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RESEARCH ARTICLE

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The health, economic and social burden of smoking in Argentina, and the impact of increasing tobacco taxes in a context of illicit trade

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Abstract

Tobacco tax increases, the most cost-effective measure in reducing consumption, remain underutilized in low and middle-income countries. This study estimates the health and economic burden of smoking in Argentina and forecasts the benefits of tobacco tax hikes, accounting for the potential effects of illicit trade. Using a probabilistic Markov microsimulation model, this study quantifies smoking-related deaths, health events, and societal costs. The model also estimates the health and economic benefits of different increases in the price of cigarettes through taxes. Annually, smoking causes 45,000 deaths and 221,000 health events in Argentina, costing USD 2782 million in direct medical expenses, USD 1470 million in labor productivity loss costs, and USD 1069 million in informal care costs—totaling 1.2% of the national gross domestic product. Even in a scenario that considers illicit trade of tobacco products, a 50% cigarette price increase through taxes could yield USD 8292 million in total economic benefits accumulated over a decade. Consequently, raising tobacco taxes could significantly reduce the health and economic burdens of smoking in Argentina while increasing fiscal revenue.

KEYWORDS
economic burden, economic model, informal care costs, labor productivity loss, tobacco tax

1 | INTRODUCTION

> Sugar, rum, and tobacco are commodities which are nowhere necessaries of life, which are become objects of almost universal consumption, and which are therefore extremely proper subjects of taxation.
>
> Adam Smith, The Wealth of Nations, Book V, Chapter III

Smoking is one of the leading causes of preventable disease and death globally, accounting for nearly 8 million deaths in 2019 (GBD 2019 Risk Factors Collaborators, 2020; GBD 2019 Tobacco Collaborators, 2021). Despite the great efforts made in tobacco control policies since the World Health Organization Framework Convention on Tobacco Control (WHO FCTC),

which led to a reduction in the prevalence of smoking worldwide, tobacco continues to be a significant cause of death and disease (GBD 2019 Risk Factors Collaborators, 2020; GBD 2019 Tobacco Collaborators, 2021).

Argentina is one of the leading tobacco-producing countries (92,961 tons in 2016), ranking third in the Americas region (only surpassed by Brazil and the United States) and seventh worldwide (Shah et al., 2019), and is one of the Latin American countries where cigarettes are most affordable (only surpassed by Paraguay and Brazil) (World Health Organization, 2021b). Despite having signed the WHO FCTC in 2003, the country has not yet ratified it, making it the only country in South America and one of the few in the world that is not a party (World Health Organization, 2003, 2020). Although there has been a prolonged decline in smoking prevalence in recent years, it remains high at 26.1% in men and 18.6% in women (Ministerio de Salud y Desarrollo Social, 2018). In addition, in Argentina, tobacco consumption has been responsible for over 14% of adult deaths and more than 220 thousand annual cases of diseases (Alcaraz et al., 2016; Pichon-Riviere et al., 2020).

Tobacco consumption also represents a high economic burden in lower and middle-income countries (LMICs). In Argentina, it implies nearly four thousand million dollars in direct medical costs yearly, representing over 7.3% of health expenditure (Alcaraz et al., 2016; Pichon-Riviere et al., 2020). However, there is a significant evidence gap on the economic burden of smoking beyond the healthcare sector, that is, the indirect costs of tobacco consumption on society, which has been shown to be significant and also need to be measured and considered in economic burden estimations (Marquez, 2017; World Health Organization, 2021c).

One component of the indirect costs of tobacco consumption is represented by the labor productivity losses as a consequence of tobacco-attributable diseases, including absenteeism, lower productivity at work, and retirement from the labor market due to disability and premature death (Ekpu & Brown, 2015; Halpern, 2001; Krol & Brouwer, 2014; Krol et al., 2011). On the other hand, recent evidence has shown that the informal care of sick people, that is, informal care usually provided by family and friends, could be a significant hidden burden asymmetrically distributed to the detriment of women (OECD, 2019). Therefore, these indirect and societal costs attributable to tobacco consumption (generally absent in the discussion of policies for tobacco control) need to be considered to empower a multisectoral collaboration to strengthen tobacco control policies.

Although there are multiple strategies to reduce tobacco consumption, raising the price of cigarettes through taxation is the most cost-effective "Best-buy" measure (Savedoff & Alwang, 2015; World Health Organization, 2017). There is evidence that higher cigarette prices encourage people to quit smoking, prevent initiation, discourage former smokers from relapsing, and decrease consumption among those who continue to smoke (Gonzalez-Rozada & Montamat, 2019; Nesson, 2017; Wilson et al., 2012; Yurekli, 2013). In Argentina, recent reforms introduced an ad-valorem tax rate of 70% and a specific minimum fixed-sum tax per quantity in 2017, although the results of this reform are not conclusive (González-Rozada, 2020; Pizarro et al., 2021).

The tobacco tax measures have been underutilized to reduce consumption and prevalence significantly around the world, and have been fought by the tobacco industry (Drope & Schluger, 2018). In Argentina, as in other Latin American countries, the tobacco industry has used the potential increase in the illicit trade of tobacco products as an argument to prevent the rise in tobacco taxes (Pizarro et al., 2018). Although there is evidence that the tobacco industry overestimates the numbers of illicit trade (Gallagher et al., 2019), this argument has been causing concern among decision-makers worldwide (Blanco et al., 2017; Roemer et al., 2001). However, there is no robust evidence about this relationship, and its potential effect on the effectiveness of tobacco tax policy remains under discussion (Maldonado, Llorente, Escobar, et al., 2020; Vellios et al., 2020).

Researchers and policymakers should rely on projections and simulation models to estimate the future impacts of tobacco control policies, such as tobacco taxation. These models use existing retrospective data on tobacco use and disease epidemiology to generate future projections allowing comparisons of tobacco control interventions using public health metrics (e.g., morbidity rates, mortality rates, and life years, among others). These simulation models have been useful across the world to inform policymakers faced with many options and decisions on tobacco control interventions with finite budgets and resources, limited timeframes, and often sudden and short political windows of opportunity (Higashi et al., 2011; Kim et al., 2021; Levy et al., 2006; Singh et al., 2021).

Our objective was to provide a comprehensive estimate of the burden caused by tobacco in Argentina, in terms of mortality, morbidity, direct medical costs, and broader societal costs, such as the cost of lost labor productivity and the cost of informal caregivers, and to assess the reduction in this burden that can be potentially achieved through measures to increase tobacco taxes, taking into account the potential impact of illicit trade in tobacco products.

