Original research

Pan American Journal of Public Health

Burden of disease in Argentina attributable to tobacco use and potential impact of price increases through taxation*

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Suggested citation (Original article) Alcaraz A, Caporale J, Bardach A, Augustovski F, Pichon-Riviere A. Carga de enfermedad atribuible al uso de tabaco en Argentina y potencial impacto del aumento de precio a través de impuestos. Rev Panam Salud Publica. 2016;40(4)204–12.

ABSTRACT

Objective. *Evaluate burden of disease in Argentina associated with tobacco use and estimate health and economic impact of cigarette price increases through taxation.*

Methods. *A microsimulation model was used to quantify smoking-attributable impact on mortality, quality of life, and costs associated with cardiovascular, cerebrovascular, and chronic obstructive pulmonary disease; pneumonia; and 10 cancers. Modeling was done to determine the effect of different price increase scenarios on tobacco use and their health and economic impact.*

Results. *In Argentina, 44 851 deaths, 20 620 cancer diagnoses, 14 405 strokes, and 68 100 hospital admissions for cardiovascular disease can be attributed to smoking every year. A total of 998 881 years of life are lost each year from premature death and disability. The cost of treating smoking-attributable health problems is 33 billion Argentine pesos (ARS). Taxes on tobacco products cover only 67.3% of this expense. If Argentina were to increase cigarette prices by 50% over the next 10 years, 25 557 deaths, 42 560 cardiovascular events, and 11 222 cancers could be prevented, with an economic benefit of 122 billion ARS in savings in health costs and increases in tax revenues (1 US$ = 8.8096 ARS).*

Conclusions. *Smoking-attributable burden of disease and costs to the health system are very high in Argentina. Higher cigarette taxes could have substantial health and economic benefits.*

Key words Tobacco use; smoking; cost of illness; cost-benefit analysis; taxes; Argentina.

Smoking is the main cause of preventable disease and death worldwide. Globally, 6.3% of the premature deaths and disability-adjusted life years between 1990 and 2010 were attributable to smoking, representing more than 6 million deaths per year (1) due to the increased risk of cancer, chronic obstructive pulmonary disease (COPD) and cardiovascular disease (2).

In South America, smoking is the third leading risk factor, based on deaths and years of healthy life lost (1), and is associated with lower productivity and a high impact on out-of-pocket expenditure—factors that contribute to poverty (3).

This addiction has a high impact on costs in health systems, representing approximately 1% of the gross domestic product (GDP) and 15% of national health expenditure in some countries (4).

In Argentina, the prevalence of smoking remains high—29.9% in men and 20.18% in women, according to the National Survey of Risk Factors 2013 (5).

The Framework Convention on Tobacco Control (FCTC) was the response of the World Health Organization (WHO) to the growing smoking epidemic. Today,

* Official English translation provided by the Pan American Health Organization. In the case of discrepancy between the two versions, the Spanish original shall prevail.

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180 countries have signed the agreement, and only 12, including Argentina, have yet to ratify it (6). Nevertheless, great progress has been made in tobacco control, especially in areas such as the creation of smoke-free environments, the banning of advertising and sponsorship, and changes in packaging and labeling (7).

Raising the price of cigarettes through taxation is a highly cost-effective measure for controlling tobacco use (4, 8). Higher prices encourage people to try to quit smoking, which increases the number and success of attempts (9). They also prevent people, especially youth, from taking up the habit, discourage former smokers from relapsing, and cause people who continue to smoke to cut back (10–12).

For World No Tobacco Day 2014, WHO urged governments to raise the price of tobacco products (13). Cigarette prices in Latin America are very low in comparison with those in other regions of the world, which facilitates access to them. In Argentina, it has been estimated that taxes on tobacco products could be raised by more than 100% (14–16).

Assessments based on economic health models are widely accepted tools for decision-making and can furnish valuable information for optimizing health resource allocation.

The purpose of our study was to evaluate the burden of disease associated with tobacco use in Argentina and predict the health and economic impact of different cigarette tax increases.

MATERIALS AND METHODS

Two models were used in this study. The smoking-attributable burden of disease model makes it possible to estimate the health and economic impact, both currently and after any intervention to reduce the prevalence of smoking. The second model makes it possible to estimate the reduction in prevalence under different scenarios of cigarette price increases through taxation.

