RESEARCH PAPER

Cost of tobacco-related diseases, including passive smoking, in Hong Kong

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Background: Costs of tobacco-related disease can be useful evidence to support tobacco control. In Hong Kong we now have locally derived data on the risks of smoking, including passive smoking.
Aim: To estimate the health-related costs of tobacco from both active and passive smoking.
Methods: Using local data, we estimated active and passive smoking-attributable mortality, hospital admissions, outpatient, emergency and general practitioner visits for adults and children, use of nursing homes and domestic help, time lost from work due to illness and premature mortality in the productive years. Morbidity risk data were used where possible but otherwise estimates based on mortality risks were used. Utilisation was valued at unit costs or from survey data. Work time lost was valued at the median wage and an additional costing included a value of US$1.3 million for a life lost.
Results: In the Hong Kong population of 6.5 million in 1998, the annual value of direct medical costs, long term care and productivity loss was US$532 million for active smoking and US$156 million for passive smoking; passive smoking accounted for 23% of the total costs. Adding the value of attributable lives lost brought the annual cost to US$9.4 billion.
Conclusion: The health costs of tobacco use are high and represent a net loss to society. Passive smoking increases these costs by at least a quarter. This quantification of the costs of tobacco provides strong motivation for legislative action on smoke-free areas in the Asia Pacific Region and elsewhere.

There is steadily mounting evidence of the harm caused to health by active and passive tobacco smoking[1 2] but policymakers can be reluctant to implement stricter legislation to protect non-smokers and restrict promotion of tobacco products. One way of enhancing appreciation of the magnitude of the problem is to transform the data on health effects of tobacco-induced disease into monetary values. This has been done to good effect in the United States where costs attributable to smoking were estimated to be over US$157 billion[3] with attributable direct health costs taking up 6–9% of the total national health care budget.[4 5] Other countries have followed suit and calculated their own financial burdens resulting from tobacco use.[6–9] However, it is difficult to extrapolate from developed to developing countries where the tobacco epidemic is usually at an earlier stage. Furthermore, none of the costings in developing countries and few of those in developed countries have included any costs for passive smoking. In Hong Kong, a special administrative region of China, the prevalence of regular smoking among men in 2000 was 22%,[10] much lower than that of mainland China where over 53% of males smoked in 1998.[11] The current peak in the prevalence of cigarette smoking in China occurred about 40 years later than in the United States but post dates that in Hong Kong by about 20 years. Although the effect of smoking is probably not yet fully expressed in terms of health impact in either Hong Kong or mainland China, the future burden of health costs in the mainland can be predicted from Hong Kong's experience.

A previous attempt to cost the health effects of smoking in Hong Kong[12] used overseas risk data because at that time there were no locally generated data. Since then local data on the risks of active and passive smoking have been published[13–20] which allow us to estimate the monetary value of tobacco-related disease. The main objectives of this costing were to raise awareness among local and regional decision-makers of the true costs of tobacco to both smokers and non-smokers and to promote tobacco control legislation. This paper describes the costing and its findings.

METHODS

We limited the costing to health-related impacts and so the values reported in this study are extremely conservative. We made 1998 the base year because we had detailed data on 81% of the deaths which occurred in that year through the University of Hong Kong Lifestyle and Mortality Study (LIMOR). From this study the risks of mortality from active smoking for those aged 35 years and over[13] and for passive smoking for those aged 60 years and over,[14] have been published.

Mortality caused by active smoking

We re-analysed the LIMOR dataset to obtain mortality from active smoking by age group (35 to 64, 65 and over), sex and cause of death (table 1). Using these risk estimates we calculated the fraction of deaths which could be attributed to active smoking. Since we knew the proportion of decedents who smoked, we could estimate the attributable fraction of those exposed[21] as the smoking-attributable fraction (SAF) for the smokers using the formula: SAF = [OR − 1]/OR, where OR is the odds ratio for disease-specific mortality caused by smoking.

Applying the SAFs to all deaths among smokers, also by disease, age and sex, we estimated the attributable number of lives lost at any age and under 65 years adjusted for the labour force participation rate. Using the difference between age at death and 65 years, we calculated average productive years lost, discounting at 3% per annum, and monetised the losses by valuing a working year at the median wage in 1998.

