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Global and regional estimates of the effectiveness and cost-effectiveness of price increases and other tobacco control policies

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The objective of this study was to provide conservative estimates of the global and regional effectiveness and cost-effectiveness of tobacco control policies. Using a static model of the cohort of smokers alive in 1995, we estimated the number of smoking-attributable deaths that could be averted by: (1) price increases, (2) nicotine replacement therapy (NRT), and (3) a package of non-price interventions other than NRT. We calculated the cost-effectiveness of these policy interventions by weighing the approximate public-sector costs against the years of healthy life saved, measured in disability-adjusted life years, or DALYs. Even with deliberately conservative assumptions, tax increases that would raise the real price of cigarettes by 10% worldwide would prevent between 5 and 16 million tobacco-related deaths, and could cost US$3–70 per DALY saved in low-income and middle-income regions. NRT and a package of non-price interventions other than NRT are also cost-effective in low-income and middle-income regions, at US$280–870 per DALY and US$36–710 per DALY, respectively. In high-income countries, price increases were found to have a cost-effectiveness of US $83–2771 per DALY, NRT US$750–7206 per DALY and other non-price interventions US$696–13,924 per DALY. Tobacco control policies, particularly tax increases on cigarettes, are cost-effective relative to other health interventions. Our estimates are subject to considerable variation in actual settings; thus, local cost-effectiveness studies are required to guide local policy.

Introduction

Smoking was estimated to have killed about 4 million people in 1998, and, on current smoking patterns, smoking will cause about 10 million deaths a year by the 2020s or early 2030s (Jha & Chaloupka, 2000; Peto & Lopez, 2001). Governments considering tobacco control policies need to weigh the costs of intervening vs. the health benefits from reducing smoking. The cost-effectiveness of different health interventions can be evaluated by estimating the expected gain in years of healthy life that each will achieve in return for the requisite public costs needed to implement that intervention. According to the World Bank's World Development Report, *Investing in Health (1993)*, interventions are considered to be cost-effective from a public sector perspective if they save a year of healthy life for less than the average gross domestic product per capita of the country (World Bank, 1993).

The purpose of this analysis is to estimate the effectiveness and cost-effectiveness of tobacco control policies in seven regions of the world. We examine price increases, nicotine replacement therapy (NRT), and non-price interventions other than NRT (such as

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comprehensive bans on advertising and promotion, bans on smoking in public places, prominent warning labels and mass consumer information), separately. As with many cost-effectiveness analyses, this analysis is subject to considerable measurement error (Walker & Fox-Rushby, 2000). Thus, we have entered a range of values for important assumptions about costs and effectiveness of interventions, and ensured that assumptions err on the conservative side, so that the potential impact of the proposed interventions is, if anything, underestimated.

Methods

We have created a simple static model of the impact of tobacco control policies using the 1995 baseline cohort of *current* smokers. We used smoking prevalence data for 139 countries to derive estimates by age, region and gender of smoking prevalence (Jha, Ranson, Nguyen, & Yach, 2002). From these numbers we took the following steps to estimate the global impact and cost-effectiveness of price and non-price interventions.

Baseline number of smoking-attributable deaths, by region, gender, and age

Using the total number of smokers alive in 1995, we made conservative assumptions about the numbers of deaths among these smokers. Recent studies in high-income countries, China and India suggest that at least one in two of regular smokers who begin smoking during adolescence will eventually be killed by tobacco (Gajalakshmi & Peto, 1997; Liu *et al.*, 1998; Peto, Lopez, Boreham, Thun, & Heath, 1994). The US Centers for Disease Control and Prevention, recognizing that some regular smokers would avoid premature death by quitting, estimated that 32% of regular smokers would die prematurely from smoking-related diseases (CDC, 1996). The applicability of these findings worldwide is uncertain, as quitting is rare in low-income and middle-income countries, where most smokers live (Jha *et al.*, in press). To be conservative, we assumed that 'only' one-third of current smokers would ultimately die of a smoking-attributable cause in all regions. The one-third risk is assumed true for males and females and for smokers of all ages. Further, we assume that *bidis*, a type of hand-rolled cigarette common in South Asia, confer the same risk of premature death as cigarettes, based on epidemiological studies from India (Gajalakshmi & Peto, 1997; Gupta & Mehta, 2000).

