Technical Document: Cost Recovery and Revenue Estimator – *CoRRE*

Introduction

CoRRE is designed for public health community, health policy advocates, and policy makers to assess the economic costs of smoking in their countries, as well as potential economic gains to be expected from reductions in smoking. The estimator is based on country-level data from UN agencies, other international organizations, government agencies, and proprietary sources. It translates the adverse effects of smoking on nations—and the opportunities to reverse those effects—into monetary values, the universal language of policy makers. *CoRRE* offers the following five sets of estimates:

- (i) national economic cost due to smoking;
- (ii) potential national economic cost recovery from reduction in smoking prevalence;
- (iii) recommended cigarette total tax and price to achieve the desired reduction in smoking prevalence;
- (iv) expected tax revenue gain from raising cigarette tax and price to the recommended levels; and
- (v) cost-of-illness broken down into excess health expenditures and loss of productivity from smoking-related morbidities and premature mortality.

The estimates are provided in equivalent local currency units, U.S. dollars, and International Purchasing Power Parity dollars (Int\$PPP).

This technical note provides a detailed guide for users to understand each step in the estimation presented in the tool including data sources, variable definitions, and references. There are three sections in the technical document. Section 1 elaborates the estimation of smoking-attributable national economic cost. Section 2 discusses the method of calculation of national economic cost recovery from reduction in smoking prevalence induced by an increase in cigarette tax and price. Section 3 explains how the tool estimates the cost-of-illness attributable to smoking.

Section 1. Smoking-attributable national economic cost

Smoking-attributable national economic cost is a measure of the cumulative, aggregate economic loss that accounts for the negative impact of smoking on population health and the economy, including by lowering income trajectories. The country level economic loss has been estimated using the difference between observed gross domestic product (GDP) and potential GDP under the counterfactual scenario of smoke-free state. It represents a more comprehensive and improved method of assessing costs and gains compared to the cost-of-illness approach. The estimator calculates the cumulative loss over a 15-year period from 2010 to 2025 in light of two considerations, drawn from the study conducted by Nargis and colleagues (2022) using U.S. data, and extrapolates those considerations to other countries with adequate data availability.

First, the adverse impacts of smoking on population health and the economy become tangible with some lag between the cause/intervention and the effects. The same is true with the reversal of adverse impacts, as observed in studies of reduced excess risk of smoking-related deaths after cessation of smoking. Nargis et al. (2022) estimated this lag to be five years on average, which implies that the population-level impact of smoking in 2020 will be reflected in the projected income values in 2025. However, the projected income values in 2025 are on a trajectory that has already been lowered by the smoking status of the population in previous years. In the present case of the five-year-lag scenario, the lowering of the income path in 2025 is traced back to the year 2020, which then goes back to 2015, and further on to 2010, with the carryover effect diminishing the further one goes into the past.

Second, the parameters used in this tool—such as the elasticity of per capita GDP (PGDP), with respect to the smoking status of the population, and the coefficient of lagged PGDP—are estimated based on state-level data from the U.S. Even though the scenarios of the tobacco epidemic and its health and economic consequences may vary widely across countries, the parameter estimates are generalizable in view of the method of estimation in Nargis et al. (2022), using relative values of all the variables as opposed to absolute values. We encourage readers who are interested in the details of the derivation of the estimation model to read the technical appendix to this article.

Variables and parameters	Data sources
Ratio of potential to observed PGDP (2015, 2020 and 2025)	1. Smoking prevalence
	estimates for reference
The ratio of potential PGDP under the counterfactual scenario of smoke-free	years were obtained from
state to the observed PGDP under the status quo is calculated using the	World Health
following variable and parameter: (i) percentage of non-smokers in the	Organization.
population, termed non-smoking prevalence (NSP) in a given year, calculated	(2023). Global Health
as the difference of smoking prevalence from 95%; NSP in the smoke-free state	Observatory database.
assumed the value of 95% to allow for 5% non-commercial smoking	Available from
prevalence; and (ii) elasticity of PGDP with respect to NSP (EPN). The formula	https://www.who.int/data
used for this calculation is given by:	<u>/gho</u>
$Ratio of potential to observed PGDP = \frac{\left(1 + EPN \times \frac{0.95 - NSP}{0.95 + NSP}\right)}{\left(1 - EPN \times \frac{0.95 - NSP}{0.95 + NSP}\right)}$	2. The EPN estimate was obtained from Nargis, N., Hussain, A. K. M. G., Asare, S., Xue, Z.,

