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The health, poverty and financial consequences of a cigarette price increase among 0.5 billion male smokers in 13 low and middle-income countries

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Keywords: tobacco, poverty, taxation, SDGs, NCD, financial protection

Objective: Higher tobacco excise taxes are required to achieve the Sustainable Development Goal (SDG) targets to reduce non-communicable disease (NCD). We examined the relevance of tobacco taxes to the SDG targets on extreme income poverty and financial protection against illness.

Design: Extended cost-effectiveness analysis of the impact of one-time 50% cigarette price increase on health, poverty and financial protection

Setting: Thirteen low and middle-income countries

Participants: 500 million male smokers

Main outcome measures: Life-years gained, treatment costs averted, catastrophic healthcare expenditures and poverty averted, and additional tax revenue by income quintile

Results: A 50% increase in cigarette prices led to about 450 million years of life gained across the 13 countries, half of which were in China. Across all countries, the bottom income quintile gained 6.7 times more life-years than the top quintile (155 vs. 23 million). Of the USD $157 billion in averted treatment costs, the bottom quintile averted 4.6 times more costs than the top quintile (46 vs. 10 million). About 15.5 million men avoided catastrophic health expenditures in a subset of seven countries without universal health coverage. As result 8.8 million men, half of whom were in the bottom quintile, avoided falling below the World Bank's international poverty line. These 8.8 million constitute 2.4% of the combined male and female poor in these countries. By contrast, of the $122 billion additional tax revenue collected, the top quintile paid twice as much as the bottom quintile. Overall, the bottom quintile would pay 10% of the additional taxes and get 31% of the life-years saved, and 29% each of the averted disease costs or averted catastrophic health expenditures.

Conclusions: Higher tobacco taxes support SDG targets on NCDs, poverty and financial protection against illness. These estimates are conservative, partly as they do not take account of loss of family income.

INTRODUCTION

On current smoking patterns where large numbers of young adults start smoking but few quit, smoking will kill about 1 billion people this century.[1] Most of these deaths will be in low and middle-income countries (LMICs). At the global level, tobacco control mostly draws on the Framework Convention on Tobacco Control, and increasingly on the United Nations (UN) 2030 Sustainable Development Goals (SDG).[2] The SDGs include goals to eradicate extreme income poverty, reduce by one third the age-standardized death rates from non-communicable diseases (NCD) and achieve universal health coverage (UHC) so as to provide financial risk protection against the impoverishment that arises from illness.[3] These three goals are interrelated, particularly as an estimated 100 million (M) individuals fall into poverty every year due to out of pocket (OOP) health expenditures[4] with much of these expenditures arising from treatment of NCDs. Tobacco use is a leading cause of NCDs (as well as of tuberculosis). In most countries, smoking prevalence and smoking-attributable diseases are highest among those with low income.[5] Smoking accounts for much of the difference in risk of death among men of different social status.[6]

Effective tobacco control could avoid hundreds of millions of premature deaths this century. It is already established that progress towards the NCD goals will depend greatly on progress in substantially raising the low tobacco cessation rates in most LMICs.[1,7,8] Tobacco taxation is the single most-effective intervention to increase cessation rates by current smokers and to decrease initiation by youth, with greatest effects among youth and persons with low income.[9,10] Higher excise taxes increase government revenue, which can be used for pro-poor health and other programs. However, high excise taxes are underused in nearly all LMICs.[2,4,11]

The relationship between higher tobacco taxes on poverty levels, impoverishment due to medical treatment costs and financial burden of higher taxes in poor and non-poor groups has been published only for China[12] and Lebanon.[13] Broad representative assessments across LMICs have not yet been done. Here, we quantify the impact of a practicable 50% cigarette price increase on health, poverty and financial outcomes in 13 LMICs with diverse socio-economic demographic characteristics, tobacco use and effective UHC coverage.

METHODS

Extended cost effectiveness analysis (ECEA) is a policy tool to assess health gains, financial protection and tax gains for governments across income groups.[14] It was developed by the Disease Control Priorities Project building on an earlier poverty and tobacco taxation analysis by the Asian Development Bank.[12,15] We calculated the number of baseline smokers in 13 LMICs and estimated the impact of a one-time 50% increase in cigarette prices on life-years gained, treatment costs averted, number of individuals avoiding catastrophic health expenditures and poverty, and share of additional tax revenues. Appendix (p 3-4) provides the details of the data sources and procedures.

Study population

We focused on 2 billion adult men in 13 LMICs (Table 1). Using the World Bank income definitions,[3] six countries are classified as lower middle-income (India, Indonesia, Bangladesh, the Philippines, Vietnam and Armenia), and seven are classified as upper middle-income (China, Mexico, Turkey, Brazil, Colombia, Thailand and Chile). We focused on male smokers, as they comprised about 90% of all smokers in the 13 LMICs.[5,16] Results were similar if we included Chile, Colombia and Mexico, where the proportion of female smokers to total smokers is relatively high (46%, 29% and 29%, respectively). For each country, we divided UN 2015 population estimates[17] for males (in 5-year age groups) into five income quintiles. To each quintile, we applied the age-specific current smoking prevalence among adults (15 years or older) from the most recent rounds of the Global Adult Tobacco Survey[16] or from nationally representative surveys using either asset index or education as a proxy for income where asset index was absent.

Table 1: Key study indicators

World Bank classification of countries	Lower middle Income						Upper middle Income						
Indicator	**IND**	**IDN**	**BGD**	**PHL**	**VNM**	**ARM**	**CHN**	**MEX**	**TUR**	**BRA**	**COL**	**THA**	**CHL[§]**
Population (2015; in millions)	1311	258	161	101	93	2.9	1376	127	79	208	48	68	18
Male population (2015; in millions)	679	130	81	51	46	1	709	63	39	102	24	34	9
No. of poor at $1.90 a day (2011; USD PPP; in millions)	268	21	28	13	3	0	25	4	0.3	8	3	0.03	1
Total health expenditure as % of GDP	5	3	3	5	7	4	6	6	5	8	7	4	8
Public expenditure on health as % of GDP	1	1	1	2	4	2	3	3	4	4	5	3	4
Out of pocket expenditure as % of total health expenditure	62	47	67	54	37	54	32	44	18	25	15	12	32
% of population covered with public financing scheme *	14	55	26	88	60	28	97	89[‡]	85	100	91	98	90
Proportion of costs paid by public financing	40	70	36	41	60	100	26	82[‡]	98	81	100	99	90
Male smoking prevalence (15-74 years old) †	10	58	28	39	46	53	52	21	39	23	18	45	48
Average sticks/day per current smoker	4	12	8	9	11	24	14	10	18	11	8	9	13
No. of male cigarette smokers (in millions)	46	53	25	16	15	1	291	10	12	16	3	12	3
Price per pack of cigarettes (2016; in USD PPP)	9.2	5.2	3.4	2.3	2.6	3.1	2.8	5.7	10.3	3.2	2.2	7.1	5.8
Excise tax increase needed for a 50% increase in price (2016; in USD PPP)	5	3	2	1	1	2	1	3	5	2	1	4	3
Share of tax to retail price (%)	43	57	77	63	36	35	51	67	82	68	50	74	65
% increase in tax rate from baseline tax rate	232	174	130	160	280	286	197	149	122	147	202	136	154
Price per pack after 50% price increase	14	8	5	3	4	5	4	9	15	5	3	11	9

Notes: Country Abbreviation: India: IND; Indonesia: IDN; Bangladesh: BGD; Philippines: PHL; Vietnam: VNM; Armenia: ARM; China: CHN; Mexico: MEX; Turkey: TUR; Brazil: BRA; Colombia: COL; Thailand: THA; Chile: CHL. *We only considered public financing schemes, but included mandatory private schemes (e.g. ISAPREs for Chile). For other countries, we excluded private insurance as they cover only a small portion of the population, and they are not mandatory. † Estimates only include cigarettes but exclude bidis mostly used in India and Bangladesh. ‡ In Mexico, though the UHC coverage rate as well as financial protection provided by the Seguro Popular for Q1 and Q2 is 100%, the policy only covers COPD among tobacco-related conditions. While for Q3-Q5 the coverage rate is 82% and financial protection is 70%, all diseases are covered by health insurance. §The World Bank classifies Chile as a high-income country, but for these analyses we considered Chile as middle-income, given that the average household income for Chileans is more or less similar to that of other upper middle-income countries like Brazil and

Price effects on smoking

Studies on cigarette price elasticity (defined by the percentage reduction in cigarette consumption resulting from a specific increase in price) have mostly been done in high-income countries, but are increasingly available for LMICs.[9,10] Several comprehensive reviews find a price elasticity of -0.4 across most countries,[18] so that a 50% price increase will reduce smoking by about 20%. Of the reduction, about half (10%) is attributable to quitting by current smokers and half to fewer cigarettes smoked. Most (but not all) of the published literature demonstrates greater price responsiveness, in the range of twice as much, in the young and among the poor.[9,18] We applied a relative weighted price elasticity matrix by age and income quintile to all estimates. Hence, price elasticity in younger smokers (15-24 years) in the bottom quintile was -1.27 whereas that in smokers aged 25+ years in the top quintile was -0.24. We applied the higher price elasticity to future smokers <15 years that have not yet started to smoke. Sensitivity analyses excluded China and India, included the three countries (Chile, Colombia and Mexico) with notable female smoking, and tested price increases by 25% and 100% with these same elasticities. We also applied country-specific price elasticities from published literature.

Price effects on mortality reduction, disease costs, income poverty and taxes paid

We conservatively assumed that half of current and future smokers would die of smoking-related causes, given that cessation rates in most LMICs are far lower than those in high-income countries.[11,19] We applied age-specific benefits of cessation from epidemiological studies in the US and the UK. We proportioned the reductions in mortality across four main causes of smoking-related mortality: chronic obstructive pulmonary disease, stroke, heart disease and cancers (ignoring tuberculosis). We used Global Burden of Disease estimates,[20] verified with local epidemiological studies if available (appendix p 3-4) to quantify tobacco-attributable diseases.

To calculate averted healthcare cost and numbers of individuals avoiding catastrophic healthcare expenditures and poverty, we derived the annual expected treatment cost, adjusted to 2015 prices for the above four diseases from peer-reviewed studies or country reports. For comparability across countries, we adjusted all cost estimates for inflation and used the World Bank's 2015 Purchasing Power Parity (PPP) conversion factors.[21,22] We

applied the World Health Organization (WHO) definition of catastrophic health expenditures meaning when OOP treatment costs exceed 10% of an individual's yearly income. We defined individuals falling into poverty when OOP costs (total cost minus that borne by public financing schemes) reduce daily income below the World Bank's poverty definition of USD 1.90/day in PPP.[3] To estimate taxes gained from additional tax revenues across income groups, we used WHO estimates of country-specific data on price per pack of cigarettes (USD PPP), tobacco tax incidence as percentage of final price and average cigarette sticks consumed by smokers per day across income quintiles.[2] All analyses were done in STATA version 13.0. The STATA code is available freely upon written request to the authors.

RESULTS

We studied 490M male smokers in the 13 countries (Table 2); 291M were in China and 199M in the other 12 countries. Smoking prevalence varied considerably across countries, as did the daily cigarettes consumed. Some countries, such as Indonesia, showed sharply lower smoking prevalence in top income quintiles, whereas Bangladesh and India showed similar cigarette smoking prevalence across quintiles. The proportion of health expenditure borne by public health systems and the co-payment requirements for the four diseases also varied. The price (all in USD PPP) per pack of the most commonly smoked cigarettes varied from $2.20 in Colombia to $10.30 in Turkey. The absolute increase in the median excise tax needed to achieve a 50% price increase was $1.70, ranging from $1.10 in Colombia and the Philippines to $5.10 in Turkey.

The number of male smokers prior to the price increase was greater (106M, or 20%, range 14-27%) in the bottom quintile than in the top (82M or 17%, range 9-24%) - a ratio of 1.3:1 (Table 2). A 50% price increase resulted in about 67M men quitting smoking, with the bottom quintile having 7.7 times as many quitters as the top (23M vs. 3M). Cessation led to about 449M years of life gained, about half of which were in China (241M). Across the 13 countries, the bottom quintile gained 6.7 times more life-years than the top (155M vs. 23M). The disease costs (all in USD PPP) averted from OOP expenditures to treat the four tobacco-attributable diseases were about $157 billion.