The potential impact of price increases

Step 1. Price elasticity for low-, medium- and high-income regions. We examined a price elasticity range from –0.4 to –1.2 in low-income and middle-income countries and –0.2 to –0.8 in high-income countries, based on an overall review of all available price elasticity studies (Chaloupka & Warner, in press). To be conservative, we used short-run elasticities because studies in high-income countries indicate a smaller response to a price increase than do long-term estimates. The price elasticity of *bidis* in South Asia is assumed equal to the price elasticity of cigarettes in low-income and middle-income regions. We base this assumption on the data from Finland suggesting that price responsiveness for hand-rolled cigarettes is approximately equal to that for cigarettes (Pekurinen, 1989). It is assumed that price elasticity is the same for males and females. The majority of studies that have looked at gender-specific price elasticity support this assumption. However, a number of studies have found that men in the USA are more price sensitive than women, while studies from the UK found women to be more price sensitive (Jacobs, 2001).

Step 2. Price elasticity by age category. Most recent studies in high-income countries that have used nationally representative surveys have found that youth are more responsive to price changes than adults. Based on several reviews, we assume in this analysis that price elasticity is three times higher amongst 15–19-year-olds, and 1.5 times higher amongst 20–29-year-olds, than amongst those 30 years of age and older (Chaloupka, Hu, Warner, Jacobs, & Yurekli, 2000). The total price elasticity for any region is the age-weighted average of the age-specific elasticities.

Step 3. Impact of a price increase on the number of smoking-attributable deaths. Price elasticity expresses the net impact of a price change on the quantity demanded for cigarettes (or *bidis*). A price change can have an impact on either the fact of smoking (or prevalence) or the rate of smoking (conditional demand) by continuing smokers. For these analyses, we used a value of 50% for impact on prevalence. Various studies suggest that slightly more than half of the price effect is on prevalence and just less than half is on average consumption by continuing smokers. Farrelly, for example, found that price elasticity in the USA was –0.25, with a prevalence elasticity of –0.15 and conditional demand of –0.10 (CDC, 1998). The effect of price on the prevalence of smoking may vary by age group, but for simplicity, we assume constant effects on prevalence across age groups.

Calculations are performed for a price increase of 10%. Change in the number of smoking-attributable deaths is the product of: (1) percentage change in the price of cigarettes; (2) price elasticity; (3) prevalence impact of 50%; (4) number of tobacco-attributable deaths prior to the price increase; and (5) a 'mortality adjustment factor'.

Mortality adjustment accounts for the fact that not all smokers will be able to avoid a premature, tobacco-related death by quitting. A recent study in the UK found that cumulative risks of death from lung cancer among quitters was as low as 10% of the risks among continuing smokers. The absolute hazards avoided depended on the age of cessation (Peto *et al.*, 2000). Doll, Peto, Wheatley, Gray, & Sutherland (1994) found that doctors in the UK who quit before age 35 returned to life-table estimates of mortality very close to those of people who had never smoked. Smokers who quit at ages 35 or older were also found to have reduced risks of tobacco-related death, but these risks appeared not to have a linear relationship with the age of quitting. Based on these studies, we make the following conservative assumptions: 95% of quitters aged 15–29 years will avoid tobacco-related death, while only 75% of quitters aged 30–39, 70% of quitters aged 40–49, 50% of quitters aged 50–59, and 10% of quitters aged 60 or older will avoid tobacco-related death. We assume that a decrease in the amount of smoking by those who continue smoking has no impact on mortality.

The potential impact of NRT

NRT in its various forms (chewing gum, transdermal patches, nasal spray, inhalers, sublingual tablets and lozenges) has repeatedly been shown to increase smokers' chances of quitting (Raw, McNeill, & West, 1998; Silagy, Mant, Fowler, & Lancaster, 1998). For example, a recent meta-analysis found that rates of cessation after at least 6 months are 1.73 times higher with NRT than in controls (Silagy *et al.*, 1998). Despite such evidence for the efficacy of NRT, it is difficult to estimate the effectiveness of NRT in real-world settings. Even if NRT could be made widely available at low cost (or even for free), it is difficult to know how many people would choose to access it and use it as indicated. We estimate that NRTs have an overall effectiveness of 0.5–2.5%. This effectiveness range was derived from reviews of NRT use in the USA, which found that about 40–50% of smokers would want to quit and that, of these, between 5% and 35% would wish to use NRTs (Shiffman *et al.*, 1997; Shiffman, Mason, & Henningfield, 1998). Further, among those who want to quit and who are willing to use NRT, we assumed that rates of cessation would be in the range of 15–25% higher among those who actually used NRT.

