Sin Taxes and Public Health: Political Process and Distributional Consequences in Mexico and Colombia

SIN TAXES AND PUBLIC HEALTH: POLITICAL PROCESS AND DISTRIBUTIONAL CONSEQUENCES IN MEXICO AND COLOMBIA

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ABSTRACT

As the burden of non-communicable diseases (NCDs) increases globally and more money is spent treating NCDs, effective solutions that prevent NCDs, while also generating fiscal revenues, are urgently needed. This dissertation uses qualitative and quantitative methods to assess two such policies: a sugar-sweetened beverage (SSB) tax in Mexico and an increased tobacco tax in Colombia. By looking at how sin-taxes are passed and at the effects of such taxes on population health and finances, this thesis provides insight into two key parts of the policy making process, namely passage, and simulation and evaluation.

Chapter One provides an overview of and some conclusions to the dissertation.

In Chapter Two, I use published documents, media articles, and interviews with key stakeholders to present a single case study on the politics of passage of the SSB tax in Mexico. This chapter explains how Mexico managed to pass an SSB tax despite opposition from a strong national SSB industry, offering important lessons for policymakers within Mexico and in other countries in developing their own strategies in passing sin taxes.

In Chapter Three, I examine the potential distributional impact (across socio-economic groups) of Mexico's SSB tax on delayed mortality rates from cardiometabolic disease and on tax revenues. Using an extended cost-effectiveness analysis framework (ECEA), I find that although the poor would benefit the most in terms of delayed death rates from the SSB tax, they would also pay a larger share of their annual income on taxes.

Chapter Three uses an ECEA framework to assess the distributional impact of Colombia's tobacco tax increase on selected health and financial outcomes. I find that the tobacco tax increase would have substantial implications for the country's population health and financial well-being, with large health benefits likely to accrue to those quitting smoking and those not initiating smoking, among the two poorest quintiles of the population. Those among the poorest income quintiles who continue smoking, however, would see the largest financial losses as a result of the tobacco tax increase.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

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CHAPTER ONE: INTRODUCTION AND DISSERTATION OVERVIEW

MOTIVATION AND BACKGROUND

In 2017, non-communicable diseases (NCDs) accounted for about 73% of global deaths, equivalent to about 41 million deaths per year [1]. All age groups are at risk for NCDs; in 2017, there were about 15 million global deaths occurring between the ages of 30 and 69, primarily in low- and middle-income countries (LMIC) [1]. Meanwhile, within countries, the poor are especially vulnerable to most NCDs and often die sooner than the rich [2,3]. The Latin America and Caribbean (LAC) region is no exception, with almost 2.6 million deaths from NCDs in 2017, making up about 76% of total deaths estimated for that year [1]. This represents an almost 90% increase in the number of NCD deaths in the region between 1990 and 2017 [1]. Cardiovascular diseases, neoplasms, and diabetes and chronic kidney diseases were the top three leading causes of death in LAC in 2017 accounting for about 54% of total deaths in the region [1]. Colombia and Mexico, the two countries in LAC that are foci of this thesis, have experienced similarly striking increases in NCDs. Between 1990 and 2017, NCD deaths in Mexico increased by about 120%, while in Colombia they increased by about 90% [1].

The rise in NCDs in the region is driven by a complex array of factors, including demographic and epidemiologic changes coupled with increasing prevalence of behavioral risk factors for NCDs [4]. While these trends are not evenly distributed between and within countries in LAC, generally speaking the region has moved from one of high fertility and mortality rates to one of lower fertility and mortality, giving rise to an aging population [4,5]. As populations in LAC age, the incidence of NCDs increases [6]. Meanwhile, countries in LAC have made great, albeit uneven, progress, in controlling infectious diseases [7]. In 1990, infectious diseases were among the top three causes of death in LAC; however, in

2017, NCDs and injuries ranked among the top three causes of death in the region [1]. The third main factor driving the rise of NCDs in LAC is increasing prevalence of behavioral risk factors, such as alcohol and tobacco consumption as well as rising overweight and obesity rates [7,8].

This dissertation examines smoking and obesity in LAC, since they are two of the most important behavioral risk factors for NCDs [8]. In LAC, tobacco was responsible for about 13% of all deaths in 2017 [1]. In 2016, an estimated 14% of the adult population, defined as those above the age of 19, in LAC smoked, compared to the global average of 20%; however, 9% of adult women in LAC smoked versus 6% of adult women globally [9]. In Colombia, smoking was the third leading risk factor for mortality in 2013 [1]. Meanwhile, in 2016, the Americas as a region led the world in prevalence of overweight (BMI ≥ 25 kg/m^2) among adults at almost 63%, compared to 39% globally [10]. The highest prevalence of obesity (BMI≥ 30 kg/m^2) in the world was also found in the Americas, where about 29% of the adult population was obese in 2016, which is greater than the global adult prevalence of about 13% [11]. In Mexico, the prevalence of overweight and obesity was similar to the LAC region, with an adult prevalence of overweight of almost 65% and of obesity of almost 29% in 2016 [12,13]. The determinants of overweight and obesity are complicated, but research has identified the behavioral determinants of overweight and obesity to include a combination of increasing consumption of energy-dense and processed foods coupled with a decrease in physical activity [8,14].

While global commitment to and knowledge on tobacco control are well established, less is known about how to address the determinants of the obesity epidemic. In 2005, the World Health Organization's (WHO) Framework Convention for Tobacco Control (FCTC)

came into force and legally bound ratifying countries to implement strong evidence-based policies to decrease tobacco consumption [15]. In LAC, 30 of 35 countries have ratified the FCTC, including Colombia and Mexico [15]. The treaty commits countries to adopt policies such as price and tax measures, labeling requirements, smoke-free environments, and advertising bans aimed at decreasing demand for tobacco products [16]. The FCTC also encourages the implementation of policies to inhibit the supply of tobacco products, such as prohibiting the sale of tobacco products to minors and tracking mechanisms to prevent smuggling of tobacco products [16]. No similar treaty exists with respect to obesity; moreover, policies aimed at addressing obesity that focus on individual behavior change are often ineffective and are not scalable to the population level [17,18]. Policy makers are increasingly looking to the tobacco control policies enshrined in the FCTC for ideas on addressing the obesity epidemic [19–21].

One such policy measure that is increasingly adopted in LAC is the use of specific excise taxes on tobacco and sugar-sweetened beverages (SSBs) to address two major behavioral risk factors for NCDs [8]. Specific excise taxes are selective and uniform taxes on goods and services, that increase all taxed items by the same amount, as in one peso-per-liter for Mexico's soda tax, which, when passed on completely by the producer, reduces the price difference between expensive and lower priced brands [22]. If the purpose of a tax is to decrease consumption, excise taxes are generally preferred to value-added-taxes (VAT), which are not usually discriminatory and tend to increase price differences between products [22]. Studies show that increasing prices of cigarettes through excise taxes, decreases cigarette consumption, thereby reducing the burden of disease stemming from

tobacco consumption [23–26]. Indeed, tobacco taxes are promoted as one of the most effective policies in decreasing tobacco consumption [27].

While taxes on tobacco for health have been implemented widely over a long period of time, taxes on SSBs as a means of improving population health are rather new [21]. Taxes on SSBs aim at curbing an important contributor to obesity in LAC, since increased consumption of SSBs in LAC has been identified as one of the causes of the obesity epidemic [8]. In Mexico this is a particularly acute problem, since in 2012, Mexicans were found to derive almost 10% of their calories from SSBs, which is almost six percentage points above WHO recommendations [28]. Studies show that SSB taxes function similar to those on tobacco, namely, they decrease consumption of SSBs and have the potential to improve population health [29–31]. Both SSB and tobacco taxes have the ability to increase government revenues, while reducing the burden of NCDs and spending on healthcare, particularly among the poor and young [21,26,32–38].

Although there is increasing global attention to using taxes as a means of improving population health, little is known on how such taxes emerge on a government's decision making agenda, are introduced as legislation, and subsequently passed in the legislatures. Furthermore, evidence on the health and financial impacts of such taxes is limited. Using the Mexican soda tax and the increased tobacco taxes in Colombia as case studies, this thesis aims to contribute to knowledge about how to develop strategies to pass excise taxes on potentially harmful products as laws and on the potential distributional impacts (by income group) of "sin" taxes.

DISSERTATION OVERVIEW AND STRUCTURE

This thesis uses both qualitative and quantitative methods to examine an SSB tax in Mexico and a tobacco tax in Colombia.

Paper I (Chapter Two): The politics of taxes for health: an analysis of the passage of the SSB tax in Mexico

Using published documents, media articles, and interviews with key stakeholders, I present a single case study on the politics of passage of the SSB tax in Mexico. This paper examines two periods that were critical in the passage of the tax. The first period is agenda setting, taking place between mid-2012 and September 8, 2013, when the tax was adopted as part of the President's fiscal reform package. The second period is legislative passage, beginning on September 8, 2013, when the bill was passed along in Congress and ending when the tax was passed in late October 2013. I use John Kingdon's three streams theory on agenda setting, which is often used to explain the passage of health policies [39–42], to demonstrate how the tax emerged on the agenda and how the process of agenda setting shaped and enabled the legislative passage of the tax in the Mexican Congress.

This paper offers important lessons for policymakers within Mexico and in other countries in developing their own strategies in passing sin taxes. The first lesson of this analysis is that passing an SSB tax was difficult and involved high-level organization, co-operation, strategic planning, and concerted effort. In order to develop political strategies to pass the tax in Mexico, an understanding of the political and economic context was crucial. Framing the tax as a means of generating revenue for the federal government was a powerful tool in getting the tax proposal onto the policy agenda and enabled buy-in from

the Ministry of Finance and Public Credit (known as *Hacienda* in Mexico for short). This buy-in was crucial, since within the government, Hacienda drove the tax with little involvement from the Ministry of Health. Forming networks within the legislature early on in the attempt to pass a SSB tax was also important, since it allowed the proponents of the tax to have a network of allies within congress when the SSB tax was introduced as a bill in the Mexican legislature. Another important strategy was early public relations campaigns to sway public perception that the obesity epidemic was driven in part by SSB consumption.

This is the first paper that uses political science theory and primary data collection with a broad range of stakeholders, to explain how Mexico managed to pass an SSB tax despite opposition from a strong national SSB industry.

Paper II (Chapter Three): Modeling the distributional impacts of a sugar-sweetened beverage tax on Mexicans' health and finances

The soda tax in Mexico was justified to the public as a means of curbing the obesity and cardiometabolic disease epidemics, while providing the government with a new source of revenue [43–45]. Given this justification, building on extended cost-effectiveness analysis (ECEA) methods [46–48], we model the impact of the tax on both delayed death rates due to cardiometabolic diseases and tax revenues, including the percentage of income spent on additional taxes, per socioeconomic group. ECEA was designed to study the impact of policy along three dimensions: health benefits, out-of-pocket (OOP) expenditure "crowded out" for households and individuals with the associated financial risk protection provided (e.g. cases of catastrophic health expenditure averted), and distributional

consequences (e.g. across socioeconomic groups, geographical settings). Since a common argument against the SSB tax was its regressivity [21], ECEA allows for the assessment of this claim by comparing the projected health benefits and tax revenues across income tertiles.

We used a biological weight loss model [49] to estimate the expected body-mass index (BMI) reduction due to the tax five years after implementation, an epidemiological disease model to project the effects of BMI reductions on delayed cardiometabolic deaths, and a distributional model [36,50] to examine the effects of the SSB tax on health and finances by income tertile. We provide a range of estimates for the impact of the SSB tax on delayed death rates and tax revenues by using two observed consumption change scenarios, both varying by income tertile. The first scenario has consumption of SSBs decreasing from 9.0% among the lowest tertile to 4.4% among the highest tertile, averaging to a 5.5% decrease; the second scenario uses a decrease in consumption ranging from 14.3% among the lowest tertile to 5.6% among the highest tertile, averaging to a 9.7% decline [34].

The analysis finds that in the fifth year after its implementation, the SSB tax would potentially delay between 3.2 and 5.9 cardiometabolic deaths per 100,000 Mexicans between the ages of 20 and 84. The largest delayed death rate would come from the poorest income tertile, with between about 3.7 and 7.1 delayed deaths per 100,000 people. In the years immediately following tax implementation, 20 to 84 year-olds would be expected to generate between 5,600 and 6,200 million Mexican pesos in revenue, with the poorest income tertile generating the lowest in mean annual taxes per person of 90 to 100 Mexican pesos. The poor, however, would spend the largest percentage of their annual

income on additional tax revenues, pointing to the potential regressivity in consumption of the tax.

In summary, the SSB tax in Mexico would produce some health benefits to the population, mostly concentrated among the poorest income tertile, however, the poor would also experience the greatest financial losses from the tax. The Mexican government, meanwhile, would benefit from a large new source of revenue.

Paper III (Chapter Four): The health, financial and distributional benefits of increased tobacco taxes in Colombia: results from a modeling study

In December 2016, Colombia passed a major tax increase on tobacco products in an effort to decrease smoking and improve population health [51]. While tobacco taxes are known to be highly effective in reducing the prevalence of smoking, they are often criticized as being regressive in consumption [21] – as in the case of SSB taxes. This analysis assesses the distributional impact (across socio-economic groups) of the new tobacco tax on selected health and financial outcomes.

This study builds on ECEA methods [35,46–48] to examine the new tobacco tax in Colombia, estimating the impact across income quintiles of the current urban population (80% of the country population) between the ages of 0 and 79. We evaluate the impact of the tax on years of life gained among those who quit or never initiate smoking, the financial costs to households of the tax among those who continue smoking, and the increased tax revenues, all associated with a 70% relative price increase of the pack of cigarettes.

The analysis shows that the tax increase would lead to an estimated 191,000 years of life gained among Colombia's current urban population over 20 years, with the most

years of life gained from the bottom two income quintiles. The additional annual tax revenues raised would amount to about 2-4% of Colombia's annual government health expenditures, with the poorest quintiles bearing the smallest tax burden increase. While we estimate greater health gains among the poorest income quintiles, the poor would spend a greater percentage of their income on tax revenues after the tax increase (0.5%) than the richest income quintile (0.1%).

The tobacco tax increase passed by Colombia would have substantial implications for the country's population health and finances through years of life gained, increased expenditures on cigarettes and on taxes. This analysis suggests that the tax is likely to be progressive in health, since the poorest quintiles are expected to get the largest share of years of life gained. However, it would likely be regressive in terms of cigarette consumption, with the poor paying a larger percentage of their income on additional cigarette taxes than the rich.

CONCLUDING REMARKS

As the burden of NCDs in LAC increases and more money is spent treating NCDs, effective solutions that prevent NCDs, while also generating fiscal revenues, are urgently needed. This dissertation uses qualitative and quantitative methods to assess two such policies. By looking at how sin-taxes are passed in Chapter Two (Paper I) and at the effects of such taxes on population health and finances in Chapters Three and Four (Papers II and III), this thesis provides insight into two key parts of the policy making process, namely passage, and simulation and evaluation. These two perspectives are complementary and linked. The evaluation of the impacts of the two sin-taxes helps to inform how such policies should be structured and how these existing policies could be improved, while the first

paper opens the black box of policy passage allowing those unfamiliar with the process insight into where, when, and how they can influence policy passage.

This dissertation highlights the need for greater understanding of how sin-taxes are passed and their potential health and financial impacts. By analyzing both the political passage and the impacts of sin taxes, we learned that what is politically feasible is not always the most effective at improving health outcomes. Using an ECEA framework allowed us to go beyond classic cost-effectiveness analysis to a more comprehensive understanding of the possible impacts of the taxes, namely across socioeconomic status. While the tobacco tax increase in Colombia represented a high enough increase in price to generate significant health benefits in terms of deaths delayed, the SSB tax in Mexico was small, compared to Colombia's tobacco tax, and we expect it to produce few premature deaths averted. In order to combat the obesity and diabetes epidemics in Mexico, policymakers in Mexico will need to rely on a broad range of policies, of which an SSB tax is only one part, while also considering an increase in the SSB tax rate so that it is more in line with the tax rates we observed for cigarettes in Colombia. Our exploration of the drivers of the passage of the SSB tax might be useful for policymakers as they consider raising the SSB tax [52]. Only by analyzing the politics of passage and the impacts of sin taxes in Mexico and Colombia can we produce better policies and generate the strategies to ensure their political passage.

REFERENCES

1. Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualizations [Internet]. 9 Nov 2018.
2. Williams J, Allen L, Wickramasinghe K, Mikkelsen B, Roberts N, Townsend N. A systematic review of associations between non-communicable diseases and socioeconomic status within low- and lower-middle-income countries. J Glob Health. 2018;8: 020409. doi:10.7189/jogh.08.020409
3. Discussion Paper: Addressing the Social Determinants of Noncommunicable Diseases [Internet]. New York, NY: United Nations Development Programme; 2013. Available: https://www.undp.org/content/dam/undp/library/hivaids/English/Discussion_Paper_Addressing_the_Social_Determinants_of_NCDs_UNDP_2013.pdf
4. Rivera-Andrade A, Luna MA. Trends and heterogeneity of cardiovascular disease and risk factors across Latin American and Caribbean countries. Prog Cardiovasc Dis. 2014;57: 276–285. doi:10.1016/j.pcad.2014.09.004
5. Rivera JA, Barquera S, Gonzalez-Cossio T, Olaiz G, Sepulveda J. Nutrition transition in Mexico and in other Latin American countries. Nutrition reviews. 2004;62: S149–S157. doi:10.1301/nr.2004.jul.S149-S157
6. Cotlear D. Population Aging: Is Latin America Ready? [Internet]. Washington, D.C: World Bank; 2011. Available: https://openknowledge.worldbank.org/handle/10986/2542
7. Health in the Americas+, 2017 Edition. Summary: Regional Outlook and Country Profiles [Internet]. Washington, D.C: Pan American Health Organization; 2017. Available: http://iris.paho.org/xmlui/handle/123456789/34321
8. WHO, PAHO, DCP3. Economic Dimensions of Non-Communicable Diseases in Latin America and the Caribbean. Washington, DC: PAHO; 2016.
9. DataBank: Smoking Prevalence [Internet]. Washington, D.C.: The World Bank; 2019. Available: https://data.worldbank.org/indicator/SH.PRV.SMOK.FE
10. Global Health Observatory data repository: Prevalence of overweight among adults, BMI>=25, age-standardized, Estimates by WHO Region [Internet]. Geneva, Switzerland: World Health Organization; 2019. Available: http://apps.who.int/gho/data/view.main.GLOBAL2461A?lang=en
11. Global Health Observatory data repository: Prevalence of obesity among adults, BMI>=30, age-standardized, Estimates by WHO region [Internet]. Geneva, Switzerland: World Health Organization; 2019. Available: http://apps.who.int/gho/data/view.main.REGION2480A?lang=en
12. Global Health Observatory data repository: Prevalence of overweight among adults, BMI>=25, age-standardized, Estimates by country [Internet]. Geneva, Switzerland: World Health Organization; 2019. Available: http://apps.who.int/gho/data/node.main.A897A?lang=en
13. Global Health Observatory data repository: Prevalence of obesity among adults, BMI>=30, age-standardized, Estimates by country [Internet]. Geneva, Switzerland: World Health Organization; 2019. Available: http://apps.who.int/gho/data/node.main.A897A?lang=en
14. Ultra-processed food and drink products in Latin America: Trends, impact on obesity, policy implications [Internet]. Washington, D.C: Pan American Health Organization;

2015. Available:
http://iris.paho.org/xmlui/bitstream/handle/123456789/7699/9789275118641_eng.pdf
15. Report on Tobacco Control for the Region of the Americas. WHO Framework Convention on Tobacco Control: 10 Years Later [Internet]. Washington, D.C: Pan American Health Organization; 2016. Available:
http://iris.paho.org/xmlui/bitstream/handle/123456789/28393/9789275118863_eng.pdf?sequence=1&isAllowed=y&ua=1
16. WHO Framework Convention on Tobacco Control. Geneva, Switzerland: World Health Organization; 2003.
17. Lv N, Azar KMJ, Rosas LG, Wulfovich S, Xiao L, Ma J. Behavioral lifestyle interventions for moderate and severe obesity: A systematic review. Preventive medicine. 2017;100: 180–193. doi:10.1016/j.ypmed.2017.04.022
18. Hardeman W, Griffin S, Johnston M, Kinmonth AL, Wareham NJ. Interventions to prevent weight gain: a systematic review of psychological models and behaviour change methods. Int J Obes Relat Metab Disord. 2000;24: 131–143.
19. Chopra M, Darnton-Hill I. Tobacco and obesity epidemics: not so different after all? Bmj. 2004;328.
20. Blecher E. Taxes on tobacco, alcohol and sugar sweetened beverages: Linkages and lessons learned. Social science & medicine (1982). 2015;136–137: 175–9. doi:10.1016/j.socscimed.2015.05.022
21. Chaloupka FJ, Powell LM, Warner KE. The Use of Excise Taxes to Reduce Tobacco, Alcohol, and Sugary Beverage Consumption. Annual review of public health. 2019; doi:10.1146/annurev-publhealth-040218-043816
22. Theory and practice of excise taxation : smoking, drinking, gambling, polluting, and driving. Oxford ; New York: Oxford University Press; 2005.
23. Linegar DJ, van Walbeek C. The effect of excise tax increases on cigarette prices in South Africa. Tob Control. 2017; doi:10.1136/tobaccocontrol-2016-053340
24. HIll C. Prix du tabac en France et conséquences sur les venters et sur la consommation. Bulletin Epidemiologique Hebdomadaire. 2010;
25. Jha P, Peto R. Global Effects of Smoking, of Quitting, and of Taxing Tobacco. The New England Journal of Medicine. 2014;370: 60–68. doi:10.1056/NEJMra1308383
26. IARC. Effectiveness of Tax and Price Policies for Tobacco Control. Lyon, France: World Health Organization; 2011.
27. WHO Technical manual on tobacco tax administration. Geneva, Switzerland: World Health Organization; 2010.
28. Aburto TC, Pedraza LS, Sanchez-Pimienta TG, Batis C, Rivera JA. Discretionary Foods Have a High Contribution and Fruit, Vegetables, and Legumes Have a Low Contribution to the Total Energy Intake of the Mexican Population. J Nutr. 2016;146: 1881S–7S. doi:10.3945/jn.115.219121
29. Andreyeva T, Chaloupka FJ, Brownell KD. Estimating the potential of taxes on sugar-sweetened beverages to reduce consumption and generate revenue. Preventive medicine. 2011;52: 413–6. doi:10.1016/j.ypmed.2011.03.013
30. Zhong Y, Auchincloss AH, Lee BK, Kanter GP. The Short-Term Impacts of the Philadelphia Beverage Tax on Beverage Consumption. American journal of preventive medicine. 2018;55: 26–34. doi:10.1016/j.amepre.2018.02.017