Abbreviations: COPD, chronic obstructive pulmonary disease; IHD, ischaemic heart disease; LIMOR, University of Hong Kong Lifestyle and Mortality Study; OR, odds ratio; PAF, population attributable fraction; SAF, smoking-attributable fraction

Table 1 Causes of death and odds ratios (OR) used in the calculation of attributable fractions to estimate health-related costs of active and passive smoking

	OR (95% CI) for mortality as used in the costing		
	Active smoking		Passive smoking
Cause of death (ICD 9 code)	Age 35 to 64	Age 65 and over	All ages
Lung cancer (162)	3.8 (3.1 to 4.7)	4.6 (4.1 to 5.2)	1.4 (1.0 to 1.9)
Oesophageal cancer (150)	8.1 (4.6 to 14.3)	2.5 (1.8–3.7)	
Stomach cancer (151)	1.7 (1.2 to 2.4)	1.2 (0.9 to 1.5)	
Liver cancer (155)	1.5 (1.2 to 1.8)	1.4 (1.1 to 1.6)	
Mouth, pharynx, larynx, pancreas, bladder cancer (140–149, 157, 161, 188)	1.7 (1.3 to 2.2)	1.8 (1.5 to 2.2)	
COPD/pulmonary heart disease (416–417, 490–492, 496)	5.0 (3.1 to 8.0)	5.8 (5.0 to 6.7)	2.0 (1.3 to 3.1)
Other respiratory (11, 12, 18, 460–466, 470–478, 480–483, 485–487, 493–495, 500–508, 510–516, 518–519)	2.0 (1.5 to 2.6)	1.5 (1.4 to 1.7)	
Stroke (430–438)	1.8 (1.4 to 2.3)	1.2 (1.0 to 1.3)	1.5 (1.2 to 1.9)
Ischaemic heart disease (410–414)	1.7 (1.3 to 2.2)	1.3 (1.2 to 1.4)	1.4 (1.0 to 1.8)
Other vascular (390–398, 401–405, 415, 420–429, 440–444, 446–448, 451–459)	1.9 (1.4 to 2.6)	1.3 (1.2 to 1.5)	
Other medical: peptic, gastric, duodenal, gastrojejunal ulcer, regional enteritis, idiopathic proctocolitis (531–534, 555–556)	2.7 (0.8 to 9.8)	1.4 (0.9 to 2.2)	

CI, confidence interval; COPD, chronic obstructive pulmonary disease; ICD 9, *International classification of diseases*, ninth revision; OR, odds ratio.

We valued an attributable death using the value of 1.4 million euros (€), a middle estimate worldwide which was used in a European valuation of air pollution related deaths.[22] With an exchange rate of €1 to HK$7.2, this was equivalent to HK$10 million or US$1.3 million. We present the results both with and without the monetary value for a life lost.

We used the groupings of cause of death reported in two studies from China.[13 23] However, the ''other medical'' group was large and diverse so we limited it to conditions recognised as tobacco-related by other studies (table 1). We included liver cancer because of its high incidence in China and Hong Kong and its strong association with smoking. We did not include pregnancy-related conditions because smoking prevalence among women in Hong Kong is low.

Mortality caused by passive smoking

This was calculated in the same way and using the same dataset as for active smoking with data on exposure to secondhand smoke in never-smokers over 60 years old, exposed at home.[14] We included only the four causes of death which have been associated with passive smoking—that is, lung cancer, chronic obstructive pulmonary disease (COPD), ischaemic heart disease (IHD), and stroke. The LIMOR dataset did not provide information about workplace exposures to secondhand smoke but there is increasing evidence that exposure at work is just as harmful as exposure at home.[24–26] We therefore extrapolated the estimated risks of home exposure to those exposed at work and further extrapolated to never-smokers aged 35–59 years. We estimated that 56% of males and 46% of females over 35 years were exposed to secondhand smoke.[15] We used the population attributable fraction (PAF)[21] rather than the SAF because we did not have direct data on the number of deaths in all of those exposed to secondhand smoke. The formula used was: $PAF = (p\ [OR - 1])/(1 + p\ [OR - 1])$ where p is the proportion of never-smokers exposed.