Table 2: Impact of a 50% cigarette price increase on health and financing outcomes

Quintiles	Lower middle Income						Upper middle Income							Min- Max (%)	Median
	IND	IDN	BGD	PHL	VNM	ARM	CHN	MEX	TUR	BRA	COL	THA	CHL		
Number of male smokers aged 15+ years prior to 50% price increase (in millions)															
Q1 (bottom 20%)	7.3	13.6	3	3	3.7	0.1	63.9	1.6	1.8	4.2	0.6	2.8	0.5	14-27	19
Q2	10.2	12	3.3	2.8	3.3	0.1	68.5	2	2.4	3.6	0.6	3.3	0.6	18-27	22
Q3	9.5	9.8	3.1	2.6	2.6	0.1	63.1	1.8	2.9	2.9	0.7	2.7	0.7	18-25	21
Q4	9.1	9.7	3.8	2.5	2.6	0.1	47.7	2	2.6	3.1	0.6	2.3	0.7	16-23	19
Q5 (top 20%)	10	7.7	3	2.2	2.4	0.1	47.7	2.1	1.9	2	0.6	1	0.8	8-24	17
Total=490	**46.1**	**52.9**	**16.2**	**13.2**	**14.6**	**0.6**	**290.9**	**9.5**	**11.6**	**15.9**	**3.1**	**12**	**3.2**		
Q1/Q5 ratio	**0.7**	**1.8**	**1**	**1.3**	**1.5**	**1.2**	**1.3**	**0.8**	**0.9**	**2.1**	**0.9**	**2.7**	**0.6**		
Total life-years gained (in millions)															
Q1 (bottom 20%)	12.3	22.5	5.4	5.3	5.6	0.1	83.6	3.7	3.3	6.5	0.9	4.5	0.8	26-40	31
Q2	13.7	15.8	4.8	4	4.1	0.1	71.6	3.8	3.4	4.5	0.8	4.2	0.8	26-32	28
Q3	9.4	9.7	3.3	2.8	2.4	0.1	49.2	2.5	3.1	2.7	0.7	2.6	0.7	17-25	20
Q4	6	6.3	2.7	1.8	1.5	0.1	24.6	1.9	1.8	1.8	0.4	1.5	0.5	8-16	12
Q5 (top 20%)	3.2	2.5	1.1	0.8	0.7	0	12	0.9	0.7	0.6	0.2	0.3	0.3	2-8	5
Total=449	44.7	56.8	17.2	14.7	14.3	0.5	241	12.8	12.2	16.1	3	13	3.1		
Q1/Q5 ratio	3.8	9.1	5.1	6.9	7.9	6.1	7	4	4.9	11	4.6	14	3.1		
Disease cost averted (adjusted for PPP in USD; in millions)															
Q1 (bottom 20%)	8 15	4 120	81	647	296	16	33 400	2 170	445	1 850	363	878	457	16-34	29
Q2	1 040	3 220	132	538	233	17	35 500	2 260	566	1 720	357	836	494	24-32	27
Q3	773	2 770	97	405	199	16	24 900	1 980	524	1 170	264	507	436	19-26	22
Q4	547	2 190	136	255	118	10	13 400	1 600	322	874	168	290	373	11-27	15
Q5 (top 20%)	313	1 050	61	119	73	4	6 980	818	132	295	93	64	224	2-12	7
Total=157 002	3 488	13 350	507	1 964	919	63	114 180	8 828	1 989	5 909	1 245	2 575	1 984		
Q1/Q5 ratio	2.6	3.9	1.3	5.4	4	3.7	4.8	2.7	3.4	6.3	3.9	13.7	2		
Additional tax revenues (adjusted for PPP in USD; in billions)															
Q1 (bottom 20%)	0.9	2.1	0.2	0.2	0.5	<0.1	9.5	0.3	0.6	0.2	<0.1	0.4	0.1	5-22	10
Q2	1.6	2.6	0.4	0.2	0.4	0.1	14.2	0.5	1.6	0.5	0.1	0.8	0.2	13-21	17
Q3	1.9	3.4	0.5	0.3	0.4	0.1	14.9	0.4	2.8	0.8	0.1	0.8	0.2	16-26	21
Q4	2.5	4.8	0.8	0.4	0.5	0.1	12.7	0.8	3.2	0.8	0.1	1	0.3	19-30	26
Q5 (top 20%)	3.5	3.4	0.8	0.3	0.5	0.1	15	0.9	2.9	0.7	0.1	0.7	0.4	19-35	26
Total=122	10.4	16.4	2.6	1.5	2.4	0.3	66.3	2.9	11.1	3.1	0.4	3.6	1.3		
Q1/Q5 ratio	0.3	0.6	0.2	0.6	1.1	0.6	0.6	0.3	0.2	0.3	0.2	0.6	0.2		
% additional tax to GDP	**0.1%**	**1.0%**	**0.1%**	**0.2%**	**0.4%**	**1.0%**	**0.2%**	**0.1%**	**0.7%**	**0.1%**	**0.1%**	**0.3%**	**0.3%**	**0.1-1.1%**	

Notes: Country Abbreviation: India: IND; Indonesia: IDN; Bangladesh: BGD; Philippines: PHL; Vietnam: VNM; Armenia: ARM; China: CHN; Mexico: MEX; Turkey: TUR; Brazil: BRA; Colombia: COL; Thailand: THA; Chile: CHL

These averted costs in the bottom quintile ($46 billion, median 29%, range 16-34%) were 4.6 times those in the top quintile ($10 billion, median 7%, range 2-12%). The excise tax increases needed to achieve a 50% higher price would generate about $122 billion across countries, which corresponded to between 0.1 and 1.1% of each country's gross domestic product in 2015. The extra tax revenue generated from the top quintile ($29 billion, median 23%, range 19-35%) was double that of the bottom quintile ($15 billion, median 10%, range 5-22%).

Figure 1 presents the results for poverty and catastrophic expenditures that occurred in the six countries with low coverage of UHC (India, Indonesia, Bangladesh, the Philippines, Vietnam, and China) and in Mexico, which had high OOP treatment costs for the four tobacco-attributable diseases. The 50% higher cigarette price led to about 15.5M men avoiding catastrophic health expenditures. Of these, 4.4M were in the bottom quintile (median 29%, range 24-34%), and the bottom quintile avoided 4 times more catastrophic health expenditures than the top quintile (appendix p 5). As a consequence, about 8.8M males avoided poverty across the seven countries. Of these, about 4.2M were in the bottom quintile (median 37%, range 16-68%), and another 2.5M were in the second lowest quintile. The bottom quintile avoided 18.2 times more poverty than the top quintile. The 8.8M men represent 2.4% of the baseline number of 360M men and women living in poverty in these seven countries. In most countries, there was an inverse relationship between income quintile and number of individuals who avoided catastrophic healthcare expenditures or poverty. However, in Bangladesh, a sizeable number of men who avoided poverty and catastrophic healthcare expenditures were from the 4th quintile due to the relatively high prevalence of smoking in this income group.

Figure 2 summarizes the differences in the key outcomes for the bottom and top quintile across the 13 countries. Smoking is 1.3 times as common in the bottom quintile as the top. However, they receive a significantly larger share of the health and financial benefits in terms of years of life gained, disease costs averted, and number of individuals avoiding catastrophic health expenditures in comparison to the top quintile. Overall, the bottom quintile would pay 10% of the additional taxes and get 31% of the life-years saved, and 29% each of the averted disease costs or averted catastrophic health expenditures.

Sensitivity analyses yielded similar results. If we excluded China and India, or included female smokers from Chile, Colombia and Mexico, the bottom quintile avoided 22.2 and 19 times more catastrophic health expenditures than the top quintile, respectively. Use of lower or higher price increases or country-specific elasticities showed similar greater benefits for the bottom versus top income quintiles (Figure 3; appendix p 6-10). The additional tax burden from a 100% price increase was borne mostly by the top quintile.

DISCUSSION

Key findings

Across 13 quite diverse LMICs, we demonstrate that benefits of tobacco taxation through a 50% price increase favour the bottom income quintile of the population more strongly in terms of life-years saved, OOP expenditures from averted tobacco-attributable treatment costs, catastrophic health expenditures or poverty. However, a much greater share of the additional tax burden is borne by the top quintile. Our results were consistent across a range of countries, despite quite marked differences in smoking prevalence, type of UHC system in place, and poverty levels. Our analysis challenges the conventional view that tobacco taxes are anti-poor[23] which is based on the observation that low-income smokers spend a disproportionately greater share of their income on these taxes than high-income smokers.

Relevance of higher taxes to SDGs

It is notable that higher tobacco excise taxes support three of the SDG targets on reduction of NCDs, poverty, and expanded financial protection against illness. First, just in seven countries, practicable tax hikes could avoid about 2.4% of the income poverty by averting OOP treatment costs. The reduction in poverty is heavily concentrated in the bottom quintile, but notable also the second lowest quintile, suggesting that higher tobacco taxes help protect the “near poor” from poverty. Higher tobacco excise taxes appear to be a powerful but generally under-appreciated tool for governments to reduce income poverty. Worldwide, some 20 million people could avoid poverty from a 50% higher cigarette price, which, very crudely, is akin to the numbers lifted from poverty through a one-time 1% increase in economic growth in LMICs.[24] Second, in these 13 countries alone, some 450M

life-years would be saved from higher excise taxes, contributing substantially to the SDG target of a one-third reduction in NCD death rates at ages 30-69 years by 2030.[1,8]

The relevance of higher tobacco taxes to UHC is more complex. Tobacco taxes can generate substantial revenues but, in most countries, not sufficiently to meet the financing needs of UHC. Extra tobacco revenue could finance an average of 4% of the recently-estimated costs of achieving the SDGs, ranging from 1% in India to 16% in Turkey (appendix p 11).[25] The goals of UHC are not only to improve health, but also to reduce poverty through financial risk protection.[4] Tobacco taxation is an unusually effective way to achieve both. As such, tobacco taxation (within the strategies of the FCTC) should be a prominent and early intervention in most UHC plans.

WHO has observed that between 2012 and 2014, over 100 countries raised their excise taxes on tobacco.[2] However, very few did so at the high levels required to reduce consumption, and especially as rapid income growth in many LMICs has made tobacco relatively more affordable in the last decade. The median tax increase required to achieve a 50% higher price across the countries was just under $1.70. While not small, such levels of higher taxes have been adopted in the Philippines, Turkey, France and other countries.[4,26] The large increase in excise taxes in some countries mostly reflects the low cost of manufacturing cigarettes. In addition to large tax increases that change consumer behaviour, governments need to pay attention to the structure of tax, emphasizing taxation of the “cheap, short” cigarette so as to reduce downward brand substitution. In most LMICs, and most notably in China and Indonesia, the cigarette industry manipulates a wide range of cigarette prices to limit the health impact of any tax increases by encouraging smokers to shift to cheaper brands.

Smokers, including the poor, who do not quit or significantly reduce smoking will spend more of their income on taxes. Those that quit in particular will free up additional income for other expenditures that could enhance household welfare. Male addiction to tobacco reduces household spending on health, education or other items.[27,28] While the reductions in smoking deaths from higher taxes are concentrated in men, the benefits of reduced catastrophic health expenditures and poverty benefit women and families. Effectively,

tobacco taxation enables an income transfer from male smokers to females and other family members.

Study limitations

As with any cross-country comparisons, our analyses face certain limitations. First, we might be underestimating the true benefits to the poor. Due to lack of sufficient data and comparability between all 13 countries, we did not take account of loss of productivity and family earnings due to tobacco use, and thereby the implications for being pushed into impoverishment, in our analysis. Only about 40% of welfare benefits of disease control broadly arise from averted treatment costs,[29] with the rest from productivity gains that we did not include. Second, while there is variation in estimates of price elasticities across countries, we used a middle value of about -0.4. Sensitivity analysis showed that most of our results were not markedly different with use of country-specific elasticities, most of which were similar in their poverty effects. Our core assumption of a gradient in price elasticity by age and income group is supported by economic theory and most (but not all) price elasticity studies.[9,18] Third, we did not take into account the consumers' utility or welfare derived from smoking. The welfare benefits of consuming a highly addictive product are complex, in that they represent the willingness to pay both to continue to smoke, but also to avoid the substantial discomfort from withdrawal of smoking. In the United States, analyses that take into account addiction find that higher taxes increase the welfare of smokers, especially the poorest, by serving as an external force against the addiction of tobacco.[30] Fourth, we limited our analyses to cigarette smoking. The Indian sub-continent has a sizable number of bidi (small, locally-manufactured cigarettes) users. In this region, smoking patterns are changing with cigarettes increasingly substituting bidis, particularly in the poor and in the young.[31] Similarly, we also did not account for the modest health benefits of reduced smoking amount. Finally, our estimates did not take into account the long term signalling effects of higher taxes on individual smoking behaviour. France has halved its daily per capita smoking in only 15 years (the UK took 30 years to halve consumption), in part as its government announced at the outset (in 1992) that excise taxes would rise 5% above inflation every year.[1] Like mortgages, future rational price expectations can have an additional benefit beyond the initial price shock.