31. Wright A, Smith KE, Hellowell M. Policy lessons from health taxes: a systematic review of empirical studies. BMC public health. 2017;17: 583. doi:10.1186/s12889-017-4497-z
32. Chaloupka FJ, Grossman M. Price, Tobacco Control Policies and Youth Smoking. NBER; 1996.
33. Chaloupka FJ, Yurekli A, Fong G. Tobacco taxes as a tobacco control strategy. Tobacco control. 2012;21: 172–180.
34. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. Sustained consumer response: evidence from two-years after implementing a sugar sweetened beverage tax in Mexico. Health Affairs. 2017; 10.1377/hlthaff. 2016.1231.
35. Postolovska I, Lacado 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: World Bank; 2017.
36. 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. The Lancet Global Health. 2015;3: e206–e216. doi:10.1016/S2214-109X(15)70095-1
37. Verguet S, Tarr Gi, Gavreau C, Mishra S, Jha P, Liu L. Distributional benefits of tobacco tax and smoke-free workplace in China: a modeling study. Journal of Global Health. In Press;
38. Salti N, Brouwer E, Verguet S. The health, financial and distributional consequences of increases in the tobacco excise tax among smokers in Lebanon. Social Science & Medicine (1982). 2016; doi:10.1016/j.socscimed.2016.10.020
39. Blankenau J. The Fate of National Health Insurance in Canada and the United States: A Multiple Streams Explanation. Policy Studies Journal. 2001;29: 38–55. doi:10.1111/j.1541-0072.2001.tb02073.x
40. Kusi-Ampofo O. Resistance and Change: A Multiple Streams Approach to Understanding Healht Policy Making in Ghana. Journal of Health Politics, Policy and Law. 2015;40.
41. Ha BT, Mirzoev T, Mukhopadhyay M. Shaping the Health Policy Agenda: The Case of Safe Motherhood Policy in Vietnam. International Journal of Health Policy and Management. 2015;4: 741–6. doi:10.15171/ijhpm.2015.153
42. Mosier SL. Cookies, Candy, and Coke: Examining State Sugar-Sweetened-Beverage Tax Policy from a Multiple Streams Approach. International Review of Public Administration. 2013;18: 93–120. doi:10.1080/12294659.2013.10805242
43. Camara de Diputados LXII Legislatura. Gaceta Parlamentaia LXII Legislatura Camara De Diputados Jueves 17 de Octubre Anexo VIII. 2013.
44. Gobierno de los Estados Unidos Mexicanos, Camara de Diputados. Criterios Generales de Politica Economica 2014. 2013.
45. Senado de la Republica, Senado de la Republica C de H y CP. Comisiones Unidas de Hacienda y Crédito Público y de Estudios Legislativos, Segunda. 2013.
46. Verguet S, Laxminarayan R, Jamison DT. Universal Public Finance of Tuberculosis Treatment in India: An Extended Cost-Effectiveness Analysis. Health Economics. 2015;24: 318–332. doi:10.1002/hec.3019

47. Verguet S, Kim JJ, Jamison DT. Extended Cost-Effectiveness Analysis for Health Policy Assessment: A Tutorial. Pharmacoeconomics. 2016;34. doi:10.1007/s40273-016-0414-z
48. Verguet S, Jamison DT. Health policy analysis: Applications of extended cost-effectiveness analysis methodology. In: Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, editors. Disease Control Priorities. Third. Washington, DC: World Bank; 2017.
49. García Formentí DC, Zepeda Tello R. bw: Dynamic Body Weight Models for Chidlren and Adults, R package. 2018.
50. James EK, Saxena A, Franco Restrepo C, Llorente B, Vecino-Ortiz AI, Villar Uribe M, et al. Distributional health and financial benefits of increased tobacco taxes in Colombia: results from a modelling study. 2018; tobaccocontrol-2018-054378. doi:10.1136/tobaccocontrol-2018-054378 %J Tobacco Control
51. Ley 1819 del 29 de Diciembre de 2016 Cámara. Bogota, Colombia: El Congreso de Colombia; 2016.
52. Albarrán E. Piden elevar impuesto a refrescos y cigarros. El Economista. Mexico City, Mexico; 11 Oct 2017. Available: https://www.eleconomista.com.mx/economia/Piden-elevar-impuesto-a-refrescos-y-cigarros-20171011-0156.html. Accessed 29 Jan 2019.

CHAPTER TWO, PAPER I: THE POLITICS OF TAXES FOR HEALTH: AN ANALYSIS OF THE PASSAGE OF THE SODA TAX IN MEXICO

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ABSTRACT

Using published documents, media articles, and interviews with key stakeholders, we explore the politics of passage of the SSB tax in Mexico. This paper examines two periods that were critical in the passage of the tax. The first period is agenda setting, taking place between mid-2012 and September 8, 2013, when the tax was adopted as part of the President's fiscal reform package. The second period is legislative passage, beginning on September 8, 2013, when the bill was submitted to Congress and ending when the tax was passed in late October 2013. I use John Kingdon's three streams theory on agenda setting, which is often used to explain the passage of health policies, to demonstrate how the tax emerged on the agenda and how the process of agenda setting shaped and enabled the legislative passage of the tax in the Mexican Congress.

This paper offers important lessons for policymakers within Mexico and in other countries in developing their own strategies in passing sin taxes. The first lesson of this analysis is that passing an SSB tax was difficult and involved high-level organization, co-operation, strategic planning, and concerted effort. In order to develop political strategies to pass the tax in Mexico, an understanding of the political and economic context was crucial. Framing the tax as a means of generating revenue for the federal government was a powerful tool in getting the tax proposal onto the policy agenda and enabled buy-in from the Ministry of Finance and Public Credit (known as *Hacienda* in Mexico for short). This buy-in was crucial, since within the government, Hacienda drove the tax with little involvement from the Ministry of Health. Forming networks within the legislature early on in the attempt to pass a SSB tax was also important, since it allowed the proponents of the tax to have a network of allies within congress when the SSB tax was introduced as a bill in

the Mexican legislature. Another important strategy was early public relations campaigns to sway public perception that the obesity epidemic was driven in part by SSB consumption.

This is the first paper that uses political science theory and primary data collection with a broad range of stakeholders, to explain how Mexico managed to pass an SSB tax despite opposition from a strong national SSB industry.

INTRODUCTION

Mexico and many countries around the world are grappling with the rise of non-communicable diseases (NCDs) [1,2]. As countries become increasingly urban and economies grow, their population undergoes a nutritional transition in which under-nutrition is rapidly replaced by a rise in obesity and associated NCDs [1]. Mexico has experienced one of the fastest rises in type 2 diabetes mellitus, driven by the equally dramatic increase in overweight and obesity [2,3]. Public health experts in Mexico and around the world have identified the sharp increase in consumption of sugar-sweetened beverages (SSBs) as one of the major causes of the global obesity epidemic [4,5]

In October 2013, Mexico passed a tax on SSBs. The tax, which took effect on January 1st, 2014, is an excise tax of one peso per liter (about 10% of SSB retail price) on any beverages sweetened with sugar, excluding alcoholic and dairy products [6].The tax provided significant additional revenue for the Mexican government, and also reduced SSB consumption by between about 6 and 10 percent, thereby addressing the obesity epidemic in Mexico [7,8].

Mexico was the first country in the Americas to pass an SSB tax and its passage in 2013 marked increased global interest in SSB taxes [9]. Prior to 2013, only 9 other nations had passed SSB taxes, but since Mexico passed its SSB tax, around 23 other nations and eight jurisdictions in the US have adopted a tax on SSB [9,10]. Not all attempts to pass SSB taxes have been successful. In 2016, the proposed SSB tax in Colombia did not pass in the face of organized opposition from the soda industry [11]. Although many countries have successfully adopted taxes on SSBs, little is known about the politics of adopting these measures, particularly in the context of SSB industry opposition.

This research fills a gap in the knowledge and publications about the passage of Mexico's SSB tax and about the passage of 'sin taxes' more generally. Two other studies examined the politics of passing the SSB tax in Mexico. One is a report by the Pan American Health Organization (PAHO) that analyzes the passage of the tax in Mexico and also the initial effects of the tax on health outcomes [12]. The report focuses on the role that PAHO played in promoting the tax and concludes that the tax was passed as a result of a confluence of political, economic, epidemiological, social, inter-sectoral and global factors [9]. The second study examined the strategies that civil society advocates used in working for the tax passage [13]. The study focuses on the use of paid and earned media as the primary means of influencing legislators. Both studies present the responses of the SSB industry to combat the tax, but do not include interviews with a broad group of stakeholders with diverse perspectives on the tax [12,13]. Neither study analyzed how the strategies used by proponents and opponents of the tax affected agenda setting or the legislative passage of the SSB tax in the Mexican Congress [12,13].

This paper uses qualitative methods and direct field research, combined with social science theory, to explain the legislative passage of the Mexican SSB tax in spite of a powerful SSB industry. We use John Kingdon's three streams theory on agenda setting to explain how the tax emerged on the agenda and how the process of agenda setting shaped and enabled the legislative passage of the tax [14].

Following the introduction, the paper proceeds with background on the tax, the key players, political context, and the breakdown of the votes in the Mexican Parliament. This is followed by an explanation of Kingdon's three streams theory, including why it was chosen and how it would guide the analysis. Next follows the data and methods section, where we

explain why we did stakeholder interviews, how we identified stakeholders, and how we analyzed the data. The results section is next, in which we analyze the data and explain why the pro-tax side was able to co-operate more effectively, and how the period of agenda setting influenced legislative passage, using Kingdon's theory. Finally, we present our conclusions, explain the lessons learned from this case study, and discuss limitations.

BACKGROUND

The SSB tax had potentially huge implications for large multinational corporations in Mexico, like Coca-Cola and PepsiCo, that sell sugar-sweetened beverages [15]. The ties between the SSB industry and Mexican society are pervasive, with Coca-Cola integrated into many areas of Mexican society. Coca-Cola has regularly sponsored sporting events throughout the country for over 17 years; and in 2000 Vicente Fox, who was the previous chief executive of Coca-Cola Mexico, was elected as President of Mexico [15]. Coca-Cola also has ties to the health sector in Mexico. The company has co-sponsored events with the Mexican Diabetes Association, supported a government exercise initiative aimed at combating childhood obesity, and co-sponsored a public health prize with the National Council of Science and Technology for best scientific research on diet, health and well-being [15,16].

While the ties between Coca-Cola and Mexican government and society are well known, they were not the only groups potentially affected by the SSB tax. The tax also had implications for the whole supply chain for SSBs, including Mexican sugar producers, SSB bottlers, and stores selling SSBs. These groups were represented by their own organizations, such as the Alianza Nacional de Pequeños Comerciantes (ANPEC), which

represents small businesses, and trade groups, such as the Unión Nacional de Cañeros, which represents the sugar cane industry. The SSB companies did not involve themselves directly in combating the tax, rather they used their representatives, such as the Asociación Nacional de Productores de Refrescos y Aguas Carbonatadas (ANPRAC) and through the lobbyist organization, Consejo Nacional de la Industria de Productos de Consumo (CONMexico). These groups, which we henceforth refer to as opponents to the tax, launched an offensive against the proposed tax on SSBs. These groups advertised widely against the tax and urged politicians in the Mexican Congress to oppose the tax, arguing that the tax would harm small businesses and employment, was regressive in its economic effects on poorer citizens, and would not affect obesity rates [17].

The proposal for an SSB tax received strong support from civil society, academics, and politicians. In the sphere of civil society, El Poder del Consumidor, a non-governmental organization (NGO) focused on consumer rights, helped found an umbrella organization of 22 NGOs and 650 civil society groups known as the Alianza por la Salud Alimentaria. This group supported the tax from a consumer rights perspective. One of their key allies in the civil society sphere was another alliance, called Contrapeso, a coalition of 40 civil society organizations, focusing on supporting the tax from a public health perspective. In terms of academics, the largest and most vocal supporters came from the Instituto Nacional de Salud Pública (INSP), whose researchers generated evidence on the need for a tax and estimated the effects of an SSB tax. While these groups worked for many years prior to 2012 to promote an SSB tax, it was not until mid-2012 that the supporters of the tax were able to organize effectively. A 10 million USD grant from Bloomberg Philanthropies in 2012 provided a major boost to the proponents of the SSB tax, allowing them to hire a political

strategy and lobbying firm to orchestrate the advocacy efforts inside the national government and to the Mexican public [13].

The elections of 2012 brought a new government to power in Mexico, and this presented an opportunity for the tax proponents to pursue SSB tax legislation. In 2012, the PRI (Partido Revolucionario Institucional) won the presidency, however, they lacked a majority in the Senate and the House of Deputies. The three major political parties, the PRI, the PAN (Partido Acción Nacional), and the PRD (Partido de la Revolución Democratica) then announced an agreement to work together, in the Pacto por Mexico (PPM). The three parties agreed to a set of 95 initiatives that fell under five categories: 1) rights and liberties; 2) democratic governance; 3) security and justice; 4) transparency and combating corruption; 5) economic growth, employment and competitiveness [18]. Among the issues that the PPM proposed to address is that the economy was experiencing a slowdown in growth in part due to the reduction in oil prices and slowing oil production [19]. They expressed a need to increase government revenues to fund social programs and government functions, which the Pact planned to accomplish through a large financial reform. Within the new government, the SSB tax proponents successfully organized support in the Mexican legislature, which resulted in the tax being initially presented by PAN Senator Marcela Torres Peimbert, on December 12, 2012 [20]. While this Senate bill was eventually set aside in preparation for the upcoming presidential fiscal reforms, the Treasury Department (Secretaría de Hacienda y Crédito Público and decided to include the SSB tax as part of its fiscal reform bill. In what followed, the SSB tax was pushed by Hacienda, without much input or support from the Ministry of Health (MoH).

The tax proposal garnered high-level political support from President Enrique Peña Nieto, who introduced the bill in Congress as part of his fiscal reforms in 2013 [21]. The tax was introduced as part of the Impuesto Especial sobre Productos y Servicios (IEPS), a package of direct taxes, traditionally levied on tobacco products, alcohol, beer and gasoline. The tax was ultimately passed by an alliance between three political parties, the PRI, the PRD, and the PVEM (Partido Verde Ecologista de Mexico). On October 17, 2013, the House of Deputies voted to pass the bill passed with 317 votes in favor (207 PRI, 73 PRD, and 25 PVEM votes) and 164 votes against (113 PAN and 23 PRD votes) [22]. Meanwhile, on October 29, 2013, the Senate voted to pass the bill with 73 votes in favor (54 PRI, 1 PAN, 10 PRD, and 7 PVEM votes) and 50 votes against (36 PAN and 9 PRD votes) [7].

We identified two stages involved in the passage of the SSB: first, getting the tax adopted as part of the government's fiscal reform, and second, getting the tax passed in the Mexican Congress (Figure 2-1). The first stage takes place between mid-2012, when the tax proponents began co-operating after they received a grant from Bloomberg Philanthropies, until the tax was announced as part of the President's fiscal reform package on September 8, 2013. The tax was then sent to the Mexican legislature for consideration, which initiated the second period, focused on the passage of the tax at the end of October, 2013. While the first period is notable by the lack of participation of the SSB industry, the second period features open conflict between the tax proponents and opponents. Given that these two stages involve different processes, players, and strategies, we will analyze them in turn. In the first period, we use Kingdon's three streams theory to analyze how the tax proponents set the agenda and got the tax included as part of the presidential fiscal reforms. Then we

turn to the period of legislative passage and examine key factors that enabled it to successfully pass in the Mexican Congress.

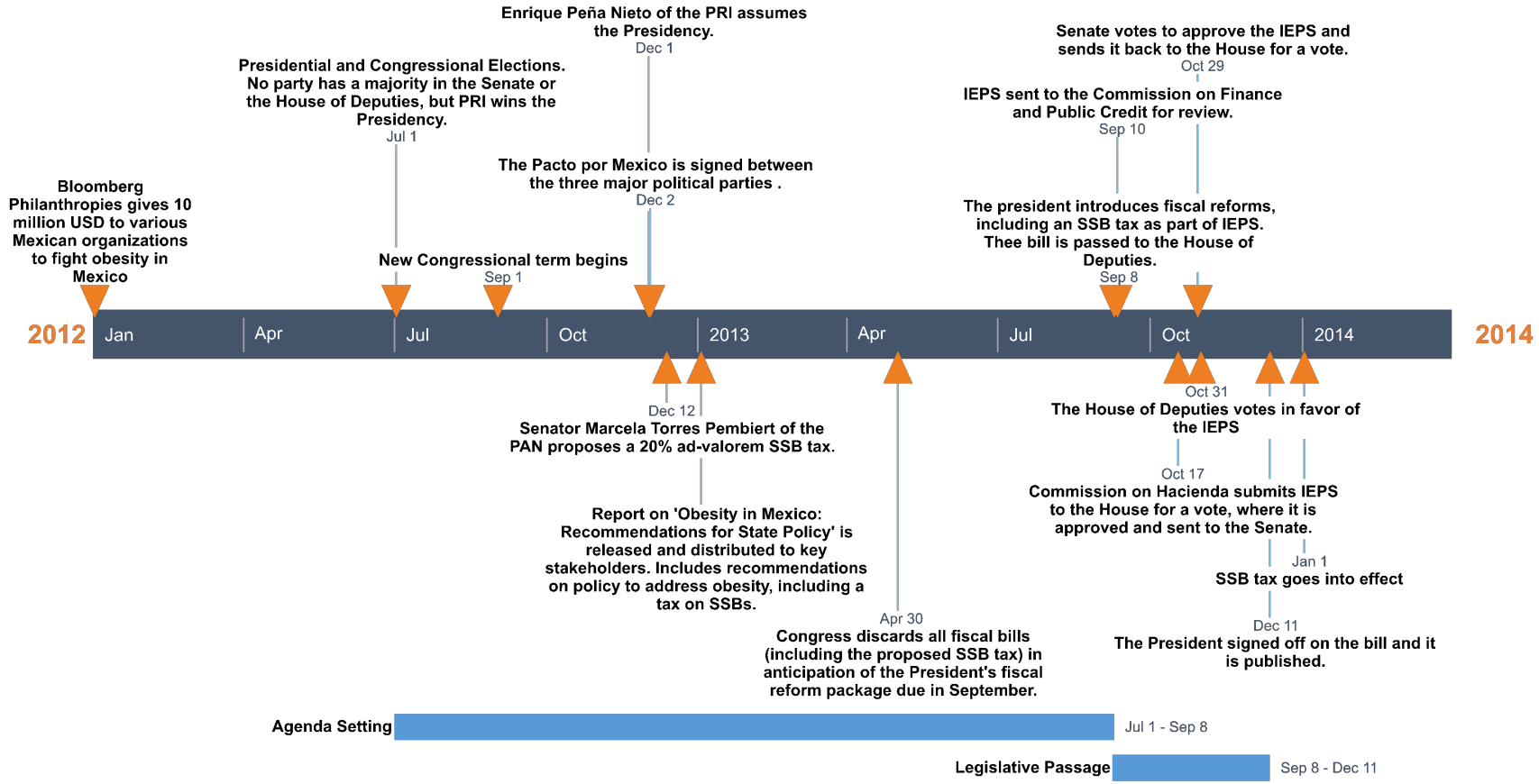

Figure 2-1. Timeline of the passage of the SSB tax.

CONCEPTUAL FRAMEWORK

This paper relies on a conceptual framework that John Kingdon developed using interviews and documents to explain how agendas are set within the US federal government [14]. Agenda setting is an important stage in the development of government policies as it restricts the set of problems being addressed and the set of policy alternatives under consideration. Kingdon's theory has been used frequently to explain health policy [23–25], including in one case to examine when and why some US state legislatures passed SSB taxes [26]. We use the theory to help understand agenda setting for the SSB tax in Mexico: how and why the SSB tax went from an existing policy idea without much support to its adoption as part of the President's 2013 fiscal reform.

Kingdon identifies three different streams that when present at the same time make a policy more likely to rise on the agenda. The first of these is the *problem stream* and explains how conditions become problems, which occurs when government officials become aware of conditions and then decide to address them. Conditions come to the attention of policymakers through indicators, such as obesity rates, focusing events, such as an economic crisis, and feedback, such as routine monitoring or complaints. Once a condition is identified, it does not necessarily become a problem, however, conditions are more likely to become a problem if they go against a prevalent norm, are poor in comparison to other nations, and in the way that they are defined. The definition of the condition is important in whether it becomes a problem, meaning if obesity were defined as an individual failure of self-control then it might be less likely to be framed as a problem by policymakers.

The second stream is the *politics stream*, which is independent of the other streams and helps explain why a problem or policy rises on the agenda. This stream refers to how events such as new administrations, changes in national mood, and organized interest groups have the ability to help set the agenda. In this stream, consensus is reached by bargaining rather than persuasion, where politicians trade favors for support. In this stream, visible participants, such as the President, high-level cabinet members, senators and deputies, are more likely to affect the agenda.

The third stream is the *policy stream* through which alternatives are generated and selected. Kingdon calls this process the "policy primeval soup" where ideas "float around, bumping into one another, encountering new ideas, and forming combinations and recombinations" [14]. The origin of policies may be hard to trace; however, the ways in which they evolve follows a logic according to their political acceptability both for the public and politicians as well as their technical viability, meaning whether they are implementable and the actual process by which they would work is understood. The alternatives are generated by policy specialists, who, in contrast to people in the politics stream, may be relatively hidden. These specialists include academics, bureaucrats, researchers, and consultants. The more united these specialists are, the greater the likelihood that they agree on a small set of alternatives and the more likely the policy alternatives are to survive and thrive. These policy specialists or entrepreneurs push their ideas for consideration in a process known as "softening up." Softening up is when policy entrepreneurs push their ideas in different forums so that both the public and politicians become familiar with the policy before it is introduced as legislation. Sometimes this is

done through hearings or discussions and other times this is done by floating trial legislation with the understanding that it will not pass this time but might at a future date.

When problems arise under favorable political circumstances and become coupled to an existing solution, there is a window of opportunity during which policies are much more likely to come onto the decision agenda. It is during these windows of opportunity that policy entrepreneurs push their policy solutions. Windows are opened by the problem or the politics stream and are sometimes predictable, as is the case for budgetary legislation that appears at regular intervals, or unpredictable, as is the case for accidents.

While Kingdon explains that the coupling of the three streams creates a window of opportunity, he is less clear on how these streams come together. Our analysis will explore how these streams came together in Mexico for the SSB tax, particularly how policy entrepreneurs assessed the three streams and helped bring them together.

STUDY DATA AND METHODS

We rely on three sources of data for this analysis: documents from government, international organizations, and civil society groups; media articles; and key informant interviews. The majority of our analysis relies on key stakeholder interviews, guided by Kingdon's theory of agenda setting.

Identifying key stakeholders

We used two sources to identify key stakeholders: government documents and newspaper articles. We searched legislative documents from the Mexican Senate and the

Chamber of Deputies, including minutes of proceedings, proposals, presentations, and reports, between September 2012, when the newly elected legislators took office, through December 2013 after the SSB tax had been passed and signed by the President. We searched these documents for any mention of a tax on sodas or SSBs, obesity, overweight, or diabetes in order to construct a database with the dates, names of the legislator(s) who introduced the topic, their party, and a brief summary of what was said. Using the same keyword search and date parameters, we generated a second database of press articles through "Nexis Uni" focusing on Mexican newspapers. These two databases allowed us to identify visible participants in the passage of the SSB tax, including legislators, bureaucrats, politicians, academics, civil society, and NGOs, whom we asked for interviews. We also used the snowballing method to identify additional stakeholders by asking participants who was important in the passage of the tax. Snowballing is a purposeful sampling method used in qualitative research to identify participants who are behind the scenes or hidden, but may be important in a public policy decision [27].

Stakeholder semi-structured interviews

After we identified key players in the passage of the tax, we sent them an email inviting them to participate, which included a description of the project, the procedures, the types of questions involved, and a copy of the consent form. We obtained approval from both the Instituto Nacional de Salud Pública's Ethics Committee (protocol number 1490) and from the Harvard T.H. Chan School of Public Health (protocol number IRB17-1928) to conduct the study. Participants were interviewed privately in person, on skype, or by phone. Interviewees were required to sign an informed consent where they agreed to have the interview taped and that explained the study risks. The recordings of the interviews

were deleted after transcription, and we refer to participants by interview number and their relationship to the passage of the tax, such as senator, NGO employee, or lobbyist.