Burden of disease model

This model was developed as part of collaboration among more than 40 investigators and health policymakers from universities, research centers, and health departments in Argentina, Bolivia, Brazil, Chile, Colombia, Mexico, and Peru, and was pre-evaluated and validated (17–19).

It consists of a first-order Monte Carlo microsimulation (probabilistic individual-level simulation), programmed in Excel (Microsoft ® Office Excel Professional Edition 2003) with macros in Visual Basic (Visual Microsoft Basic ® 6.3), that incorporates the natural history, costs, and quality of life of adults with tobacco-related illness: coronary heart disease and non-coronary heart disease; cerebrovascular disease; COPD; pneumonia; cancer of the lung, mouth, larynx, pharynx, esophagus, stomach, pancreas, kidney, bladder, and cervix; and leukemia.

In the first step, for each individual in the cohort, the model calculated the baseline risk of developing each health condition in non-smokers by age and sex. Due to the lack of good-quality data on incidence, this calculation was based on the mortality and case-fatality of each condition for acute events. The probability of a diagnosis of cancer and other diseases by age and sex was estimated through an approach that considers annual mortality rates and the estimated annual survival post diagnosis. These individuals were followed in hypothetical cohorts and, for each year, the risk of each event, progression of disease, or death was estimated in relation to demographic characteristics, smoker status, clinical conditions, and underlying risk equations. Finally, aggregate results were obtained for deaths, events, and costs attributable to smoking, reduction in life expectancy and quality-adjusted life years (QALY), and the number of years of potential life lost due to premature death and disability. A detailed description of the model and its equations has already been published (17).

The model does not directly evaluate the consequences of passive smoking, which means that the estimate of associated deaths, years of life lost, and costs was based on approximations from other studies, considering an additional burden of 13.6% in men and 12.0% in women (20).

Calibration and validation. This process allows to evaluate the reliability of the model. Six cohorts of 1 million individuals followed from the age of 35 until their death were modeled. The estimate of the sample size was based on the standard error of the parameter with the greatest variability (incidence of oral cancer) to obtain 95% confidence intervals in each cohort. This was done through three mechanisms: internal consistency, to identify errors related to the incorporation of modeling data and syntax; calibration, to ensure the replicability of the model's results with respect to given incidence and mortality indicators; and external validation, where the results obtained are compared with those of epidemiological and clinical studies not used in estimating the equations.

Information sources. The data used to populate the model were obtained through an exhaustive literature review involving multiple electronic databases, including MEDLINE, EMBASE, CENTRAL, SocINDEX, EconLit, LILACS, NBER, CRD, and the Cochrane Tobacco Addiction Group. A search strategy was developed for gray literature to collect information from relevant sources in ministries of health, ministries of finance, WHO, and annals of congress databases. The participating investigators provided additional information from risk factor surveys, vital statistics, and hospital discharge databases.

Costs of medical care. The costs of COPD events, heart attacks, and strokes (CVA) were adjusted on the basis of the calculations of the Ministry of Health's National Program for Tobacco Control, adjusted for inflation (21). Unstable angina was considered to have 75% of the value of a heart attack, according to expert opinion. The costs of lung and cervical cancer and pneumonia were estimated through the costing of each resource used in their treatment (microcosting), as indicated by oncologists, based on their customary clinical practice.

Cost estimates for the other cancers were based on the consensus of a panel of experts using the modified Delphi method, in which the cost of every cancer event is related to the cost of lung cancer.

Weighted rates of the three subsectors of the health system were used to place a value on health resources using different sources (self-managed hospitals, *obras sociales* (group health plans), and private clinics). Medication costs were calculated using the average sales price of all standard presentations.

Tax model

Smoking prevalence post-price increase was calculated as:

$$Prevalence_{post} = Prevalence_{pre} + (E_d * \Delta\ \% P * I_p * Prevalence_{pre})$$

Where $Prevalence_{pre}$ is the prevalence of smokers before the price increase; E_d is the demand price elasticity; $\Delta\ \%P$ is the percentage variation in the price; and I_p it is the proportion of variation in consumption that impacts smoker prevalence.

There is heterogeneity in the literature concerning the extrapolation of price increases to the impact on consumption and risk. Thus, three different scenarios were analyzed to estimate the expected health impact:

Short-term scenario. Reducing consumption to 50% of its current level impacts prevalence ($I_p = 0.5$), and the entire reduction in prevalence turns into an increase in the number of former smokers.