Costing of morbidity

For the costing of morbidity, we used directly derived risks of morbidity as far as possible. For example, for the impact of active smoking and of passive smoking at work on general practitioner (GP) visits we were able to use local published data[15 20] to calculate PAFs of health care utilisation and their costs. We could also do this for the impact of passive smoking on children. For the costs due to passive smoking by children less than 1 year old we used results from a local birth cohort.[18] From another local study on 8–12 year old children[19] we extrapolated the excess doctor visits caused by passive smoking and their costs to children between 1–15 years old. These estimates omit some of the early life impacts caused by passive smoking or smoking by the mother, for example, on sudden infant death syndrome, low birth weight and other birth complications, therefore these costs are underestimated.

Recent costings in the United States used data on risks of hospital utilisation by smoking status but we had no data on smoking status of inpatients. Therefore, for costs of serious illness resulting in hospital admission, we used disease, age and sex specific PAFs which were derived using the corresponding mortality risks. We applied these PAFs to data on admissions which were obtained from the Hong Kong Hospital Authority clinical medical system. This information system includes all discharges and deaths in public hospitals in Hong Kong and covers around 94% of the hospital bed-days used in Hong Kong.[27] For consultations in public outpatient clinics and accident and emergency departments, we could not obtain disease, age and sex-specific utilisation or cost data. Therefore, for active smoking, we used a PAF based on the smoking-related risk of mortality from any cause for all ages and both sexes together but we omitted these costs for passive smoking. The Hospital Authority supplied the unit average cost of bed-days in acute and long-stay hospitals and outpatient visits. For private hospitals, we obtained the number of admissions from routine data[28] and used charge data from BUPA (Asia) Limited,[29] but omitted any costs of private hospital utilisation for passive smoking-related conditions.

Other data sources

For population data on the prevalence of active and passive smoking, health care utilisation and the average cost of a GP visit, we used the University of Hong Kong-Harvard Household Survey from which some of the data have been published.[15] For time lost from work, we used the University of Hong Kong Police Health Survey from which we have already published findings on the association between passive smoking, respiratory symptoms, health care utilisation and time off work.[16 17] We calculated from this database the risk of taking time off work for a smoker compared with a never-smoker and used this together with an estimate of smoking prevalence among workers[15] and annual working days lost[30] to estimate days lost attributable to smoking. These were valued at the median wage in 1998[31] and were attributed to the public or private sector based on the proportion of employees in these sectors.[32 33]

Table 2 Summary of the annual costs (1998) for mortality and morbidity due to diseases caused by active smoking

Component of cost	No. of attributable units, best estimate (range)	Unit cost (US$)	Value (US$ million), best estimate (range)
Mortality			
Total lives lost	5596 (4096–6978)	1.3 million	7193 (5265–8969)
Productive lives lost (<65 years)	1529 (1054–1942)	–	–
Productive life years lost (<65 years)			
Undiscounted	10774 (7295–13837)	Males: 18509	199 (134–255)
Discounted at 3% per year*	8669 (5889–11111)	Females: 13882	160 (109–205)*
Morbidity			
Public hospital days			
Acute	270038	481	130 (89–166)
Long stay	152888	255	39 (29–49)
Private hospital episodes	6370	2505	16 (12–19)
Specialist outpatient clinics	256823	74	19 (16–22)
General outpatient clinics	714585	DH: 28, HA: 34	21 (19–22)
A&E (visits)	105661	74	8 (7–8)
Private GP (visits)	519962	23	12 (12–18)
Days off work (private sector)	170893	Males: 51	10 (0.5–15)
Days off work (public sector)	21610	Females: 38	1 (0.1–2)
Nursing home care			117 (106–128)
Home-based care			0.7 (0.5–0.8)
Annual costs for active smoking, excluding the value of life			532 (421–655)

*This is the value used in the main estimates of costs.
The numbers in the table are rounded and so may not sum to totals.
A&E, accident and emergency; DH, Department of Health; HA, Hospital Authority, GP, general practitioner.

We applied the PAF derived from the excess risk of mortality from any cause for active smokers aged over 65 years to the number of people in nursing homes and multiplied this by the annual unit cost of care.[34] To estimate the value of home care in the last year of life, we used additional data from LIMOR on the length of time that the decedent was unable to go outdoors alone in the year before death. We multiplied the average time spent in this state by a smoker by the number of deaths attributable to active smoking and subtracted attributable inpatient days; we did the same for passive smokers. These months of care were valued by applying the proportions who would have domestic help and the cost[10 31 35 36]; care provided by the family alone was not monetised.