Implications

Our analyses suggest that large increases in tobacco excise taxation are not only effective at reducing smoking and its consequences on diseases, but also strongly relevant to the UN SDGs for poverty and UHC. On-going efforts by countries, the World Bank, WHO and the Bloomberg Philanthropies and Gates Foundation to advance tobacco control can use our findings as significant new arguments to accelerate smoking cessation. Modest action by many governments could yield unprecedented health gains, financial protection and poverty-reduction in the 21st century.

What is already known on this topic?

- Higher-excise taxes on tobacco are essential to reach the SDGs to reduce NCD death rates by one-third by 2030.
- Low-income groups are more responsive to price increases than high-income groups. However, there are only limited published studies of the distributional impact of higher tobacco taxes on health and financial outcomes.

What this study adds?

- This is the largest study to directly quantify the potential impact of a tobacco price increase across income groups in a diverse range of low and middle-income countries covering 2 billion population and 500 million male smokers. Despite differences in socio-economic condition and health financing arrangements, tobacco taxation through a 50% price increase strongly favours the bottom quintile of the population in terms of life-years saved, out of pocket expenditures from tobacco-attributable treatment costs averted, and individuals avoiding catastrophic health expenditures or poverty.
- Higher tobacco excise taxes appear to be a powerful but generally under-appreciated tool for governments to reduce income poverty. Worldwide, some 20 million people could avoid poverty from a 50% higher cigarette price, which, very crudely, is akin to the numbers lifted from poverty through a one-time 1% increase in economic growth in LMICs.
- In these 13 countries alone, some 450M life-years would be saved from higher excise taxes, contributing substantially to the SDG target of a one-third reduction in NCD death rates at ages 30-69 years by 2030.

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Role of the funding source
The sponsors of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the manuscript. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Contributors
S Mishra, V Ulep and P Jha conducted the analyses. P Jha, S Mishra, V Ulep, P Isenman and P Marquez wrote the first draft. P Jha conceived the study and is lead facilitator of the Global Tobacco Economics Consortium. All co-authors satisfy the recommendations outlined in the ICMJE Recommendations 2013. All co-authors provided substantial contributions to the conception or design of the work or acquisition, analysis, or interpretation of data for the work, and helped with drafting the work or revising it critically for important intellectual content. All co-authors approve this version of the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. PJ is guarantor for the study, had full access to all of the data in the study, and takes responsibility for the integrity of the data and the accuracy of the data analysis.

The authors affirm that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Conflict of interest
All authors have completed the ICMJE uniform disclosure form at www.icmje.org/coi_disclosure.pdf and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years; no other relationships or activities that could appear to have influenced the submitted work.

Ethics review
Institutional review board approval was not required. No primary data collection conducted. We attest that we have obtained appropriate permissions and paid any required fees for use of copyright protected materials.

third party material where-ever it may be located; and, vi) license any third party to do any or all of the above.

The use of copyrighted materials

We attest that we have obtained appropriate permissions and paid any required fees for use of copyright protected materials (i.e. STATA software).

Data sharing statement

The parameters are included in the supplementary appendix, and the STATA code is available freely upon written request to the authors.

Figure legends:

Figure 1: Number of individuals avoiding catastrophic health expenditures and averting poverty

Catastrophic health expenditure is >10% of individual's annual income and poverty is the World Bank's international poverty line of income of USD $1.90/day in PPP.

Figure 2: Share of health and financial benefits accruing to bottom and top quintiles of the population

*Expected value if there are no differences across bottom and top

Figure 3: Sensitivity analysis for health and financial outcomes by varying degree of tobacco price increase and using country-specific elasticities

All USD are in PPP

References

1. Jha P, Peto R. Global effects of smoking, of quitting, and of taxing tobacco. N Engl J Med. 2014;370:60-8.
2. WHO report on the global tobacco epidemic, 2015. Geneva, Switzerland: World Health Organization; 2015.
3. United Nations, Economic and Social Council. Report of the inter-agency and expert group on sustainable development goal indicators, revised. New York: United Nations; 2016.
4. Health systems financing: the path to universal coverage. The world health report. Geneva: World Health Organization; 2010.
5. Palipudi KM, Gupta PC, Sinha DN, Andes LJ, Asma S, McAfee T, et al. Social determinants of health and tobacco use in thirteen low and middle income countries: evidence from Global Adult Tobacco Survey. PLoS One. 2012;7:e33466.
6. Jha P, Peto R, Zatonski W, Boreham J, Jarvis MJ, Lopez AD. Social inequalities in male mortality, and in male mortality from smoking: indirect estimation from national death rates in England and Wales, Poland, and North America. Lancet. 2006;368: 367-70.
7. Jamison DT, Summers LH, Alleyne G, Arrow KJ, Berkley S, Binagwaho A, et al. Global health 2035: a world converging within a generation. Lancet. 2013;382:1898-955.
8. Norheim OF, Jha P, Admasu K, Godal T, Hum RJ, Kruk ME, et al. Avoiding 40% of the premature deaths in each country, 2010-30: review of national mortality trends to help quantify the UN sustainable development goal for health. Lancet. 2015;385:239-52.
9. IARC. Effectiveness of tax and price policies for tobacco control: IARC handbook of cancer prevention. Lyon, France: International Agency for Research on Cancer; 2011.
10. U.S. National Cancer Institute and World Health Organization. The economics of tobacco and tobacco control. National Cancer Institute Tobacco Control Monograph 21. Bethesda, MD and Geneva: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute and World Health Organization; 2016.
11. Jha P, Khan J, Mishra S, Gupta P. Raising taxes key to accelerate tobacco control in South Asia. BMJ. 2017;357:j1176.
12. Verguet S, Gauvreau CL, Mishra S, MacLennan M, Murphy SM, Brouwer ED, et al. The consequences of tobacco tax on household health and finances in rich and poor smokers in China: an extended cost-effectiveness analysis. Lancet Glob Health. 2015;3(4):e206-16.
13. Salti N, Brouwer E, Verguet S. The health, financial and distributional consequences of increases in the tobacco excise tax among smokers in Lebanon. Soc Sci Med. 2016;170:161-9.
14. Verguet S, Kim JJ, Jamison DT. Extended cost-effectiveness analysis for health policy assessment: A tutorial. Pharmacoeconomics. 2016;34(9):913-23.
15. Jha P, Joseph RA, Li D, Gauvreau C, Anderson I, Moser P, et al. Tobacco Taxes: A win-win measure for fiscal space and health. Mandaluyong City, Philippines: Asian Development Bank; 2012.
16. Giovino GA, Mirza SA, Samet JM, Gupta PC, Jarvis MJ, Bhala N, et al. Tobacco use in 3 billion individuals from 16 countries: an analysis of nationally representative cross-sectional household surveys. Lancet. 2012;380(9842):668-79.
17. World Population Prospects: The 2015 Revision New York, NY: United Nations, Department of Economic and Social Affairs, Population Division 2015 [Available from: https://esa.un.org/unpd/wpp/]
18. Gallet CA, List JA. Cigarette demand: a meta-analysis of elasticities. Health Econ. 2003;12(10):821-35.
19. Jha P, MacLennan M, Yurekli A, Ramasundarahettige C, Palipudi KM, Zatonski W, et al. Global hazards of tobacco and the benefits of smoking cessation and tobacco tax. Seattle: Disease Control Priorities 3.
20. Institute for Health Metrics and Evaluation (IHME). GBD compare data visualization Seattle, WA: IHME, University of Washington; 2016 [Available from: http://vizhub.healthdata.org/gbd-compare]. (Accessed June 15, 2017).
21. World Bank. Consumer price index (2010 = 100) 2017 [Available from: https://data.worldbank.org/indicator/FP.CPI.TOTL?page=6]. (Accessed June 15, 2017).
22. World Bank. PPP conversion factor, private consumption (LCU per international $) 2017 [Available from: http://data.worldbank.org/indicator/PA.NUS.PRVT.PP]. (Accessed June 15, 2017).
23. Farrelly MC, Nonnemaker JM, Watson KA. The consequences of high cigarette excise taxes for low-income smokers. PLoS One. 2012;7(9):e43838.
24. Adams RHJ. Economic growth, inequality, and poverty. Findings from a new data set. Washinigton, DC World Bank; 2003.
25. Stenberg K, Hanssen O, Edejer TT, Bertram M, Brindley C, Meshreky A, et al. Financing transformative health systems towards achievement of the health Sustainable Development Goals: a model for projected resource needs in 67 low-income and middle-income countries. Lancet Glob Health. 2017;5(9):e875-e87.
26. Kaiser K, Bredenkamp C, Iglesias R. Sin tax reform in the Philippines: Transforming public finance, health, and governance for more inclusive development. Directions in development--Countries and regions. Washington, DC: World Bank; 2016.
27. John RM, Ross H, Blecher E. Tobacco expenditures and its implications for household resource allocation in Cambodia. Tob Control. 2012;21(3):341-6.
28. Bonu S, Rani M, Peters DH, Jha P, Nguyen SN. Does use of tobacco or alcohol contribute to impoverishment from hospitalization costs in India? Health Policy Plan. 2005;20(1):41-9.
29. Bloom DE, Cafiero ET, Jané-Llopis E, Abrahams-Gessel S, Bloom LR, Fathima S, et al. The global economic burden of noncommunicable diseases. Geneva: World Economic Forum; 2011.

30. Gruber J, Koszegi B. Tax incidence when individuals are time-inconsistent: the case of cigarette excise taxes. Journal of Public Economics. 2004; 88:29.
31. Mishra S, Joseph RA, Gupta PC, Pezzack B, Ram F, Sinha DN, et al. Trends in bidi and cigarette smoking in India from 1998 to 2015, by age, gender and education. BMJ Global Health. 2016;1(1).

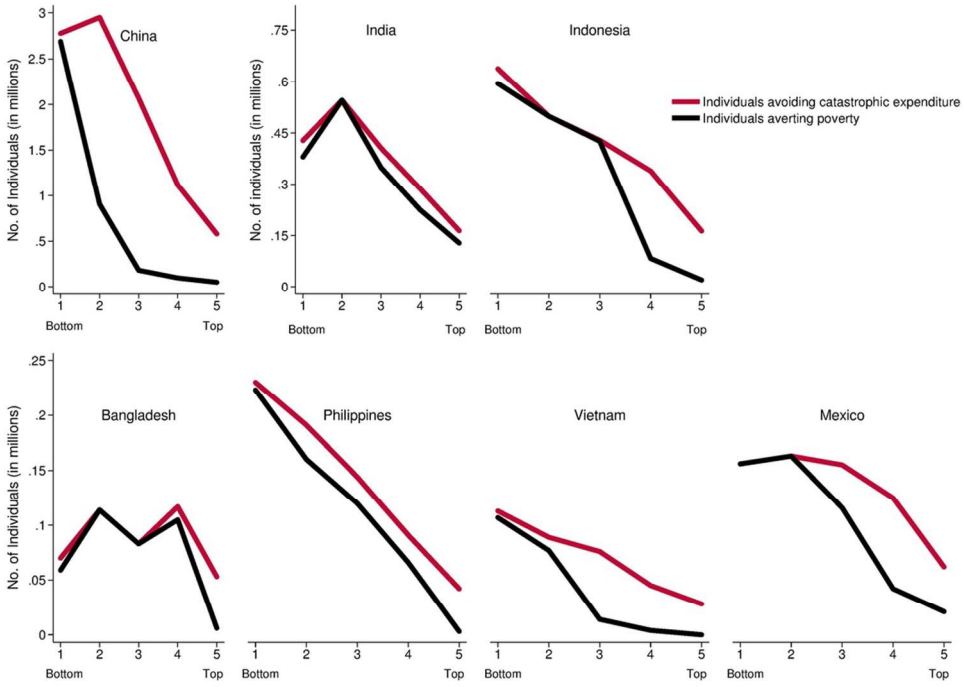

Figure 1: Number of individuals avoiding catastrophic health expenditures and averting poverty

