Socioeconomic inequalities in smoking prevalence in Mexico

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Abstract

Introduction

Globally, tobacco use poses an enormous health and economic burden. This burden is likely to increase, especially in low- and middle-income countries such as Mexico. Furthermore, smoking prevalence has widespread socioeconomic inequalities. To effectively implement tobacco control policies, it is important to be aware of socioeconomic inequalities in the distribution of smoking. The aim of this research was to understand how socioeconomic inequalities affect smoking prevalence in Mexico and how this has developed over time.

Methods

Data of wave 1 (2009) and wave 2 (2014) from the World Health Organization (WHO) study on global AGEing and adult health (SAGE) in Mexico were used. We included 1,497 participants in our analyses. The primary outcome was current smoking prevalence. The standard and Erreygers concentration indices were computed to measure socioeconomic inequality in smoking prevalence. Hereafter, possible contributors to socioeconomic inequality were assessed through a decomposition analysis. Lastly, a literature review was conducted to elucidate what tobacco control policies Mexico had implemented between 2009 and 2014 based on MPOWER measures.

Results

The overall prevalence of smoking reduced from 18 to 10 percent from 2009 to 2014. Smoking was disproportionally distributed among the rich, and this inequality increased between the two studied timepoints. Wealth and living area were the two biggest contributors to this inequality at both time points. The contribution of urban residence to socioeconomic inequality increased and the contribution of wealth decreased over time. The literature analysis showed that Mexico implemented policies in line with the WHO FCTC framework in almost all six MPOWER domains. The achievement level of Mexico in these six domains improved in three, remained stable in two, and decreased in one domain.

Conclusion

Smoking prevalence in Mexican adults is mostly concentrated among the rich. While overall prevalence of smoking reduced from 2009 to 2014, pro-rich socioeconomic inequality increased over this time. It may be that over time smoking becomes more concentrated among the poor, as the wealthier population abandons this behaviour first. To implement effective policies, it is important to continue monitoring the trend of socioeconomic distribution of smoking and what its biggest contributors are. To protect its population from developing non-communicable diseases, Mexico should take further steps to reduce the tobacco burden in its country. However, tobacco companies are proactively working against this. Therefore, strong political will and commitment is necessary to further reduce Mexico's tobacco burden.

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1. Introduction

Tobacco use is the world's leading cause of preventable death. Estimates show that in 2010, 5.7 million people died from consequences related to cigarette use. Furthermore, smoking accounted for 6.9% of life years lost and 5.5% of disability-adjusted life-years (DALYs) (1). As tobacco use continues to spread, 400 million people are projected to die from 2010 to 2050 due to smoking-attributable diseases (2). Tobacco use increases the risk of death from many non-communicable diseases (NCD), in particular (lung) cancer, cardiovascular diseases, and chronic obstructive pulmonary disease (COPD) (3). In addition to its significant adverse health effects, smoking also causes an immense economic burden. The increasing morbidity and mortality resulting from tobacco-related illnesses raises healthcare costs and results in lost productivity (4). A recent review estimated the total global economic cost of smoking to be around 1.85 trillion $US annually (4).

As concerns regarding the overall impact of tobacco use persist, additional concerns regarding the widespread existence of socioeconomic differences in smoking prevalence and outcomes has grown (5). A strong association between poverty and smoking in high income countries (HIC) exists, which can be seen on multiple levels. Firstly, smoking prevalence is higher among groups with a lower socioeconomic status (SES) (6). Moreover, people with a low SES are more likely to initiate and less likely to quit smoking compared to people with a higher SES (7). Lastly, the risk of dying due to smoking increases in lower socioeconomic groups (8).

While tobacco use affects health negatively on a worldwide scale, low- and middle-income countries (LMIC) seem to suffer a disproportionally high burden. Estimates reveal that in 2015, 80% of smokers globally were living in LMIC (9). As demand reduction measures in HIC have been effective, the tobacco industry has been marketing towards women and adolescents in LMIC more aggressively to replace lost consumers (10, 11). An increase in smoking prevalence will result in a further increase in NCD prevalence, while the risk of premature death from NCD's is higher in LMIC compared to HIC (12). Therefore, the majority of deaths related to tobacco use in the future are likely to occur in LMIC (13).

In Latin America, the proportion of DALYs that are lost every year as a result of tobacco use is high (14). Mexico is no exception, as over 43,000 Mexicans die annually from smoking-related diseases and 5.5% of deaths are attributable to tobacco smoke (15). While Mexico has relatively low smoking rates (16.3%) compared to other countries, this still translates to 14.3 million smokers and an at risk population of nearly 30 million (16). Furthermore, regarding other risk factors for NCD's, Mexico's profile is very unfavourable. Over 70 percent of the population is overweight or obese, and prevalence of excessive alcohol consumption is rising (16). Mexico has already experienced a rise in NCD's in recent years (17). Therefore, all possible action to protect the Mexican population from developing NCD's should be taken. As socioeconomic inequalities in Mexico pose a serious problem, it is important to understand the relationship between socioeconomic inequality and smoking (18). While this relationship has been widely studied in HIC, less research has been done in LMIC such as Mexico (19). However, preliminary evidence suggests a different relationship than in HIC, as research in Mexico shows the prevalence of tobacco use to increase with increasing income level (20).

Given the importance of tobacco as a risk to health, investigating the distribution of tobacco use is essential for identifying priority areas for policy action. Mexico has recognized the need for action, as it became the first country in Latin America to implement the World Health Organization's Framework Convention on Tobacco control (WHO FCTC) in 2004 (21). In 2008, MPOWER measures were developed by the WHO to help countries implement the WHO FCTC successfully (22). Since, Mexico has made an effort to reduce tobacco use through a range of policy measures (21). However, in order to implement

policy most effectively, it is important to know what role socioeconomic inequality plays in smoking prevalence.

Therefore, the aim of this research is to understand how socioeconomic inequalities affect smoking prevalence in Mexico by answering the following research question:

How did socioeconomic status relate to smoking prevalence in adults in Mexico in the period of 2009-2014?

In order to provide an answer to this question, four sub questions will be investigated:

- ❖ What is the socioeconomic distribution of smoking prevalence in adults in Mexico?
- ❖ What are the biggest contributors to socioeconomic inequality in smoking prevalence in adults in Mexico?
- ❖ How did socioeconomic inequalities in smoking prevalence and its contributors evolve in adults in Mexico in the period 2009-2014?
- ❖ What steps advised by the WHO trough the MPOWER package has Mexico taken on a national level to reduce tobacco use in the period 2009-2014?

Outline

In chapter two, the theoretical background necessary for answering our research questions and interpreting our findings will be provided. The relationship between socioeconomic status and smoking will be discussed, as well as how tobacco control policies may influence this relationship. Subsequently, a description of the used dataset in general and the study population in particular will be provided in chapter three. Hereafter, the statistical methods to determine and investigate the possible socioeconomic inequality in smoking and the methods for finding tobacco control policy measures implemented by Mexico will be discussed. Our findings from the analyses described in chapter three will be presented in chapter four. Subsequently, these findings will be interpreted and reviewed in chapter 5. Finally, limitations and recommendations of our research will be discussed.

2. Theoretical background

This chapter will provide the necessary information to answer our research questions and put our findings into context. First off, background information on the relationship between socioeconomic status and health (behaviour) is provided. Subsequently, the different dynamic of this interaction in developed and developing countries is discussed with the help of a model of four different stages of the tobacco epidemic. This will help us to understand how socioeconomic inequality in smoking prevalence might evolve in different contexts. Hereafter, to identify possible contributors to socioeconomic inequality, underlying factors that affect socioeconomic inequality in health are discussed. Lastly, different policy measures to combat the tobacco epidemic and how they can differentially impact socioeconomic inequality in smoking prevalence are discussed in detail.

2.1 Socioeconomic status and health behaviour

Socioeconomic status (SES) is defined as the position a person occupies in society due to their combined economic and social status. Generally, it is measured using a composite measure of education, income, and occupation, or a combination of them (23). The relationship between SES and health has long been a research topic of interest. Originally, in the 1960s it was believed that with medical technologies advancing and economics developing, health inequalities would be reduced. However, the opposite seemed to happen, with health inequalities actually increasing (24). Since then, many studies have found a connection between better health conditions and a higher SES (24, 25). While this correlation seems to be widely accepted, the mechanism behind it remains up for debate. Different perspectives exist, but a growing consensus has appeared that the influence of SES on health is mediated by people's lifestyles. A healthy lifestyle consists of a series of behavioural patterns trough which someone maintains and promotes good health. Lifestyle involves both behavioural risk factors, including smoking and drinking, and behaviour promoting health, such as exercise and stress management. Lifestyle could mediate the link between a higher SES and better health, by expanding the range of possible lifestyles to choose from (24). This hypothesis was supported by a study excluding the effect of lifestyle on the overall effect of SES on health, after which the effect was significantly reduced (26).

2.2 Socioeconomic status and smoking in developed and developing countries

One key lifestyle factor influencing an individual's health is smoking (27). As smoking has a huge impact on both an individual's as well as on a society's health, much research has been done on the relationship between SES and smoking behaviour. However, most of this research has been done in HIC (19). Here, smoking rates are higher among those with a lower SES. For example, one study in the United States found that < 20% at or above the poverty level smoke, while this percentage goes up to > 30% in people below the poverty level (28). Furthermore, while people in a low SES group are as likely to attempt quitting as people in high SES groups, they are less likely to be successful in these attempts. Different studies have suggested multiple explanations for this, such as reduced social support for quitting, stronger addiction to tobacco, and targeted marketing by tobacco companies (19).