To calculate a range for the best estimate of costs, we used the upper and lower bounds of the 95% confidence intervals for the risk estimates and re-worked the costings. Whenever we had alternative options for values, such as in the estimation of the costs of private hospital inpatient episodes, we used the lower option to give a conservative estimate. All reported costs are in US dollars (US$1 = HK$7.8) and are for one calendar year (1998).

RESULTS

We estimated that 5596 deaths among those 35 years and over in Hong Kong in 1998 were attributable to active smoking (table 2) and 1324 deaths were attributable to passive smoking (table 3). Of the passive smoking attributable deaths, 239 were from lung cancer, 303 from COPD, 309 from IHD and 473 from stroke. This amounts to 6920 tobacco-related deaths out of a total of 32 847 deaths in a population of 6.5 million people in 1998.

The discounted value of productive years of life lost was $174 million, $160 million for active smoking and $14 million for passive smoking (tables 2 and 3). For adults, the attributable cost of public hospital use was $230 million a year, $169 million for active smoking and $61 million for passive smoking (tables 2 and 3). This represents about 7% of the Hospital Authority's total expenditure on public hospitals in 1998. The cost of visits to specialist outpatient clinics by adults as a result of active smoking amounted to $19 million (table 2) representing 5% of all visits to non-paediatric specialist clinics. The value of the extra medical care due to passive smoking exposure in children was $4 million a year (table 3).

The cost of visits to public primary care outpatient clinics which were attributable to active smoking was estimated as $21 million which is 12% of the total cost for such clinics in 1998. The cost of attributable visits to accident and emergency departments as a result of active smoking was $8 million (table 2) or 5% of the cost of all visits. The attributable cost of private GP consultations due to active smoking was $12 million (table 2) and $32 million for passive smoking (table 3).

The value of the attributable absences from work was $11 million for active smoking (table 2) and $45 million for passive smoking (table 3). This does not include time taken off work for doctor consultations or a period of suboptimal productivity before doctor consultation and on return to work.

The attributable cost of nursing home care in those over 65 years for disease due to active smoking was $117 million while the cost of home-based care was $0.7 million (table 2). For passive smoking, home-based care cost $0.3 million (table 3) but we could not estimate the cost of nursing home care for conditions caused by passive smoking.

Our conservative estimate of the annual health-related cost of tobacco in Hong Kong in 1998 is $688 million with a range of $469–$916 million. This includes $459 million for health care costs ($341 million for medical care and $118 million for long term care) and $230 million for productivity losses. About 23% of the total costs and 28% of the medical care costs were due to passive rather than active smoking. The proportion of the morbidity costs which fell on the public sector was 70% for active smoking and 50% for passive smoking. In addition, there were 6920 (4430–9229) attributable deaths of which 19% were attributable to passive smoking. If we add the value of attributable lives lost but deduct productivity loss due to premature death to avoid double counting the value of a lost life, the annual cost would be $9.4 billion.

Table 3 Summary of the annual costs (1998) for mortality and morbidity due to diseases caused by passive smoking

Component of cost	No. of attributable units, best estimate (range)	Unit cost (US$)	Value (US$ million), best estimate (range)
Mortality			
Total lives lost	1324 (334–2251)	1.3 million	1702 (429–2893)
Productive lives lost (<65 years)	178 (38–310)	–	–
Productive life years lost (<65 years)			
Undiscounted	1031 (211–1800)	Males: 18500	18 (4–31)
Discounted at 3% per year*	815 (168–1423)	Females: 13900	14 (3–24)*
Morbidity			
Admissions and outpatient use in children			4 (–)
Public hospital days			
Acute	88916	481	43 (13–70)
Long stay	69588	255	18 (6–29)
Private GP (visits)	Approx 1500000	23	32 (3–60)
Days off work (private sector)	942409	Males: 51	41 (15–66)
Days off work (public sector)	102390	Females: 38	4 (2–7)
Home-based care			0.3 (0.1–0.5)
Annual costs for passive smoking, excluding the value of life			156 (48–261)

*This is the value used in the main estimates of costs.
The numbers in the table are rounded and so may not sum to totals.
The following could not be estimated: numbers and costs of episodes in a private hospital; specialist outpatient clinic, general outpatient clinic and accident and emergency clinic visits; nursing home care.