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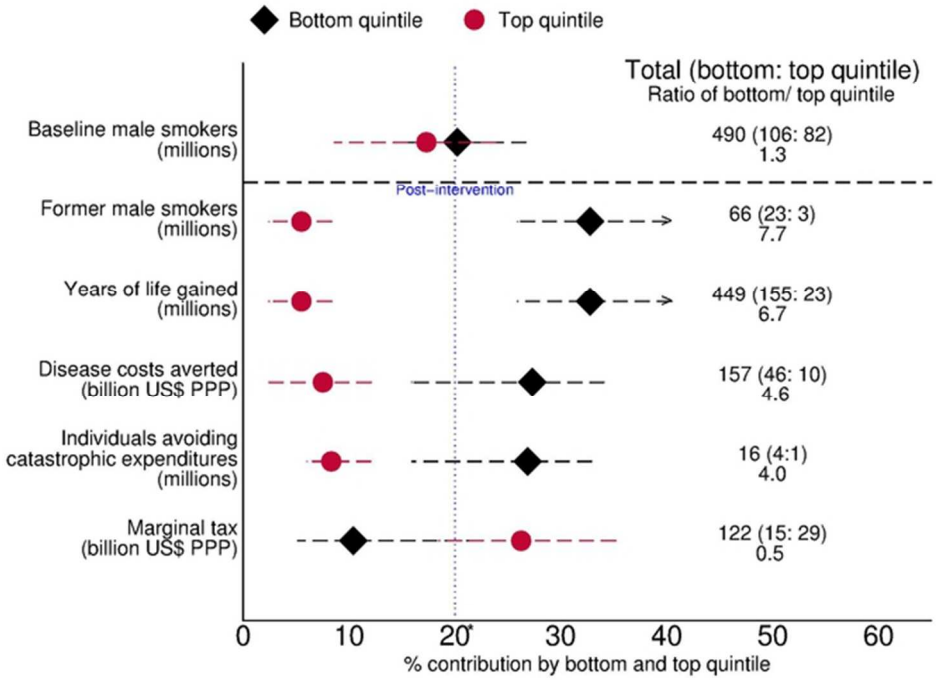

Figure 2: Share of health and financial benefits accruing to bottom and top quintiles of the population

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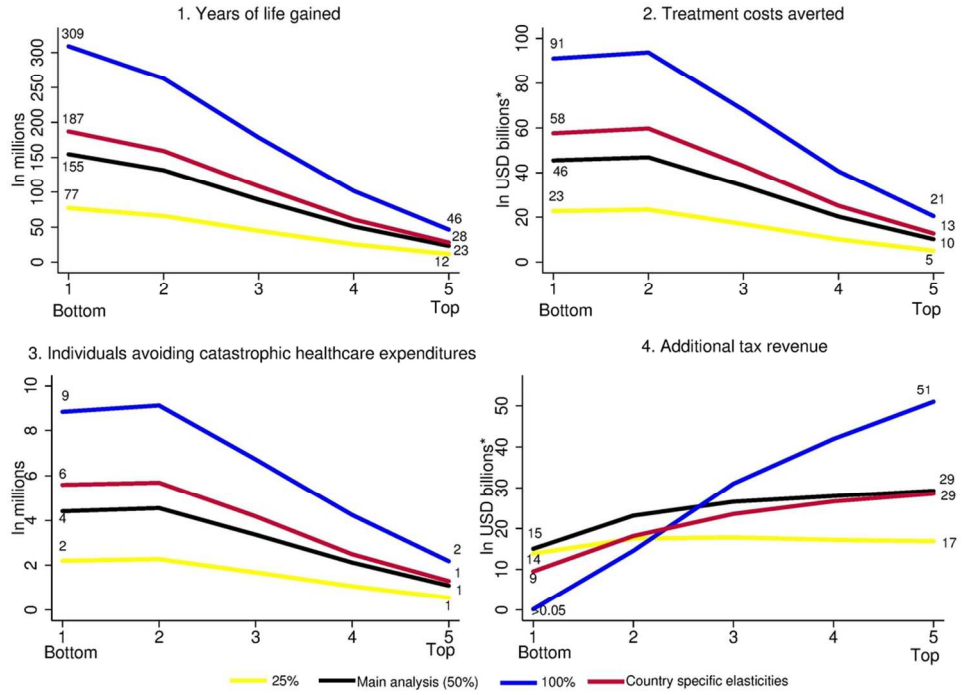

Figure 3: Sensitivity analysis for health and financial outcomes by varying degree of tobacco price increase and using country-specific elasticities

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Supplementary appendix: The health poverty and financial consequences of a cigarette price increase among 0.5 billion male smokers in 13 low and middle-income countries

Supplementary appendix: The health poverty and financial consequences of a cigarette price increase among 0.5 billion male smokers in 13 low and middle-income countries

Appendix Table 1: Input parameters for 13 countries

			Lower middle Income				Upper middle Income							
Indicators	**IND**	**IDN**	**BGL**	**PHL**	**VNM**	**ARM**	**CHN**	**MEX**	**TUR**	**BRA**	**COL**	**THA**	**CHL**	**Source**
Population (males in millions)														(1)
0-4	65.1	12.7	7.8	5.7	3.8	0.1	44.6	6.0	3.5	7.7	1.9	2.0	0.6	
5-9	66.9	11.8	8.0	5.3	3 4	0.1	42.4	6.2	3.4	7.9	2.0	2.1	0.6	
10-14	66.9	12.1	8.4	5.1	3.6	0.1	40.4	6.2	3.4	8.9	2.1	2.1	0.6	
15-19	64.9	11.8	8.2	5.1	4.5	0.1	42.0	6.2	3.4	8.9	2.1	2.2	0.7	
20-24	62.1	10.7	7.7	4.8	4.4	0.1	55.9	5.6	3.2	8.4	2.1	2.3	0.7	
25-29	58.7	9.9	7.2	4.2	4.0	0.1	67.0	5.0	3.2	8.8	2.0	2.3	0.7	
30-34	54.1	10.7	6.6	3.7	3.6	0.1	51.1	4.8	3.2	8.9	1.9	2.5	0.7	
35-39	47.2	10.0	5.8	3.3	3.3	0.1	48.8	4.7	3.0	8.1	1.7	2.8	0.6	
40-44	41.8	9.3	5.0	3.0	3.0	0.1	61.0	4.0	2.6	7.0	1.5	2.8	0.6	
45-49	36.5	8.3	4.5	2.7	2.7	0.1	62.7	3.4	2.3	6.4	1.5	2.8	0.6	
50-54	31.9	6.9	3.7	2.3	2.2	0.1	50.6	2.9	2.0	5.9	1.3	2.5	0.6	
55-59	26.9	5.6	2.6	1.9	1.5	0.1	40.1	2.2	1.7	4.8	1.1	2.2	0.5	
60-64	21.7	4.0	1.7	1.4	0.8	0.1	39.2	1.8	1.3	3.8	0.9	1.7	0.4	
65-69	14.2	2.5	1.5	1.0	0.5	<0.1	25.4	1.3	0.9	2.7	0.6	1.2	0.3	
70-74	9.6	1.7	1.1	0.6	0.4	<0.1	16.8	1.1	0.7	1.8	0.4	0.8	0.2	
Smoking prevalence, by age														(2–14)
15-19	4%	21%	12%	19%	12%	26%	14%	19%	21%	9%	7%	34%	38%	
20-24	9%	47%	29%	29%	42%	35%	49%	29%	47%	20%	19%	52%	46%	
25-29	9%	54%	34%	39%	45%	43%	53%	27%	54%	18%	26%	48%	51%	
30-34	13%	52%	38%	49%	58%	52%	52%	22%	52%	20%	25%	49%	55%	
35-39	12%	51%	36%	49%	62%	60%	58%	24%	51%	24%	21%	50%	56%	
40-44	12%	50%	33%	48%	56%	66%	68%	19%	50%	24%	17%	50%	55%	
45-49	14%	45%	36%	48%	62%	68%	67%	23%	45%	27%	13%	50%	53%	
50-54	12%	42%	31%	47%	60%	67%	58%	21%	42%	29%	16%	47%	49%	
55-59	10%	32%	26%	45%	64%	64%	58%	17%	32%	27%	17%	44%	44%	
60-64	8%	33%	19%	43%	47%	60%	47%	19%	33%	24%	19%	44%	40%	
65-69	7%	20%	18%	40%	45%	55%	38%	15%	20%	20%	21%	34%	35%	
70-74	6%	16%	22%	36%	34%	51%	21%	10%	16%	16%	21%	34%	31%	
Smoking prevalence, by income quintile														(2–14)
Q1	8%	72%	26%	32%	58%	49%	59%	21%	32%	31%	16%	48%	30%	
Q2	11%	63%	29%	31%	53%	61%	63%	26%	41%	27%	18%	57%	38%	
Q3	10%	52%	26%	28%	42%	59%	58%	24%	50%	22%	19%	46%	46%	
Q4	10%	51%	33%	27%	40%	49%	44%	27%	45%	22%	17%	40%	48%	
Q5	10%	41%	26%	24%	38%	42%	44%	27%	34%	15%	18%	18%	51%	
Number of cigarettes consumed daily per person														(2–14)
Q1	4	18	8	10	14	24	16	13	18	6	6	9	18	
Q2	4	19	8	9	10	24	16	10	19	11	8	9	15	
Q3	4	18	7	10	10	24	14	8	18	14	8	7	11	
Q4	4	17	7	9	10	24	13	9	17	11	8	9	11	
Q5	4	16	8	7	9	24	13	8	16	12	10	10	10	
Share to the total deaths														(15)
COPD	23%	9%	31%	10%	11%	7%	19%	8%	15%	2%	19%	83%	14%	
Stroke	18%	50%	16%	35%	47%	24%	39%	12%	24%	5%	22%	37%	34%	
Heart disease	44%	40%	49%	49%	28%	63%	30%	47%	46%	7%	52%	33%	42%	
Lung cancer	15%	2%	5%	6%	13%	6%	12%	33%	15%	1%	7%	16%	10%	
Annual treatment cost from tobacco attributable diseases (in USD PPP-adjusted)														(7,8,16–28)
COPD	240	2 977	431	601	400	425	2 256	767	1 604	879	1 289	426	552	
Stroke	895	825	431	1 873	866	350	2 197	3 527	1 850	2 963	1 446	937	4 433	
Heart disease	494	3 935	431	774	1 384	1 724	11 774	4 152	1 537	1 484	968	1 163	3 946	
Lung cancer	895	5 372	644	720	1 319	4 781	14 794	11 811	1 902	2 308	10 240	2 399	21 738	

	Lower middle Income						Upper middle Income							
Indicators	**IND**	**IDN**	**BGL**	**PHL**	**VNM**	**ARM**	**CHN**	**MEX**	**TUR**	**BRA**	**COL**	**THA**	**CHL**	**Source**
Probability of seeking care														(7,8,25,29–34)
COPD	65%	70%	41%	80%	52%	25%	33%	96%	70%	79%	70%	99%	88%	
Stroke	67%	70%	41%	80%	52%	75%	80%	96%	70%	88%	70%	99%	88%	
Heart disease	70%	70%	41%	80%	52%	75%	81%	96%	70%	87%	70%	99%	88%	
Lung cancer	72%	70%	41%	80%	52%	40%	50%	96%	70%	90%	70%	99%	88%	
Health utilization (relative)														(7,8,,19,30,35–42)
Q1	0.8	0.6	0.5	0.8	0.6	0.7	0.79	0.8	0.8	0.7	1.0	1.0	0.9	
Q2	0.9	0.7	0.9	0.9	0.7	0.7	0.98	0.8	1.0	0.9	1.1	1.0	1.0	
Q3	1.0	1.0	1.0	1.0	1.0	1.0	1.00	1.0	1.0	1.0	1.0	1.0	1.0	
Q4	1.1	1.2	1.7	1.0	0.9	1.1	1.08	1.1	1.1	1.1	1.1	1.0	1.2	
Q5	1.2	1.5	2.0	1.1	1.2	1.2	1.15	1.1	1.2	1.1	1.2	1.0	1.4	
Insurance coverage rate														(7,8,29,43–53)
	11%	55%	26%	88%	60%	28%	97%	91%	85%	100%	91%	98%	90%	
Financial support														(26,43,44,46–49,54–56)
	40%	70%	40%	40%	60%	100%	30%	70%	100%	80%	100%	100%	90%	
Household income per capita (in USD PPP-adjusted)														(57–65)
	1 559	1 940	1 437	2 888	2 436	2 888	5 405	4183	10 865	7 511	3 075	7 788	9 419	
Gini														
	0.3	0.4	0.3	0.4	0.4	0.3	0.5	0.5	0.4	0.5	0.5	0.4	0.5	(66)
Individual Income (by quintile)														Authors' calculation
Q1	899	1 008	857	1 393	1 309	1 739	2 435	1 861	5 567	3 017	1 192	4 158	3 886	
Q2	1 243	1 478	1 164	2 125	1 883	2 346	3 866	2 972	8 229	5 100	2 055	6 009	6 467	
Q3	1 501	1 841	1 391	2 711	2 326	2 792	5 027	3 886	10 310	6 881	2 797	7 438	8 654	
Q4	1 791	2 264	1 645	3 401	2 831	3 292	6 423	4 980	12 712	9 042	3 721	9 065	11 293	
Q5	2 352	3 104	2 133	4 795	3 823	4 255	9 260	7 227	17 492	13 550	5 641	12 292	16 813	
Price elasticity														(28 67–79)
	-0.35	-0.30	-0.49	-0.87	-0.53	-0.56	-0.54	-0.52	-0.39	-0.38	-0.78	-0.39	-0.21	
PPP conversion factor														(80)
	19	4 800	31	20	8 836	202	4	10	2	2	1 292	13	376	