While research in HIC countries show a correlation between higher SES and better health (behaviour), including lower smoking rates, recent evidence suggests that this social gradient is not universal (29). As the relationship between health behaviours and SES seems weak in Hispanics in the US, this pattern raises questions about the relationship between health behaviour and SES in their home countries, such as Mexico. A study in Mexican adults found that the prevalence of tobacco use actually increased with increasing income level (20). Several reasons could explain why a positive association between SES and healthy behaviour may not exist everywhere, especially in LMIC such as Mexico. Firstly, income levels among the poor are significantly lower in LMIC compared to HIC, affecting their ability to buy

cigarettes (29). This is supported by research in Mexico showing that respondents with no formal education, who are least likely to have much disposable income, were most likely to have never smoked (71%) (20). Second, health information, which could reduce adverse health behaviour in higher SES groups in HIC, is likely to be less available or influential in Mexico (29).

The process of economic development could also produce a different social gradient of tobacco use in Mexico compared to developed countries. Interestingly, the relationship between smoking and SES appears to change as a nation goes through economic development. To illustrate how tobacco use spreads in a country as it goes through economic development, Lopez et al. introduced a descriptive model based on nearly 100 years of observations of countries with a long history of widespread tobacco use (Figure 1) (30). According to this model, the rise and fall of tobacco use can be compared to an epidemic, where tobacco use spreads from a small part to a bigger part of the population and subsequently declines again. Lopez et al. divided the tobacco epidemic into four stages based on smoking prevalence. In the early stage, economic development generally increases both tobacco supply and demand. In this stage, a higher SES is positively associated with smoking and smoking is seen as a status symbol, especially in men. These early adopters are more open to innovations and have sufficient means to afford them. In the second stage, smoking becomes more common and more equally distributed over the population. The positive socioeconomic gradient in tobacco use decreases as people in lower socioeconomic groups start smoking. The third stage shows a peak and a subsequent decline in the prevalence of smoking. This decline is most prevalent among higher socioeconomic groups, as increased health knowledge encourages higher educated people to avoid smoking. In the final stage of the model, smoking will be most prevalent among lower socioeconomic groups, who adopted smoking at a later stage. This pattern emerges later for women than for men(30). Whereas in most developed countries this transition has been completed, Mexico is thought to be in the early stages of this trajectory (31). As Mexico's economy grows and its society goes through changes, it is important to investigate how SES affects smoking behaviour and how this has been developing over recent years.
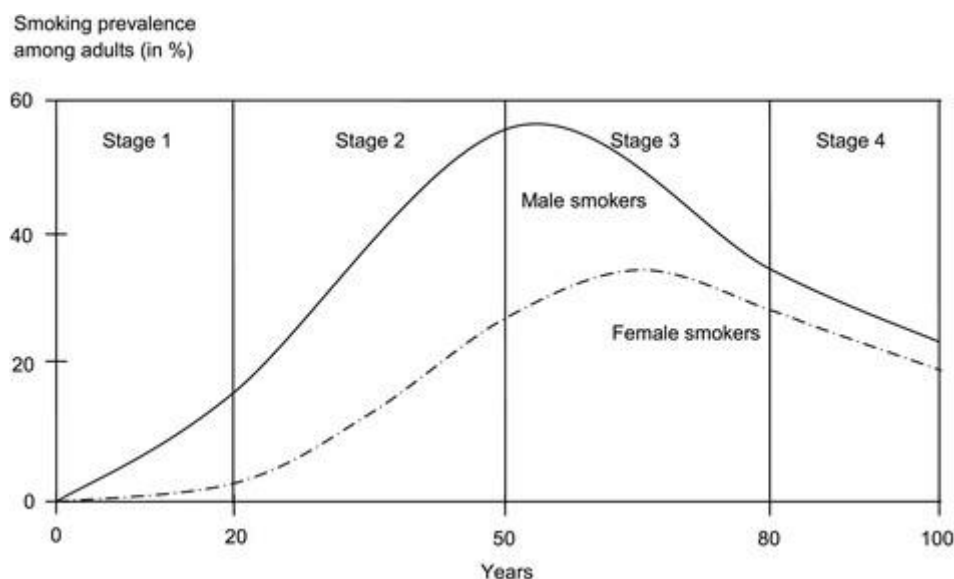

Figure 1. Model of the stages of the smoking epidemic developed by Lopez et al. (30)

2.3 Factors influencing socioeconomic inequality in smoking

In addition to investigating whether socioeconomic inequalities exist in smoking, it is also important to understand what the underlying drivers of this inequality are. There are many different factors that might contribute to socioeconomic inequality in smoking prevalence. For example, literature shows smoking prevalence among Mexican men to be roughly four times higher than among women (32). Literature also shows smoking prevalence to be affected by age and place of residence (33). This is confirmed by research in Mexico, where evidence suggest age and site of residence to have an effect on the relationship between socioeconomic distribution and smoking (34). In addition, intimate relationships have an important impact on health behaviours, including smoking (35). Data from the United States show a prevalence of current cigarette smoking of 13.1% and 20.0% among adults who are married/cohabiting and divorced/separated/widowed, respectively (36). Another factor important when investigating smoking prevalence is depression. Research shows a positive association between negative affective states, such as depression, and smoking prevalence (37). Lastly, health insurance may impact smoking prevalence in the population. Health insurance increases contact with health-care providers, which could reduce risky health behaviour as information regarding its negative consequences is provided (38). Additionally, coverage of smoking cessation services can result in an increased motivation to quit (39). Consequently, smoking rates might be lower in the insured versus the uninsured population. These factors are important to investigate, as identifying main drivers of socioeconomic distribution in smoking prevalence can help define priority areas for effective policy action.

2.3 Tobacco control policies

Mexico has already made important steps to reduce its tobacco burden, being the first country in Latin America to implement the WHO FCTC in 2004 (40). This framework is a global tobacco control treaty sponsored by the WHO and became the first major international tool to reduce the global tobacco burden. It is a legal instrument that provides guidelines and best practices to prevent tobacco consumption and exposure to tobacco smoke (40). The instrument includes guidelines for demand- and supply-side reduction guidelines. Demand side reduction guidelines include: tax increases; increasing protection from tobacco smoke exposure by establishing smoke-free places ; regulating the content of tobacco products; including health warnings on packaging and labelling of tobacco products; strengthening public awareness of consequences of tobacco use; implementing a comprehensive ban on advertising and promotion of tobacco products; and promoting cessation of tobacco use (41). To help countries move towards the goals set by the WHO FCTC, the WHO developed the MPOWER measures in 2008 (Figure 2) (22). These measures operationalise the guidelines from the WHO FCTC and make it easier to track a country's progress in meeting the WHO FCTC requirements. MPOWER measures include the six most cost-effective tobacco control strategies that the WHO recommends member countries to implement. MPOWER stands for: Monitor the consumption of tobacco and the prevention policies; Protect people from exposure to second-hand tobacco smoke; Offer help for ceasing tobacco consumption, Warn about the dangers of tobacco, Enforce prohibitions on advertising, promotion, and sponsorship, and Raise the taxes on tobacco. Each of these components reflects one or more of the demand-side reduction guidelines described in the WHO FCTC. To track progress in tobacco control legislation on a national level, the WHO bi-annually attributes a score to each of the MPOWER measures for every country that ratified the WHO FCTC. These scores range from 1 to 4 for the monitoring component and from 1 to 5 for the other components (42). A score of 1 means that no data is reported. For monitoring, the highest score means that representative data for both adults and youth is collected periodically. The score for protecting increases as more public places become completely smoke-free. The level for offering cessation services rises as more cessation services are covered by insurance. A country's score on warning improves as health warnings on

packaging increase and mass media campaigns are conducted. The score for enforcing advertising and promotion bans improves as these bans become more comprehensive. Lastly, as the tax-percentage on tobacco products increases the score for raising taxes improves (42). In figure 2 detailed requirements for each level of the components can be found.

While the MPOWER measures have proven to reduce the overall burden of tobacco on a national level, they will likely have a different effect on different socioeconomic groups (43). Literature consistently points out tobacco price increases as the intervention with the greatest potential to reduce pro-poor socioeconomic inequality in smoking (43). This is due to price increases having a greater impact on smoking prevalence in low-income compared to high-income groups. Evidence for the impact of the other interventions on socioeconomic inequality of smoking is less clear. For implementing smoke-free environments, one systematic review found no evidence of a differential effect on smoking prevalence by education or income (44). However, several studies have found that smoke-free environments are more likely to be implemented in professional compared to manual work environments (45). Additionally, there is weak evidence that legislation banning smoking in pubs and restaurants is more likely to be enforced in more advantaged areas compared to disadvantages areas (46). Overall, implementing smoke-free environments might have a bigger impact on higher SES groups, but the evidence supporting this is weak (43). The evidence for the effect of educational and mass media campaigns on socioeconomic inequality so far has been inconclusive (43). Nevertheless, there is an indication that mass media campaigns have a bigger impact among high-SES smokers (47). So far, no evidence exists to support that health warnings on tobacco products have an impact on socioeconomic inequality in smoking (43). Research investigating the impact of offering smoking cessation support revealed that these services result in higher quit rates in high-SES smokers compared to low-SES smokers (7). However, this effect can be diminished by concentrating cessation support services in less advantaged communities (43).