The interview guides had lines of inquiry divided into the two periods, the agenda setting period and legislative passage period. In order to avoid imposing our own conceptions on the passage of the tax, we left the questions open ended and allowed interviewees to emphasize aspects that they thought were important. We continued interviewing until we stopped uncovering new themes.

Table 2-1. Number of interviews conducted with key-stakeholders in Mexico

Membership	Number of interviews
NGOs	3
Academics	4
Political strategists	2
Bureaucrats	3
Politicians	1
Trade associations	2
Industry	1
Lobbyist	1
Total	17

Analytic method

Interviews were conducted and transcribed in Spanish. Analysis of the interviews began by identifying the key players mentioned in interviews, their strategies, and the context during the two periods. We then went over the interviews again, this time guided by Kingdon's three streams model to identify how the agenda was set. Within the agenda setting period, we looked for themes within the model that were reflected in the

interviews. The third step in our analysis involved triangulation to look for agreement between what was said in interviews, and what appeared in published articles and other documents. We used this analysis to construct an explanation for how the SSB tax rose to prominence on the agenda and how it was ultimately passed by the Mexican legislature.

STUDY RESULTS

Agenda setting

Politics stream

The politics stream began opening with the 2012 elections that brought a new government to power. The new President had promised fiscal reforms as part of his platform. Political strategists advocating for the SSB tax explained that they had done political mapping and analyzed the political context, so they were aware that there was an opening of the political stream [28]. These strategists knew that there was going to be a fiscal reform in the fall of 2013 and they positioned and framed the SSB tax so that it would fit in the reform. Tax proponents also recognized that the first year of a new administration is the optimal time for subject change, since the new government has a new set of subjects on its agenda, making it a good time to get new policies passed [29]. Timing is key, since after the first year of an administration, as one academic explained, co-operation between political parties generally decreases and in the case of the SSB tax it would have likely allowed opponents to the SSB tax more time to lobby government officials [29].

The PPM was also important in indicating to the tax proponents that the political environment might be favorable for an SSB tax [28]. Most interviewees supporting the tax

explained that the PPM was indicative of a new political context in which the three major political parties were not only co-operating, but they were invested in the success of a package of reforms, including a fiscal reform [29–34]. The political strategists assisting the tax proponents assessed the political context and predicted the opening of the politics stream, so they began working to link this stream with the problem stream and the tax policy to ensure that the SSB tax was included in the President's fiscal reform package and became part of the government's decision-making agenda [28].

This strategic understanding of the political context in the new administration also helped the tax proponents decide to engage solely with Hacienda to push the tax, rather than also trying to involve the MoH [30,32]. Academics and NGOs were aware that the new Secretary of Health, Mercedes Lopez Juan, had worked closely with the food and beverage industry at her previous job and had made public statements against the tax and in favor of health education as a means to combat obesity in Mexico [29,32,35]. They were also aware that not only was Hacienda the more powerful government institution but that they also had the ability to set taxes, while the Ministry of Health did not [32]. The political strategists, academics from INSP, and NGOs, including El Poder del Consumidor and Contrapeso, all expressed that they decided to go through Hacienda, without garnering support from the MoH, since they believed they would encounter opposition to the tax from the Secretary of Health [30,32,34].

Problem stream

At the same time, Mexico's new administration faced an economic crisis as the price of oil began to fall in 2013 [19]. A government report outlining Mexico's economic outlook

reported an unexpected slowing in economic growth producing an estimated budget shortfall of 74 billion pesos (0.5% of gross domestic product) compared to the approved budget for 2013, largely due to the falling production and price of oil [19,36]. Many advocates for the tax, including academics who spoke with Hacienda in the beginning of 2013, were well aware of the need for additional sources of revenue and worked to place the SSB tax in this light [33,34]. One person interviewed stated that the need for additional revenue was the main factor driving Hacienda to include it as part of the 2013 fiscal reform [33]. The need for additional government revenue may help explain why the idea of a new tax was well received, but it does not explain why a tax on SSBs was included in the fiscal reform.

Academics worked strategically to generate evidence aligning the second part of the problem stream, namely, the need to address the obesity epidemic. Numerous scientific articles were published to document the rise in obesity, diabetes and obesity-related disease in Mexico between 1993 and the mid-2000s [3,33,34,37–43]. Then studies linking the obesity and diabetes epidemic to the increasing consumption of SSBs were published [4,33,34,43]. These academics held meetings with officials from Hacienda in the spring of 2013, providing them with evidence documenting the huge increase in obesity and diabetes rates and showing that a major driver was the increase in consumption of SSBs [43,44]. Government officials explain they used this evidence in their arguments to demonstrate the need for the tax when it was included as part of the fiscal reform.

Meanwhile, NGOs used this evidence to increase public and government awareness of the problem. El Poder del Consumidor and the Alianza por la Salud Alimentaria brought visibility to the obesity epidemic, through demonstrations, such as one held in October

2012 where demonstrators dedicated an altar on the Día de los Muertos (Day of the Dead) to those who died from diabetes between 2006-2012 [45]. They also organized paid advertising campaigns, such as the "First obesity, then diabetes" campaign that used graphic images on billboards of individuals with amputations from diabetes [13,30]. These NGOs linked the consumption of SSBs to the obesity using demonstrations and the well-known "Would you give them 12 spoons of sugar?" advertising campaign [13,30,46]. Once the NGOs had established the relationship between obesity and SSBs in the public's mind, they moved on to advocate for the adoption of an SSB tax as the means to address the problem [13,30]. These campaigns were very successful in conveying the magnitude of the obesity and diabetes epidemics in Mexico; indeed, one bureaucrat explained that there was a public perception that the epidemics were so severe that the government had to do whatever it takes to address the problem [47].

There was also international pressure to address the obesity epidemic, which contributed to the emergence of obesity and diabetes as problems on the government agenda. In 2011, the United Nations Special Rapporteur on the Right to Food called on Mexico to declare a state of emergency in response to the obesity epidemic [48]. The Organization for Economic Co-operation and Development (OECD) highlighted the scale of the obesity epidemic in Mexico and urged action [49]. One government official interviewed stated that material provided by PAHO was used to frame and understand the problem of obesity and diabetes when they went to justify the tax as part of the fiscal reform [44].

Policy stream

The idea for an SSB tax as a means of addressing the obesity epidemic was not new [44,47]. Indeed, there were previous attempts during the 2006 to 2009 legislative session to introduce an SSB tax [31,34]. As part of the multi-sectorial government program called the Acuerdo Nacional de Salud Alimentaria, under the previous administration of Calderon, there were discussions between the MoH and Hacienda to use an SSB tax as a means of alleviating the obesity epidemic; however, these discussions came late in the administration's term and the tax was never passed [29]. While the idea for an SSB tax to address obesity had existed for a number of years prior to its passage in 2013, previous attempts at attaching this policy to the obesity and diabetes epidemic did not succeed. Timing was an important factor, since previous efforts lacked the budget shortfall that the tax also proposed solving and those efforts came late in the Calderon administration when the political window was not open [32].

The major difference in 2012 and 2013 was the strategic co-operation between the NGOs, academics, and political lobbyists, made possible through the funding provided by Bloomberg Philanthropies. When Bloomberg Philanthropies began looking into the possibility of working to address the obesity epidemic in Mexico, they gathered a group of different NGOs, academics, and a lobbyist to discuss what could be done [30]. Bloomberg Philanthropies decided to support these organizations by providing money, which allowed these groups to increase their activities to promote the tax [30]. One participant explained that the influx of money allowed them to hire a professional political strategy firm and to launch major paid media campaigns, whereas previously they had relied on their own political analysis and on earned media campaigns, meaning press coverage of events [30].

Perhaps equally important was the impetus the Bloomberg Philanthropies grant provided for them to work together strategically and all agreed that their priority was to promote the tax. This created agreement among NGOs, academics, and the lobbyists that they would work together to push the SSB tax, rather than work separately to promote the tax. Several participants explained that the public health NGOs, under Contrapeso, directly lobbied Hacienda and the legislature, while the consumer rights NGOs, led by El Poder del Consumidor, focused on public awareness campaigns in the media [28,30,32,50]. Indeed, this co-operation was strategically designed, with the political strategists proposing the division of labor according to each group's strengths in the political and public spheres, while also finding a champion within the legislature to begin the work of softening up the government [28].

Through their own political mapping, the political strategists explained that they recognized the need for a champion within the legislature to introduce the idea of an SSB tax and they identified several potential legislators [28,32]. Their main proposal within the Senate was Marcela Torres Peimbert of the PAN who proposed an SSB tax in December 2012 [28]. By selecting someone from the conservative opposition party that traditionally favors business, the tax proponents gained political legitimacy for the tax proposal [28]. This proposal allowed the Senator the opportunity to familiarize the legislature with the tax and shore up support as 37 deputies and 13 other senators signed on to support the bill [20,28]. This also softened up Hacienda, by signaling that those within the legislature were amenable to the tax, while introducing the policy as a solution to the obesity and diabetes epidemic as well as the expected national revenue shortfall.

Meanwhile, academics and experts in the global health community, such as PAHO, continued meeting with Hacienda to provide them with evidence on the technical feasibility of the tax and its impacts on consumption [44]. Academics produced estimates on the price elasticity of demand for SSBs as well as the cross-price elasticity of demand for alternatives [4,33]. Studies found demand for SSBs was elastic, meaning a rise in the price of SSBs would lead to a decline in consumption, however, demand was not so elastic that consumers would stop drinking SSBs altogether [33,34,43]. These studies also found that substitutes for SSBs were healthy, so consumers would probably switch to healthier products in response to a rise in price of SSBs [33,34,43]. These results, which were shared with Hacienda, served as a proof of concept that the SSB tax would not only generate revenue, but also that the tax would produce health benefits, allowing them to address two problems with one policy [29,33,34,43,44,47].

Legislative passage

Once the President announced that the SSB tax would be part of the fiscal reform, Mexico's SSB industry began lobbying against the proposal. Part of Hacienda's strategy to decrease opposition to the tax was to keep secret its inclusion as part of the fiscal reform, meaning that neither the tax supporters nor the tax opponents were certain of its inclusion until Enrique Peña Nieto unveiled the fiscal reform on September 8, 2013 [29,44,47,51–53].

While Hacienda used secrecy to delay opposition to the tax, the SSB lobby failed to anticipate the tax. One trade group reported repeatedly warning people in the SSB industry that the tax was coming in Spring 2013, however those warnings went unheeded, in part because the industry was unaccustomed to being in conflict with the government and may

have wanted to avoid such conflict until they were certain the tax was coming [54]. This failure to begin positioning themselves in opposition to the tax meant that they lost important time [54]. This led to an inability of industry lobbyists and trade groups to effectively frame the obesity epidemic as a result of an imbalance of calories and lack of exercise, since the tax supporters had already framed the issue as being driven by excessive SSB consumption.

While the SSB industry was waiting for the formal announcement of the legislative proposal, the tax supporters had already been working to push for the tax. Long term co-operation during agenda setting meant that the tax supporters were strategically better prepared to lobby Congress and that they had already obtained key allies within the Congress. Indeed, when those opposed to the tax went to lobby Congress, the political strategists supporting the tax were told of these activities by their allies in Congress [28,32].

The third element that ensured the passage of the SSB tax was the nature of politics in Mexico. Until recently, Mexican politicians were unable to serve consecutive terms in the Senate or the House of Deputies, meaning that once their term was up they had to find other positions, often assisted by their political party [55]. The reelection prohibition combined with the role that the parties played in moving politicians from one elected position to the next created significant party loyalty [56]. Since the SSB tax was a presidential reform, it meant that all members of the President's PRI party were almost certainly going to vote in favor of the reform.

DISCUSSION

This paper presents a single case study to explain the successful passage of the SSB tax in Mexico, using published documents, media articles, interviews with key stakeholders, and Kingdon's theory of agenda setting. We found that one of the major drivers of success was the influx of money from Bloomberg Philanthropies, which allowed for the hiring of professional political strategists who understood and analyzed the political economy context. Knowing that the politics stream was opening with the PPM signed, a new administration, and a promised fiscal reform, the tax supporters created an alliance of NGOs and academics and legislators to bring the problem and policy streams together and put the SSB tax on the legislative agenda as part of the fiscal reform. Together with academics, Contrapeso, El Poder del Consumidor and many other NGOs, the political strategists brought public awareness and government attention to the impact that SSB consumption was having on high rates of obesity and diabetes, which aligned the politics and problem streams. The SSB tax had existed as a policy solution to the obesity and diabetes epidemics, however, through alliances with Senators and members of the House of Deputies, the tax supporters were able to raise the profile of the tax to Hacienda and within the Mexican Congress. The merging of the three streams enabled the inclusion of the SSB tax as part of the President's fiscal reform.

We found that the politics of agenda setting were different from the politics of legislative passage, insofar as participants and strategies were different; however, careful agenda setting can pave the way for successful passage. Hacienda had designed its own strategies for passage, separate from those of civil society supporters, specifically, the use of secrecy while they were preparing the tax as part of the fiscal reform that prevented the

tax opponents from becoming an effective force against the tax. It was both Hacienda's secrecy on the proposal and the established ties between the legislature and the tax supporters that enabled the legislative passage of the tax. The tax opponents had less time to respond to the tax, and their strategy to engage in a public debate against the tax failed to have much impact, as the relationship between obesity and SSBs was already widely known by the public.

This study offers important insight into the passage of the SSB tax in Mexico, but the study does have some limitations. One important limitation is that it is a single case study, so the findings may not be generalizable to other places. There may also be other possible explanation for how the tax was passed. By using Kingdon's framework, we also run the risk of imposing a US centric explanation of how government agendas are set, however, this framework has been widely used in international settings to explain agenda setting and legislative passage [23–25,57]. Although we interviewed until we reached thematic saturation, the sample size (17 interviews) and the fact that we only interviewed one person in some categories (i.e. politicians) does mean that some of the findings should be interpreted with caution. Nonetheless, given that much of the debate over the tax is a matter of public record, we used legislative documents, media articles, and information from other stakeholders to generate our findings. There is also the possibility that those who were against the tax might be less likely to want to be interviewed. Additionally, there is the danger of bias, insofar as the passage of the tax affects the way that participants view the events. We attempted to attenuate this potential bias by triangulating and using media articles and other documents in addition to interviews.

Nonetheless there are certain findings that might be applicable to other countries and cities looking to pass an SSB tax. The first is that passing an SSB tax is difficult and involves high-level organization, co-operation, strategic planning, and effort. In order develop political strategies to pass the tax, an understanding of the political and economic context is crucial. Academics and NGOs played critical roles in generating scientific analysis and presenting the results to both the public and government officials. Revenue generation is a powerful tool in getting such taxes onto the agenda and enables buy in from the Ministry of Finance, which was crucial, since within the government, it was an Hacienda-driven reform with little involvement from the Ministry of Health. Forming networks within the legislature and the Ministry of Finance early on in the attempt to pass an SSB tax is important, as are early public relations campaigns to shape public perception that the obesity epidemic is driven in part by SSB consumption. Finally, it is important to recognize that while the public health community learns from the analysis of the passage or failure to pass such reforms, the SSB industry and their allies are also learning and changing their strategies.

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REFERENCES

1. Rivera JA, Barquera S, Gonzalez-Cossio T, Olaiz G, Sepulveda J. Nutrition transition in Mexico and in other Latin American countries. Nutrition reviews. 2004;62: S149–S157. doi:10.1301/nr.2004.jul.S149-S157
2. Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualizations [Internet]. 9 Nov 2018.
3. Rivera Dommarco JA, Hernandez Avila M, Aguilar Salinas CA, Vadillo Ortega F, Murayama Rendon C. Obesidad en Mexico: Recomendaciones para una politica de Estado. National Academy of Medicine; The National Institute of Public Health; the Autonomous institute of Public Health; 2013.
4. Barquera S, Hernandez-Barrera L, Tolentino ML, Espinosa J, Ng SW, Rivera JA, et al. Energy intake from beverages is increasing among Mexican adolescents and adults. The Journal of nutrition. 2008;138: 2454. doi:10.3945/jn.108.092163
5. HSPH. Sugary Drinks. In: Nutrition Source. n.d.
6. Camara de Diputados LXII Legislatura. Gaceta Parlamentaia LXII Legislatura Camara De Diputados Jueves 17 de Octubre Anexo VIII. 2013.
7. Senado de la Republica, Senado de la Republica C de H y CP. Comisiones Unidas de Hacienda y Crédito Público y de Estudios Legislativos, Segunda [Internet]. 2013. Available: http://infosen.senado.gob.mx/sgsp/gaceta/62/2/2013-10-29-1/assets/documentos/Dic_Minuta_MiscelaneaL.pdf
8. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. In Mexico, evidence of a sustained consumer response two years after implementing a sugar sweetened beverage tax. Health Affairs. 2017; 10.1377/hlthaff. 2016.1231.
9. Peter Rubinstein. A bittersweet pill for a fat nation to swallow: Has a radical plan to help this country kick its sugar habit finally paid off? BBC. London, England; 19 Nov 2018.
10. WCRFI. NOURISHING framework: Use economic tools to address food affordability and purchase incentives [Internet]. World Cancer Research Fund International; 2018. Available: https://www.wcrf.org/sites/default/files/Use-economic-tools.pdf
11. Maria Isabel Garcia, Manuela Villar Uribe, Roberto F Iunes. The political economy of the 2016 tobacco and proposed sugar-sweetened beverage tax increase in Colombia. Washington, D.C.: World Bank Group; 2017.
12. OPS. Experiencia de México en el establecimiento de impuestos a las bebidas azucaradas como estrategia de salud públuca. Mexico DF, Mexico; 2015.
13. Elisabeth Donaldson. Advocating for Sugar-Sweetened Beverage Taxation: A Case Study of Mexico. Baltimore; 2015.
14. Kingdon JW. Agendas, alternatives, and public policies. Updated 2nd ed. Boston: Longman; 2011.
15. Tina Rosenberg. Sugar. The long read. How one of the most obese countries on earth took on the soda giants. The Guardian. 2015.
16. EFE. Gobierno de México y Coca-Cola acuerdan fomentar investigación científica. Agencia EFE. Mexico; 2016.
17. Sarah Boseley. Mexico enacts soda tax in effort to combat world's highest obesity rate. The Guardian. 2014.
18. Luisa Béjar Algazi. Proceso Legislativo y sociedad civil organizada: El Pacto Por México. Mexico City, Mexico; n.d.

19. Gobierno de los Estados Unidos Mexicanos, Camara de Diputados. Criterios Generales de Politica Economica 2014. 2013.
20. Senado de la Republica, Senado de la Republica. Iniciativa, De los Senadores Marcela Torres Peimbert, Gabriela Cuevas Barrón, Juan Carlos Romero Hicks, Francisco Salvador López Brito, Martín Orozco Sandoval, Luz María Beristáin Navarrete, Mario Delgado Carrillo, Sofío Ramírez Hernández, Javier Corral Jurado, Ernesto Ruffo Appel, Benjamín Robles Montoya, Jorge Luis Preciado Rodríguez, Víctor Hermosillo y Celada y Dolores Padierna Luna, la que contiene proyecto de decreto por el que se reforman y adicionan diversas disposiciones a la Ley del Impuesto Especial sobre Producción y Servicios. Dec 11, 2012.
21. Mark Bittman. Viva México!, Sunday Op-Ed. New York TImes. New York; 2013.
22. Cámara de Diputados, Cámara de Diputados. De la Comisión de Hacienda y Crédito Público, con proyecto de decreto que reforma, adiciona y deroga diversas disposiciones de la Ley del Impuesto al Valor Agregado, de la Ley del Impuesto Especial sobre Producción y Servicios, de la Ley Federal de Derechos y se expide la Ley del Impuesto sobre la Renta (en lo general y en particular los artículos no reservados). 2013.
23. Blankenau J. The Fate of National Health Insurance in Canada and the United States: A Multiple Streams Explanation. Policy Studies Journal. 2001;29: 38–55. doi:10.1111/j.1541-0072.2001.tb02073.x
24. Kusi-Ampofo O. Resistance and Change: A Multiple Streams Approach to Understanding Healht Policy Making in Ghana. Journal of Health Politics, Policy and Law. 2015;40.
25. Ha BT, Mirzoev T, Mukhopadhyay M. Shaping the Health Policy Agenda: The Case of Safe Motherhood Policy in Vietnam. International Journal of Health Policy and Management. 2015;4: 741–6. doi:10.15171/ijhpm.2015.153
26. Mosier SL. Cookies, Candy, and Coke: Examining State Sugar-Sweetened-Beverage Tax Policy from a Multiple Streams Approach. International Review of Public Administration. 2013;18: 93–120. doi:10.1080/12294659.2013.10805242
27. Heckathorn DD. SNOWBALL VERSUS RESPONDENT-DRIVEN SAMPLING. Sociological methodology. 2011;41: 355–366. doi:10.1111/j.1467-9531.2011.01244.x
28. Two political strategists. Interview Number 6. Erin James, editor. 2018;
29. Academic. Interview Number 12. Erin James, editor. 2018;
30. NGO. Interview Number 1. Erin James, editor. 2018;
31. Senator. Interview Number 16. Erin James, editor. 2018;
32. NGO. Interview Number 7. Erin James, editor. 2018;
33. Academic. interview Number 10. Erin James, editor. 2018;
34. Academic. Interview Number 11. Erin James, editor. 2018;
35. Ruth Rodriguez. ¿Educación, mejor que gravar refrescos? El Universal. Ciudad de México, México; 14 Mar 2013.
36. Secretaria de Salud. Gasto en Salud por Fuente de Financiamiento y Entidad Federativa, 1990-2016. 2018.
37. Barquera S, Tovar-Guzman V, Campos-Nonato I, Gonzalez-Villalpando C, Rivera-Dommarco J. Geography of diabetes mellitus mortality in Mexico: an epidemiologic transition analysis. Archives of medical research. 2003;34: 407–14. doi:10.1016/s0188-4409(03)00075-4

38. Stevens G, Dias RH, Thomas KJ, Rivera JA, Carvalho N, Barquera S, et al. Characterizing the epidemiological transition in Mexico: national and subnational burden of diseases, injuries, and risk factors. PLoS Medicine. 2008;5: e125. doi:10.1371/journal.pmed.0050125
39. Burgos LÁ, Hurtado LC, González Domínguez D, Aracena Genao B, Montañez Hernández JC, Serván Mori EE, et al. Cuentas en diabetes mellitus, enfermedades cardiovasculares y obesidad, México 2006. Ciudad de México/Cuernavaca, México; 2009.
40. Villalpando S, Shamah-Levy T, Rojas R, Aguilar-Salinas CA. Trends for type 2 diabetes and other cardiovascular risk factors in Mexico from 1993-2006. Salud publica de Mexico. 2010;52 Suppl 1: S72-9.
41. Avila-Curiel A, Shamah-Levy T, Galindo-Gomez C, Cuevas-Nasu L, Moreno-Macias H, Chavez-Villasana A. [Diabetes mellitus within low socioeconomic strata in Mexico City: a relevant problem]. Revista de investigacion clinica; organo del Hospital de Enfermedades de la Nutricion. 2007;59: 246–55.
42. Barquera S, Campos-Nonato I, Hernandez-Barrera L, Flores M, Durazo-Arvizu R, Kanter R, et al. Obesity and central adiposity in Mexican adults: results from the Mexican National Health and Nutrition Survey 2006. Salud publica de Mexico. 2009;51 Suppl 4: S595-603.
43. Academic. Interview Number 2. Erin James, editor. 2018;
44. Bureaucrat. Interview Number 8. Erin James, editor. 2018;
45. Notimex. Coloca Poder del Consumidor ofrenda en memoria de muertos por diabetes. Notimex. México; 2012.
46. Alianza por la Salud Alimentaria. Campaña 12 cucharadas [Internet]. 2018.
47. Bureaucrat. Interview Number 4. Erin James, editor. 2018;
48. UN News. UN expert urges Mexican state of emergency to battle food poverty and obesity. UN News. 2011.
49. Obesity is rising in developing countries, warns OECD. Deutsche Presse-Agentur. 2010.
50. NGO. Interview Number 9. Erin James, editor. 2018;
51. Lobbyist. Interview Number 3. Erin James, editor. 2018;
52. Trade group. Interview Number 5. Erin James, editor. 2018;
53. Industry. Interview Number 14. Erin James, editor. 2018;
54. Trade Group. Interview Number 15. Erin James, editor. 2018;
55. Alberto Diaz-Cayeros. Do Federal Institutions Matter? Rules and Political Practices in Regional Resource Allocaiton in Mexico. In: Edward GIbson, editor. Federalism and Democracy in Latin America. Baltimore, MD: Johns Hopkins University Press; 2004. pp. 297–322.
56. Langston J. Political institutions and political career patterns in Mexico. Foro internacional. 2009;xlix: 237–270.
57. Exworthy M, Blane D, Marmot M. Tackling Health Inequalities in the United Kingdom: The Progress and Pitfalls of Policy. Health Services Research. 2003;38: 1905–1922. doi:10.1111/j.1475-6773.2003.0**0208.x**

CHAPTER THREE, PAPER II: MODELING THE DISTRIBUTIONAL IMPACTS OF A SUGAR-SWEETENED BEVERAGE TAX ON MEXICANS' HEALTH AND FINANCES

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ABSTRACT

Background: In 2014, Mexico implemented a one peso-per-liter tax on SSBs in order to reduce consumption of SSBs, decrease obesity rates and associated cardiometabolic diseases, while also providing a source of government revenue. This study examines the potential distributional impact (across income tertiles) of the tax on delayed mortality from cardiometabolic disease and on tax revenues.