where: NSP = Non-smoking prevalence, derived as 100% less percentage of smokers in a population; the NSPs for 2010, 2015, and 2020 were used for calculating the ratios of potential to observed PGDP for 2015, 2020, and 2025 respectively. EPN = Elasticity of per capita income with respect to NSP, estimated at 0.143 (Nargis et al., 2022) which indicates that for every 1% increase in the percentage of nonsmokers in the population due to reduction in smoking in a given year <i>t</i> , per capita income is expected to increase by 0.143% in 5 years in <i>t</i> +5.	Majmundar, A., Bandi, P., Islami, F., Yabroff, K. R., & Jemal, A. (2022). Economic loss attributable to cigarette smoking in the USA: An economic modelling study. <i>The Lancet Public</i> <i>Health, 7</i> (10), e834– e843.
Potential PGDP (2015, 2020, and 2025) The potential PGDP represents the level of GDP per person that could be achieved at the desired smoke-free state. This potential PGDP is calculated by adjusting the observed PGDP in 2025 prices of each year with their ratios of potential to observed PGDP: Potential PGDP = Ratio of potential to observed PGDP × Observed PGDP	Observed PGDP (2015, 2020) and projected PGDP (2025) were retrieved from International Monetary Fund (IMF) (April 2024). <i>World Economic Outlook Database</i> . Washington, D.C., United States of America: International Monetary Fund (IMF). Available from https://www.imf.org/exter nal/datamapper/datasets /WEO
PGDP gap (2015, 2020, and 2025) The PGDPs for 2020 and 2015 are converted to 2025 constant prices by	1. PGDP (2015, 2020, and 2025) and GDP deflator (2015 and 2020) retrieved
PGDP gap (2015, 2020, and 2025) The PGDPs for 2020 and 2015 are converted to 2025 constant prices by multiplying with the ratio of the GDP deflator for 2025 to the GDP deflators for 2020 and 2015, respectively:	1. PGDP (2015, 2020, and 2025) and GDP deflator (2015 and 2020) retrieved from International Monetary Fund (IMF). <i>World Economic Outlook</i>
PGDP gap (2015, 2020, and 2025)The PGDPs for 2020 and 2015 are converted to 2025 constant prices by multiplying with the ratio of the GDP deflator for 2025 to the GDP deflators for 2020 and 2015, respectively:PGDP in reference year in 2025 constant prices = PGDP in reference year GDP deflator (2025)×	1. PGDP (2015, 2020, and 2025) and GDP deflator (2015 and 2020) retrieved from International Monetary Fund (IMF). <i>World Economic Outlook</i> <i>Database</i> . Washington, D.C., United States of
PGDP gap (2015, 2020, and 2025)The PGDPs for 2020 and 2015 are converted to 2025 constant prices by multiplying with the ratio of the GDP deflator for 2025 to the GDP deflators for 2020 and 2015, respectively:PGDP in reference year in 2025 constant prices = PGDP in reference year GDP deflator (2025) $\times \frac{GDP \ deflator \ (reference \ year)}{GDP \ deflator \ (reference \ year)}$	1. PGDP (2015, 2020, and 2025) and GDP deflator (2015 and 2020) retrieved from International Monetary Fund (IMF). <i>World Economic Outlook</i> <i>Database</i> . Washington, D.C., United States of America: International Monetary Fund (IMF).
PGDP gap (2015, 2020, and 2025)The PGDPs for 2020 and 2015 are converted to 2025 constant prices by multiplying with the ratio of the GDP deflator for 2025 to the GDP deflators for 2020 and 2015, respectively:PGDP in reference year in 2025 constant prices = PGDP in reference year GDP deflator (2025)× $\frac{GDP \ deflator \ (2025)}{GDP \ deflator \ (reference \ year)}$ The PGDP gap for each reference year is then given by:PGDP gap in 2025 constant prices = Potential PGDP in 2025 constant prices = Potential PGDP in 2025 constant prices = Observed PGDP in 2025 constant prices	1. PGDP (2015, 2020, and 2025) and GDP deflator (2015 and 2020) retrieved from International Monetary Fund (IMF). <i>World Economic Outlook</i> <i>Database</i> . Washington, D.C., United States of America: International Monetary Fund (IMF). https://www.imf.org/exter nal/datamapper/datasets /WEO
PGDP gap (2015, 2020, and 2025)The PGDPs for 2020 and 2015 are converted to 2025 constant prices by multiplying with the ratio of the GDP deflator for 2025 to the GDP deflators for 2020 and 2015, respectively:PGDP in reference year in 2025 constant prices = PGDP in reference year GDP deflator (2025) $\times \frac{GDP \ deflator \ (2025)}{GDP \ deflator \ (reference \ year)}$ The PGDP gap for each reference year is then given by:PGDP gap in 2025 constant prices = Potential PGDP in 2025 constant prices -Observed PGDP in 2025 constant pricesPGDP gaps for 2015 and 2020 (in 2025 constant prices) are then multiplied with a coefficient of lagged income, estimated at 0.531 (Nargis et al., 2022):	1. PGDP (2015, 2020, and 2025) and GDP deflator (2015 and 2020) retrieved from International Monetary Fund (IMF). <i>World Economic Outlook Database</i> . Washington, D.C., United States of America: International Monetary Fund (IMF). https://www.imf.org/exter nal/datamapper/datasets /WEO 2. The estimate of the coefficient of lagged income was obtained from Nargis N. Hussain