	M Monitoring	P Smoke-free policies	O Cessation programs	W Warnings		E Advertising bans	R Taxation
				Health warnings	Mass media		
Level 1	No known data or no recent data or data that are not both recent and representative	Data not reported/ not categorized	Data not reported	Data not reported	Data not reported	Data not reported	Data not reported
Level 2	Recent and representative data for either adults or youth	Up to two public places completely smoke free	None	No warnings or small warnings	No national campaign of at least three weeks conducted in the last year	Complete absence of ban, or ban that does not cover national television, radio, and print media	≤25% of retail price is tax
Level 3	Recent and representative data for both adults and youth	Three to five public places completely smoke-free	NRT and/or some cessation services (neither cost-covered)	Medium size warnings missing some appropriate characteristics	National campaign conducted with 1-4 appropriate characteristics	Ban on national television, radio, and print media only	26-50% of retail price is tax
Level 4	Recent, representative, and periodic data for both adults and youth	Six to seven public places completely smoke-free	NRT and/or some cessation services (at least one of which is cost-covered)	Medium size warnings with all appropriate characteristics	National campaign conducted with 5-6 appropriate characteristics	Ban on national television, radio, and print media as well as on some but not all other forms of direct and indirect advertising	51-75% of retail price is tax
Level 5	-	All public places completely smoke-free	National quit line, and both NRT and some cessation services cost-covered	Large warnings with all appropriate characteristics	National campaign conducted with at least 7 appropriate characteristics including airing on television and/or radio	Ban on all forms of direct and indirect advertising	>75% of retail price is tax

Figure 2. Different levels of achievement of MPOWER measures (42)

3. Methods

3.1 Sage study design

For this study, we used data from two waves of the World Health Organization (WHO) study on global AGEing and adult health (SAGE) in Mexico. Full details for this study are available elsewhere (48). In brief, the SAGE study is a multi-country, longitudinal study based on nationally representative samples of individuals over the age of 50, with a smaller sample of adults aged 18–49 years in each country for comparisons. The main aims of the SAGE study are to improve our understanding of the effects of ageing on well-being, to examine changes in the health state of adults and to determine trends and patterns over time.

Sage data has been collected in six countries: China, Ghana, India, Mexico, Russia, and South-Africa. To date, data of three waves have been published. The data for wave 0 was collected in 2003/04, for wave 1 between July and September 2009, and for wave 2 between July and October 2014. For selection of participants, multistage cluster sampling strategies were used in all countries. Households were then classified into one of two categories: a 50+ household and a 18-49 household. All persons aged 50 years and older from the first group of households were selected, and one person aged 18-49 was selected from the second group of households. Supplementary and replacement samples were included to account for losses to follow up. For data collection, a standardized survey instrument, set of methods, interviewer training and translation protocols were used in all SAGE countries. The SAGE questionnaire consists of a household questionnaire, an individual questionnaire, and/or a proxy questionnaire. The SAGE household questionnaire consists of a household roster and modules about the dwelling, income, transfers in and out of the household, assets, and expenditures. The individual questionnaire consists of modules on health and its determinants, disability, work history, risk factors, chronic conditions, caregiving, subjective well-being, health care utilization and health systems responsiveness. The proxy questionnaire asks about health, functioning, chronic conditions, and health care utilization (48).

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Research and Ethics Committees of Mexico's National Institute of Public Health and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study**.**

3.2 Study sample

Our analysis included participants who participated in wave 1 and wave 2 in Mexico to study changes over time. Data from wave 0 could not be included, as this data was incompatible with the data from wave 1 and 2. To create our final dataset, all individuals in both the household and individual datasets with an incomplete questionnaire were removed, after which the two datasets were merged for both waves separately. Consequently, the datasets of waves 1 and 2 were merged. Hereafter, participants only present in one of the waves were removed. Finally, participants with missing data on any of the following indicators were excluded: current smoking, wealth index, or any of the explanatory variables included in the decomposition analysis.

3.3 Variables

Dependent variable

The dependent variable of this study was current smoking. The SAGE study asked participants whether they had ever smoked. Consequently, participants who answered ''yes'' were asked about current use of any tobacco products. Hereafter, users were categorized into current daily users, non-daily users, former users, and never-users. For this analysis, participants were further categorized in current non-smokers (former and never-users) and current smokers (daily and non-daily users).

Independent variable

In this study, the independent variable was the wealth index (WI), used here as a measure of SES. The WI is a composite measure of a household's living standard and places individual households on a continuous scale of relative wealth (49). To calculate this index, the household and individual questionnaire were merged, after which a principal components analysis was conducted to produce a ranking based on 29 households assets, such as household ownership and access to utilities (50). A complete overview of the included components can be found in appendix I. Hereafter, wealth quintiles were formed by ranking the scores from lowest to highest. The lowest 20% in the 1st quintile represent the country's poorest individuals and the highest 20% in the 5th quintile represent the country's richest individuals.

Explanatory variables

To understand socioeconomic inequality in smoking prevalence, it is important to understand what the underlying drivers of this possible inequality are. The following explanatory variables were included in this analysis to determine their individual contribution to socioeconomic inequality in smoking prevalence: sex, living area, marital status, feeling depressed, being insured, age and wealth. The variables were transformed into dummy variables, to be able to interpret the contribution of each category to the overall socioeconomic inequality in smoking prevalence. The first category was used as the reference group. The following categories were created: sex (male; female), living area (rural; urban), marital status (not married: married), feeling depressed (experienced no depressed period in last 12 months; experienced a depressed period in last 12 months), age (20-39; 40-59; 60-79; 80-100), and wealth (poorest; poor; middle; rich; richest). Sex, living area, feeling depressed, and wealth were already categorized correctly. The variables marital status and age had to be recoded for our analysis. To obtain the variable marital status, participants were asked about their current marital status and given five options: never married; currently married; cohabiting; separated/divorced or widowed. We further categorized this data in married (currently married and cohabiting) and not married (never married, separated/divorced and widowed). Age was further categorized in four age groups, ranging from 20-39, 40-59, 60-79, and 80-100.

3.4 Statistical analysis

All statistical analysis were conducted using Stata 16. Summary statistics for categorical variables were presented as proportions, and for continuous variables as means with standard deviations. Two tests were used to test for differences between the five wealth quintiles: ANOVA tests for normally distributed continuous variables, and chi-square tests for categorical variables. Results were deemed statistically significant at an alpha level of 0.05.

Measurement of socioeconomic inequality

To assess socioeconomic inequality in smoking prevalence, first the prevalence of smoking over the wealth quintiles was determined for both time points. Then, a concentration index was calculated. A concentration index is used to measure and compare the degree of socioeconomic-related inequality in varying health outcomes (51). The standard CI can be derived from the concentration curve, which plots the cumulative percentage of a health variable against the cumulative percentage of the population, ranked by wealth. The standard concentration index is equal to twice the area between the concentration curve and the 45° line of equality, which is represented by the following formula:

$$CI = \frac{2}{\mu} cov(h, r)$$

(1),

where μ is the mean prevalence of smoking, h is the health variable and r is the ranking based on the wealth index (51). If there is no socioeconomic inequality in smoking, the concentration index will be zero. When smoking is more prevalent among the rich, the concentration index will be positive and vice versa (51). Strictly, the concentration index is an appropriate measure of socioeconomic inequality in health when health is measured on a ratio scale. In this case, the bounds of the concentration index are between -1 and +1. However, most health variables are binary and not on a ratio scale. When the standard CI is used to measure socioeconomic inequality in a binary health variable, its bounds will be equal to μ-1 and μ+1, instead of -1 and +1. Here μ refers to the mean of the variable being analysed. This has the following implication: if μ is very low, the range of the concentration index will be very large and if μ is very high, the range of the concentration index will be very small (52). This observation has sparked a big debate, which is yet to be resolved, about how to best 'correct' the concentration index when the variable being analysed is binary (53). Three alternative concentration indices have been proposed: the generalized concentration index, the concentration index composed by Wagstaff, and the concentration index composed by Erreygers (53). The concentration index computed by Erreygers is often used in the literature (53). Therefore, in this report we will compare the standard concentration index and the Erreygers index.

It is important to understand that the standard concentration index measures relative socioeconomic inequality in health, while the Erreygers index measures absolute inequality (53). Furthermore, when analysing a binary health variable the value of the standard concentration index will depend on the mean of the health variable (52). This would make comparisons between populations with different health means problematic. Therefore, when measuring socioeconomic inequality in one population, the standard concentration index would be sufficient. However, when comparing socioeconomic inequality between different populations to each other, the Erreygers concentration index would be more appropriate to use.

In our analysis, we first calculated the standard concentration index. Then, we applied the Erreygers standardization, to observe potential differences between the two indices.

Decomposition of socioeconomic inequality

While it is valuable to know the socioeconomic distribution of smoking prevalence, this measure cannot explain its underlying drivers. To determine these, the standard concentration index was decomposed following an approach developed by Wagstaff et al. (54). This approach allowed us to estimate the contribution of our explanatory variables to the total inequality. A decomposition analysis separates the socioeconomic inequality into two components: a component explained by our explanatory variables and an unexplained component, represented by the residual (51). The first component is calculated through four stages. First, the coefficient (beta) of every explanatory variable is calculated through a regression analysis. Second, the elasticity for each explanatory variable with respect to the dependent variable is calculated. The elasticity refers to the responsiveness of smoking to the explanatory variable, which is defined as the change in smoking prevalence in response to a change in the explanatory variable (55). In the third stage, the concentration index of each explanatory variable is computed. Lastly, the contribution of each explanatory variable to the total inequality is calculated by multiplying the elasticity of each determinant by its concentration index (54). The following equation presents how to calculate this contribution:

$$\text{Contribution total CI} = \text{Elasticity}_{\text{smoking}/x} * CI_x \ (2)$$

If the contribution of the explanatory variable is positive, this means that the combined effect of the elasticity and concentration index increases the socioeconomic inequality in smoking prevalence, and vice versa for a negative contribution (54). The contributory factors we investigated were sex, living area, marital status, feeling depressed, being insured, age and wealth. Our analysis was conducted for both 2009 and 2014, to observe trends over time.