Methods: We use a biological weight loss model to estimate the expected BMI reductions due to the tax five years after implementation, an epidemiological model to estimate the tertile-specific effects of BMI reductions on deaths associated with obesity, and distribute the effects of the SSB tax on tax revenues by income tertile. We use parameters that vary by income tertile when available. We provide a range of estimates for the impact of SSB tax on the delayed death rate and tax revenues by using two evidence-based estimates of SSB consumption decrease.

Findings: In year five after SSB tax implementation, we found between 3.2 and 5.9 deaths delayed per 100,000 people from cardiometabolic diseases. We found that although the poor would benefit the most in terms of delayed death rates, they would also pay a larger share of their annual income on taxes. We estimate that the SSB tax would provide between about 5,900 and 6,240 million Mexican pesos per year or about 0.03% of GDP.

INTRODUCTION

Mexico has gone through an epidemiological transition, where non-communicable diseases (NCDs) have largely displaced infectious diseases in terms of mortality and morbidity [1,2]. Indeed, between 1980 and 2000, Mexico saw an unprecedented rise in obesity and a 47% rise in mortality from type 2 diabetes [1]. In 2012, type II diabetes was the second leading cause of death, while overweight, obesity, and high blood glucose levels accounted for 54% of all deaths [2]. Obesity became such a major risk factor for disease in Mexico that in 2008, the Ministry of Health estimated that spending on the treatment of obesity-related diseases, also known as cardiometabolic diseases, accounted for about 33% of total federal expenditures on health [3].

While the obesity epidemic has increased among Mexican adults, public health experts have highlighted the increased prevalence of overweight and obesity among children and the poor as a particular cause for concern [1]. The prevalence of childhood obesity in Mexico has increased significantly and was among the highest in the world in 2012 [4]. As this population of obese children ages, they are more likely to become obese adults experiencing associated diseases and deaths [5]. Obesity was once associated with overconsumption among the rich, while the poor suffered from under-nutrition and underweight [6]. Since 1990, however, obesity and overweight are more evenly distributed across income quintiles in Mexico, with the poor experiencing higher rates of increase in obesity than the rich [6]. A major academic report examining obesity in Mexico explained that poverty both causes and is a consequence of obesity [1]. The poor are often unable to afford healthier foods and opt for cheaper energy-dense foods leading to overweight and

obesity [1,7]. At the same time, the poor are more likely to become even poorer as they pay for the treatment of and lose productivity due to obesity-related diseases [1].

Public health experts have identified the rise of sugary-sweetened beverage (SSB) consumption as a major driver of the obesity epidemic in Mexico [1,8]. In 2012, a study reported that Mexicans were the highest consumers of SSBs in the world, drinking an average of 163 liters per person per year [9]. A study published by an SSB industry trade group in 2005 found that Mexicans in the poorest income decile spent the highest percentage of their household expenditures on SSBs (about 5%) [10]. Energy intake from beverages rose between 1999 and 2006, while energy intake from non-beverage food remained constant [8]. SSBs were found to be a major contributing factor to this increased energy intake, which unlike other beverages, such as fruit juices and milk, contain no added nutritional value [8].

In 2013, the Mexican legislature passed an SSB tax, which was justified to the public as a means of curbing the obesity and cardiometabolic disease epidemics, while providing the government with a new source of revenue [11–13]. The tax took effect on January 1st 2014, as a one-peso-per-liter (about 10% of the retail price of SSBs) excise tax on beverages containing added sugar, excluding milk and alcohol [11]. As a producer-level excise tax, soda bottlers pay the tax at the beginning of the fiscal year on the total volume of sodas that they expect to produce in the coming year.

Several research studies in Mexico have examined the impacts of the tax on sales and consumption of SSBs as well as on health [14–20]. Five studies estimated the impact on prices of SSBs and on purchases, finding that prices increased and purchases of SSBs declined across Mexico with the greatest declines among the poor and in 2015 [14–18].

Another study, by Barrientos-Gutierrez *et al.,* looked at the expected impact of the tax on adult weight and cases of diabetes in Mexico, predicting that the tax would generate a 2.5% reduction in obesity prevalence and prevent 90,000 to 130,000 cases of diabetes by 2030 [19]. While the Barrientos-Gutierrez *et al.* study examined the effects of the tax on the prevalence of obesity by income tertile, they did not estimate the effect of the tax on cases of diabetes by income tertile [19]. A study by Sanchez-Romero *et al*., focused on the effects of the SSB tax on the incidence of diabetes, cardiovascular disease (CVD) events, health costs associated with treating diabetes, and 10-year mortality [20]. Sanchez-Romero *et al*., find that the tax prevents about 190,000 cases of incident type 2 diabetes, 20,000 strokes and myocardial infarctions, and almost 19,000 deaths between 2013 and 2022 [20]. Our study expands upon previous research of the effects of the SSB tax on health and tax revenues generate by examining the distributional impacts (by income tertile) of the tax.

Given that the government justified the SSB tax as a means of preventing cardiometabolic diseases caused by the obesity epidemic and generating revenue, we modeled the impact of the tax on delayed deaths due to cardiometabolic diseases and on tax revenues. Furthermore, since a common argument against the SSB tax was its regressivity, we consider the potential health benefits, tax revenues by income tertile, and tax revenues as a percentage of mean income by income tertile in order to assess this claim. In short, this analysis explores the distributional impacts of the SSB tax on delayed deaths from cardiometabolic diseases and on tax revenues.

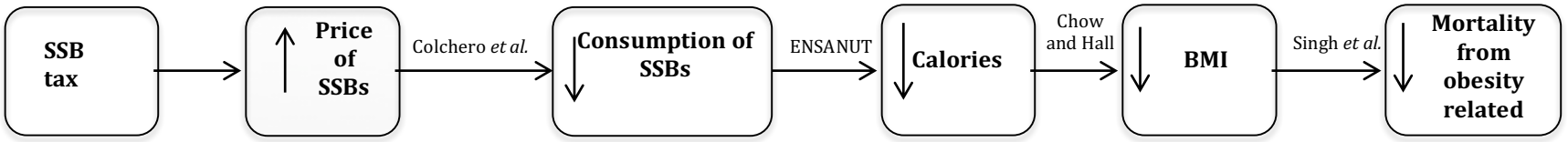
Building on the work of Barrientos-Gutierrez *et al*., we develop an epidemiological model to estimate the impact of weight loss on mortality from cardiometabolic diseases. Then, drawing from extended cost-effectiveness analysis (ECEA) methods [21–24], we

modeled the impact of the tax on health (e.g. delayed death rate) and financial outcomes (e.g. the distribution of the burden of tax revenues across socioeconomic groups in Mexico).

METHODS

We explore the effect of the tax on the two following outcomes by household income tertile: the number of delayed deaths from cardiometabolic diseases, including, ischemic heart disease (IHD), ischemic stroke, hemorrhagic stroke, hemorrhagic heart disease, and diabetes; and the additional tax revenues borne at the household level following the implementation of the SSB tax (Figure 3-1). Since death can only be delayed and not completely averted, we use the term 'delayed deaths' to refer to those deaths that are temporarily averted as a result of the SSB tax. We estimate delayed deaths in year 5 after the implementation of the tax. The additional annual tax revenues are estimated beginning in the year the tax was implemented.

We use a biological weight loss model to estimate the expected body-mass index (BMI) reduction due to the tax five years after the tax was implemented, an epidemiological disease model to project the effects of BMI reductions on delayed cardiometabolic deaths, and a distributional model [25–27] to examine the effects of the SSB tax on health and finances by income tertile.



Source: Colchero et al., 2017; ENSANUT, 2012; Chow and Hall, 2008; Singh et al., 2013

Figure 3-1. Sketch of the epidemiological model used to examine the impact of the SSB tax on mortality from obesity-related diseases, with the data input sources or methodology used above the connecting arrows.

Data inputs

Our baseline population comes from the 2012 Encuesta Nacional de Salud y Nutrición (National Health and Nutrition Survey, known by its spanish acronym ENSANUT), which is a nationally representative survey conducted by the Instituto Nacional de Salud Pública (INSP) that collects data on population-level health and nutrition. The survey includes 50,528 households in all 32 Mexican federal entities (31 states and Mexico City), representing slightly over 29 million households and about 70 million adults over the age of 20 [28,29]. The survey also includes a 24-hour food-frequency questionaire, which surveys a smaller nationally representative sub-sample of adults (n=2,735; representing 63 million Mexican adults) and details their average consumption, including weekly amounts of soda, juice, water, milk, and flavored waters (known as aguas frescas in Mexico) consumed [30]. We used survey weights and included all individuals between the ages of 20 and 84 with complete data on sex, weight, height, age, and consumption to estimate delayed deaths from cardiometabolic diseases and tax revenues at the population level by tertile. We excluded individuals already diagnosed with diabetes (n=247), who had a previous heart attack (n=33), a brain embolism or stroke (n=29), or who were pregnant (n=17), since their relative risk of disease differs from those without co-morbid conditions. After removing individuals that did not meet our inclusion criteria, the final sample included 2,378 individuals, representing over 54 million Mexican adults.

We obtain the observed decrease in soda consumption from 2012 levels from a 2017 study [18], which used store purchases of taxed beverages (SSBs) for 6,645 households between January 2012 and December 2015. The authors estimated predicted volumes of sales using pre-tax data (2012-2013) for comparisons with actual purchases in

2014 and 2015 [18]. The authors found an average 5.5 percent reduction in purchases of SSBs in 2014 and a 9.7% reduction in 2015, yielding an average decline of 7.6 percent across both years [18]. The study reported a gradient in decrease in consumption for the 5.5% SSB reduction estimate ranging from 9.0% among the lowest tertile to 4.4% among the highest tertile, for an average drop of 5.5% (supplementary appendix, Table 3-S2) [18]. For the 9.7% SSB reduction scenario, the study found a decrease in consumption ranging from 14.3% among the poor to 5.6% among the rich, averaging to a 9.7% decline (supplementary appendix, Table 3-S2) [18]. We use these gradients across income tertiles to determine post-tax tertile-specific consumption levels and refer to the two scenarios by their average decline (i.e. 5.5% SSB reduction and 9.7% SSB reduction).

We use the Global Burden of Disease (GBD) study to obtain the estimated number of deaths due to each obesity-related disease by age group in Mexico in 2016 (supplementary appendix, Table 3-S3) [2]. Since we only had estimated deaths by age-group and the proportion of the population in each income tertile by age-group, we assumed that deaths were proportional to the size of the income tertile in each age-group.

We used the Encuesta Nacional de Ingresos y Gastos de Hogares 2014 (National Survey of Household Income and Spending, known by its Spanish acronym as ENIGH), a nationally representative survey conducted by Mexico's National Institute of Statistics and Geography, to obtain the average income per income tertile [31].

Modeling approach

We used a previously developed weight loss model to estimate the impact of the tax on SSB consumption, BMI, and diabetes in Mexico [19,32,33]. This model is a validated bio-

mathematical weight model of the physiological processes using macronutrient flux balances to predict weight change after changes in energy intake over time [33–35]. Advantages of this model, as opposed to a static model which translates 3500 calories per pound of weight [36], are that weight change is non-linear, is not immediate, and is based on physiological processes [33].

We initialize the model using sex, weight, height, and age from ENSANUT 2012. We apply income tertile-specific proportional reductions in SSB consumption from the Colchero *et al.* estimates [18] to the baseline consumption of SSBs in 2012 in order to derive the absolute reduction in SSB intake for each subgroup of participants (mL/person/day) under the 5.5% and 9.7% consumption reduction scenarios (Table 3-1). We then used the post-tax consumption estimates in the model to obtain expected weight loss due to decreased SSB consumption five years after the tax.

Table 3-1. Mean[a] pre-tax volume of SSBs consumed, calories from SSBs, and BMI; mean change in volume, calories, and BMI five years after tax implementation under the 5.5% and 9.7% SSB reduction scenarios broken down by sex, income tertile, and age group.

Variables	Pre-tax			5.5% SSB reduction scenario			9.7% SSB reduction scenario		
	Volume[b]	Calories[c]	BMI[d]	Change in volume[b]	Change in calories[c]	Change in BMI[d]	Change in volume[b]	Change in calories[c]	Change in BMI[d]
Total	337 (522)	429 (587)	28.4 (5.6)	-22 (35)	-9 (14)	-0.16 (0.25)	-42 (70)	-16 (27)	-0.29 (0.48)
Sex									
Male	429 (587)	167 (227)	27.5 (4.7)	-29 (40)	-11 (16)	-0.18 (0.26)	-55 (82)	-21 (32)	-0.34 (0.52)
Female	260 (418)	101 (163)	29.1 (6.3)	-17 (27)	-6 (10)	-0.13 (0.23)	-31 (51)	-12 (20)	-0.25 (0.42)
Income tertile									
Low	306 (538)	119 (210)	27.7 (6.07)	-53 (94)	-11 (19)	-0.19 (0.34)	-21 (37)	-21 (37)	-0.65 (0.37)
Middle	376 (604)	146 (232)	28.7 (5.41)	-49 (79)	-8 (13)	-0.15 (0.22)	-19 (30)	-19 (30)	-0.35 (0.52)
High	331 (393)	129 (154)	28.7 (5.06)	-22 (27)	-7 (8)	-0.13 (0.17)	-9 (10)	-9 (10)	-0.16 (0.21)
Age group									
20-34	441 (597)	170 (234)	27.1 (5.2)	-54 (79)	-11 (16)	-0.19 (0.28)	-21 (31)	-21 (31)	-0.36 (0.53)
35-44	309 (533)	119 (198)	29.6 (6.0)	-37 (73)	-8 (13)	-0.14 (0.23)	-15 (27)	-15 (27)	-0.27 (0.48)
45-54	283 (402)	110 (156)	29.9 (5.8)	-37 (57)	-7 (11)	-0.14 (0.21)	-14 (22)	-14 (22)	-0.27 (0.43)
55-64	297 (463)	111 (176)	28.6 (5.0)	-37 (67)	-7 (13)	-0.14 (0.24)	-14 (26)	-14 (26)	-0.27 (0.48)
65-74	139 (202)	51 (79)	28.5 (5.4)	-17 (31)	-3 (6)	-0.07 (0.11)	-6 (12)	-6 (12)	-0.13 (0.22)
75-84	277 (351)	113 (143)	26.4 (4.7)	-29 (37)	-7 (9)	-0.13 (0.16)	-11 (15)	-11 (15)	-0.22 (0.28)

[a]Standard deviation reported in parentheses.
[b]Volumes reported in ml/person/day
[c]Calories reported in kcal./person/day
[d]BMI reported in kg/m^2

The second component of our model translates the absolute BMI reductions into delayed mortality during the fifth year after the tax was implemented from IHD, ischemic stroke, hemorrhagic stroke, hypertensive heart disease, and diabetes, using relative risks from a previous meta-analysis [37]. The meta-analysis pooled data from 123 cohorts around the world to assess the effects of different metabolic risk factors, including BMI, on cardiovascular diseases stratified by age. We use the age-specific relative risks from this study for each 5 kg/m^2 increase in BMI, with the risk for hemorrhagic stroke starting at BMIs above 25 kg/m^2 [37] (supplementary appendix , table 3-S1).

We calculated the population attributable fraction (PAF), which quantifies the proportion of deaths delayed associated with weight loss from the soda tax by sex, age group, and income tertile (see supplementary appendix). Using the PAF multiplied by the deaths attributable to each disease, we estimated the sex-, tertile-, and age group-specific delayed deaths in the fifth year after the tax was implemented. We used estimated weight loss from five years after the implementation of the tax, since weight loss after calorie reduction is not immediate and we wanted to allow enough time after calorie reduction for weight to stabilize. We present these delayed deaths as delayed death rates per 100,00 population.

Lastly, we used the consumption estimates from the disease model as inputs into a distributional model which evaluates the impact of increased SSB taxes on tax revenues born by income tertile. Using the liter-per-year consumption post-tax and the tax rate per liter (1 peso/L), we were able to obtain SSB tax revenues at the individual level. We then aggregated the estimated SSB revenues by sex, income tertile, and age group. We also calculated the average percentage of income spent on taxes on SSBs after the tax increase

by income tertile using the average tertile-specific income and the estimated tax expenditures.

Sensitivity analysis

We conducted two sensitivity analyses. The first uses a constant decline in consumption of SSBs of 7.6%, which was the average decline found in the Colchero *et al.* study across 2014 and 2015, to estimate delayed death rates and tax revenues [18]. The second uses constant death rates across all income tertiles and the 5.5% SSB reduction scenario to estimate delayed death rates.

RESULTS

Five years after the SSB tax was implemented, we would expect to see a mean decrease in BMI of 0.16 kg/m^2 under the 5.5% SSB reduction scenario (Table 3-1). This decrease in BMI would translate into about 3.2 delayed deaths per 100,000 people (1.2% of total all-cause deaths) among Mexicans aged 20-84 in the fifth year after tax implementation (Table 3-2).

Table 3-2. Delayed death rate per 100,000 people (percentage of all-cause deaths) under 5.5% and 9.7% reduction in consumption scenarios by cardiometabolic disease in the fifth year after the tax was implemented.

Variable	5.5% SSB reduction scenario					
	IHD	Ischemic stroke	Hemorrhagic stroke*	Hypertensive heart disease	Diabetes	Total
Total	1.0 (0.8%)	0.1 (0.64%)	0.4 (1.2%)	0.1 (1.3%)	1.6 (1.8%)	3.2 (1.2%)
Sex						
Male	1.6 (0.95%)	0.1 (0.80%)	0.5(1.5%)	0.2 (1.7%)	2.1 (2.1%)	4.5 (1.4%)
Female	0.5 (0.56%)	0.1 (0.47%)	0.3 (1.0%)	0.1 (1.0%)	1.2 (1.8%)	2.1 (0.9%)
Income tertile						
Low	1.2 (0.95%)	0.1 (0.69%)	0.5 (1.5%)	0.1 (1.4%)	1.9 (2.1%)	3.7 (1.4%)
Medium	0.9 (0.84%)	0.1 (0.69%)	0.4 (1.4%)	0.1 (1.4%)	1.5 (1.9%)	2.9 (1.3%)
High	1.0 (0.65%)	0.1 (0.57%)	0.3 (0.9%)	0.1 (1.2%)	1.5 (1.4%)	3.0 (0.9%)
Age group						
20-34	0.1 (2.2%)	0.01 (2.5%)	0.1 (3.8%)	0.01 (3.1%)	0.1 (4.5%)	0.3 (2.9%)
35-44	0.3 (1.5%)	0.02 (1.8%)	0.2 (2.7%)	0.02 (2.2%)	0.4 (3.3%)	1.0 (2.2%)
45-54	0.9 (1.3%)	0.05 (1.5%)	0.5 (2.1%)	0.1 (2.0%)	1.7 (2.8%)	3.2 (2.0%)
55-64	2.1 (1.1%)	0.2 (1.2%)	0.9 (1.6%)	0.2 (1.8%)	4.4 (2.3%)	7.8 (1.7%)
65-74	2.5 (0.42%)	0.3 (0.43%)	0.8 (0.6%)	0.4 (0.9%)	4.8 (1.0%)	8.8 (0.7%)
75-84	9.5 (0.67%)	1.4 (0.53%)	2.0 (0.7%)	1.8 (1.2%)	11.4 (1.4%)	26.1 (0.9%)

Table 3-2 (continued). Delayed death rate per 100,000 people (percentage of all-cause deaths) under 5.5% and 9.7% reduction in consumption scenarios by cardiometabolic disease in the fifth year after the tax was implemented.

Variable	9.7% SSB reduction scenario					
	IHD	Ischemic stroke	Hemorrhagic stroke*	Hypertensive heart disease	Diabetes	Total
Total	1.8 (1.4%)	0.2 (1.1%)	0.7 (2.3%)	0.2 (2.3%)	2.9 (3.2%)	5.9 (2.1%)
Sex						
Male	2.8 (1.7%)	0.2 (1.4%)	0.9 (2.7%)	0.3 (2.9%)	3.8 (3.7%)	8.0 (2.4%)
Female	1.0 (1.1%)	0.1 (0.9%)	0.5 (1.9%)	0.2 (1.9%)	2.2 (2.7%)	4.0 (1.8%)
Income tertile						
Low	2.2 (1.8%)	0.2 (1.3%)	0.9 (2.8%)	0.3 (2.6%)	3.5 (3.9%)	7.1 (2.6%)
Medium	2.0 (1.9%)	0.2 (1.6%)	0.8 (3.2%)	0.3 (3.3%)	3.4 (4.4%)	6.6 (3.0%)
High	1.2 (0.8%)	0.1 (0.7%)	0.4 (1.1%)	0.2 (1.4%)	1.8 (1.7%)	3.8 (1.1%)
Age group						
20-34	0.3 (4.1%)	0.01 (4.1%)	0.2 (6.8%)	0.01 (5.4%)	0.1 (8.0%)	0.6 (5.3%)
35-44	0.6 (2.9%)	0.03 (3.3%)	0.4 (5.0%)	0.04 (4.1%)	0.7 (6.0%)	1.8 (4.2%)
45-54	1.8 (2.6%)	0.1 (3.0%)	0.9 (4.1%)	0.1 (3.7%)	3.3 (5.4%)	6.2 (3.9%)
55-64	4.0 (2.0%)	0.3 (2.2%)	1.6 (3.0%)	0.4 (3.3%)	8.4 (4.4%)	14.7 (3.1%)
65-74	4.6 (0.8%)	0.6 (0.8%)	1.5 (1.0%)	0.7 (1.6%)	8.8 (1.8%)	16.2 (1.2%)
75-84	15.5 (1.1%)	2.3 (0.9%)	3.3 (1.2%)	3.1 (2.1%)	18.7 (2.4%)	42.9 (1.5%)

*Only for those with BMIs above 25 kg/m^2.