India(IND); Indonesia (IDN); Bangladesh (BGD); Philippines (PHL); Vietnam (VNM); Armenia (ARM): China (CHN); Mexico (MEX); Turkey (TUR); Brazil (BRA); Colombia (COL); Thailand (THA); Chile (CHL)

Appendix Table 2. Number of individuals avoiding catastrophic health expenditure and averting poverty

Quintile	Lower middle Income IND	IDN	BGL	PHL	VNM	Upper middle Income CHN	MEX	Range of quintile share Min-Max (%)	Median (share)	Mean (share)
Number of people avoiding catastrophic expenditures from treatment related costs (in millions)										
Q1 (bottom 20%)	0.43	0.64	0.07	0.23	0.11	2.78	0.16	24-34	29	27
Q2	0.55	0.50	0.11	0.19	0.09	2.95	0.16	24-31	26	27
Q3	0.41	0.43	0.08	0.14	0.08	2.07	0.15	18-23	22	21
Q4	0.29	0.34	0.12	0.09	0.04	1.12	0.13	11-19	16	16
Q5 (top 20%)	0.16	0.16	0.05	0.04	0.03	0.58	0.06	6-10	8	8
Total=15.5	1.83	2.07	0.44	0.70	0.35	9.49	0.66			
Q1/Q5	**2.6**	**3.9**	**1.3**	**5.5**	**4.1**	**4.8**	**2.5**			
Number of people averting poverty from treatment related costs (in millions)										
Q1 (bottom 20%)	0.38	0.59	0.06	0.22	0.11	2.69	0.16	16-68	37	38
Q2	0.55	0.50	0.11	0.16	0.08	0.91	0.16	23-37	31	31
Q3	0.35	0.43	0.08	0.12	0.01	0.18	0.12	5-27	21	18
Q4	0.22	0.08	0.11	0.07	<0.01	0.10	0.04	2-12	8	10
Q5 (top 20%)	0.13	0.02	0.01	<0.01	<0.01	0.05	0.02	0-4	1	2
Total=8.8	1.63	1.62	0.37	0.57	0.20	3.93	0.50			
Q1/Q5	**0.2**	**0.4**	**0.2**	**0.4**	**0.5**	**0.7**	**0.3**			

Note: India(IND); Indonesia (IDN); Bangladesh (BGD); Philippines (PHL); Vietnam (VNM); Armenia (ARM): China (CHN); Mexico (MEX); Turkey (TUR); Brazil (BRA); Colombia (COL); Thailand (THA); Chile (CHL)

Appendix Table 3a: Sensitivity Analysis- additional life years gained (in millions)

	Lower middle Income						Upper middle Income									
Quintile	**IND**	**IDN**	**BGL**	**PHL**	**VNM**	**ARM**	**CHN**	**MEX**	**BRA**	**TUR**	**COL**	**CHL**	**THA**	**Range of quintile share Min- Max (%)**	**Median (share)**	**Mean (share)**
25%																
Q1	6.1	11.2	2.7	2.7	2.8	0.1	41.8	1.9	3.3	1.6	0.5	0.4	2.2	26-40	31	33
Q2	6.8	7.9	2.4	2.0	2.0	0.1	35.8	1.9	2.2	1.7	0.4	0.4	2.1	26-32	28	29
Q3	4.7	4.8	1.6	1.4	1.2	0.1	24.6	1.3	1.3	1.5	0.3	0.4	1.3	17-25	20	20
Q4	3.0	3.2	1.3	0.9	0.8	<0.05	12.3	0.9	0.9	0.9	0.2	0.3	0.7	10-16	12	13
Q5	1.6	1.2	0.5	0.4	0.4	<0.05	6.0	0.5	0.3	0.3	0.1	0.1	0.2	2-8	5	5
Total	**22.3**	**28.3**	**8.6**	**7.3**	**7.1**	**0.2**	**120.5**	**6.4**	**8.0**	**6.1**	**1.5**	**1.5**	**6.5**			
50%																
Q1	12.3	22.5	5.4	5.3	5.6	0.1	83.6	3.7	6.5	3.3	0.9	0.8	4.5	26-40	31	33
Q2	13.7	15.8	4.8	4.0	4.1	0.1	71.6	3.8	4.5	3.4	0.8	0.8	4.2	26-32	28	29
Q3	9.4	9.7	3.3	2.8	2.4	0.1	49.2	2.5	2.7	3.1	0.7	0.7	2.6	17-25	20	20
Q4	6.0	6.3	2.7	1.8	1.5	0.1	24.6	1.9	1.8	1.8	0.4	0.5	1.5	10-33	13	17
Q5	3.2	2.5	1.1	0.8	0.7	<0.05	12.0	0.9	0.6	0.7	0.2	0.3	0.3	2-8	5	5
Total	**44.7**	**56.8**	**17.2**	**14.7**	**14.3**	**0.5**	**241.0**	**12.8**	**16.1**	**12.2**	**3.0**	**3.1**	**13.0**			
100%																
Q1	24.6	44.9	10.8	10.6	11.2	0.3	167.0	7.4	13.0	6.5	1.8	1.6	9.0	26-40	31	33
Q2	27.3	31.6	9.6	8.1	8.1	0.3	143.0	7.5	8.9	6.8	1.7	1.6	8.4	26-32	28	29
Q3	18.9	19.4	6.6	5.6	4.8	0.2	98.4	5.1	5.4	6.1	1.3	1.4	5.1	17-25	20	20
Q4	12.0	12.6	5.4	3.5	3.1	0.1	49.2	3.8	3.7	3.6	0.8	1.0	2.9	10-16	12	13
Q5	6.4	4.9	2.1	1.5	1.4	<0.05	24.0	1.9	1.2	1.3	0.4	0.5	0.6	2-8	5	5
Total	**89.2**	**113.4**	**34.4**	**29.3**	**28.6**	**1.0**	**481.6**	**25.7**	**32.2**	**24.3**	**6.0**	**6.2**	**26.0**			
50% (country-specific elasticity)																
Q1	10.7	16.8	6.6	11.6	7.4	0.2	113.0	4.8	6.1	3.2	1.8	0.4	4.4	26-40	31	33
Q2	11.9	11.9	5.9	8.8	5.4	0.2	96.6	4.9	4.2	3.3	1.6	0.4	4.1	26-32	28	29
Q3	8.2	7.3	4.0	6.1	3.2	0.1	66.4	3.3	2.5	3.0	1.3	0.4	2.5	17-25	20	20
Q4	5.2	4.7	3.3	3. 8	2.0	0.1	33.2	2.4	1.7	1.8	0.8	0.3	1.4	10-52	13	18
Q5	2.8	1.8	1.3	1. 7	0.9	<0.05	16.2	1.2	0.6	0.6	0.4	0.1	0.3	2-8	5	5
Total	**38.8**	**42.6**	**21.1**	**31. 9**	**18.9**	**0.7**	**325.4**	**16.7**	**15.1**	**11.9**	**5.9**	**1.6**	**12.8**			

Note: India(IND); Indonesia (IDN); Bangladesh (BGD); Philippines (PHL); Vietnam VNM); Armenia (ARM): China (CHN); Mexico (MEX); Turkey (TUR); Brazil (BRA); Colombia (COL); Thailand (THA); Chile (CHL)

Appendix Table 3b: Sensitivity Analysis- Additional tax revenue (in billions)

	Lower middle Income						Upper middle Income							Range of quintile share	Median (share)	Mean (share)
Quintile	**IND**	**IDN**	**BGL**	**PHL**	**VNM**	**ARM**	**CHN**	**MEX**	**BRA**	**TUR**	**COL**	**CHL**	**THA**	**Min- Max (%)**		
25%																
Q1	0.7	2.0	0.2	0.2	0.4	<0.05	8.2	0.3	0.2	0.8	<0.05	0.1	0.5	9-27	15	15
Q2	1.2	2.0	0.3	0.2	0.3	<0.05	10.3	0.4	0.4	1.5	<0.05	0.2	0.6	16-24	19	19
Q3	1.2	2.3	0.3	0.2	0.3	<0.05	9.7	0.3	0.6	2.1	0.1	0.2	0.5	15-26	20	21
Q4	1.5	3.0	0.5	0.2	0.3	<0.05	7.6	0.5	0.5	2.2	0.1	0.2	0.7	17-27	24	23
Q5	2.0	2.0	0.5	0.2	0.3	<0.05	8.5	0.5	0.4	1.8	0. 1	0.3	0.4	15-31	20	21
Total	**6.6**	**11.3**	**1.9**	**1.0**	**1.6**	**0.2**	**44.2**	**2.1**	**2.2**	**8.4**	**0.3**	**1.0**	**2.7**			
50%																
Q1	0.9	2.1	0.2	0.2	0.5	<0.05	9.5	0.3	0.2	0.6	<0.05	0.1	0.4	5-22	10	11
Q2	1.6	2.6	0.4	0.2	0.4	0.1	14.2	0.5	0.5	1.6	0.1	0.2	0.8	13-21	17	17
Q3	1.9	3.4	0.5	0.3	0.4	0.1	14.9	0.4	0.8	2.8	0.1	0.2	0.8	16-26	21	21
Q4	2.5	4.8	0.8	0.4	0.5	0.1	12.7	0.8	0.8	3.2	0.1	0.3	1.0	19-30	27	26
Q5	3.5	3.4	0.8	0.3	0.5	0.1	15.0	0.9	0.7	2.9	0.1	0.4	0.7	19-35	23	26
Total	**10.4**	**16.4**	**2.6**	**1.5**	**2.4**	**0.3**	**66.3**	**2.9**	**3.1**	**11.1**	**0.4**	**1.3**	**3.6**			
100%																
Q1	<0.05	<0.05	<0.05	<0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0-4	0	1
Q2	1.3	1.5	0.1	0.1	0.4	<0.05	10.4	0.1	0.2	0.1	<0.05	<0.05	0.2	0-14	7	7
Q3	2.3	3.9	0.4	0.4	0.6	0.1	18.3	0.4	0.9	2.6	0.1	0.2	0.8	14-25	21	20
Q4	3.8	7.2	1.1	0.5	0.8	0.1	19.5	1.1	1.2	4.5	0.1	0.5	1.5	26-40	34	33
Q5	6.2	6.0	1.4	0.6	0.9	0.1	26.4	1.5	1.3	4.7	0.2	0.8	1.2	31-51	35	38
Total	**13.5**	**18.6**	**3.0**	**1.6**	**2.7**	**0.3**	**74.6**	**3.1**	**3.6**	**11.9**	**0.5**	**1.5**	**3.7**			
50% (country-specific elasticity)																
Q1	1.1	3.4	<0.05	<0.05	0.3	<0.05	3.0	<0.05	0.3	0.7	<0.05	0.3	0.4	0-17	8	6
Q2	1.8	3.5	0.2	<0.05	0.3	<0.05	8.6	0.3	0.6	1.7	<0.05	0.4	0.8	0-21	17	14
Q3	2.0	4.0	0.4	<0.05	0.4	<0.05	11.5	0.3	0.8	2.9	<0.05	0.4	0.8	5-26	19	19
Q4	2.6	5.3	0.7	0.2	0.5	0.1	11.1	0.7	0.9	3.3	0.1	0.4	1.0	22-40	27	29
Q5	3.6	3.6	0.8	0.3	0.5	0.1	14.2	0.8	0.7	2.9	0.1	0.5	0.7	18-64	27	32
Total	**11.1**	**19.8**	**2.1**	**0.5**	**1.9**	**0.2**	**48.4**	**2.1**	**3.3**	**11.4**	**0.2**	**2.0**	**3.7**			