3.5 Implemented tobacco control policies in Mexico

To gain a broader perspective to help interpret our findings, a literature review was conducted to create an overview of the steps Mexico had taken to reduce its tobacco burden between the two measured timepoints in our analysis (2009 and 2014). The goal of this review was not to evaluate Mexico's implemented policy, but to gain an overview of what actions Mexico had taken in accordance with the MPOWER package developed by the WHO. This was done to better interpret the effects over time found in our data analysis.

Literature selection was done through several sources and grey literature was included. A comprehensive and broad search of PubMed and ScienceDirect was performed using the following key words: tobacco control polic* Mexico, tobacco polic* Mexico, and Mexico smok* polic*. Only documents published after 2009 were included. After removal of duplicates, 535 documents resulted from this search. Consequently, their titles and/or abstracts were screened for relevance. Documents not mentioning specific tobacco control policies implemented between 2009 and 2014 were excluded, after which 11 documents remained. Reference lists of these documents were manually searched to identify additional relevant documents through snowballing. To identify relevant grey literature, first a google search was conducted to find relevant organizations and websites publishing documents on tobacco control measures in Mexico. Through this process the WHO and tobacco control laws were identified as important sources (56, 57). Six documents from these websites referring to tobacco control policies implemented, or progress made between 2009 and 2014 were downloaded and included in our review. An overview of all included documents can be found in appendix II.

Hereafter, relevant information was extracted from the selected documents. A data extraction sheet was developed and filled in. This data extraction sheet included the following: background information (title; journal; author; source; type of document; year published), health policy information (type of

tobacco control measure; aim/goal; target setting; target population; year of implementation). Only policies implemented on a national level were included, as our statistical analysis was conducted on a nationwide sample. Therefore, regional differences could not be considered.

After filling in the data extraction sheet, an overview was created of the implemented tobacco control policies between 2009 and 2014 on a national level. The policies were ordered through the MPOWER package developed by the WHO (22). No policies were found that fell beyond the scope of the MPOWER measures. Consequently, from bi-annual reports developed by the WHO to track the global tobacco epidemic the level of achievement for each of the domains was extracted for both measured timepoints.

4. Results

4.1 Background characteristics

Figure 3 shows a flowchart representing the steps taken to construct our final dataset. First, respondents with an incomplete questionnaire were removed from the individual and household datasets, which resulted in the datasets presented on top in Figure 3. After merging of the household and individual datasets for each wave and excluding non-matched observations (i.e., individuals who did not complete both the individual and the household questionnaire), wave 1 included 2,680 and wave 2 4,417 matched respondents. 1,183 participants were only present in wave 1, meaning that they were lost in follow-up. The 2,920 participants only present in wave 2 came from an additional sample included in this wave. After exclusions, 1,497 participants were present in both waves and included in our analysis. Their general characteristics, both in total and subdivided over the five wealth quintiles, are reported in table 1. In the total sample the majority (63.8%) was female, and the average age was 62.0 years, which stayed rather consistent over the five wealth quintiles. Overall, the majority of our sample lived in an urban area (70.4%). Participants in a higher wealth quintile were more likely to be urban residents, with the percentage of people living in an urban area going from 36.7% in the lowest quintile to 91.0% in the highest quintile. The overall percentage of participants currently smoking was 18.4%, with the lowest percentage in the first wealth quintile (14.7%) and the highest percentage in the fourth wealth quintile (21.4%). Overall, people in a higher wealth quintile were also more likely to have consumed alcohol in the last 30 days and to be insured. The distribution of being married or to have had a period of feeling depressed in the last 12 months was not significantly different over the wealth quintiles.
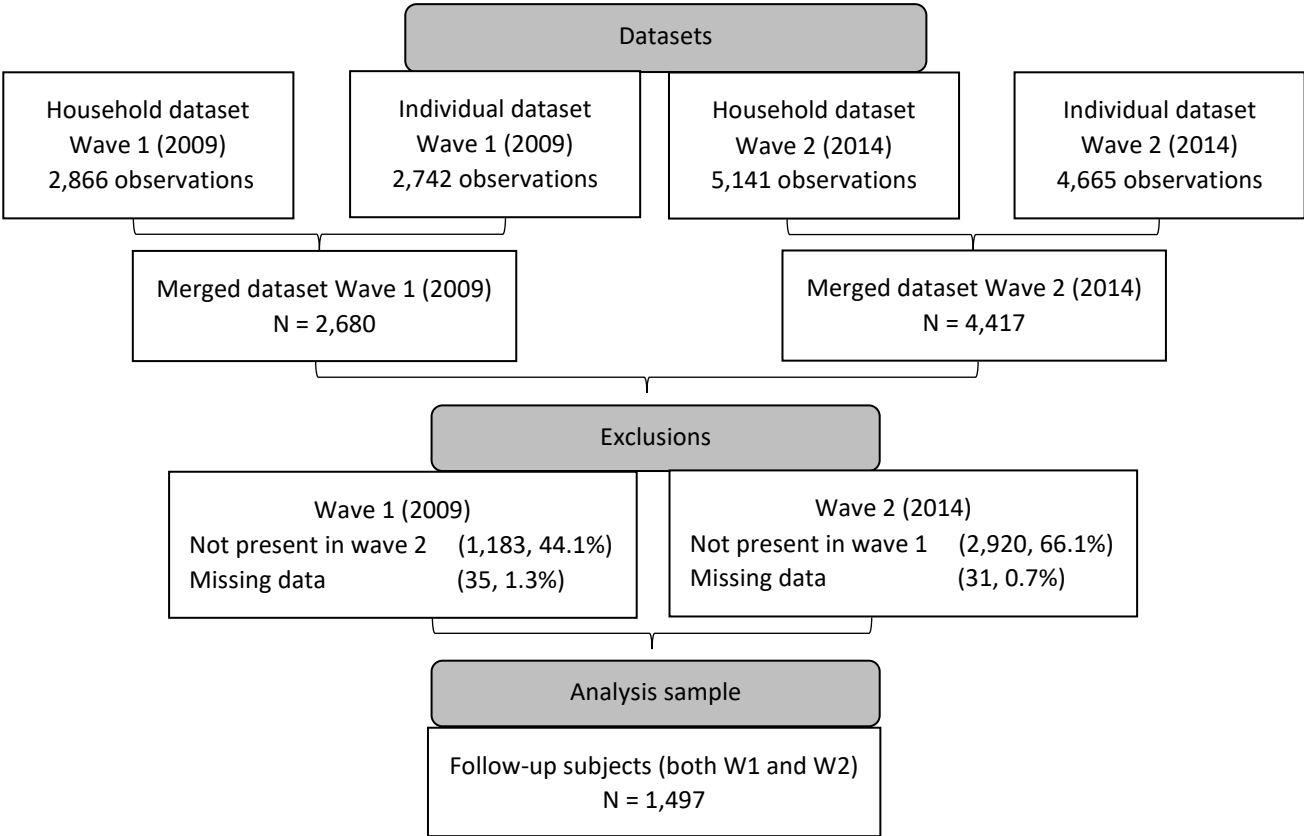

Figure 3. Flowchart of construction analysis sample

Table 1: Background characteristics of participants in Wave 1

	Total	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P-value
Numbers enrolled	1,497	300	299	300	299	299	
Sex, n (%)							
Female	955 (63.8)	195 (65.0)	191 (63.9)	191 (63.7)	189 (63.2)	189 (63.2)	
Male	542 (36.2)	105 (35.0)	108 (36.1)	109 (36.3)	110 (36.8)	110 (36.8)	0.991
Age (years)	62.0 ± 12.9	63.2 ± 13.2	61.7 ± 13.8	62.9 ± 12.3	61.4 ± 12.8	60.9 ± 12.1	0.133
Age groups, n(%)							
Age 20-39	119 (7.9)	25 (8.3)	31 (10.4)	20 (6.7)	27 (9.0)	16 (5.4)	
Age 40-59	395 (26.4)	64 (21.3)	71 (23.8)	71 (23.7)	79 (26.4)	110 (36.8)	
Age 60-79	905 (60.5)	187 (62.3)	184 (61.5)	194 (64.7)	178 (59.5)	162 (54.2)	
Age 80-100	78 (5.2)	24 (8.0)	13 (4.4)	15 (5.0)	15 (5.0)	11 (3.7)	**0.001****
Site, n (%)							
Urban	1,054 (70.4)	110 (36.7)	197 (65.9)	227 (75.7)	248 (82.9)	272 (91.0)	
Rural	443 (29.6)	190 (63.3)	102 (34.1)	73 (24.3)	51 (17.1)	27 (9.0)	**0.000*****
Marital status, n (%)							
Married	1,001 (66.9)	192 (64.0)	195 (65.2)	208 (69.3)	206 (68.9)	200 (66.9)	
Unmarried	496 (33.1)	108 (36.0)	104 (34.8)	92 (30.7)	93 (31.1)	99 (33.1)	0.582
Currently smoking, n (%)							
Currently using tobacco	276 (18.4)	44 (14.7)	56 (18.7)	54 (18.0)	64 (21.4)	58 (19.4)	
Currently not using tobacco	1,221 (81.6)	256 (85.3)	243 (81.3)	246 (82.0)	235 (78.6)	241 (80.6)	0.306
Consumed alcohol last 30 days, n (%)	244 (16.3)	41 (13.7)	35 (11.7)	43 (14.3)	55 (18.4)	70 (23.4)	**0.001****
Insurance status, n (%)							
Is insured	984 (65.7)	173 (57.7)	171 (57.2)	214 (71.3)	210 (70.2)	216 (72.2)	
Is not insured	513 (34.3)	127 (42.3)	128 (42.8)	86 (28.7)	89 (29.8)	83 (27.8)	**0.000*****
Period feeling depressed last 12 months, n (%)	372 (24.9)	70 (23.3)	87 (29.1)	79 (26.3)	69 (23.1)	67 (22.4)	0.280

* Denotes statistical significance, at p< 0.05
** Denotes statistical significance, at p< 0.01
*** Denotes statistical significance, at p< 0.001

4.2 Changes in smoking prevalence

Table 2 shows the prevalence of smoking in 2009 and 2014 and its change over this time, both in the total sample and in the five wealth quintiles. In 2009, the difference in smoking prevalence between the quintiles is not statistically significant. In 2014, the difference is statistically significant and gradually increases, with the exception of quintile 4, from quintile 1 to quintile 5. The overall prevalence of smoking reduced by 8.3%, from 18.4% in 2009 to 10.1% in 2014. The drop in smoking prevalence was highest in quintile 4 (11.4%) and lowest in quintile 5 (5.7%). Overall, with the exception of quintile 4, a gradual decrease in the reduction of smoking prevalence can be seen from quintile 1 to quintile 5. In Figure 4 the prevalence rates are presented visually. The figure clearly shows the overall reduction in smoking prevalence across all wealth quintiles. Additionally, while the reduction of smoking prevalence was greatest in quintile 4, this quintile also started out with the highest smoking prevalence. Lastly, in 2014 the lowest smoking prevalence occurs in the poorest and the highest smoking prevalence in the richest quintile.