We assume that adults of ages 30–59 years will be more willing and able to use this intervention than individuals of ages 15 to 29 years and 60 years and older, given they have more disposable income, and are more likely to be aware of the risks of smoking and the benefits of cessation (Peto *et al.*, 2000). Hence, NRT is assumed to be 1.5 times as effective among adults aged 30–59 as among other adults.

Potential impact of non-price interventions other than NRT

Non-price interventions other than NRT include: complete bans on advertising and promotion of all tobacco products, related logos or trademarks; dissemination of information on the health consequences of smoking (including new research findings); and restrictions on smoking in public places and work places. Complete bans on advertising and promotion may have a modest impact on prevalence (Saffer, 2000). Information 'shocks' and new research in the USA in the 1960s are judged to have been responsible for reducing the prevalence of smoking by 5–10% (USDHHS, 1989). Work-place bans on smoking in the USA are judged to have reduced total smoking prevalence by approximately 4–10% (Woollery, Asma, & Sharpe, 2000). Specific attempts to quantify the aggregate impact of non-price interventions have not yet been made. Thus, in this analysis, it is assumed that a package including all of the non-price interventions would reduce prevalence by between 2% and 10%. This estimate is low in comparison to the impact found for individual interventions, but is in keeping with our efforts to be conservative. We assume constant effectiveness of a package of these interventions across age groups.

Cost-effectiveness of anti-smoking interventions

Tobacco control policies can cost very little. Tax increases can often be implemented by legislation alone, if a strong tax collection system is in place. To be conservative, we estimate that interventions such as research dissemination and mass counter-advertising campaigns incur administrative costs, and that tax increases incur enforcement costs to collect taxes. We further assume that one-time costs for NRTs would be required to help some of the 1995 cohort of smokers to quit. We use the same annual, public-sector costs for both price increases and the set of non-price interventions other than NRT. Based on costing estimates in the World Bank Review of Disease Control Priorities (Barnum & Greenberg, 1993), and our desk review of costs for mass information campaigns in World Bank projects, we assume that the annual costs of *each* are 0.005–0.02% of current gross national product (GNP), in 1997 US dollars. The low end of this range approximates actual levels of spending on tobacco control in North America. For example, in the USA, an average of 0.003% of GNP was spent on tobacco research and education from 1994 to 1996 (Pechman, Dixon, & Layne, 1998).

The assumed cost of the NRT intervention can be broken down into two components. The first is the 'non-drug' costs of the intervention (for example, administrative and education costs). These costs are assumed to be the same as the cost of a price increase and the cost of non-price interventions other than NRT (i.e., 0.005 to 0.02% of GNP per person per year). The second component is the cost of the drugs themselves (i.e., the cost of nicotine gum, patches, etc.). Based on industrial marketing data (IMS Global Services, 1998), we assume that each individual who attempts to quit in low-income or middle-income countries will spend $50 for short-term use of NRT. In high-income countries, we assume that the amount spent will be $100 (Novotny, Cohen, Yurekli, Sweanor, & de Beyer, 2000). Further, we calculate NRT costs to include the fact that for every person who is successful at quitting, 10 others will use NRT unsuccessfully (Silagy *et al.*, 1998).

Table 1. Estimated number of smokers alive in 1995 who will ultimately die of smoking-attributable causes, and change in number of smoking-attributable deaths with price increases of 10%, NRT of 0.5% and 2.5% effectiveness, and non-price interventions of 2% and 10% effectiveness, by World Bank region