National economic costThe country-level totalSmoking-attributable national economic cost in 2025 constant prices = [PGDPobtained from U.S.gap (2025) + PGDP gap (2020) + PGDP gap (2015)] X Population (2025)Census Bureau.International Database(IDB). Available fromhttps://www.census.gov/data-data-tools/demo/idb/#/pop?COUNTRY_YEAR=2022&COUNTRY_YEAR=2022&COUNTRY_YEAR=2022&COUNTRY_YEAR=2022&CARS=2020&popPages=BYAGE&ageGroup=BR		study. The Lancet Public Health, 7(10), e834– e843.
	National economic cost Smoking-attributable national economic cost in 2025 constant prices = [PGDP gap (2025) + PGDP gap (2020) + PGDP gap (2015)] X Population (2025)	The country-level total population data were obtained from U.S. Census Bureau. International Database (IDB). Available from https://www.census.gov/ data- tools/demo/idb/#/pop?C OUNTRY_YEAR=2022&C OUNTRY_YEAR=2022&C OUNTRY_YR_ANIM=2022 &menu=popViz&POP_YE ARS=2020&popPages=BY AGE&ageGroup=BR

Note: The PGDP gap (2025) is linked to the smoking status of the population in 2020, while the PGDP gap (2020) and PGDP gap (2015) are linked to the income-propagation mechanism in the previous decade. The estimates from further back in the past become negligible and are omitted for simplification of the estimation procedure. The current estimate of the cumulative economic loss can be taken as a close approximation to the true estimate.

Section 2. National economic cost recovery from reduction in smoking

This section provides users with the option to select a desired absolute reduction in smoking prevalence ranging from -1% point to -5% points. Based on the selected percentage-point reduction, the tool will estimate the expected economic gain from the reduction in smoking and the recommended cigarette price and tax per pack needed to achieve that reduction.

