the case of inpatient care. Tob Control 2007; 16 (6): 405-9
36. Esson KM, Leeder SR. The Millennium Development Goals and tobacco control: an opportunity for global partnership. Geneva: WHO, 2004
37. Epigear. Ersatz 1.0. Brisbane (QLD): Epigear International PTY LTD, 2009
38. Veerman J, Mackenbach J, Barendregt J. Validity of predictions in health impact assessment. Br Med J 2007; 61 (4): 362
39. Mendez D, Warner KE, Courant PN. Has smoking cessation ceased? Expected trends in the prevalence of smoking in the United States. Am J Epidemiol 1998; 148 (3): 249-58
40. Heston A, Summers R, Aten B. Penn world table version 6.3. 2009 [online]. Available from URL: http://pwt.econ.upenn.edu/php_site/pwt63/pwt63_form.php [Accessed 2009 Apr 29]
41. Hutubessy R, Chisholm D, Edejer TT. Generalized cost-effectiveness analysis for national-level priority-setting in the health sector. Cost Eff Resour Alloc 2003; 1 (1): 8
42. International Monetary Fund. World economic outlook database. 2006 [online]. Available from URL: http://www.imf.org/external/pubs/ft/weo/2009/01/weodata/weorept.aspx?sy=2006&ey=2007&scsm=1&ssd=1&sort=country&ds=.&br=1&c=582&s=NGDPPC&grp=0&a=&pr.x=88&pr.y=12 [Accessed 2009 Apr 12]
43. Ranson MK, Jha P, Chaloupka FJ, et al. Global and regional estimates of the effectiveness and cost-effectiveness of price increases and other tobacco control policies. Nicotine Tob Res 2002; 4 (3): 311-9
44. Jha P, Chaloupka FJ. Tobacco control in developing countries. Oxford: Oxford University Press, 2000
45. Peto R, Boreham J, Lopez AD, et al. Mortality from tobacco in developed countries: indirect estimation from national vital statistics. Lancet 1992; 339 (8804): 1268-78
46. Chen ZM, Xu Z, Collins R, et al. Early health effects of the emerging tobacco epidemic in China: a 16-year prospective study. JAMA 1997 Nov 12; 278 (18): 1500-4
47. Gu D, Kelly TN, Wu X, et al. Mortality attributable to smoking in China. N Engl J Med 2009 Jan 8; 360 (2): 150-9
48. Niu SR, Yang GH, Chen ZM, et al. Emerging tobacco hazards in China: 2. Early mortality results from a prospective study. BMJ 1998 Nov 21; 317 (7170): 1423-4
49. Peto R, Chen ZM, Boreham J. Tobacco: the growing epidemic in China. CVD Prevent Control 2009; 4 (1): 61-70
50. Lopez AD, Collishaw NE, Piha T. A descriptive model of the cigarette epidemic in developed countries. Tob Control 1994; 3 (3): 242-7
51. Lam TH, He Y, Li LS, et al. Mortality attributable to cigarette smoking in China. JAMA 1997 Nov 12; 278 (18): 1505-8
52. US Department of Health and Human Services. Reducing the health consequences of smoking: 25 years of progress. A report of the Surgeon General. Atlanta (GA): Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 1989
53. Barendregt JJ, Bonneux L, van der Maas PJ. The health care costs of smoking. N Engl J Med 1997 Oct 9; 337 (15): 1052-7
54. Drummond M, Sculpher M, Torrance G, et al. Methods for the economic evaluation of health care programmes. Oxford: Oxford University Press, 2005
55. Carter R, Vos T, Moodie M, et al. Priority setting in health: origins, description and application of the Australian Assessing Cost Effectiveness initiative. Exp Rev Pharmacoeconomics Outcomes Res 2008; 8 (6): 593-617

Correspondence: Mr *Hideki Higashi*, The University of Queensland, School of Population Health, Herston, QLD 4006, Australia.
E-mail: h.higashi@uqconnect.edu.au