We found a linear relationship between BMI change and income tertile, with the poorest tertile losing 0.19 kg/m^2 and the richest losing an estimated 0.13 kg/m^2, under the 5.5% reduction in SSB consumption scenario (Table 3-1). Similarly, the percentage of all-cause deaths delayed decreases with increasing income tertile; however, the magnitudes of these differences are small and we have not evaluated their significance (Table 3-2). The youngest age group (20-34 year-olds) would experience the greatest percentage of total all-cause deaths delayed (2.9%), however, the oldest age group (75-84 year-olds) would experience the largest delayed death rates (9.5 per 100,000 people) (Table 3-2). We estimate that the greatest total delayed death rate and percentage of delayed deaths were from diabetes (1.6 deaths per 100,000 people and 1.8% of all diabetes deaths) (Table 3-2).

We found similar patterns but different magnitudes under the 9.7% reduction in consumption of SSBs scenario across income tertiles. This scenario would yield a BMI reduction of 0.29 kg/m^2, five years post-tax implementation among 20-84 year-old Mexicans (Table 3-1). This BMI reduction would generate 5.9 delayed deaths per 100,000 people from cardiometabolic diseases in the fifth year after the tax was implemented (Table 3-2). The largest delayed death rate would come from the poorest income tertile (7.1 per 100,000 people); however, the greatest percentage of all-cause deaths delayed would be from the middle tertile (3.0%) (Table 3-2). This discrepancy is driven by the lower total number of deaths from cardiometabolic diseases among the middle-income tertile than among the lower-income tertile, such that the number of deaths delayed would represent a higher total percentage of deaths in the middle income tertile relative to the lower income tertile (supplementary appendix).

We also estimated annual tax revenues under both the 5.5% and 9.7% reduction scenarios by sex, income tertile, and age group, beginning in the year immediately following the implementation of the SSB tax. We estimated that the populations between 20 and 84 years old would generate 6,240 million Mexican pesos (470 million USD) in tax revenues, assuming an average of 5.5% SSB reduction across income tertiles (Table 3-3). Under this scenario, we found that each person in our population would generate a mean of 115 Mexican pesos (9 USD) in taxes (Table 3-3). Meanwhile, if SSB consumption were to decline by an average of 9.7% across income tertiles, we would expect a total of 5,850 million Mexican pesos (440 million USD) in annual tax revenues or a mean of 108 Mexican pesos (8 USD) per person (Table 3-3). Under both consumption reduction scenarios, men would bear a larger share of the burden of tax revenues than women (58% versus 42%) and the burden of tax revenues would decline with age under both the 5.5% and 9.7% estimates (Table 3-3). The poor would bear the smallest share of the burden of tax revenues, while the middle tertile would bear the largest share (Table 3-3). Under both consumption reduction scenarios, annual tax revenues would amount to about 1% of Mexico's 2016 government health expenditure and about 0.03% of 2016 GDP.

Table 3-3. Annual total tax revenues in millions of Mexican pesos (in millions of USD*) and mean tax revenues by person in Mexican pesos (in USD*) under 5.5% and 9.7% reduction in consumption scenarios, broken down by sex, income tertile, and age group.

Variable	5.5% average SSB reduction		9.7% average SSB reduction	
	Total annual tax revenues	Mean annual tax	Total annual tax revenues	Mean annual tax
Total	6,238 (469.3)	115 (9)	5,852 (440.3)	108 (8)
Sex				
Male	3,263 (272.6)	147 (11)	3,390 (255.0)	137 (11)
Female	2,615 (196.7)	89 (7)	2,463 (185.3)	84 (6)
Income tertile				
Low	1,872 (140.8)	103 (8)	1,701 (128.0)	92 (7)
Middle	2,371 (178.4)	130 (10)	2,182 (164.2)	119 (9)
High	2,010 (151.2)	114 (9)	1,982 (149.1)	113 (8)
Age group				
20-34	3,096 (232.9)	148 (11)	2,908 (218.8)	139 (10)
35-44	1,297 (97.6)	104 (8)	1,217 (91.6)	98 (7)
45-54	911 (68.5)	97 (7)	849 (63.9)	90 (7)
55-64	606 (45.6)	98 (7)	566 (42.6)	91 (7)
65-74	148 (11.1)	46 (3)	139 (10.4)	44 (3)
75-84	180 (13.6)	97 (7)	173 (13.0)	93 (7)

* Pesos were converted into 2014 USD using World Bank estimates (https://data.worldbank.org/indicator/PA.NUS.FCRF?end=2017&locations=MX&start=1991)

We estimated the mean tax revenues as a percentage of mean income by income tertile to explore the potential for regressivity in consumption of SSBs after the tax was implemented. We find that under both consumption reduction scenarios, the poorest income tertile would spend a larger percentage of their annual income on tax revenues than the rich (Table 3-4).

Table 3-4. Mean tax revenues as a percentage of mean income by income tertile under 5.5% and 9.7% reduction in consumption scenarios.

Income Tertile	5.5% average SSB reduction	9.7% average SSB reduction
Low	0.19%	0.17%
Middle	0.11%	0.10%
High	0.03%	0.03%

Sensitivity analysis

We conducted two sensitivity analyses. In the first scenario, we assumed a constant reduction in consumption of SSBs of 7.6% without any variation across income tertiles. We estimated that the tax would delay about 3.7 deaths per 100,000 people deaths (1.4 % of total all-cause deaths) among the Mexican population aged 20 to 84 in the fifth year after the tax was implemented (Table 3-5). Under this scenario, the poor would experience the smallest rate of delayed deaths and the smallest percent of total all-cause cardiometabolic deaths in the fifth year after tax implementation (Table 3-5). We found as age groups increase, the expected delayed death rates would also increase (Table 3-5).

Table 3-5. Sensitivity analysis: delayed death rate per 100,000 people (percentage of all-cause deaths) by cardiometabolic disease under constant 7.6% consumption decrease (sensitivity analysis 1) and death rates are constant (sensitivity analysis 2) across income tertiles in the fifth year after implementation of the tax.

Variable	Sensitivity Analysis 1: Constant 7.6% reduction in consumption of SSBs					
	IHD	Ischemic stroke	Hemorrhagic stroke*	Hypertensive heart disease	Diabetes	Total
Total	1.2 (0.9%)	0.1 (0.8%)	0.4 (1.4%)	0.2 (1.5%)	1.9 (2.0%)	3.7 (1.4%)
Sex						
Male	1.6 (1.1%)	0.1 (0.9%)	0.5 (1.7%)	0.2 (2.0%)	2.0 (2.4%)	4.4 (1.6%)
Female	0.7 (0.7%)	0.1 (0.5%)	0.4 (1.2%)	0.2 (1.2%)	1.6 (1.7%)	3.0 (1.1%)
Income tertile						
Low	1.0 (0.8%)	0.1 (0.6%)	0.4 (1.3%)	0.1 (1.1%)	1.6 (1.8%)	3.1 (1.2%)
Medium	1.2 (1.1%)	0.1 (0.9%)	0.5 (1.9%)	0.2 (1.9%)	2.0 (2.6%)	3.9 (1.7%)
High	1.4 (0.9%)	0.2 (0.8%)	0.5 (1.3%)	0.2 (1.6%)	2.0 (1.9%)	4.2 (1.3%)
Age group						
20-34	0.2 (2.4%)	0.01 (2.8%)	0.1 (4.2%)	0.01 (3.5%)	0.1 (5.0%)	0.4 (3.3%)
35-44	0.4 (1.8%)	0.02 (2.1%)	0.2 (3.1%)	0.02 (0.9%)	0.5 (3.8%)	1.1 (2.6%)
45-54	1.0 (1.5%)	0.1 (1.7%)	0.5 (2.4%)	0.1 (2.3%)	1.9 (3.2%)	3.7 (2.3%)
55-64	2.4 (1.2%)	0.2 (1.3%)	1.0 (1.8%)	0.3 (2.0%)	5.1 (2.7%)	8.9 (1.9%)
65-74	2.7 (0.5%)	0.3 (0.5%)	0.9 (0.6%)	0.5 (1.0%)	5.4 (1.1%)	9.8 (0.7%)
75-84	11.7 (0.8%)	1.7 (0.7%)	2.5 (0.9%)	2.2 (1.5%)	13.9 (1.8%)	32.0 (1.1%)

Table 3-5 (continued). Sensitivity analysis: delayed death rate per 100,000 people (percentage of all-cause deaths) by cardiometabolic disease under constant 7.6% consumption decrease (sensitivity analysis 1) and death rates are constant (sensitivity analysis 2) across income tertiles in the fifth year after implementation of the tax.

Variable	Sensitivity Analysis 2: Constant death rates					
	IHD	Ischemic stroke	Hemorrhagic stroke*	Hypertensive heart disease	Diabetes	Total
Total	1.0 (0.8%)	0.1 (0.6%)	0.4 (1.2%)	0.1 (1.3%)	1.6 (1.8%)	3.3 (1.2%)
Sex						
Male	1.2 (0.8%)	0.1 (0.8%)	0.4 (1.4%)	0.1 (1.9%)	1.7 (2.0%)	3.6 (1.3%)
Female	0.8 (0.8%)	0.1 (0.5%)	0.3 (1.1%)	0.1 (0.9%)	1.5 (1.5%)	2.9 (1.1%)
Income tertile						
Low	1.4 (1.1%)	0.1 (0.7%)	0.5 (1.6%)	0.1 (1.2%)	1.9 (2.2%)	4.0 (1.5%)
Medium	1.0 (0.8%)	0.1 (0.7%)	0.4 (1.3%)	0.1 (1.4%)	1.7 (1.9%)	3.3 (1.2%)
High	0.7 (0.5%)	0.1 (0.5%)	0.3 (0.9%)	0.1 (1.4%)	1.2 (1.3%)	2.4 (0.9%)
Age group						
20-34	0.1 (2.1%)	0.01 (2.5%)	0.1 (3.7%)	0.01 (3.0%)	0.1 (4.4%)	0.3 (2.9%)
35-44	0.3 (1.5%)	0.02 (1.8%)	0.2 (2.7%)	0.02 (2.2%)	0.4 (3.3%)	1.0 (2.3%)
45-54	0.9 (1.3%)	0.1 (1.5%)	0.5 (2.1%)	0.1 (1.9%)	1.7 (2.8%)	3.2 (2.0%)
55-64	2.2 (1.1%)	0.2 (1.2%)	0.9 (1.6%)	0.2 (1.7%)	4.5 (2.4%)	7.9 (1.7%)
65-74	3.2 (0.5%)	0.3 (0.5%)	0.9 (0.6%)	0.4 (0.8%)	5.1 (1.1%)	9.9 (0.7%)
75-84	8.8 (0.6%)	1.4 (0.5%)	2.0 (0.7%)	2.0 (1.3%)	11.3 (1.4%)	25.5 (0.9%)

*Only for those with BMIs above 25 kg/m^2.

We estimated that the population between 20 and 84 would generate 6,174 million Mexican pesos (464.5 million USD), averaging out to about 114 Mexican pesos per person per year (9 USD), in tax revenues (Table 3-5). Among income tertiles, the poorest would pay the least per person in taxes with a mean of 104 Mexican pesos per year compared with a mean of 112 Mexican pesos per year in the highest income tertile, (Table 6). Meanwhile the 65 to 74-year-olds would pay the least in mean taxes per person (46 Mexican pesos per year) (Table 3-6).

Table 3-6. Sensitivity analysis: annual total tax revenues in millions and mean tax revenues by person in Mexican pesos (in USD*), using constant 7.6% decrease in consumption, broken down by sex, income tertile, and age group.

Variable	Total annual tax revenues	Mean annual tax revenues
Total	6,174 (464.5)	114 (9)
Sex		
Male	3,593 (270.3)	146 (11)
Female	2,581 (194.2)	88 (7)
Income tertile		
Low	1,898 (142.8)	104 (8)
Middle	2,310 (173.8)	127 (10)
High	1,965 (147.9)	112 (8)
Age group		
20-34	3,067 (230.7)	147 (11)
35-44	1,282 (96.4)	103 (8)
45-54	902 (67.8)	96 (7)
55-64	600 (45.1)	97 (7)
65-74	147 (11.1)	46 (3)
75-84	178 (13.4)	96 (7)

When looking at the percentage of mean income spent on taxes by income tertiles, we find that the poor would spend a larger percentage of their income on tax revenues that the richest income tertile (Table 3-7).

Table 3-7. Sensitivity analysis: Mean tax revenues as a percentage of mean income by income tertile under the constant 7.6% decrease in consumption.

Income Tertile	Tax revenues as a percentage of income, post tax increase
Low	0.19%
Middle	0.11%
High	0.03%

For the second sensitivity analysis, we used the 5.5% SSB reduction scenario and constant death rates across income tertiles. We found an inverse relationship between income tertile and delayed death rates (Table 3-5).

DISCUSSION

In 2014, Mexico implemented a one peso-per-liter tax on SSBs, equivalent to about a 10% tax on SSBs. This study considered the expected impact of the tax in terms of improved population health benefits and raising government revenue, while also looking at the distributional health and financial impact of the tax to revisit the possible regressivity of the tax.

Our findings fall in line with those of other studies on the projected impacts of the SSB tax in Mexico. Our findings fall in line with those of other studies on the projected impacts of the SSB tax in Mexico. One study estimated about 18,900 deaths delayed over ten years, which roughly amounts to 1,890 delayed deaths per year, which is consistent with our estimates (3.2 deaths per 100,000 people, which was 1,760 delayed deaths before translating into death rates, assuming a 5.5% average reduction in SSB consumption over income tertiles) [20]. The Mexican government estimated that the tax would generate

about 12 billion Mexican pesos in annual revenues [12]. We project smaller annual tax revenues, however, much of this discrepancy between our and government estimates is likely due to the fact that we use a healthier subsample of about 54 million people while their figure is for the whole Mexican population of about 124 million people.

To our knowledge, our paper is one of the first that estimates the impacts of Mexico's SSB tax on delayed deaths from cardiometabolic diseases and tax revenues by income tertile. We found that the SSB tax would yield small health benefits in terms of deaths delayed, while providing the Mexican government with a large new source of revenue. When examining the distributional health effects of the tax, we found that while the poorest income tertile would experience the largest delayed deaths rates, they would also pay a larger percentage of their income in annual taxes on SSBs after the tax was implemented.

Our findings that the tax would generate small benefits in terms of deaths delayed is driven by the small expected reductions in calories from SSBs as a result of the tax and the short time frame, 5 years, over which the health impact is estimated. Assuming consumption of SSBs fell by 5.5% averaged across income tertiles, ,the tax is projected to decrease mean calorie consumption by 9 calories per person per day, the equivalent of just over one almond (7.7 calories) per day, which generated a mean reduction in BMI of only 0.16 kg/m^2 five years post-tax implementation. If reductions in SSB consumption fell by 9.7% averaged across income tertiles, representing about double the mean calorie reduction compared with the first scenario, we would expect a mean decrease in BMI of 0.29 kg/m^2 five years after the tax was implemented. While these reductions in BMI appear small and indeed have a limited impact on delaying mortality from cardiometabolic

diseases, other studies that estimate the impacts on morbidity find a much larger effect [19,20]. This is likely due to the fact that other studies estimate averted cases of disease over ten or more years, while we examine delayed deaths in only the fifth year after the tax was implemented [19,20].

Our analysis has a number of limitations. The first is that the relative risks were derived from 123 different prospective observational studies, none of which were specific to the Mexican population. The 5.5% and 9.7% SSB reduction scenarios were derived from studies looking at soda purchases, which are estimated using surveys that might underestimate actual consumption [18]. These two reduction scenarios appear have different ranges of changes in consumption in response to the tax, but importantly also appear to come from two different distributions. Nevertheless, another study using a different Mexican data source finds a similar decrease in SSB purchases of about 6% since the SSB tax was implemented [15]. While we would have liked to examine the impacts of the tax by income quintile to get a better sense of how the tax would likely impact different income groups, we looked at the impacts by income tertile since the estimated reduction in SSB consumption were only presented by income tertile. We assumed that reductions in consumption were stable over the five-year period, however we have not tested this assumption. We did project the effects of the tax under two scenarios (5.5% and 9.7% SSB reduction) in order to capture a range of possible impacts, while also conducting a sensitivity analysis in which we assumed that reductions in consumption were the same across income tertiles. We were unable to find tertile-specific deaths by disease, so we distributed the age-specific deaths proportional to the tertile in each age group. This likely underestimated the true effect, since the poor often have worse health outcomes for the

same diseases than the middle and upper tertiles. In order to address this possible bias, we conducted a sensitivity analysis where we assumed that the death rates were equally distributed over income tertiles. Another major limitation is that we did not generate uncertainty estimates, so we were unable to evaluate whether the delayed deaths in different groups (tertile, sex, and age) were significantly different from one another. We also present average estimates, which masks important variations within income tertiles. We counted all delayed deaths equally, regardless of when in a person's lifetime those delayed deaths occur although we do present disaggregated estimates of delayed death rates by age-group.

This study evaluated the Mexican SSB tax according to the goals it was designed to achieve as well as its distributional impact. The first goal of the tax was to decrease obesity and the burden of cardiometabolic diseases. We found that the SSB tax would be expected to yield small numbers of deaths delayed, in part because the tax is low and induces small changes in calories consumed, but also because our timescale is short. The second goal was in generating tax revenues. We would expect the tax to generate large government revenues, amounting to almost 0.03% of GDP. When considering the distributional impact of the tax, we found that the tax would produce more health benefits to the poorest income tertiles, however, the poor would also pay a larger share of their average income on taxes than the rich. Earmarking tax revenues for programs directed towards the poor could reverse the regressivity in consumption that we would expect after tax implementation. Given that the tax is expected to produce small health benefits, it is important that the tax is just one piece in a larger strategy to address the obesity and cardiometabolic disease epidemics.

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REFERENCES

1. Rivera Dommarco JA, Hernandez Avila M, Aguilar Salinas CA, Vadillo Ortega F, Murayama Rendon C. Obesidad en Mexico: Recomendaciones para una politica de Estado. National Academy of Medicine; The National Institute of Public Health; the Autonomous institute of Public Health; 2013.
2. Institute for Health Metrics and Evaluation (IHME). GBD Compare Data Visualizations [Internet]. 9 Nov 2018.
3. Secretaría de Salud. Acuerdo Nacional para la Salud Alimentaria, Estrategia contra el sobrepeso y la obesidad. Ciudad de México, México: Gobierno Federal de los Estados Unidos Mexicanos; 2010.
4. Hernandez-Cordero S, Cuevas-Nasu L, Moran-Ruan MC, Mendez-Gomez Humaran I, Avila-Arcos MA, Rivera-Dommarco JA. Overweight and obesity in Mexican children and adolescents during the last 25 years. Nutrition & diabetes. 2017;7: e247. doi:10.1038/nutd.2016.52
5. Singh AS, Mulder C, Twisk JW, van Mechelen W, Chinapaw MJ. Tracking of childhood overweight into adulthood: a systematic review of the literature. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2008;9: 474–88. doi:10.1111/j.1467-789X.2008.00475.x
6. Gonzalez de Cossio T, Dommarco JRi, Lopez-Acevedo GC, Soto GMR. Nutrición y Pobreza: Política Pública Basada en Evidencia [Internet]. World Bank; 2008. Available: http://documents.worldbank.org/curated/en/688351468049752976/Nutrición-y-Pobreza-Política-Pública-Basada-en-Evidencia
7. Moreno-Altamirano L, Hernandez-Montoya D, Silberman M, Capraro S, Garcia-Garcia JJ, Soto-Estrada G, et al. [The nutrition transition and the double burden of malnutrition: changes in dietary patterns 1961-2009 in the Mexican socioeconomic context]. Arch Latinoam Nutr. 2014;64: 231–240.
8. Barquera S, Hernandez-Barrera L, Tolentino ML, Espinosa J, Ng SW, Rivera JA, et al. Energy intake from beverages is increasing among Mexican adolescents and adults. The Journal of nutrition. 2008;138: 2454. doi:10.3945/jn.108.092163
9. Colchero MA, Salgado JC, Hernandez-Avila M, Velasco-Bernal A, Carriedo A, Rivera-Dommarco JA. Aspectos económicos relacionados con un impuesto al refresco en México. Instituto Nacional de Salud Pública; n.d.
10. ANPRAC. La industria de refescos y aguas carbonatadas en 2005: annuario estadístico. Mexico DF, Mexico: Asociación Nacional de Productores de Refrescos y Aguas Carbonatadas; 2005.
11. Camara de Diputados LXII Legislatura. Gaceta Parlamentaia LXII Legislatura Camara De Diputados Jueves 17 de Octubre Anexo VIII. 2013.
12. Gobierno de los Estados Unidos Mexicanos, Camara de Diputados. Criterios Generales de Politica Economica 2014. 2013.
13. Senado de la Republica, Senado de la Republica C de H y CP. Comisiones Unidas de Hacienda y Crédito Público y de Estudios Legislativos, Segunda. 2013.
14. Colchero MA, Molina M, Guerrero-López CM. After Mexico Implemented a Tax, Purchases of Sugar-Sweetened Beverages Decreased and Water Increased: Difference by Place of Residence, Household Composition, and Income Level. The Journal of nutrition. 2017;147: 1552–1557. doi:10.3945/jn.117.251892