2.1. Expected national economic cost recovery from desired smoking reduction

The expected national economic cost recovery is estimated as a gain in projected GDP in five years from the year of reduction in smoking prevalence to the desired level.

Variables and Parameters	Data Sources
Ratio of potential to projected PGDP (2028)	1. Smoking prevalence (2022) data were
The ratio of potential PGDP under the counterfactual scenario of a smoke-free	retrieved from World
state to the projected PGDP under the status quo is calculated using non-	Health Organization.
smoking prevalence (NSP) (100% less smoking prevalence) in the base year,	(2023). Global Health
non-smoking prevalence in the smoke-free state (assumed at 95% to allow for	Observatory database.
5% non-commercial smoking prevalence), and elasticity of per capita income	https://www.who.int/data
with respect to NSP (EPN).	<u>/gho</u>
The base year for the desired reduction in smoking prevalence and	2. The EPN estimate was
corresponding increase in non-smoking prevalence is 2023, and the expected	obtained from Nargis, N.,
economic gain is projected for 2028 (i.e., five years after the intervention).	Hussain, A. K. M. G.,
	Asare, S., Xue, Z.,
The formula used for this calculation is as follows:	Majmundar, A., Bandi, P.,
Ratio of potential to projected PGDP = $\frac{\left(1 + EPN \times \frac{0.95 - NSP}{0.95 + NSP}\right)}{\left(1 - EPN \times \frac{0.95 - NSP}{0.95 + NSP}\right)}$	Islami, F., Yabroff, K. R., & Jemal, A. (2022). Economic loss attributable to cigarette smoking in the USA: An
where:	economic modelling
NSP = non-smoking prevalence, derived as 100% less percentage of smokers in a country's population; the NSPs for 2010, 2015, and 2020 were used for calculating the ratios of potential to projected PGDP for 2015, 2020, and 2025, respectively; and	Health, 7(10), e834– e843.
EPN = elasticity of per capita income with respect to NSP, estimated at 0.143 (Nargis et al., 2022), which indicates that for every 1% increase in the percentage of non-smokers in the population due to reduction in smoking in a given year t , PGDP is expected to increase by 0.143% in five years in t +5.	
Potential PGDP (2028)	Projected PGDP (2028) in
The notential DCDD (2020) in 2020 constant prices under the second is of the	2028 prices were
desired reduction in smoking provalence is calculated by adjusting the	International Manatany
	Fund (IMF) (April 2024).

projected PGDP (2028) in 2028 constant prices under the status quo with the ratio of potential to projected PGDP (2028):	World Economic Outlook Database. Washington, D.C., United States of
Potential PGDP = Ratio of potential to projected PGDP × Projected PGDP	America: International Monetary Fund (IMF). https://www.imf.org/exter nal/datamapper/datasets /WEO
Expected PGDP gain (2028)	
Expected PGDP gain (2028) is given by the difference between potential PGDP (2028) and projected PGDP (2028) in 2028 constant prices:	
PGDP gain = Potential PGDP - Projected PGDP	
National economic cost recovery	The country-level projected total
National economic cost recovery	population data were
= Expected PGDP gain (2028) \times Projected population (2028)	obtained from U.S.
	Census Bureau.
	International Database
	(IDB). Available from
	https://www.census.gov/
	tools/demo/idb/#/pop?C
	OUNTRY_YEAR=2022&C
	OUNTRY_YR_ANIM=2022
	&menu=popViz&POP_YE
	ARS=2020&popPages=BY
	AGE&ageGroup=BR

2.2. Recommended cigarette price per pack

The tool calculates the recommended price of a 20-cigarette pack to attain the desired smoking prevalence. This is based on the desired percentage decrease in smoking prevalence and the price elasticity of smoking prevalence.