2 | METHODS

2.1 | The economic model

The economic model used in this study is based on a well-established state transition or Markov probabilistic microsimulation of individuals (first-order Monte Carlo micro-simulation technique) developed in Microsoft Excel by Pichon-Riviere

et al. (2011, 2020). This model has been previously validated and applied in 12 countries, and its details can be found in several publications (Alcaraz et al., 2016; Bardach et al., 2016, 2018; Castillo-Riquelme et al., 2020; Pichon-Riviere et al., 2011, 2020; Pinto et al., 2019). Specifically, this model estimates the disease and economic burden of tobacco consumption and evaluates the impact of several tobacco control interventions.

In this paper, we have extended the model by adding several relevant modules that address the societal costs generated by tobacco consumption and the potential effects of the illicit trade of tobacco products. The societal costs module estimates the economic burden associated with labor productivity loss costs and the informal care costs attributable to tobacco consumption. The illicit trade module considers the potential "switching" effects between the licit cigarettes market and the illicit trade of tobacco products on the effectiveness of tobacco control policies. By incorporating these modules, the economic model provides a more comprehensive understanding of the economic burden attributable to tobacco consumption and the costs and benefits of different tobacco control interventions, which can be used to inform policy decisions and public health strategies.

The model incorporates the natural history, smoking-related relative risks (see Table S3), direct medical costs, labor productivity loss costs, informal care costs and quality of life of the significant tobacco-related diseases: acute myocardial infarction (AMI), non-AMI coronary events, stroke, chronic obstructive pulmonary disease (COPD), pneumonia, lung cancer, and nine other types of cancers, considering the effects in the first year as in subsequent years. The model estimates total tobacco-attributable disease events, deaths, healthcare costs and other societal costs, and healthy years of life lost (YLL), which aggregate health losses both due to YLL by premature mortality as well as quality-of-life losses.

It uses hypothetical cohorts of individuals aged 35 years to death in annual cycles whose risks for occurrence of an adverse health event, disease progression, and death are estimated based on population demographic characteristics, clinical conditions, and underlying risk equations to provide aggregate results in disease incidence, disease events, mortality, quality of life, and health care costs and other societal costs for each sex and age stratum for smokers, ex-smokers, and never-smokers.

All costs were estimated in local currency units in 2020 and then converted to US dollars of that year using the average exchange rate published by the Central Bank of Argentina (Banco Central de la República Argentina, 2021).

2.2 | Estimation and data sources for the smoking-related disease burden

The main health outcomes of the model were the number of deaths, disease events and healthy life-years lost (both due to years lost by premature mortality and quality-of-life losses). The disease burden was estimated by analyzing differences in acute and chronic events and deaths between the results predicted by the model according to current data on smoking prevalence and the results expected for a hypothetical cohort of never-smokers in Argentina. Health outcomes were calculated from the simulation of each individual's lifetime to obtain aggregated results. Passive smoking and perinatal effects were estimated to impose an additional burden of 13.6% for men and 12% for women (CDC, 2009). For further details see Pichon-Riviere et al. (2011, 2020). Disease burden results are reported for one calendar year (2020).

The main sources of epidemiological, clinical and economic parameters are summarized in Table 1. We obtained the most recent and representative information on smoking prevalence from a national survey of risk factors (Ministerio de Salud y Desarrollo Social, 2018). Data on demography, the total number of annual deaths, and fatality rates of cardiovascular diseases—estimated from hospital discharge databases—were taken from official national sources (INDEC, 2020a; Ministerio de Salud, 2020). For the information on the total number of deaths, incidence, and fatality rate of cancers, the data was obtained from the official GLOBOCAN website (IARC, 2020). For further details see the Supporting Information S1.

The model calibration and validation process were performed by comparing the disease-specific mortality predicted by the model by sex and age with Argentinian national statistics (Ministerio de Salud, 2020). Predicted mortality within 15% of the references was considered acceptable, and for deviations more than 15%, risk equations were modified. Model results were externally validated against other epidemiological and clinical studies not used for equation estimation and development (Pichon-Riviere et al., 2011, 2020). For further details please see the Figures S1 and S2.

2.3 | Estimation and data sources for the key economic parameters

2.3.1 | Direct medical costs

We followed a micro-costing approach and an indirect estimation approach to estimate the direct medical costs of the health conditions attributable to tobacco consumption. Under the micro-costing approach, the identification and quantification of

TABLE 1 Main demographic, epidemiological, and economic parameters considered in the model.

Parameter		Value	Source
Total target population (>35 years)		20,404,023	INDEC (2020b)
Smoking prevalence by sex and age group	Men	16%	Ministerio de Salud y Desarrollo Social (2018)
	Women	13%	
	Men 35–49 years	30.6%	
	Women 35–49 years	21.1%	
	Men 50–64 years	24.9%	
	Women 50–64 years	20.5%	
	Men ≥ 65 years	7%	
	Women ≥ 65 years	6%	
Overall crude mortality rate per 100,000 (men/women)	Acute myocardial infarction	110.8 (136.6/88.2)	Ministerio de Salud (2020)
	Ischemic heart disease (non-acute myocardial infarction)	28.1 (35.8/21.3)	
	Other cardiovascular disease	187.3 (206.6/170.4)	
	Stroke	94.5 (100.9/88.9)	
	Pneumonia	148.5 (144.2/152.3)	
	COPD	30.0 (38.3/22.6)	
	Lung cancer	46.0 (65.3/29.0)	
Overall case fatality rate	Acute myocardial infarction	25.5%	Ministerio de Salud (2020)
	Ischemic heart disease (non-acute myocardial infarction)	5.5%	
	Stroke	22.5%	
	Lung cancer	49.6% (1 year mortality since diagnosis)	IARC (2020)
Direct medical costs	Myocardial infarction	$6179	Own estimation
	Ischemic heart disease (acute event)	$4634	
	Ischemic heart disease (chronic stage)	$1141	
	Stroke	$1351	
	Pneumonia	$543	
	COPD (mild disease)	$262	
	COPD (moderate disease)	$578	
	COPD (severe disease)	$1768	
	Lung cancer (first year of diagnosis)	$20,621	
	Lung cancer (second year and beyond)	$26,601	
Annual wage (average)	Men	$6301	Own estimation based on INDEC (2020a)
	Women	$4611	
	Men 35–49 years	$6329	
	Women 35–49 years	$4669	
	Men 50–64 years	$6258	
	Women 50–60 years	$4515	
Caregiver hourly wage (average)		$2.75	Own estimation based on INDEC (2020a)
Long-term wage growth		1.06%	World Bank (2020)
Discount rate		5%	MERCOSUR (2009)