Note: India(IND); Indonesia (IDN); Bangladesh (BGD); Philippines (PHL); Vietnam (VNM); Armenia (ARM): China (CHN); Mexico (MEX); Turkey (TUR); Brazil (BRA); Colombia (COL); Thailand (THA); Chile (CHL)

Appendix Table 3c: Sensitivity Analysis- Number of treatment cost averted (in billions)

	Lower middle Income						Upper middle Income									
Quintile	**IND**	**IDN**	**BGL**	**PHL**	**VNM**	**ARM**	**CHN**	**MEX**	**BRA**	**TUR**	**COL**	**CHL**	**THA**	**Range of quintile share Min- Max (%)**	**Median (share)**	**Mean (share)**
25%																
Q1	0.4	2.1	<0.05	0.3	0.1	<0.05	16.7	1.1	0.9	0.2	0.2	0.2	0.4	16-34	29	28
Q2	0.5	1.6	0.1	0.3	0.1	<0.05	17.7	1.1	0.9	0.3	0.2	0.2	0.4	24-32	27	27
Q3	0.4	1.4	0.0	0.2	0.1	<0.05	12.4	1.0	0.6	0.3	0.1	0.2	0.3	19-26	22	22
Q4	0.3	1.1	0.1	0.1	0.1	<0.05	6.7	0.8	0.4	0.2	0.1	0.2	0.1	11-27	15	16
Q5	0.2	0.5	0.0	0.1	0.0	<0.05	3.5	0.4	0.1	0.1	0.0	0.1	<0.05	2-12	7	7
Total	**1.7**	**6.7**	**0.3**	**1.0**	**0.5**	**<0.05**	**57.0**	**4.4**	**3.0**	**1.0**	**0.6**	**1.0**	**1.3**			
50%																
Q1	0.8	4.1	0.1	0.6	0.3	<0.05	33.4	2.2	1.9	0.4	0.4	0.5	0.9	16-34	29	28
Q2	1.0	3.2	0.1	0.5	0.2	<0.05	35.5	2.3	1.7	0.6	0.4	0.5	0.8	24-32	27	27
Q3	0.8	2.8	0.1	0.4	0.2	<0.05	24.9	2.0	1.2	0.5	0.3	0.4	0.5	19-26	22	22
Q4	0.5	2.2	0.1	0.3	0.1	<0.05	13.4	1.6	0.9	0.3	0.2	0.4	0.3	11-27	15	16
Q5	0.3	1.1	0.1	0.1	0.1	<0.05	7.0	0.8	0.3	0.1	0.1	0.2	0.1	2-12	7	7
Total	**3.5**	**13.4**	**0.5**	**2.0**	**0.9**	**0.1**	**114.2**	**8.8**	**5.9**	**2.0**	**1.2**	**2.0**	**2.6**			
100%																
Q1	1.6	8.2	0.2	1.3	0.6	<0.05	66.8	4.3	3.7	0.9	0.7	0.9	1.8	16-34	29	28
Q2	2.1	6.4	0.3	1.1	0.5	<0.05	70.9	4.5	3.4	1.1	0.7	1.0	1.7	24-32	27	27
Q3	1.6	5.5	0.2	0.8	0.4	<0.05	49.8	4.0	2.3	1.1	0.5	0.9	1.0	19-26	22	22
Q4	1.1	4.4	0.3	0.5	0.2	<0.05	26.9	3.2	1.8	0.6	0.3	0.7	0.6	11-27	15	16
Q5	0.6	2.1	0.1	0.2	0.1	<0.05	14.0	1.6	0.6	0.3	0.2	0.4	0.1	2-12	7	7
Total	**7.0**	**26.7**	**1.0**	**3.9**	**1.8**	**0.1**	**228.4**	**17.7**	**11.8**	**4.0**	**2.5**	**4.0**	**5.1**			
50% (country-specific elasticity)																
Q1	0.7	3.1	0.1	1.4	0.4	<0.05	45.1	2.8	1.7	0.4	0.7	0.2	0.9	16-34	29	28
Q2	0.9	2.4	0.2	1.2	0.3	<0.05	47.9	2.9	1.6	0.6	0.7	0.3	0.8	24-32	27	27
Q3	0.7	2.1	0.1	0.9	0.3	<0.05	33.6	2.6	1.1	0.5	0.5	0.2	0.5	19-26	22	22
Q4	0.5	1.6	0.2	0.6	0.2	<0.05	18.1	2.1	0.8	0.3	0.3	0.2	0.3	11-27	15	16
Q5	0.3	0.8	0.1	0.3	0.1	<0.05	9.4	1.1	0.3	0.1	0.2	0.1	0.1	2-12	7	7
Total	**3.0**	**10.0**	**0.6**	**4.3**	**1.2**	**0.1**	**154.1**	**11.5**	**5.5**	**1.9**	**2.4**	**1.0**	**2.5**			

Note: India(IND); Indonesia (IDN); Bangladesh (BGD); Philippines (PHL); Vietnam (VNM); Armenia (ARM): China (CHN); Mexico (MEX); Turkey (TUR); Brazil (BRA); Colombia (COL); Thailand (THA); Chile (CHL)

Appendix Table 3d: Sensitivity Analysis- Number of individuals averting catastrophic expenditures from treatment related costs (in millions)

Quintile	Lower middle Income IND	IDN	BGL	PHL	VNM	Upper middle Income CHN	MEX	Range of quintile share Min- Max (%)	Median (share)	Mean (share)
25%										
Q1	0.21	0.32	0.03	0.11	0.06	1.39	0.08	16-33	29	27
Q2	0.27	0.25	0.06	0.10	0.04	1.47	0.08	24-31	26	27
Q3	0.20	0.21	0.04	0.07	0.04	1.03	0.08	19-23	22	21
Q4	0.14	0.17	0.06	0.05	0.02	0.56	0.06	12-27	16	16
Q5	0.08	0.08	0.03	0.02	0.01	0.29	0.03	6-12	8	8
Total	**0.92**	**1.03**	**0.22**	**035**	**0.17**	**4.75**	**0.33**			
50%										
Q1	0.43	0.64	0.07	0.23	0.11	2.78	0.16	16-33	29	27
Q2	0.55	0.50	0.11	0.19	0.09	2.95	0.16	24-31	26	27
Q3	0.41	0.43	0.08	0.14	0.08	2.07	0.15	19-23	22	21
Q4	0.29	0.34	0.12	0.09	0.04	1.12	0.13	12-27	16	16
Q5	0.16	0.16	0.05	0.04	0.03	0.58	0.06	6-12	8	8
Total	**1.83**	**2.07**	**0.44**	**0.70**	**0.35**	**9.49**	**0.66**			
100%										
Q1	0.86	1.28	0.14	0.46	0.23	5.55	0.31	16-33	29	27
Q2	1.09	1.00	0.23	0.38	0.18	5.90	0.33	24-31	26	27
Q3	0.81	0.86	0.17	0.29	0.15	4.14	0.31	19-23	22	21
Q4	0.57	0.68	0.23	0.18	0.09	2.23	0.25	12-27	16	16
Q5	0.33	0.33	0.11	0.08	0.06	1.16	0.12	6-12	8	8
Total	**3.66**	**4.14**	**0.87**	**1.40**	**0.70**	**18.98**	**1.32**			
50% country specific elasticity										
Q1	0.37	0.48	0.15	0.50	0.15	3.75	0.20	23-33	31	29
Q2	0.48	0.37	0.12	0.42	0.12	3.98	0.21	24-31	25	27
Q3	0.35	0.32	0.10	0.31	0.10	2.79	0.20	21-23	22	22
Q4	0.25	0.25	0.06	0.20	0.06	1.51	0.16	12-19	13	14
Q5	0.14	0.12	0.04	0.09	0.04	0.78	0.08	6-9	8	8
Total	**1.59**	**1.55**	**0.46**	**1.52**	**0.46**	**12.81**	**0.86**			

Note: India(IND); Indonesia (IDN); Bangladesh (BGD); Philippines (PHL); Vietnam (VNM); Armenia (ARM): China (CHN); Mexico (MEX); Turkey (TUR); Brazil (BRA); Colombia (COL); Thailand (THA); Chile (CHL)

Appendix Table 4: Estimated impact excluding China and India and including females in Colombia Mexico and Chile

Indicators	13 countries (main analysis)	12 countries (excluding China)	11 countries (excluding China and India)	11 countries (excluding China and India but including females in Chile, Colombia and Mexico)
Number of smokers (in millions)	490	199	153	160
Number of life-years gained (in millions)	449	208	164	171
Disease cost averted (in billion USD) PPP-adjusted	157	43	39	44
Marginal tax gained (in billion USD) PPP-adjusted	122	55	45	47
Number of individuals averting catastrophic expenditure (Q1/Q5)	18.2	18.5	22.2	19.0
Number of individuals averting poverty (Q1/Q5)	4.0	3.2	3.5	3.3

Appendix Table 5: Estimated number of resources to achieve 5% government health expenditure/GDP and SDG

Countries	Government health expenditure		Share of government health expenditure to GDP	Estimated government health expenditure to reach 5% of the current GDP		Deficit per capita (in USD)	Additional revenue		Share of additional revenue to deficit	Share of additional revenue needed to reach 2030 health SDGs
	Total (in million USD)	per capita		Total	per capita		Total (in million USD)	per capita		
India	29 538	23	1.4%	104 442	80	57	3 548	4	7%	1%
Indonesia	9 674	38	1.1%	43 097	167	130	7 779	35	27%	7%
Bangladesh	1 385	9	0.7%	9 754	61	52	901	6	11%	1%
Philippines	4 667	46	1.6%	14 623	145	99	804	6	6%	1%
Vietnam	7 058	77	3.6%	9 680	106	29	983	11	37%	2%
Armenia	210	69	2.0%	526	174	105	119	36	35%	8%
China	321 085	234	2.9%	553 233	403	169	41 065	27	16%	6%
Mexico	44 528	351	3.9%	57 190	450	100	1 427	11	11%	2%
Thailand	12 034	177	3.0%	19 758	291	114	1 233	24	21%	6%
Chile	10 098	563	4.2%	12 040	671	108	924	40	37%	10%
Turkey							3 046	65	NA	16%
Brazil			already attained the target threshold				2 763	14	NA	4%
Colombia							162	4	NA	1%
Median	**9886**	**73**	**2.4%**	**17191**	**171**	**103**	**1108**	**18**	**19%**	**4%**

Derivation of outcomes

We estimated the impact of a 50% price increase in cigarette prices on the following health and financial outcomes for each of the 13 countries:

a. Baseline number of male smokers by age and quintiles
b. Years of life gained after price intervention
c. Treatment cost averted
d. Individuals averting catastrophic health expenditures and poverty
e. Additional tax revenue

Baseline number of male smokers by age and quintiles

Data Sources: (1) 2015 population from UN Population Division; (2) smoking prevalence, by quintile and age-group (5-year) from GATS and similar local surveys.

We defined a current smoker as one who smokes cigarettes either daily or at least once every week. We focused only on manufactured cigarettes and not on bidis, small and locally-grown cigarettes sold commonly in India and Bangladesh. We used asset index as measure of income. For countries without readily[Available asset index in their respective surveys, we used educational attainment as proxy, and applied the relative prevalence of smoking among illiterate or completion of primary, secondary or high school or college. The following countries have readily[Available asset index: Bangladesh, Philippines, Chile, Colombia, Armenia and Mexico.