Variables and parameters	Data sources
Desired percentage decrease in smoking prevalence The desired percentage decrease in smoking prevalence is a measure used to quantify the reduction in smoking rates between the baseline and the desired level. The formula used for this calculation is as follows: Desired percentage decrease in smoking prevalence = (Baseline smoking prevalence – Desired smoking prevalence) Baseline smoking prevalence	Baseline cigarette smoking prevalence (2022) data were retrieved from World Health Organization. (2023). <i>Global Health</i> <i>Observatory database</i> . https://www.who.int/data /gho
Required percentage increase in cigarette priceThe required percentage increase in cigarette price is determined based on the desired percentage decrease in smoking prevalence. This calculation leverages the concept of price elasticity of smoking prevalence, which measures the responsiveness of smoking prevalence to changes in cigarette price.The formula used for this calculation is as follows:Required percentage increase in cigarette price Desired percentage decrease in smoking prevalencePrice elasticity of smoking prevalencePrice elasticity of smoking prevalenceObserved percentage increase in cigarette price Desired percentage decrease in smoking prevalencePrice elasticity of smoking prevalenceNote: The value of the price elasticity of smoking prevalence used in this tool is -0.20, based on the midpoint of the range of estimates in previous studies (U.S. National Cancer Institute and World Health Organization, 2016).	The price elasticity of smoking prevalence estimates was obtained from U.S. National Cancer Institute and World Health Organization. (2016). <i>The Economics of Tobacco</i> <i>and Tobacco Control</i> . National Cancer Institute Tobacco Control Monograph 21. NIH Publication No. 16-CA- 8029A. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva, CH: World Health Organization.
Recommended cigarette price per pack Recommended cigarette price per pack = Baseline cigarette price per pack × (1 + Required percentage increase in cigarette price)	Baseline cigarette price per pack (2022) data were retrieved from World Health Organization. (2023). WHO Report on the Global Tobacco Epidemic. 2023.

2.3. Recommended total tax per pack of cigarettes

Recommended total tax per pack of cigarettes is the recommended tax per 20-cigarette pack to attain the recommended cigarette price level that would lead to the desired reduction in smoking prevalence.

Variables and parameters	Data sources
Baseline total tax per pack of cigarettes (2022)	Baseline cigarette price
	per pack of 20 pieces of
The baseline total tax per pack of cigarettes is determined by using the baseline	the most-sold cigarette
cigarette price per pack and the total cigarette tax share:	brand (2022) and total
	cigarette tax share
Baseline total tax per pack of cigarettes	(excise, sales, and other
= Baseline cigarette price per pack × Total cigarette tax share	taxes combined) for the
	most-sold brand (2022)
	were retrieved from
	World Health
	Organization.
	(2023). WHO Report on
	the Global Tobacco
	Epidemic, 2023.
Recommended increase in total tax per pack of cigarettes	Baseline cigarette price
	per pack (2022) data
The desired increase in total tax per pack of cigarettes is determined by the	were retrieved from
difference between the recommended cigarette price per pack and the	World Health
baseline cigarette price per pack, under the assumption that the tax increase is	Organization.
fully passed on to retail price increase:	(2023). WHO Report on
	the Global Tobacco
Recommended increase in total tax per pack of cigarettes	Epidemic, 2023.
= Recommended cigarette price per pack	
-Baseline cigarette price per pack	
The details of the coloulation of the recommended signature price per peak are	
available in Section 2.2 above	
Becommended total tax per pack of cigarettes	
Recommended total tax ner nack of cigarettes	
= Baseline total tax per pack of cigarettes	
+Recommended increase in total tax per pack of cigarettes	
······································	

2.4. Expected cigarette tax revenue

Expected cigarette tax revenue is the revenue expected to be generated through cigarette sales at the desired smoking prevalence. It is calculated based on the recommended cigarette tax and projected cigarette sales and smoking intensity at the desired smoking prevalence. These are annual estimates

referring to a one-year window after the implementation of the recommended increases in cigarette tax and price.