TABLE 1 (Continued)

Parameter		Value	Source
Retirement age	Men	65 years	Quagliato (1999)
	Women	60 years	
Economic parameters	Own price elasticity of demand	−0.441	González-Rozada (2020)
	Tax revenue from tobacco taxes (million)	$1,353,595,236	AFIP (2020)
	Taxes as a percentage of the price of cigarettes	76.2%	World Health Organization (2021b)
	Percentage of illicit trade	13.7%	Pizarro et al. (2021)
	Proxy of cross price elasticity of demand between licit and illicit cigarettes	0.17	Own estimation based on Maldonado, Llorente, Iglesias, et al. (2020)
	Gross domestic product (GDP—million)	$421,237,140,039	OECD (2020)
	Total health spending (% of GDP)	9.12%	World Bank (2020)

Note: Monetary values are expressed in 2020 USD. Exchange rate 2020 (average of the year): USD 1 = ARS 70.63 (Argentinian pesos).

Abbreviations: COPD, chronic obstructive pulmonary disease; GDP, gross domestic product.

healthcare resources associated with the diagnosis, treatment, and follow-up of each health condition were carried out by reviewing local clinical practice guidelines, specialized literature, and the advice of local experts. The unit costs of each healthcare resource were obtained from the Institute for Clinical Effectiveness and Health Policy Unit Cost Database (Palacios et al., 2019). Given that the Argentinean health system is formed by three subsystems, the final cost of each health condition was estimated as a weighted average cost, with the weights defined according to the covered population by each subsystem: public sector (38% of the population), social security (46%) and the private sector (16%) (Palacios et al., 2020). This approach was used for the following conditions: AMI, non-AMI coronary event, diagnosis and annual follow-up of a stable coronary patient, non-ischemic cardiovascular death (the list of non-ischemic cardiovascular conditions included in this category can be found in the Supporting Information S1), stroke, and its yearly follow-up, pneumonia, mild, moderate, and severe COPD, and the diagnosis and treatment of first-year lung cancer. The direct medical costs of the rest of the cancer events were estimated based on the opinion of local experts, relating the direct medical cost of each cancer event with the direct medical cost of lung cancer (Alcaraz et al., 2016; Pichon-Riviere et al., 2020).

2.3.2 | Labor productivity loss costs

The estimation of the labor productivity loss costs was based on the human capital approach, considering two main factors: (i) the premature death of individuals and (ii) the decrease in productivity at work due to the health event (presenteeism). To calculate the cost of premature death, we estimated the labor productivity loss of an individual as the present value of their future income using the Value of a Statistical Life formula (Lev & Schwartz, 1971). To estimate annual market wages per sex and age we used a Mincer equation (Harberger et al., 2012; Lemieux, 2006) with nationally representative data from the Encuesta Permanente de Hogares for the third quarter of 2020 (INDEC, 2020a). We then applied the expected wage growth rate using data from the World Bank, a discount rate of 5%, and the Argentinean official retirement ages by sex. For further details see Table 1.

Regarding the estimation of economic losses due to presenteeism, we adopted an indirect estimation criterion based on previous research conducted by Krol et al. (2013) and Knies et al. (2010). Specifically, we assumed that the reduction in work productivity of individuals was directly proportional to the reduction in their quality of life due to a health condition attributed to smoking (Krol & Brouwer, 2014). For more information and an application of this methodology, please see Pinto et al. (2019) and Table S4.

2.3.3 | Informal care costs

This study incorporated an estimation of the cost of informal care provided to patients with diseases attributable to smoking. Informal care refers to the hours of unpaid care, usually performed by the patient's family or friends and mainly provided by

women. Given that microdata on the use of time in unpaid care tasks in Argentina did not present the information we needed, we followed a procedure in several stages to estimate the costs of informal care. First, we searched PubMed and LILACS databases for systematic reviews containing information on the costs and time use of informal caregivers for the considered diseases (García-Mochón et al., 2019; Jaracz et al., 2015; Kamal et al., 2017; PAHO, 2008; Pedraza, 2015; Reca et al., 2008; Souliotis et al., 2017; Stevens et al., 2018; Yabroff & Kim, 2009; Zhu & Jiang, 2018). Secondly, for some cases where data was not available, we used an indirect estimate through interpolation of available data. We estimated the linear relationship between the hours per day of informal care for the health events considered and the quality of life of the patients in these health events. We used the method of ordinary least squares for econometric estimation to perform the interpolation. Finally, we conducted a survey with formal caregivers and interviewed clinical specialists to validate and/or adapt the data obtained. The monetary value of the estimated hours of informal care was calculated using the good proxy approach (van den Berg et al., 2006), using nationally representative microdata of hourly wage of social assistance of health care workers as a proxy of the opportunity cost of the informal caregiver (INDEC, 2020a). For further details, please see Espinola et al. (2023) and Table S5.

2.4 | Estimation of the effect of the tobacco tax policy on deaths and disease events, societal costs and tax revenues

The model estimates the expected health and economic benefits of implementing different price increases through tobacco taxes considering two structural modeling assumptions: (i) A base case situation in which after the tobacco tax increase the illicit trade variables (size of the market, prices, etc.) remain unchanged, and (ii) An alternative situation where we assume the illicit trade variables change after the tobacco tax increase. These situations are described below.

In the base case, the model estimates the expected health and economic benefits of implementing different price increases through tobacco taxes based on the estimated baseline prevalence change. Mathematically, the effect of price increases through taxes on the prevalence of smoking was calculated as

$$Prev_{post-tax} = Prev_{pre-tax} + \left(\varepsilon_d * \Delta P * I_p * Prev_{pre-tax}\right)$$

where $Prev_{pre-tax}$ is the baseline prevalence of smoking before the price increase; ΔP is the percent price variation; I_p is the proportion of the variation on cigarette consumption expected to impact on smoking prevalence; and ε_d is the own-price elasticity of the demand for cigarettes. For further details see Pichon-Riviere et al. (2020).

It is important to note that the price elasticity of demand is a crucial parameter for estimating the impact of tax increases on tobacco consumption. In Argentina, several studies have produced estimations of this parameter (Chaloupka et al., 2014; Cruces et al., 2022; Gonzalez-Rozada, 2019, 2020; Martinez et al., 2015). To select the most appropriate estimate for our analysis, we prioritized studies published in peer-reviewed journals and those that used the most recent data. After careful consideration, we selected the study by González-Rozada (2020) as the primary source for the price elasticity of demand for cigarettes in Argentina. For further details about the main characteristics of these studies, please see the Table S1.