Medium-term scenario. Same as the previous scenario but also incorporates the potential effects of the reduction in the number of cigarettes smoked. While this is a controversial issue and the reduction in risk varies with the different health conditions (22, 23), in this scenario it is assumed that a reduction in consumption implies a reduction in excess risk to the smoker. This reduction in risk is applied, at most, to 75% of the total excess risk that separates a smoker from a former smoker, since it is assumed that the additional 25% of the risk will be eliminated only when the subject becomes a former smoker. Calculation of this value of 75% as the maximum benefit that a smoker could obtain by reducing consumption is based on the maximum difference in the existing risk of lung cancer (82%), ischemic heart disease (57%), and COPD (80%) between heavy and light smokers as opposed to a former smoker (22).

Long-term scenario. This is the maximum effect and can be expected in the long term (for example, 10 years). It is similar to the previous scenario but, in this case, a 75% reduction in consumption impacts prevalence ($I_p = 0.75$), and the former smoker population remains constant with respect to the base-line scenario, since the entire reduction in prevalence increases the population of non-smokers.

The cumulative base case is constructed by combining the three scenarios described above and aggregating the results at 10 years. For this purpose, we assume a linear evolution from the short-term to the medium-term scenario for a period of five years, and then an evolution to the long-term scenario from year six to ten.

Based on these estimates of changes in prevalence and redistribution that impact the proportion of smokers, former smokers, and non-smokers in the population, the smoking-attributable burden of disease that would be expected in the country under these new conditions is re-estimated, using the same methodology that was used for the base-line estimate of burden of disease. The health impact is then calculated as the observed difference between the two estimates, in terms of deaths, events, years of life lost, disability, and health care costs.

Impact on tax revenues

This was estimated as follows:

$$\Delta\%R = (1 + \Delta\%\text{consumption}) * \left(1 + \frac{\Delta\%\text{price}}{\%\text{tax}}\right) - 1$$

Where $\Delta\%\ R$ is the percentage variation in tax revenue; Δ %consumption is the percentage variation in consumption expected from the increase in the sales price; Δ %price is the percentage change in the retail price; and %tax is the proportion of the initial retail price corresponding to taxes.

Total economic impact. This is estimated by combining the variation in direct health expenditure attributable to smoking calculated in the first point with the variation in tax revenues.

RESULTS

Table 1 summarizes the main demographic, epidemiological, cost, and tax parameters used in the model.

Calibration and validation. The average rate of events was within 10% of the rates reported in the national figures for each parameter, indicating excellent internal validity. Evaluation of the correlation between the observed and expected results yielded R^2 values of 0.700 to 0.999 (perfect correlation = 1), indicating a high degree of correlation. The external validation was conducted by comparing the results of the model with published epidemiological studies that had not been used as data sources. A very good correlation was observed between the predicted results and the results observed in the studies. Figure 1 shows the main results of this process.

Smoking-attributable deaths and events. The model estimated that in 2015, cigarettes were responsible for 44 851 deaths in Argentina, representing 13.2% of the total deaths in the country each year (Table 2). Thirteen percent of cardiovascular deaths and 14% of deaths from CVA were attributable to smoking. These percentages were much higher with respiratory pathologies such as COPD (75%) and lung cancer (82%). Furthermore, 16% of deaths from pneumonia and 33% of deaths from other cancers were attributable to this addiction.

Each year, smoking is responsible for 215 035 events. Of these, 26 346 correspond to myocardial infarctions, 34 976 to episodes of acute coronary syndrome, 14 405 to CVA, and 20 627 to new cancer diagnoses. The proportion attributable to cancer is 82% for lung cancer and cancer of the larynx, 66% for cancers of the mouth and pharynx, and 65% for esophageal cancer, with an influence on stomach, pancreatic, and kidney cancer as well (Table 2).

The impact is more marked in men: 33% of all deaths and 36% of events due to pathologies associated with smoking are attributable to smoking, while in women, these figures are 19% and 28%, respectively.

Years of life lost and quality of life associated with smoking. Among men, smokers had a life expectancy 4.91 years shorter than non-smokers, while in former smokers, the figure was 1.99 years. This effect was also significant in women, among whom life expectancy was 4.17 years shorter for smokers and 1.48 among former smokers versus non-smokers.