Table 2. Change over time in smoking prevalence reported in total and per quintile

	Total	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	P-value
Numbers enrolled	1,497	300	299	300	299	299	
Wave 1 (2009), n (%)							
Currently using tobacco	276 (18.4)	44 (14.7)	56 (18.7)	54 (18.0)	64 (21.4)	58 (19.4)	
Currently not using tobacco	1,221 (81.6)	256 (85.3)	243 (81.3)	246 (82.0)	235 (78.6)	241 (80.6)	0.306
Wave 2 (2014), n (%)							
Currently using tobacco	151 (10.1)	15 (5.0)	32 (10.7)	33 (11.0)	30 (10.0)	41 (13.7)	
Currently not using tobacco	1,346 (89.9)	285 (95.0)	267 (89.3)	267 (89.0)	269 (90.0)	258 (86.3)	**0.01****
Δ smoking prevalence, n (%)	**-125 (-8.3)**	**-29 (-9.7)**	**-24 (-8.0)**	**21 (-7.0)**	**34 (-11.4)**	**17 (-5.7)**	

** Denotes statistical significance, at p< 0.01
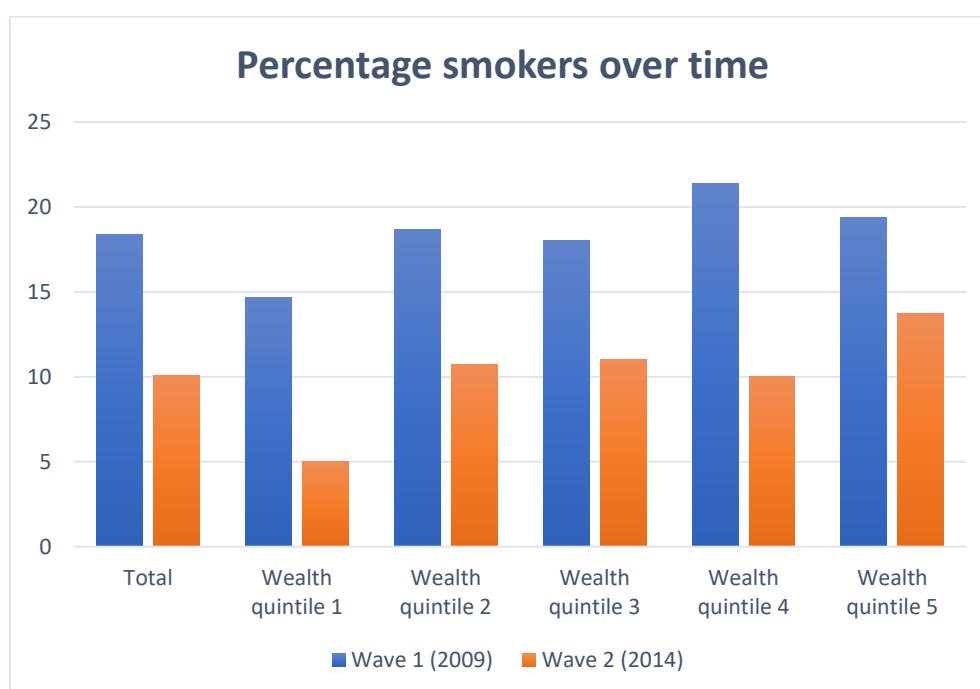
Figure 4. Prevalence of smoking reported in total and per quintile in 2009 and 2014

4.3 Socioeconomic inequality in smoking prevalence

In table 3 both the standard as well as the Erreygers concentration indices for both time points can be found. All concentration indices are positive, meaning that smoking is most concentrated among the wealthiest population groups in both wave 1 and wave 2. This is in line with our findings in table 2, where smoking prevalence was lower in the poorer and higher in the richer quintiles. Both the standard as well as the Erreygers normalized concentration index show increased socioeconomic inequalities between 2009 and 2014, indicating that smoking became more concentrated among the wealthier over the two time points. However, the standard concentration index gives higher absolute values as well as a bigger increase over time compared to the Erreygers normalized concentration index. Lastly, only the concentration indices from wave 2 were statistically significant different from zero.

Table 3. Concentration indices of smoking prevalence

	Index value	Standard error	P-value
Wave 1 (2009)			
Standard CI	0.06	0.03	0.06
Erreygers normalized CI	0.04	0.02	0.06
Wave 2 (2014)			
Standard CI	0.14	0.04	**0.001***
Erreygers normalized CI	0.06	0.02	**0.001***
Δ Concentration index			
Standard CI	+ 0.08		
Erreygers normalized CI	+ 0.02		

*** Denotes statistical significance, at $p < 0.001$

4.4 Decomposition of the socioeconomic inequality in smoking prevalence

In table 4 and 5, the results of the decomposition analysis for wave 1 (2009) and wave 2 (2014) are presented, respectively. The contribution of each explanatory variable to the socioeconomic inequality of smoking prevalence is explained. As explained in the methods section, the contributions of each explanatory variable come from multiplying the concentration index of the variable with the elasticity of the outcome variable with respect to the explanatory variable. The elasticity refers to the responsiveness of smoking to the explanatory variable, which is defined as the change in smoking prevalence in response to a change in the explanatory variable (55). If the contribution of the explanatory variable is positive, this means that this factor increases the socioeconomic inequality in smoking prevalence, and vice versa for a negative contribution.

The results of the decomposition of the concentration index of wave 1 (2009) show that wealth is the most important contributor to inequality in smoking prevalence, with a percentage contribution of 48.21 percent (table 4). This is expected, as the wealth quintiles are composed based on the wealth indices for each respondent. The high positive elasticity of the richer and richest group show that smoking is positively related to household wealth. Another important contributor to socioeconomic inequality in smoking prevalence was living in an urban area. This explanatory variable contributed to 40.44 percent of the inequality in smoking prevalence. Again, the high positive elasticity shows that smoking is positively associated with living in an urban area. The high positive concentration index demonstrates that living in an urban area is more concentrated among the wealthier population. These factors combined result in the high positive contribution of urban residence. Being female, feeling depressed, and being insured also contributed positively to socioeconomic inequality in smoking prevalence. However, these contributions were small compared to the contributions of

wealth and urban area. The elasticity of being female is very high and negative, revealing that smoking is negatively associated with being female. However, due to its small negative concentration index, the total contribution of this variable is positive and small. Age and marital status both had small negative contributions. This means that these factors reduced the socioeconomic inequality in smoking prevalence. In marital status, this was due to a negative elasticity and a positive concentration index. This indicates that being married or cohabiting was negatively associated with smoking, but positively associated with wealth. The contribution of the residual was 0.006, meaning that 10.78 percent of the socioeconomic inequality could not be explained by the explanatory variables included in our analysis.

Table 4. Results for the decomposition of the concentration index of smoking in wave 1.

Current smoking prevalence Wave 1 (2009)	Beta	Elasticity	CI	Contribution	Percentage contribution
Female (ref: male)	-0.268	-0.927	-0.003	0.003	**4.78**
Urban area (ref: rural)	0.041	0.158	0.150	0.024	**40.44**
Marital status (ref: not married)	-0.065	-0.237	0.010	-0.002	**-4.10**
Feeling depressed (ref: not feeling depressed)	-0.004	-0.005	-0.029	0.000	**0.24**
Insured (ref: not insured)	0.000	0.000	0.055	0.000	**0.07**
Age (total) (ref: age group 1: 20-39)					**-0.42**
Age group 2 (40-59)	-0.098	-0.141	0.101	-0.014	-24.17
Age group 3 (60-79)	-0.099	-0.326	-0.024	0.008	13.30
Age group 4 (80-100)	-0.168	-0.048	-0.129	0.006	10.44
Wealth (ref: poorest)					**48.21**
Wealth (poorer)	0.022	0.024	-0.400	-0.010	-16.19
Wealth (middle)	0.017	0.018	0.001	0.000	0.02
Wealth (richer)	0.044	0.047	0.401	0.019	32.37
Wealth (richest)	0.022	0.023	0.801	0.019	32.01
Sub total				0.053	**89.22**
Residual				0.006	**10.78**
Concentration index				0.059	**100**

The results of the decomposition of the concentration index of wave 2 (2014) show that living in an urban area is the most important contributor to inequality in smoking prevalence, with a percentage contribution of 61.02 percent (table 5). This high positive contribution is due to a high elasticity and concentration index. This shows that living in an urban area is both positively associated with smoking and being wealthier. In this analysis, the second most important contributor to inequality in smoking prevalence was the wealth index (31.30 %). Being female, feeling depressed, age, and being insured all contributed positively to socioeconomic inequality in smoking prevalence. However, these contributions were very small. Only marital status contributed negatively to socioeconomic inequality. However, this negative contribution was very small (1.68%). The contribution of the residual was a lot smaller compared to wave 1 (table 4). The residual only accounted for 3.94% of the socioeconomic inequality in our analysis, meaning that most of the inequality could be explained by the explanatory variables included in our analysis.