To account for the potential uncertainty in the estimated price elasticity of demand for cigarettes in Argentina, we conducted a deterministic sensitivity analysis. This analysis allows us to explore how different values of the price elasticity of demand affect our estimations of the impacts of tobacco tax policy. We used the dispersion measures reported by González-Rozada (2020) as a range of potential values for this parameter.

As previously mentioned, there is no robust evidence about the relationship between the tobacco tax increase policy and the size of the illicit trade of tobacco products. However, in an alternative situation, the model allows for a potential prevalence adjustment due to the potential substitution effect between cigarettes from the licit and the illicit markets after the tax increase policy, measured by a proxy of their cross-price elasticity of demand ε_{cp}, weighted by the size of the illicit trade market α in the country:

$$Prev_{post-tax} = Prev_{pre-tax} + \left[(1-\alpha) * \varepsilon_d + (\alpha) * \varepsilon_{cp}\right] * \Delta P * I_p * Prev_{pre-tax}$$

In the absence of country-specific estimates for the cross-price elasticity between the licit and the illicit markets, we used information of the consumption of cigarettes in the illicit market before and after a tobacco tax reform in Colombia (Maldonado, Llorente, Escobar, et al., 2020) to estimate a proxy of cross-price elasticity of the demand between the licit and illicit tobacco products.

To estimate the health and economic benefits derived from increased tobacco taxes, the model considers three price increase scenarios with different timeframes. The first scenario is a short-term and conservative one, where previous studies have

suggested that in the short and medium term approximately 50% of the reduction in consumption is due to a decreased prevalence of smoking, while the other 50% is due to reduced consumption by people who continue to smoke (Chaloupka et al., 2000; IARC, 2012). In this scenario, we assume that 50% of the reduced consumption is due to the reduction in prevalence ($I_p = 0.5$), which leads to an increase in the number of people who formerly smoked. The second scenario is a medium-term one, which is similar to the short-term scenario but also includes potential health benefits associated with the reduction in the number of cigarettes smoked by people who continue to smoke. Given that low-intensity smokers have a lower excess disease risk than high-intensity smokers compared to people who have never smoked (82% less for lung cancer, 57% less for ischemic heart disease, and 80% less for COPD) (Doll et al., 2004), we assumed that a reduction in the number of cigarettes smoked would result in a proportional reduction in the 75% of excess risk difference between a person who smokes and a person who formerly smoked. The third scenario is a long-term one, which is the maximum effect scenario analyzed. It is similar to the medium-term scenario, but here ($I_p = 0.75$) and we assume that the entire reduction in prevalence results in an increased population of people who have never smoked, instead of one of the people who formerly smoked. To analyze the three scenarios in a unified way, we developed a base-case with the results accumulated over a 10-year period. We assumed a linear progression from scenario one to scenario two over 5 years and a progression to scenario three in years 6–10. For further details see Table S2.

Finally, the effect of a tax increase on fiscal revenues was estimated as follows:

$$V_r = \Delta c \times \frac{\Delta P}{pV}$$

where V_r is the calculated variation in tax revenues, Δc represents the expected variation in consumption due to the price increase as a proportion of the baseline consumption, ΔP represents the change in cigarette prices as a proportion of the baseline price, and pV represents the proportion of the price, before the price increase, represented by taxes.

3 | RESULTS

Table 1 summarizes the main demographic, epidemiological, and economic inputs considered in the model (for the rest of the parameters, see Supporting Information S1). The model estimations concerning health and financial burden and the impact of increasing tobacco taxes are described below.

3.1 | Deaths and health events attributable to tobacco consumption

Table 2 show that in 2020 tobacco was responsible for nearly 45,000 deaths annually, and this figure represents approximately 14.3% of the total deaths in adults 35 years of age or older in Argentina. In particular, approximately 12% of all cardiac disease deaths and 10% of all cerebrovascular disease deaths can be attributed to smoking. The attributable percentages are higher in respiratory diseases such as COPD (73%) and lung cancer (78%). In addition, 12% of pneumonia deaths and nearly 29% of cancer deaths other than lung cancer could be attributed to this addiction.

Related to disease events, smoking was responsible for 221,107 events annually. Of these, over 100,000 correspond to new cases of COPD; over 56,000 correspond to cardiovascular disease episodes and over 33,000 to pneumonia events. The attributable tobacco fraction in the disease events is higher in lung cancer and laryngeal cancer (78%), mouth and pharyngeal cancer (62%), and esophagal cancer (61%). The burden of disease attributable to tobacco consumption is more significant in men than in women.

3.2 | Healthy years of life lost associated with smoking

A total of 1,423,531 healthy life-year lost can be attributed to tobacco use each year, due to a combination of 78.3% of YLL for premature death and 21.7% for years living in suboptimal conditions of health-related quality of life. There were 964,687 healthy life-years lost attributable to smoking in men, and 458,843 healthy life-years lost in women. Most healthy life-years lost are due to cardiovascular diseases (25%), lung cancer (22%) and COPD (22%).

3.3 | Direct and indirect economic burden attributable to smoking

The total economic burden attributable to tobacco consumption is over USD 5300 million. Figure 1 shows the annual economic burden attributable to tobacco consumption disaggregated by health condition and cost type. The total economic burden

TABLE 2 Annual burden of disease attributable to tobacco consumption in Argentina for 2020.