The reduction in life expectancy was more pronounced when expressed in quality-adjusted life years (QALY), with a 6.06 QALY difference between smokers and non-smokers in men and 5.80 QALY in women.

A total of 883 966 years of life lost (YLL) due to smoking was observed annually in Argentina, the result of a combination of 72.3% of YLL due to premature death (YLL-pd) and 27.7% of YLL to living in suboptimal health-related quality of life (YLL-hrqol) conditions. Of the total YLL, 562 344 were among men and 321 621, among women.

TABLE 1. Demographic, epidemiological, cost, and tax data included in the model, 2015 [a]

	Men	Women		Source
Population ≥ 35 years (millions)	14.5	17.1		(24)
Prevalence of smoking (percentage of the population)				
35–49 years	31.0	22.7		(5)
50–64 years	30.1	22.7		(5)
≥ 65 years	9.2	10.4		(5)
Crude death rate, per 10 000 population				
Myocardial infarction	46.1	33.1		(25)
Other cardiovascular diseases	118.7	104.5		(25)
Stroke	52.5	43.9		(25)
Pneumonia	104.4	72.4		(25)
COPD	4.3	1.9		(25)
Lung cancer	15.6	4.6		(25)
Other cancers	3.0	1.5		(25)
Costs and quality of life	Cost in the first year or year of the event (ARS)	Annual follow-up cost (year 2 and subsequent years) (ARS)	Quality-adjusted life years (QALY)	Source QALY
Myocardial infarction	36 151	14 309	0.8	(26)
Other cardiovascular diseases	27 113	14 309	0.8	(27)
Stroke	47 881	16 442	0.641/0.74b	(26, 28)
Pneumonia	2 420	-	0.994	(29)
Mild COPD	1 406	1 406	0.935	(30)
Moderate COPD	3 343	3 343	0.776	(30)
Severe COPD	48 998	48 998	0.689	(30)
Lung cancer	193 925	250 756	0.5	(31)
Mouth cancer	139 632	95 284	0.84	(32)
Esophageal cancer	162 898	110 331	0.63	(33, 34)
Stomach cancer	159 022	120 365	0.55	(35)
Pancreatic cancer	131 870	90 271	0.55	(36)
Kidney cancer	139 632	97 795	0.78	(37)
Tax data				
National revenues from taxes on tobacco (ARS. millions)		22 425		(38)
Gross domestic product (GDP-ARS. millions)		4 388 834		(39)
Elasticity of demand		-0.299		(40)
Total health expenditure (% GDP)		0.73		(39)

[a] Exchange rate: 1 US$ = 8.8096 ARS.
[b] First year and subsequent years.
ARS=Argentine pesos; US$=United States dollars; COPD=chronic obstructive pulmonary disease.

If, moreover, passive smoking and other causes not included in the model (perinatal disease and accidents related to smoking) are considered, the figure rises to 998 881 YLL annually.

The majority of YLL-pd are due to lung cancer (23%), COPD (21%), ischemic cardiovascular deaths (24%), and stroke (8.9%).

Costs associated with smoking. Tobacco-related diseases in Argentina have an annual direct cost of ARS 88 993 895 613, of which 37% is attributable to smoking (table 2).

The main determinants of this high cost were heart disease, due to its high prevalence, and cancers—mainly lung cancer—and COPD, due to the high attributable proportion and the high cost of treatment.

Expected effect of price increases through taxation. Table 3 shows the health and financial impact of raising cigarette prices by 25%, 50%, and 100%.

Figure 2 shows how the benefits in terms of mortality and costs increase over the years with the 50% price increase scenario, achieving a substantial cumulative reduction in deaths and health care costs.