15. Colchero MA, Guerrero-Lopez CM, Molina M, Rivera JA. Beverages Sales in Mexico before and after Implementation of a Sugar Sweetened Beverage Tax. PLoS One. 2016;11: e0163463. doi:10.1371/journal.pone.0163463
16. Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. Bmj. 2016;352. doi:10.1136/bmj.h6704
17. Colchero M, Salgado J, Unar-Munguía M, Molina M, Ng S, Rivera-Dommarco J. Changes in Prices After an Excise Tax to Sweetened Sugar Beverages Was Implemented in Mexico: Evidence from Urban Areas. PLOS ONE. 2015;10. doi:10.1371/journal.pone.0144408
18. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. In Mexico, evidence of a sustained consumer response two years after implementing a sugar sweetened beverage tax. Health Affairs. 2017; 10.1377/hlthaff. 2016.1231.
19. Barrientos-Gutierrez T, Zepeda-Tello R, Rodrigues ER, Colchero-Aragonés A, Rojas-Martínez R, Lazcano-Ponce E, et al. Expected population weight and diabetes impact of the 1-peso-per-litre tax to sugar sweetened beverages in Mexico. PLOS ONE. 2017;12: e0176336. doi:10.1371/journal.pone.0176336
20. Sánchez-Romero L, Penko J, Coxson P, Fernández A, Mason A, Moran A, et al. Projected Impact of Mexico's Sugar-Sweetened Beverage Tax Policy on Diabetes and Cardiovascular Disease: A Modeling Study. PLoS Medicine. 2016;13. doi:10.1371/journal.pmed.1002158
21. Verguet S, Kim JJ, Jamison DT. Extended Cost-Effectiveness Analysis for Health Policy Assessment: A Tutorial. Pharmacoeconomics. 2016;34. doi:10.1007/s40273-016-0414-z
22. Verguet S, Laxminarayan R, Jamison DT. Universal Public Finance of Tuberculosis Treatment in India: An Extended Cost‐Effectiveness Analysis. Health Economics. 2015;24: 318–332. doi:10.1002/hec.3019
23. Verguet S, Jamison DT. Health policy analysis: Applications of extended cost-effectiveness analysis methodology. In: Jamison DT, Gelband H, Horton S, Jha P, Laxminarayan R, editors. Disease Control Priorities. Third. Washington, DC: World Bank; 2017.
24. Postolovska I, Lacado 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: World Bank; 2017.
25. James EK, Saxena A, Franco Restrepo C, Llorente B, Vecino-Ortiz AI, Villar Uribe M, et al. Distributional health and financial benefits of increased tobacco taxes in Colombia: results from a modelling study. Tobacco Control. 2018; doi:Z
26. 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. The Lancet Global Health. 2015;3: e206–e216. doi:10.1016/S2214-109X(15)70095-1
27. Salti N, Brouwer E, Verguet S. The health, financial and distributional consequences of increases in the tobacco excise tax among smokers in Lebanon. Social Science & Medicine (1982). 2016; doi:10.1016/j.socscimed.2016.10.020

28. Gutiérrez JP, Rivera-Dommarco J, Shamah-Levy T, Villalpando-Hernandez S, Franco A, Cuevas-Nasu L, et al. Encuesta Nacional de Salud y Nutrición 2012. Resultados Nacionales. Cuernavaca, México: Instituto Nacional de Salud Pública; 2012.
29. Romero-Martínez M, Shamah-Levy T, Franco-Núñez A, Villalpando S, Cuevas-Nasu L, Gutiérrez JP, et al. Encuesta Nacional de Salud y Nutrición 2012: diseño y cobertura. salud pública de méxico. 2013;55: S332–S340.
30. INSP. Encuesta Nacinoal de Salud y Nutrición 2012. Mexico City, Mexico; 2012.
31. INEGI. Encuesta Nacional de Ingresos y Gastos de los Hogares (ENIGH) 2014. 2014.
32. García Formentí DC, Zepeda Tello R. bw: Dynamic Body Weight Models for Chidlren and Adults, R package. 2018.
33. Zepeda Tello R, García Formentí DC. Brief Explanation on Hall Model and Inputs. Ciudad de México, México: Instituto Nacional de Salud Publica; n.d.
34. Hall KD, Sacks G, Chandramohan D, Chow CC, Wang YC, Gortmaker SL, et al. Quantification of the effect of energy imbalance on bodyweight. The Lancet. 378: 826–837. doi:10.1016/S0140-6736(11)60812-X
35. Chow CC, Hall KD. The dynamics of human body weight change. PLoS computational biology. 2008;4: e1000045. doi:10.1371/journal.pcbi.1000045
36. Lin B-H, Smith TA, Lee J-Y, Hall KD. Measuring weight outcomes for obesity intervention strategies: the case of a sugar-sweetened beverage tax. Econ Hum Biol. 2011;9: 329–341. doi:10.1016/j.ehb.2011.08.007
37. Singh GM, Danaei G, Farzadfar F, Stevens GA, Woodward M, Wormser D, et al. The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. PLOS ONE. 2013;8: e65174. doi:10.1371/journal.pone.0065174

SUPPLEMENTARY APPENDIX

1. Estimating the population attributable fraction and averted deaths

For each age group and income tertile we calculated the following.

1. We calculate the density of the normal distribution around each slice (width) of BMI:

$$P_i = \left(\frac{1}{\sigma_x * \sqrt{2\pi}} * e^{-\frac{1}{2}*\left(\frac{\lambda_i - \mu_x}{\sigma_x}\right)^2} \right) * width$$

where $\lambda_i = individual\ BMI;\ \mu_x = age\ group\ and\ tertile\ specific\ pre-tax\ mean\ BMI\ ;\ \sigma_x = age\ group\ and\ tertile\ specific\ pre-tax\ standard\ deviation\ of\ BMI; width = 0.1 kg/m^2$

2.Calculating the z-score for each slice:

$$z_i = (\lambda_i - \mu_x)/\sigma_x$$

3.Calculating the corresponding level for each slice in the post-tax BMI distribution:

$$bmi_{posttax} = z_i * \sigma_x + \varrho_x$$

where $\varrho_x = age\ group\ and\ tertile\ specific\ post-tax\ mean\ BMI$

4.Calculating the relative risk for each slice:

$$rr_i = e^{(\lambda_i - bmi_{posttax}) * \beta_{disease}}$$

where $rr = 1\ if\ \lambda \leq bmi_{posttax};\ \beta_{disease} = beta$ specific to each disease (Table A1)

5. Calculating the PAF:

$$PAF = \frac{\sum_i P_i * (rr_i - 1)}{\sum_i P_I * (rr_i - 1) + 1}$$

6. Calculated averted deaths:

$$Averted\ deaths = PAF * \theta$$

where $\theta = deaths\ by\ disease$

Table 3-S1. The LogRR for association between each additional 1kg/m^2 increase in BMI and mortality from cardiovascular disease and diabetes[1][1].

Age group	IHD	Ischemic stroke	Hemorrhagic stroke*	Hypertensive heart disease	Diabetes
20-34	0.101	0.124	0.186	0.153	0.220
35-44	0.101	0.124	0.186	0.153	0.220
45-54	0.088	0.103	0.148	0.141	0.196
55-64	0.073	0.081	0.112	0.128	0.168
65-74	0.060	0.060	0.078	0.119	0.142
75-84	0.046	0.038	0.053	0.098	0.106

[1] Since we didn't have a relative risk for age groups below 35 and our study population includes adults between the ages of 20 and 84, we assumed that the relative risk of the 35-44 age group applied to the 20-34 age group as well.

*The association for hemorrhagic stroke only applies to BMIs above 25 kg/m^2.

Table 3-S2. Estimated relative change in SSB purchases per capita per day by income tertile for 2014 and 2015.

Income Tertile	Relative change in SSB consumption using data from *2014*	Relative change in SSB consumption using data from *2015*
Low	-9.0%	-14.3%
Middle	-5.9%	-11.7%
High	-4.4%	-5.6%
Average	-5.5%	-9.7%

Reproduced from Colchero et al, *Health Affairs,* 2017[2].

Table 3-S3. Deaths from cardiovascular diseases and diabetes in 2016 in Mexico by sex, income tertile, and age groups [3].

Variable	Deaths IHD	Deaths ischemic stroke	Deaths hemorrhagic stroke	Deaths hypertensive heart disease	Deaths diabetes
Total	68,330	8,631	16,948	5,578	49,474
Sex					
Male	41,674	4,404	8,799	2,269	25,176
Female	26,656	4,228	8,148	3,309	24,298
Income tertile					
Low	22,842	2,917	5,656	1,907	16,458
Medium	18,518	2,165	4,826	1,477	14,042
High	26,971	3,549	6,466	2,194	18,974
Age Group					
20-34	1,327	73	541	56	336
35-44	2,728	120	992	123	1,519
45-54	6,552	331	2,138	348	5,771
55-64	12,503	901	3,461	808	11,853
65-74	18,852	2,264	4,610	1,522	15,384
75-84	26,368	4,942	5,204	2,721	14,612

REFERENCES

1. Singh GM, Danaei G, Farzadfar F, Stevens GA, Woodward M, Wormser D, et al. The age-specific quantitative effects of metabolic risk factors on cardiovascular diseases and diabetes: a pooled analysis. PLoS One. 2013;8(7):e65174. Epub 2013/08/13. doi: 10.1371/journal.pone.0065174. PubMed PMID: 23935815; PubMed Central PMCID: PMCPMC3728292.

2. Colchero MA, Rivera-Dommarco J, Popkin BM, Ng SW. Sustained consumer response: evidence from two-years after implementing a sugar sweetened beverage tax in Mexico. Health Affairs. 2017; 10.1377/hlthaff. 2016.1231.

3. GBD Compare Data Visualizations [Internet]. IHME, University of Washington. 2018 [cited 2018-11-09]. Available from: https://vizhub.healthdata.org/gbd-compare/.

CHAPTER FOUR, PAPER III: THE DISTRIBUTIONAL HEALTH AND FINANCIAL BENEFITS OF INCREASED TOBACCO TAXES IN COLOMBIA: RESULTS FROM A MODELING STUDY

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ABSTRACT

Background: In Colombia, smoking is the second leading modifiable risk factor for premature mortality. In December 2016, Colombia passed a major tax increase on tobacco products in an effort to decrease smoking and improve population health. While tobacco taxes are known to be highly effective in reducing the prevalence of smoking, they are often criticized as being regressive in consumption. This analysis attempts to assess the distributional impact (across socio-economic groups) of the new tax on selected health and financial outcomes.

Methods: This study builds on extended cost-effectiveness analysis (ECEA) methods to study the new tobacco tax in Colombia, and estimates, over a time-period of 20 years and across income quintiles of the current urban population (80% of the country population), the years of life gained with smoking cessation and the increased tax revenues, all associated with a 70% relative price increase of the pack of cigarettes. Where possible, we use parameters that vary by income quintile, including price elasticity of demand for cigarettes (average of -0.44 estimated from household survey data).

Findings: Over 20 years, the tax increase would lead to an estimated 191,000 years of life gained among Colombia's current urban population, with the largest gains among the bottom two income quintiles. The additional annual tax revenues raised would amount to about 2-4% of Colombia's annual government health expenditure. Those who continue smoking among the poorest income quintiles would spend the largest percentage of their income on additional tax revenues.

Conclusions: The tobacco tax increase passed by Colombia has substantial implications for the country's population health and financial well-being, with large health benefits likely to accrue to those quitting smoking and those not initiating smoking, among the two poorest quintiles of the population. Those among the poorest income quintiles who continue smoking, however, would see the largest financial losses as a result of the tobacco tax increase.

Keywords: smoking; tobacco tax; equity; distributional impact; extended cost-effectiveness analysis; Colombia

INTRODUCTION

Like many South American countries, Colombia faces a high burden of non-communicable diseases (NCDs). The World Health Organization (WHO) estimates that in Colombia NCDs accounted for 73% of total deaths in 2015 [1]. As a middle-income country with a multi-payer health system that provides universal health care, Colombia is struggling with the financial implications tied to increasing demand for health services, driven in part by the management of NCDs [2].

In 2013, the Colombian government committed to substantially decrease the burden of NCDs, of which a key stated target was to reduce the prevalence of smoking to 10% from 13% among 18-69 year-olds between 2012 and 2021 [3]. Colombia also committed to the Sustainable Development Goals (SDGs), which, under SDG3 calls for "healthy lives for all people" by 2030 [4]. Part of this goal is the reduction of premature mortality by one third, which smoking cessation and prevention will help Colombia to achieve. With around 3 million urban smokers, about 12% of the urban population between the ages of 10 and 79, smoking is the third leading risk factor for mortality [5,6]. Estimates from 2013 indicate that treating tobacco-related illnesses cost an estimated 4,230,000 million Colombian pesos (COP) annually, or almost US$2.1 billion, equivalent to about 0.6% of the country's gross domestic product (GDP) [7-10]. As such, decreasing smoking prevalence in Colombia holds promise in decreasing NCDs and with it the financial burden of treating smoking-related diseases [3].

In 2008, Colombia ratified WHO's Framework Convention on Tobacco Control (FCTC), thereby making a legal commitment to implement strong tobacco control policies. Colombia has implemented several FCTC recommendations for reducing tobacco

consumption, including national smoke-free areas and advertising and promotion bans [10].

In December 2016, Colombia legislated an increase in both excise taxes and value-added taxes (VAT) of tobacco products in the context of a general tax reform [11]. Indeed, WHO recommends that excise taxes should be at least 70% of the retail price of cigarettes to maximize the effect against smoking [12,13]. Prior to the tobacco tax reform, Colombia fell short of this benchmark, as the former (pre-2017) tax on the most sold brand pack of cigarettes was <50% of the retail price, with excise taxes constituting only about 30% (22% specific, i.e. defined amount per pack; 8% ad valorem, i.e. defined percentage per pack value) of the retail price [14,15] (Figure 4-1). From 2017 onwards, the reform doubles the specific excise tax to COP$ 1400 (2017), triples it to COP$ 2100 (2018), and subsequently (2019 and beyond) increases the price of cigarettes by the country's annual rate of inflation plus four percentage points [11,15]. The legislation also increases the value-added tax (VAT) from 16 to 19% of the base price of a cigarette pack in 2017. The new taxes (post-2019) will constitute about 62% of the retail price with specific excise taxes making up roughly 43% of the retail price, still falling short of WHO's 70% benchmark.

Nevertheless, tripling the specific excise tax [15] is expected to substantially decrease tobacco consumption in Colombia. Most evidence supports the use of large price increases to decrease tobacco consumption [16-19]: it discourages non-smokers (e.g. the young) from beginning smoking; it pushes smokers to quit or to decrease their smoking; and it discourages former smokers from resuming smoking. Additionally, the young appear to be more price responsive than the old, which has the potential for large future gains in

terms of decreasing tobacco use and associated mortality and morbidity [19-21]. The poor also seem to be more price responsive than the rich [19,20,22,23], which is important since much of the controversy around raising tobacco taxes is consumption regressivity. Despite differing tax structures for tobacco products, increasing specific excise taxes remains one of the most effective means of decreasing tobacco consumption [14,19]. Uniform specific excise taxes equalize the price of all tobacco products by narrowing the price gaps between cheaper and more expensive cigarettes, and therefore can prevent tobacco users from potential product substitution and switching to consuming cheaper cigarette brands [18,19]. In this paper, we examine the potential impact of Colombia's new tobacco tax increase, and draw from extended cost-effectiveness analysis (ECEA) methods [24,25] to model the impact of the tax on selected health and financial outcomes across socioeconomic groups in Colombia.

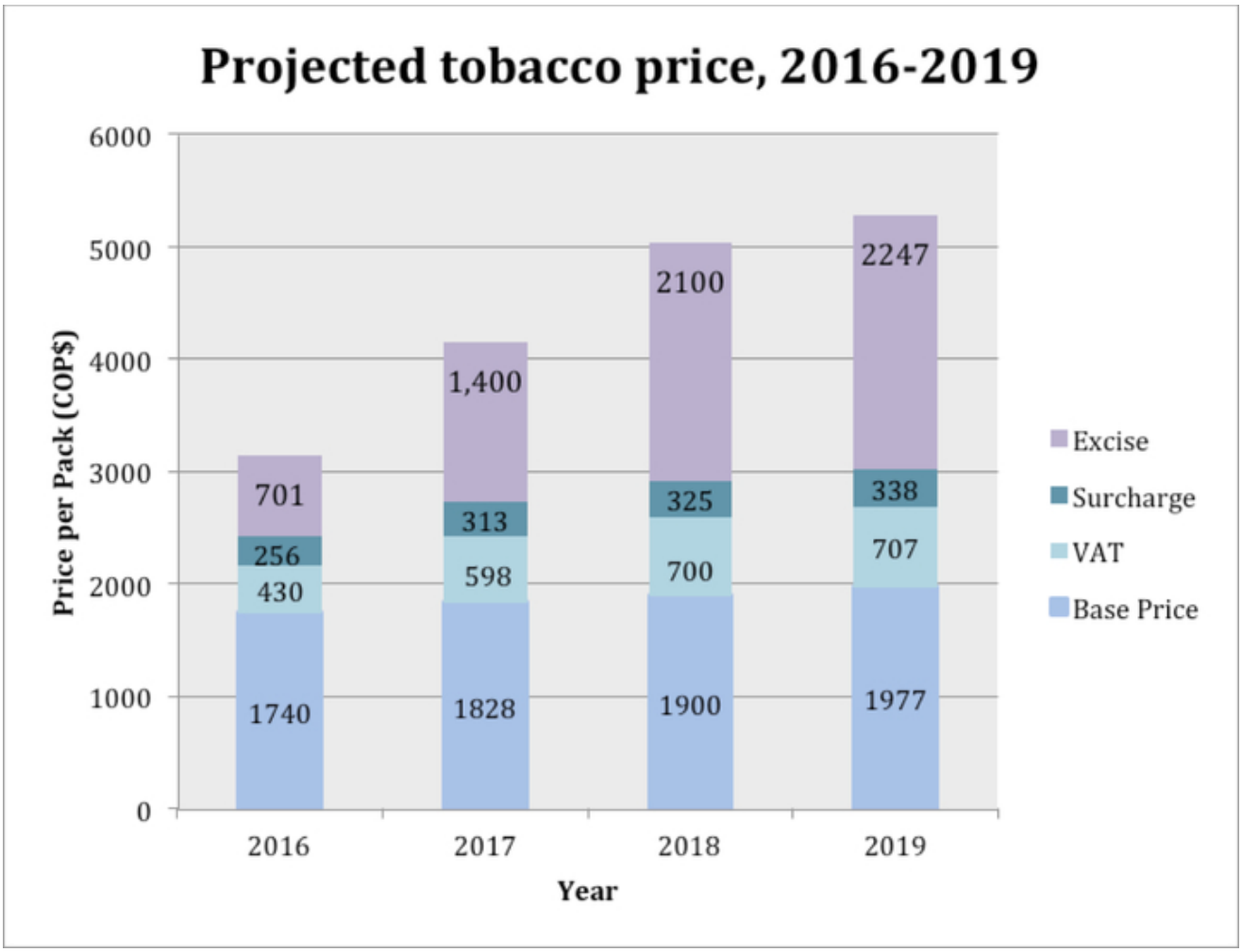

Figure 4-1. Projected tobacco price, 2016-2019, following Colombia's tax policy.

Prior to the tobacco tax reform (2016), specific excise taxes (COP$ 701) would represent about 22% of the retail price of cigarettes; while they would represent 34% (COP$ 1400), 42% (COP$ 2100), and 43% (COP$ 2247) of the retail price in 2017, 2018, and 2019, respectively. Overall, the retail price will have risen by 69% over 2016-2019.
Source: Llorente 2017 [15].

METHODS

Modeling approach

Extended cost-effectiveness analysis (ECEA) has been previously applied to examine the distributional impact of tobacco tax policy in China [26,27], Lebanon [22], and Armenia [23]; while the distributional incidence of tobacco taxes has also been previously studied in Chile [28]. Here, we draw from a previously published ECEA tobacco tax model [26,27] to study impact on: the years of life gained (YLG) associated with smoking cessation; the change in tobacco tax burden; and the change in cigarette expenditure.

Our study uses varying inputs across urban income quintiles and age groups (Table 4-1) to estimate hypothetical tax policy impact among the current urban population (77% of the country population as of 2016 [9]). The population is divided into seven age groups (<15, 15-24, 25-49, 50-64, 65-69, 70-74, and 75-79 year-olds) further disaggregated by income quintile. As data on smoking prevalence by age group and income quintile were only available for Colombia's urban population [6], we restricted our analysis to the urban population under age 80, implying that our results capture a lower bound of the potential policy impact since it excludes the rural population. Therefore, we use age-specific smoking prevalence data and further distribute it across income quintiles using quintile-specific smoking prevalence data to obtain the number of current smokers per age group and income quintile. To account for the fact that households in lower income quintiles have more children, we further adjust the population size of "future smokers" (age < 15) by modifying the distribution of those future smokers per quintile. Furthermore, consistent with findings from the literature, the model assumes that, for all smokers (young and old),

the participation elasticity is half the total price elasticity, implying that increased prices affect the smoking participation by half and the other half affects the consumption of cigarettes among those who do not quit [19]. Younger (age < 20) smokers are also assumed to be twice as responsive as older smokers (age > 35), consistent with reviews [19], with a linear increase in price elasticity modifier (from 1 to 2) from age 35 to age 20 (over age groups 20-24, 25-29, and 30-34 year-olds).

We examine hypothetical impact over a time-period of 20 years in three ways. First, we estimate the number of YLG among those quitting smoking as a result of increased prices. We assume no health gains for those who do not quit but reduce smoking consumption. The YLGs depend on age at quitting: there is an inverse relationship between YLG and age at smoking cessation: quitting at age 30, 40, 50, or 60, leads to gains of about 10, 9, 6, or 3 years of life, respectively [18,29]. Using the product of the participation elasticity, the change in price, and such an estimated age-specific YLG among quitters, we obtain the YLG due to increased prices for those who would have died prematurely over the next 20 years (see supplementary appendix, section 1, for further detail).

Second, we calculate tax revenues before and after the tax increase and the change in revenues borne by each income quintile. We use estimated baseline cigarette consumption by quintile (from 5.7 cigarettes per day among the poorest to 10.1 among the richest) and the average tax per cigarette pack (COP$ 1389) to calculate revenues before tax increase. We then estimate post-tax increase revenues by income quintile and compare them to the pre-tax increase revenues to examine the change in revenues. We also calculated the percentage of income spent on increased taxes in the first year using the net

change in tax revenues by income quintile, the number of smokers, and mean annual income per income quintile.

Third, to generate estimates of expenditure on cigarettes by quintile we use the estimated number of smokers by income quintile after the tax increase and the projected price per pack of cigarettes. We then compare these new estimates under the post-tax scenario to the pre-tax scenario to quantify the change in consumption and hence expenditure on cigarettes by quintile.

While the tax is designed to increase the average price of cigarettes three times, we only report aggregate findings, and assume no change in household income and socioeconomic status over time.

Model inputs

We use parameters that vary by income quintile where possible in order to capture the distributional impact of the tax (Table 4-1). Average price and taxes per cigarette pack were sourced from a recently published report [15] (Figure 4-1). The report used the median cigarette price obtained from the Departamento Administrativo Nacional de Estadística (DANE) to calculate the total taxes per pack. Then taxes were added to the base price as outlined in the December 2016 law to obtain the predicted prices over 2017-19.

We assume the tax is completely passed onto the consumer as estimates have shown [15]. In a sensitivity analysis, we also modeled the outcomes using the price of a premium pack of cigarettes (Marlboro Red) with a tax inclusive retail price in 2016 of COP$ 3772 [14].

Table 4-1. Inputs and corresponding sources used in the analysis of the distributional impact of increased tobacco taxes among Colombia's urban population, on years of life gained, tax revenues and cigarette expenditure.

Input	Value	Data sources
Size of urban population (ages 0-79)	35,317,947	Departamento Administrativo Nacional de Estadística (DANE) [33]
Urban population structure – distribution of population across age groups (years)		
<15	28%	DANE, Population Projections [33]
15-24	19%	
25-49	35%	
50-64	13%	
≥65	6%	
Urban smoking prevalence by age group		
<17	5%	ENCSPC and SABE [6,34]
18-24	16%	
25-34	16%	
35-44	11%	
45-64	14%	
≥65	12%	
Urban household smoking prevalence per income quintile (%)		
Quintile 1 (poorest)	11%	ENCV 2014 [30]
Quintile 2	12%	
Quintile 3	13%	
Quintile 4	12%	
Quintile 5 (richest)	12%	
Urban individual cigarette consumption (cigarettes per day) per income quintile		
Quintile 1 (poorest)	5.7	Derived from ENCV 2014 and Llorente 2017 [15,30]
Quintile 2	7.8	
Quintile 3	8.1	
Quintile 4	8.3	
Quintile 5 (richest)	10.1	
Total fertility rate (children per woman of reproductive age, nationally) per income quintile*		
Quintile 1 (poorest)	2.8	ENDS Colombia 2015 [35]
Quintile 2	2.3	
Quintile 3	1.9	
Quintile 4	1.5	
Quintile 5 (richest)	1.3	
Mean annual household income (in COP$, urban households)		
Quintile 1 (poorest)	27,600,000	ENCV 2014 [30]
Quintile 2	53,400,000	
Quintile 3	78,100,000	
Quintile 4	112,000,000	
Quintile 5 (richest)	303,000,000	

*Mean total fertility rate in urban areas is 1.8 [35] and most of the urban population is within national income quintiles 2 to 5, hence we distributed 1.3 to 2.3 among the five urban income quintiles studied, to account for the fact that households in lower income quintiles have more children.