	Deaths attributable to smoking						Events attributable to smoking					
	Men		Women		Total		Men		Women		Total	
Condition	*N*	% of condition specific death	*N*	% of condition specific death	*N*	% of condition specific death	*N*	% of condition specific event	*N*	% of condition specific event	*N*	% of condition specific event
Myocardial infarction	2877	21%	923	9%	3801	16%	17,912	26%	4336	11%	22,247	21%
Ischemic heart disease	672	18%	191	8%	864	14%	25,945	24%	7939	14%	33,884	20%
Non-ischemic cardiovascular disease	4303	14%	1078	4%	5381	10%	-	-	-	-	-	-
Stroke	1371	13%	804	8%	2175	10%	7355	14%	4049	9%	11,404	12%
Lung cancer	6018	86%	2573	65%	8591	78%	6557	86%	2981	65%	9538	78%
Pneumonia	2683	18%	1245	7%	3928	12%	20,235	21%	12,452	15%	32,687	18%
COPD	5059	79%	4058	66%	9117	73%	56,680	73%	45,015	62%	101,695	67%
Mouth and pharynx cancer	570	72%	119	39%	690	63%	1263	72%	289	39%	1551	62%
Esophagus cancer	915	69%	283	45%	1198	61%	1120	68%	360	45%	1480	61%
Stomach cancer	529	25%	96	9%	625	19%	675	25%	130	9%	805	19%
Pancreatic cancer	462	20%	449	18%	911	19%	535	20%	513	18%	1048	19%
Kidney cancer	581	36%	32	4%	613	26%	1151	37%	71	5%	1222	26%
Laryngeal cancer	574	80%	86	66%	660	78%	1123	80%	165	65%	1287	78%
Leukemia	185	19%	46	6%	232	13%	301	20%	74	6%	374	14%
Bladder cancer	508	42%	88	20%	597	36%	1266	42%	175	20%	1441	37%
Cervical cancer	0	-	227	11%	227	11%	0	-	445	11%	444	11%
Passive smoking and other causes	3714	100%	1476	100%	5149	100%	-	-	-	-	-	-
Total	**31,021**	**31%**	**13,774**	**16%**	**44,759**	**24%**	**142,118**	**33%**	**78,994**	**25%**	**221,107**	**30%**

Note: *Percentage of condition-specific deaths are deaths attributable to tobacco consumption as a proportion of total condition-specific deaths in the population 35 years and older (e.g., deaths caused by myocardial infarction in men: 2877/21% means that there are 2877 deaths from myocardial infarction attributable to smoking in men, which represent 21% of the total deaths caused by that condition in men). **Percentage of condition-specific events are health events attributable to tobacco consumption as a proportion of total condition-specific events (e.g., events caused by myocardial infarction in men: 17,912/26% means that there are 17,912 deaths from myocardial infarction in men attributable to smoking, which represent 26% of the total deaths caused by that condition in men).

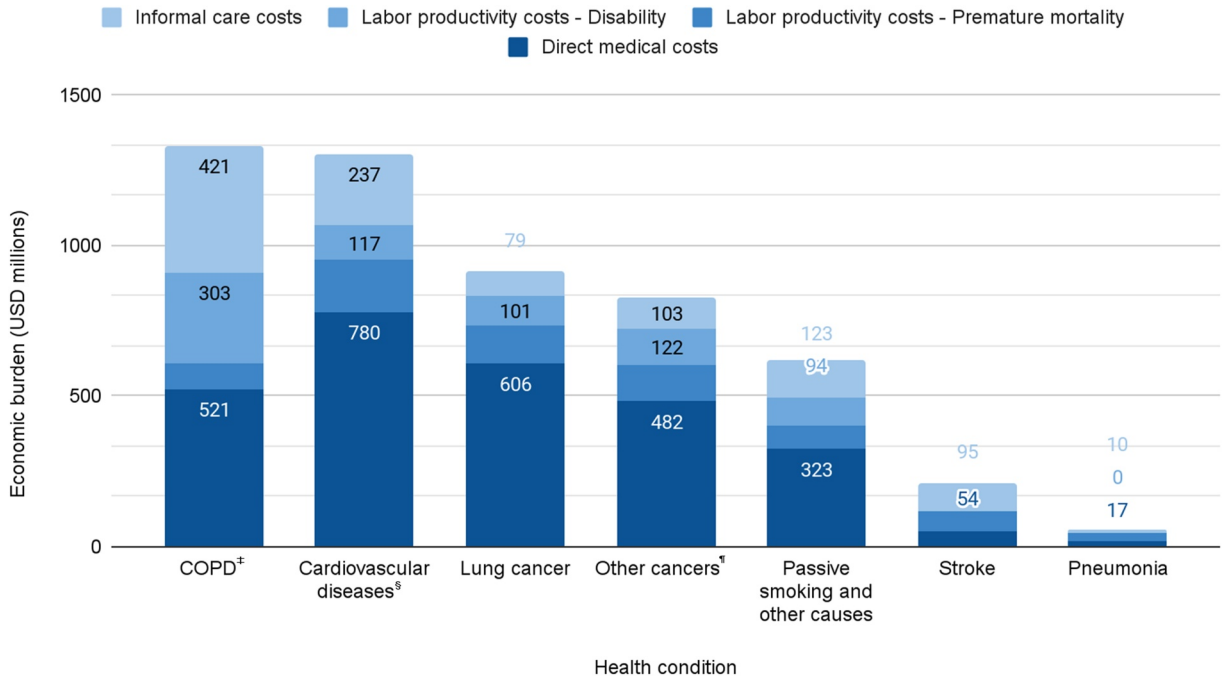

FIGURE 1 Annual economic burden attributable to tobacco consumption in Argentina by condition and type of costs. Monetary values expressed in 2020 million USD. Exchange rate 2020 (average of the year): USD 1 = ARS 70.63 (Argentinian pesos). ‡COPD, Chronic obstructive pulmonary disease. §Cardiovascular diseases: Acute myocardial infarction (AMI), ischemic heart disease-non myocardial infarction, non-ischemic cardiovascular disease. ¶Other cancers: Oral, Stomach, Esophageal, Pancreatic, Kidney, Bladder, Laryngeal, Cervical, and Leukemia.

attributable to tobacco involves direct medical costs of USD 2782 million (52%), labor productivity loss costs (due to premature mortality and disability) of USD 1470 million (28%) and informal caregiver costs of USD 1.069 (20%). Of the total economic burden, USD 1330 million corresponds to COPD, USD 1301 million to cardiovascular diseases, USD 912 million to lung cancer, and USD 827 million to other cancers.

The primary determinant of direct medical costs are cardiovascular diseases, generating healthcare costs of USD 780 million. Other conditions with high economic burden and high healthcare costs are lung cancer, with a healthcare cost of USD 606 million, and COPD, with a cost of USD 521 million. COPD and cardiovascular diseases attributable to tobacco consumption also represent high labor productivity loss costs (USD 388 million for COPD and USD 284 million for cardiovascular diseases), and informal care costs (USD 421 million for COPD and USD 237 million for cardiovascular diseases). Table 3 shows the total economic burden attributable to tobacco consumption disaggregated by sex.

3.4 | The expected benefits of increasing the tobacco retail price through taxes

Table 4 shows the cumulative 10-year health and economic benefits of a 25%, 50% and 75% increase in the retail price of cigarettes through taxes under two scenarios: a base case scenario that assumes that the illicit trade of tobacco products will remain unchanged after the tobacco tax increase, and an alternative scenario considering a prevalence adjustment for the potential effect of an increase in illicit trade. Additionally, the table presents the results of the deterministic sensitivity analysis, which was carried out by setting a range of price elasticities of the demand for tobacco products according to González-Rozada (2020).