Table 5. Results for the decomposition of the concentration index of smoking in wave 2.

Current smoking prevalence Wave 2 (2014)	Beta	Elasticity	CI	Contribution	Percentage contribution
Female (ref: male)	-0.116	-0.732	-0.003	0.002	**1.56**
Urban area (ref: rural)	0.083	0.578	0.150	0.087	**61.02**
Marital status (ref: not married)	-0.035	-0.235	0.010	-0.002	**-1.68**
Feeling depressed (ref: not feeling depressed)	-0.005	-0.014	-0.029	0.000	**0.27**
Insured (ref: not insured)	0.002	0.016	0.055	0.001	**0.62**
Age (total) (ref: age group 1: 20-39)					**2.97**
Age group 2 (40-59)	-0.071	-0.188	0.101	-0.019	-13.31
Age group 3 (60-79)	-0.092	-0.549	-0.024	0.013	9.27
Age group 4 (80-100)	-0.149	-0.077	-0.129	0.010	7.01
Wealth (ref: poorest)					**31.30**
Wealth (poorer)	0.028	0.055	-0.400	-0.022	-15.52
Wealth (middle)	0.027	0.054	0.001	0.000	0.03
Wealth (richer)	0.008	0.016	0.401	0.006	4.47
Wealth (richest)	0.038	0.075	0.801	0.060	42.32
Sub total				0.136	**96.06**
Residual				0.006	**3.94**
Concentration index				0.142	**100**

In figure 5, the percentage contribution of the various investigated factors to the socioeconomic inequality of smoking prevalence are presented visually for both time points. Overall, one of the most interesting differences is that the wealth index contributed more to socioeconomic inequality in smoking prevalence in wave 1 compared to wave 2, with a difference of approximately 17 percent. This is likely due to an increase of the contribution of living in an urban area, as this contribution increased in wave 2 compared to wave 1 with approximately 20 percent. This increase can be attributed to an increase in elasticity, as the concentration index of living in an urban area remained constant (table 4,5). This means that the positive association between smoking and living in an urban area increased between 2009 and 2014. In other words, urban residents are more likely to smoke compared to rural residents, and this probability increased between 2009 and 2014. The contributions of age, being insured, feeling depressed, and marital status to socioeconomic inequality remained small in both waves. However, the contribution of being female did decrease with approximately 3 percent. This is due to a reduction in the negative elasticity of being female (table 4,5). This demonstrates that the negative association between smoking and being female reduced between 2009 and 2014.
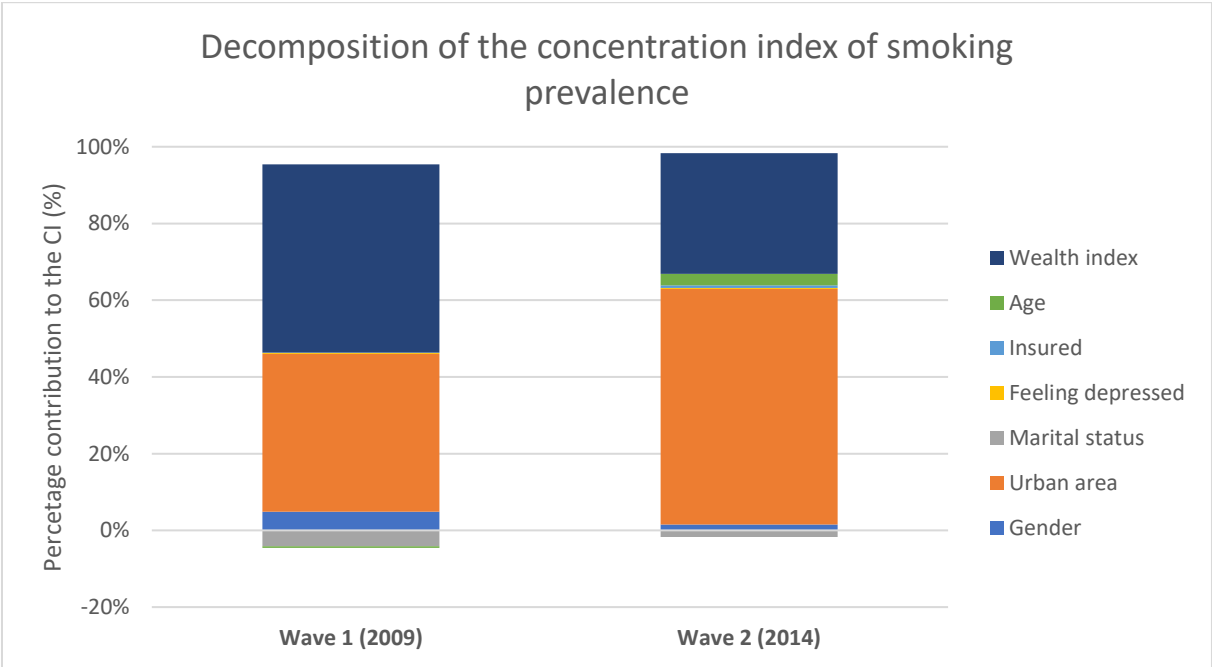
Figure 5. Percentage contribution of various factors to the socioeconomic inequality of smoking prevalence.

4.4 Implemented tobacco control policies in Mexico

In order to increase the understanding of our results, we created an overview of the tobacco control policies implemented by Mexico in the period 2009-2014. These findings can be used to help interpret the increase in pro-rich socioeconomic inequality found in our statistical analysis. Relevant policies were identified by means of a literature review. An overview of the included documents for our literature review can be found in appendix II. We categorized the policies according to the MPOWER measures developed by the WHO (Table 6) (22). No policies were found that fell beyond the scope of the MPOWER measures. Consequently, the achievement level on each domain for the years 2009 and 2014 was extracted from WHO reports and included in table 6. These levels range from 1 to 4 for the monitoring component and from 1 to 5 for the other components. A higher level means that a country scores better on this particular domain.

In all MPOWER components, except protecting people from second-hand smoke, Mexico implemented policies in line with the WHO FCTC framework (Table 6). To improve monitoring of the tobacco epidemic, a surveillance system was developed and the sale of cigarettes was further restricted. The general law on tobacco control (GLTC) implemented in 2009 prohibits indoor smoking but allows for designated smoking areas according to specific regulations. As this is not completely smoke-free, this policy is not in line with WHO FCTC recommendations. Overall, cessation services were expanded and its insurance coverage increased, meaning that Mexico made progress in the domain offering help for ceasing tobacco consumption. Key steps were taken in the domain warn about the dangers of tobacco, as warning labels on packaging and labelling were expanded and a national media campaign was conducted in 2013. Mexico was less successful in enforcing prohibitions on advertising, promotion, and sponsorship. While promotion and advertising of tobacco products became more restricted after implementation of the GLTC, the law still allowed for advertising targeted towards adults. As this is not in line with WHO FCTC recommendations, Mexico scores low on this component. Lastly, Mexico managed to raise tobacco taxes for three consecutive years, resulting in a 10 percent tax increase over less than five years. Most implemented policies between 2009 and 2014 were part of the GLTC. After implementation of this law, the implementation of new policies has been slow.

Overall, the achievement level of Mexico in the six MPOWER domains improved in three, remained stable in two, and decreased in one domain. Mexico reached the highest level of achievement in two domains: Offer help for ceasing tobacco consumption and Warn about the dangers of tobacco. In the domain Protect people from exposure to second-hand tobacco smoke Mexico's score reduced from 2 to 1. Mexico's score in Enforce prohibitions on advertising remained relatively low at 2, and its score on Raise the taxes on tobacco remained relatively high at 4.

Table 6. Overview of tobacco control policies implemented by Mexico in the period 2009- 2014.

	Policy intervention	Year	In line with	Level achieved 2009 [42]	Level achieved 2014 [58]
M (16, 59, 60)	National program for tobacco established.	2009*	✓	2	3
	National and subnational tobacco surveillance system using global indicators developed to track the epidemic and the tobacco control policies.	2009*	✓		
	Sales to under aged people and of single cigarettes is prohibited.	2009*	✓		
P (16, 59-62)	Prohibited for anyone to use or have any tobacco product lit in 100% smoke-free spaces, such as public and private schools of basic education and high schools.	2009*	✓	2	1
	In indoor places with public access designated smoking areas according to specific regulation requirements are allowed.	2009*	✘		
O (16, 59, 60, 62)	The Mexican standard for the prevention, treatment and control of addiction was updated and modified. It provides new guidelines for diagnosis and treatment of nicotine addiction.	2009	✓	4	5
	A network of over 350 specialized care units for addiction treatment was established.	2009*	✓		
	A call center to provide smokers on how to quit smoking and to provide brief advice was established.	2010	✓		
W (16, 59, 60, 62-65)	On tobacco product packages and all their external packaging and labelling, there must be warning legends, pictograms, and images. The pictogram must cover 30% of the front side, and text health warnings must cover 100% of the back side and 100% of one lateral side.	2009*	✓	3	5
	The use of terms such as ''low tar content'', ''light'', or ''smooth'' suggesting reduced damage caused by tobacco is prohibited.	2009*	✓		
	Every year eight different pictograms are released in four waves, which are rotated every three months.	2011	✓		
	National media campaign set up to warn about the dangers of tobacco and promote quitting.	2013	✓		
E (16, 59, 60)	All forms of sponsorships (e.g., sponsoring music concerts) and promotional distributions (free samples) are prohibited.	2009*	✓	2	2
	Adds are banned on TV, but allowed in magazines for adults, personal print media and POS with specific rules.	2009*	✘		
R (16, 60, 62, 66-70)	Tax increase to 61.4% of the final price of a package of cigarettes (from 58.6%)	2009	✓	4	4
	Tax increase to 62.7% of the final price of a package of cigarettes.	2010	✓		
	Tax increase to 68.8% of the final price of a package of cigarettes.	2011	✓		

*Part of the general law on tobacco control (GLTC) (59)

5. Discussion and conclusion

5.1 Key findings

This thesis aimed to investigate how socioeconomic status affected smoking prevalence in adults in Mexico in the period 2009-2014. The concentration index revealed smoking to be disproportionally distributed among the rich. While there was an overall reduction in smoking prevalence, pro-rich socioeconomic inequality increased. Between 2009-2014, Mexico took steps that improved its overall accordance with the MPOWER framework.