Variables and parameters	Data sources
Baseline number of adult smokers (2020)	1. Number of cigarettes
	sold per country in 2022
The baseline number of adult smokers is estimated by multiplying the baseline	were retrieved from
smoking prevalence by total population in 2020.	Euromonitor
	International. (2024).
Baseline smoking intensity (2020)	Market sizes: Cigarettes
	[Dataset]. Passport.
Smoking intensity is a measure that quantifies the average number of cigarettes	https://www.portal.euro
consumed by each smoker over a one-year period. The baseline smoking	monitor.com/
intensity is calculated by dividing the annual total number of cigarettes sold by	
the total number of adult smokers:	2. Smoking prevalence
	data were retrieved from
Baseline smoking intensity	World Health
Baseline total cigarette sales (million pieces)	Organization. (2023).
Baseline number of adult smokers	Global
	Health Observatory data
	repository.
	https://www.who.int/data
	<u>/gho</u>
	3. Total population data
	were retrieved from U.S.
	Census Bureau.
	International Database
	(IDB). Available from
	https://www.census.gov/dat
	<u>a-</u>
	tools/demo/idb/#/pop?COU
	NIRY_YEAR=2022&COUNIR
	<u>Y_YR_ANIM=2022&menu=p</u>
	opPages=BYAGE&ageGroup
	=BR
Expected percentage reduction in smoking intensity	Price elasticity of
	smoking intensity
The expected percentage reduction in smoking intensity quantifies the	estimate was obtained
expected decrease in the average number of cigarettes consumed per smoker	from U.S. National
due to an increase in cigarette prices. This calculation leverages the concept of	Cancer Institute and
price elasticity of smoking intensity, which measures the responsiveness of	World Health
smoking intensity to changes in cigarette prices.	Organization. (2016). The
	Economics of Tobacco
The formula used for this calculation is as follows:	and Tobacco Control.
	National Cancer Institute
Expected percentage reduction in smoking intensity	Tobacco Control
= Price elasticity of smoking intensity	Monograph 21. NIH
× Recommended percentage increase in cigarette price	Publication No. 16-CA-
	8029A. Bethesda, MD:

The value of the price elasticity of smoking intensity used in the tool is -0.20, based on the midpoint of the range of estimates in previous studies (U.S. National Cancer Institute and World Health Organization, 2016). The details of the calculation of the recommended percentage increase in cigarette price are available in Section 2.2 above.	U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute; and Geneva, CH: World Health Organization.
Expected reduced smoking intensityThe expected reduced smoking intensity quantifies the average number of cigarettes consumed per smoker after increasing cigarette tax and price to the recommended levels. It is calculated by applying the expected percentage reduction in smoking intensity to the baseline smoking intensity.The formula used for this calculation is as follows:Expected reduced smoking intensity = Baseline smoking intensity × (1 + Expected percentage reduction in smoking intensity)	
Expected reduced number of smokers The expected reduced number of smokers is determined by applying the desired smoking prevalence to the adult population in 2023. The formula used for this calculation is as follows: Expected reduced number of smokers = Desired smoking prevalence × Adult population in 2023	Adult population (15+) data for 2023 were retrieved from U.S. Census Bureau. International Database (IDB). Available from https://www.census.gov/ data- tools/demo/idb/#/pop?C OUNTRY_YEAR=2022&C OUNTRY_YEAR=2022&C OUNTRY_YEAR=2022&C OUNTRY_YR_ANIM=2022 &menu=popViz&POP_YE ARS=2020&popPages=BY AGE&ageGroup=BR
Expected reduced annual total cigarette sales (million pieces)The expected reduced annual total cigarette sales are determined by multiplying the expected reduced smoking intensity by the expected reduced number of adult smokers. This calculation helps estimate the expected reduced total number of cigarettes that will be sold at the desired smoking prevalence and expected smoking intensity at the recommended cigarette price and tax.The formula used for this calculation is as follows:Expected reduced annual total cigarette sale = Expected reduced smoking intensity × Expected reduced number of smokers	

Expected cigarette tax revenue	
$Expected annual cigarette tax revenue= \left(\frac{Expected reduced annual cigarette sales in million pieces}{20}\right)$ × Recommended cigarette tax per pack	

Note: The expected cigarette tax revenue is determined by multiplying the expected reduced cigarette sales (converted to 20-cigarette packs in millions) by the recommended cigarette tax per pack. This calculation helps estimate the expected annual total tax revenue generated from cigarette sales after the implementation of cigarette tax and price increases.