In the base case, an increase of 50% in the price of tobacco products through taxes would avoid a total of 32.9 thousand deaths and nearly 139 thousand disease events attributable to smoking in 10 years. Furthermore, a total of 1,172,964 healthy life-years lost could be averted. Concerning economic benefits, the country would save USD 2064 million to direct medical costs avoided, USD 792 million for labor productivity loss costs avoided, and USD 1499 million for avoided informal care costs, and tax collection of USD 3937 million, getting a total economic benefit of USD 8292 million in 10 years. Figure 2 shows these results for the base case disaggregated for each of the 10 years considered in the analysis.

In an alternative scenario that considers an adjustment for the potential effects of illicit trade of tobacco products, the 50% price increase through taxes would avoid 26.6 thousand deaths and nearly 112,000 events could be avoided. The country would save USD 7465 million, corresponding to USD 1673 million to avoid direct medical costs, USD 641 million labor productivity

TABLE 3 Annual economic burden attributable to tobacco consumption in Argentina by sex, health condition and type of costs.

Type of cost		Sex	Atribuible costs (USD millions)							
			COPD	Cardiovascular diseases	Lung cancer	Other cancers	Passive smoking and other causes	Stroke	Pneumonia	Total
Direct medical costs		Men	292.1	612.7	396.6	379.9	234.4	31.8	10.3	1957.8
		Women	229.3	167.3	209.7	102.0	88.4	21.7	6.3	824.7
		Total	521.4	780.0	606.3	481.9	322.7	53.5	16.6	2782.5
Labor productivity loss costs	Premature mortality	Men	63.7	144.1	99.8	100.5	66.6	58.1	23.3	556.0
		Women	21.7	23.8	25.5	19.7	12.1	4.3	5.9	112.9
		Total	85.4	167.9	125.3	120.2	78.7	62.4	29.2	669.0
	Disability	Men	217.6	108.4	83.9	108.9	77.0	47.3	0.2	643.1
		Women	85.2	8.4	16.9	13.4	16.9	17.0	0.1	158.0
		Total	302.8	116.8	100.8	122.3	93.9	64.3	0.3	801.1
Informal care costs		Men	235.1	186.2	52.1	79.0	83.5	55.6	6.2	697.7
		Women	186.3	51.0	27.2	23.9	39.8	39.2	3.8	371.2
		Total	421.4	237.2	79.4	102.9	123.3	94.8	9.9	1068.9
Total			1330.9	1301.9	911.6	827.3	618.6	275.1	56.0	5321.4

Note: Monetary values expressed in 2020 million USD. Exchange rate 2020 (average of the year): USD 1 = ARS 70.63 (Argentinian pesos). Cardiovascular diseases: Acute myocardial infarction (AMI), Ischemic heart disease-non myocardial infarction, Non-ischemic cardiovascular disease. Other cancers: Oral, Stomach, Esophageal, Pancreatic, Kidney, Bladder, Laryngeal, Cervical, and Leukemia. Results reflect the annual economic burden for 2020.

Abbreviation: COPD, chronic obstructive pulmonary disease.

loss costs, and USD 1214 million in avoided informal care costs, and USD 3937 in higher tax revenue. This means that even in an alternative scenario that considers the potential effects of illicit trade, the country retains at least 90% of the total economic benefits derived from increasing cigarette prices through taxes.

4 | DISCUSSION

We aimed to estimate the disease and wide societal economic burden attributable to smoking in Argentina and project the health and economic benefits of increasing tobacco taxes. For that, we extended a microsimulation model to quantify deaths, health events, direct medical costs and other societal costs attributable to smoking. In addition, the model estimated the health and economic benefits of different increases in the retail price of cigarettes through taxes considering the potential effects of the illicit trade of tobacco products.

Our model has estimated that smoking is responsible for causing approximately 45 thousand deaths in Argentina in the year 2020. This number is consistent with the results reported by the GBD study for the year 2019. Specifically, when we compared our results to the IHME-GBD data visualization tool considering the same age groups and diseases that our model, we found that smoking and second-hand smoking contributed to about 56 thousand deaths (with a lower range value of around 48 thousand deaths) in 2019 (Institute for Health Metrics and Evaluation, 2020). This higher number of deaths reported by GBD is probably due to GBD considering "smoking" to be the use of any smoked tobacco product (instead, our model only considers combustible cigarettes).

The burden of disease attributable to tobacco consumption is not too distant from the overall COVID-19 death toll in the country in 2020 (Rearte et al., 2021). In addition, tobacco consumption is also responsible for 221 thousand disease events, of which 65% correspond to respiratory conditions. This could have additional implications in the actual scenario, given that smokers are more vulnerable to getting severe COVID-19 symptoms than non-smokers (Gupta et al., 2021; World Health Organization, 2021a). Smoking also imposes an unbearable economic burden on society by USD 5321 million per year, equivalent to 1.2% of the national gross domestic product (GDP). In 2020, the fiscal revenue for tobacco taxes in Argentina was USD 1353 million, so this value only covers 25% of the total economic costs attributable to tobacco consumption.

Our study reveals, based on a prior modeling study for Argentina (Pichon-Riviere et al., 2020), that the smoking-attributable burden of disease remained stable in the country between 2015 and 2020, with an estimated 45,000–48,000 deaths and 221,000–224,000 health events per year. However, our study highlights the significant economic burden of smoking in Argentina when we consider the broader societal costs of tobacco consumption, which include the costs of labor productivity loss and

TABLE 4 Cumulative 10-year health and economic benefits of a 25%, 50% and 75% increase in the retail price of cigarettes through taxes in Argentina.