5.2 Interpretation of key findings

To estimate the importance of socioeconomic inequality in smoking prevalence, it is important to also investigate the overall trend in smoking prevalence in Mexico. We found a reduction in overall smoking prevalence from 18 to 10 percent, which is consistent with other literature. The WHO reported an adult daily smoking prevalence of 14 and 8 percent in 2009 and 2014, respectively (42, 58). On the contrary, the global adult tobacco survey (GATS) reported a small, non-significant increase in the prevalence of current smoking from 15.9% in 2009 to 16.3% in 2015 (71). However, this survey is administered to persons 15 years of age and older, which could explain these different findings. In contrast, our analysis included an oversampling of adults over the age of 55 and included no participants under the age of 20. In Mexico, smoking prevalence decreased among adults but increased among adolescents between 2009 and 2015 (71). As adolescents were included in the GATS and not in our analysis, this could explain why the GATS found no reduction in overall smoking prevalence between 2009 and 2014 and we did.

Our finding that smoking in Mexican adults is disproportionately distributed among higher compared to lower socioeconomic groups is supported by other literature (5, 71). This pattern is inconsistent with findings in other countries, and literature shows Mexico to be one of the few countries where a positive relationship between wealth and smoking exists (11). This could be an indication that Mexico has not yet transitioned to an advanced stage of the tobacco epidemic, when health concerns weigh more heavily than affordability among the more advantaged population (30). Due to the overall high level of inequality in Mexico, it is likely that smoking prevalence among the poorest is lowest due to smoking being unaffordable for this group. Research shows that that smokers in the poorest households of the population spend approximately 3.5% and 4.1% of their total expenditure on tobacco products in 2006 and 2008, respectively (66). This was the highest percentage of all wealth quintiles. As this group has the most limited resources, resources that are spent on tobacco compete directly with spending on health, food, education, and other necessities. This is likely to discourage people in this group to initiate or motivate them to quit smoking.

To our knowledge, no other literature has investigated trends in socioeconomic inequality in smoking prevalence over time. Therefore, we are unable to compare this finding to other studies. A possible explanation of the growing pro-rich socioeconomic inequality could be the tobacco control legislation measures implemented by Mexico. Raising tobacco taxes has a higher impact on low-SES groups as they are more price sensitive than high-SES groups (43). Between 2009 and 2014 Mexico increased taxes from 61.4% to 68.8% of the final price of a pack of cigarettes (16). This is not above the 75% recommended by the WHO, but it is higher than the 2014 average in LMIC (63.3%) (72). In the region, only Argentina and Chile succeeded in raising taxes above 75% (73). While the increase in tobacco taxes will have a bigger impact on the poorer quintiles, mass media campaigns are more likely to reach the wealthier population groups. At first glance, it seems that Mexico has improved most in the warning component of the MPOWER framework over the studied time-period. From this, it could be expected that pro-rich socioeconomic inequality reduced over this time. However, a more in depth-

look reveals that actually, anti-tobacco mass media campaigns have been conducted sporadically over the last decade. Furthermore, when implemented their content has been outdated and their impact left unmeasured (16). Only one mass media campaign was conducted between 2009 and 2014, in 2013 (58). Therefore, in the WHO report of 2014, Mexico reached the highest achievement level in this component. Since then, no mass media campaigns have been conducted, and Mexico's achievement level in this area fell again (74). Since mass-media campaigns have been inconsistent, its possible positive effect on reducing pro-rich socioeconomic inequality in smoking prevalence was likely not reached. The effect of the other policies on socioeconomic inequality in smoking prevalence is difficult to estimate, as literature regarding this shows mixed outcomes (43).

Our decomposition analysis revealed that wealth and urbanization have the highest positive contribution to smoking being more concentrated among the rich. This means that they contribute most to smoking being less concentrated among the poor and more among the rich in Mexico. Both these findings were in line with our expectations. As shown before, literature consistently shows a positive association between higher wealth and smoking prevalence in Mexico (11). The large positive contribution of urban residence to socioeconomic inequality comes from urban residents being both more likely to smoke and to be wealthier. First, research in Mexico reveals urban residents to have a higher probability of smoking compared to rural residents (29). Similar results were found in Peru, where smoking rates were highest in urban settings (75). On the contrary, in developed countries such as the United States rural residents are more likely to smoke compared to urban residents (76). However, this is a trend that has developed over time, and is likely to be different in LMIC such as Mexico. Research investigating time trends in rural-urban smoking prevalence in six European countries found similarities between the diffusion of smoking from high to low socioeconomic groups and the diffusion of smoking from urban to rural populations (77). Urbanization can influence the economic development of rural areas and provide them with improved infrastructure and facilities (78). Additionally, rural residents might receive money from family members that have moved to the city (79). This combination can allow rural residents to adopt a more urban lifestyle (79). This could be an indication that over time, Mexico's smoking pattern will evolve to higher smoking rates in rural versus urban populations. Second, rural residents are more likely to live in poverty compared to urban residents, indicating that urban residents are more likely to be richer (80). On average, urban residents have more job opportunities, better access to education, and access to proper sanitation and health services. Regardless of being more wealthy, urban residents are likely to score higher on the wealth index as composed by the DHS, since the index is constructed in a way that it depends on assets and services mainly owned by urban populations (81).

The contributions of the other explanatory variables to socioeconomic inequality in smoking were very small. Our results show a large negative association between smoking and being female, which was in line with our expectations (32). However, being female was not unevenly distributed over the wealth quintiles, resulting in a small contribution to overall socioeconomic inequality in smoking prevalence. While already small, the contribution of being female reduced between 2009 and 2014 due to a smaller negative association between smoking and being female. Again, this was expected, as women pick up smoking at a later stage than men (30). Therefore, gender differences in smoking prevalence generally become smaller over time. On the contrary, feeling depressed and being insured were unevenly distributed over the wealth quintiles. Therefore, their small contributions could be attributed to a small association between these variables and smoking. The fact that we did not find an association between these factors and smoking, does not mean that this relationship is not present in the Mexican population. Literature regarding this association has given mixed results (38, 82). Therefore, further research might be necessary to investigate this further.

Another interesting finding was that over time, the contribution of urban residence to socioeconomic inequality grew, while the contribution of wealth reduced. This might indicate that the odds of rich urban residents smoking increased from 2009 to 2014. This is contrary to what would be expected from the literature. Overall, the urban rich are likely to develop healthier lifestyles over time, as they receive health information faster and have the means to adapt their behaviour accordingly (43). Additionally, as a country goes through economic development and rural areas receive improved infrastructure and facilities, rural-urban differences in health behaviours usually diminish (78). Further research is needed to uncover why the contribution of urban residence to socioeconomic inequality increased instead of reduced over the studied time period.

While the rise in pro-rich socioeconomic inequality could be partly explained by Mexico's tobacco raises, it is valuable to take a broader look at the steps Mexico has taken to control its tobacco burden. Overall, Mexico has taken some steps forward. However, Mexico has not managed to implement legislation that fully adheres to the MPOWER framework. As mentioned earlier, the high score on the Warn component came from one incidental campaign and not a structural improvement in legislation. Additionally, the low score achieved in Protecting people from second-hand smoke is due to a major loophole in regulation, which allows designated smoking areas at work and in public places. Furthermore, the GLTC does not address smoking on public land or in transportation areas. While the Ministry of Health was successful in specifying strict protection criteria for designated smoking areas, enforcement of this mandate has proven to be difficult. The low score on Enforce prohibitions on advertising, promotion, and sponsorship is due to the GLTC allowing publicity and promotion of tobacco products aimed at adults through adult magazines, personal communication through mail, or within areas only accessible by adults. Advertising and promotion at sale points is prohibited, but this is not enforced successfully (16).

Despite these shortcomings in the GLTC, Mexico has taken little action since its implementation in 2009. One possible explanation for this could be a successful lobby by tobacco companies in Mexico. In general, a huge challenge for developing countries in implementing tobacco control policies has been a negative influence from tobacco companies (83). As their future depends on increasing tobacco use in LMIC, they invest heavily in targeted marketing and delaying tobacco control legislation in these countries (83). Their influence in Mexico can be seen in multiple ways. First, one month after the WHO FCTC ratification in 2004, Mexico signed an agreement with tobacco companies. This agreement restricted the application of successful tobacco control measures and accepted self-regulation by the industry of advertising and warning labels. While in 2006 this agreement was canceled, it shows the influence tobacco companies can have on federal legislation in Mexico. Second, tobacco companies have lobbied against tax raises extensively, and managed to block one in 2013. Additionally, after a tax raise in 2011 the tobacco industry launched a campaign claiming that this had led to a rise in illicit trade and lowered government tax-revenues. While this has been refuted multiple times, the media campaign continues to be present and periodically pops up again. Third, tobacco companies have been able to successfully market 14-cigarette packs. These packs make tracking of production sales and tax revenues more difficult for the federal government (16).