One of the most important inputs is the price elasticity of demand for cigarettes. We used the Encuesta Nacional de Calidad de Vida (ENCV) household surveys [30] combined with the Encuesta Anual Manufacturera (EAM) reporting cigarette sales [31] for the years 2003, 2010, 2011 and 2014 (we had four price values to estimate an average price elasticity of demand), to derive an estimated average price elasticity of -0.44 for Colombia (further detail is provided in the supplementary appendix, section 2.1), consistent with previous average estimates of about -0.40 [19]. As price elasticity estimates per income quintile were not available for Colombia, we identified 11 other studies from Latin American countries with price elasticity estimates ranging from -0.85 to -0.22 (supplementary appendix, section 2.2). Subsequently, we distributed the variation in these 11 estimates (interquartile range of 0.42) across our average price elasticity of -0.44 to derive a price elasticity per income quintile (Table 2; supplementary appendix, section 2.2) assuming the poor have a greater price elasticity than the rich, consistent with previous studies [19,20,22,23]. We also proceeded to sensitivity analyses using two alternative flat price elasticity across income quintiles so to better understand the distributional impact of the tax: -0.40 as indicated by WHO [19]; and -0.78 as recently estimated by Maldonado and colleagues for Colombia [32].

Table 4-2. Assumed price elasticity of demand for cigarettes by income quintile and age group.

Income quintile	Age < 20 years	20-24 year-olds	25-29 year-olds	30-34 year-olds	Age > 35 years
1 (Poorest)	-1.22	-1.08	-0.92	-0.77	-0.61
2	-1.06	-0.92	-0.79	-0.66	-0.53
3	-0.88	-0.77	-0.66	-0.55	-0.44
4	-0.70	-0.61	-0.53	-0.44	-0.35
5 (Richest)	-0.52	-0.46	-0.40	-0.33	-0.26

Sensitivity analyses

We pursued five univariate sensitivity analyses for the legislated tax increase: i) where the price elasticity was set flat to -0.40 across income quintiles; ii) where the price elasticity was set flat to -0.78 across income quintiles; iii) where the youth elasticity modifier was set to 1 instead of 2 (the young would be as price elastic as adults); iv) where the mean price of a pack of cigarettes was set to COP$ 3772; and v) where the baseline cigarette consumption was set flat to an average 8 cigarettes per day across income quintiles. The first three sensitivity analyses attempt to address the uncertainty underlying estimates of price elasticity, a key input in tax policy impact. The last two sensitivity analyses aim to address the lack of evidence in the distribution in the price and consumption of the different cigarette brands. Furthermore, since Colombia's legislated specific excise tax increases remain below WHO recommendations, we provide estimates for two additional specific excise tax increase scenarios that would hypothetically take place in 2020. The first scenario raises specific excise taxes to make up 50% of the retail

price of cigarettes, representing a 18% increase compared with the 2019 retail price; the second increases them to 70% of the retail price, corresponding to a 97% increase compared with the 2019 retail price (see supplementary appendix, section 3).

RESULTS

For the current urban population, with a cumulative 69% price increase in an average pack of cigarettes spread out over three consecutive tax increases (Figure 1), we would expect about 191,000 YLG over 20 years (Table 4-3). About 50% of these YLG would come from the two poorest income quintiles while the smallest proportion (28%) would come from the two richest income quintiles.

Table 4-3. Summary findings for the distributional health and financial consequences of increased tobacco taxes among Colombia's current urban population, across income quintiles, over 20 years.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Years of life gained[1]	191,000 (2900)	49,000 [26%] (700)	46,000 [24%] (700)	42,000 [22%] (600)	31,000 [16%] (500)	23,000 [12%] (400)
Change in annual tax revenues[2]						
In year 1	701,000	75,000 [11%]	122,000 [17%]	150,000 [21%]	153,000 [22%]	201,000 [29%]
In year 10	786,000	86,000 [11%]	139,000 [18%]	169,000 [22%]	171,000 [22%]	221,000 [28%]
In year 20	1,257,000	145,000 [12%]	233,000 [19%]	277,000 [22%]	270,000 [21%]	332,000 [26%]
Percentage of annual household income spent on increased tax revenues						
In year 1	--	0.5%	0.4%	0.3%	0.2%	0.1%
Change in annual household expenditure on cigarettes[2]						
In year 1	658,000	60,000 [9%]	106,000 [16%]	139,000 [21%]	149,000 [23%]	204,000 [31%]
In year 10	795,000	64,000 [8%]	116,000 [15%]	227,000 [21%]	165,000 [23%]	223,000 [31%]
In year 20	1,046,000	83,000 [8%]	166,000 [16%]	227,000 [22%]	245,000 [23%]	325,000 [31%]

[1]Ten-year estimates are provided in parentheses. [2]In COP$ million. The distribution of outcomes across income quintiles is provided in brackets.

Furthermore, the net annual gains in tax revenues compared with pre-increase (2016) would be of roughly COP$ 700,000 million (year 1 after tax increase), COP$ 790,000 (year 10 after increase), and COP$ 1,260,000 million (year 20 after increase) (Table 4-3). Since the richest income quintile is assumed to be more inelastic with respect to price, it would have the highest number of people who continue or initiate smoking so it would shoulder the highest burden of the projected additional tax revenues. We see that the two bottom income quintiles would see about 30% of the additional tax burden, while the top two quintiles would bear about 50% of this burden. The average annual tax revenue gains under the three consecutive tax increases would amount to about 2-4% of Colombia's government health expenditure and about 0.1% of its 2016 GDP.

Beyond the aggregate findings on increased tax revenues, the poor would spend a larger proportion of their income on cigarettes and related taxes than the rich. We explored the potential for regressivity in consumption in our estimates of the percentage of income spent on taxes by income quintile after the first year of tax increases. Indeed, we find some regressivity in consumption after tax increases, with the poorest income quintile spending 0.5% of their annual income on additional taxes, whereas the richest income quintile would spend only 0.1% of their annual income on additional taxes (Table 4-3).

Lastly, we estimate that households in all income quintiles would spend more on cigarettes than before. The net increase in cigarette expenditure compared with pre-increase (2016) would be of roughly COP$ 660,000 million (year 1 after tax increase), COP$ 800,000 (year 10 after increase), and COP$ 1,050,000 million (year 20 after increase). We would see the greatest net annual increase among the richest quintile (about 31% of the total increase) and the smallest increase among the poorest quintile (about 9%).

Table 4-4. Summary findings for the sensitivity analyses of the distributional health and financial consequences of increased tobacco taxes among Colombia's current urban population, across income quintiles, over 20 years.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
		Price elasticity set to -0.40 across all income quintiles				
Years of life gained	175,000	32,000 [18%]	35,000 [20%]	38,000 [22%]	35,000 [20%]	35,223 [20%]
Change in annual tax revenues[1]	710,000	92,000 [13%]	137,000 [19%]	155,000 [22%]	147,000 [21%]	179,000 [25%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.6%	0.6%	0.3%	0.2%	0.1%
Change in annual household tobacco expenditure[1]	672,000	87,000 [13%]	130,000 [19%]	147,000 [22%]	139,000 [21%]	169,000 [25%]
		Price elasticity set to -0.78 across all income quintiles				
Years of life gained	334,000	61,000 [18%]	67,000 [20%]	72,000 [22%]	67,000 [20%]	67,000 [20%]
Change in annual tax revenues[1]	486,000	63,000 [13%]	94,000 [19%]	106,000 [22%]	101,000 [21%]	122,000 [25%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.5%	0.3%	0.2%	0.2%	0.1%
Change in annual household tobacco expenditure[1]	315,000	41,000 [13%]	61,000 [19%]	69,000 [22%]	65,000 [21%]	79,000 [25%]

Table 4-4 (continued). Summary findings for the sensitivity analyses of the distributional health and financial consequences of increased tobacco taxes among Colombia's current urban population, across income quintiles, over 20 years.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
			Youth price elasticity modifier of 1			
Years of life gained	191,000	49,000 [26%]	46,000 [24%]	42,000 [22%]	31,000 [16%]	23,000 [12%]
Change in annual tax revenues[1]	762,000	86,000 [11%]	137,000 [18%]	164,000 [22%]	164,000 [22%]	211,000 [28%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.6%	0.4%	0.3%	0.2%	0.1%
Change in annual household tobacco expenditure[1]	756,000	78,000 [10%]	129,000 [17%]	161,000 [21%]	167,000 [22%]	221,000 [29%]
			Mean initial price per pack of cigarettes of COP$ 3,772			
Years of life gained	178,000	45,000 [26%]	43,000 [24%]	39,000 [22%]	29,000 [16%]	22,000 [12%]
Change in annual tax revenues[1]	832,000	91,000 [11%]	146,000 [18%]	178,000 [21%]	181,000 [22%]	236,000 [28%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.6%	0.4%	0.3%	0.2%	0.1%
Change in annual household tobacco expenditure[1]	747,000	69,000 [9%]	121,000 [16%]	157,000 [21%]	169,000 [23%]	231,000 [31%]

Table 4-4 (continued). Summary findings for the sensitivity analyses of the distributional health and financial consequences of increased tobacco taxes among Colombia's current urban population, across income quintiles, over 20 years.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
	Cigarette consumption set to 8 cigarettes per day across all income quintiles					
Years of life gained	191,000	49,000 [26%]	46,000 [24%]	42,000 [22%]	31,000 [16%]	23,000 [12%]
Change in annual tax revenues[1]	686,000	106,000 [15%]	126,000 [18%]	148,000 [22%]	147,000 [21%]	159,000 [23%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.7%	0.4%	0.3%	0.2%	0.1%
Change in annual household tobacco expenditure[1]	636,000	85,000 [13%]	109,000 [17%]	137,000 [22%]	144,000 [23%]	161,000 [25%]

[1]In COP$ million, these estimates are for year 1 after tax policy increase.
The distribution of outcomes across income quintiles is provided in brackets.
[2] Estimates are for year 1 after tax policy increase.

In addition, when we hold the price elasticity of demand for cigarettes constant, this would change both absolute and distributional impact of the tax increase (Table 4-4). Under both scenarios, we find the greatest number of YLG from the third income quintile (22%). With fewer people quitting smoking under the lower elasticity scenario, we find a greater increase in tax revenues under the lower elasticity scenario (COP$ 710,000 million) than under the higher elasticity scenario (COP$ 490,000 million). The richest income quintile would have the largest (25%) and the poorest income quintile the smallest (13%) increase in tax revenues and household expenditure on tobacco after the tax increases under both cases. The poor would still pay a larger percentage of their annual income on tax revenues than any other income quintile. When we simulated a case where the young would not be more price elastic than adults (multiplier of one), we see that the health benefits would remain similar over 20 years (190,000 YLGs), as the cessation or initiation prevention benefits among those aged < 35 today (future YLGs) would not have yet occurred. Likewise, we would find only slight changes in terms of tax revenues and cigarette expenditure (about COP$ 760,000 million for both year 1 after tax increase).

Furthermore, when we used as an alternative the mean price per cigarette pack of the premium brand of cigarettes (retail price of 3,772 COP$ in 2016), the relative price increase would change, leading to fewer YLGs over 20 years than under our primary analysis (about 178,000 YLG). Meanwhile, the tax revenues would be greater than in the primary analysis (COP $830,000 million in year 1 after increase), with large revenues from the top income quintile (COP $236,000 million or 28% of total revenues). Lastly, when we hold cigarette consumption equal across all income quintiles, this would greatly change the distributional impact, with more of the change in tax revenues borne by the poorest (15%)

than under the main analysis (11%) and a larger percentage of income spent on increased tax revenues among the poorest quintile than in the main analysis (0.7% vs. 0.5%).

In the future, if Colombia were to increase specific excise taxes to 50% of the retail price after 2019, 245,000 YLG would occur over 20 years (Table 4-5). This represents an additional 54,000 YLG above the legislated tax increases. If the specific excise tax rises to 70% of the price, we would expect 479,000 YLG, which is an additional 288,000 YLG over 2017-2019. The distribution of YLG by income quintile would however remain similar. Additional tax revenues under the 50% scenario would be of about COP $930,000 million after the first year, with the poorest income quintile spending 0.7% of their annual income on additional taxes. A 70% specific excise tax would lead to an estimated additional revenue increase of COP $1,060,000 million over 2016, which while in line with our estimates of the impacts of the legislated tax increases, changes the distribution of the tax burden by income quintile. Indeed, the richest quintile would now carry 46% of the tax burden while the poorest quintile would only carry 1% of the increased tax burden; and the poorest would now spend 0.1% of their annual income on tax revenues while the richest would spend 0.3% of their annual income on additional tax revenues. Estimates for household expenditure on cigarettes would follow a similar pattern: households would spend less on cigarettes post-2020 (than in 2019) by an estimated COP $610,000 million after the first year.

Table 4-5. Summary findings of the distributional health and financial consequences of future increases in tobacco specific excise taxes among Colombia's current urban population, across income quintiles, over 20 years.

Outcome	Total	Income quintile I	Income quintile II	Income quintile III	Income quintile IV	Income quintile V
Simulated tax scenario 1: specific excise tax equal 50% of retail price of cigarettes						
Years of life gained	245,000	62,000 [25%]	59,000 [24%]	54,000 [22%]	40,000 [16%]	30,000 [12%]
Change in annual tax revenues[1]	932,000	93,000 [10%]	157,000 [17%]	197,000 [21%]	207,000 [22%]	278,000 [30%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.7%	0.5%	0.4%	0.3%	0.1%
Change in annual household tobacco expenditure[1]	846,000	69,000 [8%]	128,000 [15%]	175,000 [21%]	196,000 [23%]	278,000 [33%]
Simulated tax scenario 2: specific excise tax equal to 70% of retail price of cigarettes						
Years of life gained	479,000	120,000 [25%]	114,000 [24%]	105,000 [22%]	79,000 [17%]	61,000 [13%]
Change in annual tax revenues[1]	1,062,000	9,000 [1%]	90,000 [8%]	197,000 [19%]	282,000 [27%]	484,000 [46%]
Percentage of annual household income spent on increased tax revenues[2]	--	0.1%	0.4%	0.5%	0.5%	0.3%
Change in annual household tobacco expenditure[1]	605,000	-82,000	-26,000	88,000	203,000	422,000

[1]In COP$ million, these estimates are for Year 1 after tax policy increase. The distribution of outcomes across income quintiles is provided in brackets (except for the change in annual household tobacco expenditure where decreases in cigarette consumption are estimated for the bottom two income quintiles).

[2] Estimates are for year 1 after tax policy increase

DISCUSSION

In 2016 through legislation Colombia decided on substantially increasing its tobacco taxes, tripling the specific excise tax over two years and increasing the VAT by 3 percentage points. These measures are expected to result in a roughly 70% relative price increase over three years (Figure 4-1). This large and swift increase in the price of cigarettes would have the potential for substantial impacts on reducing the number of smokers, decreasing the premature deaths attributable to tobacco and its associated years of life lost, and increasing government revenues. Our analysis of the potential impact of the tax policy demonstrates considerable health benefits to the poorest income quintiles who would quit or not initiate smoking, however, we would expect to see some financial losses to those who continue or start smoking among the poorest income quintiles of Colombia's urban population.

We find the greatest health benefits and the smallest net change in the tax burden among the bottom income quintile, with a gradient showing the number of years of life gained decreasing and the net change in tax burden increasing as we switch from the bottom to the top income quintile. We do, however, find that the poor would spend a larger percentage of their income on increased taxes. These findings point to the potentially pro-poor health dimensions of the legislated increases in tobacco taxes in Colombia, while also highlighting that those poor who continue smoking would suffer both financial costs and health losses. In addition, our two simulated specific excise tax increase scenarios provide evidence supporting the large benefits of maintaining high levels of taxes into the future. In particular, when the specific excise tax is set to 70% of the retail price of cigarettes, per World Health Organization recommendations, representing a further substantial relative price increase (97% compared with 2019 prices), as expected the health gains would

become far greater, however, they would be accompanied with decreases in tax revenues (from 2019 to 2020).

Nevertheless, our analysis presents a number of limitations, primarily related to the model inputs. First, we derived price elasticity of demand for cigarettes by income quintile based on household survey data and a review of the literature from Latin American countries. In particular, our average price elasticity of demand was estimated using only four price data points, which might introduce the possibility of confounding by variations in tobacco control policy over time. However, our derived price elasticity estimates are consistent with previously published evidence [19], including studies reporting on price elasticity across income quintiles. For example, a Korean study found that a price elasticity among the poor of -0.81 vs. -0.32 among the rich [36]; a study in Moldova found a price elasticity of -0.51 among the poor vs. -0.26 among the rich [37]; an ECEA of tobacco tax in Lebanon estimated a price elasticity of -0.32 among the poor vs. -0.22 among the rich [22]; and Postolovoska and colleagues estimated a price elasticity of -0.74 among the poor vs. -0.28 among the rich from the Kyrgyz Republic [23]. We also ran two sensitivity analyses with alternative values for price elasticity (-0.40 and -0.78) [19,32] to understand the impact this parameter would have on our findings. Second, we relied on household surveys to estimate the prevalence of smoking and the number of cigarettes smoked per day. However, we used average price of cigarettes to determine cigarette consumption from weekly household cigarette expenditure using the Encuesta Nacional de Calidad de Vida (ENCV) [30] and Encuesta Annual Manufacturera (EAM) [31] even though the price per pack of cigarettes could range depending on various factors. Therefore, we pursued two sensitivity analyses in varying price per pack and cigarette consumption. Third, we did not

have the prevalence of smokers in rural areas, which prevented us from producing estimates for Colombia's whole population (both urban and rural), implying that our estimates would represent a lower bound of the potential tax policy impact. Fourth, we used a static model focusing on the current population and did not examine the evolution of health and financial benefits far into the future (beyond 20 years). Indeed, the health benefits and years of life gained will likely be greater as younger age groups quit smoking and/or are prevented from smoking initiation, thus yielding even greater health benefits in the longer 30-to 50-year time horizon. Fifth, we assumed fixed household income trajectories in the future, meaning we did not allow for social mobility across income quintiles over time. Sixth, our model did not take cigarette smuggling into account (except under the -0.78 price elasticity scenario as reported by Maldonado and colleagues [32]), which might increase in response to tax increases and bring cheaper cigarettes onto the market, undercutting the health benefits of the tax [38]. However, studies show that even with smuggling, tobacco tax increases still largely reduce smoking prevalence [39]. Finally, our findings should be interpreted with caution as they are largely dependent on the utilization of many different data sources with varying underlying assumptions, due to data limitations. Seventh, by looking at average estimates, we are considering the average welfare, rather than the welfare of those most impacted (i.e., those poor who continue smoking, are addicted, and who smoke more than average) by the tax.

It is critical that Colombia keeps raising taxes as incomes grow and cigarettes become relatively cheaper. Evidence from France with raising cigarette prices through tax increases indicates that once prices stabilize, cigarette sales no longer decrease and smoking rates remain unchanged [17]. Our analysis shows that the 70% increase in the

average price per cigarette pack would put Colombia closer to meeting its commitments of decreasing smoking rates and the prevalence of NCDs. Using these additional tax revenues on programs that benefit the poor could reverse the potentially regressive effects (in consumption) of the tax among the poor who continue smoking. The tax increase will also help Colombia deal with the increasing financial strain that the growing burden of NCDs places on the health system.