Procedure:

In each quintile (i) and for each 5-year age group (a), we applied the estimates of smoking prevalence, $Prev_{a,i}$ from the most recent rounds of the Global Adult Tobacco Survey (GATS) or similar nationally representative survey for all $a > 15$. For future smokers i.e. $a < 15$ we assume the same smoking prevalence as for the 15-19 year olds. If P is the population and $P_{i,a}$ is the smoking prevalence of quintile i and age group a, then the baseline number, bl of smokers, $Sk_{bl,i,a}$ can be calculated by the following formula:

$$Smk_{\ bl,i,a} = \sum_{a=1}^{18} \sum_{i=5}^{5} P_{a,i}\, Prev_{a,i} \qquad \text{(i)}$$

Years of life gained after price intervention

Data Sources: (1) risk-reduction by age-group from Verguet et al; ⁽(81) and (2) model-based estimates from the IHME's Global Burden of Disease.

Procedure*:*

A price increase results in reduction of number of smokers and is subject to the responsiveness of smoker to price change. The price elasticity, ϵ of a smoker in turn is influenced by a and i. As per the literature, the ϵ for cigarettes is about -0.4 meaning a 50% price increase will reduce smoking by about 20%.[82,83] Of this reduction, about half (10%) is attributable to participation elasticity i.e. quitting by current smokers and half to demand elasticity resulting in less amount smoked. Consistent with the published literature showing greater price responsiveness in the young and among the poor[82,83], we doubled the national ϵ among younger smokers (15-24 years old), and also applied this higher price elasticity to future smokers below 15 years old that have not yet started to smoke.[84,85] Similarly, we used a relative weighted price elasticity matrix by income and age drawn from existing studies with the smokers in the bottom quintile (20%) of the population being more price responsive compared to the top quintile. Therefore, the number of quitters is estimated by:

$Quit_{\ i,a} = Smk_{\ bl,i,a} - Smk_{\ cur,i,a}$, where;

$$Smk_{\ cur,i,a} = Smk_{\ bl,i,a}\left(\frac{1}{2}\epsilon_p \frac{\Delta price}{price} + 1\right) \qquad \text{(ii)}$$

Among persistent smokers, about half of prolonged smokers who do not quit are killed by smoking. This risk is particularly relevant to smokers below age 35 years in LMIC who are likely to have smoked from early in adult life. [86] Here, we conservatively assumed half of current and future smokers would be killed, given that smoking cessation rates in most LMICs are far lower than that in high-income countries. [86,87] Reductions in the excess (all-cause) mortality from smoking are greatest in smokers who quit early in life (and naturally in those who do not start). We applied age-specific benefits of cessation from epidemiological studies in the US and the UK among men and women, [77,88,89] corresponding roughly 97% of smokers avoided excess mortality by quitting by at 15-44 to about 25% avoided excess mortality by quitting by age 65 years. We adopted the risk reduction estimates $RR(a)$ by age group from Verguet et al. Further, we fitted a cubic spline to derive the age-specific life years gained from smoking cessation for all ages $Y(a)$. [81] To be conservative, we ignored the beneficial effects of reduced smoking amount. We proportioned the reductions in overall mortality across income quintiles and across four main causes of smoking-related mortality: chronic obstructive pulmonary disease (COPD), stroke, heart disease and tobacco attributable cancers from model-based estimates from the

Global Burden of Disease. [15] For China and India, we were able to compare the GBD with direct large epidemiological studies, which yielded generally consistent results for male smoking deaths, but not for women where the GBD estimated wrongly that about 8% of Chinese adult female deaths are due to smoking when the prevalence of adult female smoking is only 2% and even lower in the cohort of women born after 1950. [89] This discrepancy did not, however affect the calculations for males. The total deaths averted are estimated by:

$$D_{averted,i} = (\frac{1}{2}\sum_{a=1}^{18} Quit_{i,a})\, RR(a) \quad \text{(iii)}$$

Further, the life years gained (LYG) are estimated by:

$$LYG_{i,a} = \left(Quit_{i,a}\right) Y(a) \quad \text{(iv)}$$

Treatment cost averted

Data Sources: (1) treatment cost, insurance coverage rate, financial support, and healthcare utilization were obtained from peer-reviewed journals and country reports; (2) Purchasing Power Parity (PPP) adjustment factor, and Consumer Price Index were obtained from World Bank

Procedure:

We calculated the treatment cost averted by smokers who quit after price intervention. We obtained local treatment cost estimates, C_d for each of the 4 disease conditions d each country. To equalize the purchasing power of local currencies, we adjusted our cost estimates using a 2015 PPP conversion factor. We estimated the averted total healthcare expenditure (treatment cost), $TC_{averted,i,d}$ conditional to seeking health-care or being ill, HC using the following formula:

$$TC_{averted,i,d} = D_{averted,i,d}\, C_d HC_{i,d} \quad \text{(v)}$$

We also derived the averted OOP health expenditure, $OOP_{averted,i,d}$ by adjusting the treatment cost with coverage rate of the publicly-funded system, Cov, probability of seeking health-care conditional on being ill, HC, and the percentage of total costs covered by the public healthcare system, $Copay$:

$$OOP_{averted,i,d} = D_{averted,i,d}\, HC_{i,d}\, EC \text{ where, } EC = Cov\, Copay\, C_d \quad \text{(vi)}$$

Individuals averting catastrophic health expenditures and poverty

Data Sources: (1) Gini Coefficient from the World Bank; (2) average household income capita (2015) were obtained from statistical offices of countries (PPP-adjusted).

Procedure:

Individuals averting catastrophic health expenditures i.e. greater than 10% of their income, attributable to tobacco: We applied the World Bank definition of poverty i.e. earn less than US$ 1.9 /day/capita, World Health Organization's definition of catastrophic health expenditures meaning when out-of-pocket treatment costs exceed 10% of an individual's income for our analysis. We used average household income per capita obtained from statistics offices of respective countries and Gini Coefficient from World Bank to construct gamma distribution of per capita household income.[90] The probability $P_{i,d}$ of individuals falling into poverty or incurring catastrophic health expenditures was derived from this distribution of household income. We estimated the total number of individuals having catastrophic health care expenditures attributed to out-of-pocket cost $C_d EC$ that would be averted by a 50% increase in price by following formula:

$$\sum_d D_{averted,i,d}\, P_{i,d} HC_{i,d}$$

Additional tax revenue

Data Sources: (1) price of most sold brand cigarette, and the share of tax to retail price from the World Health Organization; (2) average number of cigarette of current smokers from GATS.

Procedure:

The tax collected at the baseline is given by the formula:

$$Total\ tax_{bl,q} = Smk_{\ bl,i,a}\ \left(365\frac{Cig_q}{20}\right) TR_{bl} \text{ and,} \quad \text{(vii)}$$

$$Total\ tax_{post,q} = Smk_{\ cur,i,a}\ \left(365\frac{Cig_q}{20}\right) TR_{new}, \text{ where;} \quad \text{(viii)}$$

Cig_q is the average number of sticks consumed by smokers in quintile q, TR_{bl} is the tax rate per pack of cigarettes at the baseline, and TR_{new} is the new tax rate post price increase. Thus, marginal tax revenues, $MTax_i$ gained is given by:

$$MTax_i = Total\ tax_{post,q} - Total\ tax_{post,q} \quad \text{(ix)}$$

References for the supplementary appendix:

1. World population prospects: the 2015 Revision New York, NY: United Nations, Department of Economic and Social Affairs, Population Division 2015 [Available from: https://esa.un.org/unpd/wpp/] (Accessed June 15, 2017)
2. International Institute for Population Sciences. Global Adult Tobacco Survey: India report. Mumbai, India. Indian Ministry of Health and Family Welfare. 2010.
3. Indonesia Global Adult Tobacco Survey 2011. Ministry of Health, CDC Foundation, U.S. Centre for Disease Control and Prevention, World Health Organization. Jakarta. 2012.
4. Ministry of Health and Family Welfare. Global Adult Tobacco Survey: Bangladesh report. World Health Organization, 2009.
5. Food and Nutrition Research Institute. 8th National Nutrition Survey: report (Philippines). Taguig City. 2014.
6. Ministry of Health Viet Nam, Hanoi Medical University, General Statistics Office of Vietnam, U.S. Centre for Disease Control and Prevention, World Health Organization. Global Adult Tobacco Survey Viet Nam-2010. 2010.
7. Postolovska I, Lavado RF, Tarr G, Verguet S. Estimating the distributional impact of increasing taxes on tobacco products in Armenia: results from an extended cost-effectiveness analysis. Washington DC: The World Bank; 2017.
8. Verguet S, Gauvreau CL, Mishra S, Maclennan M, Murphy SM, Brouwer ED, et al. The consequences of tobacco tax on household health and finances in rich and poor smokers in China: an extended cost-effectiveness analysis. Lancet Glob Heal 2014;3(4):14–8.
9. Instituto Nacional de Salud Publica, U.S. Center for Disease Control and Prevention, CDC Foundation, World Health Organization, Johns Hopkins Bloomberg School of Public Health, International R. Global Adult Tobacco Survey 2015 (Mexico). 2016.
10. Public Health Institution of Turkey, Turkish Statistical Institute, Hacettepe University, CDC Foundation, U.S. Center for Disease Control and Prevention, World Health Organization. Global Adult Tobacco Survey 2012 (Turkey). Ankara: Ministry of Health. 2014.
11. Ministerio de Saude, Instituto de Nacional de Cancer, Instituto Brasileiro de Geografia e Estatistica, U.S. Centers for Disease Control and Prevention B, Pan-American Health Organization, Health. Global Adult Tobacco Survey 2008 (Brazil). 2010.
12. National Government of the Republic of Colombia. Estudio nacional de consumo de sustancias psicoactivas de Colombia 2013. 2014.
13. Ministry of Public Health, World Health Organization, U.S. Centre for Disease Control and Prevention. Global Adult Tobacco Survey 2011 (Thailand). 2011.
14. Ministerio de Salud. Encuesta Nacional de salud Chile 2009-2010. 2010.
15. Institute for Health Metrics and Evaluation (IHME). GBD Compare data visualization. Vol. 2017. Seattle, WA: IHME, University of Washington; 2016. [Available from: http://vizhub.healthdata.org/gbd-compare] (Accessed May 20, 2017)
16. Aras D, Aydoğdu S, Bozkurt E, Cavuşoğlu Y, Eren M, Erol Ç, et al. Cost of heart Failure Management in Turkey: Results of a Delphi Panel. Anatol J Cardio 2016; 16:554–62.
17. Asil T, Celik Y, Sut N, Dogan A, Balci K, Yilmaz A, et al. Cost of acute ischemic and haemorrhagic stroke in Turkey. Clin Neurol Neurosurg 2011;113(2):111–4. [Available from: http://dx.doi.org/10.1016/j.clineuro.2010.09.014] (Accessed May 15, 2017)
18. Tedavi H, Koah E, Maliyeti A. The cost of COPD exacerbations managed in hospital. Turk Toraks Derg 2013; 14:19–23.
19. Pichon-Riviere A, Bardach A, Augustovski F, Alcaraz A, Reynales- Shigematsu LM, Pinto MT, et al. Economic impact of smoking on health systems in Latin America: A study of seven countries and its extrapolation to the regional level. Pan-American Journal of Public Health 2016;40(4):1–9.

20. Ross H, Trung DV, Phu VX. The costs of smoking in Vietnam: the case of inpatient care. Tobacco Control 2007;405–10.

21. Le T, Nguyen T, Nguyen H, Nguyen N. Inpatient treatment cost of stroke: an analysis in Ho Chi Minh City 115 People's Hospital, Vietnam. Value Heal 2016;9(7):649.

22. Sutrisna B, Surtidewi L, Jusuf A, Hudoyo A, Kusmana D, Setianto B, et al. Estimating the annual cost of smoking-related diseases in Indonesia. Media Med 2009;43(18):247–53.

23. Leartsakulpanitch J. The economic burden of smoking-related disease in Thailand: a prevalence-based analysis. J Med Assoc Thai 2007;90(9):1925–9.

24. Kuptniratsaikul V, Kovindha A, Massakulpan P, Kuptniratsaikul PS. Inpatient rehabilitation services for patients after stroke in Thailand: a multi-centre study. J Rehabil Med 2009; 41:684–6.