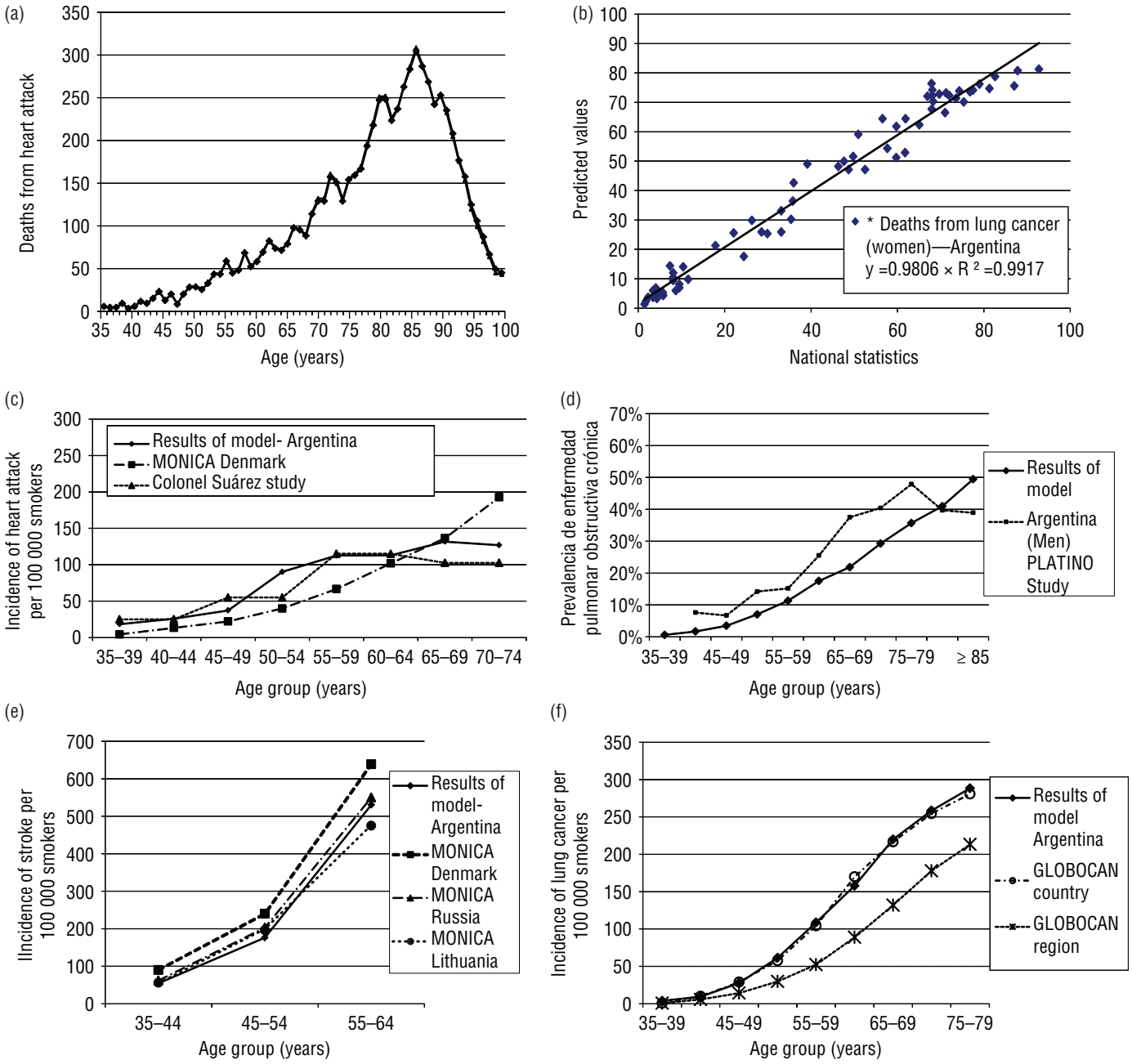
DISCUSSION

In Argentina, smoking is a major cause of death, disease, diminished quality of life, and higher health care costs, with cardiovascular diseases, COPD, and lung cancer accounting for the greatest burden. Smoking is directly responsible for nearly 1 million years of healthy life lost each year and is the cause of 13.2% of all deaths in people over the age of 35: a total of 44 851 preventable deaths annually. It also generates direct costs to the health system in excess of ARS 33 billion per year, or 0.75% of the gross domestic product (GDP), and 7.5% of total health expenditure. In 2015, taxes on the sale of cigarettes and other tobacco products in Argentina totaled roughly ARS 22 billion, a figure that covers just two-thirds of the estimated direct expenditures (38).

In the past 10 years, inflation and income growth in Argentina have outstripped the rise in cigarette prices, meaning that the availability of cigarettes has markedly increased, especially among the lower-income population (10, 41). A 50% increase in cigarette prices through taxation—a highly feasible scenario—could prevent 25 557 deaths, 42 560 YLL, and 645 258 events and, moreover, yield an economic benefit of more than ARS 120 billion in 10 years.