		Change in number of deaths (millions)					
	Smoking-attributable deaths (millions)	10% price increase		NRT with effectiveness of:		Non-price interventions with effectiveness of:	
Region		Low elasticity[a]	High elasticity[a]	0.5%	2.5%	2%	10%
East Asia and Pacific	142	−2.2 −(1.6%)	−6.6 −(4.7%)	−0.5 −(0.4%)	−2.5 −(1.8%)	−2.0 −(1.4%)	−10.2 −(7.2%)
Europe and Central Asia	40	−0.6 −(1.5%)	−1.8 −(4.5%)	−0.1 −(0.3%)	−0.7 −(1.7%)	−0.6 −(1.4%)	−2.8 −(6.9%)
Latin America and Caribbean	32	−0.5 −(1.7%)	−1.6 −(5.0%)	−0.1 −(0.4%)	−0.6 −(1.9%)	−0.5 −(1.6%)	−2.5 −(7.9%)
Middle East and North Africa	12	−0.2 −(1.6%)	−0.6 −(4.9%)	−0.05 −(0.4%)	−0.2 −(1.9%)	−0.2 −(1.5%)	−0.9 −(7.7%)
South Asia (cigarettes)	28	−0.3 −(1.3%)	−1.0 −(3.8%)	−0.1 −(0.3%)	−0.4 −(1.5%)	−0.3 −(1.2%)	−1.6 −(5.9%)
South Asia (bidis)	31	−0.4 −(1.2%)	−1.2 −(3.7%)	−0.1 −(0.3%)	−0.5 −(1.5%)	−0.4 −(1.2%)	−1.8 −(5.9%)
Sub-Saharan Africa	18	−0.3 −(1.5%)	−0.8 −(4.5%)	−0.1 −(0.4%)	−0.3 −(1.8%)	−0.3 −(1.4%)	−1.3 −(7.1%)
Low-income and middle-income	303	−4.6 −(1.5%)	−13.7 −(4.5%)	−1.1 −(0.3%)	−5.3 −(1.7%)	−4.2 −(1.4%)	−21.2 −(7.0%)
High-income	67	−0.5 −(0.7%)	−2.0 −(3.0%)	−0.2 −(0.3%)	−1.2 −(1.7%)	−0.9 −(1.4%)	−4.7 −(7.0%)
World	370	−5.1 −(1.4%)	−15.7 −(4.2%)	−1.3 −(0.3%)	−6.5 −(1.7%)	−5.2 −(1.4%)	−25.9 −(7.0%)

[a] Low elasticity is −0.2 for high-income regions and −0.4 for low-income and middle-income regions. High elasticity is −0.8 for high-income regions and −1.2 for low-income and middle-income regions.

The costs of a price increase and of NRT are assumed to occur only for the year of implementation. Non-price interventions, in contrast, comprise ongoing costs for counter-advertising and research, so these costs are assumed to recur each year for a period of 30 years. Costs of interventions are discounted by between 3% and 10% per annum. Despite our efforts to be conservative in estimating the public costs of the various interventions, note that the cost estimates may be low if implementation of anti-tobacco interventions requires months or years of expensive lobbying.

The effectiveness of the interventions is measured by the numbers of deaths averted, calculated as described above. Future deaths among the cohort of smokers alive in 1995 are converted into DALYs using the region-specific ratios of tobacco-attributable deaths from a study by Murray and Lopez (1996). It is assumed that DALYs will be lost at a steady rate over the next 30 years, and, like costs, DALYs lost in the future are discounted by between 3% and 10%.

Results

Potential impact of price increases

With a price increase of only 10%, it is predicted that 5–16 million smoking-attributable deaths will be averted worldwide (approximately 1–4% of all smoking-attributable deaths expected amongst those who smoke in 1995; Table 1). Low-income and middle-income countries account for about 90% of averted deaths. East Asia and the Pacific alone will account for roughly 40% of averted deaths.

Of the tobacco-related deaths that would be averted by a price increase, 80% would be male, reflecting the higher overall prevalence of smoking in men. The greatest relative impact of a price increase on deaths averted is among younger age cohorts (Table 2). A price

Table 2. Worldwide change in number of smoking-attributable deaths, with a price increase of 10% and high elasticity estimate (−0.8 for high-income countries and −1.2 for low-income and middle-income countries), by age

Age categories	Millions of deaths prevented (%)	% of total
15–19	−3.7 −(12.5%)	23.7%
20–29	−5.4 −(6.1%)	34.5%
30–39	−3.2 −(3.3%)	20.1%
40–49	−2.2 −(3.1%)	14.3%
50–59	−1.0 −(2.3%)	6.2%
60+	−0.2 −(0.5%)	1.2%
Total	−15.7 −(4.2%)	100.0%
% Total	(100.0%)	

Table 3. Range of cost-effectiveness values for price, NRT and non-price interventions (US dollars/DALY saved), by region