	Base case			Alternative scenario considering illicit trade		
	Price increase			Price increase		
Benefits	**25%**	**50%**	**75%**	**25%**	**50%**	**75%**
Health effects (*N*)						
Deaths averted	16,450 (15,144–17,755)	32,900 (30,289–35,511)	49,350 (45,433–53,266)	13,328 (12,270–14,385)	26,655 (24,540–28,771)	39,983 (36,809–43,156)
Coronary heart disease events averted	24,977 (22,995–26,959)	49,954 (45,989–53,919)	74,931 (68,984–80,878)	20,236 (18,630–21,842)	40,472 (37,260–43,684)	60,708 (55,890–65,526)
Stroke events averted	8716 (8024–9408)	17,432 (16,048–18,815)	26,147 (24,072–28,223)	7061 (6501–7622)	14,123 (13,002–15,244)	21,184 (19,503–22,866)
COPD events averted	7167 (6598–7736)	14,334 (13,196–15,472)	21,501 (19,795–23,208)	5807 (5346–6268)	11,613 (10,692–12,535)	17,420 (16,037–18,803)
Cancer events averted	28,681 (26,405–30,958)	57,362 (52,810–61,915)	86,044 (79,215–92,873)	23,237 (21,393–25,081)	46,474 (42,786–50,163)	69,712 (64,179–75,244)
Healthy life-years lost averted	586,482 (539,936–633,028)	1,172,964 (1,079,872–1,266,057)	1,759,446 (1,619,808–1,899,085)	475,161 (437,450–512,872)	950,322 (874,899–1,025,744)	1,425,483 (1,312,349–1,538,616)
Economic effects (USD millions)						
Healthcare cost savings	$1032 ($950–$1114)	$2064 ($1901–$2228)	$3342 ($2851–$3097)	$836 ($770–$903)	$1673 ($1540–$1805)	$3097 ($2851–$3342)
Labor productivity loss costs saved	$396 ($364–$427)	$792 ($729–$855)	$1282 ($1093–$1188)	$321 ($295–$346)	$641 ($591–$692)	$1188 ($1093–$1282)
Informal caregivers costs saved	$750 ($690–$809)	$1499 ($1380–$1617)	$2425 ($2069–$2247)	$607 ($559–$656)	$1214 ($1118–$1311)	$2247 ($2069–$2425)
Increased tax revenue	$2458 ($2299–$2611)	$3937 ($3768–$4082)	$4412 ($4407–$4437)	$2458 ($2299–$2611)	$3937 ($3768–$4082)	$4437 ($4407–$4412)
Total economic benefit	$4636 ($4303–$4961)	$8292 ($7778–$8782)	$11,461 ($10,420–$10,969)	$4222 ($3923–$4516)	$7465 ($7017–$7890)	$10,969 ($10,420–$11,461)

Note: Monetary values expressed in 2020 million USD. Exchange rate 2020 (average of the year): 1 USD = 70.63 ARS (Argentinian pesos).

Abbreviation: COPD, chronic obstructive pulmonary disease.

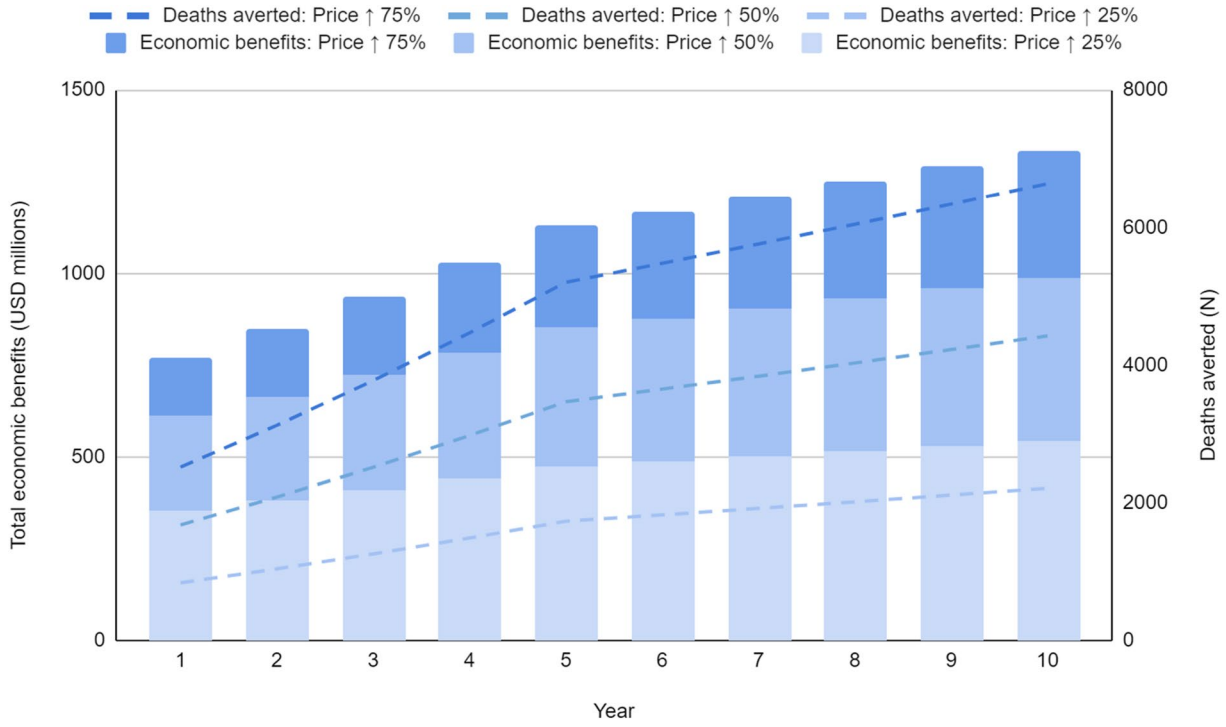

FIGURE 2 Health and economic benefits of a 25%, 50% and 75% increase in the retail price of cigarettes through taxes in Argentina. Monetary values expressed in 2020 million USD. Exchange rate 2020: USD 1 = ARS 70.63 (Argentinian pesos).

informal care. Specifically, Pichon-Riviere et al. (2020) estimated that in 2015 the economic burden of smoking (consisting only of the direct medical costs) was equivalent to 0.6% of the country's GDP, but in our study, the economic burden represented 1.2% of GDP. By taking into account the broader societal costs of smoking, policymakers can make informed decisions based on accurate estimation of the costs of tobacco use and develop more effective strategies to reduce its negative impact on the health and economy.

The results suggest healthy taxes could be a significant tool for tobacco control and should be at the center of public policy discussion. According to the Global Action Plan for the Prevention and Control of non-communicable diseases (NCDs) 2013–2020, healthy taxes are recommended as "best buys" in the fight to reduce the burden of NCDs since their implementation costs are far outweighed by their benefits (World Health Organization, 2021c). Our study provides detailed evidence on this issue. Simulating an increase in taxes that raise the price of tobacco products by 50%, it would be possible to avoid 22 thousand deaths, 94 thousand NCD events and get a total economic benefit of more than USD 8 billion in a time frame of 10 years.