25. World Health Organization. Impact of tobacco-related illnesses in Bangladesh. 2005.

26. Ulep V, dela Cruz N. Analysis of out-of-pocket expenditures in the Philippines. Philipp J Dev 2013; 1072:93–122.

27. Philippine Health Insurance Corp. Implementing guidelines on medical and procedures case rates. Philippines: Philippine Health Insurance Corporation; 2013. [Available from: https://www.philhealth.gov.ph/circulars/2013/annexes/circ35_2013/] (Accessed June 8, 2017)

28. Fuchs A, Meneses F. Are tobacco taxes really regressive? Evidence from Chile. Washington DC: The World Bank; 2017.

29. Lagomarsino G, Garabrant A, Adyas A, Muga R, Otoo N. Moving towards universal health coverage: health insurance reforms in nine developing countries in Africa and Asia. Lancet 2012;380(9845):933–43. [Available from: http://dx.doi.org/10.1016/S0140-6736(12)61147-7] (Accessed June 15, 2017)

30. Brown C, Pagan J, Rodriguez-Orregia E. The decision-making process of health care utilization in Mexico. Health Policy 2005; 72:81–91.

31. Frenz P, Delgado I, Kaufman JS, Harper S. Achieving effective universal health coverage with equity: evidence from Chile. Health Policy Plan 2014; 717–31.

32. Van Minh H, Xuan Tran B. Assessing the household financial burden associated with the chronic non-communicable diseases in a rural district of Vietnam. Glob Health Action 2012; 5:1–7.

33. Blay SL, Fillenbaum GG, Andreoli SB, Leite F, Blay SL, Fillenbaum GG, et al. Equity of access to outpatient care and hospitalization among older community residents in Brazil. Med Care 2008;46(9):930–7.

34. OECD. OECD Reviews of health care quality: Turkey 2014: raising standards. 2014.

35. Boccolini CS, Roberto P, Souza B De. Inequities in healthcare utilization: results of the Brazilian National Health Survey, 2013. Int J Equity Health 2016;1–8. [Available from: http://dx.doi.org/10.1186/s12939-016-0444-3] (Accessed July 3, 2017)

36. Uddin J, Alam N, Sarma H, Ashique M, Chowdhury H, Alam DS, et al. Consequences of hypertension and chronic obstructive pulmonary disease, healthcare-seeking behaviours of patients, and responses of the health system: a population-based cross-sectional study in Bangladesh. BMC Public Health 2014;1–11.

37. Rokx C, Schieber G, Harimurti P, Tandon A, Somanathan A. Health financing in Indonesia. Washington DC: The World Bank; 2009.

38. Sözmen K, Ünal B. Explaining inequalities in health care utilization among Turkish adults: Findings from Health Survey 2008. Health Policy 2016;120(1):100–10. [Available from: http://dx.doi.org/10.1016/j.healthpol.2015.10.003] (Accessed July 5, 2017)

39. Philippine Statistical Authority, ICF International. 2013 National Demographic and Health Survey Report. Manila, Philippines; 2014.

40. Netithanakul A, Soonthorndhada K. Equity in health care utilization of the elderly: evidence from Kanchanaburi DSS, Thailand. J Popul Soc Stud 2009;18(1):103–22.

41. Núñez A, Chi C. Equity in health care utilization in Chile. Int J Equity Health 2013;1–16.

42. Thi N, Ha H, Berman P, Larsen U. Household utilization and expenditure on private and public health services in Vietnam. Health Policy Plan 2002;17(1):61–70.

43. Amaya-Lara JL. Catastrophic expenditure due to out-of- pocket health payments and its determinants in Colombian households. Int J Equity Health 2016;1–11[Available from: http://dx.doi.org/10.1186/s12939-016-0472-z

44. Boniilla-Chacín ME, Aguilera N. The Mexican social protection system in health. 2013.

45. Bitrán R, Escobar L, Patricia G. After Chile's Health Reform: Increase in coverage and access, decline in hospitalization and death rates. Health Aff 2010; 29(12):2161–2170.

46. Zhang Y, Tang W, Zhang X, Zhang Y, Zhang L. National health insurance development in China from 2004 to 2011: Coverage versus benefits. 2015;1–10.

47. Van Tien T, Thi Phuong H, Mathauer I, Phuong N. A health financing review of Vietnam: with a focus on social health insurance. 2011.

48. Paim J, Travassos C, Almeida C, Bahia L, Macinko J. The Brazilian health system: history, advances and challenges. Lancet 2011; 6736(11).

49. Yardim MS, Cilingiroglu N, Yardim N. Catastrophic Health expenditure and impoverishment in Turkey. Health Policy. Jan;94(1):26-33. [Available from: http://dx.doi.org/10.1016/j.healthpol.2009.08.006] (Accessed July 10, 2017)

50. Mahendradhata YD, Trisnantoro L, Listyadewi S, Harimurti PW, Prawira J. The Republic of Indonesia health system review. Vol. 7. 2017.

51. Philippine Health Insurance Corp. PhilHealth Stats and Charts 2014. 2014.

52. Shijith V, Sekher T. Who gets health insurance coverage in India? New findings from nationwide surveys. In: XXVII IUSSP International Population Conference. 2013. p. 1–26.

53. Mustafa A, Begum T. Universal health coverage assessment People's Republic of Bangladesh. 2014;(December):1–16.

54. Tangcharoensathien V, Patcharanarumol W, Ir P, Aljunid SM, Mukti AG, Akkhavong K, et al. Health-financing reforms in southeast Asia: challenges in. Lancet 2011;377(9768):863–73. [Available from: http://dx.doi.org/10.1016/S0140-6736(10)61890-9] (Accessed May 20, 2017)

55. Huq NM, Al-amin AQ, Howlader SR. Paying out-of-pocket for healthcare in Bangladesh - A burden on poor? Iran J Public Heal 2015;44(7):1024–5.

56. Schrepel C, Tanenbaum E, Paccione GA. How do patients view Chile's AUGE plan? A survey in a rural clinic. Soc Med 2014;8(3):101–12.

57. Instituto Brasileiro de Geografia e Estatistica. Censos Demograficos 2010. [[Available from: ftp://ftp.ibge.gov.br/Censos/Censo_Demografico_2010] (Accessed April 2, 2017)

58. National Bureau of Statistics of China. Household consumption and expenditure 2015. [Available from: http://data.stats.gov.cn/english/easyquery.htm?cn=C01] (Accessed May 2, 2017)

59. National Statistics Office (Thailand). 2015 Household Socio-economic Survey. 2016. [Available from: http://web.nso.go.th/en/survey/house_seco/data/Full_Report2015.pdf] (Accessed May 2, 2017)

60. Philippine Statistical Authority. Income and expenditure. 2016. [Available from: https://psa.gov.ph/survey/annual-poverty-indicator] (Accessed June 18, 2017)

61. General Statistics Office of Vietnam. Monthly average income per capita at current prices by income source and by province. 2010. [Available from: http://www.gso.gov.vn/default_en.aspx?tabid=487&ItemID=4327] (Accessed July 13, 2017)

62. Bangladesh Bureau of Statistics. Bangladesh - Household Income and Expenditure Survey 2010. Dhaka; 2012.

63. Turkish Statistical Institute. Turkish Statistical Institute Income and Living Conditions Survey- 2015. 2016. [Available from: http://www.turkstat.gov.tr/PreHaberBultenleri.do?id=21584] (Accessed July 18, 2017)

64. National Statistics Service of the Republic of Armenia. Household income, expenditure, and basic food consumption 2010-2014. 2015. [Available from: http://www.armstat.am/file/article/6._poverty_2015e_3.pdf] (Accessed June 18, 2017)

65. Instituto Nacional de Estadística y Geografia. 2014 National Survey of Household Expenditure. 2016.

66. World Bank. Gini Index. 2016. [Available from: http://data.worldbank.org/indicator/SI.POV.GINI] (Accessed June 17, 2017)

67. Eozenou P, Fishburn B. Price elasticity estimates of cigarette demand in Vietnam. Florence, Italy; 2001

68. Nargis N, Ruthbah UH, Hussain AKMG, Fong GT, Huq I, Ashiquzzaman SM. The price sensitivity of cigarette consumption in Bangladesh: evidence from the International Tobacco Control (ITC) Bangladesh Wave 1 (2009) and Wave 2 (2010) Surveys. Tob Control. 2014;23 Suppl 1(0 1): i39-47. [Available from: http://www.ncbi.nlm.nih.gov/pubmed/24105828%5Cnhttp://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=PMC4090419] (Accessed June 13, 2017)

69. Adioetomo M, Djutaharta T, Hendratno. Cigarette consumption, taxation, and household income: Indonesia case study. Washington D.C.; 2005.

70. Barber S, Adioetomo M, Ahsan A, Setyonaluri D. Tobacco economics in Indonesia. 2008.

71. John RM. Price elasticity estimates for tobacco products in India. Heal Policy Plan. 2008;23(3):200–9. [Available from: http://www.ncbi.nlm.nih.gov/pubmed/18424474] (Accessed June 28, 2017)

72. Maldonado N, Llorente B, Deaza J. Cigarette taxes and demand in Colombia. Rev Panam Salud Publica.2016;40(4):229–36. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/28001198] (Accessed June 8, 2017)

73. Quimbo SLA, Casorla AA, Miguel-Baquilod M, Medalla FM, Xu X, Chaloupka FJ. The economics of tobacco and tobacco taxation in the Philippines. 2012.

74. Sánchez DD. Economía del control del tabaco en los países del mercosur y estados asociados: Chile. Washington D.C.: Pan American Health Organization; 2006. [Available from: http://iris.paho.org/xmlui/handle/123456789/2811] (Accessed June 18, 2017)

75. Sarntisart I. An economic analysis of tobacco control in Thailand. Health, Nutrition and Population. Washington D.C.: The World Bank; 2003.

76. Jimenez-Ruiz JA, Saenz de Miera B, Reynales-Shigematsu LM, Waters HR, Hernandez-Avila M. The impact of taxation on tobacco consumption in Mexico. Tob Control. 2008;17(2):105–10. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/18285383] (Accessed July 6, 2017)

77. Postolovska I, Lavado R, Tarr G, Verguet S. Estimating distributional impact of increasing tobacco taxes in Armenia: Results from an extended cost-effectiveness analysis. Washington DC: The World Bank; 2017.

78. Hu TW, Mao Z, Shi J, Chen W. The role of taxation in tobacco control and its potential economic impact in China. Tob Control 2010;19(1):58–64. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/20008158] (Accessed July 5, 2017)

79. Yürekli A, Önder Z, Elibol M, Erk N, Cabuk A, Fisunoglu M, et al. The economics of tobacco and tobacco taxation in Turkey. Int Union Against Tuberc Lung Dis 2010

80. World Bank. PPP Conversion Factor. 2016.

81. Verguet S, Tarr G, Gauvreau C, Mishra S, Jha P, Liu L. Distributional benefits of tobacco tax and smoke-free workplaces in China: a modeling study. J Glob Health 2017; in press.

82. Gallet CA, List JA. Cigarette demand: a meta-analysis of elasticities. Heal Econ. 2003;12(10):821–35. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/14508867] (Accessed July 8, 2017)

83. IARC. Effectiveness of tax and price policies for tobacco control: IARC handbook of cancer prevention. Vol. 14. Lyon, France: International Agency for Research on Cancer; 2011.

84. Pirie K, Peto R, Reeves GK, Green J, Beral V, Million Women Study C. The 21st century hazards of smoking and benefits of stopping: a prospective study of one million women in the UK. Lancet 2013;381(9861):133-41.

85. Jha P, Ramasundarahettige C, Landsman V, Rostron B, Thun M, Anderson RN, et al. 21st-century hazards of smoking and benefits of cessation in the United States. N Engl J Med 2013;368(4):341-50.

86. Doll R, Peto R, Boreham J, Sutherland I. Mortality from cancer in relation to smoking: 50 years of observations on British doctors. Br J Cancer 2005;92(3):426–9. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/15668706] (Accessed July 6, 2017)

87. Peto R, Lopez AD, Boreham J, Thun M, Heath Jr. C. Mortality from tobacco in developed countries: indirect estimation from national vital statistics. Lancet 1992;339(8804):1268–78. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/1349675] (Accessed July 6, 2017)

88. Jha P, Joseph RA, Li D, Gauvreau C, Anderson I, Moser P, et al. Tobacco Taxes: A win-win measure for fiscal space and health. Mandaluyong City, Philippines: Asian Development Bank; 2012.

89. Chen Z, Peto R, Zhou M, Iona A, Smith M, Yang L, et al. Contrasting male and female trends in tobacco-attributed mortality in China: evidence from successive nationwide prospective cohort studies. Lancet 2015;386(10002):1447–56. [Available from: https://www.ncbi.nlm.nih.gov/pubmed/26466050] (Accessed July 8, 2017)

90. Kemp-Benedict E. Income distribution and poverty methods for using available data in global analysis. 2001.