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REFERENCES

1. World Health Organization. Noncommunicable diseases progress monitor 2017. Available from: http://apps.who.int/iris/bitstream/handle/10665/258940/9789241513029-eng.pdf;jsessionid=E29119B0C1B1B9C38F18F8FB4D2E9099?sequence=1 (accessed June 9, 2018).
2. OECD. OECD reviews of health systems: Colombia 2016. OECD Reviews of Health Systems. Paris, France: OECD Publishing, 2015.
3. Ministerio de Salud y Protección Social, Gobierno de Colombia. Plan Decenal de Salud Pública (PDSP) 2012-2021. Bogota, Colombia: Ministerio de Salud y Protección Social, Gobierno de Colombia, 2013. Available from: https://www.minsalud.gov.co/Documentos%20y%20Publicaciones/Plan%20Decenal%20-%20Documento%20en%20consulta%20para%20aprobación.pdf (accessed June 9, 2018).
4. United Nations. Sustainable Development Goals. Available from: https://sustainabledevelopment.un.org/sdgs (accessed June 9, 2018)
5. Institute for Health Metrics and Evaluation. GBD 2016. Seattle: University of Washington, 2018. Available from: https://vizhub.healthdata.org/gbd-compare/ (accessed June 9, 2018).
6. Ministerio de Salud y Protección Social, Ministerio de Justicia, Gobierno de Colombia, UNODC, OEA. Estudio Nacional de Consumo de Sustancias Psicoactivas en Colombia 2013 -- Informe Final. Bogota, Colombia: 2014. Available from: https://www.unodc.org/documents/colombia/2014/Julio/Estudio_de_Consumo_UNODC.pdf (accessed June 9, 2018).
7. Pichon-Riviere A, Bardach A, Alcaraz A, Caporale J, Augustovski F, Torres EP, et al. Carga de Enfermedad Atribuible al Tabaquismo en Colombia. Buenos Aires, Argentina: Instituto de Efectividad Clínica y Sanitaria (IECS), 2013. Available from: https://www.iecs.org.ar/wp-content/uploads/Carga-de-enfermedad-tabaquismo-Colombia-NOV2013-IECS-Doc-Tec-N°-9-1.pdf (accessed June 9, 2018).
8. Pichon-Riviere A, Bardach A, Augustovski F, Alcaraz A, Reynaldes-Shigematsu LM, Pinto MT, et al. Impacto econónmico del tabaquismo en los sistemas de salud de América Latina: un estudio en siete países y su extrapolación a nivel regional. Revista Panamericana de Salud Publica 2016;40(4):213-21.
9. World Bank. World Development Indicators. Available from: http://data.worldbank.org/data-catalog/world-development-indicators (accessed June 9, 2018).
10. World Health Organization. Framework Convention on Tobacco Control. Available from: http://www.who.int/fctc/en/ (accessed June 9, 2018).
11. República de Colombia, Diario Oficial. Ley 1819 del 29 de Diciembre de 2016 Cámara, (2016). Available from: http://www.gydconsulting.com/userfiles/Ley-1819-29-dic-16-Reforma-Tributaria-Diario-Oficial-50101.pdf (accessed June 9, 2018).
12. World Health Organization. Tobacco free initiative. Available from: http://www.who.int/tobacco/economics/taxation/en/index1.html (accessed June

10, 2018).
13. World Health Organization. World Health Organization technical manual on tobacco tax administration. Geneva: World Health Organization, 2010.
14. World Health Organization. World Health Organization report on the global tobacco epidemic, 2017. Geneva: World Health Organization, 2017.
15. Llorente B. Colombia: Monitoreo de impuestos de cigarillos. Bogota, Colombia: Fundación Anáas, 2017. Available from: http://fundacionanaas.org/documentos/Informes/2017/Informe-Precios-Colombia-Marzo-2017.pdf (accessed June 9, 2018).
16. Linegar DJ, van Walbeek C. The effect of excise tax increases on cigarette prices in South Africa. Tobacco Control 2018; 27:65-71.
17. Hlll C, Legoupil C. Taxation et prix du tabac en France et conséquences sur sur la consommation. Bulletin Epidemiologique Hebdomadaire 2018; (14-15):309-316.
18. Jha P, Peto R. Global effects of smoking, of quitting, and of taxing tobacco. New England Journal of Medicine 2014; 370:60-68.
19. World Health Organization, International Agency for Research on Cancer (IARC). IARC Handbooks on Cancer Prevention, Tobacco Control, Volume 14: Effectiveness of Tax and Price Policies for Tobacco Control. Lyon, France: World Health Organization 2011.
20. Chaloupka F, Yurekli A, Fong G. Tobacco taxes as a tobacco control strategy. Tobacco Control 2012; 21(2):172-80.
21. Chaloupka F, Weschler H. Price, tobacco control policies and smoking among young adults. Journal of Health Economics 1997; 16(3):359-373.
22. Salti N, Brouwer E, Verguet S. The health, financial and distributional consequences of increases in the tobacco excise tax among smokers in Lebanon. Social Science & Medicine 2016; 170:161-169.
23. Postolovska I, Lavado R, Tarr G, Verguet S. The health gains, financial risk protection benefits, and distributional impact of increased tobacco taxes in Armenia. Health Systems & Reform 2018; 4(1):30-41.
24. Verguet S, Kim JJ, Jamison DT. Extended cost-effectiveness analysis for health policy assessment: a tutorial. Pharmacoeconomics. 2016; 34(9):913-923.
25. Verguet S, Laxminarayan R, Jamison DT. Universal public finance of tuberculosis treatment in India: an extended cost-effectiveness analysis. Health Economics 2015; 24(3):318-32.
26. 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 Global Health 2015; 3(4):e206-e16.
27. Verguet S, Tarr G, Gauvreau C, et al. Distributional benefits of tobacco tax and smoke-free workplaces in China: a modeling study. Journal of Global Health 2017; 7(2):020701.
28. Fuchs A, Meneses F. Are tobacco taxes really regressive? Policy Research Working Paper 7988. Washington, DC: World Bank, 2017.
29. Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. BMJ 2004; 328(7455):1519.
30. Dirección de Metologia y Producción Estadístíca – DIMPE. Encuesta Nacional de

Calidad de Vida (ENCV). Available from: http://microdatos.dane.gov.co/index.php/catalog/456/datafile/F32 (accessed June 9, 2018).
31. Departamento Administrativo Nacional de Estadística (DANE). Encuesta Anual Manufacturera. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/industria/encuesta-anual-manufacturera-enam (accessed June 9, 2018).
32. Maldonado N, Llorente B, Deaza J. Cigarette taxes and demand in Colombia. Revista Panamericana de Salud Publica 2016; 40(4):229-236.
33. Departamento Administrativo Nacional de Estadística (DANE). Estimación y proyección de poblacion nacional, departamental y municipal total por area 1985-2020. Bogota, Colombia: DANE, 2005. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/demografia-y-poblacion/proyecciones-de-poblacion (accessed June 10, 2018).
34. Ministerio de Salud y Protección Social, Ministerio de Justicia, Gobierno de Colombia. SABE Colombia 2015: Estudio Nacional de Salud, Bienestar y Envejecimiento. Resumen Ejecutivo. Bogota, Colombia: Ministerio de Salud y Protección Social, 2015. Available from: https://www.minsalud.gov.co/sites/rid/Lists/BibliotecaDigital/RIDE/VS/ED/GCFI/Resumen-Ejecutivo-Encuesta-SABE.pdf (accessed June 10, 2018).
35. Ministerio de Salud y Protección Social, Gobierno de Colombia, Profamilia. Colombia Encuesta Nacinal de Demográfia y Salud 2015. Bogota, Colombia: Ministerio de Salud y Protección Social, Gobierno de Colombia, 2017. Available from: https://www.dhsprogram.com/pubs/pdf/FR334/FR334.pdf (accessed June 10, 2018).
36. Choi SE. Are lower income smokers more price sensitive?: the evidence from Korean cigarette tax increases. Tob Control. 2016;25(2):141-6.
37. Fuchs, A., & Meneses, F. *Tobacco Price Elasticity and Tax Progressivity in Moldova*. Washington, DC: World Bank Group, 2018.
38. Joossens L, Raw M. Progress in combating cigarette smuggling: controlling the supply chain. Tobacco Control 2008; 17(6):399-404.
39. Iglesias RM. Increasing excise taxes in the presence of an illegal cigarette market: the 2011 Brazil tobacco tax reform/El alza de los impuestos indirectos en presencia de un mercado negro de cigarrillos: la reforma brasilena de los impuestos sobre el tabaco del 2011. Revista Panamericana de Salud Publica 2016; 40(4):243-249.

SUPPLEMENTARY APPENDIX

1. Estimating years of life gained, net change in tax revenues, and net change in household cigarette expenditure

We build here on previously published extended cost-effectiveness analysis studies of tobacco taxation [1,2] and summarize below our methods for estimating:

i) the years of life gained (YLG) upon smoking cessation associated with increased tobacco prices;

ii) the net change in annual tax revenues associated with increased tobacco taxes;

iii) the net change in household annual expenditure on cigarettes associated with increased tobacco prices.

1.1. Years of life gained associated with increased tobacco taxes

Colombia's life expectancy at birth is 73.8 years and its life expectancy at age a, denoted $l(a)$ is:

$l(a)$ = {73.8; 70.7; 65.6; 60.9; 56.3; 52.9; 47.5; 43.1; 38.6; 34.1; 29.7; 25.4; 21.4; 17.6; 14.2; 11.2; 8.4} years at age a = {0; 5; 10; 15; 20; 25; 30; 35; 40; 45; 50; 55; 60; 65; 70; 75; 80} [3]. Furthermore, the health benefits of smoking cessation vary with age a at cessation: cessation can lead to 10, 9, 6, and 3 YLG when a smoker quits at age a = 30, 40, 50, or 60 years, respectively [4]. Therefore, we estimated the numbers of YLG as a function of age a at quitting by building on the following linear model:

$$YLG = \beta_0 + \beta_1 * a\,, \quad (1)$$

where: $\beta_0 = 17.80$, $\beta_1 = -0.24$, with $R^2 = 0.96$.

As a result, we could derive the following function $YLG(a)$:

$YLG(a) = 10$, when $a \leq 32.5$;

$YLG(a) = 17.80 - 0.24 * a$, when $32.5 < a \leq 72.5$;

$YLG(a) = 0.40$, when $a > 72.5$.

If we denote $S_{a,I}$ $S_{a,I}$the number of smokers of age a among income quintile I prior tax increase, and $P_{a,I}$ $P_{a,I}$ the price elasticity for age a and quintile I (Table 2 in the main text), we could derive (assuming participation elasticity of $1/2$) the following number of quitters at age a as:

$$Q_{a,I} = \frac{1}{2} * \frac{\Delta p}{p} * P_{a,I} * S_{a,I}\ , \qquad (2)$$

where p is the retail price of cigarettes, and Δp is the change in the price of cigarettes.

Tables A1 and A2 below list the number of current smokers (above age 15) and potential "future smokers" (below age 15) before taxes are raised (Table 4-S1), and the number of quitters (above age 15) and averted potential future smokers (below age 15) after taxes are raised (Table 4-S2).

Subsequently, we can derive the total number of YLG, per age group a and income quintile I as:

$$TYLG_{a,I} = Q_{a,I} * YLG(a). \qquad (3)$$

Accounting for life expectancy at age a ($l(a)$), as discussed previously, $TYLG_{a,I}$ will be delayed and occur into the future at $\tau = l(a) - YLG(a)$. In other words:

$$TYLG_{a,I}(t) = Q_{a,I} * YLG(a) * \delta(t - \tau)\ . \qquad (4)$$

For example: when $a = 80$, $\tau = 8.4 - 0.4 = 8$; when $a = 60$, $\tau = 21.4 - 3.4 = 18$.

As a result, over a 20-year time period post-tax policy, YLG will be obtained among those quitting at an age of roughly 55 years and above.

Table 4-S1. Number of current smokers (age > 15) and potential "future smokers" (age < 15) before tax increase, by five-year age group and income quintile.

	Future smokers			
Age group	**0-4**	**5-9**	**10-14**	**15-19**
QI	76,500	75,900	77,000	61,100
QII	74,400	73,800	74,800	66,600
QIII	70,700	70,200	71,200	72,200
QIV	56,200	55,800	56,600	66,600
QV	47,200	46,800	47,500	66,600
Total	325,000	322,500	327,100	333,100

	Current smokers											
Age group	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**
QI	99,400	94,300	66,500	49,000	44,200	52,100	56,500	42,300	27,200	20,000	14,500	11,000
QII	108,500	102,800	72,500	53,500	48,300	56,900	61,600	46,100	29,700	21,800	15,800	12,000
QIII	117,500	111,400	78,600	57,900	52,300	61,600	66,800	50,000	32,200	23,600	17,100	13,100
QIV	108,500	102,800	72,500	53,500	48,300	56,900	61,600	46,100	29,700	21,800	15,800	12,000
QV	108,500	102,800	72,500	53,500	48,300	56,900	61,600	46,100	29,700	21,800	15,800	12,000
Total	542,400	514,100	362,600	267,400	241,400	284,400	308,100	230,600	148,500	109,000	79,000	60,100

Table 4-S2. Number of current smokers who quit ("quitters" age > 15) and averted potential future smokers (age < 15) after tax increase, by five-year age group and income quintile.

	Averted potential future smokers		
Age group	**0-4**	**5-9**	**10-14**
QI	24,600	24,400	24,800
QII	20,800	20,700	21,000
QIII	16,800	16,600	16,900
QIV	10,800	10,700	10,900
QV	6,900	6,800	6,900
Total	79,900	79,200	80,500

	Quitters												
Age group	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**
QI	19,700	28,400	23,400	13,900	8,300	7,500	8,800	9,600	7,200	4,600	3,400	2,500	1,900
QII	18,700	26,900	22,100	13,100	7,800	7,100	8,300	9,000	6,800	4,300	3,200	2,300	1,800
QIII	17,100	24,600	20,200	12,000	7,100	6,400	7,600	8,200	6,100	4,000	2,900	1,600	2,100
QIV	12,800	18,400	15,000	8,900	5,300	4,800	5,600	6,100	4,600	2,900	2,200	1,600	1,200
QV	9,800	14,000	11,400	6,700	4,000	3,600	4,300	4,600	3,500	2,200	1,600	1,200	900
Total	78,100	112,300	92,100	54,600	32,500	29,400	34,600	37,500	28,200	18,000	13,300	9,200	7,900

1.2. Net change in annual tax revenues

The net change in annual tax revenues after tax increase, denoted $Tax_{a,I}$ in age group a and income quintile I, is given by:

$$Tax_{a,I} = S_{a,I} * Cig_I * [tax_{post} * (1 + P_{a,I} * \frac{\Delta p}{p}) - tax_{ante}], \qquad (5)$$

where Cig_I is the number of cigarette packs consumed per year among income quintile I, tax_{ante} is the share of taxes within the retail price of cigarettes before policy, and tax_{post} is the share of taxes within the retail price after policy.

As discussed in 1.1 above, $S_{a,I}$ will vary over time. Thus, over a 20-year time period post-tax increase, $Tax_{a,I}$ will be generated from the tobacco consumption of various age groups: in year 1, from the whole current smoking population (i.e. those with a > 15 years); in year 10, from the smoking population, which would be constituted of those currently aged 5-74 year-olds (i.e. those currently aged 75-79 year-olds will have already died 10 years later, and those currently aged 5-14 year-olds as they will have initiated smoking 10 years later at age 15); in year 20, from the smoking population, which would be constituted of those currently aged 0-54 year-olds (i.e. those currently aged 55-79 year-olds will have already died 20 years later, those currently aged 0-14 year-olds as they will have initiated smoking 20 years later at age 15, and an additional 0-5 year-olds, not yet born, as they will have initiated smoking 20 years later at age 15).

1.3. Net change in annual household expenditure

The net change in annual household cigarette expenditure after tax increase, denoted $Cons_{a,I}$ in age group a and income quintile I, is given by:

$$Cons_{a,I} = S_{a,I} * Cig_I * [p_{post} * (1 + P_{a,I} * \frac{\Delta p}{p}) - p_{ante}], \quad (6)$$

where p_{ante} is the retail price before policy, and p_{post} is the retail price after tax increase.

As discussed in 1.1 and 1.2, $S_{a,I}$ will vary with time, hence over a 20-year time period post-tax policy, $Cons_{a,I}$ will be generated from the consumption of various age groups: in year 1, from the whole current smoking population (i.e. those with a > 15 years); in year 10, from the smoking population, which would be constituted of those currently aged 5-74 year-olds (i.e. those currently aged 75-79 year-olds will have already died 10 years later, and those currently aged 5-14 year-olds as they will have initiated smoking 10 years later at age 15); in year 20, from the smoking population, which would be constituted of those currently aged 0-54 year-olds (i.e. those currently aged 55-79 year-olds will have already died 20 years later, those currently aged 0-14 year-olds as they will have initiated smoking 20 years later at age 15, and an additional 0-5 year-olds, not yet born, as they will have initiated smoking 20 years later at age 15).

2. Price elasticity of demand for cigarettes

In this section we detail the methods that lead to the derivations for the analysis of: the average price elasticity drawing from Colombian household survey data (2.1); and the price elasticity by income quintile drawing from studies from other Latin American countries (2.2).

2.1. Average price elasticity derived from household survey data

Price elasticity of demand for the purchase of cigarettes in Colombia was calculated using the National Quality of Life Survey (Encuesta Nacional de Calidad de Vida or ENCV) for the years 2003, 2010, 2011 and 2014 as the primary source of information [5]. The ENCV collected information on household expenditure on cigarettes only for these 4 years (i.e. we had four data points to estimate average price elasticity). The ENCV is a nationally representative, repeated cross-sectional survey of approximately 20,000 households each survey year. Our analysis includes a total of 83,017 households of which 10,159 reported a purchase of cigarettes over the past 7 days prior to their interview.

The ENCV provides information on the reported total weekly expenditure on cigarettes per household, yet not the number of cigarettes purchased nor their price. For this reason, we also used the Encuesta Annual Manufacturera (EAM) for each of the 4 years which provides information on the total annual number of cigarettes sold nationally and their value [6]. The World Bank World Development Indicators were used to extract the consumer price index for each survey year [7].

A log-log linear regression model was used to calculate the price elasticity of demand using the above described data. The model used is the following:

$$\ln(\mathrm{Q}) = \beta_0 + \beta_1(\ln(\mathrm{P})) + \beta_3(\ln(\mathrm{Y})) + \sum \beta_x(\mathrm{hh}) + \beta_4(\mathrm{D}) + \beta_5(\mathrm{U}) + \varepsilon \ln(Q) = \beta_0 + \beta_1(\ln(P)) + \beta_3(\ln(Y)) + \sum \beta_x(hh) + \beta_4(D) + \beta_5(U) + \varepsilon\,, \qquad (7)$$

where the included variables are defined as:

- Q: quantity of cigarette packs (20 units) purchased by the household on a weekly basis. Calculated using the household weekly expenditure reported in ENCV, divided by the average cigarette pack price on the given year (P) as reported in EAM.

- P: average price per cigarette pack (20 units) for a given year of the survey, adjusted for inflation and tax. Calculated using EAM.
- Y: Monthly total household income adjusted for inflation minus the monthly household expenditure on food in the household. Calculated using ENCV.
- *hh*: includes the natural logarithm of the number of persons reported living in a given household, the natural logartihm of the percentage of children under the age of 18 that live in the household, the gender of the household head and the natural logarithm of the age of the household head.
- D: Department (subnational administrative unit). Departments included are only those from which data were collected across the 4 ENCV surveys included in the analysis.
- U: Urban location of the household. As reported in ENCV.

The average price elasticity of demand calculated was then: -0.44 (95% CI: -0.53 to -0.35).

2.2. Price elasticity by income quintile

First, we sourced studies from Latin America that estimated the price elasticity of demand for tobacco products, and could identify such 11 studies from 8 countries, which are summarized in Table A3. The price elasticities reported ranged from -0.22 in Chile to -0.85 in Brazil and displayed an interquartile range of 0.42 and a standard deviation of 0.23.

Table 4-S3.Price elasticity of demand for cigarettes from the 11 Latin American country studies.

Country	Price elasticity	Source
Mexico	-0.52	Jimenez-Ruiz et al. 2008 [8]
Argentina	-0.27	Gonzalez-Rozada 2006 [9]
Argentina	-0.34	Martinez et al. 2008 [10]
Argentina	-0.31	Martinez et al. 2008 [11]
Brazil	-0.8	Lobao and Carvahlo 1998 [12]
Brazil	-0.8	Iglesias et al. 2007 [13]
Bolivia	-0.85	Alcaraz 2006 [14]
Chile	-0.45	Debrott Sanchez 2006 [15]
Mexico	-0.25	Olivera-Chavez 2010 [16]
Uruguay	-0.55	Ramos and Curti 2006 [17]
Peru	-0.7	Gonzalez-Rozada and Ramos-Carbajales 2016 [18]

Second, we used the interquartile range and mean of these 11 studies (IQR = 0.42 and m = -0.53) and applied it to the Colombian context i.e. the average price elasticity of -0.44PE_{av} = -0.44 (as detailed in section 2.1), in the following so to derive price elasticity per income quintile: PE_q

$PE_1 = PE_{av} + \frac{IQR}{2m} PE_{av} = -0.61;\ PE_2 = PE_{av} + \frac{IQR}{4m} PE_{av} = -0.53;\ PE_3 = PE_{av};\ PE_4 = PE_{av} - \frac{IQR}{4m} PE_{av} = -0.35;\ PE_5 = PE_{av} - \frac{IQR}{2m} PE_{av} = -0.26(8)$,

where: IQR = 0.42, m = -0.53, and PE_{av} = -0.44.

3. Increased specific excise tax simulated after 2019

We use the base price per pack of cigarettes from 2019 (COP$ 1977) and the inflation rate from the International Monetary Fund of 3.5% per year [19] to calculate the new base price per pack in 2020 (COP$ 2046).

The projected value-added tax (VAT) for 2020 was calculated by adjusting the 2019 VAT for inflation (3.5% per year), and the surcharge was assumed to remain the same. Hence, the retail price without specific excise tax would be P = COP$ 3116.

When considering a specific excise tax constituting T of the retail price of cigarettes, we solve for X such that: $T = \frac{X}{X+P}$ T=X/(X+P). When T = 0.50, we obtain: X = COP$ 3116, and the retail price of cigarettes becomes COP$ 6232, i.e. a 18% increase compared with a 2019 price of COP$ 5269. When T = 0.70, we obtain: X = COP$ 7271, and the retail price of cigarettes becomes COP$ 10,386 i.e. a 97% increase compared with a 2019 price of COP$ 5269.

References

1. 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 Global Health 2015; 3(4):e206-e16.
2. Verguet S, Tarr G, Gauvreau C, et al. Distributional benefits of tobacco tax and smoke-free workplaces in China: a modeling study. Journal of Global Health 2017; 7(2):020701.
3. Doll R, Peto R, Boreham J, Sutherland I. Mortality in relation to smoking: 50 years' observations on male British doctors. BMJ 2004; 328(7455):1519.
4. United Nations Population Division. World Population Prospects, the 2017 Revision. Available from: https://esa.un.org/unpd/wpp/ (accessed June 10, 2018).
5. Dirección de Metologia y Producción Estadístíca – DIMPE. Encuesta Nacional de Calidad de Vida (ENCV). Available from: http://microdatos.dane.gov.co/index.php/catalog/456/datafile/F32 (accessed June 9, 2018).
6. Departamento Administrativo Nacional de Estadística. Encuesta Anual Manufacturera. Available from: https://www.dane.gov.co/index.php/estadisticas-por-tema/industria/encuesta-anual-manufacturera-enam (accessed June 9, 2018).
7. World Bank. World Development Indicators. Available from: http://data.worldbank.org/data-catalog/world-development-indicators (accessed June 9, 2018).
8. Jimenez-Ruiz JA, Saenz de Miera B, Reynales-Shigematsu LM, Waters HR, Hernandez-Avila M. The impact of taxation on tobacco consumption in Mexico. Tobacco Control 2008; 17(2):105-10.
9. Gonzalez-Rozada M. Economía del control del tabaco en los países del Mercurosur y Estados Asociados: Argentina: 1996-2004. Washington, DC: PAHO, 2006.
10. Martínez E, Mejía R, Estable EP. Elasticity of cigarette demand in Argentina: An empirical analysis using vector error-correction model, Working Paper No.1. Salta, Argentina: UNSa, 2008. Available from: http://www.economicas.unsa.edu.ar/ielde/items_upload/WPIelde_Nro1.pdf (accessed June 9, 2018).
11. Martinez E, Mejia R, Pérez-Stable EJ. An empirical analysis of cigarette demand in Argentina. Tobacco Control 2015; 24(1):89-93.
12. Lobão W, Carvalho JL. Vício privado e políticas públicas: a demanda por cigarros no Brasil. Revista Brasileira de Economia 1998; 52:67-104.
13. Iglesias R, Jha P, Pinto M, da Costa e Silva VL, Godinho J. Tobacco control in Brazil. Health and Nutrition Discussion Paper. Washington, DC: World Bank, 2007. Available from: http://siteresources.worldbank.org/BRAZILEXTN/Resources/TobaccoControlinBrazilenglishFinal.pdf (accessed June 9, 2018).
14. Alcaraz VO. Economía del Control del Tabaco en los países del Mercosur y Estados Asociados: Bolivia 2006. Available from: http://www1.paho.org/Spanish/AD/SDE/RA/Tab_Mercosur_BOL.pdf?ua=1 (accessed June 9, 2018).
15. Debrott Sánchez D. Economía del Control del Tabaco en los países del MERCOSUR y

Estados Asociados: Chile 2006. Available from: http://www1.paho.org/Spanish/AD/SDE/RA/Tab_Mercosur_CHI.pdf?ua=1 (accessed June 9, 2018).
16. Olivera-Chávez RI, Cermeño-Bazán R, de Miera-Juárez BS, Jiménez-Ruiz JA, Reynales-Shigematsu LM. El efecto del precio del tabaco sobre el consumo: un análisis de datos agregados para México. Salud pública de México 2010; 52(Suppl 2):S197.
17. Ramos A, Curti D. Economía del Control de Tabaco en los países del Mercosur y Estados Asociados: Chile. Washington, DC: PAHO, 2006
18. Gonzalez-Rozada M, Ramos-Carbajales A. Implications of raising cigarette excise taxes in Peru. Revista Panamericana de Salud Pública 2016; 40:250-5.
19. International Monetary Fund. World Economic Outlook April 2018 Database. Available from: http://www.imf.org/external/pubs/ft/weo/2018/01/weodata/index.aspx (accessed June 11, 2018).