This study addresses the evidence gap on the economic burden of smoking beyond the healthcare sector, that is, the indirect costs of tobacco consumption. In particular, labor productivity loss costs attributable to tobacco consumption represent 52% of the total direct medical costs of smoking in Argentina. A similar study in Brazil estimated that labor productivity loss costs represented 50% of the direct medical costs attributable to tobacco consumption (Pinto et al., 2019). In Colombia, a technical report estimated that the productivity loss costs attributable to smoking represent 164% of the total direct medical costs (PNUD, 2019). However, the Colombian study considered all the life-years gained (i.e., does not restrict the population to active working years) to estimate the productivity loss costs. In addition, the technical report values each year of lost productivity as 1.4 times the GDP per capita, while our study used nationally representative information on annual wages stratified by sex and age.

Our study highlights the gender inequalities imposed by tobacco consumption. While the prevalence of smoking is higher among men, and therefore also the burden of disease and the direct medical costs, it is important to recognize that smoking affects both men and women in different ways. In particular, our results show that smoking can increase gender gaps related to informal care costs, which are usually ignored by economic burden literature. Specifically, the informal care costs attributable to smoking represent losses of about USD 1 billion, accounting for 20% of the total economic burden attributable to smoking. According to official information, women in Argentina spend three times more time on housework and providing informal care than men (D'Alessandro et al., 2020), reflecting disparities in caregiving responsibilities. Therefore, gender-equitable progress in combating the tobacco epidemic will not be possible without addressing gender bias, stigmatization, sexism, and lack of

intersectionality (Bottorff et al., 2014). Our study sheds light on the gendered nature of smoking and highlights the need for gender-sensitive interventions that address the different ways in which smoking affects men and women in Argentina.

This study intends to shed light on the potential effect of the illicit trade of tobacco products on the effectiveness of the tobacco tax increase policy in Argentina. Despite significant efforts to measure illicit trade in countries in the region (Maldonado, Llorente, Iglesias, et al., 2020; Paraje, 2019; Paraje et al., 2020; Pizarro et al., 2021; Szklo et al., 2018), there is a considerable research gap in the literature on estimating the impact of tobacco tax policies on illicit trade and on the effect of illicit trade on consumption or prevalence of smoking. Previous studies have reported conflicting results, with some suggesting that raising taxes may increase the probability of purchasing illicit trade cigarettes (Gallego et al., 2020), while others have found no statistically significant results for switching from licit to illicit cigarettes (Divino et al., 2022). In our study, we showed that even in a scenario that accounts for the potential impact of illicit trade, Argentina could still realize approximately 92% of the economic and health benefits derived from increasing tobacco taxes as compared to the scenario without illicit trade.

The study presented here has limitations. First, although we considered most of the relative mortality risks from diseases with a proven causal relationship to smoking, we have not included others, such as hepatocarcinoma and diabetes. Likewise, other relative risks for mortality from conditions with a lower level of evidence, such as breast and prostate cancer, have not been entered into the model either. In addition, the estimate of disease burden from passive smoking and perinatal effects were not directly included in the model, for which indirect estimation methods were used. Our results are conservative, and the burden of disease and associated costs may be even higher than those estimated in the model. Additionally, some of the input data like mortality and case fatality rates might have caveats, such as garbage coding, among others, and represent only an approximation for the country, given the fragmentation and decentralization of the health system.

Second, our study estimated direct medical costs based on a review of local clinical practice guidelines, specialized literature, and input from local experts. However, we acknowledge that this approach may assume an ideal scenario in which all patients receive the same diagnosis, treatment, and follow-up care as recommended. This could have implications for the study results, as the estimated economic burden may not reflect the actual costs incurred by the healthcare system. If patients do not receive the recommended care, the costs estimated in our study may not accurately reflect real-world costs. Nevertheless, the use of clinical practice guidelines and expert input is a widely accepted approach to estimating healthcare costs in many countries, including Argentina.

Third, there are several relevant indirect costs of tobacco use that were not included in our model, such as the cost of lost labor productivity due to absenteeism. Research has shown that smokers are more likely to take sick leave and experience greater productivity losses due to smoking-related illnesses than non-smokers (Leigh & Paul Leigh, 1995; Troelstra et al., 2020). Furthermore, as a tobacco-growing country, Argentina may face environmental impacts, among other costs outside the healthcare sector. For instance, there is evidence that suggested that an estimated 200,000 ha of forests/woodlands were removed by tobacco farming each year, with deforestation mainly occurring in the developing world (Geist, 1999). In addition, the tobacco industry contributes to climate change with annual greenhouse gas emissions of 84 megatonnes of carbon dioxide equivalent, reducing climate resilience, wasting resources, and damaging ecosystems necessary for human society (Zafeiridou et al., 2018).

Finally, our model does not consider the distributive or equity impacts of increasing tobacco taxes on the smoking population (for applications of this type of study see James et al., 2019; Love-Koh et al., 2020; Postolovska et al., 2018; Salti et al., 2016; Verguet et al., 2015). Socioeconomic inequalities in smoking prevalence and involuntary exposure to secondhand smoke remain high in Argentina, to the detriment of people with lower education and socioeconomic status (Santero et al., 2019). An extended cost-effectiveness analysis conducted in 13 LMICs (including Brazil, Mexico, Colombia, and Chile) suggests that a 50% increase in tobacco prices strongly favors those in the bottom income group for life years saved, out-of-pocket expenses from tobacco attributable treatment costs averted, and avoidance of catastrophic health expenditures or poverty (Global Tobacco Economics Consortium, 2018). However, some previous studies in Argentina estimate the effect in different directions. On the one hand, Gonzalez-Rozada (2019) found that the wealthiest households are more responsive to the rise in tobacco prices, which led to a 61% greater welfare loss for the poorest ones. On the other hand, Cruces et al. (2020) found that the elasticity of the demand for cigarettes was −0.8 for people in the lowest income decile, while for the highest income decile was −0.44.

It is expected that the results presented here on the disease and economic burden attributable to smoking will empower decision-makers in Argentina to ratify the Framework Convention on Tobacco Control, and advance in the strengthening of cost-effective policies such as the increase in tobacco taxes.

5 | CONCLUSION

Our study shows that incorporating wider effects in the economy (labor productivity loss costs and informal care costs) reveals that the tobacco economic toll is much larger, and also that increasing tobacco tax is a win-win situation for gaining health and saving costs, even after considering the potential effects of illicit trade.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

All data is available in both the manuscript and supplementary material.

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