The results observed were consistent with numerous global studies that report similar results in terms of the global burden and the potential reduction of consumption through taxation (4, 8, 42, 43). In Argentina, studies conducted more than 10 years ago reported that 15.72% of deaths and 825 000 YLL were attributable to smoking (44, 45), while the losses in future income from premature death represented 0.17% of annual GDP and 14.4% of total health expenditure (21, 46). In 2007, Ferrante reported that an 80% tax increase could reduce smoking prevalence by 8% in one year and by up to 20% in 30 years (15). Martínez estimated that the maximum impact would be obtained with a 110% increase in the price (14), while González-Rozada found that the optimal increase would be a tax of 83.5% of the price, which would increase tax revenues by 134% (16).

FIGURE 1. Internal consistency, calibration, and external validation of the burden of disease model in Argentina.



A. Calibration: annual number of deaths predicted by the model versus national statistics. Example: myocardial infarction in women.
B. Correlation between the values predicted by the model and the expected values according to national statistics. Example: lung cancer in women. C, D, E, F. External validation through selected epidemiological studies in men.
C. Incidence of heart attack predicted by the model versus population-based incidence studies: Danish WHO MONICA study register, [MS27] y Estudio de incidencia de infarto en Argentina (Coronel Suárez) [MS29,30].
D. Prevalence of chronic obstructive pulmonary disease (COPD) predicted by the model versus the prevalence reported by the PLATINO study (PLATINO Latin American Project for the Investigation of Obstructive Lung Disease) [MS31]
E. Incidence of stroke (CVA) predicted by the model versus the WHO MONICA study register in selected countries (Finland WHO MONICA study register North Karelia province, Russia WHO MONICA study register Novosibirsk city, Lithuania WHO MONICA study register Kaunas city) [MS28].
F. Incidence of lung cancer predicted by the model versus estimates from the International Agency for Research on Cancer (IARC) [MS16,17] The aforementioned bibliographic references correspond to the previously published methodological study (MS) (17).

One of the limitations of this study is that it is a conservative estimate, since it does not include all the dimensions that smoking impacts, such as the cost of employee absenteeism and lost productivity, out-of-pocket expenditures, and other consequences for the household economy, which could even double or triple the economic burden (4, 47-49). Furthermore, Argentina's lack of detailed information on epidemiological parameters and costs for the model creates uncertainty about the results. A similar problem arises with the estimate of the burden of disease from

Table 2. Deaths, events, and costs associated with and attributable to smoking, 2015 [a]

Pathology associated with smoking	Total deaths	Total attributable deaths		Total events	Attributable events		Total costs (millions of ARS)	Attributable costs (millions of ARS)	
		n	%		n	%		n	%
Myocardial infarction	17 023	3 019	18	99 682	26 346	26			
Coronary syndrome not AIM	5 204	830	16	152 641	34 976	23	42 876	9 770	23
Death from non-ischemic cardiovascular causes	62 073	6 779	11	N/A	N/A	N/A			
Stroke	21 309	2 708	13	97 011	14 405	15	15 684	2 493	16
Lung cancer	10 024	8 247	82	11 554	9 514	82	7 538	6 207	82
Pneumonia	21 959	3 544	16	129 446	25 707	20	313	62	20
Chronic obstructive pulmonary disease	11 856	8 846	75	137 477	92 974	68	6 797	5 039	74
Mouth and pharyngeal cancer	937	615	66	2 484	1 643	66	15 786	5 921	38
Esophageal cancer	2 028	1 315	65	2 796	1 825	65			
Stomach cancer	3 343	658	20	5 365	1 113	21			
Pancreatic cancer	4 270	933	22	4 906	1 078	22			
Kidney cancer	1 804	473	26	4 058	1 103	27			
Laryngeal cancer	963	783	81	1 985	1 622	82			
Leukemia	1 695	252	15	2 221	336	15			
Bladder cancer	1 474	577	39	5 061	2 041	40			
Cervical cancer	964	112	12	3 003	351	12			
Passive smoking and other causes	5 160	5 160	100	N/A	N/A	N/A	N/A	3 834	100
Total from pathologies associated with smoking	172 085	44	26	659 690	215	33	88 994	33 326	37

AMI=acute myocardial infarction; ARS=Argentine pesos; N/A=not applicable.