2.5. Expected cigarette tax revenue gain

Expected cigarette tax revenue gain illustrates how much additional revenue can be generated through recommended increases in cigarette price and tax to attain the desired reduction in smoking prevalence.

Variables and parameters	Data aguraga
	Data sources
Baseline cigarette tax revenue (2023)	Data on the number of
	cigarettes sold in
The baseline cigarette tax revenue is determined by multiplying the baseline	individual countries in
total cigarette sales (converted to 20-cigarette packs in millions) by the	2023 were obtained from
baseline cigarette tax per pack. This calculation helps to estimate the total tax	Euromonitor
revenue generated from cigarette sales before applying recommended	International. (2024).
cigarette price and tax. The formula used for this calculation is as follows:	Market sizes: Cigarettes
	[Dataset]. Passport.
Baseline cigarette tax revenue	https://www.portal.euro
Baseline total cigarette sales in million pieces	monitor.com/
$=\left(\begin{array}{c} 20 \end{array} \right)$	
× Baseline cigarette tax per pack	
The details of the calculation of baseline cigarette tax per pack are provided in	
Section 2.3 above.	
Expected cigarette tax revenue gain	
Expected tax revenue gain	
= Frnected cigarette tax revenue - Raseline cigarette tax revenue	

Section 3. Cost-of-illness attributable to smoking

3.1. Smoking-attributable direct cost-of-illness: Health expenditure

The smoking-attributable direct cost or health expenditure is the aggregate health expenditure to treat illnesses caused by smoking and exposure to second-hand smoke. This calculation provides an estimate of the smoking-related financial burden on a nation's public and private health care systems funded by taxpayers' money, donors' aid, and/or out-of-pocket expenses of the patients and their families.

Variables and parameters	Data sources
Smoking- and second-hand-smoke-exposure–attributable fraction (SAF) of total health expenditure (%) (2021)	1. The age-specific smoking-attributable death rate (SAD) for 25
The SAF estimates the percentage of health care costs that can be attributed to	years and older age group
smoking-related illnesses and deaths. The country-specific SAF is drawn from	for both smoking and
the studies that estimated SAF for individual countries. As this type of study is	second-hand smoke
limited to only a few countries, country-specific SAF for the remaining	exposure were obtained
countries is calculated with a generalized formula as follows:	from the Global Burden
CAE a factor la calda com en ditumo - Concelhing a staniko de bla de sta mate (CAD) nom	of Disease Collaborative
SAF of total health expenditure = Smoking-attributable death rate (SAD) per	Network. (2022). Global
100,000 population aged 25 years and above × 0.024643	2021 (CRD 2021) results
The coefficient 0.024643 relates SAD to SAF of total health expenditure, as	Seattle United States:
estimated in Goodchild et al. (2018), based on prior country-specific SAF	Institute for Health
estimates.	Metrics and Evaluation
	(IHME).
	https://vizhub.healthdata
	.org/gbd-results/
Total health expenditure (2021)	2.Goodchild, M., Nargis, N., & Tursan d'Espaignet, E. (2018). Global economic cost of smoking-attributable diseases. <i>Tobacco</i> <i>Control, 27</i> (1), 58-64.
	expenditure (2021) data
The total health expenditure, which includes both public and private spending,	were retrieved from the
is calculated by multiplying the per capita health expenditure in 2021 by the	WHO Global Health
total population. This calculation provides an estimate of the overall financial	Observatory Database.
resources dedicated to health care in a country or region.	
	2. Total population 2021
	data were retrieved from
	U.S. Census Bureau.
	International Database.
	Available from

	https://www.census.go
	v/data-
	tools/demo/idb/#/pop?
	COUNTRY_YEAR=2022
	&COUNTRY_YR_ANIM=
	2022&menu=popViz&P
	OP_YEARS=2020&pop
	Pages=BYAGE&ageGro
	up=BR
Smoking-attributable direct cost or health expenditure (2021)	
Smoking-attributable direct cost = SAF \times Total health expenditure	