In spite of these difficulties in implementing successful tobacco control legislation, the overall prevalence of smoking in adult Mexicans is relatively low and has reduced over time (16). It is important to understand that tobacco use is complex and depends on a mix of biological, psychological, social and cultural factors (84). While tobacco control legislation has proven to influence smoking prevalence, in Mexico other factors could be of importance as well. First, it is important to consider the importance of religion in Mexico. Nearly all Mexicans report a religious preference, and 89% identifies themselves as catholic. Furthermore, 84% of Mexicans report religion to be very important

or important (85). Christian leaders have described smoking as ''contrary to the original form of man's creation'', and the Vatican disapproves of it (84). In Mexico, religious involvement was found to be negatively associated with smoking (85). Therefore, the importance of religion could explain the overall low prevalence of smoking in Mexico. Second, our study period overlaps with the economic crisis of 2008, which affected Mexico's economy severely (86). Economic hardship can lead to a reduction in smoking prevalence, as it reduces the affordability of cigarettes (87). This effect is likely to be larger in lower socioeconomic groups, which could be an additional explanation for the growing pro-rich socioeconomic inequality found in this study. Third, public awareness of the dangers of tobacco exposure has been increasing over time. As the negative health consequences of smoking become more known and accepted, overall attitudes towards smoking change (32). While these factors cannot be overlooked in explaining smoking prevalence and its reduction, effective tobacco control legislation is important in maintaining progress. Furthermore, tobacco control policies are able to consider socioeconomic inequalities, and effectively target groups with the highest tobacco burden. Therefore, they are an essential tool in combatting the tobacco burden in Mexico effectively.

5.2 Recommendations

As this research demonstrates, smoking prevalence in Mexican adults is disproportionally distributed among higher socioeconomic groups and this inequality increased over time. However, it is important to acknowledge that adolescents have vastly different smoking patterns. Therefore, further research is necessary to determine socioeconomic inequality and its trend over time in this part of the Mexican population. Additionally, further research is necessary to understand the increasing contribution of urban residence to the pro-rich socioeconomic inequality in smoking. Understanding the underlying reasons of the increasing probability of urban residents to smoke is necessary to tackle them and reduce smoking prevalence in this population. Overall smoking prevalence reduced in Mexico in the studied time period. Nonetheless, as implementation of successful tobacco control policies in Mexico has been challenging, this might be partly due to other factors than effective tobacco control policies. In order to better protect the Mexican population from the harms of tobacco use, Mexico needs to take further steps to amend the GLTC to meet FCTC recommendations. As smoking prevalence is mostly concentrated in the wealthiest, periodic mass media campaigns warning about the dangers of tobacco use might be most effective in reducing smoking prevalence in the population. While mass media campaigns affect the entire population, they reach higher socioeconomic groups faster and more effectively.

5.3 Limitations

This study has several limitations. First, measurement of current tobacco use relies on self-reported measures. Therefore, the possibility of recall bias cannot be excluded. Additionally, due to the negative effects of tobacco use, respondents might have omitted information regarding their use. Second, our analysis had an oversampling of older adults and sampling weights to correct for this were unavailable. This was inherent to the SAGE study design, but could have introduced some bias in our results. As younger adults are more likely to smoke and less likely to belong to the wealthiest quintile, oversampling of older adults could have led to an overestimation of pro-rich socioeconomic inequality in smoking. Third, we were unable to include more recent data than 2015. While new data for the SAGE study has been collected, this data has not been made available to the public yet. Its inclusion could have given us a completer and more recent picture of the development of socioeconomic inequality. We were also unable to include data from wave 0 in our analysis, as this dataset differed too much from wave 1 and 2. Since Mexico ratified the WHO FCTC in 2004, it would have been interesting to observe the trend in smoking prevalence from this point onward. Lastly, our analysis only included the older population of Mexico. Smoking is more prevalent among adolescents

compared to adults, and it could be that the socioeconomic distribution in this population has a different distribution.

For our literature review we only reviewed federal legislation, as region was unknown for our sample population. However, some important state level legislation was passed in the study period that was not included in our analysis. Several major cities, including Mexico City, implemented a 100% smoke free law in restaurants, bars and nightclubs. We were not able to investigate whether or not this had an effect on our findings. Lastly, some of the literature found describing tobacco control policies in Mexico were only published in Spanish. Therefore, these could not be taken under evaluation.

5.4 Conclusion

To conclude, smoking prevalence in Mexican adults is mostly concentrated among the rich. While overall prevalence of smoking reduced from 2009 to 2014, pro-rich socioeconomic inequality increased over this time. While currently the socioeconomic distribution in Mexico is pro-rich, it is likely that over time this distribution will shift towards the poor. As Mexico is facing an increase in NCD's and a population with an unfavourable risk profile, all available action to protect the Mexican population from unhealthy behaviour should be taken. To deploy tobacco control policies most effectively, it is important to keep monitoring the trend of socioeconomic distribution of smoking and what its biggest contributors are. While some tobacco control measures were implemented in Mexico between 2009 and 2014, there is still room for improvement in its legislative framework. Mexico should take further steps to alter the GLTC to meet FCTC recommendations. However, tobacco companies are proactively working against this. Therefore, strong political will and commitment is necessary to further reduce Mexico's tobacco burden.

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Appendix I. Components of PCA analysis

1	Television in household
2	Security system in home
3	Car in household
4	Presence of electricity
5	Bicycle in household
6	Built-in kitchen sink in household
7	Hot running water in household
8	Washing machine in household
9	Dishwasher in household
10	Refrigerator in household
11	Employ someone in house who is not a family member
12	Mobile phone in household
13	A bullock/ animal drawn cart in household
14	A computer in household
15	A HiFi or music center in household
16	Livestock
17	Internet access in home
18	A motorbike
19	A second home
20	Own land or property
21	Possession of other valuable items (e.g., jewelry, books, art)
22	Presence of regular source of income
23	Dwelling owned
24	Hard floor in dwelling
25	Cement, brick, stone, or wooden walls in dwelling
26	Main source of drinking water in household protected
27	Flushed toilet facility
28	No shared toilet facility
29	Gas or electricity as fuel for cooking

Appendix II. Overview of documents included in literature review

Articles from PubMed and ScienceDirect search

Title	Author(s)
Tobacco control in Mexico: a decade of progress and challenges. (16)	Luz Myriam Reynales-Shigematsu. Heather Wipfl, Jonathan Samet, Justino Regalado-Pineda, Mauricio Hernández-Ávila
Mexico's Commitment to Global Health (61)	Erick Alexánderson , Edgar Illescasz , Daniel Sierraz
Bridging the divide: global lessons from evidence-based health policy in Mexico (64)	Julio Frenk
Current and emerging issues in tobacco prevention and control (60)	Luz Myriam Reynales-Shigematsu , Reina Roa-Rodríguez , Jessica L Barrington-Trimis , Adriana Blanco-Marquizo
The Economics of Tobacco and Tobacco Taxation in Mexico (66)	Hugh Waters, Belen Sáenz de Miera, Hana Ross, Luz Myriam Reynales Shigematsu
Effects of tobacco control policies on smoking prevalence and tobacco-attributable deaths in Mexico: the SimSmoke (62)	Luz Myriam Reynales-Shigematsu, Nancy L. Fleischer, James F. Thrasher, Yian Zhang, Rafael Meza, K. Michael Cummings, and David T. Levy
Mexico *SimSmoke*: how changes in tobacco control policies would impact smoking prevalence and smoking attributable deaths in Mexico (63)	Nancy L. Fleischer,a James F. Thrasher,b,c Luz Myriam Reynales-Shigematsu,c K. Michael Cummings,d Rafael Meza,e Yian Zhang,f and David T. Levyg
Tobacco consumption, mortality and fiscal policy in Mexico (67)	Guerrero-López, Carlos Manuel Muños-Hernández, José Alberto Sáenz de Miera-Juárez, Belén Reynales-Shigematsu, Luz Myriam
Smoking trends in Mexico, 2002–2016: before and after the ratification of the WHO's Framework Convention on Tobacco Control (68)	Luis Zavala-Arciniega , Luz Myriam Reynales-Shigematsu, David T Levy , Yan Kwan Lau, Rafael Meza , Daniela Sarahí Gutiérrez-Torres, Edna Arillo-Santillán, Nancy L Fleischer, James Thrasher
Cigarette prices, cigarette expenditure and smoking-induced deprivation: findings from the International Tobacco Control Mexico survey (69)	Mohammad Siahpush, James F Thrasher, Hua H Yong, K Michael Cummings, Geoffrey T Fong, Belén Saenz de Miera, and Ron Borland
Tax, price and cigarette brand preferences: a longitudinal study of adult smokers from the ITC Mexico Survey (70)	Belén Sáenz de Miera Juárez, James F Thrasher, Luz Myriam Reynales Shigematsu, Mauricio Hernández Ávila, Frank J Chaloupka

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Documents selected from the WHO and tobacco control laws

Title	Source
WHO REPORT ON THE GLOBAL TOBACCO EPIDEMIC, 2009: Implementing smoke-free environments (42)	WHO
WHO report on the global tobacco epidemic 2011: Warning about the dangers of tobacco (88)	WHO
WHO report on the global tobacco epidemic, 2013: enforcing bans on tobacco advertising, promotion and sponsorship (89)	WHO
WHO report on the global tobacco epidemic, 2015: raising taxes on tobacco (58)	WHO
The general Law on Tobacco Control (59)	Tobacco control laws
Ministry of health agreement amending the health messages and information to appear on packaging and labelling (65)	Tobacco control laws