TABLE 3. Cumulative impact on health and tax revenues at 10 years with three scenarios of cigarette price increases through taxation in Argentina[a]

Impact on health and tax revenues	Price increase		
	25%	50%	100%
Deaths prevented	12 779	25 557	51 114
Heart disease prevented	21 280	42 560	85 120
Stroke prevented	7 725	15 451	30 902
New cancer cases prevented	5 611	11 222	22 443
Years of life lost from premature death and disability prevented	309 293	618 586	1 237 171
Health costs avoided (millions of ARS)	9 895	19 790	39 581
Increase in tax revenues (millions of ARS)	57 580	103 100	157 960
Total economic benefit (millions of ARS)	67 475	122 891	197 542

ARS=Argentine pesos; US$=United States dollars.
[a] Calculated with an exchange rate of 1 US$ = 8.8096 ARS.

passive smoking and perinatal effects, for which indirect estimation methods had to be used since they were not directly included in the model. At any rate, the substantial number of health problems considered by the model, the effort made to obtain better data, and the exhaustive calibration and validation of the model make the results obtained robust.

Despite clear evidence of the benefits of raising taxes on tobacco products, many countries in Latin America have still not done so or taken sufficient action in this regard, mainly due to the lack of evidence at the local level that could reduce decision makers' uncertainty about the potential impact of the measure. There are other barriers as well, among them pressure from tobacco companies and concern about job losses or other adverse economic effects, despite abundant evidence of positive labor and economic scenarios. Studies in Argentina have evaluated different scenarios for changes in the price structure that it would be feasible to implement.

The results of this study are expected to contribute to greater awareness about the effects of smoking in Argentina and serve as support and a catalyst for policymakers to implement this highly cost-effective policy.

CONCLUSIONS

The burden of disease and cost to the health system associated with smoking are very high in Argentina. Increasing cigarette taxes, which are currently very low in comparison with those of other countries in the region and the rest of the world, could yield major health and economic benefits.

Funding. This project was financed with research grants from the International Development Research Center of Canada (IDRC), the Initiative for Cardiovascular Health Research in the Developing Countries (IC-Health), the International Clinical Epidemiology Network (INCLEN Trust), the American Cancer Society, the National Cancer Institute of France, and the Institute of Cancer Research of the United Kingdom.

Conflicts of Interest. None declared.