3.2. Smoking-attributable indirect cost-of-illness: Productivity loss

The smoking-attributable cost due to productivity loss represents the economic burden caused indirectly by reduced productivity related to illnesses from smoking and second-hand smoke exposure. This includes both the morbidity cost (productivity losses due to illness and disability) and the mortality cost (productivity losses due to premature deaths). The total productivity loss is calculated by summing up these costs.

Variables and parameters	Data sources
Morbidity cost (2021)	1. YLD 2021 data were
	obtained from Global
The indirect cost due to smoking-related morbidity is calculated by considering	Burden of Disease
the years lived with disability (YLD) due to illnesses attributable to smoking and	Collaborative Network.
exposure to secondhand smoke, PGDP (2021), and the employment rate, which	(2022). Global Burden of
reflects the proportion of the working-age population engaged in employment	Disease Study 2021 (GBD
in 2021.	2021) Results. Seattle,
	United States: Institute
The formula used for this calculation is as follows:	for Health Metrics and
	Evaluation (IHME).
Smoking-attributable morbidity cost = Smoking-attributable YLD \times PGDP \times	https://vizhub.healthdata
Employment rate	.org/gbd-results/
	2. DODD (2021) and
	2. PGDP (2021) and
	dete were retrieved from
	International Monotary
	Fund (IME) World
	Fconomic Outlook
	Database Washington
	D.C., United States of
	America: International
	Monetary Fund (IMF).
	https://www.imf.org/exter
	nal/datamapper/datasets
	<u>/WEO</u>

Mortality cost (2021)	1. YLL 2021 data were obtained from Global
The indirect cost due to smoking-related mortality is calculated by considering	Burden of Disease
the years of life lost (YLL) attributable to premature mortality from illnesses	Collaborative Network.
caused by smoking and exposure to secondhand smoke, PGDP (2021), and the	(2022). Global Burden of
employment rate, which reflects the proportion of the working-age population	Disease Study 2021 (GBD
engaged in employment in 2021.	2021) Results. Seattle,
The formule used for this calculation is as follows:	for Hoolth Matrice and
	Evaluation (IHME) 2022
Smoking-attributable mortality cost = Smoking-attributable YLL \times PGDP \times	https://vizhub.healthdata
Employment rate	.org/gbd-results/
	00
This estimate is simplified from the human capital approach in the cost-of-	2. PGDP 2021 and
illness studies that estimates discounted future productivity losses from the	employment rate 2021
year after death to the expected life years of individuals stratified by age and	data were retrieved from
sex at death. The estimates from the two approaches would be the same under	Fund (IME) World
for future income are equal.	Economic Outlook
	Database. Washington,
	D.C., United States of
	America: International
	Monetary Fund (IMF).
	https://www.imf.org/exter
	nal/datamapper/datasets
Smoking-attributable indirect cost or productivity loss (2021)	
Smoking-attributable indirect cost = Smoking-attributable morbidity cost +	
Smoking-attributable mortality cost	

3.3. Annual smoking-attributable cost-of-illness

The annual smoking-attributable cost-of-illness represents the total economic burden of smokingrelated diseases on society. This includes both the direct health care costs and the indirect costs associated with lost productivity due to smoking-related illnesses and premature deaths from those illnesses. The total cost of illness is calculated by summing these two components.

 $\label{eq:stars} Annual \, smoking-attributable \, cost-of-illness = Smoking-attributable \, direct \, cost + Smoking-attributable \, indirect \, cost$