DISCUSSION

Our estimate of $688 million for the current annual monetary value of the diseases caused by tobacco is larger than previous estimates for Hong Kong. The Hospital Authority previously estimated $90 million for hospital care for cancer, heart and respiratory disease.[37] Another costing based on overseas risk estimates was $193 million annually at 1998 prices.[12] Our costing is more comprehensive and uses locally derived data for all risks and costs. It is also more comprehensive than costings in other countries because we were able to include estimates of costs for major health problems associated with passive smoking, such as stroke and COPD. Almost a quarter of the cost of tobacco-related disease was due to the effects of passive smoking. Although the risk from passive smoking exposures is likely to be lower than that from active smoking, passive smoking is much more prevalent and thus the aggregated costs are relatively high.

The present study has limitations due to the non-availability of some of the data required. First, we have used attributable fractions derived from mortality risks to estimate some of the morbidity costs. This allowed us to use local data but requires us to make assumptions about comparability of the risks. We do not have risk estimates for admission to hospital for smokers relative to non-smokers but disease-specific mortality risks should not overestimate attributable admissions unless smokers use less hospital care than non-smokers with the same disease. A cohort study from Korea[38] demonstrates the relationship between the risks of mortality and of hospital admission for current smokers in an East Asian population. For lung cancer, the risks for mortality (relative risk (RR) 4.0) and admission (RR 4.2) are almost the same; for IHD, the risk of admission is higher (RR 1.5 and 2.0) and for stroke the risk of mortality is slightly higher (RR 1.8 and 1.4) but the risk does not vary much between the two measures. Other studies of differences in utilisation between smokers and non-smokers have identified a higher rate of hospital utilisation by smokers.[39–41] Much of this excess is likely to be caused by a higher incidence of disease, which is already reflected in our mortality-based disease specific attributable risks.

Second, by using a population-based attributable fraction, we make the assumption that the proportion exposed—for example, among those admitted to hospital—is the same as the proportion exposed in the general population. This assumption is likely to lead to an underestimation of the true cost of hospital-based care since smokers are usually over-represented in a hospital population. Over-utilisation by smokers is sometimes less apparent as we move down the levels of care towards primary care services,[42] but Miller *et al*[43] found that smoking-attributable fractions for ambulatory care were larger than those for hospital care in the United States.

Third, for utilisation attributable to active smoking, hospital inpatient costs were the largest item and we could apportion these by age, sex and disease subgroups. However, for some categories of care such as outpatient visits, we were unable to separate out the effects of these variables and so could have under- or overestimated these costs. Fourth, we have used contemporary prevalence ratios for ever-smoking when estimating the PAFs but current mortality and morbidity result from smoking rates in the past. It would require detailed data going back many years to estimate the effect of this assumption. However, using the proportion of ever-smokers rather than current smokers tends to smooth out changes in smoking behaviour over time. Rising rates of smoking among young people suggest that this costing may be an underestimate of the burden of disease in the future.

Fifth, we had no specific risk data for the impact of passive smoking on adults under 60 years old so we extrapolated the risks for adults over 60 to those aged 35–59 years. The age of 35 has been identified as a significant cut-off point for active smoking beyond which exposure is reflected in disease and reduced life expectancy[44] and table 1 shows that the risks of mortality did not vary much with age beyond 35. We have used the same cut-off for the impact of exposure due to passive smoking. The number of attributable cases does increase with age because the risks are applied to a greater baseline rate of disease and this is incorporated by using age and disease specific population rates of deaths and admissions.

Finally, we have omitted some categories of health-related costs. Our value of $1.3 million for a lost life attempts to put a value on the suffering caused by the loss of a loved one, but we have not included any value for pain and suffering due to disease or the considerable input by families to the care of their sick relatives, and we have only included four disease groups in the costing of passive smoking in adults.

The estimate of days of work lost by passive smokers is larger than that for active smokers, probably for two reasons.