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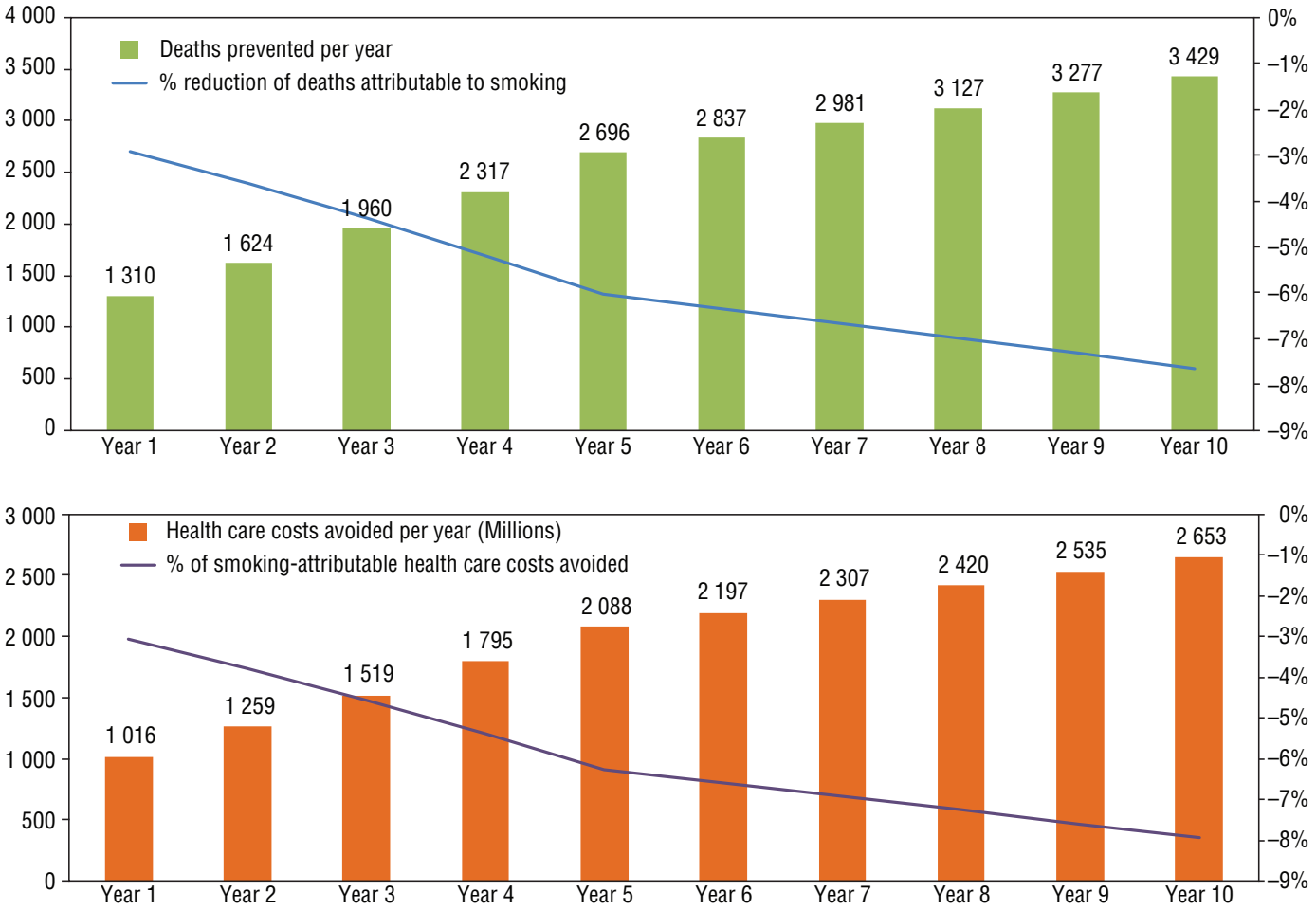
FIGURE 2. Scenario with a 50% increase in cigarette prices: benefits expected at 10 years in Argentina, 2015.



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Manuscript received on 22 December 2015. Accepted for publication, following review, on 29 March 2016

Carga de enfermedad atribuible al uso de tabaco en Argentina y potencial impacto del aumento de precio a través de impuestos

RESUMEN

Objetivo. Evaluar la carga de enfermedad asociada al consumo de tabaco en Argentina y estimar el impacto sanitario y económico de aumentos de precio en los cigarrillos a través de impuestos.

Métodos. Se utilizó un modelo de microsimulación para cuantificar el impacto en la mortalidad, calidad de vida y costos atribuibles al tabaquismo por enfermedad cardiovascular, cerebrovascular y pulmonar obstructiva crónica, neumonía y diez neoplasias. Se modeló el efecto de diferentes escenarios de aumento de precio en el consumo de tabaco y su impacto en los ámbitos sanitario y económico.

Resultados. En Argentina, se pueden atribuir 44 851 muertes, 20 620 diagnósticos de cáncer, 14 405 accidentes cerebrovasculares y 68 100 hospitalizaciones por enfermedad cardiovascular por año al tabaquismo. Cada año se pierden 998 881 años de vida por muerte prematura y discapacidad. El costo de tratar los problemas de salud atribuibles asciende a 33 mil millones de pesos argentinos (ARS). Los impuestos al tabaco llegan a cubrir solo 67,3% del gasto. Si Argentina aumentara el precio de los cigarrillos en 50%, en los próximos 10 años se podrían evitar 25 557 muertes, 42 560 eventos cardiovasculares y 11 222 cánceres y se obtendría un beneficio económico de 122 mil millones de ARS por ahorro de costos sanitarios y aumento de la recaudación impositiva (1 USD = 8,8096 ARS).

Conclusiones. La carga de enfermedad y el costo para el sistema de salud atribuibles al tabaquismo son muy elevados en Argentina. Un aumento de los impuestos al cigarrillo podría tener importantes beneficios sanitarios y económicos.

Palabras clave Uso de tabaco; costo de enfermedad; análisis costo-beneficio; impuestos; Argentina.