Region	Price increase of 10%		NRT with effectiveness of 0.5–2.5%		Non-price other than NRT with effectiveness of 2–10%	
	Low-end estimate[a]	High-end estimate[b]	Low-end estimate[c]	High-end estimate[d]	Low-end estimate[e]	High-end estimate[f]
East Asia and Pacific	2	50	335	905	25	510
Europe and Central Asia	3	78	229	794	39	784
Latin America and Caribbean	7	169	241	1193	84	1681
Middle East and North Africa	5	116	203	899	58	1160
South Asia	1	33	289	729	16	326
Sub-Saharan Africa	2	45	216	635	23	454
Low-income and middle-income	3	70	280	870	36	710
High-income	83	2771	750	7206	696	13,924
World	12	313	358	1917	145	2896

[a] Calculations based on: intervention cost of 0.005% of GNP, high elasticity (–1.2 for low/middle-income regions, –0.8 for high-income regions), benefits (DALYs saved) distributed over 30 years and discounted at 3%.
[b] Calculations based on: intervention cost of 0.02% of GNP, low elasticity (–0.4 for low/middle income regions, –0.2 for high-income regions), benefits (DALYs saved) distributed over 30 years and discounted at 10%.
[c] Calculations based on: effectiveness of 2.5%, intervention cost of 0.005% of GNP (plus drug costs), benefits distributed over 30 years and discounted at 3%.
[d] Calculations based on: effectiveness of 0.5%, intervention cost of 0.02% of GNP (plus drug costs), benefits distributed over 30 years and discounted at 10%.
[e] Calculations based on: effectiveness of 10%, intervention cost of 0.005% of GNP and repeated annually over 30 years and discounted at 3%, benefits (DALYs saved) distributed over 30 years and discounted at 3%.
[f] Calculations based on: effectiveness of 2%, intervention cost of 0.02% of GNP and repeated annually over 50 years and discounted at 10%, benefits (DALYs saved) distributed over 50 years and discounted at 10%.

increase of 10% (and using a high elasticity of –1.2 for low/middle-income regions and –0.8 for high-income regions) will prevent roughly 13% of smoking-attributable deaths among smokers aged 15–29 in 1995, compared with 6% of deaths among 20–29-year-olds, and 2–3% of deaths among 30–49-year-olds. Approximately 40% of deaths averted will occur among smokers who are aged 30 years and older at the time of cessation.

Potential impact of NRT

Provision of NRTs with an effectiveness of 0.5% is predicted to result in about 1 million smoking-attributable deaths being averted (Table 1). NRT of 2.5% effectiveness is predicted to have about five times the impact. Again, low-income and middle-income countries account for roughly 80% of averted deaths. The relative impact of NRT on deaths averted is 1.5–2.2% amongst individuals aged 15–59 years, and lower amongst those 60 years and older (results not shown).

Potential impact of non-price interventions other than NRT

A package of non-price interventions other than NRT that decreases the prevalence of smoking by 2% is predicted to prevent about 5 million smoking-attributable deaths (more than 1% of all smoking-attributable deaths amongst those who smoke in 1995; Table 1). A package of interventions that decreases the prevalence of smoking by 10% would have an impact five times greater. Low-income and middle-income countries account for approximately four-fifths of quitters and averted deaths. The greatest relative impact of non-price interventions on deaths averted would be among younger age cohorts; a package that results in a 10% decrease in smoking prevalence would avert roughly 10% of smoking deaths amongst smokers aged 15–29 in 1995, and 5–8% of deaths amongst smokers aged 30–59 in 1995 (results not shown). The cohort aged 20–29 in 1995 will account for the greatest percentage (about 32%) of deaths averted.

Cost-effectiveness of anti-smoking interventions

In general, price increases are found to be the most cost-effective anti-smoking intervention. These could be achieved for a cost of US $12–313 per DALY saved globally. Wider access to NRT could be achieved for between $358 and $1917 per DALY saved, depending on assumptions used. Non-price interventions other than NRT could be implemented for between $145 and $2896 per DALY saved, depending on assumptions (Table 3). Thus, NRT and other non-price measures are slightly less cost-effective than price increases, but remain cost-effective in many settings.