First, those who continue to smoke tend to be less susceptible to its effects, the healthy smoker effect, or less health conscious. In our analysis, the risk of taking time off work was higher for passive (adjusted OR for males 1.80, 95% confidence interval (CI) 1.41 to 2.30) than for active smokers (OR 1.37, 95% CI 1.16 to 1.63). The same effect has been shown for doctor consultations.[39 42 45 46] Second, the prevalence of passive smoking is higher than that of active smoking. Together, these data give a higher population attributable fraction for passive than for active smoking.

In applying attributable risks to nursing home data, we assumed that the attributable proportion of nursing home use was similar to that for mortality. In the absence of evidence to the contrary, we consider this a reasonable assumption; the only alternative would be to drop this item which would underestimate the costs.

Economic assessments sponsored by the tobacco industry have, in the past, claimed net benefits from tobacco marketing and consumption.[47 48] They often cite the tax revenue from tobacco as a source of funds for the government and claim that this tax revenue outweighs any excess health care costs. While our costing has been unable to quantify some categories of costs, our annual estimate of direct costs and productivity loss alone is more than double the Hong Kong SAR government's annual revenue from tobacco tax.

Warner[49] points out the weaknesses in previous economic arguments put forward by both the tobacco industry and tobacco control advocates. The issue most relevant to this paper is that only those smoking-related costs which fall on society are true social costs. For example, it could be argued that the cost of premature mortality could be considered an economic cost to the smoker's family and not to society since another worker would take over the role of the lost worker. If we exclude all of those costs which we might assume to be private costs, we have an estimate of $331 million for the societal costs of smoking. Of our total costs, 64% fall on the public sector but this proportion will be different in other countries with different health and welfare systems.

The visits to primary care clinics attributable to active smoking could be presented in units of working time. If we assume that the average doctor sees 60 patients a day, five days a week for 48 weeks of the year, then the attributable visits represent the workload of 50 full-time doctors in the public sector and 36 full-time GPs in the private sector. For passive smoking, we have only estimated the extra workload in the private sector which is the equivalent of 104 full-time GPs. These ''doctor-equivalents'' are another useful means of emphasising the real costs of disease burden on the population.

Although some of our risk estimates for active smoking[13] are lower than those in the West, they are similar to those from Korea.[38] They are therefore likely to be applicable to Asia Pacific countries with a similar smoking history and will at least reflect, for those countries like China with an even more immature smoking epidemic, the likely future health care burden. With few smoke-free laws in Hong Kong, many non-smokers are probably exposed to a high level of background smoking and this could be another reason for the lower estimates of risk for active smoking.

The costs of passive smoking in any country will depend to a great extent on its prevalence. In our estimates we used an exposure prevalence of about 50% but biochemical measures often show self-reported exposure to be an underestimate.[50] If the prevalence of passive smoking was higher than we have estimated, the associated costs would be higher too. If those in other countries wish to use our example to estimate their own passive smoking costs, they could upwardly adjust their costs of active smoking by multiplying by 1.3 to include costs due to passive smoking. They should, however, note that the prevalence of active smoking in Hong Kong is lower than in most Asia Pacific countries; it is therefore quite likely that other population's passive smoking burden is even higher than in Hong Kong, unless there is effective protection for non-smokers in public places, workplaces and their own homes.

These findings will give a strong boost to the Hong Kong government's aim to promote tobacco control and the urgently needed evidence on which to base legislation. Stronger arguments citing health costs can be made against the catering industry's proposals for extended ''grace periods'' before implementation of smoke-free legislation covering all restaurants and bars. Each day of delay in implementing the legislation in Hong Kong can now be translated into an additional monetary burden to the community.

What this paper adds

The maturity of the tobacco epidemic in Hong Kong is behind those in Western countries but ahead of those in East Asia, including mainland China. The cost of tobacco-related disease in Hong Kong therefore provides Asian countries with a prediction of their own future costs.

This article provides the most comprehensive costing to date in terms of passive smoking effects in adults. The costs of passive smoking were almost a quarter of the total costs and 28% of the medical care costs. Since Hong Kong has a relatively low prevalence of smoking among men, other countries' passive smoking costs are likely to be even higher.

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Competing interests: TH Lam is Vice-Chairman and AJ Hedley former Chairman of the Hong Kong Council on Smoking and Health.

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