For a given set of assumptions, the variation in the cost-effectiveness of each intervention between low-income and middle-income regions is relatively small. All three interventions are most cost-effective in South Asia and Sub-Saharan Africa. The difference between low-income and middle-income countries and high-income countries is more pronounced. For NRT, the cost per year of healthy life gained is three to eight times

Table 4. Cost-effectiveness of non-price anti-tobacco interventions in high-income countries

Source	Intervention/country	Cost-effectiveness
Buck, Godfrey, Parrott, & Raw (1997)	Community-wide interventions, UK	£107–3622 per life-year saved (approximately US$171–5800)
Buck *et al.* (1997)	Brief advice from a physician, UK	£469 (US$750) per life-year saved
Buck *et al.* (1997)	Addition of nicotine gum, UK	£2370 (US$3800) per life-year saved
Reid (1996)	Proposed mass television campaign, UK[a]	US$10–20 per life-year saved
Mudde & De Vries (1999)	Mass media-led smoking cessation campaign including television shows, a television clinic, a quit line, local group programs, and a comprehensive publicity campaign, Netherlands	US$12 per quitter
Tillgren *et al.* (1993)	'Quit and win' contest, Sweden	US$188–1222 per life-year saved
Oster, Huse, Delea, & Colditz (1986)	Nicotine gum, as an adjunct to counselling, USA	US$4113 and $9473 per life-year saved
Fiscella & Franks (1996)	Nicotine patch therapy matched with brief physician counselling, USA	US$4390 for 35-year-old males to $10,943 for 65–69-year-old males
Wasley, McNagny, Phillips, & Ahluwalia (1997)	Nicotine patches as an adjunct to briefing doctors visits, USA	$1796 and $4391 per life-year saved

[a]This analysis assumed lower costs (US$18 million per year, or 0.0015% of GNP), and a quit rate of 2.5%.

higher in high-income countries than elsewhere. For non-price interventions other than NRT, the cost in high-income countries is 20 times higher; and for price increases, almost 40 times higher.

The estimates of cost-effectiveness are subject to wide ranges. For price increases, the high-end estimates are roughly 25 times the low-end estimates, and this difference is consistent among the regions. For NRT, the high-end estimates are 2.5–10 times the low-end estimates, varying among the regions. Finally, for non-price interventions other than NRT, the high-end estimates are 20 times the low-end estimates, and this difference is consistent among the regions.

Discussion

Our analyses suggest that price increases of 10% would be the most effective and cost-effective of the three interventions examined. Accepting that the results in this study represent very conservative estimates, the reductions in mortality are still quite impressive. Price increases as low as 10%, NRT use that enables 0.5% of smokers to quit, and non-price interventions that reduce smoking prevalence by 2% could save many lives if applied to large populations.

Comparison with existing estimates

We can compare our results against existing studies only for high-income countries, given the lack of studies elsewhere. Moore (1996) estimated the impact of an increase of 10% in the cigarette *tax* on tobacco-related death rates for the period from 1954 through 1988. Assuming that taxes are 25% of price, a 10% tax increase results in a *price* increase of 2.5%. The higher price resulted in a 1.5% decrease in the annual number of deaths from respiratory cancers and a 0.5% decrease in the annual number of deaths from cardiovascular disease. This represents a short-run decrease in tobacco-related deaths of more than 1.5% (Peto *et al.*, 1994). Other studies using an indirect methodology similar to ours have generally found greater reductions in smoking-attributable mortality with smaller price increases (Harris, 1987; Warner, 1986). For example, Warner (1986) estimated that an increase of 8% in cigarette prices in the USA would avoid about 450,000 deaths, or about 3% of the tobacco-attributable deaths. In contrast, we find that in high-income countries, a 10% price increase would decrease tobacco-attributable premature deaths by 0.7–3%. This suggests that our analyses are conservative.

Our cost-effectiveness results for high-income countries appear to be conservative compared with those of existing studies in high-income countries. Table 4 presents the values of cost-effectiveness of non-price anti-tobacco interventions found in several other studies. In general, these values correspond with the higher end of the range of estimates of cost-effectiveness of NRT and other non-price interventions for high-income countries calculated above.

Comparing cost-effectiveness to other health interventions

Our findings suggest that these interventions are also cost-effective relative to other health interventions. The cost-effectiveness of tax increases compares favorably with many health interventions. Depending on the assumptions made about elasticity and the administrative costs of raising and monitoring higher tobacco taxes, the cost of implementing a price increase of 10% ranges from $3 to $70 per DALY in low-income and middle-income countries. Countries that implement these interventions may experience much wider ranges (see Table 3, where for the various regions, the values range from 1 to 169). Overall, tax increases represent cost-effectiveness values comparable to many health interventions financed by governments, such as child immunization (cost per DALY of about $25; World Bank, 1993). Non-price measures may also be highly cost-effective for low-income and middle-income countries. Depending on the assumptions used, a package could be delivered for as little as $36 per DALY. This level of cost-effectiveness compares reasonably with several established interventions in public health, such as the package for the integrated management of the sick child, which has been estimated to cost between $30 and $50 per DALY in low-income countries, and between $50 and $100 in middle-income countries (WHO, 1996). NRT and other non-price interventions are also likely to be good investments, but the extent to which they should be utilized should be determined with country-specific cost-effectiveness analyses.

We found cost per DALY saved of anti-tobacco interventions to be considerably higher for high-income vs. low- and middle-income countries. Nonetheless, anti-tobacco interventions, particularly price increases, are likely to be cost-effective in comparison with many other health care interventions. For example, Field *et al.* (1995) found that the most cost-effective primary-care intervention for reducing coronary risk factors was minimal screening of blood pressure and personal history of vascular disease, which cost £310–930 (approximately US $496–488) per year of life gained for men and pounds sterling £1100–3460 (approximately US $1760–5536) for women. These ranges overlap with the estimates of cost-effectiveness of both price and non-price interventions for tobacco control interventions in high-income countries.

Effectiveness by region and with combined interventions

In this analysis, the effectiveness of non-price interventions is assumed to be the same in all regions. It may be possible, however, that effectiveness of these interventions differs between countries. For example, information campaigns may be much more effective in developing countries, given the relative novelty of the information (Kenkel & Chen, 2000), and thus their impact might be similar to the impact of the health reports of the 1960s in the USA and the UK (USDHHS, 1989). One could similarly argue that advertising and promotion bans would also be relatively more effective in these countries. In contrast, enforcement of clean air laws is more difficult in lower-income countries (Woollery *et al.*, 2000).

No attempt has been made in this analysis to examine the impact of combining the various packages of interventions (for example, price increases with NRT, or NRT and other non-price interventions). Although a number of studies have compared the impact of price and non-price interventions, few empirical attempts have been made to assess how these interventions might interact. While price increases have been found in this analysis to be the most cost-effective anti-smoking interventions, policy makers should utilize both price and non-price interventions to counter smoking. For example, non-price measures may be required to have an impact on the most heavily dependent smokers, for whom medical/social support in stopping will be necessary.

Conservative assumptions on effectiveness and cost-effectiveness

Several aspects of the design of our model are meant to ensure conservative results. First, we use only the 1995 cohort of smokers, and ignore effects on future cohorts. Second, we estimate that only one in three of current smokers are killed by their addiction. Third, we estimate that the reduced rate of smoking has no impact on mortality. Finally, our analysis is also conservative in estimating the public-sector costs of intervening. Some of the interventions, such as raising taxes or banning advertising and promotion, have zero or minimal costs, as these are 'stroke-of-the-pen' interventions. To be conservative, we have assigned substantial implementation and administrative costs, along with drug costs for NRT.

It is important to note that the cost perspective is that of the public sector financier or provider. Costs borne by individuals are not included in our cost-effectiveness analyses. The exclusion of costs to individuals has led to criticisms of cost-effectiveness analyses (Warner, 1997). It is difficult to describe the personal (or individual) costs of being prevented from smoking in certain places. The biggest costs of tax increases are likely to be those borne by individuals, in the way of lost satisfaction. The welfare impact is difficult to estimate, given that welfare losses would differ for current smokers vs. future smokers, and because of the addictive properties of smoking. Private costs are, as a rule, not included in cost-effectiveness analyses of health interventions (Jamison, 1993), even though many health interventions do impose such costs. For example, child immunization imposes costs of parents taking time off work, travel to the clinic, etc. Tobacco control interventions are not, in principle, different from these other interventions.

Conclusions

Tobacco control is cost-effective relative to other health interventions. Our analyses suggest that tax increases would be cost-effective. Non-price measures are also cost-effective in many settings. Measures to liberalize access to NRT, for example, by changing the conditions for its sale, are likely to be cost-effective in most settings. However, individual countries would need to make careful assessments before deciding to provide subsidies for NRT and other cessation interventions for poor smokers. As with all cost-effectiveness analyses, our estimates are subject to considerable variation in actual settings, notably in costs. Thus, local cost-effectiveness studies are required to guide local policy.

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